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RESEARCH AND TECHNOLOGY PROGRESS REPORTS

FOR THE PERIOD OCTOBER 1, 1973 THROUGH MARCH 31, 1974

(NASA-TM-81088) RESEARCH AND TECHNOLOGY PROGRESS REPORTS, 1 OCTOBER 1973 - 31 MARCH 1974 (NASA) 495 p

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COMPILED AND EDITED BY:
RESEARCH PLANNING OFFICE
SCIENCE AND ENGINEERING DIRECTORATE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PREFACE

This issue of MSFC's Research and Technology Progress Reports has been prepared in accordance with instructions for reporting Research and Technology from the Office of Aeronautics and Space Technology. A format is used, which provides only a narrative summary report at the RTOP level. Milestone Schedule Charts and Financial Status Charts are no longer required as elements of each progress report. However, as both charts provide useful information to individuals and groups within NASA having a program management function, they are available separately, in a supplementary volume, to those having a special need for them.

Issues of these reports are published twice a year, with reporting dates conforming to the OAST requirements of April 1 and October 1.

NOTE

The sequence of the contents of this report is indicated by the number at the center of the top margin of each page. Entries on the form completing the "Page_____of____" block should be ignored. Their only purpose is to indicate the number of report pages (including charts) submitted on a particular unit of work and the relative location of a particular page within that group.

To insure positive identification of text with charts, a Cross-Reference Table has been provided in the supplement.

To facilitate identification of certain research which was reported with codes differing from those assigned by NASA Headquarters, a Table of Corresponding Codes has also been included. All reports in this document are identified by Headquarters assigned codes.

TABLE OF CONTENTS

OAST

RTOP CODE NO.	TITLE	PAGE NO.
113-31-12	MAIN PROPULSION FOR SPACE SHUTTLE VEHICLES	1
113-31-14	SHUTTLE MAIN PROPULSION TECHNOLOGY	3
114-03-33	STRUCTURAL COMPOSITE MATERIALS FOR SPACE SHUTTLE	8
114-08-04	SPACE SHUTTLE COMPOSITES FOR PRIMARY STRUCTURE	12
115-17-04	SHUTTLE GUIDANCE	16
124-07-06	AEROTHERMODYNAMICS	18
124-08-37	SPACE SHUTTLE ADVANCED COMPOSITES FOR PRIMARY STRUCTURE	20
501-08-10	ATMOSPHERIC PARAMETERS	22
501-38-13	HAZARD AVOIDANCE AND ELIMINATION	37
502-01-03	PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS	52
502-21-27	SPACE VEHICLE THERMAL CONTROL	56
502-21-28	OPTICAL CONTAMINATION	59
502-21-30	ENVIRONMENTAL DESIGN CRITERIA	61
502-22-11	SPACE VEHICLE DYNAMICS	66
502-23-21	LARGE TELESCOPE TECHNOLOGY	70
502-23-31	OPTICAL MASS MEMORY	73
502-23-42	INERTIAL COMPONENTS	76
502-23-51	DESIGN, PROCESSING AND TESTING OF LSI ARRAYS	79

TABLE OF CONTENTS (Cont'd)

OAST

RTOP CODE NO.	TITLE	PAGE NO.
502-23-52	SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC PARTS	84
502-24-17	SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION STAGE	87
502-24-21	LAUNCH VEHICLE PROPULSION TECHNOLOGY	89
502-25-73	MULTI-KW DC DISTRIBUTION SYSTEM	97
502-33-53	SENSORS AND INSTRUMENTATION RESEARCH	99
503-24-06	REUSABLE NUCLEAR STAGE TECHNOLOGY	105

TABLE OF CONTENTS

OMSF

RTOP CODE NO.	TITLE	PAGE NO.
908-51-05	ELECTRICAL POWER	109
908-51-08	STABILIZATION AND CONTROL	111
908-51-21	MANUFACTURING AND INSPECTION	116
908-52-08	STABILIZATION AND CONTROL	118
908-52-10	GUIDANCE AND NAVIGATION	126
908-52-37	CRYOGENICS	128
908-52-39	AEROTHERMODYNAMICS	135
908-54-05	ELECTRICAL POWER	139
908-54-08	STABILIZATION AND CONTROL	141
909-51-02	THERMAL CONTROL	145
909-51-05	ELECTRICAL POWER	153
909-51-07	COMMUNICATIONS	157
909-52-39	AEROTHERMODYNAMICS	159
909-52-46	PHYSICAL STANDARDS	165
909-52-47	ENVIRONMENTAL QUALITY	169
909-54-05	ELECTRICAL POWER	175
909-54-07	COMMUNICATIONS	183
909-54-21	MANUFACTURING AND INSPECTION	185
909-54-22	TRANSPORTATION	195
909-54-33	INFORMATION MANAGEMENT SYSTEM	200
909-55-01	STRUCTURAL	203
909-55-02	THERMAL CONTROL	212

TABLE OF CONTENTS (Cont'd)

OMSF

RTOP CODE NO.	TITLE	PAGE NO.
909-55-03	PROPULSION	217
909-55-05	ELECTRICAL POWER	221
909-55-10	GUIDANCE AND NAVIGATION	236
909-55-37	CRYOGENICS	240
909-55-40	AEROELASTICITY	245
909-55-47	ENVIRONMENTAL QUALITY	251
970-62-20	FOOD, ATMOSPHERE, WATER AND WASTE MANAGEMENT	254
970-62-23	WATER AND WASTE MANAGEMENT	256
970-62-40	CVT EC/LSS SUPPORT PROGRAM	258
970-63-10	REQUIREMENTS FOR WORK PERFORMANCE DESIGN	269
970-63-20	TELEOPERATOR MANIPULATION AND CONTROL	274
972-30-00	AEROELASTICITY	292
972-50-00	AEROELASTICITY	294
975-61-05	ZERO-G ATMOSPHERIC CLOUD PHYSICS PROGRAM	296
975-72-01	SPACECRAFT SURFACES	297
975-72-39	OPTICAL CONTAMINATION	299
976-30-02	THERMAL CONTROL	301
976-30-04	SPACE SHUTTLE AUXILIARY PROPULSION SYSTEM (APS)	302
976-30-38	MATERIALS	304
976-30-40	AEROELASTICITY	307
976-30-45	SPACE SHUTTLE DYNAMICS AND AEROELASTICITY	310

TABLE OF CONTENTS (Cont'd)

OMSF

RTOP CODE NO.	TITLE	PAGE NO.
976-30-50	EASTERN TEST RANGE OCEAN WAVE STATISTICS FOR SPACE SHUTTLE BOOSTER DESIGN AND RECOVERY OPERATIONS	317
976-30-61	STRUCTURES	319
976-30-84	SHUTTLE DEVELOPMENT	325
976-30-93	STRUCTURAL	331
982-52-03	SHUTTLE MAIN PROPULSION TECHNOLOGY	332
982-52-61	SPACE SHUTTLE ENGINE AND VEHICLE TPS REVIEW	334
983-15-21	INSTRUMENTATION FOR SPACE SHUTTLE	337

TABLE OF CONTENTS

OA

RTOP CODE NO.	TITLE	PAGE NO.
161-80-01	SPACE STATION THERMAL CONTROL	341
175-21-71	CLIMATOLOGICAL-STATISTICAL ATMOSPHERIC AND CLOUD COVER MODELS	343
175-61-71	STATISTICAL DATA MANAGEMENT METHODS	345
175-61-73	ANALYSIS OF THE ENERGY INTERACTIONS BETWEEN ATMOSPHERIC LEVEL AND SOLAR TERRESTRIAL RELATIONSHIPS	349
177-53-71	REMOTE SENSING FOR GEOLOGICAL RESOURCES SURVEY	350
179-10	MATERIALS AND PROCESS R&D	352
179-11-10	STUDY OF LIQUID-SOLID TRANSITION FOR MATERIALS PROCESSING IN SPACE	375
179-11-11	SINGLE CRYSTALS OF METAL SOLID SOLUTIONS	378
179-11-12	SEGREGATION EFFECTS DURING SOLIDIFICATION IN WEIGHTLESS MELTS	380
179-11-14-02	IMMISCIBLE MATERIALS - GROUND BASED STUDIES	382
179-11-21-00	ZONE REFINING IN A ZERO-GRAVITY ENVIRONMENT	384
179-12-13	GROWTH OF SINGLE CRYSTAL RIBBON IN SPACE	385
179-12-13-06	ANALYTICS OF CRYSTAL GROWTH	387
179-12-15-01	SPACE PROCESSING RESEARCH ON CRYSTAL GROWTH	388
179-12-15-02	CRYSTAL GROWTH AND CHARACTERIZATION	389
179-12-16	GRAVITATIONAL EFFECTS ON PROCESS-INDUCED DISLOCATIONS IN SILICON	390
179-12-23	CRYSTAL GROWTH IN FUSED SOLVENT SYSTEMS	392

TABLE OF CONTENTS (Cont'd)

OA

RTOP CODE NO.	TITLE	PAGE NO.
179-12-23-02	SOLUTION CRYSTAL GROWTH	395
179-15-11-02	CONVECTION ANALYSIS	396
179-15-12-01	SORET SEPARATION IN ZERO GRAVITY	399
179-15-12-02	DIFFUSION ANALYSIS IN LOW GRAVITY	401
179-20	SPACE PROCESSING EQUIPMENT TECHNOLOGY	403
179-21-20	SOLAR ENERGY CONCENTRATOR SYSTEM FOR CRYSTAL GROWTH AND ZONE REFINING IN SPACE	412
179-24-30-01	CRYSTAL GROWTH TECHNIQUES IN ZERO GRAVITY	414
179-26-11-01	ACOUSTIC MIXING FOR SPACE PROCESSED MATERIALS	415
179-30	GROUND BASED SPACE PROCESSING TESTS	416
179-40	SPACE PROCESSING FLIGHT SYSTEMS	418
645-10-01	ZERO-G CLOUD PHYSICS EXPERIMENTS	419
684-30-90	TERMINAL GUIDANCE AND NAVIGATION FOR COMET AND ASTEROID RENDEZVOUS	421

TABLE OF CONTENTS

OSS

RTOP CODE NO.	TITLE	PAGE NO.
180-17-50	SYSTEM PERFORMANCE AND TECHNOLOGY ASSESSMENT FOR UNMANNED MISSIONS	423
180-17-52	SYSTEM AND TRAJECTORY ANALYSIS	425
180-17-53	DYNAMIC TESTS OF INERTIAL SENSORS	429
180-17-54	GUIDANCE COMPUTER TECHNOLOGY	434
180-17-55	CONTAMINATION CONTROL IN HYBRID MICROELECTRONIC MODULES	437
180-17-56	SOLAR ELECTRIC PROPULSION STAGE (SEPS) TECHNOLOGY	439
180-17-57	SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION STAGE	447
186-68-64	COMET AND ASTEROID RENDEZVOUS AND DOCKING (CARD)	458
188-36-56	MAGNETOSPHERIC-PHYSICS-PARTICLE AND PARTICLE/PHOTON INTERACTIONS	459
188-38-52	REAL TIME SOLAR MAGNETOGRAPH (RTSM)	461
188-41-51	ULTRAVIOLET AND OPTICAL ASTRONOMY	465
188-41-54	SUPPORTING STUDIES FOR RELATIVITY EXPERIMENT	468
188-45-52	METEOR ASTRONOMY	470
188-46-64	COSMIC RAY AND GAMMA RAY ASTRONOMY INVESTIGATIONS	472
188-48-51	INTERDISCIPLINARY SPACE RESEARCH	476
188-78-57	LARGE SPACE TELESCOPE (LST)	478

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AND
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PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
Marshall Space Flight Center	01 10 73 31 03 74	CURRENT NO.: 113-31-12	PRIOR NO.: 128-31-63

4. TITLE:

MAIN PROPULSION FOR SPACE SHUTTLE VEHICLES

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
T. W. Winstead	453-3854	A. L. Worlund

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Rapid Start of LH_2 Turbopumps

CONTRACT: NAS8-27608, Rockwell International/Rocketdyne

OBJECTIVES: To develop data on the rapid start of LH_2 turbopumps under conditions applicable to the Space Shuttle APS turbopumps, with emphasis on insulation coatings to reduce prechill requirements, and on deadhead starts.

APPROACH: Using data from contracts NAS8-20167 and NAS8-20324 as baseline:

(1) Perform analyses to select optimum coatings for the various feedline components and evaluate turbopump starting relationships.

(2) Conduct laboratory tests to determine thermophysical properties of candidate coating materials.

(3) Conduct tests on both uncoated and coated RL-10 turbopumps using various applicable starting modes.

STATUS: Technical Progress: The comparative testing has been completed and demonstrated that 30% reductions in chilldown time and mass are practically achievable. The data indicated that 60% reductions are probable, but this was not demonstrated due to sequencing peculiar to the test facility.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
ASR 71-311	First Quarterly Progress Report	G. S. Wong	October 1971
ASR 72-6	Second Quarterly Progress Report	G. S. Wong	January 1972
ASR 72-93	Third Quarterly Progress Report	G. S. Wong	April 1972
ASR 72-146	Fourth Quarterly Progress Report	G. S. Wong	July 1972
ASR 72-239	Fifth Quarterly Progress Report	G. S. Wong	October 1972
ASR 73-5	Sixth Quarterly Progress Report	G. S. Wong	January 1973
R-9273	Final Report	G. S. Wong	October 1973

FIRST BENEFITING PROJECT: SPACE SHUTTLE

Post-test inspection of the feed system indicated excellent coating adhesion after 12 cryogenic cycles totaling 680 seconds exposure.

The coating on the RL-10 turbopump was Kel-F with microballoons. A thickness of .020" was selected for the heavy housing components to retard heat flow and .005" for the rotating components to accelerate chilldown. Temperature and pressure fluctuations were minimal during chilldown of the insulated pump, as the coating surface rapidly cools to below the metastable boiling regime.

Management Progress: The final report draft has been submitted and approved, and a final briefing was given on October 4, 1974. This will be the final URS report.

Conclusions: Laboratory tests provided significant data on the use of coatings to enhance cooldown of turbomachinery for LH_2, LN_2, and LOX. Limited testing demonstrated the feasibility of deadhead starts and coated turbopumps. A 30 percent reduction in chilldown requirements was demonstrated, and a 60 percent reduction indicated but not demonstrated due to facility-peculiar sequencing limitations.

Problems: Erosion of coating at tip of impeller blade.

Cause of Problem: Possibly due to deep cavitation during partial chilldowns where pump performance could not be developed.

Problem Solution: Reduced flow velocity profile by considering coating during initial design.

Forecast: Applications development testing can proceed on LH_2, LN_2, or LOX coated turbomachinery with low risks, based on the data established under this program. Preliminary data indicates significant weight and cost savings are possible for altitude-restart applications.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 113-31-14	PRIOR NO.:

4. TITLE:

Shuttle Main Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMP H. Harman	453-5620	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: 035, Pressure Transducer for Active Pogo Control
H-92100A, NBS, Washington, D. C. and Boulder, CO

OBJECTIVE(S): A very high resolution, responsive pressure transducer, is required to measure pressure oscillations of 8 to 10 psi in an 8000 psi liquid oxygen or hydrogen line with an accuracy of 1% in amplitude and phase and the pressure oscillations in the combustion chambers. The main problems requiring development are transducer stability and sensitivity in such a hostile environment.

APPROACH: A development program to test, evaluate, modify, and retest various types of pressure transducers will be initiated to produce a pressure transducer meeting the described objective.

STATUS: Technical Progress - NBS Boulder has stopped work due to a lack of funds. Requested funds have not been granted to continue the cryogenic testing. NBS, Washington, D. C. is continuing with the hot gas portion of the contract. Sensors being evaluated are: Kaman Sciences, Sensotec, Sensometrics, PCB, Inc. and Entran, Inc.
Management Progress - none
Forecast - Development will result in productivity of a prototype transducer for testing and flight qualification.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 113-31-14 PAGE 2 OF 2

STATUS (CONCLUDED): NBS, Washington, D. C. has been granted an extension of time and will continue investigation of candidate sensors on the hot gas portion of the subject contract.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 to 31 03 74	113-31-14	

4. TITLE:

Shuttle Main Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMF H. Goldstein	453-5613	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Cryogenic Facility Mass Flowmeter
H-87466A, NBS, Boulder, CO

OBJECTIVE(S): To develop a cryogenic mass flowmeter capable of measuring mass flow with an accuracy of 0.5% over the flow range of the Space Shuttle engine. Dynamic response will also be considered for use in POGO effect testing.

APPROACH:
1. Modification of electromagnetic flowmeter to eliminate leave-line drift.
2. Design and fabrication of auto-correlation flowmeter.
3. Modification of N. B. S. flow facility to include dynamic flow calibration.
4. Calibration of dynamic flowmeters for NASA to be used for pogo investigation.

STATUS: The electromagnetic flowmeter task was discontinued because of insufficient documentation. The auto-correlation flowmeter was built but was not tested because special emphasis was put on the dynamic flow facility modification. The N. B. S. facility modification has been completed and is presently being used to evaluate an ultrasonic flowmeter that was developed for Langley Research Center for the pogo investigation program. Evaluation of the NASA dynamic orifice system is continuing.
Conclusions - Facility modification appears to meet objectives.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly and Quarterly Reports			

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	113-31-14	

4. TITLE:

Shuttle Main Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMT William B. White	453-5619	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Fast Response High Temperature Sensor

NAS8-28952 Kollsman, Syosset, NY
NAS8-28953 International Harvester, San Diego, CA
H-96516A Barnes Engineering, Stamford, CT

OBJECTIVE(S): The control Shuttle APU and APS turbine temperature was expected to require a reliable sensor capable of continuous operation in a hot gas environment of 1000°C to 1400°C at pressures up to 8000 psig while providing a time response characteristic and reliability requirements not compatible utilizing conventional temperature measuring techniques such as thermocouples or resistance elements. Therefore, technology development is needed to arrive at a satisfactory solution.

APPROACH: A literature and market survey was conducted to determine the most feasible approach for non-contacting fast response temperature sensors. Representative systems were obtained for tests and evaluation based on preliminary requirements of engine operating characteristics. The most feasible approach was to be developed into a prototype flight system.

STATUS: Technical Progress - All hardware and final reports have been received. Operational verification has been completed on each system.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1.	Final Report, System for Measuring Turbine Blade Temperatures, Contract NAS8-28952	J. Micaliand M. Wengryn	12/72
2.	Radiation Pyrometer for Gas Turbine Blades Contract NAS8-28953	D. Rohy W. Compton	10/73
3.	Turbine Blade Temperature Measuring System Solar P/N 106751	D. Rohy W. Compton	10/73

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 113-31-14 PAGE 2 OF 2

STATUS (CONCLUDED): Management Progress - All contracts have been completed.

Conclusions - Evaluations of the measuring systems received under this program have demonstrated the feasibility of using the remote sensing techniques for temperature inputs to an engine control system. Experience gained in this program will allow the direct application of the remote sensing technique to prototype a flight system in the event a firm requirement is generated.

Problems - none

Forecast - none

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 114-03-33	PRIOR NO.:

4. TITLE:

Structural Composite Materials for Space Shuttle

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
F.P. Lalacona	205-453-5516	R. J. Schwinghamer

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of a Method for Fabricating Metallic Material Composite Shapes By A Continuous Process. NAS8-27010 Commonwealth Scientific Corporation.

OBJECTIVE: To develop a method for automatically fabricating a metallic composite utilizing automatic mechanical winding techniques and consolidating the cladded filament by heat and pressure into a structural shape. The materials shall be aluminum for the matrix, boron and graphite for the reinforcement. The structural shapes to be fabricated shall be tube, "I" beam, and hat section of "Z" section.

APPROACH: A study shall be made of the necessary die design required to produce structural shapes of boron-aluminum and graphite-aluminum composites by a continuous process. Various parameters such as differences in thermal expansion of die material, dwell time at temperature, reaction between filament and matrix, and matrix-filament mechanical properties of the resultant composites shall be evaluated.

STATUS: Technical Progress: Modifications in the B/al tube manufactured have been made and 2.00 inch diameter tubes three feet long have been fabricated successfully. This preform was not treated with acrylic binder as previously prior to cold drawing resulting in eliminating two steps in the process.

Several small tubes (G/al) 3.00 inches long with 1/4 inch diameter were successfully fabricated using the electron beam process. Tests are in progress to evaluate both physically and mechanically these graphite/aluminum composite tubes.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NONE			

FIRST BENEFITTING PROJECT: Spacelab

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 114-03-33 PAGE 2 OF 2

Management Progress: This program has been extended to November 1, 1974.

Conclusions: None to report at this time.

Problem: None

Forecast: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 -31 03 74	CURRENT NO.: 114-03-33	PRIOR NO.:

4. TITLE:

Structural Composite Materials for Space Shuttle

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
F. P. Salacona	205-453-5516	R. J. Schwinghamer

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Evaluation of Boron/Aluminum Structural Components for Space Shuttle NAS8-27738 General Dynamics/Convair

OBJECTIVE: The objective of this program is to evaluate the properties of boron-aluminum structures and at the same time to establish and facilitate processing techniques, design analysis, and fabrication characteristics of boron-aluminum composites.

APPROACH: Boron-Aluminum properties will be evaluated by testing the composite in tension, fatigue, and shear from -320°F to +800°F. Structural assemblies will be designed involving the following structures: (1) Compression panel, (2) Thrust structure truss beam, and (3) Thrust structure shear web beam. In addition, a manufacturing process development task is to be conducted, which shall include studies in machining, joining, chemical treatment, and tooling requirements. Finally, boron-aluminum components selected from the design analysis, will be fabricated and these components subjected to structural tests.

STATUS: Technical Progress: Rework was performed on the elastic-buckling tubes (straightening of bent tubes) and retested. The rework supporting bent and straightening area with titanium foil strips. Shear beam repair was found to be too costly. Therefore, three additional components for repair were selected in its stead.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
GDCA-OB073-006	Design, Mfg. Dev. Test and Evaluation of Boron/Aluminum Structural Components for Space Shuttle Vol I: Design and Analysis Vol II: Materials & Processing Vol III: Shear Beam Component Test and Analysis	M. F. Miller J. L. Christian W. F. Wenmhold	August 1973
		E. E. Spier M. E. Miller	February 1974

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 114-03-33 PAGE 2 OF 3

Management Progress: The contract has been extended for an additional 8 months to May 31, 1974.

Conclusions: It has been established that B/Al composites can be successfully fabricated into useful structural components, such as, a shear beam with properties exceeding that of aluminum at both room temperature and at 600°F. Also, resistance welding and mechanical joining methods were found to be well within the state-of-the-art.

Problem: None

Forecast: None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE OF	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 114-08-04	PRIOR NO.:

4. TITLE:

Space Shuttle Composites for Primary Structure

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. E. Engler	453-4050	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Graphite/Epoxy Metering Shell

OBJECTIVE(S): To demonstrate the dimensional stability and the structural integrity of a graphite/epoxy shell structure as applied to a metering structure of a space optical telescope system.

APPROACH: Technology investigations in the areas of structural design and analysis, materials evaluation, fabrication, quality assurance, and testing will be conducted. Representative requirements of a large space telescope payload for the Space Shuttle will be utilized for the design, fabrication, and test of a half-scale shell assembly. The potential of a shell structure in achieving a very high degree of dimensional stability under static, dynamic and thermal loads will be evaluated.

STATUS: The contractor (General Dynamics/Convair Aerospace Division) conducted a preliminary design effort to compare truss and shell structural concepts. It was concluded that both concepts had the potential for meeting the performance requirements. A half-scale shell structure with a full-scale laminate was selected for an in-depth investigation. A laminate was designed for a nominal zero coefficient of thermal expansion utilizing a selected graphite/epoxy material system. Structural element testing is currently being done to confirm the properties of the laminate design. Tooling for the fabrication and assembly of the half-scale shell structure has been completed.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Quarterly Progress Reports			

1 Encl

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 114-08-04 PAGE 2 OF 2

MANAGEMENT PROGRESS: None

PROBLEMS: Inability to obtain graphite/epoxy tapes on the planned delivery schedule.

REPORTS: Quarterly progress reports issued under contract NAS8-28201.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 114-08-04	PRIOR NO.:

4. TITLE:

Space Shuttle Composites for Primary Structure

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. E. Engler	453-4050	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Graphite/Epoxy Metering Truss Structure Components

OBJECTIVE(S): To confirm the structural integrity, manufacturing feasibility, thermal response and environmental suitability of graphite/epoxy structural members for use on a space operational optical system.

APPROACH: Conduct investigations into material characteristics, configurations of structural components and joints, fabrication, quality assurance and testing to achieve components having a near zero coefficient of thermal expansion. Representative requirements for a large space telescope will be utilized for the design, fabrication, and test of a truss subassembly (two struts plus an apex fitting). The potential of the selected graphite/epoxy material system when used in a truss design to achieve a structure having a very high degree of dimensional stability and no adverse outgassing characteristics will be evaluated.

STATUS: This development effort was redirected to development of advanced composites for use in structures for Space Shuttle payloads. The Boron/Epoxy Truss Beam Assembly fabricated before the redirection has not been tested due to program priorities at MSFC.

For the redirected effort, the contractor (Grumman Aerospace Corp.) investigated various material systems and laminate orientations. Element test specimens were fabricated and tested to determine strength, stiffness and coefficient of thermal expansion values, and a material/laminate combination was subsequently selected. Humidity and

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
Monthly Progress Report			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 114-08-04 PAGE 2 OF 2

outgassing tests were also conducted on element test specimens. Subcomponent tube specimens were fabricated to measure the coefficient of thermal expansion in the anticipated structural configuration.

MANAGEMENT PROGRESS: None

PROBLEMS: Inability to test boron/epoxy beam at MSFC.

Difficulty in obtaining required accuracy with test instrumentation for graphite/epoxy components.

REPORTS: Monthly progress reports issued under contract NAS8-26675

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	115-17-04	115-17-04

4. TITLE:

Shuttle Guidance

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-GG R. R. Burrows	205-453-0445	James C. Blair

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Uniform Shuttle Guidance
NAS8-28425, International Business Machines Corporation
18100 Frederick Pike
Gaithersburg, MD 20760

OBJECTIVE(S): The space tug is to be a versatile tool for exoatmospheric transportation, able to complete complicated orbital maneuvers without either on-board or ground based human intervention. As a result, the requirement for reliable automatic guidance and control is especially stringent. This effort will be directed towards the adaptation of the GUIDE algorithm (developed under NAS8-24018 for optimal space shuttle ascent and orbital guidance studies) for real-time optimal guidance of the space tug in applications such as transfer from low earth orbit to rendezvous with a synchronous equatorial satellite.

APPROACH: Currently existing algorithms will be adapted to tug real-time optimal guidance applications. A Bolza formulation with terminal constraints will be used with tuning of the matrix to achieve a suitable compromise between the constraints and fuel cost for a variety of missions. Complete simulation of missions using two or three burns separated by coast arcs will be conducted. The developed algorithm will be checked for efficiency in a real-time feedback guidance mode and in an on-board targeting mode. Finally, the algorithm will be documented and a FORTRAN implementation delivered to MSFC.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: SPACE TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 115-17-04 PAGE 2 OF 3

STATUS: Technical Progress: The GUIDE 71/6 algorithm was reprogrammed to remove the atmosphere and is presently being altered to initialize with two new sets of orbital elements. The final program will include four separate ways to initialize the target orbit parameters and will automatically choose to solve either a rendezvous or five constraint mission depending on which parameters are specified. An automatic convergence technique was devised in an attempt to converge the three burn mission starting from the near impulsive case. This technique worked adequately down to a thrust multiplier of 2, at which point the targeting scheme ceased to converge. It appears that the problem lies in the sensitivity of $|\bar{u}|$ across the transfer orbit where $\bar{u}$ is the impulsive primer vector (costate) for initialization at perigee. A previously undetected error in the Newton-Raphson iteration scheme used by the subroutine to solve for a generalized eccentric anomaly was discovered and corrected.

Management Progress: Work under this contractual effort is now scheduled to be concluded by June 30, 1974.

Conclusions: None

Problems: The major problem now encountered deals with automatic convergence as outlined above.

Causes of Problems: The problem appears to lie in the sensitivity of $\bar{u}$ across the transfer orbit.

Suggested Solutions: It should be noted that the problem encountered with convergence as outlined above is limited to the case where no mission information is available. Since, in the real world, mission information is available for each flight, the problem, if it cannot be solved completely, would still not be particularly harmful to the overall results of this effort. Work will continue, however, to find a solution.

Forecast: A space tug real-time optimal guidance algorithm will be developed on schedule.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 124-07-06	PRIOR NO.: 124-07-06
4. TITLE: Aerothermodynamics			
5. RESPONSIBLE INDIVIDUAL: S&E-AERO-AT Homer B. Wilson	TELEPHONE: 205 453-1163	APPROVAL: Werner K. Dahm	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: High Altitude Plume Expansion
NAS8-24072, Calspan Corporation
P. O. Box 235
Buffalo, New York 14221

OBJECTIVE(S): The objective of this research is to provide experimental data on rocket exhaust flow fields from both single and clustered rocket nozzles at high-altitude ambient conditions.

APPROACH: The feasibility of obtaining combustion chamber pressures up to 3000 psi in H_2-O_2 short-duration models will be investigated and the most optimum technique selected. Heat transfer and pressure data will be obtained on a model using the selected technique.

STATUS: Technical Progress - A constant pressure combustion technique was selected in preference to a constant volume technique because it allows close control of flow termination, minimizing nozzle throat heating, and provides constant chamber pressure for longer periods. Use of the constant pressure system requires handling of oxygen at pressures approximately twice the desired engine combustion chamber pressure. A chamber pressure of about 3000 psi was found to be feasible but would require extensive development. The most cost effective chamber pressure was found to be 1500 psi. Heat transfer and pressure data were obtained on a model using this technique which was designed and fabricated under Rockwell International Space Shuttle funding. These data were obtained during three check out firings of the

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 124-07-06

PAGE 2 OF 3

STATUS (CONCLUDED)

model to provide preliminary data early in the test program. All work on this task is complete and this is a final report.

Management Progress - None

Conclusions - The constant pressure combustor design was found to be the most desirable up to chamber pressures of 1500 psi. Higher pressures would require a significant development effort. Although only a relatively small amount of heat transfer and pressure data were obtained, the general levels expected were confirmed. Substantially, more data will be obtained during the Rockwell test program.

Problems - None

Forecast - None

Publications - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	124-08-37	

4. TITLE:

Space Shuttle Advanced Composites for Primary Structures

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
ASTN J. M. Stuckey	3-1222	R. J. Schwinghamer

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: In House Effort on Evaluation of Graphite Composites

OBJECTIVE(S): To evaluate and optimize curing and processing conditions for graphite prepreg materials through fabrication of test specimens and to develop realistic design information for composite materials. Recently to qualify graphite/epoxy laminates as the material for the optical bench of the Large Space Telescope (LST).

APPROACH: Initial efforts are concentrated upon available high modulus and high tensile graphite-epoxy prepreg materials. Test pieces are being fabricated, and the physical and mechanical properties obtained for finished products over a wide temperature range are correlated with processing and curing history. Optimization of cure procedures using a dielectric monitor will be studied. In addition, polyimide specimens provided under Contract NAS8-26198 will be tested at -423°F, and cure procedures developed under that program will be checked for reproducibility. Based on available data four commercially available high modulus graphite/epoxy prepreg were selected for qualification to the unique requirements of the LST.

STATUS: Technical Progress--Efforts on the report on the evaluation of 0/90 bidirectional graphite/epoxy-phenolic laminates obtained from General Electric have been delayed Emphasis is being placed on high modulus graphite/epoxy laminates for LST. Laminates are being fabricated from three candidate epoxy prepregs and test specimens are being prepared for thermal expansion, thermal conductivity, outgassing, environmental

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 124-08-37

PAGE 2 OF 2

STATUS (CONCLUDED): exposure, moisture sorption, and mechanical property tests. Data on mechanical properties as fabricated are being obtained at 75°F and -100°F. Moisture sorption tests have been initiated.

Management Progress--Emphasis shifted to qualifying high modulus graphite/epoxy laminates for LST.

Conclusions--Data shows a problem with graphite and boron/epoxy laminates from moisture sorption; polyimide laminates are not encountering the same difficulty. Tests on the pyrone resin/graphite laminate show that more development effort is required before commercial application.

Problem--Tensile testing at -423°F (temporarily postponed) has resulted in specimen failures in the reinforced area rather than the test area. One prepreg eliminated from program due to inability of the prepreg suppliers to obtain the basic epoxy resin which was discontinued by the manufacturer. Another prepreg has been ordered as a replacement.

Cause of Problems--Differences in thermal expansion of adhesive and reinforcement add to the thermal stresses introduced by the test temperature.

Suggested Solutions--Reduce mismatch in thermal expansion by using a filled adhesive to bond reinforcement and use reinforcements of glass or graphite laminates.

Forecast--The program in progress should establish that graphite/epoxy can be used for LST. Thermal expansion, outgassing, and moisture sorption-disorption data should indicate the more desirable laminates for LST application.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 23	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	501-08-10	133-61-10

4. TITLE:

Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George Fichtl, S&E-AERO-YA	205-453-3109	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK (1) Definition of and Effect of Wind Shear on the Operation of Aeronautical System

TASK (2) Fog Microphysical Research and Numerical Modeling of Fog

TASK (3) Wind Profiles Over Non-Uniform Surfaces Relative to Design of Aircraft and Space Vehicles

TASK (4) Atmospheric Parameters for the Definition of Clear Air Turbulence Statistics

TASK (5) Wake Structure Model Development for Aeronautics

TASK (6) Definition of the Horizontal and Vertical Structure of Turbulence for Aeronautical System Design and Operation

TASK (7) Structure of Turbulence in Severe Atmospheric Conditions

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
(See Attached)			

FIRST BENEFITTING PROJECT: (See Attached)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 2 OF 23	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 /4	CURRENT NO.: 501-08-10	PRIOR NO.: 133-61-10
4. TITLE: Atmospheric Parameters			
5. RESPONSIBLE INDIVIDUAL: George Fichtl, S&E-AERO-YA	TELEPHONE: 205/453-3109	APPROVAL: William W. Vaughan	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK(1) Definition of and Effect of Wind Shear on the Operation of Aeronautical Systems
In-House Effort

NAS8-26600, University of Dayton Research Institute, Dayton, Ohio

NAS8-28136, Aeronautical Research Associates of Princeton, Princeton, N. J.

OBJECTIVES: To develop environmental wind models of low-level atmospheric shear flows for the safe design and operation of aeronautical systems. The models shall define the steady-state and turbulent spatial variations of wind along the flight path of aeronautical systems during the take-off and landing flight phases.

APPROACH: Develop models of wind shear which define the average, as well as extreme, wind shears that could occur over and around airports. The analysis will primarily be concerned with wind shear in stable air (nighttime flows) although some consideration will be given to unstable daytime and neutral boundary layer flows. These studies will be based on analyses of atmospheric boundary layer wind profile data from the 150-meter ground wind facility at KSC and the MSFC eight-tower ground wind facility. In addition, aircraft response studies will be conducted to determine those magnitudes of wind shear which adversely affect the landing and take-off of aeronautical systems.

STATUS: Technical Progress: The effort by John C. Houbolt of the Aeronautical Research Association of Princeton, has been completed. This effort was concerned with the identification of the major problems relative to the definition of low level wind environments for the take-off and landing of aeronautical systems. The final report NASA CR-2360 noted fifteen conclusions and eight specific recommendations which hopefully will be acted upon by the NASA whenever possible relative to technology development

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR-2288	A Model of Wind Shear and Turbulence in the Surface Boundary Layer	James K. Luers	July 1973
NASA CR-2287	Effect of Shear on Aircraft Landing	James K. Luers & Jerry B. Reeves	July 1973
NASA CR-2360	Survey on Effect of Surface Winds on Aircraft Design and Operation and Recommendations for Needed Research	John C. Houbolt	December 1973

FIRST BENEFITTING PROJECT: Aeronautical (Vehicle Take-off and Landing) & Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 501-08-10

PAGE 3 OF 23

STATUS: (continuted) in the area of atmospheric parameters.

Conclusions: The major conclusion of the ARAP report is that the problem of maintaining control of the aircraft, particularly during hover, take-off, approach and landing, is probably the most critical design and operational problem that is due to surface winds and gusts. The report further noted that better sensors and cues or displays to the pilot are needed; it is very difficult for him to detect what the winds and gusts are doing, and what his aircraft motions are. Other conclusions were noted in the report. It is planned that the FY75 atmospheric parameters research program will be designed to respond to many of the operational and design deficiencies in aeronautics, where appropriate, as noted in the ARAP report. This will be especially true for wind and turbulence model development and the use of these models in developing better procedures at aerodromes for reporting the environment to pilots.

Problems: The work concerning the development of reporting requirements, criteria and procedures for reporting low level wind environments (wind shear, etc.) to pilots prior to take-off or landing has been delayed due to funding cost and obligation problems. It is anticipated that these problems will be resolved with the coming of the new fiscal year funding (FY75).

Causes: See problems for solution.

Forecast: During the next reporting period a research plan for FY75 efforts in the area of low level wind environment reporting requirements, procedures, and criteria will be developed.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 5 OF 23	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	501-08-10	133-61-10

4. TITLE:

Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-YE Otha H. Vaughan	205-453-3109	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK(2): Fog Microphysical Research and Numerical Modeling of Fog

Contract No.: NAS8-29533 Colorado State University
Ft. Collins, Colorado 80521

OBJECTIVE(S): To study the life cycle and microphysical properties of both field and laboratory simulated warm fogs, perform studies leading to the development of techniques for field fog modification programs, and develop numerical models of fog formation and dissipation techniques for use in predicting success criteria for field testing in the future.

APPROACH: To develop techniques for use in field fog modification operations requires a thorough understanding of a fog's microphysical characteristics under natural conditions of formation and dissipation, as well as how the fog will react to the modification or dissipation techniques. This research program will use previous reports from other researchers, contracted theoretical and laboratory studies, inhouse laboratory studies, as well as data generated from field test programs from all available sources. These data will be used in providing the knowledge required to develop the most reliable, ecologically safe, and economic solution to the fog problem.

STATUS: Technical Progress: Dr. James Connell, a full-time research associate at Colorado State University, has completed a first-draft of the Warm Fog Nucleation Study report. This report covers a literature survey of all the nucleants used in fog modification, theoretical aspects of nucleation activity, effects of both advertent and inadvertent nucleant behaviour in the formation, stabilization, and dissipation of

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR-2201	"A Field Investigation and Numerical Simulation of Coastal Fog"	E. J. Mack, W. J. Eadie, C. W. Rogers, W. C. Kocmond & R. Pilie	Feb. 1973
NASA CR-2078	"Project Fog Drops, Part I: Investigations of Warm Fog Properties"	R. Pilie, W. Eadie, E. Mack, C. Rogers, & W. Kocmond	Aug. 1972
NASA CR-2079	"Project Fog Drops, Part II: Laboratory Investigations"	W. Kocmond, E. Mack, U. Katz, & R. Pilie	July 1972
NASA CR-1731	"Investigations of Warm Fog Properties & Fog Modification Concepts"	Kocmond, Pilie, Eadie, Mack & Leonard	April 1971

FIRST BENEFITTING PROJECT: Aeronautics

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-08-10 PAGE 6 OF 23

STATUS (Cont'd):

warm fogs, air flow and turbulence aspects in fog formation and dissipation, instrumentation requirements for present and future research programs and suggested research programs which are needed to fill the gaps in our present understanding of the life cycle of warm fogs.

Problems: None

Forecast: After a review by members of the Colorado State University staff, the rough draft will be sent to the COR for his comments.

Funds have been obligated starting in FY-75 to continue the numerical modeling of the life cycle of fog. Laboratory research programs as identified by the CSU research personnel will be started in FY-76 and the computer modeling plus the laboratory research should provide an excellent basis to plan possible field tests of the various materials which prove to be most effective in laboratory fog dissipation testing studies.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 8 OF 23	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	501-08-10	133-61-10

4. TITLE:

Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
G. H. Fichtl, S&E-AERO-YA	205/453-3168	W. W. Vaughan, S&E-AERO-Y

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK (3)Wind Profiles Over Non-Uniform Surfaces Relative to Design of Aircraft and Space Vehicles

NAS8-29584, University of Tennessee Space Institute, Tullahoma, Tennessee

OBJECTIVES: To develop a mathematical model of the flow of air over low-level natural and man-made obstructions. The model will be used to calculate the flow over the typical types of ground obstructions found at and in the vicinity of airports, heliports, etc. The results will be analyzed to determine if hazards exist in the flows relative to the safe operation of aeronautical systems. The results will be generalized so as to provide guidelines relative to the operation of aeronautical systems over low-level obstacles.

APPROACH: The approach will consist of a mathematical model based on the boundary layer equations for atmospheric flows. The dissipation terms resulting from atmospheric turbulence will be expressed in terms of mean flow parameters. The resulting equations and associated boundary conditions will be solved with numerical finite difference techniques to produce the flow field of air over obstacles for various geometries. The sensitivity of the model relative to the closure hypothesis to represent the dissipation terms will be determined. Various geometries for the low-level surface obstructions (buildings, small hills, etc.) will be selected and an assessment will be made of the character of the flows relative to the safe operation of aeronautical systems. The results of the study will be verified at MSFC with field experiments.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR-2182	A Boundary Layer Approach to the Analysis of Atmospheric Motion Over a Surface Obstruction	Walter Frost, J. R. Maus, W. R. Sinclair	January 1973

FIRST BENEFITTING PROJECT: Aeronautical (Aircraft Control Systems) & Space Shuttle

STATUS: Technical Progress: The contractor is in the final stages of the analysis of the turbulence kinetic energy budget of the flow over surface obstructions. These results will be useful in the definition of turbulence flows for aircraft design during the take-off and landing flight phase. In addition, studies concerning the position of secondary eddies from obstacles relative to the flight path of aeronautical systems has been completed. These results which will be published in a NASA CR will be extremely useful in both design and operational applications. Efforts have been initiated toward the development of three-dimensional models of flow over surface obstructions. The current work, in anticipation of FY 75 efforts, is concerned with the definition of the distribution of pressure over three-dimensional obstacles. This pressure field will in turn be used to calculate the associated flow field. The present analysis is concerned with ellipsoidal obstacle geometry. Bluff bodies shall be considered in a later analysis.

Management Progress: Close coordination has been maintained with the contractor during the reporting period via telephone and visits to UTSI by the NASA monitor and to MSFC by the contractor. A paper entitled "A Boundary Analysis of Atmospheric Motion over a Semi-Elliptical Surface Obstruction" which discusses some of the major results of the FY72 and FY73 efforts has been accepted for publication in the International Journal of Boundary Layer Meteorology. Three contractor reports concerning a) turbulent kinetic energy in flow over surface obstructions b) flow over two-dimensional bluff bodies, and c) the dynamics of aircraft flight are in preparation. The reports concerning items a) and c) are essentially complete and will be transmitted to the NASA in rough draft form in the next four to six weeks. The report concerning item b) will be available in four to five months.

A contract has been signed to extend the present effort into FY75. The new effort shall be concerned with completing the definition of wind fields associated with individual buildings, that show possible hazardous wind disturbances to aeronautical systems and the assessment of the level of danger to aircraft passing through them. Wind around groups of buildings will also be studies and first trial mathematical analyses of these flow fields will be conducted.

Problems - None

Cause of Problem - None

Forecast - This contract is being performed on schedule. The next reporting period will provide for documentation of efforts to date via NASA contractor reports. In addition efforts will be intensified relative to the analysis of flow over three-dimensional obstacles.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-08-10	PRIOR NO.: 131-61-10

4. TITLE:

Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George H. Fichtl, S&E-AERO-YA	205/453-3168	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK (4) Atmospheric Parameters for the Definition of Clear Air Turbulence Statistics
In-House Effort

OBJECTIVE(S): To develop models of clear air turbulence (CAT) with detailed wind and temperature profile data between 1 to 18 km altitude.

APPROACH: The plan is to relate nondimensional numbers which define the flow over relatively small vertical scales (100-300 m) to corresponding numbers defined over relatively larger vertical scales (1000-5000 m). This will result in conditional distribution functions of small scale parameters given certain values for the large scale defining flow parameters. This data analysis will establish the statistical relationships between the various scales of motion in the context of the selected nondimensional numbers. One obvious nondimensional number that will be used in the analysis will be the Richardson number; however, it is possible to define others. Once these statistical relationships are determined then the probability of the occurrence of CAT can be determined given the large scale nondimensional numbers, provided that critical nondimensional numbers on the small scale can be defined relative to the generation of CAT. Assuming that this can be accomplished, CAT occurrence climatology can be derived for various locations once the climatology of the large scale nondimensional numbers is known, using relatively available rawinsonde data. The development of the statistical relationships between the large and small scale flows will be first determined for Cape Kennedy, Florida because of the large data base that now exists.

STATUS: Technical Progress: The technical progress during this reporting period has been concerned with the theoretical formulation of the problem of relating large and small scale parameters indicative of CAT. A selection of detailed wind and temperature profiles for Richardson number analyses have been selected for data

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
Fichtl, G. H. and Dennis Camp, 1973:	Spectral Structure of Tropospheric Vertical Temperature Profiles over Cape Kennedy, Florida.	Journal of Geophysical Research, 78, 6218-6223.	

FIRST BENEFITTING PROJECT: Aeronautical (Aircraft Structures) & Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-08-10 PAGE 12 OF 23

STATUS: (continued) processing. These data will be processed during the next reporting period.

Conclusions: At the present time we have no major conclusions to report.

Problems: None

Forecast: Work will continue on studies relative to the development of the Richardson number probability model for clear air turbulence probability determination.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 14 OF 23	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-08-10	PRIOR NO.: 133-61-10

4. TITLE:
Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
G. H. Fichtl, S&E-AERO-YA	205/453-3168	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK (5) Wake Structure Model Development for Aeronautics

NAS8-29583, "Wind Tunnel Investigation of Wakes Downwind of Buildings and Natural Obstacles" Colorado State University, Ft. Collins, Colorado 80521.

NAS8-29582, "Feasibility of Aircraft Platforms to Measure Building Wakes for Aeronautical Safety Applications," Texas A&M University, College Station, Texas 77843.

OBJECTIVES: To determine the structure of wakes downstream of low-level obstacles for application to the safe operation of aeronautical systems.

APPROACH: 1. Data Acquisition

a. Determine the feasibility of probing these wakes with instrumented aircraft to determine if useful data for the development of wake models can be obtained with aircraft platforms.

b. Determine the feasibility of obtaining realistic useful information about low-level obstacle wakes with wind tunnels. Realistic data will be judged on the basis of similarity considerations.

c. Determine the feasibility of obtaining useful information about low-level obstacle wakes with meteorological towers with the MSFC eight-tower array.

2. Select optimum data acquisition approach and collect data. It may turn

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Reports			

FIRST BENEFITTING PROJECT: Aeronautical (Aircraft Take-off and Landing) & Space Shuttle

APPROACH: (continued) out that we need to use each approach outlined above.

3. Develop models of low-level obstacle wakes (buildings, hills, trees, etc.) with data using theory and dimensional analysis to guide the model development.

STATUS: Technical Progress: The Colorado State University (CSU) contractor has obtained wind tunnel data with regard to the behavior of wakes downwind from buildings and natural obstacles. Analysis of these data by CSU is underway. The CSU wind tunnel data are to be compared with natural environment data collected at the MSFC eight tower array. The Texas A&M University (TAMU) contractor has had difficulties in acquiring data due to recording difficulties. This reporting period has been primarily devoted to eliminating these difficulties.

Management Progress: During the reporting period a contract continuation was awarded to CSU for continuation of the wind tunnel effort in FY75.

Problems: There have been some data recording difficulties on the TAMU contract (see Technical Progress above); however, these problems appear to be solved at this time.

Cause of Problems: See Technical Progress and Problems.

Forecast: We look forward to a vigorous data acquisition program by TAMU in the next reporting period. In addition, CSU will be approximately one-half the way through their data analysis work and perhaps begin the documentation process for the report of the FY74 work.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 17 OF 23

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-08-10	PRIOR NO.: 133-61-10

4. TITLE:
Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George H. Fichtl, S&E-AERO-YA	205/453-3168	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK(6) Definition of the Horizontal and Vertical Structure of Turbulence for Aeronautical System Design and Operation
Contract No. NAS8-28659, University of Oklahoma, Norman, Oklahoma

OBJECTIVE(S): To define the horizontal and vertical structure of atmospheric turbulence in the atmospheric boundary layer for application to the safe operation and design of aeronautical systems.

APPROACH: Develop models of turbulence with empirical/theoretical techniques. The approach involves the acquisition of atmospheric turbulence data from the KSC 150-meter tower and the NASA/MSFC four and eight-tower arrays. These data will be used to develop statistical and spectral models of turbulence. The models will describe the statistical relationship between turbulence velocity fluctuations at different points in space and time.

STATUS: Technical Progress: During this reporting period five cases of flow over a bluff body in the NASA MSFC eight tower array were selected for analysis. The data have been sent to the MSFC Computation Laboratory for processing. The geometry of the bluff body used in this field program in relation to the location of the wind sensors to measure the flow about, over, and behind the bluff body is similar to the one used by the CSU in their wind tunnel studies of wakes behind buildings (see report on Task #5). The results of this analysis will produce a model of the turbulence structure of wakes behind buildings and natural obstructions.

Management Progress: The contract with the University of Oklahoma has been completed. The contractor submitted two reports on the use of the acoustic sounding technique for measuring the turbulent properties of the atmospheric boundary layer

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Fichtl, G. H., 1972:	Probability Distribution of Vertical Longitudinal Shear Fluctuations. Journal Applied Meteorology, 6, 918-925.		
Fichtl, G. H., 1972:	Wind Shear Near the Ground and Aircraft Operations. Journal of Aircraft, 9, 765-770.		

FIRST BENEFITTING PROJECT: Aeronautical (Flying Qualities) & Space Shuttle

relative to the safe operation of aeronautical systems. These reports will be published as NASA CR's. A paper by Dr. Prem Kumar concerning the statistical properties of lateral wind shear has been accepted for publication and will appear in the March 1974 edition of the Journal of Applied Meteorology.

Conclusions: The University of Oklahoma studies have shown that the acoustic sounding technique is a viable method for probing the atmospheric boundary layer for use in studies of atmospheric parameters relative to the safe operation of aeronautical systems.

Problems: Funding in the area of turbulence simulation has been low due to FY74 resource allocations. It is anticipated that these funding problems will be relieved with FY75 resources.

Forecast: The next reporting period will be concerned with the definition of a program for the development of nonstationary turbulence simulation models for application in aircraft design studies and pilot training and checkout. In addition efforts will press forward concerning the analysis of data from the MSFC eight tower array.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 20 OF 23

1. CENTER:	2. PERIOD COVERED:	3. CODE CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	501-08-10	133-61-10

4. TITLE:

Atmospheric Parameters

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-X George H. Fichtl GHF	205-453-3168	W. Vaughan William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK(7) Structure of Turbulence in Severe Atmospheric Conditions
Contract No. NAS8-27334 Pennsylvania State University
NAS8-21140 State College, PA

OBJECTIVE(S): Develop models of the horizontal and vertical structure of turbulence in severe atmospheric conditions as found in thunderstorms, etc. for application to the safe operation of aeronautical systems.

APPROACH: Perform scale and dimensional analyses to determine the scaling parameters of the problem and synthesize hypotheses which can be used to model statistical turbulence parameters that are relevant to the design and operation of space vehicles operating in severe weather in the atmospheric boundary layer. The resulting hypotheses will be formulated in such a way that they can be verified by experiment. The verified hypotheses will then be used to develop the models of the turbulence parameters. In addition, the relationships between the scaling parameters and the meso-scale and synoptic scale flow field (using Cape Kennedy, Florida, for example), will be established, if such relationships do in fact exist. These relationships and the turbulence models will be used to develop the climatology of the turbulence parameters.

STATUS: Technical Progress: During the last reporting period efforts were expended in the area of turbulence simulation in severe atmospheric conditions. The results to date look promising relative to the development of new procedures which realistically produce the nonstationary and non-Gaussian character of atmospheric turbulence. Documentation of the efforts concerning the behavior of the cold air out flow of tunderstorms is nearing completion and a report should be delivered to the NASA in the next two months.

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR-3289	Variation of the Low Level Winds During the Passage of a Thunderstorm Gust Front	R. W. Sinclair, R. A. Anthes, & H. A. Panofsky	July 1973
NASA CR-3361	Determination of Critical Nondimensional Parameters in Aircraft Dynamic Response to Random Input	S. E. Hillard & M. M. Sevik	January 1974

FIRST BENEFITTING PROJECT: Aeronautical (Vehicle Take-off and Landing) & Space Shuttle

Conclusions: the main conclusions of NASA CR-2361 are as follows:

1. The response of an aircraft to atmospheric turbulence is dependent on the parameters of relative mass, Mach number, and the reduced frequency at which it is being forced.

2. The ratio of mode reduced frequency parameter to forcing reduced frequency is dependent on Mach number and flight altitude.

3. Secondary excitation of modes other than the mode under consideration will occur. The amplitude of secondary excitation can be comparable to the primary mode amplitude.

4. Resonant frequencies remain nearly constant with variation in relative mass. These frequencies vary proportionally to the reciprocal of the Mach number at a given altitude.

5. The magnitudes of the rigid modes increase with decreasing Mach number while the elastic modes decrease with decreasing Mach number.

6. The critical reduced frequencies are related to the reciprocal of the critical wavelengths of the turbulence spectra by the factor π times the mean aerodynamic chord.

7. The critical wavelengths of the turbulence spectra decrease in a logarithmically linear fashion with logarithmically increasing relative mass.

Problems: At the present time the only problem concerning this effort is funding. It is anticipated that these funding problems will be resolved with FY75 resources.

Causes of Problems: See problems.

Forecast: During the next reporting period the contractor will press forward in the area of turbulence simulation and documentation of results of simulations will be initiated. In addition to these efforts the RTOP technical monitor will map out a FY75 follow-on program in this area. The follow-on program will be concerned with the definition of the causitive mesoscale factors which lead to severe meteorological conditions.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	501-38-13	133-61-13

4. TITLE:

Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IRT James A. Dunkin	205-453-5912	W. K. Dahn

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Development of a Laser Doppler Clear Air Turbulence Detection System
NAS8-28424, Raytheon Company
Sudbury, Massachusetts 01776

Objective (S): To determine the feasibility of developing a laser Doppler system for the measurement and detection of clear air turbulence for on-board airliner application.

Approach: (1) Evaluate data from flight test. (2) System ground test to precisely determine the as-flown condition (3) Make system modification based on data evaluation. (4) Perform ground test on modified system. (5) Flight test.

Status: The field test phase of the CAT system ground test is complete, however evaluation of the data from the field test is not complete at this time. The remaining ground test effort will be performed in the lab in order to evaluate a number of system parameters which could not be adequately measured in the field test. The results of the evaluation of the field test data will be used to configure many of the lab tests in order that all questions about CAT system performance be answered prior to the start of system modifications.

Technical Progress: One of the major objectives of the field test was to determine if the optical receiver was focused at infinity or at some finite range. The field test results show that the optical receiver is properly focused at infinity.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
ER70-4203	Development of a CO_2 Laser Doppler Instrumentation Detection of Clear Air Turbulence. Final Report. NAS8-24742	C. Sonnenschein A. Jelalian W. Keene	6/5/70
ER72-4243	Development of CO_2 Laser Doppler Instrumentation for Detection of Clear Air Turbulence. Final Report, Modification of NAS8-24742	C. Sonnenschein A. Jelalian W. Keene	May 72

FIRST BENEFITTING PROJECT: OAST Laser Doppler Clear Air Turbulence Project

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF 3

STATUS (CONCLUDED)

Conclusions - Preliminary results indicate that the feasibility of making turbulence measurements ahead of the aircraft with a pulsed CO_2 laser Doppler system was demonstrated. However, data evaluation is continuing and a final conclusion has not been reached at this time.

Problems - Preliminary aerosol data evaluation indicates that the system should have had clear air returns in many instances when no return was obtained. Investigations are proceeding to resolve this dicrepancy.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 501-38-13	PRIOR NO.: 133-61-13

4. TITLE:
Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IR Ed Gleason	205-453-1570	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Design, Fabrication and Development of Signal Processing Units for Use With Atmospheric Laser Doppler Systems
NAS8-29822
Raytheon Company
Sudbury, Massachusetts 01776

OBJECTIVE(S): The laser doppler system yields atmospheric velocity information in the form of a shift in frequency of the signal. This shift is directly related to the wind velocity at the point of interest. To process the signal into meaningful velocity information spectrum analyzers and filter banks have been used with limited success. This task will develop a "state-of-the-art" signal processing system for laser doppler systems.

APPROACH: Conventional processing systems had limitations in bandwidth, frequency, discrimination, were difficult to align, and bulky. This effort will develop and design a system using the surface wave delay line principle which will provide a satisfactory answer to the problem of real time velocity information retrieval and display.

STATUS: Technical Progress - The first signal processor was completed November 9, 1973. Acceptance tests were observed by COR on November 12, 13, & 14, 1973. Signal processor was received at MSFC November 27, 1973 and integrated into the LDV-I system the first week of December. The second processor was received at MSFC January 5, 1974 and the third March 12, 1974.
(Cont'd)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF

All units operated satisfactorily in laboratory tests. Several flybys have been conducted utilizing Gulfstream and DC-3 aircraft for the purpose of detecting generated wake vortices. In early runs, some degree of successful detection was observed. The latest test on March 14, 1974 all runs resulted in successful vortex detection resulted.

Management Progress - A contract modification was submitted to include capability of processor to drive the X, Y & Z display outputs to a remote display up to 1500 feet from sensor van. A receiver is to be provided to accept, translate and invert these signals for displaying the outputs of two sensors (LDV systems) on a common display in proper perspective. This work will be done as a field modification to the processors.

Conclusions - This contract resulted signal processors which provide a high degree of capability for the intended purpose.

Problems - None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 501-38-13	PRIOR NO.: 501-38-13

4. TITLE:

Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AF James W. Bilbro	205-453-1091	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of a Frequency Translator for use with Atmospheric Laser Doppler Systems
NAS8-29706
Raytheon Company
Sudbury, Massachusetts 01776

OBJECTIVE(S): To develop a frequency translator for use with the atmospheric laser Doppler System. This translator is necessary to remove the ambiguity in determining velocity direction, thus optimizing system performance of atmospheric measurements.

APPROACH: Two methods for frequency translation will be investigated, the Bragg cell and the offset laser. In the Bragg cell method, a portion of the outgoing laser beam is split off and translated to a particular frequency through the use of acousto-optic techniques. The translated portion is used as the local oscillator for heterodyne detection. In the offset laser method, a separate laser is used to provide the local oscillator signal.

STATUS: Technical Progress - The final interferometer unit was delivered and checked out without the Bragg cell on March 11, 1974. This program has been delayed substantially by late component delivery by vendors and various technical problems. The Bragg cell units are not operating satisfactorily and will remain at the contractors facility until a solution can be determined. The interferometer assembly and detector evaluation has been completed satisfactorily.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: FAA Airport Vortex Detection Project

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF 3

STATUS (CONCLUDED)

Management Progress - The contract for the investigation of translation methods and fabrication of three translators was let April 11, 1973. A change order was initiated May 10, 1973, to delete the investigation of the offset laser method and to substitute the design of an interferometer optics package. One complete optics package was to be assembled and the material for two additional packages was to be provided by the Raytheon Company. A modification to the contract has been completed. This will include the assembly of the other two optics packages, the evaluation of three GFE detectors to be used with the optics package, the design and fabrication of bias networks to be used with the detectors and a complete ray trace of the optics package and telescope of the LDV system. This modification was effective November 29, 1973. A no-cost extension was granted this contract effective February 20, 1974.

Conclusions - None

Problems - None

Forecast - None

Publications - None

PROGRESS REPORT
EARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CEN

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2. PERIOD COVERED: 01 10 73 31 03 74

3. CODE

CURRENT NO.: 501-38-13

PRIOR NO.: 501-38-13

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SO BLE INDIVIDUAL: RO-AF M. Huffaker

TELEPHONE: 205-453-1156

APPROVAL: Werner K. Dahm

6. ACC SHMENTS (Milestones, Problems, Near term activities):

TA Test Planning and Modeling of CAT Regions in The Stratosphere

NA 3984, Physical Dynamics

P. Box 1069

Be ley, California 94701

OB TIVE(S): To develop theoretical models of laser Doppler systems. To outline Ge rograms for understanding and improving laser Doppler systems performance. at te mathematical models of atmospheric targets (CAT, vortices stable-unstable heres).

AP CH: Using theoretical models developed under previous contracts, determine the fe ility of performing ground based CAT measurements. Determine the approach an tline of mathematical realizations of CAT, mountain wave turbulence, stable stable atmospheres.

ST : Technical Progress - (1) A study to determine the range of condition for wh a one-dimensional laser-Doppler scanning system can determine three-dimensional at heric wind velocity data has been completed and documented. (2) A study to de ine the feasibility of measuring CAT and high altitude winds from a ground based pl m using the CAT detection system has been completed. (3) An analysis of the se ary backscatter problem on the FAA optical system has been performed and do nted. (4) Studies have been completed which formulate the data reduction pr ure and data analysis to be used in analyzing the results of the fly-by tests at C and JFK. (5) This contract effort was completed in January 1974.

7. REPOR

NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FI BENEFITTING PROJECT: OAST Laser Doppler Vortex and Clear Air Turbulence Program

MSFC - Form 150 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF 3

STATUS (CONCLUDED)

Management Progress - Work is on schedule. This is a final report.

Conclusions - Study (1) has been implemented in the field test program at MSFC. Study (2) will be used in evaluating the CAT detection system. Study (3) has been used in determining a solution to this design problem.

Problems - None

Forecast - None

Publications - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-38-13	PRIOR NO.: 501-38-13

4. TITLE:

Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AF James W. Bilbro	205-453-1091	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development, Testing, Fabrication, and Delivery of Various Components of a Laser Doppler System
NAS8-29824, Lockheed Missiles & Space Company
Huntsville, Alabama 35805

OBJECTIVE(S): Laser Doppler systems at MSFC have been employed for monitoring ground winds, clear air turbulence and aircraft trailing vortices. As a result of a NASA-FAA agreement the design and development of a laser Doppler system for the primary purpose of detecting and monitoring aircraft trailing vortices in an airport environment will be undertaken.

APPROACH: An automatic scan system will be developed to allow the laser Doppler system to operate in a three-dimensional line scan mode and a two-dimensional plane scan mode. This system will also operate in a search mode or a detail scan mode. In addition to this development, the system will be upgraded to accept components being developed under other contracts, and field test support will be provided for verification of system parameters.

STATUS: Technical Progress - Fabrication of the three-scan system has been completed with the delivery of the final unit to MSFC on February 20, 1974. The final check out and acceptance of the first unit delivered has been completed and the other two units are presently undergoing final tests at MSFC. The delay from the original completion date is a reflection of primarily increased complexity in the original design. The system upgrade task has been completed with only minor

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: FAA Airport Vortex Detection Project

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF 3

STATUS (CONCLUDED)

delays due to manpower difficulties. The system engineering/simulation effort has been delayed by primarily manpower difficulties, however the data processing program is essentially complete and is undergoing checks to reduce computation time.

Management Progress - Contract effort was let April 30, 1973. A modification to the contract for an extended scope of work was let January 29, 1974. A further modification to the contract for additional testing is being processed.

Conclusions - None

Problems - None

Forecast - None

Publications - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-38-13	PRIOR NO.:

4. TITLE:

Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AF William C. Cliff	205-453-1157	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study on LDV Atmospheric Interrogation System
NAS8-29606, Lockheed Missiles & Space Company
P. O. Box 1103 West Station
Huntsville, Alabama 35807

OBJECTIVE(S): Field test and evaluate the feasibility of using a single MSFC ground-based laser Doppler velocimeter to determine its capability for measuring two- and three-dimensional atmospheric wind fields.

APPROACH: Test a single ground-based LDV radiometer system employing a conical scan as well as a simple two-point spatial measurement in atmospheric boundary layer flows. The measurements are to be made for varying ranges between 10 to 500 meters.

STATUS: Technical Progress - Two-point spatial measurements have been performed. Conical scan measurements with a constant central angle and constant focal length have been performed. Conical scan measurements with a constant central angle and varying focal length have been performed.

Management Progress - All progress reports required for this contract have been received along with a final report which has been accepted. This project is terminated.

Conclusions - A single MSFC ground-based CO_2 LDV system employing a conical scan has shown feasibility for measuring two- and three-dimensional wind components in

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Laser Doppler Technology Project

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 501-38-13 PAGE 2 OF 3

STATUS (CONCLUDED)

atmospheric boundary layers. Phase correlation of the Doppler velocity output with a reference signal has been shown to give the atmospheric wind direction while the Doppler frequency indicates wind velocity. The results of a single LDV system employing a two-point scan to determine two-dimensional wind velocity information were not remarkable. This is the final report.

Problems - None

Forecast - None

Publications - LMSC-HREC TR D306888, "A Study on Laser Doppler Velocimeter Atmospheric Wind Interrogation Systems," Final Report, October 1973.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 501-38-13	PRIOR NO.: 501-38-13

4. TITLE:

Hazard Avoidance and Elimination

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AF William C. Cliff	205-453-1157	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Purchase of Equipment for Laser Doppler System
NASA/MSFC
S&E-AERO-AF
Inhouse

OBJECTIVE(S): Purchase required hardware to maintain and optimize system performance and continuously upgrade system in accordance with new developments in theory and instrumentation.

APPROACH: Purchase off-the-shelf items to insure test objectives are met in the shortest possible time.

STATUS: Technical Progress - Purchases to date include a CO_2 laser and a 5/4 wave plate.

Management Progress - The CO_2 laser and 5/4 wave plate have been received and accepted.

Conclusions - This is the final report

Problems - None

Forecast - None

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: FAA-NASA Trailing Vortex Project

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 501-38-13	PRIOR NO.: 501-38-13

4. TITLE:
Hazard Avoidance and Elimination
(Laser Doppler Wake Vortex System)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AF Edwin A. Weaver	205-453-2544	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: NASA Support to FAA on Aircraft Wake Turbulence Problems

OBJECTIVE(S): Develop a system capable of tracking wing tip vortices in an airport environment. Measure flow details in the cores of wing tip vortices of low flying aircraft. Establish a rudimentary vortex tracking system at Kennedy International Airport by 1974.

APPROACH: Develop a laser Doppler system to detect and measure wake vortices. This will require system engineering studies of the vortex problem and the interaction with the laser system. The development of a signal processor and display for observing and tracking, preparing test plans and data reduction procedures; and evaluation methods for the operational modes will be carried out. Three units will be fabricated, assembled and checked out with verification fly-by testing in the line scan and tracking modes.

STATUS: Technical Progress - The scanning laser Doppler system for detection of aircraft wake vortices has been assembled. A two-van system is in system check out, calibration, and testing at the MSFC test site. Several flyby tests have been conducted at this site. The initial tests established operating plans and procedures. Recent flights have been conducted for vortex detection and tracking. Vortices from a C-47 aircraft with velocities in excess of 40 feet per second have been tracked for 25 seconds. A system safety analysis, safety design review and hardware inspection have been completed. A safe operating plan has also been established. Spare parts are on order and should arrive to support the requested test phase at John F. Kennedy International Airport.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: FAA Airport Vortex Detection Project

MSFC - Form 360 (March 1973)

STATUS (CONCLUDED)

The third set of hardware is installed at the laboratory for component and system testing and problem solving. This equipment is installed at a 100-meter optical tunnel. This enables variable range measurements in a controlled environment. When laboratory testing is complete the equipment will be installed in van three for use in the line scan mode.

System simulation programs have been developed. Operator training for vortex tracking is underway using these programs and the tracking panel from the scan system. Data processing programs have been developed and debugged for the high speed PCM data recorded during tests. Slow speed data algorithms have been developed and the initial programs were written for data processing.

Planning is complete for moving the equipment to the Kennedy International Airport test site. Van modifications for power, humidity and temperature control are being made.

Management Progress - Lockheed Missiles and Space Company was selected for system integration and testing at the MSFC test site. All major contractual actions have been initiated for the remaining effort required by the NASA/FAA interagency agreement.

Conclusions - The basic system design approach is satisfactory for vortex detection measuring and tracking.

Problems - The frequency translator shows a 10-to 13-decibel power loss. No significant power loss was anticipated. Troubleshooting of this component will continue independent of system tests. The system was designed to operate with or without the translator. The focal volume is larger than planned by a factor of 3 to 5. Laboratory tests are being made to find the reason for this. It will result in a degraded system performance if this problem is not resolved.

Causes of Problems - Cause of problem is being determined.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-01-03	PRIOR NO.: 114-03-01

4. TITLE:

PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. Urban, S&E-SSL-NP I. Dalins, S&E-SSL-N	453-5130 453-5137	R. Decher, S&E-SSL-N

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): The Superconductivity research program will seek increased understanding of the phenomenon of superconductivity and material improvements leading to higher transition temperatures, more stable and less massive conductors, and more easily fabricated instrumentation of greater sensitivity and increased ruggedness for a wide variety of space and ground applications, such as superconducting magnets, sensitive magnetometers, infrared detectors, and magnetic shields.

The Surface Science program will seek to advance the understanding of various atomic, molecular, ionic, and electronic interactions at and on crystalline surfaces having a bearing on physical, chemical, and electronic processes of importance to space science and technology. This technical effort has been reoriented to study the origin as well as the consequences of the existence of surface states primarily in semiconductors with wide energy gaps between the valence and conduction bands.

The technical information obtained from this research is useful in solar energy conversion as well as other electronic processes occurring in semiconductors for applications in light amplification, detection, and generation of electromagnetic radiation. This research in surface science is part of a NASA-wide effort (working group).

APPROACH: The primary research tools in the superconductivity studies include: (1) ultrasonic attenuation and velocity measurements to determine the temperature and magnetic dependence of the energy gap and other parameters in ordered superconducting crystals; (2) study of the critical properties of new superconducting materials fabricated chiefly by, and to improve of known materials by, explosive shock

7. REPORT NO.: TITLE:	AUTHOR(s):	DATE TRANSMITTED
Calculation of the Temperature and Purity Dependence of Sound Attenuation in Superconducting Nb - accepted for publication by Physical Review	C. C. Sung L. L. Lacy	
Properties of Materials for Electronic Applications, presented at the First Annual MSFC Research & Technology Review	L. L. Lacy E. W. Urban	Feb. 1973
Measurements of Ultrasonic Velocities Using a Digital Averaging Technique, J. Acoust. Soc. of Am., 52, p 189-195	L. L. Lacy A. C. Daniel	1972
Ultrasonic Absorption in Superconducting Single Crystals of $Nb_{1-x}Mo_x$, published in the Proceedings of the Thirteenth International Conference on Low Temperature Physics	L. L. Lacy	Aug 1972

FIRST BENEFITTING PROJECT: SUPERCONDUCTIVITY - Stanford Gyro Relativity Experiment
SURFACE SCIENCE - Solar Power Generation Program

compaction; (3) study of magnetic flux pinning mechanisms and magnetic instabilities through measurements of magnetic flux flow, flux flow resistivity, and the peak effect in Type II superconductors; (4) studies to imprive thin film junction and microbridge instruments, such as magnetometers through the use of advanced thin film, microciruitry and superconducting materials characterization techniques.

The Surface Science studies are fundamental in character but are oriented as much as possible toward solving the scientific problems encountered in GaAs solar cell development. The major effort is now being made to gain a better insight and make pertinent measurements of surface recombination velocity because this parameter affects the solar cell energy conversion efficiency. The effort is performed in cooperation with MIT, where surface photovoltage spectroscopic methods have been developed to gain insight about the behavior of certian surface states. Equipment to measure these parameters on well characterized GaAs surfaces especially with low Energy Electron Diffraction (LEED) and Auger Electron Spectroscopy (AES) have been, or are in the process of being developed in-house.

STATUS: Superconductivity - During the report period considerable progress has been made, particularly in the thin superconductor films and materials studies. The thin film studies seek to develop very thin uniform and continuous films on quartz substrates suitable for use in sensitive instrumentation, such as narrow pickup loops for magnetic moment measurements and strips which may be etched into microbridge structures for rugged, stable, low current density Josephson junctions. Optically transparent niobium films less then $5x10^{-9}$m (50Å) thick have been reproducibly sputter deposited on two types of glass substrate. These films were superconducting at 4.2K. By guiding the electron beam of a scanning electron microscope, it has been possible to make 10^{-7}m wide in niobium films $6x10^{-6}$ m wide and as thin as about 10^{-8} m, to form microbridge Josephson junctions.

The materials studies continue to aim toward superconductors with higher transition temperatures, critical dields and critical currents. The Department of Defense Advanced Research Projects Agency (ARPA) funds referenced in the last report have been received by MSFC and contracted to the University of Alabama - Huntsville (UAH). A number of new shock wave compacted specimens have been produced and their properties are now being measured. The Principal Investigator (G. Otto) attended the recent conference on Lattice Instabilities in Superconductors and obtained a great deal of valuable and pertinent information. Preliminary studies have been made to determine immiscible metallurgical system candidates which would be likely to exhibit new or improved superconducting properties if melted, mixed and resolidified in reduced gravity, such as is available in the MSFC drop tower. The improvement of nondestructive materials characterization techniques mentioned in previous reports has led to the development of an automated eddy current decay apparatus in which it is possible to determine very rapidly the electrical resistivity of arbitrary shaped bodies as a function of temperature without making damaging electrical of mechanical contact to the specimens.

Surface Science - Studies of Atomic interactions of oxygen with clean surfaces were continued with a combination of LEED and AES techniques. It appears that oxidation of the GaAs (III) surface, which occurs after extensive exposure to oxygen, does not lead to the formation of the triplet in the LEED pattern. This seemingly simple result appears to have broad consequences in supporting the validity of a mod l that

STATUS: Cont'd

the triplet is indicative about the emphasized ionic bonding character of the surface atoms. The adsorption of the electronegative oxygen atoms yields excess negative charge which compensates the crystal potential due to the asymetric character of chemical bonds in the GaAs crystal. The results obtained with LEED and AES as well as the general concept of ionicity in semiconductors was compared with other related investigations. The importance of ionicity in semiconductor properties has been recognized long time ago, even as far to the middle of 1930's (linus Pauling, Coulson etc.). The concept of ionicity in surface interactions could very well be of great importance in affecting the surface recombination velocity. Theoretical investigation shows that Coulomb centers positive ions on semiconductors will attract electrons from the bulk if not screened by electrons available in the inversion layer. This theoretically derived conclusion agrees with the fact GaAs solar cells coated with a very thin layer of Al exhibit greater efficiences. Research at MIT continued on the refinement of the surface photovoltage spectroscopy is trying to find experimental parameters that would yield information similar to the recombination velocity measurements.

Management Progress: A seven (7) month extension of the Grant for the complementary Surface Studies at MIT was initiated. The period of performance was reduced as a result of funding limitations. The turbo molecular pump on the LEED AES and molecular beam apparatus sustained bearing trouble and necessitiated returning to the manufacturer for repairs around February 1, 1974. This imposed certain limitations on the experimental capability. A special laboratory developed specimen manipulator has been tested for leaks on the ultra high vacuum system. This manipulator is designed to have features not available on conventional ones.

Conclusions: Theoretical studies of the implications of ionicity in semiconductors leads to certain insight that warrants certain new experimental investigations of the atomic bonding of surface atoms. The information obtained by this method of attack promises to be about equally significant as the surface recombination velocity measurements. The latter has turned out to be a rather difficult measurement to perform, especially on test samples characterized on atomic scale with AES LEED etc.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-01-03 PAGE 4 OF 5

REPORTS: Continued

Joule Heating Power Dissipation in a Type II Superconductor Tube, Phys. Rev. B, 5, 3530	E. W. Urban	1972
Synthesis of Superconducting Compounds by Explosive Compaction of Powders. U. S. Patent # 3,752,665	U. Roy G. H. Otto O. Y. Reece	Aug 1973
Shock Wave Synthesis and Characterization of Nb_3Sn, submitted to Journal of the Less-Common Metals on March 5, 1973	G. H. Otto U. Roy O. Y. Reece	Mar. 1973
The Precipitation of In_2 Bi from Supersaturated α-Phase, submitted to the Journal of the Alabama Academy of Sciences	G. H. Otto	Aug 1973
The Role of Trapping Photovoltage Spectroscopy Surface Science, Vol. 38 (1573) 252-256	J. Lagowski H. C. Gatos	1973
Surface Photovoltage Spectroscopy & Surface Piezo-electric Effect in GaAs, Surface Science Vol. 40 (1973) 216-226	J. Lagowski I. Baltov H. C. Gatos	1973
Sticking Probabilities for the Adsorption of Hydrogen on Clean Ni (111), Ni (100) Ni Sheet and Evaporated Ni Films, Surface Science Vol 41 (1974) 624-628	A. M. Horgan I. Dalins	1973

The following articles (papers) mentioned in earlier reports as submitted have appeared now in the following:

A Study of the Effectiveness of the Standard Surface Cleaning Techniques as Applied to Ni (111), and Ni (100), and Ni Sheet using Auger Electron-Spectroscopy (AES) - J. Vac Sci. Technol. Vol. 10, (1973) 523-532	A. M. Horgan I. Dalins	1973
Adsorption of Hydrogen, Carbon Monoxide, and Oxygen on Vacuum Degassed Stainless Steel 304 at 20°C, J. Vac. Sci. Technol. Vol. 10 (1973) 559-56	A. M. Horgan	1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-21-27	114-03-51

4. TITLE:

SPACE VEHICLE THERMAL CONTROL

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Daniel Gates, S&E-SSL-T	453-3102	W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Thermal Control Coatings

NAS8-285 - NETCO NAS8-26791 ITT Research Inst. NAS8-21270 Stanford Res. Inst.

OBJECTIVE(S): Research on the development of thermal control surface coatings will yield a white paint for coating of any size, shape or complex substrate by normal painting procedure. While maintaining the ϵ_h (infrared emissivity) at 0.9, the α (sun spectrum absorption) will be as low as possible, for the least load on the vehicle thermal system. At the same time, there must be little change in these optical properties with extended times of exposure to the space environment.

APPROACH: The development of thermal control surface coatings has the following phases: (1) Inorganic paint technology - pigments and silicate binders, (2) silicone binder development - methyl silicones of the RTV-602 and OI-650 types and their improvement (3) pigment synthesis - low adsorption edge materials such as Zn_2TiO_4 and $CaWO_4$ and, their treatment by reactive encapsulation and calcining of the surface, and (4) general paint studies - solar simulation facility, correlation with space experiment results, degradation of optical properties investigations, and paint surface protection systems.

New equipment being used includes: (1) the CREF (combined radiation environmental facility), which exposes samples to vacuum, ultraviolet and proton radiation and measures the optical properties in reflectance mode while in vacuum, and (2) the ISSIS (in-situ system for infrared studies), which measures samples in the transmittance mode with similar exposure to the CREF.

7. REPORT NO.: TITLE:	AUTHOR(s):	DATE TRANSMITTED
Investigation of Environment Effects on Coatings for Thermal-Control of Large Space Vehicles. Final report on Contract NAS8-5379, IITRI Report # IITRI-U6002-97, October 9, 1971	G. A Zerlaut J. E. Gilligan N. A. Ashford	1971
Recent Advances in Environmental Testing of Thermal Control Materials, presented to the AIAA 7th Thermophysics Conference, San Antonio, Texas		Apr 1972
Advanced Technology Developments in Thermal Control Materials, invited paper presented to 74th Annual Meeting of American Ceramic Society, Washington, D. C., May 9, 1972	G. A. Zerlaut	May 1972

FIRST BENEFITTING PROJECT: SKYLAB

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 502-21-27

PAGE 2 OF 4

STATUS: Technical Progress - A OI-650 binder/Zn_2TiO_4 paint has been prepared with an α_s = 0.12 and good stability to simulated environment of ultraviolet, vacuo and protons. The α_s is 0.[illegible] with up to 2000 ESH uv at a 3X factor of exposure. Stability of Zn_2TiO_4 with and without reactive encapsulation has shown marked improvement by plasma calcining. Combination of methyl silicone (OI-650) with ZnO pigment to form a paint has been satisfactory, and continued testing has established that this is a viable coating system. This new paint is designated A-429m. The ISSIS, an instrument for transmission measurements, is complete and is being assembled and tested. Zn_2TiO_4 has been made from an oxalate precursor and exhibits excellent batch-to-batch reproducibility. OI-650 plate resin has been end-blocked, and the resultant binder has been found to retain the desired elastomeric qualities.

Management Progress - NAS8-26791 has been negotiated for 12 months extension and the work scheduled within this framework. Addition of one man to the IIT Research Institute has been found necessary for the pigment pilot plant production of Zn_2TiO_4 to meet the time line. The Zn_2TiO_4 pigment with end-blocked OI-650 vehicle should be available by mid 1974, with the present revised schedule. A contract has been awarded to NETCO (NAS8-28517) to provide assistance in theoretical studies of the reactive encapsulation process for pigment stabilization.

Conclusions - Progress on the Zn_2TiO_4 paints is satisfactory and samples have been provided of methyl silicone and silicate binder coatings for space experiments. This pigment is appreciably better than present ZnO both in initial α_s and $\Delta\alpha_s$. Calcining in the RF facility is a viable method of completing reactions or fixing reactive encapsulation. Samples of Zn_2TiO_4 in silicate binder are on OSO-8 and English Black-Arrow Space Experiments. The Zn_2TiO_4 pigment with end-blocked OI650 vehicle should be available as viable paint by June 1974.

Problems - Space experiments, for calibration of experimental progress, have not been available in sufficient numbers to obtain a high degree of confidence in the use of new and improved coatings on unmanned and manned vehicles. Cleaning and/or restoration of coatings while in space remains to be done if extended life above 3 to 5 years is to be obtained. Soiling of coatings in handling, assembly, erection, etc., required development of strippable (or other) protection. Production processes of new improved paints should be initiated with user (MSFC & MSC) as early as feasible. The present situation of IIT manufacture of paint and/or pigment for S-13g needs to be reduced to engineering practice; but even if this is accomplished, there will still be dependence on the "consulting" available from the IITRI group.

Forecast - (1) Use of the CREF will give experience, as data is generated, in the problems of environments which contain high-energy components. (2) With the availability of the ISSIS instrumentation, the examination of changes in transmission of the vehicles will allow improvement of this part of the paint system. (3) Completion of the chemical reactions in pigment preparation can be obtained with good control of the process by use of the RF plasma and without agglomeration of the particles. (4) By means of reactive encapsulation and/or calcining, the surface of the pigment may be passivated toward use with methyl silicone binders to accrue the advantages of this type of paint binder. (5) Our efforts will continue to be able to supply a white thermal-control paint for space use, at any time, on which optical and other pertinent measurements have been consistent with the state-of-the-art at this time. (6) A contract is anticipated from the contamination program concerning cleaning of various optical surfaces in space, including thermal control paints.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-21-27 PAGE 3 OF 4

REPORTS: Continued

Thermal Control Materials and Technology in the 1970's. Presented to the ASME Intersociety Conference on Environmental Systems, San Diego, Cal.	J. E. Gilligan G. A. Zerlaut	July 1973
A Review of Current Refractory Composites Research in Ceramics. Presented to the 21st Meeting of Refractory Composites Working Group, Los Alamos, NM	S. A. Bortz Y. Harada	July 1973
Improved Zn_2TiO_4 Thermal Control Pigment. Presented at the 26th Pacific Coast Meeting of the American Ceramic Society, San Francisco, Cal.	D. W. Gates J. E. Gilligan	Oct 1973
Report #IITRI-C6233-28 (Triannual Report) Development of Space Stable Thermal Control Coatings for Use on Large Space Vehicles. Jan. 1 through Apr. 30, 1973.	J. E. Gilligan Y. Harada	
Report IITRI-C6233-32 Triannual Report, Development of Space Stable Thermal Control Coatings for Use on Large Space Vehicles. May 1 thru Aug. 31, 1973	J. E. Gilligan & Y. Harada	Sept. 1973
Zn_2TiO_4 Pigment for Use in Thermal Control Coatings in Space. 78th Annual Meeting of the American Ceramic Society, Chicago, Ill May 1, 1974	D. W. Gates Y. Harada W. R. Logan J. E. Gilligan	May 1974
Current Technology for Development of Low α_s/ϵ Coatings. International Conference "Evaluation of Space Environment on Materials" (ESRO sponsored), Toulouse, France, June 19, 1974	J. E. Gilligan Y. Harada D. W. Gates	June 1974

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-21-28	PRIOR NO.: 114-03-07

4. TITLE: OPTICAL CONTAMINATION

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Hoyt M. Weathers	205 453-3040	Hoyt M. Weathers Hoyt M. Weathers

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Optical Contamination

Contract No.	Contractor
NAS8-29268	Walter C. McCrane Associates
NAS8-29269	Commonwealth Scientific Corp.

OBJECTIVE: To provide the basic research data and technological development information needed to further define and characterize the induced environment of spacecraft. This basic and applied research is being applied in experiment/sensor definitions for the Shuttle payload programs. The end items of this task will be technical reports and informal data used as input to other program activities of other MSFC elements.

APPROACH: The optical environment for purposes of contamination research is considered to include the X-ray, ultraviolet, visible, and near infrared portions of the electromagnetic spectrum. Emphasis is being placed on the extreme and vacuum ultraviolet wavelengths as it is in this region that contamination's greatest effects upon optical efficiency have been observed. Recognizing that some finite amount of contamination will be unavoidable on Shuttle payloads, SSL is investigating long-term subtle degradation effects and techniques of avoiding the more severe damage early in the payload's mission life.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA TM R-409	The Application of Holography as a Real-Time Three-Dimensional Motion Picture Camera	Robert L. Kurtz	September 1973
NASA TN D-7433	Contamination Assessment and Control in Scientific Satellites	Robert J. Naumann	October 1973
NASA TM X-64794	Column Densities Resulting from Shuttle Sublimator/Evaporator Operation	Robert J. Naumann	October 15, 1973
NASA TM X-64792	A Survey of Mass Analyzers	W. Walding Moore, Jr. and Philip W. Tashbar	November 1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-21-28 PAGE 2 OF 3

STATUS: Skylab experience has shown that thin film deposition and agglomeration from vacuum condensable material can be controlled more esaily than that of particulate generation and migration. X-ray optical systems are more sensitive to particulates than are systems whose operational wavelengths are in the visible or infrared regions. Optical samples exposed on flight experiment T-027 have been returned to the laboratory and analyzed. A report of the results has been published.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-21-30	PRIOR NO.:

4. TITLE:

Environmental Design Criteria

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-YS Robert E. Smith	205/453-3140	Leonard A. Bates William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASKS: (1) Theoretical Model of Thermospheric Heating
Contract No. NAS8-25750, University of Alabama, Huntsville, AL 35810

(2) Traveling Ionospheric Disturbances
Contract No. NAS8-29317, University of Alabama, Huntsville, AL 35810

OBJECTIVE(S): Complete the development of technically sound and concisely written engineering descriptions in the earth's ground winds, inflight winds, inflight atmosphere, surface extremes, space and terrestrial environment, lunar surface, earth orbit, planetary, and other environments in which space vehicles may be expected to operate. To examine, on a continuing basis, natural environment data obtained from ground, flight and other means to determine the need for updating or modification to engineering design criteria documents, reports, and monographs. The resulting product shall provide engineering interpretations of the environment applicable to design/operation problems and use in development of specific space vehicle design criteria.

APPROACH: (1) Develop a theoretical model from basic principles and adjust resulting equation parameters so that calculated results agree with observational data from satellite orbital decay analyses.

(2) Develop an empirical/theoretical model of the effects of traveling ionospheric distrubances (TID) on the neutral atmosphere. Model to be based on TID data from Doppler array and ionosonde data.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Investigation of Atmospheric Dynamics Using a CW Doppler Sounder Array	G. L. Rao	February 1974 (to be published as a Contractor Report)

FIRST BENEFITTING PROGRAM: Space Shuttle

STATUS: Technical Progress:

NAS8-52750. A final report documenting the theoretical model of Joule heating of the theromosphere by magnetic storms is in publication. Insufficient observational data precluded the development of an engineering type model. The collection of data as well as the development of an engineering model will continue under an in-house program.

NAS8-29317. This contract effort was terminated with the publication of a report entitled: "Investigations of Atmospheric Dynamics Using a CW Doppler Array"; however, the model was not completed because the techniques required to extract the necessary data from the CW Doppler array measurements could not be fully implemented during the period of performance of the contract. The measurements are available and the data reduction technqiue developments are continuing under an in-house effort so that the work accomplished under this contract will be utilized at a later date.

Management Status:

Work funded by the 502-21-10 source has been terminated due to termination of the funding source.

CONCLUSIONS:

Three dimensional models of the ionosphere and Joule heating of the thermosphere have been developed theoretically; however, engineering models could not be completed due to a lack of corroborative observational data and a lack of funds which caused the work to be terminated.

PROBLEMS:

Simplified engineering models appear to be a long term development. Existing corroborative observational data required in the model development are lacking.

FORECAST:

Contract efforts in these areas have been terminated as of March 31, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-21-30	PRIOR NO.: 502-21-30

4. TITLE:

Environmenal Design Criteria

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-YT Lee W. Falls	205 453-3141	Leonard L. DeVries for William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task 1: Environmental Design Criteria
Contract No. H-84897A; H-95560A
NOAA-EDS, National Climatic Center
Asheville, North Carolina 28801

Task 2: Statistical Studies of Atmospheric Variables Related to the Space Shuttle Program
Contract No. NAS8-29286
Appalachian State University
Department of Mathematics
Boone, North Carolina 28607

Task 3: Martian Surface Models Monograph
Contract No. NAS8-29605
TRW Systems Group
TRW Inc., 1 Space Park
Redondo Beach, California 90278

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROGRAM: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 502-21-30

PAGE 2 OF 4

OBJECTIVE: Complete the development of technically sound and concisely written engineering descriptions and statistical analyses of the earth's ground winds, inflight atmosphere, and surface extremes. To examine, on a continuing basis, natural environment data obtained from ground, flight, and other means to determine the need for updating or modifying engineering design criteria documents, reports, and monographs. The resulting product shall provide engineering interpretations of the environment applicable to design/operational problems and use in development of specific space vehicle design criteria. To formulate the available knowledge, experience, and pertinent data into a useable set of surface models of the Martian surface for space vehicle design purposes.

APPROACH: Establish earth natural environment criteria for design and engineering application to the overall space vehicle system and assist in the interpretation and utilization of these data. This will include developing and evaluating new methods for the description of natural environment parameters for application to vehicle engineering design and operational problems, performing studies of terrestrial environment parameters and formulating scientific and engineering documentation on natural environment in the form of reports or monographs. Statistical methods will be used including (1) Monte Carlo procedures, (2) multivariate analysis, (3) decision theory, (4) combinatorial analysis, and (5) probability theory. Collect and review Mars surface data. Data will include Mariner IX and Russian orbiters Mars 2 and 3 data, along with Martian surface data prior to Mariner IX. From the data collected, formulate Mars surface models.

TASK 1:
STATUS: Technical Progress: A comprehensive study describing Cape Kennedy wind shears at several altitudes over 6, 12, 24, and 48 hours was completed. Graphs of those altitudes and time periods chosen for publication have been printed. Eight years of Vandenberg AFB rawinsonde winds aloft have been made serially complete. These winds will be used for Space Shuttle launch and entry studies.

Management Progress: Contract H-95560A modified to add $30K and extend period of performance to Dec. 31, 1974.

CONCLUSIONS: The detailed Cape Kennedy wind shear analysis and the Vandenberg serially complete winds are necessary to satisfy Space Shuttle launch and landing wind related studies.

PROBLEMS: None.

FORECAST: Continue work toward completion of design criteria monograph. Direct selected contractual efforts and revisions in the extensive technical review and critical analysis of atmospheric parameters concerned with entry heating models and atmospheric dynamics in particular.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-21-30 PAGE 3 OF 4

TASK 2:

STATUS: Technical Progress: It appears a member of the gamma family will explain the variability of duration times of atmospheric variables above a given threshold or constraint. A computer program has been developed and a final report on this problem is being prepared.

A report and computer program is being prepared on the calculations of a conditional bivariate normal distribution which is applicable to a problem related to the Space Shuttle.

A report is being prepared on the application of the multivariate Beta distribution to cloud cover at two or more stations and over different time periods.

PROBLEMS: No significant problems.

FORECAST: In addition to the problems already solved investigations are continuing relating to (1) effects of autocorrelation existing in atmospheric variables (2) statistical variability in nonlinear systems, (3) convolution of distribution functions, and (4) launch delay risk distributions.

TASK 3:

STATUS: Technical Progress: The Mars surface Models Monograph is in its final draft form. Appropriate reviews by the technical monitors and various NASA centers have been initiated.

PROBLEMS: None.

FORECAST: A final report is due in May 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-22-11	PRIOR NO.:

4. TITLE:
Space Vehicle Dynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. B. Herring	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Modified Vibration Test Criteria for Qualifying Space Vehicle Components NAS8-30630 Wyle Laboratories

OBJECTIVE(S): 1. To develop and apply mechanical impedance concepts to established methods of deriving component test criteria.
2. To compare the impedance ratio concepts to the constant mass attenuation method and show differences.
3. Document developments, demonstrations, and methods of applications in a technical report at the design engineer's level.

APPROACH: The computation of input impedances of component and primary structure will be based on nomograms and design charts developed under the force spectra program, reference NAS8-25811. No computer programs will be used in the calculations. Examples and demonstrations will be used to illustrate the significance of the impedance ratio concepts. The modified response spectrum of the primary structure at component attachment points will be computed by the following equation:

$$\Phi'_{\alpha(\omega)} = I_{\alpha(\omega)} \left| \frac{Z_{S(\omega)}}{Z_{S(\omega)} + Z_{L(\omega)}} \right|^2$$

$\Phi_{\alpha(\omega)}$ = PSD of unloaded primary structure response as defined by current methods

$Z_{S(\omega)}$ = Input impedance of support structure

$Z_{L(\omega)}$ = Impedance of component

ω = Frequency

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-22-11 PAGE 2 OF 2

STATUS: Technical Progress--None
Management Progress--Contract has been negotiated on March 11, 1974. The contract is currently getting underway.
Conclusions--None
Problems--None
Forecast--None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-22-11	PRIOR NO.:

4. TITLE:
Space Vehicle Dynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. R. Admire	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Response Prediction for Preliminary Design (Contract Pending)

OBJECTIVE(S): The basic objective in this study is to develop response prediction techniques for complex space vehicle structures. The techniques are to be suitable for both disturbances causing weakly stationary responses and transient random disturbances.

APPROACH: The approach will be to develop computer programs to predict the time responses described above. The program will be evaluated to determine their accuracy and computation cost for use in preliminary design.

STATUS: Technical Progress--None
Management Progress--Contract award is pending.
Conclusions--None
Problems--None
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Shuttle Payloads

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-22-11	PRIOR NO.:

4. TITLE:
Space Vehicle Dynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. B. Herring	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Utilizational Survey of Prototype Structural Test Article (Contract Pending)

OBJECTIVE(S):

1. Survey the aerospace and aircraft industry to determine the latest procedures and practices in utilizing prototype test articles in operational flight systems. The survey should determine the following information about test articles:
   a. Disposition of test article
   b. Extent of damage during testing
   c. Refurbishment
   d. Test article substitute programs
   e. Other pertinent information
2. Document the results in a final report

APPROACH: The contractor should contact aircraft and aerospace contractors and determine how each firm utilizes particular test articles. In cases where the test article is programmed to be utilized as a flight article, determine what testing compromises are made such as utilizing computer analyses versus test programs.

STATUS: Technical Progress--None.
Management Progress--Technical proposals submitted for the scope of work are being evaluated. At present, there is no research contract.
Conclusions, Problems, & Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

MSFC - Form 350 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-23-21	PRIOR NO.: 115-22-09

4. TITLE: Large Telescope Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
I. L. Randall, S&E-ASTR-A	453-3770	J. C. Taylor

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Active Mirror Program, IH/NAS8-28019, University of Alabama, Tuscaloosa, Alabama.

OBJECTIVE: To develop the technology required for actively correcting the figure of a large telescope primary mirror (3 meter diameter). Large diffraction limited telescopes such as LST impose tolerances on the figure of the primary mirror which are unprecedented in large optics. For manufacture and testing in a "one g" gravitational field and later for operation in "zero-g" the primary mirror will require a multi-point corrective mount to achieve the required surface quality of $\lambda/50$ RMS. This research is principally an experimental program to verify structural models of mirrors under point and distributed loads, development of interferometric methods for measuring surface errors to one-hundreth wave accuracy and verification of control algorithms which define the corrective forces.

APPROACH: The MSFC experimental facility currently consists of a 20 inch diameter thin deformable spherical mirror with 16 force actuators on the back. The mirror is mounted with optical axis horizontal in a seismically isolated vacuum tank. The mirror is defined by a three point kinematic mount. Gravity induced sag is counteracted by force couples at 19 points. A laser unequal-path interferometer located at the center-of-curvature senses the figure errors as commanded by a digital computer. The computer processes the error signals, calculates the appropriate corrective forces and updates the commands to the force actuators.

This facility is an adequate test-bed for developing and refining much of the technology required for active correction of mirror figures. However, it is unrealistically simple in two regards.

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: LST

First, a center-of-curvature laser interferometer is not practical for use on large space telescopes. Secondly, the structural modeling of a thin deformable mirror is trivial when compared to the complexity of modeling a thick light weighted structure.

A second experimental phase which will utilize a thick light weight 27 inch diameter mirror will follow the thin mirror program. A focal plane figure sensor which utilizes stellar illumination to interferometrically measure the total wave front error is being developed under contract.

STATUS:

Technical Progress

1. The measurement of the flexibility matrix for the 20 inch thin mirror has been completed. Correlation of this data with the analytical predictions is in progress.

2. The convergence properties of the figure control system is being tested on the 20 inch mirror using different measurement sets, actuator sets and flexibility matrices.

3. Static deformation tests on the 27 inch lightweight mirrors has begun.

4. The test fixtures for the active figure control tests of the 27 inch mirror are 90% completed. This system uses 40 of the actuators that were salvaged from the Langley Research Center Active Optics Program.

5. A thermal deformation test program for the 27 inch mirrors has been approved to start in early FY 75.

Management Progress

A contract has been let to modify the laboratory facilities which will improve the accoustical environment that has hampered interferometric testing.

Conclusions

The convergence of the mirror figure control system is not seriously degraded by amplitude scaling errors in the actuator influence functions. Such errors only result in additional control interations but the final steady-state figure is not changed. Conversely, sign errors in an element of the flexibility matrix, even for small elements, can degrade the convergence properties considerably. It may be advisable to replace small elements of the flexibility that are uncertain in sign with zeros. This area of concern is still under investigation.

Problems

Several epoxy joints that fasten the actuator attachment studs to the back of the mirror have failed. These failures have occurred at different times throughout the life of this mirror. The cause of failure is uncertain. A test program to identify the best adhesive for bonding metals to mirror materials is being conducted by another element at MSFC.

Forecast

1. Testing with the 20 inch thin mirror will be concluded in a few weeks. The system will be partially disassembled to allow a check of the actuator spring calibrations.

2. The interferometer used in the active mirror control tests will be modified to improve its signal to noise ratio. A new collimating beam expander has been purchased to which will

increase the usable power from the laser. A new image disector with a larger aperture has been purchased to increase the area over which the phase signal is integrated.

3. The active figure control testing of the 27 inch lightweight mirror will begin about July 1974.

THIS IS THE LAST RTOP PROGRESS REPORT THAT WILL BE SUBMITTED. THIS WORK IS NOW SPONSORED BY THE LARGE SPACE TELESCOPE (LST) PROJECT. THE HARDWARE, RESULTS AND EXPERIENCE OBTAINED FROM THIS RTOP ARE BEING USED DIRECTLY IN THE LST TECHNOLOGY PROGRAM.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-23-31	115-23-40

4. TITLE:

Optical Mass Memory

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Earl J. Reinbolt, S&E-ASTR-R	453-3770	J. C. Taylor

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Optical Memory System, Breadboard and Components and Technique Development
NAS8-26672, Radiation, Inc., January 1962 - July 1974
NAS8-26808, RCA, March 1971, April 1974
NAS8-28949, Radiation, Inc., June 1972 - April 1974

OBJECTIVE: Projected spacecraft systems of the 70's and 80's will require onboard multifunctional integrated computer systems of large capacity. Mass memories of 5×10^{12} or larger will be associated with such systems. The long range objective of this RTOP is a random access, read-write memory of 10^{12} bit capacity utilizing holographic techniques for writing on an erasable medium. Ideally, this memory should replace all storage media associated with a large operational computer. Most certainly this replacement will include everything from on-line discs, drums, etc., to stored tapes. The memory is to have limited or no moving parts, occupy a relatively (to present systems) small volume and be available for spacecraft use in the next decade. The large memory capacity does not, of course, have to be used in conjunction with a computer. It can be used as storage for data to be transmitted (or carried to earth) at a later time.

APPROACH: The key elements of a read-write holographic optical mass memory are a laser(s), beam deflector(s), data composer, reversible holographic storage medium, and an output detector array. These elements combined with suitable optics, electronics and mechanical structures provide a functioning read-write memory. The RTOP approaches the problem on three levels:

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NAS12-2200 October 1970	Investigations of Optical Memory Techniques	Radiation, Inc.	
NAS8-26360 February 1971	Optical Read/Write Memory System Design	Radiation, Inc.	
NAS8-26672 February 1972	Optical Read/Write Memory System Components	Radiation, Inc.	
NAS8-26635 May 1972	Dynamic Holographic Storage in Lithium Niobate	Isomet	
NAS8-26808 November 1972	Interim Report - Optical Memory Development Vol. 1: Prototype Memory System Vol. 2: Gain-Assisted Holographic Storage Media Vol. 3: The Membrane Light Valve Page Composer	RCA	
August 1973	Updated Optical Read/Write Memory System Components	Radiation, Inc.	

FIRST BENEFITTING PROJECT: Shuttle/LST

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 502-23-31

PAGE 2 OF 3

APPROACH (CONCLUDED):

1. Overall Memory System. This includes system design to accomplish progressively higher bit capacity and a study of memory architecture and computer interfaces.

2. Optical Memory Component and Technique Development. Special emphasis is placed on critical items such as the storage material and data composer.

3. Optical Memory Breadboard. A breadboard containing all of the key elements has been constructed and is and will continue to be used experimentally to study all component interfaces within the memory, allow development of new devices, and the enhancement of old devices. Plans are to interface the breadboard with an operating computer to study the computer-memory relationship.

This approach provides vital information as to system feasibility in an economical way and helps avoid premature large fund-commitment to such computer memory systems.

STATUS: Technical Progress: The memory breadboard has been functioning and has proved helpful in identifying system problems not apparent when only considering system components. New designs for the photoplastic holographic storage array are being tested. Increased numbers of recording cycles and reduced exposure times should result. Improvements are being made in the thermoplastics storage material itself. Work is continuing on the ferroelectric ceramic, PLZT, for the page composer. Material (PLZT) provided by vendors has proved to be poor, but efforts to improve this situation are having some success. Device fabrication techniques are improving also. The PLZT is now being studied for three possible modes of operation; strain, scattering and interferometric. The membrane approach to the block data composer has been successful on an 8 x 8 page composer. Prospects are now good for having the breadboard functioning with a 32 x 32 block data composer, a 5 x 5 holographic array, and a 32 x 32 photodetector array by the end of 1973, with an experimental interface to an operating computer well under way. The extension of the 32 x 32 photodetector array to a 128 x 128 array or mosaic is technically feasible; however, the cost would divert needed development in more critical areas. Work on characterization of doped lithium niobate as a memory storage material is under way at RCA, Princeton. Quarterly Progress Reports dated April 14, 1973 and July 14, 1973 are available. Since in the past no effort has been made to characterize and use lithium niobate as a operating element of a Holographic Optical Mass Memory as specified in the objectives to this RTOP, this is proving to be a valuable study.

Device fabrication problems with PLZT are under control. Material (PLZT) from suppliers continues to be a problem. Efforts to completely characterize the PLZT both chemically and with respect to desirable optical properties are being accelerated. Increased pressure is being exerted on suppliers to maintain consistency and exact specifications. Lack of uniformity in the PLZT and difficulty in performing exact analysis have prevented Radiation from achieving a 128 x 128 page composer at this time. The possibility of using line page composers utilizing accusto-optical techniques is being evaluated.

Management Progress: The RCA contract NAS8-26808 has been extended to April 1974. An interim report has been completed. The Radiation contract NAS8-26672 has been extended to July 1, 1974. An interim report is now available. These dates represent program stretch-outs and these changes and other consequences are reflected in the milestone schedule.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 502-23-31

PAGE 3 OF 3

Conclusions: Both in-house and contractual efforts are progressing well. The breadboard facility is providing useful information for evaluation and optimization of system components and their interrelationships. A 10^9 bit capacity planar optics memory of relatively small size will be possible in the near future.

Forecast: A fully operational breadboard in 1974. A 32 x 32 block data composer, 5 x 5 hologram array and 32 x 32 photodetector array.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-23-42	PRIOR NO.: 115-17-05

4. TITLE:

Inertial Components

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
B. F. Walls/S&E-ASTR-G	205-453-0793	Richard Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Three-Axis Ring Laser Guidance Platform Development Inhouse

OBJECTIVE: To produce a three-axis strapdown inertial navigation system using laser gyros with performance that is equal to or exceeds the present high quality inertial navigation systems in accuracy and reliability with a considerable reduction in weight, size and cost.

This system will be used in a wide range of navigation vehicles including ships, space vehicles and aircraft.

The system will have the following advantages over present navigation systems.

1. Weight, less than 20 lbs
2. Lifetime, greater than 2 years
3. Power, less than 30 watts
4. Volume, less than 300 cu-in
5. Warm-up time, less than 20 minutes
6. Cost, less than $20,000
7. Digital output to interface with strapdown digital computers
8. Easily adaptable to redundant configurations
9. Fast preflight checkout

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

1. Ten Monthly Progress Reports, Dec 1970 to Sept 1971, File 4720 CF.2.33658, "Three-Axis Strapdown Ring Laser IMU", Sperry Gyroscope.

2. "An Improved Ring Laser Rate Sensor for Use in Strapdown Inertial System" by I. N. Hutchinson, P. K. Inglima. Sperry Gyroscope presented at AIAA Guidance, Control and Flight Mechanics Conference, August 1970, Santa Barbara, California.

3. "Effect of Discharge Tube Aging on Laser Gyro Drift Stability" by E. Vaher, W. M. Macek and John M. Abdale, Sperry Gyroscope, presented to CLEA Conference in Washington, D. C. on June 4, 1971.

4. "Improvement in Laser Gyro Technology", Vols I and II, by E. O. Vaher and I. N. Hutchinson, Sperry Gyroscope, prepared under contract NAS8-24436.

5. Monthly Progress Reports, 1972 to March 1974, "Three-Axis Strapdown Ring Laser IMU", Sperry Gyroscope, Contract NAS8-24436.

FIRST BENEFITTING PROJECT: No yet program oriented.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-23-42 PAGE 2 OF 3

APPROACH: A. Technology Development - Perform development testing to identify problem areas and possible improvements in the bias techniques, discharge tube life, and control electronics. Modify these components for improvement.

B. Environmental and Operational Tests - Perform environmental and operational tests to prove the capability of the laser gyro to function in a three-axis attitude reference system.

C. System Integration - Interface the three-axis laser gyro strapdown sensor package (including accelerometers) with computer and software for a complete navigation system.

D. Overall System Performance Tests - Perform navigation system field test in a mobile van and in an aircraft flight to prove capabilities of a laser gyro navigation system.

STATUS: Technical Progress:

A. Technology Development - The laser gyro tube life has been increased from an average of 200 operating hours to better than 10,000 hours and all tubes are still operating. At present, the nine improved tubes have accumulated over 108,000 hours without a failure. Development work to improve the biasing techniques and stability of the control electronics are continuing.

B. Environmental and Operating Tests - The three-axis laser gyro strapdown platform has accumulated over 4000 hours of operating time in environmental and operational tests. The latest developments have improved the long-term drift stability to better than 0.02 °/hr, repeatability to better than 0.2 °/hr and scale factor linearity well below 0.01% up to 200 °/sec input rate. The test data has provided information for the improvement to the control electronics, voltage control, temperature control and vibration stability.

C. Complete System Integration - Work is progressing on the design, build, and documentation of the updated three-axis laser gyro package, including three accelerometers and the computer interface. This work will result in a complete laser gyro navigation system with computer and software.

D. Overall System Performance Tests - Plans are being made at MSFC to perform navigation system field tests in a mobile van on the complete laser gyro navigation system and also to perform flight test evaluation on this system in an aircraft at Langley Research Center.

Management Progress:

1. Presented data and development progress at the Interagency Laser Gyro Meeting on June 6-7, 1973, at Applied Physics Lab and Dec. 5-6, 1973, at Holloman AFB. These meetings were attended by representatives of various Centers of the Navy, Air Force, Army and NASA. Several Centers expressed interest in cooperating with us on our planned system van test and flight test programs to the point of assisting with technology, equipment and possible funding.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-23-42 PAGE 3 OF 3

Management Progress (cont.)

2. Evaluating test data, writing reports and preparing technical presentations for candidate user project offices.

3. Preparing the work statement for the next development phase.

Conclusions:

A. Technology Development - The operating life of the laser gyro has a proven increase from 200 hours to greater than 10,000 hours. The life tests are continuing with every indication of proving even greater life. One tube already has over 28,000 hours of operation. This year's work has included making defined modifications to the electronic control circuits, correcting grounding problems and improving vibration capabilities and temperature sensitivities.

B. Environmental and Operational Tests - These tests on the present three-axis laser gyro development system have shown that the laser gyros can fulfill the requirements for many navigation system applications in accuracy, stability and life, with a reduction in cost by an order of magnitude. The laser gyro system has the very unique feature of easily performing self-tests for preflight operational tests.

C. Complete System Integration - The preliminary mating test between the complete laser gyro inertial measurement unit (IMU) and the inhouse developed SUMC computer was made Mar. 12, 1974. All interfaced equipment checked out and only two minor problems were found and corrected. The IMU system calibration test and the computer program test are continuing with plans to complete system integration tests and start mobile van test in April 1974.

D. Overall System Performance Tests - The mobile van test will be completed by May 31, 1974, and the complete system will be taken to Langley Research Center and flight tested in a helicopter. The results of the data analysis from these tests such prove the capabilities of this approach to strapdown system applications.

Problems:

No problems are now anticipated except the normal technology problems of system interface and testing.

Forecast:

Mobile van navigation test completed by May 31, 1974

Aircraft flight test completed by August 15, 1974.

Redundant system program definition completed by May 30, 1974.

System design completed June 30, 1974. Computer build completed by June 30, 1974. Accelerometer electronics completed by June 30, 1974. Gyro design completed by June 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-23-51	PRIOR NO.: 115-25-02

4. TITLE:

Design, Processing and Testing of LSI Arrays

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. L. Anderson, S&E-ASTR-RM	205-453-3770	J. C. Taylor

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: LSI Materials, Array Design and Technology
NAS12-2207, RCA, Princeton, NJ
NAS8-26379, Texas A&M, College Station, TX
NAS8-26749, Mississippi State University, State College, MS
NAS8-26384, Autonetics, Anaheim, CA
NAS8-25621, M&S Computing Company, Huntsville, AL
NAS12-2233, RCA, Camden, NJ

OBJECTIVE: To develop the design capability, processing techniques, and test methods for hybrid and large scale integrated circuits (LSI) that will be required in future programs.

APPROACH: Utilize computer techniques and programs for design and testing of LSI arrays. Some of the work to be completed will be an improved method of cell design, a two-dimensional layout and interconnection program for LSI arrays, test sequence generation program for sequential circuits, etc.

Develop advanced integrated circuit processing techniques that can, with proper emphasis and guidance, be ready for future programs. Longer range efforts will be to explore advanced ideas and theories of such items as bulk effect integrated circuits, line modeling, line automation, silicon on sapphire beam-lead processing and surface and bulk studies in silicon material.

Develop advanced hybrid microcircuit packaging for all future programs. Particular emphasis will be placed on bonding techniques and adhesives for wire and die. The

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Internal Report November 1972	Guidelines for Ceramic Dielectric, Monolithic Multilayer Chip Capacitors	MSFC	
Internal Report November 1972	Guidelines for Thick-Film Single Chip Resistors and Custom Networks	MSFC	
Internal Report December 1972	Guidelines for Beam-Lead Transistors	MSFC	
73-0002 January 1973	Artwork Interactive Design System (CIDS) Program Description	M&S Computing, Inc.	
73-0001 January 1973	Sigma 2 Graphic Display Software Program Description	M&S Computing, Inc.	
NAS12-2233 November 1972	SUMC-DV Hardware Manual	RCA, Camden, NJ	

FIRST BENEFITTING PROJECT: All MSFC Approved Programs

criteria in these investigations will include compatibility with other parts and processing techniques, bond strength, corrosivity, and outgassing.

All in-house programs in all types of microelectronics will complement contract efforts in accomplishing the above program objectives.

STATUS: Technical Progress:

NAS12-2207 - This contract was established to develop the necessary system, circuit and processing techniques for the fabrication of high speed, low power complementary silicon-on-sapphire random access memory arrays. A follow-on contract was negotiated with the following tasks proposed:

1. Establish a process for a hermetically sealed beam lead chip including Si_3N_4 or Al_2O_3 junction seal, with the potential for high yield in a manufacturing process.

2. Determine the sources of the yield and reliability defects and develop the technology to minimize these defects and reduce parameter spread. This effort will be directed toward a full understanding of the material defects and the process interactions which will result in control of the fabrication technology and provide predictable performance.

3. The 256-bit RAM will be used as a vehicle for this effort. At the completion of the contract, 10 of these devices will be delivered to MSFC for evaluation. These devices will have beam leads, hermetically sealed junctions, and information on the processes used in their fabrication displaying parameter variance (σ^2) on such items as threshold voltage, leakage, saturation resistance, etc.

NAS8-26379 - During Phase I of this effort (Aug. 1970 - Feb. 1971), the contractor Sirtl-etched a number of Lopex and Czochralski silicon wafers from a major supplier and found a general pattern of swirls, pits, and related defects. It has been difficult to find sufficiently good wafers to test the effect of thermal stresses. It has been shown that wafers held in position other than horizontally tend to induce defects during eat cycles. However, if stress-relieved plain wafers (as chemically etched) are placed on a flat surface, they can be thermally shocked as high as 1150°C and then cooled to room ambient quickly without propagating defects. Therefore, heat gradients are not of themselves detrimental to the wafer if it does not have inherent stresses. The following interim conclusions are made:

1. Commercial wafers have a wide range of damage in general.

2. This damage is caused by poorly controlled ingot growth and wafer preparation, mostly the latter.

3. A slow rate of polish and fine grit reduces this damage.

4. To reduce defects, flat quartz slabs no less than 1/4" thick are recommended for placing the wafers on during oxidation, epitaxy, or diffusion.

5. Steam oxidation produces more defects than does dry or wet oxidation. The water bath should be kept at constant temperature, as at 25°C.

6. A source for very low defect wafers has been found. It has been shown that wafers may be 100 percent Sirtl-etched as a selection approach on a nondestructive basis. The Cr present can be removed as shown by neutron activation analysis detecting residual Cr as low as one part in 10^{12}. The relationship between time of Sirtl-etch, degree of agitation, and temperature (quantity related) has been established in terms of defect type and location on the wafer, whether surface or bulk.

7. It has also been shown that completely Sirtl-etched wafers do not induce dislocations during thermal cycle even if placed over the hole in a quartz slab.

8. CV plots on a 7000Å wet oxygen oxide showed that the minority carrier lifetime is decreased in the presence of excess dislocations, causing the MOS device to behave as a low frequency device.

9. A study of SiO_2-Si interface stress showed that wet O_2 is the best compromise for growing the oxide.

10. A study of boron diffusion showed that damage at drive in is less if deposition is made at 950°C rather than at higher temperatures. Longer drive ins produce more damage.

11. Dry O_2 oxidation creates more Si-SiO_2 interface stress than does steam oxidation.

12. Twenty-three wafers have been used for fabricating bipolar digital devices. The etched, thinner wafers were more fragile. Chromium contamination did not appear as a problem. Leakage was somewhat higher than on non-etched wafers.

A summary comparison is being made on the etched and unetched wafers.

Also, a handbook is being written which will show the overall influence of material properties and defects on semiconductor device performance and yield. This will be ready by late summer.

NAS8-26749 - CCD Model: The electrostatic model of the CCD structure has been developed and has evoked some very interesting results. This mathematical model uses a finite difference technique with a specified number of points to solve a two-dimensional Gauss equation. Experiments are being conducted to relate the experimental and theoretical charge transfer times and efficiencies of the CCD circuit. Work is being done to incorporate the transport equation to the model. Preliminary results look very good.

Diffusion Modeling: The "doped oxide" diffusion technique is proving to be much better than gaseous diffusion for sources and drains of C-MOS devices. The major reason is that the oxide is deposited at relatively cool temperatures (~400°C) so that for p and n diffusions can be driven in simultaneously, thereby achieving greater process control. The p-wells are presently diffused by the silicon nitride technique. Ion implantation will ultimately provide the necessary control of depth and sheet resistivity. Work is continuing in this area to correlate the experimental results obtained with theoretical curves obtained from independent sources. Comprehensive tables are being prepared to summarize the important parameters of diffusions from doped oxides. A secondary effort will include investigation of the applicability of "paint-on" diffusion sources to MOS technology.

NAS8-26384 - Autonetics has essentially completed most of the laboratory work on this phase of the contract. The characteristics being tested are bond strength, corrosivity, and outgassing. Although only a select few materials were chosen for testing, preliminary results show that by careful and qualification, organic adhesives can reliably be used in assembly of microcircuits. An extension to the present contract with Autonetics has been negotiated to extend the work they are doing on evaluating bonding adhesives. The range of adhesives has been extended to include two gold filled, one silver filled, and one non-precious metal filled conductive types. The previous work concerned only electrically insulative adhesives. In testing the conductive adhesives, uncased MOS, pnp and npn transistors and integrated circuits have been mounted on alumina substrates having thick-film gold conductors and thick-film resistors. The compatability of the adhesives with the parts and substrates and the electrical integrity of the bond joints will be thoroughly evaluated. These evaluations will cover as a minimum: adhesive strength, corrosivity, high temperature life test outgassing, and voltage-current interface breakdown phenomena.

The extended portion of the contract covering conductive adhesives has progressed to the point where corrosivity tests are in process. The bond strength tests for these same materials is complete. The test specimen substrates for mounting semiconductor chips for the organic coating phase of this effort have been fabricated and the devices mounted. The test set up for testing the electrical parameters has been assembled and debugged and tests are being made.

A temporary setback was encountered in etching thin-film aluminum substrates for corrosivity tests of nonconductive adhesives. The problem has been resolved and the final part of that phase is almost complete.

NAS8-25621 - Debug information as received from RCA was incorporated into the Placement and Route in 2 Dimension (PR2D) computer program.

The Mask Analyzer Program (MAP) has been debugged to such an extent that a major test run involving LSI data will be attempted shortly.

Debugging and testing of the Artwork Interactive Design System (AIDS) in conjunction with MSFC personnel is proceeding satisfactorily. AIDS has matured such as to make it a standard tool within the microelectronic design automation effort at MSFC.

This contract will be updated to produce user documentation for the following programs: Mask Analyzer Program; LOGSIM/FETSIM; and the Network Interface Processor for LOGSIM/FETSIM-TPG-PRF-PR2D. Also software will be generated to interface the input and the output of the MAP program to the Network Interface Processor and the AIDS system.

NAS12-2233 - Several debug modifications of the Placement and Route in 2 Dimensions (PR2D) computer program were delivered to MSFC. Effort is underway to expand the PR2D capability to silicon on sapphire (SOS) technology.

Fabricated chips implemented in silicon gate C-MOS technology proved to be faster than the equivalent chips using metal gate technology by only 30 percent rather than by 200-300 percent as anticipated. The slow down was traced to cell interconnect capacitance as encountered on an LSI design. The speed achieved makes the silicon gate technology not usable for the SUMC program. Furthermore, a 30 percent speed increase is judged to be insufficient to justify the significantly more complex silicon gate fabrication process. Therefore, emphasis was shifted to the SOS technology which is

expected to achieve speeds adequate for the SUMC program. SOS cell design is presently under way. Preliminary data sheets for 11 C-MOS SOS cells were delivered in March 1974. Delivery of final versions of the silicon gate C-MOS cells has been delayed due to changes in layout rules that are being incorporated to improve yield.

In-house Activities - Refinement of the C-MOS/Si Gate/Beam-Lead Process is progressing very well. The doped oxide diffusion technique is excellent for the p and n diffusions. However, the reproducibility has not been adequate for the p-wells. The boron nitride technique is used to diffuse the p-wells.

The new monolithic "hands-off" processing facility will be ready by July 22. Most of the major equipment has been ordered. Everything will be ordered by the end of March. The purpose of this facility is to, as nearly as possible, process wafers with zero defects.

Logic devices are being fabricated for the Computer Division's HODAD Computer. These devices have been thoroughly tested and evaluated by the Computer Division and are working well within the design specification.

The development of prototype hybrid microcircuits for in-house evaluation has continued. The major prototype program involves the development of a gyro control system using hybrid packaging technology. Six different packages are being fabricated for this project with three microcircuits currently in the final packaging phase.

Plans are nearing completion for the relocation of the Macrodata MD 200/500 LSI tester. This tester which was developed and purchased with 502-23-52 funds will be used to validate the performance of the automatic test pattern generation software and to help characterize devices produced in the processing laboratory.

In cooperation with Goddard Space Flight Center a cost comparison is being made for LSI chips designed by the standard cell approach as against the universal array approach. The universal array approach in TTL technology has already been completed. The universal array approach in C-MOS metal gate will also be tried by Goddard. MSFC is designing two chips in the standard cell approach in order to verify proper operation of PR2D and to assist in the cooperative effort. One chip is an operational equivalent of a present TTL chip with fixed or predefined placement of 40 pads on a 140 x 160 mil chip with about 350 transistors. The second chip is a combination of two of the TTL chips with 64 pads on a 200 x 240 mil chip with about 850 transistors.

The operation of the multilayer hybrid/printed wiring board automatic layout program is being validated on two very dense and complex designs. One is a printed wiring board design that was provided by Goddard and the other is a hybrid design provided by KSC.

Management Progress: Planning is under way on programs using FY 74 funds. All FY 74 funds will be obligated by May 1, 1974.

Forecast: A fully automated microelectronics capability should be functioning by the end of FY 75. The design phase is well advanced at this time. Automatic testing at 10 MHz is presently available, but this must be increased in speed by 5 to 10 times. Wafer process automation will now receive primary attention and should be complete by the projected time.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-23-52	115-25-03

4. TITLE:

Screening and Reliability Testing of Microcircuits and Electronic Parts

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. C. Hamiter, Jr. S&E-QUAL-QT	205-453-3986	Spencer E. Smith, S&E-QUAL-Q

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE: To develop approaches for assessing and assuring predictable long operating life of microcircuits and other electronic devices used in aerospace applications.

APPROACH: This activity is coordinated with the NASA Predictable Long Life Microelectronics Program. Specific tasks are:

1. Elimination of microcircuit failure mechanisms caused by loose conducting particles, bad wire bonds, and damaged or improperly dressed lead wires. This is being accomplished primarily by the transition from "flying leads" to "beam leads" and the development of metallization passivation techniques.

2. Development of an all tantalum capacitor (wet tantalum slug and tantalum case) to eliminate failure mechanisms caused by silver electromigration during reverse bias.

3. Develop new and improved screening and accelerated testing techniques for quicker more accurate assessments of long life stability and characteristics. This includes development of electromagnetic screening techniques for microcircuits, identifying failure mechanisms of solid encapsulated microcircuits used in space environments, and assessing the effects of applicational and environmental stresses on long life characteristics of solid tantalum capacitors.

(Cont'd on page 2)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NAS8-28096	Final Report	Texas Instruments	Oct. 5, 1973
NAS8-29819	Monthly & Quarterly Progress Reports	Sprague	October 15, 1973 - March 15, 1974
NAS8-29940	Monthly & Quarterly Progress Reports	Hughes Aircraft	November 1973 - February, 1974
NAS8-28265	Final Report	Bedford Engr.	March 1974
NAS8-30373	Monthly Progress Report	Hughes Aircraft	December 1973 - January 1974
NAS8-30394	Monthly Progress Report	Hughes Aircraft	January 1974
NAS8-28748	Monthly Progress Report	Electronic Communications, Inc.	Oct 1973 - February 1974

STATUS: Technical Progress:

1. NAS8-28096, "Development and Production Implementation of Packaged Beam Lead Low Power Transistor-Transistor Logic Integrated Circuits with Protective Overlay Coating," Texas Instruments - All microcircuits have been manufactured and tested. The devices passed all environmental tests without any failures. This program has demonstrated the beam-lead package reliability and proven the capability of depositing glassivation on beam-leaded microcircuit die.

2. NAS8-29819, "Design, Development, Manufacture, and Qualification of Wet-Slug All-Tantalum Capacitors," Sprague Electric Company - Fabrication and evaluation of the welding equipment has been completed with over two hundred units having been welded. Preparation and processing parameters for the mono-metallic tantalum cathode have been finalized and implemented during this period. The deposition and sintering parameters of the tantalum powder to the case has been modified to improve the adhesive characteristic without sacrificing capacitance, efficiency or stability. To date, the program has been successful in developing an all tantalum capacitor in the T-3 case size with a minimum of two volts reverse characteristic with no observed degradation. The program is now ready to move into the qualification phase.

3. NAS8-29940, "Procedure Development for Application of Parylene Coating and Associated Controls and Inspection Criteria," Hughes Aircraft - The optimum coating thickness for hybrid microcircuits has been determined to be approximately 0.2 mil. This thickness provides optimum adhesion and insulation characteristics. A method for visual detection of the transparent Parylene on unwanted surfaces, such as, sealing areas where welding or soldering the case assembly is necessary, has been developed. A dye (anthracene) added to the raw Parylene causes it to be florescent under ultraviolet light. The Parylene coating has been tested on interconnecting wire bonds and the bond strength does not appear to be affected.

4. NAS8-30394, "Reliability Testing for Assessment of Application and Environmental Stresses on Long Life Characteristics of Solid Tantalum Capacitors," Hughes Aircraft - This program is to develop effective and realistic engineering data and criteria to quantify the degradation that results in solid tantalum capacitors from various space applicational conditions and environmental stresses. The program began in January, 1974 and the effort to date has consisted of planning the tests, designing the power inverters to be used in providing fast ripple voltages and initiating part procurement.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 502-23-52

PAGE 3 OF 3

5. NAS8-30373, "Electromagnetic Radiation Screening of Microcircuits for Long Life Applications," Hughes Aircraft - Preliminary results with power transistors indicate electromagnetic screening may be a more cost effective screen for semiconductor device channeling. The electromagnetic screening (X-ray) could reduce the present test time (using high temperature-reverse bias) from days to hours.

6. NAS8-28265, "Photomultiplier Tube Reliability Study," Bedford Engineering Company - This program is complete. Sufficient data and information were generated to prepare a screening and inspection specification for photomultiplier tubes used in space applications.

7. NAS8-28748, "High Reliability Hybrid Microcircuit Switching Device," Electronic Communications, Inc. - The layout of the substrate pattern has been changed to accommodate the redesign to delay the turn-on of the normally open contact.

Management Progress:

1. A Scope of Work for a "Study of Solid Encapsulated Microcircuits for Long Life Applications" has been prepared and proposals for the program have been evaluated. A contract should be awarded by April 15, 1974. The objective of this program is to gather and evaluate background information relative to solid encapsulated microcircuits. This assessment will be used to develop a detailed evaluation program that will determine the performance capability of solid encapsulated devices in long life space applications.

2. Contract NAS8-30394, "Reliability Testing for Assessment of Application and Environmental Stresses on Long Life Characteristics of Solid Tantalum Capacitors," was awarded to Hughes Aircraft on January 3, 1974.

3. Contract NAS8-30373, "Electromagnetic Radiation Screening of Microcircuits for Long Life Applications," was awarded to Hughes Aircraft on November 16, 1973.

4. A Scope of Work for a "Reliability Study of the Surge Pulse Life of Transient Voltage Suppressor (TVS)" has been prepared and contract award should be made by end of April, 1974. The purpose of this program is to determine the TVS mean time between failure as a function of surge pulse current; identify all significant failure mechanisms; develop guidelines for application and derating of these devices; and establish screening and inspection criteria.

PROBLEMS: Contract NAS8-30373, "Electromagnetic Radiation Screening of Microcircuits for Long Life Application," - Progress has been delayed due to difficulties in modifying existing X-ray apparatus for the required pulse mode.

FORECAST: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 to 31 03 74	502-24-17	502-24-17

4. TITLE:

Solar Array Technology for SEPS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Dr. J. B. Stephens, S&E-AERO-YA	205-453-3168	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Environmental Impact of Solar Electric Propulsion System Operation NAS8-29621, Rockwell International Space Division, Downey, California

OBJECTIVE: The objective of the study is to determine the effects of the operation of a mercury ion thruster on the earth's environment.

APPROACH: Identify and investigate in detail the effect on the environment of using a solar electric propulsion system with a mercury ion thruster. All aspects of the operation of such a thruster from the time of its launch up to geosynchronous altitude and return shall be studied. Normal usage as well as possible abort modes will be analyzed in detail. Lifetimes of mercury ions at orbital altitudes, trajectories, and/or precipitation into the lower atmosphere or to the surface will be studied for the various modes of usage in earth orbital operations, i.e., operation in near-earth orbits, operation between near-earth and geosynchronous altitudes, operation at geosynchronous altitude, operation from near-earth to heliocentric orbits. Additionally, the effects of mercury release by failures which result in aborting the mission will be studied.

Develop analytical models which can be used to study the motion, dispersion, diffusion, mirroring, or precipitation of the mercury ions into the atmosphere during the operational and abort modes. Utilize the NASA/MSFC Multi-layer Diffusion Model to ascertain the transport patterns of mercury released in

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
SD 73-SA-0167	Study of the Environmental Impact of Solar Electric Propulsion System Operation	J. B. Weddell, E. P. French, J. W. Haffner, and C. D. Martin	Feb. 25, 1974

FIRST BENEFITTING PROJECT: Solar Electric Propulsion System (SEPS)

the troposphere.

STATUS: Technical Progress: The failure mode analysis for a SEPS mission has been completed and shows that mercury would normally be released in the magnetosphere or above, unless there is a failure. The transport and decay of mercury in the magnetosphere has been analyzed using the program SPIRAL. The effects due to aborts resulting from explosion have been analyzed in the ionosphere and the ozone layer. The NASA/MSFC Multilayer Diffusion Model has been utilized to analyze on-pad explosions and aborts in the troposphere.

From the studies above, it has been determined that the normal operations of SEPS will not result in any adverse ecological consequences. Mercury released beyond the magnetosphere in interplanetary missions will be deflected from our terrestrial environment by the earth's bow shock. The normal operations of SEPS in the magnetosphere on geosynchronous missions will result in the ionized mercury being held in the earth's magnetic field and slowly diffusing back to the earth at rates well below the toxic threshold for mercury. The effects on communications will be limited to wavelengths which are normally reflected by the E-layer; therefore, there will not be an adverse impact in this area. Worst case analysis shows that a conflagration due to a failure in the ionosphere or the ozone layer would result in a perturbation of this region of the same order as normally experienced in the nature cycle. Worst case analysis shows that a conflagration in the troposphere results in an environmental perturbation which is acceptable.

Management Progress: None

Forecast: Additonal investigation will be required by specialists in selected areas to assess theoretical contingenceis which could potentially occur: that is, (1) the photodissociation of mercury oxide in the stratosphere, and (2) mercury deposition diffusion model for the troposphere

Problems: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 09 74	502-24-21	113-31-14

4. TITLE:

Launch Vehicle Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. A. Gross	205-453-3816	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Dynamics of Unsteady Cavitating Cascades, NAS8-29313, NAS8-28046; California Institute of Technology, Pasadena, California

OBJECTIVES: The dynamics of the cavitating pump inducer represent the major area of limited understanding in describing the engine for vehicle Pogo evaluation. This requires that acceptable engine Pogo data await the availability of engine test results. The objective of this effort is to improve the basic understanding of cavitating inducer dynamics so that accurate engine model for Pogo can be prepared and used prior to acquisition of test results.

APPROACH: Analysis of the dynamics of cavitating pump inducers will be conducted based upon blade cavitation and bubble growth theories of cavitation. The results of these analyses will be correlated with existing data where possible. In addition, the analyses results will be used to guide the design of a verification test facility. The test facility will be designed and built and analyses verification tests will be run.

STATUS: Technical Progress: Employing finite cavity cascade theory, both quasistatic and a more complete, general dynamic analyses were made for the compliance of a cavitating cascade. The general dynamic case is a new fundamental problem in unsteady dynamics. The basic analytical formulation of this case was completed and work is continuing with the objective of obtaining numerical results. In the quasistatic case the completed analysis was extended to a number of existing turbopumps (J-2, F-1, H-1) rocket engines and the resulting compliances compared with values deduced from experiments. Though the validity of much of this experimental data is open to some doubt, the fact that the

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
ASME Polyphase Flow Forum - San Francisco	A Note on Turbopump Blade Cavitation Compliance for the POGO Instability	C. Brennan and A. J. Acosta	March 1972
Journal of Spacecraft and Rockets, Vol. 10, No. 3, pp 175-180	Theoretical Quasistatic Analyses of Cavitation Compliance in Turbopumps	C. Brennan and A. J. Acosta	March 1973
Submitted for publication to ASME	A Note on the Unsteady Cavity Flow in a Tunnel	J. H. Kim and A. J. Acosta	--
ASME Paper 73-FE-34	The Dynamic Behavior and Compliance of a Stream of Cavitating Bubbles	C. Brennan	June 1973

FIRST BENEFITTING PROJECT: SSME

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-24-21 PAGE 2 OF 3

STATUS (CONCLUDED):

theory underpredicted by as much as an order of magnitude in some instances motivated a study of other forms of cavitation as a source of compliance. As a result, an in-depth study of the dynamic behavior and compliance of streams of cavitating bubbles was undertaken with both mainstream and backflow streams in mind. This investigation led to some very satisfactory results in terms of agreement with existing data.

To verify the results of these analyses, a small-scale model system was constructed and is now being used to obtain beneficial data. The model system consists of a 3" pump loop with provisions for flow perturbations upstream and downstream of the pump. Perturbation flow is being measured using laser velocimeters. A model SSME oxidizer inducer will be tested to provide data directly usable to that program. Testing to date indicates all desired data to support the analyses can be obtained.

Management Progress: Funding for this effort has been transferred to SSME (983-15-11). A one-year extension effective October 27, 1973, has been made to the contract. The extension was funded for $52,900.

Conclusion: Quasistatic analysis of blade compliance gave results which are significantly lower than available data. Analysis based upon dynamic behavior of streams of cavitating bubbles gave compliance reasonably close to existing data. This analysis gives a result which is mathematically complex and frequency dependent.

Problems: None

Forecast: No further URS reports will be issued on this task.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-24-21	113-31-12

4. TITLE:

Launch Vehicle Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
K. W. Gross	205-453-3815	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Performance Data Analysis Manual, NAS8-28603; North American Rockwell, Rocketdyne Division, Canoga Park, California

OBJECTIVE: Develop a JANNAF reference manual which specifies standardized methods for determining rocket engine performance from test data.

APPROACH: Identify particular measurements for overall and individual performance loss determination. Specify methods for instrument calibration, data recording, data averaging, and uncertainty determination. Establish acceptable measurement practices and criteria for test model selection. Determine optimum methods for reducing existing test data which has been accumulated without the benefit of these standardized measuring procedures. Select specific experimental performance data for the calibration of analytical performance evaluation procedures.

STATUS: Technical Progress: All task items have been completed and the recommended procedures are published in the "JANNAF Rocket Engine Performance Test Data Acquisition and Interpretation Manual," CPIA Publication 245.

An additional document entitled "JANNAF Rocket Engine Performance Methodology Sample Cases," CPIA Publication 245/246, was distributed as a supplement. This document shows performance data obtained from testing of three rocket engines as well as all necessary parameters necessary to conduct an analytical performance prediction in compliance with the standardized reporting format. At present, analytical performance predictions for the same three rocket engines, considered as sample cases, are conducted under a separate contract, monitored by the Air Force Rocket Propulsion Laboratory. The results will be included in CPIA 245/246 at a later date.

REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
CPIA 245	JANNAF Rocket Engine Performance Test Data Acquisition and Interpretation Manual	Rocketdyne	1 Nov 1973
CPIA 245/246	JANNAF Rocket Engine Performance Methodology Sample Cases	Rocketdyne	1 Nov 1973

FIRST BENEFITTING PROJECT: SSME

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-24-21 PAGE 2 OF 3

STATUS (CONCLUDED):

Management Progress: CPIA Publication 245 has been identified as a preliminary document in order to distribute the manual and exercise the procedures within the rocket community. At a later date the JANNAF Performance Standardization Working Group will take the appropriate action to identify subject document as the reference procedures.

Conclusion: The program objective was successfully met. A standardized technique for treating performance data obtained from engine testing is feasible provided the proper measurements are made.

Problems: None

Forecast: This is the last URS report that will be issued on this task.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-24-21	PRIOR NO.: N/A

4. TITLE: Launch Vehicle Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
K. W. Gross	205-453-3815	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Coaxial Injection Combustion Model, NAS8-29664, North American Rockwell, Rocketdyne Division, Canoga Park, California

OBJECTIVE: Provide an operational computer program and documentation applicable to coaxial injection and combustion of liquid-gas propellants for advanced rocket engines. Structure the computer program to fit into the standardized JANNAF performance evaluation procedure.

APPROACH: Modify the numerical analysis of an existing computer program and conduct all necessary iterations within the program to increase solution accuracy and to economize computer execution time. Update and extend the physical propellant properties to conform with the format of other JANNAF computer programs.

STATUS: Technical Progress: The original computer program was structured to be rerun several times to accomplish the analysis of a full combustor using coaxial injection elements. To avoid such a slow and tedious process involving handwritten transfer of data, it was decided to modify the computer program so that it performs all necessary iterations within a single run. The results punched on computer cards are then directly applicable to the JANNAF Two-Dimensional Kinetics (TDK) computer program. This change in the scope of work required contract extension of two additional months. During the effort to improve the "cup" pressure drop calculation, the computation of the pressure recovery due to the expansion around the oxidizer post has proven to be more complicated than anticipated. Consequently, a number of techniques are still being investigated. Due to this problem, another contract extension of one and one-half months was granted. An interim computer program has been provided to MSFC to make it operational on the UNIVAC 1108, such that changes for a satisfactory "cup" pressure drop computation can

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Program Plan	L. P. Combs	21 May 73
Monthly Progress Report for:			
Period Ending:	31 May 1973	L. P. Combs	13 June 73
" "	30 June 1973	"	12 July 73
" "	31 July 1973	"	10 August 73
" "	31 August 1973	"	10 Sept. 73
" "	30 Sept. 1973	"	5 Oct. 73
" "	31 Oct. 1973	"	7 Nov. 73
" "	30 Nov. 1973	"	5 Dec. 73
" "	31 Dec. 1973	"	11 Jan. 74
" "	31 Jan. 1974	"	11 Feb. 74
" "	28 Feb. 1974	"	11 March 74

FIRST BENEFITTING PROJECT: SSME

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-24-21 PAGE 2 OF 3

STATUS (CONCLUDED):

quickly be implemented. Preparation of a user's manual is complete except for the pressure drop calculation part.

Management Progress: To remain within the originally amount of funding, mutual agreement between the contractor and MSFC was obtained to perform all necessary iterations within a single computer run. The user's manual will be provided to MSFC without a draft and modification cycle and printing of additional copies and distribution of the copies will be conducted by MSFC.

Conclusion: The task objective is expected to be successfully met and an operational computer program and associated user's manual will be available on April 15, 1974.

Problems: Predicted cup pressure drops are not satisfactory compared with existing test data.

Cause of Problem: Inclusion of a rigorous analytical model to determine the pressure recovery in the "cup."

Solution of the Problem: A number of techniques to obtain a satisfactory solution are being investigated.

Forecast: If a rigorous solution for the "cup" pressure drop fails, an existing simplified approach will be used in the computation process.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-24-21	PRIOR NO.: None

4. TITLE: Launch Vehicle Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
K. W. Gross	205-453-3815	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Boundary Layer Integral Matrix Procedure (BLIMP), NAS8-23667, Aerotherm Division, Acurex Corporation, Mountain View, California

OBJECTIVE: Provide a computer program and documentation for rocket nozzle boundary layer performance loss and heat transfer calculations capable of treating regenerative, transpiration, film, and ablatively cooled designs. This program will become a part of the standardized JANNAF rocket nozzle performance determination methodology.

APPROACH: Tailor the existing BLIMP program to rocket nozzle boundary layer analysis. Accept solutions from other JANNAF reference programs to account for the streamwise variations in the gas elemental compositions, pressure, enthalpy, and velocity from the combustion chamber to nozzle exit. In compliance with standard procedures, the thrust chamber contour radii as a function of axial distance will be used, and the thrust loss and boundary layer displacement thickness along the wall will be incorporated. The existing thermochemical calculation procedure will be replaced by the JANNAF one-dimensional equilibrium (ODE) model. A "refit" option, rearranging nodal points across the boundary layer under large parameter gradient conditions, will be included. An interim user's manual will be provided emphasizing the important input/output formats and program options. The computer program must be compatible with MSFC's UNIVAC 1108 computer and program operation will be verified with a liquid engine test case. To establish the validity of the code for problems of immediate concern, the code will be verified by comparing predicted results to well documented high quality experimental data for flows which include the following features: turbulence, blowing, streamwise pressure gradients and variable free stream gas composition.

7. REPORT NO.:	TITLE:	AUTHOR(s).	DATE TRANSMITTED
	Project Work Plan	Howard Morse	3 July 73
	First Monthly Status Report	Howard Morse	1 August 73
	Second " " "	"	1 Sept. 73
	Third " " "	"	1 Oct. 73
	Fourth " " "	"	1 Nov. 73
	Fifth " " "	"	26 Nov. 73
	Final Report (Draft)	Acurex Corp.	31 Jan. 74
	User's Manual	"	15 March 74

FIRST BENEFITTING PROJECTS: Shuttle and Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-24-21 PAGE 2 OF 3

STATUS: Technical Progress: All tasks of the scope of work have been completed. Due to the limited availability of test data, the program verification could not be conducted to the extent as originally planned. The contractor was therefore directed to include an additional sample case treating a solid rocket motor boundary layer. The modified BLIMP computer program has been provided to MSFC and is operational on the UNIVAC 1108 computer. The user's manual describing the computer program input requirements and printout results has been completed and published. Review of the final report has been accomplished and publication will start shortly.

Management Progress: Requests to various Government agencies and private industry to provide experimental data necessary to establish the validity of the BLIMP program predictions have resulted in only two sets of data. In order to use the assigned funds for this task efficiently, the contractor was directed to execute a solid motor boundary layer sample case which is of interest to MSFC.

Conclusion: All task objectives have been met successfully.

Problems: None

Forecast: Only the final report remains to be published and is scheduled for April 1974. Therefore, this is the last URS report that will be issued on this task.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 502-25-73	PRIOR NO.:

4. TITLE:

Multi KW DC Distribution System - Evaluation and Demonstration

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. L. Felch	453-4630	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Study on Multi-KW DC Distribution System

Contract No: NAS8-28726 - TRW INC., Redondo Beach, Calif.

Objective(s): To demonstrate and evaluate the significant benefits of reliability, weight and system design flexibility disclosed by the Space Vehicle Electrical Power Processing, Distribution, and Control Study (RTOP 113-60-21) for DC power distribution in excess of 100 volts.

Approach: Design and fabricate technology test facility at MSFC. Contract effort for program definition of detailed test objectives, test article sizing/selection and test procedures. MSFC inhouse effort for design, procurement and installation of the technology test facility; component and system testing, analysis and evaluation.

Status: Technical Progress - Program objectives and system baseline established and system design in progress.

Management Progress - Procurement of hardware with FY-74 funding has been initiated. TRW contract extension procurement action initiated.

Conclusions - None.

Problems - Costing limitations on FY74 funds will delay delivery of most hardware buys until after July 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Project: CVT

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-25-73 PAGE 2 OF 2

Forecast - Milestone schedules have been updated to reflect current design progress and hardware deliveries. A coordination meeting at MSFC with TRW is planned for April 2, 3, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-33-53	PRIOR NO.: 115-24-05

4. TITLE:
Sensor and Instrumentation Research

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMF John Hamlet	453-3943	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Propellant Utilization Instrumentation, NAS8-27657, SCI Electronics, Inc., Huntsville, AL

OBJECTIVE(S): To develop instrumentation for shuttle propellant utilization.

APPROACH: Areas requiring technology advancement will be defined based on system requirements. Engineering model will be developed under contract to demonstrate achieved improvements. Loading requirements and liquid level measuring requirements will be incorporated with this work where applicable.

STATUS: Technical Progress - Major problem areas in signal conditioning have been defined, Phase I, design definition, is completed and design goals established. Three engineering models are completed and evaluation started.

Management Progress - Contract extended to March 31, 1973. The contract was modified to delete the qualification and reliability requirements and to specify that three engineering models be built instead of the qualification unit and production unit.
Conclusions - None
Forecast - Evaluation of the hardware will require more time than originally estimated because of the additional engineering models to be tested and because of lack of manpower.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Phase I	Design Definition		
Final Report			
Operations Manual and Documentation			

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-33-53	115-24-05

4. TITLE:

Sensors and Instrumentation Research

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMF H. Goldstein	453-5613	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Cryogenic Mass Flowmeter
NAS8-27732, Simmonds Precision Products, Inc., Vergennes, VT

OBJECTIVE(S): To develop a capacitance densitometer coupled with a head type meter for providing a rugged flight type cryogenic mass flowmeter capable of operating over the flow range of 100 - 200 lbs/sec for LH_2 and 475-1200 lbs/sec for LOX with a pressure drop of 5 psi to 10 psi.

APPROACH: A combination capacitance densitometer head meter will be developed which will adhere to the Shuttle engine line configuration. A 4" prototype of this device will be built and tested for flow rates up to 90 lbs/sec.

STATUS: Technical Progress - Work is completed on the fabrication of the 4" prototype meter.
Management Progress - The 4" prototype meter has been delivered to the test stand. The earliest date that testing can be started is July 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Phase I Report		

MSFC - Form 350 (March 1973)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	502-33-53	115-24-05

4. TITLE:

Sensors and Instrumentation Research

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMF H. E. Thompson	453-3943	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Propellant Quantity Gaging under Zero G
NAS8-28574, TRW Systems, Redondo Beach, CA
NAS8-30160, Bendix, Davenport, IA
NAS8-25097, Metro Physics, Phoenix, AZ

OBJECTIVE(S): To develop an instrumentation system capable of providing accurate propellant quantity measurement under zero "g" conditions. The system shall be capable of providing a measurement of propellant quantity of the maneuvering tanks with an accuracy of better than two percent. Hopefully, the technique chosen will be capable of providing a highly accurate quantity measurement at accelerations of earth gravity, boost phase, and zero "g" so that one system can be used for quantity measurements under these conditions.

APPROACH: A survey and evaluation has been conducted to define techniques for zero "g" quantity gaging, including those within the present state-of-the-art and promising potential techniques. Extensive evaluation was made of the various techniques, both experimentally and by means of computer simulations, to select the most promising for further development. A detailed development specification will be prepared embodying the most promising approach.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report	Contract NAS8-26116 TRW; Zero "G" Propellant Gaging of Cryogenics NASA Technical Memorandum NASA TMX-58063, Volume II. Phase A Final Report Contract NAS8-30160, Bendix Corporation	N. E. Staniey R. G. Morrison	

FIRST BENEFITTING PROJECT: Space Shuttle & Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 502-33-53 PAGE 2 OF 3

STATUS: Technical Progress

1. Contract NAS8-28574 TRW Systems Inc. This contract has been completed and no further development of the RIGS is planned at this time.

The contractor constructed two gages to operate in an isothermal mode. The first unit gaged water but gave unsatisfactory results on a LOX tank. The problems were due to flimsy bellows which were unpredictable. To eliminate the bellows problem an augmented RIGS was constructed which used metal bellows driven by a torque motor. The double differentiation of the follower bellows position signal introduced excessive noise in the control system and filtering of the signal to remove noise made the gage insensitive to ullage volume changes. In view of other gaging techniques available additional work was not pursued.

2. Nuclear Attenuation Gaging Systems are under study. This method seems promising for LH_2 but the source strength required to gage LOX is so high as to be a safety hazard.

3. Point sensor Contract NAS8-25097 with Metro Physics, Inc. for furnishing four zero "g" point sensors with electronic readout units to gage cryogenics has been completed. The point sensors use carbon film electronic beam deposited on the glass substrate. Trouble had been experienced in producing uniform carbon films but problems were solved and delivery made of the sensors in March 1974. Testing of these sensors in a drop tower will be performed at MSFC.

4. RF System, Bendix Contract NAS8-30160. A flight system was flown aboard the KC-135 aircraft during September 1972. Flight data from 66 parabolas during low "g" and two "g" maneuvers agreed closely with the calibration obtained on the ground in one "g".

An 18,500 gallon LOX tank was gaged at MSFC in February 1973. Preliminary tank gaging studies were performed using the math model to select a gaging frequency and predicted observable mode count when empty and full. After the predictions were made, Bendix came to MSFC and ran the tests to verify their calculations. The tank measurements and the predicted response based upon the math model agreed closely.

Bendix has constructed a vacuum jacketed cryogenic tank for LOX and LH_2 test. The tank holds about 250 gallons and is designed to gimbal. A data acquisition system has been installed in the test area which can record data rapidly at each fill level as the tank is rotated. These tests were performed using LO_2 and LH_2 to complete Phase B of the contract. The test results are awaiting analysis of the thousands of data points taken during testing.

Phase C is under contract and includes improvements to mode processing circuits, additional testing with cryogenics and pressure tests, and the gaging of a large LH_2 tank.

Management Progress - Contract NAS8-30160, Bendix Corporation. Due to requirements for reduced spending rate, test schedules have been stretched out and tasks modified to reduce costs. Tasks planned for accomplishment in March 1973 were delayed until June 30, 1973. Additional tasks to obtain circuit refinements and improved gaging accuracy are to be accomplished by Jan. 1975.

Conclusion - The Bendix RF system is capable of gaging fluids though more refinement is required. Testing of the RIGS showed problems to be too great to warrant development of this system.

Problems - The Bendix RF system is capable of gaging fluids though a better understanding of the math model and of the elements which comprise the math model is required. It is believed that further analysis of past tank data along with data from the 18,500 gallon LOX tank and from the jacketed cryogenic tank will offer significant information and lead to a better definition and understanding of the tank parameters and gaging system elements and of how they relate to each other. Improvements in antenna design have been made which produce a more uniform illumination of the tank.

Forecast - The Bendix Corporation RF system will be used as a basis for establishing the most feasible approach to pursue in prototype hardware.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 502-33-53	PRIOR NO.: 502-33-86

4. TITLE:

Sensors and Instrumentation Research

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMF Alex Hafner	453-3940	Walter Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Gas Analyzer
NAS8-30254, Honeywell, Inc., Minneapolis, Minn.

OBJECTIVE(S): To develop gas sensor systems and environmental control monitors to determine the amount of O_2 and CO_2 in the habitable atmosphere on the Space Shuttle, and to detect the presence of hazardous or toxic gases and leakage or accumulation of fuel or oxidizer.

APPROACH: A study of the requirements and constraints of the applications and the techniques available is continuing. Appropriate sensors are being evaluated and tested and new techniques investigated. A contract has been awarded for a pulsed inlet mass spectrometer. After preliminary investigations and evaluations are completed, a development program will be initiated for flight systems.

STATUS: Technical Progress - The development of a Pulsed Gas Analyzer (NAS8-30254, Honeywell) is continuing. The analyzer has a pulsed inlet system to admit small quantities of gas to be sampled, and four channels to analyze four constituents at once, eg O_2, N_2, CO_2, H_2O. The contract will be amended to provide further refinements in the design.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
1. Monthly Reports Contract NAS8-30254	Cabin Atmosphere Monitoring System	W.W. Bursach Honeywell, Inc.	9/12/73
2. Final Report (Phase I-A) NAS8-30254	Cabin Atmosphere Monitoring System, Pre-Prototype Model Development	"	2/20/73

FIRST BENEFITTING PROJECT: Space Shuttle, Space Lab

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 503-24-06	PRIOR NO.: 112-30-19

4. TITLE:

Reusable Nuclear Stage Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IM T. N. Marshall	453-4626	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Solid/Triple Point Liquid Hydrogen Mixture Measuring System H-13232A, National Bureau of Standards, Boulder, CO

OBJECTIVE(S): To develop instrumentation for slush hydrogen. The instrumentation to be developed will be density, mass flow, temperature, level, and phase.

APPROACH: A hydrogen slush density reference system was developed at NBS, Boulder and used as a standard for evaluating density measuring techniques. This reference system was used in establishing the most feasible methods for measuring hydrogen slush density. A hydrogen slush flow loop at NBS, Boulder has been used as a system for evaluating hydrogen mass flow techniques. This study is to be used as a basis for determining the techniques that can be developed into prototype mass flowmeters. A large slush hydrogen flow/generation system being fabricated at MSFC will be utilized to develop prototype instrumentation to an operational status.

STATUS: Technical Progress - The final report from the National Bureau of Standards has been received. This project is considered closed.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report	Instrumentation for Storage and Transfer of Hydrogen Slush	NBS	Jan 1974

FIRST BENEFITTING PROJECT: TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 503-24-06	PRIOR NO.: 112-30-19

4. TITLE:

Reusable Nuclear Stage Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMT Joe E. Zimmerman	453-5618	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Thin Film Cryogenic Thermometer
H-92167A, NBS, Boulder, CO

OBJECTIVE(S): The objective of this task is to optimize the thin film deposition parameters and manufacturing techniques of carbon thin film thermometers, and to produce representative quantities for field applications.

APPROACH: The thin film deposition parameters (pressure, substrate material, substrate temperature, and rate of deposition of the carbon film) will be varied during the initial deposition runs to determine the optimum conditions for producing the most repeatable and reproducible films for application as cryogenic temperature sensors. The initial deposition runs will also serve to define how closely the deposition parameters must be maintained to produce good quality films. Seventy-five films will be deposited as deliverable items. Ten of the films will be subjected to intensive calibration and thermal cycling to verify the analytical expression of resistance versus temperature between $6^{\circ}K$ and $80^{\circ}K$.

STATUS: Technical Progress - The thin film deposition process has been finalized and the required number of thin film sensors delivered. Thermal cycling tests and calibration tests at 22 points between 5 and 80 degrees Kelvin were completed on 10 of the sensors , and sensitivity curves established for the usable temperature

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
1.*NBS 9744	Final Report on Low Gravity Thermometer	J. C. Jellison, R. S. Collier, L. O. Mullen, & R. J. Richards	11/69
2. TBD	Carbon Thin Film Thermometer	R. S. Collier L. L. Sparks T. R. Strobridge	10/73

*This report describes the original thin film thermometer investigation conducted prior to the present program.

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 503-24-06

PAGE 2 OF 2

STATUS (CONCLUDED): Technical Progress (cont'd) - temperature range. The remaining sensors were given a three point calibration and fitted to the established sensitivity curves.

Management Progress - A draft copy of the final report has been received and approval given for final printing and distribution.

Conclusions - The calibrations show that the carbon film resistance vs. temperature curve is smooth with no apparent perturbations in the entire cryogenic range between 6 and 80 degrees Kelvin. The films are sensitive in the subcooled hydrogen slush applications. The film deposition process has been refined to the point where reasonable reproducibility and stability of the films may be achieved.

Problems - none

Forecast - This effort is considered complete with the publication of the final report.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-51-05	908-51-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. E. Young	453-4566	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Thermoelectric Power Generation

Contract No: In-house

Objective: To support the technology development of a reactor/thermoelectric power system which is a candidate for manned Earth Orbital Applications. Subsidiary objectives include evaluation of performance, lifetime, and reliability characteristics from life test data; determination of thermal and electrical characteristics; comparison of actual device performance with predicted performance derived from computer modeling; and performance of detailed post-test analysis.

Approach: The objective will be accomplished through a continuation of in-house effort on the basic research device, development of user application criteria, and integration studies.

Status: Technical Progress: Tests are in progress; data is being gathered and evaluated.

Phase I - Experimental devices have been procured (1 Each TEM/9U and 1 Each TEM/X Module) and have been on test in a subsystem environment.

Tests were terminated as scheduled on TEM/9U after more than 20,000 hours of operation. The TEM/X Module has been on test for over 8500 hours. All facilities for testing and data gathering are operating satisfactorily.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1	Test & Evaluation of a Tubular Thermoelectric Module (TEM/9U, S/N 17)	S&E-ASTR-EPN	May 1, 1972

First Benefiting Project: Space Station

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE 908-51-05 PAGE 2 OF 2

Management Progress: A facility has been established for test and evaluation of thermoelectric devices.

The TEM/X currently is operating 24 hours/day.

Conclusions: Results of TEM/9U testing and analysis indicate that a Space Station Thermoelectric Power System could be fabricated using TEM/9U basic technology. However, improvements in the form of lower rates of power degradation and higher efficiency performance are desirable. The TEM/X series of modules have incorporated design changes which should provide these improvements.

Problems: Module power degradation resulting from thermal cycling has been a problem. Test evidence indicates that this problem has been solved in the TEM/X series modules. The problems associated with expanding available component technology into system technology need attention.

Forecast: The remaining part of the fiscal year will be devoted to gathering and evaluating data from the TEM/X converter.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-51-08	908-51-08

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George B. Doane III S&E-ASTR-G	205-453-0787	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Control Moment Gyro for Stabilization and Control
NAS8-25756 The Bendix Corporation

OBJECTIVE: To develop a modularized family of CMGs which will be able to meet various requirements of future Space Station/Space Base vehicles. The modularized CMG system will be centered around nominal 2000H to 6000H CMGs which have as much commonality of design as is feasible. Prime emphasis is being placed on long life, and repairability in the Space Station environment, monitoring impending failure and incorporation of redundancy where feasible.

APPROACH: The approach for developing long life, highly reliable CMG system is based upon the following improvements: (1) Replaceable spin bearings, (2) Brushless dc spin motors, (3) Improved wet lubricated actuators with brushless dc torquers and tachometers, and spin motor electronics, and (4) Increasing reliability and improving the electronics.

STATUS: Technical Progress - While under test at Bendix/Teterboro the 6000H wheel failed catastrophically. Since the majority of the evaluation testing was completed, it was considered to be in the best interest of the Government to terminate the contract rather than replace the wheel. The 2000H CMG remains in-house and additional testing is planned. Because of the failure of the 6000H wheel, plans to modify the 2000H CMG to run at a 3000 ft-lb-sec momentum level have been dropped. The Bendix/Teterboro contract will be considered complete upon delivery of documentation and final reports.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

The following presentations have been reproduced and bound for distribution.

"Design Review, ATM CMG Product Improvement Program," NAS8-27756, at MSFC, July 21, 1970, presented by Bendix Corporation, Navigation and Control Division.

"Advanced Design CMG Critical Design Review, ATM CMG Improvement Program," NAS8-25756, January 22, 1971.

FIRST BENEFITTING PROJECTS: Large Space Telescope and Sortie Lab

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-51-08	

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
W. A. Swords S&E-ASTR-GMF	205-453-5753	R. H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: CMG Bearing Signature Analysis
NAS8-25706 Mechanical Technology Inc., Latham, NY

OBJECTIVES: The objective of this effort is to develop a method of early detection of bearing failure in CMG type spin bearings. This method will serve to give useful data on impending failure of CMG bearings before and after launch where failure would be catastrophic.

APPROACH: Phase I - CMG Investigation - Data has been taken on a multiplicity of of CMG mounted bearings in CMGs by using high frequency accelerometers mounted strategically around the CMG. Readings were taken on bearings known to be good and bearings showing signs of failure. After the readings were taken on the subject bearings, they were disassembled to verify the predicted failure. At the completion of Phase I, a report was issued giving the results.

Phase II - Spin Bearing Investigation - To eliminate the harmonics of the CMG bearings and to further refine the failure detection technique, individual sets of CMG bearings are being run in a bearing test fixture. This eliminates the CMG housing and allows a study of bearings as individual components. A series of bearings determined to be good and a series of bearings with known defects are being run to obtain signatures and establish a criteria for determining when a bearing is beginning to degrade and what effect flaws have in the signature. At the completion

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MTI-71TR1	Design and Fabrication of Prototype System for Early Warning of Impending Bearing Failure	J. J. Broderick R. F. Burchill H. L. Clark	Jan. 1972
MTI-73-TR-33	Review of Mechanical Vibration Tests Conducted on Control Moment Gyros and Life Test Fixtures	R. F. Burchill	Aug. 24, 1973

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-51-08 PAGE 2 OF 2

APPROACH: Phase II (cont'd)

of this effort an overall review of the data will result in limits being established on the signature to separate good bearings from bad ones.

STATUS: All spin bearing tests have been completed. The contract completion date has been held up pending approval of additional funding. The scheduled completion date is now April 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-51-08	

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. M. Seltzer, S&E-ASTR-A	453-4713	Hans H. Hosenthien

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Systems Research Laboratory, NAS8-28584.

OBJECTIVE:

The objective is to make optimum use of an in-flight digital computer so that it may be sized as small as possible. The techniques that are now being developed under modern control theory will be expanded. Analytical tools will be developed so that the design engineer can use them in the design of sampled-data control systems. A potentially powerful modern technique is under development for digital redesign of an existing acceptable (in terms of dynamic response) continuous control system. New innovations in the state space techniques that enable one to design a sampled-data control system using continuous system techniques will be thoroughly investigated. These investigations should extend the newly achieved results of sampled-data analysis in the state space domain and should investigate their applicability to space vehicle control system design. These investigations should further explore the techniques for solving linear continuous-data systems, such as the Nyquist criterion, Routh-Hurwitz criterion, root locus diagram, or Bode diagram extending these to the study of linear and nonlinear sampled-data control systems. The synthesis of linear continuous data systems and nonlinear continuous data systems will be determined. The ultimate goal of these investigations should achieve a sampled-data design tool that may be employed by the control system engineer who does not possess a deep mastery of mathematical and control system theory.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Bimonthly Report III-73	Continuous & Discrete Describing Function Analysis of the LST System	B. C. Kuo G. Singh R. A. Yackel	Nov. 1, 1973
Bimonthly Report IV-73	Continuous & Discrete Describing Function Analysis of the LST System	B. C. Kuo G. Singh R. A. Yackel	Jan. 1, 1974
Final Report IV-73	Continuous & Discrete Describing Function Analysis of the LST System	B. C. Kuo G. Singh R. A. Yackel	Jan. 1, 1974

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-51-08 PAGE 2 OF 2

APPROACH:

A comparison of the various state space implementations will be made with existing modified frequency domain techniques, such as the familiar z-transform technique. These comparative results will determine those techniques which are most easily implemented by the space vehicle control system designer. Analytical tools will be developed so that the design engineer can use them in the design of sampled-data control systems. The approach includes the following activities.

1. Suitable dynamic models will be developed for use in the major activities of this research task.

2. Professor Kuo has developed a technique for designing a sampled-data system whose response matches that of a continuous data system model at the sampling instants. The technique is rigorously applicable only to regulator problems and as such will be developed further.

3. The point-by-point comparison method (activity 2) will be extended from the regulator problem to the tracking problem. The extension technique will be scrutinized mathematically.

4. The convergence properties of the series approximations used in the point-by-point methods (activities 2 and 3) will be investigated as a function of the sampling period.

5. Optimal control theory (the Riccati equation in particular) will be utilized to develop a sampled-data design technique, using a quadratic performance index rather than a point-by-point comparison technique. An investigation will be made of complexity versus accuracy improvements achieved through the solution of the inverse problem of optimal control and a Liapunov function equation.

6. Since the optimal control method (#5) is really applicable to the regulator problem, an attempt will be made to develop a technique that extends this method to solve the tracking problem.

7. The point-by-point method (#2) will be compared with the optimal control technique (#5) for the regulator problem.

8. The two methods (#3 and #6), as extended to apply to the tracking problem, will be compared.

9. A parameter optimization digital redesign technique will be developed. A quadratic performance index is defined by using the difference between the status of a continuous data system and the states of the digital system to be designed. This index is minimized by selecting optimal values of the chosen parameters.

STATUS:

1. A discrete-data describing function for the nonlinear frictional torque characteristics expected of CMG's has been derived. It is being used to predict the range of sample periods that will not cause limit cycle behavior.

2. The complexity of the system model to which the sampled-data work is being applied is being increased to improve fidelity.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 74 31 03 74	CURRENT NO.: 908-51-21	PRIOR NO.:

4. TITLE:

Manufacturing and Inspection

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
M. C. McIlwain	453-1435	R. M. Henritze

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Detection of Lack of Fusion Using Opaque Additives - NAS 8-28708, McDonnell-Douglas Astronautics Company, Huntington Beach, California

OBJECTIVES: (1) To develop a reliable means of detecting lack of fusion; (2) To develop a means of maintaining cleanliness in weld area indefinitely using thin copper coatings.

APPROACH: A thin copper coat preplaced in joint area protects cleanliness by preventing formation of aluminum oxide. When welded into joint, any remaining trace of coating in radiographs is readily seen, and is an indication of lack of fusion. The program will be accomplished in two phases.
Phase I: Development of Methods - This phase will concern itself with the development of a technically feasible and metallurgically acceptable coating.
Phase II: Evaluation of Coating - This phase will determine the level of confidence attained in the radiographic determination of LOF by the opaque tracer developed in Phase I. Phase II will also determine the effectivity of this coating as a protection for maintaining welding cleanliness for extended periods.

STATUS: Technical Progress: Phase II has been completed and the final contractor report has been delivered. In Phase II, it was determined that opaque additives (copper) of a thickness of 0.0004 inches would yield 100% detectability for LOF defects in 1/2 inch thick 2219-Aluminum welds. It was also determined that the vapor

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MDC G4298	Detection of Lack of Fusion Using Opaque Additives	J. L. Cook	Oct. 1972
MDC G4538	Detection of Lack of Fusion Using Opaque Additives (Final report)	J. L. Cook	May 1973

First Benefiting Project: Space Shuttle - All programs requiring weld inspection.

deposited copper plating used as the opaque additive protected the surface cleanliness of the aluminum for periods up to 60 days. No detrimental effects on weld strength, due to the opaque additive, were noted in the study. However, the metallurgical studies conducted on weld specimens by the contractor were very limited. Additional metallurgical studies have been performed in-house to more completely characterize weld microstructures containing the copper additives.

Management Progress: The contractual phase of this study has been completed. In-house metallurgical studies have been completed as has in-house evaluation of the enhancement of detection utilizing Ultrasonic Inspection techniques. The summary report on the in-house studies was prepared in draft form and submitted to Dr. Haeussermann (S&E review coordinator) for subsequent transmittal to Dr. Lucas. Further action is contingent upon Dr. Lucas' recommendation. The formal preparation and release of the summary report is likewise pending.

Conclusions: The opaque additives provide protection to maintain surface cleanliness and highly enhance detectability of LOF type defects. However, no plating process exists which would allow application of this inspection aid on an economical production basis.

PROBLEMS: This program did not evolve an economical production type plating process.

FORECAST: Final Report by June 1, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-08	908-52-08

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL	TELEPHONE:	APPROVAL:
S&E-AERO-DDD, Stephen W. Winder	205 - 453-2521	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Advanced Control Concepts
Contract Number NAS8-29193; Northrop Services, Inc., Huntsville, Alabama

OBJECTIVE(S): The planned generation of Space Shuttle vehicles pose several challenging control problems over its operational range. In particular, the ascent phase of flight is one area in which new problems arise. In ascent, the mated configuration has only one plane of symmetry causing the inherent problem of zero lift and zero moment occurring at different angles of attack. Cross-coupling problems are also severe in some candidate designs.

The parallel burn configuration currently being considered has insufficient control authority in its orbiter engines to control headwinds or crosswinds unless the aerodynamic surfaces on the orbiter and/or the solid rocket motors are used. When these additional control effectors are used, the number of control effectors becomes greater than the number of states to control. Hence, the way to blend these effectors to produce the proper control forces and moments will have to be determined from an infinity of possible solutions. One way to approach the problem is to determine the blending of the control effectors to produce a trim solution of zero forces and moments acting on the vehicle.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
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FIRST BENEFITTING PROGRAM: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-52-08 PAGE 2 OF 4

PROACH: The solution to the trim problem does not yield a unique set of trim nditions. The proposed approach is to include in the equations defining trim, the nalty functions that arise from hinge moment contraints, thrust losses and similar nstraints, and then solve the trim problem for the optimum trim condition. This ocedure will result in an algebraic optimization problem that will select the trim int.

luable insight can be gained by first solving for the trim boundaries that are de-ined by the trim equations and the control limits without penalty function consider-tions.

e proposed technical approach is divided into three tasks:

o Task 1 will be technology development and consist of three phases:

* Phase I will formulate constraints and limits for the control deflections n a performance index suitable for analysis.

* Phase II will involve solving the trim problem without "hard" limits on he control deflections. In addition the trim boundaries will be established.

*Phase III will be an extension of Phase II procedures to include erformance indices that cannot be handled analytically. "Hard" limits on the control eflections will be considered as an integral part of the problem and its solution.

o Task 2 will involve solving a sample Shuttle problem to illustrate the echniques developed under Task 1 above and will run concurrently with the studies f Task 2.

o Task 3 will assess the dynamic responses as influenced by the chosen trim olution.

he completion of the above tasks will yield computational algorithms capable of stablishing the trim solutions (or any specified desired state) for several types of erformance indices that include hard constraints. Computer programs necessary to emonstrate the ability of the algorithms will be developed.

STATUS:
Technical Progress--All phases of the program have been completed. The sample problem considered in Task 2 was the Rockwell International RI 049 configuration during ascent through the first ninety seconds of flight. For study purposes, the configuration was assumed to have thrust vector control (TVC) on the solid rocket booster (SRBs). The dynamic response study was changed somewhat to allow more flexibility for the technique that was developed. The RI control system was used to generate force and moment commands. These commands were distributed to the various control effectors by the methods developed in the contract. The trim solution was used to gain insight on how

STATUS (CONCLUDED):
to develop and apply the concept but the dynamic study actually allowed the concept to be used to generate the actuator commands.

Management Progress--An oral presentation was made by the contractor on January 15, 1974, that summarized the results of the effort.

Conclusions--The techniques developed in this study do provide investigative tools which allow an assessment of the control authority/performance interaction. Some specific observations that may be made are:

1. The Simplex based algorithm works for general problems. The cost function may be of any form as long as it is piecewise differentiable. The algorithm considers the variables' bounds explicitly in the solution.

2. The algorithm is most effective where there is adequate surplus trim power to give flexibility to the solution.

3. The algorithm can be used to solve problems such as "optimally" trimming the Shuttle ascent vehicle or the orbiter in reentry. ("Optimal" trim means approximately the optimal trim solution with respect to a particular cost function.) It is also useful in obtaining a feel for the trim range and an insight into the basis of signal splitting schemes on the conventional Shuttle ascent control systems. The algorithm may be used in flight if sufficient digital computer speed is available.

4. The dynamic survey performed on the RI configuration showed the Simplex control scheme to be close to the results obtained from the RI control scheme. The Simplex scheme saved about 10 percent of the thrust-drag losses compared with the RI control scheme.

Problem--None

Forcasts--None

Publications--A final report has been submitted by the contractor. Copies are available from the contract C.O.R.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-08	908-52-08

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Paul T. Golley S&E-ASTR-GM	205-453-5755	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Actuator-to-Digital Interface Units
NAS8-26755 Electronic Communications, Inc.

OBJECTIVE: To develop a suitable interface between the Shuttle data bus and two types of redundant hydraulic servo actuators. One type is double fail-operate "look and switch"; the other is a single fail-operate majority vote.

APPROACH: In-house investigation led to the conclusions that the most reasonable way to perform the interface between the basically analogue actuator and the quad-redundant data bus was through an electronic interface unit. These units are to be designed to provide the following functions: to perform actuator redundancy management, self-test; to report redundancy status; to decode incoming information and encode return information; and to perform the necessary D/A and A/D conversions and analogue signal amplification. Separate designs will be required for the "look and switch" and "majority vote" actuators.

STATUS: Technical Progress - Both the majority vote and the "look and switch" units have been delivered, and the contracted effort is complete. This will be the final report on this task.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report:	"Final Report for Actuator Digital Interface Unit (AIU)", dated October 1973, Electronic Communications, Inc., 1501 72nd Street N, St. Petersburg, FL 33733		

FIRST BENEFITTING PROGRAM: Space Shuttle

MSFC - Form 360 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-08	908-52-08

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DDD, Stephen W. Winder	205 - 453-2521	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Advanced Control Concepts
NAS8-29192, The Singer Company, Kearfott Division, Little Falls, New Jersey

OBJECTIVE(S): Because of the possible launch configurations required to boost a Space Shuttle into orbit, it is anticipated that a large number of control effectors, including both aerodynamic surfaces and gimballed rocket engines, will be required to control the vehicle during ascent through the atmosphere. One objective in controlling the vehicle is to determine the deflection angle settings of the control effectors required to trim the vehicle for headwind and sidewind disturbances. Because of the launch configuration and the large number of controls, the control engineer is faced with two challenging problems. First, to compute the trim solution may entail solving a system of coupled, nonlinear equations. Second, if the number of control variables exceeds the number of independent trim equations to be satisfied, then the trim solution is not unique.

APPROACH: To solve the uniqueness problem, additional constraints must be imposed. A logical choice for the additional constraints is the minimization of a performance criterion that penalizes the degradation in vehicle performance caused by large trim deflection angles. The performance criterion proposed for the investigation penalizes the following effects:

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-08	908-52-08

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REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRST BENEFITTING PROJECT: Space Shuttle

STATUS (CONTINUED):

Conclusions--The investigations of this contract were directed to find tools and techniques that could be used in the design and analysis of Shuttle control systems. As a result, several of the ideas resulting from this effort, although promising, have not been fully explored as to their utility to the Shuttle control problem. We hope that future in-house effort will refine and clarify these concepts.

Solutions to the trim problem can be efficiently calculated using numerical methods to solve the trim problem of Phase I. The results of this investigation indicate that numerical solution by the Newton-Raphson method is preferable to the steepest descent method because it yields faster convergence and does not require the user to specify an iteration step size. If the initial guess of the solution used to start the Newton-Raphson method is not in the region of convergence then the method may not converge or may converge to the wrong solution. In this case, the steepest descent method should be used for the first few iterations to generate a good starting solution to the Newton-Raphson method. This hybrid method could be implemented in the computer program with minor modifications. However, it appears that for most practical trim problems an initial guess of $\delta = 0$ is always in the region of convergence.

Only the steady-state performance of the control system for bias inputs is considered in the trim calculation. The dynamic or transient response of the controls for fluctuating inputs must also be considered in the overall system design. For the nonlinear trim problem, an integral E proportional to the control energy is defined and is computed using the controllability Grammian W. A measure for selecting the trim solution is given by the value of E. If the trim problem is linear, then the value of the controllability index or E does not vary with the trim solution.

The basic question in studying the dynamic response problem is: "What is the maximum deflection of each control for the possible fluctations in the disturbance inputs?" One possible approach to the dynamic response problem is to examine the values of E_i, where E_i denotes the energy expended by the ith control to return the vehicle to trim. The values E_i can be readily computed from the controllability Grammain W. Although this approach has potential in gaining insight into dynamic response problem, it possesses two major limitations. First, there is no simple relationship between the energy E_i and the maximum value of the transient response curve showing the variation in the control deflection angle with time. Second, the control signal corresponding to E_i cannot be realized by a linear feedback control system. However, the approach does yield a consistant measure upon which to relate trim solutions to dynamic responses.

The most realistic method and possibly the only practical method for studying the dynamic response problem is to design the control system and simulate the closed-loop performance. The application of optimum control theory provides a method for the design of a linear feedback control system that can solve both the trim problem and the dynamic response problem. A correlation between the trim solution and the optimum control solution has been derived and indicates how the solution to the trim problem can be used to select the proper control weighting in performance criterion of the optimum control approach. This saves design time since the trim problem is easier to

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-52-08 PAGE 4 OF 5

STATUS (CONCLUDED):

solve and also lends more insight into the problem.

Problem--None

Forcasts--None

Publications--A final report has been submitted by the contractor. Copies are available from the contract C.O.R.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 908-52-10	PRIOR NO.: 908-52-10

4. TITLE:

Guidance and Navigation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. R. Kissel - S&E-ASTR-GDA	453-4276	R. H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Strapdown System Development and Field Test
NAS8-27335 TRW, Inc.

OBJECTIVE(S): To develop concepts for checkout, failure detection, failure isolation and correction, and redundancy management in a redundant sensor strapdown system.

APPROACH: Residual hardware was used to assemble a prototype redundant (dodecahedron) sensor strapdown system. This system will be used to test the redundancy management concepts and demonstrate the failure detection and isolation schemes. Testing includes van tests, rate tests and g-sensitive drift tests. Demonstration occurs when the concepts are being tested.

STATUS: Technical Progress--The strapdown system is operational and functioning satisfactorily with its test console. Preliminary work was started on debugging the calibration and navigation computer programs. The system is now inactive. The TRW study has been completed and a final report published on schedule.

Management Progress--The TRW contract was concluded on schedule.

Conclusions--Two of the seven simulated FDIC methods were consistently better performers than the rest. These were the minimax and the squared error methods, both products of MIT personnel.

Problems--Due to reduced in-house contractor support and other higher priority programs, all tests have been suspended. Also the software development work in-house has been suspended. All remaining FY73 funds were expended on the TRW contract.

Forecast--Complete software development to perform navigation (SEE PAGE 2)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
18313-6004-RU-00	Competitive Evaluation of Failure Detection algorithms for Strapdown Redundant Inertial Instruments.	James Wilcox	April 1973

FIRST BENEFITING PROJECT: Shuttle

and calibration routines and also incorporate the most desirable FDIC scheme from the TRW study effort.

Perform laboratory and field tests on the completed system and analyze the test data.

Publications--"Competitive Evaluation of Failure Detection Algorithms for Strapdown Redundant Inertial Instruments." Final Report, April 1973. TRW Report No. 18313-6004-RU-00.

Remarks--The results of the TRW work were presented by TRW at the AIAA Guidance and Control Conference held in Key Biscayne, Florida on Aug. 20, 1973.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: Marshall Space Flight Center	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 908-52-37	PRIOR NO.: 976-30-37

4. TITLE:

CRYOGENICS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George M. Young	453-3854	A. L. Worlund

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Zero-G Fluid Retention and Expulsion

CONTRACT: NAS8-27685, McDonnell Douglas/Western Division

OBJECTIVES: The objectives of this task include study and definition of an acquisition system for supplying LH_2 and LO_2 under in-orbit conditions. To provide specifics for the study, the following two design reference missions were identified: (a) cryogenic auxiliary propulsion system (APS) and (b) main propulsion for an Advanced Spacecraft Propulsion Module (ASPM). The ASPM requirements are representative of a vehicle such as the Space Tug. This effort concentrates on concepts that utilize the favorable surface tension characteristics of fine-mesh screens and will significantly advance cryogenic acquisition technology in general. The anticipated analytical and experimental results will provide a sound technology base for the subsequent design of cryogen supply subsystems for future space vehicles.

APPROACH: Phase I establishes parameters and component problem areas that should control acquisition system design and includes trade studies of variables influencing acquisition system design and interfaces with other systems. Phase II provides a design to meet each of the reference missions. Bench tests necessary to the design phase will be conducted. Based on these two designs, a ground test article(s) will be designed to demonstrate operational principles and hardware fabrication. Phase III will consist of fabrication of the test article(s) designed in Phase II. Phase IV will consist of supplementary studies and bench tests which are desirable to support the designs generated or to evaluate potential problem areas associated with the design.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MDC-G2562	"Study and Design of a Cryogenic Propellant Acquisition System" First Quarterly Report	G. W. Burge/P. L. Klevatt	Oct 15, 1971
MDC-G2743	Second Quarterly Report	G. W. Burge/P. L. Klevatt	Jan 15, 1972
MDC-G2940	Third Quarterly Report	G. W. Burge/P. L. Klevatt	Apr 15, 1972
MDC-G3695	Fourth Quarterly Report	G. W. Burge/J. B. Blackmon	July 15, 1972
MDC-G4271	Fifth Quarterly Report	G. W. Burge/J. B. Blackmon	Oct 15, 1972
MDC-G4354	Sixth Quarterly Report	G. W. Burge/J. B. Blackmon	Jan 15, 1973
MDC-G5038	Final Report	G. W. Burge/J. B. Blackmon	To Be Published

FIRST BENEFITING PROJECT: SPACE TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-52-37 PAGE 2 OF 3

STATUS: Technical Progress: The technical efforts under this contract are complete. Test articles have been fabricated and delivered to MSFC.

Management Progress: Final presentation and approval of contract results are scheduled for last week of March 1974.

Conclusions: A number of important overall conclusions resulted from the in-depth study of surface tension acquisition/expulsion systems conducted under this study.

1. Practical screen surface tension acquisition devices can be designed and built to satisfy a broad range of applications for cryogenic storage and transfer systems. These systems are relatively low in weight and can be designed using present technology to satisfy potential failure modes without relying on extensive in-orbit experimentation.

2. In order to arrive at valid acquisition concept selections, the evaluation must be conducted on an overall feed system basis. Each particular acquisition concept places constraints on other interfacing subsystems, such as pressurization and thermal management, which influences their overall design and optimization.

3. For a system with a limited number of defined expulsion steps, a liquid settling approach (using an auxiliary thruster) may be weight competitive with a surface tension acquisition system. This, however, reduces system flexibility.

4. In order to further optimize and improve surface tension acquisition system design, additional research is required to improve qualitative and quantitative understanding of the influence of environmental conditions on surface tension device behavior and performance including pressurant gas heating, feed system vibration and feed system flow dynamics. Techniques are currently available for designing around potential problems in these areas, but this generally results in weight penalties and operational constraints that could be relieved with improved understanding.

Problems: No significant problems.

Cause of Problem: N/A

Problem Solution: N/A

Forecast: Final approval of contract efforts and reports in April 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 908-52-37	PRIOR NO.:
4. TITLE: Cryogenics			
5. RESPONSIBLE INDIVIDUAL: Kenneth G. Anthony	TELEPHONE: 453-5701	APPROVAL: G. A. Kroll	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Long-Life Valve Design Concepts
NAS8-28518 Fairchild Industries, Stratos Division
Manhattan Beach, CA

OBJECTIVE: The purpose of this program is to develop fluid control component designs for use under conditions where long-life and ability to withstand extreme environments are requirements. Operating life of 10 years with temperature extremes of +200° F to -423° F are the design goals.

APPROACH: Areas to be considered are analysis to determine vulnerable subassemblies establishment of design criteria to preclude vulnerability, conceptual design of subassemblies, and breadboard development verification testing to confirm design criteria.

The effort shall consist of the following tasks:

a. Analysis and design criteria preparation
b. Conceptual design
c. Manufacture and perform breadboard testing
d. Confirm and publish design criteria

STATUS: Manufacturing was completed & testing began October 1.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Reports	Progress Reports	J. R. Jones	Monthly

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-37	

4. TITLE:

Cryogenics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
ASTN L. M. Thompson	3-1222	R. J. Schwinghamer

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: "Design and Development of Polyphenylene Oxide Foam as a Reusable Internal Insulation for LH_2 Tanks", NAS8-27566 with General Dynamics Corporation/Convair Division.

OBJECTIVE(S): To develop information on polyphenylene oxide (PPO) foam and other materials required for a minimum weight internal insulation system usable in LH_2 tanks to a maximum outer surface temperature of 350°F. This effort, shall define a preferred lightweight PPO foam internal insulation system that will not be adversely affected by launch, flight, reentry, and landing, and will be reusable for up to 100 flights with minimum refurbishment.

APPROACH: To meet the objectives the following 13 task areas shall be performed: (a) effect of thermal cycling on mechanical properties and dimensional and weight stability; (b) materials and process specifications; (c) tank surface preparation; (d) methods for close-outs; (e) fabrication techniques for PPO foam; (f) techniques for making joints; (g) repair procedures; (h) techniques for surface rigidization; (i) physical properties thermal correlation; (j) geometric properties of foam. The following 3 task areas were added in Modification No. 1: (k) configuration screening on PPO foam samples;(l) properties of two additional PPO foam configuration and (m) fabrication and evaluation of close-out design.

STATUS: Technical Progress--All necessary physical properties of 72 PPO foam panels have been determined. Close-out adhesives have been evaluated and repair techniques are about 90% complete. Substrate preparation procedures are under study. A

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

REPORTS: 26 Monthly and 3 Phase reports have been issued.

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 908-52-37

PAGE 2 OF 2

STATUS (CONCLUDED): 100 inch test tank internally insulated with the PPO foam has sucessfully passed 100 fill and drain cycles using liquid hydrogen on a NASA Houston contract. A no cost contract extension to March 31, 1974 was necessary in order to test new PPO samples made in a Pilot Plant facility by an automated process. These sample were originally scheduled for delivery in February 1973 and are December 1973. The supplier has experienced many problems with mixing,extruding and curing the samples in this new facility.

Management Progress--N/A

Conclusions--All available test results indicated that PPO foam is an acceptable material for certain tank insulations. All test data were obtained for internal use in liquid hydrogen.

Problem--Pilot Plant scale-up problems have caused an unavoidable delay in finishing this contract. These are hopefully being resolved.

Causes of Problems--The scale-up involved in going to a batch process to a pilot plant operation.

Suggested Solutions--Contract was extended to March 1974 to allow supplier time for problem solution.

Forecast-Projected completion date is now June 30, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 908-52-37	PRIOR NO.: 908-52-37

TITLE: Cryogenics

RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. A. Hein	453-5706	G. A. Kroll

ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract NAS8-27504, Convair Division, Gen. Dynamics, San Diego, CA

TASK: Vacuum Jacketed Ducting Technology Investigation

OBJECTIVES: Improved vacuum jacketed ducting for space environment at liquid hydrogen temperature to provide minimum heat transfer, weight, and space envelope for 100 missions at 4 1/2 minutes per mission.

APPROACH: Two duct systems to be fabricated and tested: one state-of-the-art and one advanced design duct system for comparative testing. Conduct structural analysis-investigate effect of thickness on strength and thermal stresses in core materials; investigate heat cure adhesives at cryogenic operating temperatures to determine residual stresses between cure and operating temperatures; investigate the use of pot ting compound for stiffening the honeycomb end structures.

STATUS: Tests complete on (4) core thicknesses, from 0.25-0.40 inch, data relative to stress and critical buckling pressures given for each core thickness; tests complete on (2) adhesives, room cure Crest 7343 and high temp. cure (350° F) HT424, comparative data listing shear, tension and compression stresses given in table and curve form. Schedule is modified due to late delivery of duct test specimen from Arrowhead. The last test specimen is to be delivered 6-30-74. Testing and final report to be complete 9-30-74.

REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
Monthly/Quarterly Reports	"Vacuum Jacketed Ducting Technology Investigation"	K. Leonhard, Gen. Dynamics, San Diego, CA	Jun 1971 Feb 1974
Interim Report CASD-NAS 73-002	"	"	Jun 1973

First Benefiting Project: Shuttle Feedlines

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-37	

4. TITLE:

Cryogenics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. B. Wynn	453-3922	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Life Test Methodology
NAS8-27438 Battelle Memorial Institute, Columbus, Ohio

OBJECTIVE(S): Develop a methodology that permits ultimate component life assessment and/or verification for long-life Space Shuttle application.

APPROACH: Literature survey, establish environments imposed by extended space missions and determine environments affecting long-life components, establish most critical failure areas and determine wear and creep characteristics. Establish accelerated test program. Verify accelerated test program.

STATUS: Contract awarded on June 25, 1971, to Battelle Memorial Institute. Propulsion components and literature have been reviewed. Earth and orbital environments established. Analyze aging on propulsion mechanical component. Creep and wear on nonmetallic parts are life limiting. Developed tests to determine wear and creeps characteristics. During next 6 months, perform tests to prove the long-life of the components and provide final report.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
Interim Report	Development of Life-Test Methodology for Long-Life Mechanical Components Phase I: Development of Methodology	D. B. Hamilton et. al.	July 31, 1973

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 908-52-39	PRIOR NO.: 908-52-39

4. TITLE:

Aerothermodynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AT Homer B. Wilson, Jr.	205-453-1163	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Aerodynamic Astronautical Heating Tests for Advanced Saturn Configurations
NAS8-27090, Calspan Corporation
P. O. Box 235
Buffalo, New York 14221

OBJECTIVE(S): To develop new and improved capability for conducting short-duration Space Shuttle base heating tests. New instrumentation and methods of measuring heating rate are desired and an improved simulation of the orbiter engines and external flow will be required for the Space Shuttle.

APPROACH: New instrumentation capable of measuring gas temperature and other flow properties will be selected and evaluated by tests in typical base heating flow conditions. External flow simulation will be improved by extending the pressure temperature and Mach number range of the present facility.

STATUS: - Technical Progress - A hot wire resistance thermometer has been found through analyses to be potentially capable of measuring base gas temperature. Tests are planned to further prove this technique. The external flow facility has been modified to provide longer flow times (up to one-tenth second) and an external flow temperature up to 600 ^{o}F. Two new nozzles providing test section Mach numbers of 3.5 and 4.5 have been designed. These nozzles have been fabricated with funds provided by the Shuttle program. All of the results of this contract are being used in the Shuttle launch vehicle base heating tests currently being conducted by Rockwell International.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-52-39 PAGE 2 OF 3

STATUS (CONCLUDED)

Management Progress - This contract was modified September 13, 1973, to provide $47.7 K for nozzle fabrication.

Conclusions - None

Problems - None

Forecast - None

Publications - None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-52-39	908-52-39

4. TITLE:

Aerothermodynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AAE Paul E. Ramsey	205-453-2519	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASKS: Aerodynamic of the Space Shuttle Booster

H-74005A: Naval Ship Research and Development Center, Washington, D. C. 20034

NAS8-26701: Wind Tunnel Testing on Space Shuttle Configuration, Calspan Corporation, Buffalo, N. Y.

OBJECTIVE: Provide experimental, wind tunnel static stability, drag, and control test data to support aerodynamic studies of Space Shuttle concepts in the subsonic/transonic regimes. The major study area of interest are launch vehicle ascent, booster reentry, and rage safety aerodynamics. Data obtained will be utilized to provide solutions to Space Shuttle aerodynamic problems which will enable efficient design of launch and booster configurations. Specific problems are: (1) Launch vehicle performance optimization while maintaining acceptable stability and control margins during ascent, orbiter position on booster, effectiveness of aerodynamic control during launch, geometrical shaping such as nose cone configuration and booster length to diameter ratio, drag reduction, booster and orbiter engine plume effects, booster engine locations, Reynolds number effects on static stability and control effectiveness, and interference loads on the launch vehicle components. (2) Booster reentry aerodynamics needed for recovery of booster components and high alpha aerodynamics for range safety.

APPROACH: The current Rockwell orbiter, external tank, and parallel burn SRB booster will be used as the baseline configuration. The above problem areas will be studied experimentally in facilities supplied under contracts listed above on large scale

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
HREC-6370-1 LMSC/HREC D225587	Interim Results of Parametric Studies of Space Shuttle Booster and Orbiter Concepts	Dale Bradley	May 4, 1972
HREC-6370-2 LMSC/HREC TR D306346	Summary of Results of Parametric Studies of Space Shuttle Booster, Orbiter, & Launch Vehicle Concepts	Dale Bradley Robert E. Buchholz	N/A

FIRST BENEFITING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-52-39 PAGE 2 OF 3

APPROACH (CONCLUDED):
models supplied by MSFC. Both pressure and force tests will be conducted to obtain loads and static stability data. Also, development, design and fabrication efforts will be supplied to support the experimental studies in the CAL 8-foot Transonic and NSRDC 7 x 10-foot Transonic facilities and other NASA facilities such as the MSFC 14-inch TWT and the Ames Unitary Plan Tunnels.

STATUS:

Technical Progress - All Shuttle investigations conducted to date in the Calspan and NSRDC facilities have been documented and the results summarized in the first two reports listed above. Several tests were conducted in the NSRDC and CAL facilities during the duration of this RTOP to study configuration geometry, engine location effects on static stability, control effectiveness, drag reduction and engine plume effects on a Shuttle booster. The results of these test programs are too extensive to mention here, but are discussed in past RTOP reports and above listed reports.

The major effort at Calspan during this report period was the development, fabrication and checkout of small solid rocket motors for use in a hot engine plume test in the MSFC 14-inch TWT. This test investigated the feasibility of simulating the Shuttle SRM motors in a wind tunnel which will provide the information needed for aerodynamic testing of Shuttle configurations with engine exhaust effects.

Plans to conduct large scale force and pressure tests on the latest SRB configuration at high alpha for reentry and recovery analysis have been delayed until small scale tests in the MSFC 14-inch TWT are completed and the configuration evolution becomes relatively stable.

Management Progress - Part of the effort during this report period was funded under cost code 976-10-00.

Problems - Because of the procurement lead time of test model hardware for large wind tunnels and rapid Shuttle configuration changes, it has been difficult to form firm plans for conducting tests in the above facilities.

Causes of Problems - Long procurement time for large wind tunnel models and Shuttle configuration not yet stable.

Suggested Solutions - None

Forecast - None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-54-05	908-54-05

4. TITLE:

ELECTRICAL POWER

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
W.J. Robinson, S&E-SSL-SG	453-0029	W. H. Sieber

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): The objective of this program is to develop technology for transmission of electrical power over microwave and laser links through the feasibility phase and to investigate the practicality of transmitting power over microwave and laser beams between earth-orbiting satellites. The distances contemplated are 1 to 2 km, and the power levels are in the vicinity of 2 kw. Later the power level is expected to increase to the 50- to 100kw range if the nuclear reactor must be separated from the base station. The important parameters for use in planning earth orbital scientific programs are efficiency, distances, and power levels.

Background - The feasibility study of wireless power transmission at MSFC began in 1967 as a result of a need to transfer some 2 kw of electrical power between earth-orbiting satellites. A wireless power transmission system has a transmitter, beam-forming device, and a receiving device which captures the electromagnetic energy and converts it to dc power.

NASA technical memorandum report #53806 entitled "The Feasibility of Wireless Power Transmission for an Orbiting Astronomical Station" was published May 27, 1969, and is a report of the development of microwave and laser components which may be applicable to wireless power transmission systems. The investigation showed that component development in the microwave wavelength region was well ahead of that in the laser region. For example, transmitting devices in the microwave region were capable of some 400 kw of output, whereas devices developed in the laser region were capable of only about 10 kw output. Components for conversion of microwave and laser to dc electrical power were very poor in the microwave and nonexistent in the laser region.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
PT-2931	Free-Space Microwave Power Transmission Study, Phase I	W. C. Brown	June 1970
PT-3539	Free-Space Microwave Power Transmission Study, Phase II	W. C. Brown	Sept 1972

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 908-54-05 PAGE 2 OF 3

Background – Continued

A contract with Raytheon Company (Mr. W. C. Brown, Principal Investigator) was let in December 1969 to study the problem areas and improvements needed in microwave power transmission components.

In November 1970 a performance demonstration of a system using "off-the-shelf" components resulted in some 18% efficiency from a source of 60 Hz, 120V ac to the receiving antenna load. A performance demonstration is scheduled for May 1974 to show the results of the study effort over the past three years, and a system efficiency of some 50% is expected.

The in-house effort consisted of construction of three large receiving antennas for operation on the Astrionics Antenna Range to determine efficiency and power levels as a function of distance between transmitting antenna and receiving antenna. This effort is expected to be completed by May 1974.

APPROACH: The demonstration is scheduled at MSFC in May 1974 to show the results of the NASA-Raytheon joint effort in this program since 1969. The major improvement has been in the receiving subsystem efficiency.

System components in addition to receiving components of better efficiency have been assembled or purchased by the contractor for the demonstration. The system components will be shipped to MSFC and assembled in Building 4481. The system demonstration is expected to attain an overall efficiency of about 50%.The system efficiency value and other pertinent data will be published in a final report for distribution.

In-House Effort - This effort will utilize the three large receiving antennas which were built for range operation. A 5-kw, 2.45-GHz transmitter is being used as the microwave power source on the Astrionics Range to determine efficiency and power levels possible at given distances up to 120 meters. The results of the range tests will be included in the final report.

STATUS: All in-house activity is taking place on the Astrionics Antenna Range. Measurements are being made at distances from 15 meters to 120 meters.

The Raytheon contractor is assembling the equipment prior to shipment to MSFC for use in the second demonstration.

REMARKS: Because the extended program to build a 50-kw receiving antenna at MSFC has been transferred to another NASA Center, copies of all records and equipment built at MSFC should be transferred to the responsible NASA Center with the exception of the first receiving antenna, which should be offered to our space museum.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-54-08	

4. TITLE:

Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. M. Seltzer, S&E-ASTR-A	453-4713	Hans H. Hosenthien

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Univ. of California Office of Extramural Support, Los Angeles, CA, NAS8-28358.

OBJECTIVE:

To establish criteria for observability, controllability, stability, and performance of nonrigid spacecraft with active control systems having sensors and/or actuators attached to elastic portions of the vehicle.

APPROACH:

To begin with explicit determination of the desired criteria for relatively simple idealizations of flexible spacecraft, and proceed when possible to generic conclusions.

STATUS:

1. Literal criteria have been developed for the controllability and observability of general models of flexible spacecraft. Results are interpreted in special cases and in physical terms, permitting in some cases the identification of uncontrollable and unobservable states simply by examination of scalars composed of modal parameters and location matrices for sensors and actuators. A procedure has been established for isolation of uncontrollable states, whereby sensor and actuator configurations assure that uncontrollable flexible mode states are also unobservable; in many applications such states can then be removed by coordinate turncation.

2. Necessary and sufficient conditions have been established for the commutativity of matrix inversion involved in certain coordinate transformations and the coordinate truncations

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report UCLA-ENG-7413	Attitude Control Concepts for Precision-Pointing Nonrigid Spacecraft	Peter W. Likins	Feb. 1974

FIRST BENEFITTING PROJECT: LST

MSFC - Form 350 (March 1973)

that are essential to practical structural dynamics. Computational constraints demand that truncations precede the generation of explicit transformed equations, while mathematical arguments imply the opposite sequence. Results jeopardize the utility of two of the three transformation procedures considered here for rotating flexible bodies.

3. Modal analyses have been performed for the transverse vibrations of a uniform Euler-Bernoulli beam, rotating about an axis orthogonal to the beam. Results are obtained for a cantilever beam emanating radially from a base which is rotating but not translating in inertial space, and for a beam with built-in ends spanning the diameter of a ring which is rotating about its inertially fixed symmetry axis. The equations are formulated in terms of a small parameter ϵ which is proportional to beam stiffness and inversely related to mass density, length, rotation rate, and the pretension of the diametral beam. The resulting singular perturbation problem has been analyzed by the method of matched asymptotic expansions, employing asymptotic expansions for the central region and for boundary layers at either end.

4. General - purpose simulation equations for arbitrary spacecraft are under development In conjunction with this effort is the evaluation of the influence of sensor and actuator location on flexible spacecraft performance and the preliminary evaluation of the concept of a disturbance-insensitive control system.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	908-54-08	

4. TITLE:
Stabilization and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. M. Seltzer, S&E-ASTR-A	453-4713	Hans H. Hosenthien

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities): Univ. of Santa Clara, CA, NAS8-27799.

OBJECTIVE:

Develop and apply multilevel methods for the analysis and design of complex attitude control systems.

APPROACH:

The purpose of the research is to investigate stability of the spinning Skylab control system by the modern decomposition-aggregation methods. Such an investigation is motivated by the fact that the mathematical model of the system is exceedingly complex and a straightforward analysis would become bogged down in the welter of detail requiring an excessive computer storage and time to complete the investigation. The multilevel decomposition-aggregation approach offers to solve the stability problems "piece-by-piece" and not only make more economical the computer use, but also reduce the liability of the errors in the analysis. Furthermore, by decomposing the system into parts that have important physical meaning, the decomposition-aggregation approach yields significant structural information about the behavior of the system, which is not generally available in a straightforward stability investigation.

STATUS:

The decomposition-aggregation stability method has been further developed to determine the conditions on system parameters which permit decomposition to be used. To reduce the well known inherent conservative characteristics yielded by Liapunov functions, an optimization problem has been formulated and resolved producing an optimum comparison system. This

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR-2196	Decomposition-Aggregation Stability Analysis	D. D. Siljak S. Weissenberger S. M. Cuk	Nov. 73
Proceedings of the Seventh Asilomar Conf.; Pacific Grove, Calif., 27-29 Mar. 73	Decomposition-Aggregation of the Spinning Skylab	S. M. Cuk D.D. Siljak	Nov. 27-29, 73

FIRST BENEFITTING PROJECT: LST

MSFC - Form 350 (March 1973)

system provides the best estimate of the stability region of the important parameters. In the sample problem, this parameter was an important structural characteristic of an eleventh order system model.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 909-51-02	PRIOR NO.: 908-51-02
4. TITLE: THERMAL CONTROL			
5. RESPONSIBLE INDIVIDUAL: D. Wilkes, S&E-SSL-TR J. Trenkle, S&E-SSL-TR	TELEPHONE: 453-3090	APPROVAL: W. C. Snoddy W. C. Snoddy, S&E-SSL-T	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): (1) Problem - The optical properties of thermal control surfaces have been shown to be altered considerably under the space environments, including solar electromagnetic radiation and thermal vacuum. (2) Application - The thermal control surfaces used on long Shuttle mission payloads will be required to remain stable in their optical properties for up to a 10-year lifetime. This is a stringent requirement because of the harsh vacuum ultraviolet and particulate environment to which they will be subjected as well as the possibility of their being contaminated by the life support and operational functions of the vehicle. (3) Objective - To insure thermal control systems design, design engineers must have available all initial properties data on thermal control surfaces and the changes in these data which will occur during mission lifetime. The objective of this task is to generate the required design data for all candidate thermal control surfaces.

APPROACH: Thermal control surfaces will be tested in the laboratory to establish the effects of the simulated mission-environment on these surfaces. This will include vacuum and solar ultraviolet radiation as well as different types of contamination. The mechanisms of these damaging effects will be pursued so these effects could be minimized by special design, time-lining, orientation, material selection, etc. Accelerated testing rates will be used to provide the required 5-to 10-year tests.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Since the beginning of this task, monthly, quarterly, semi-annually and special reports have been submitted as required.

Since the facility has been finished and testing just begun, no report of results of long-term tests has been generated.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-51-02 PAGE 2 OF 3

STATUS: An in-house testing facility consisting of a clean vacuum system, 5-kw Hg-Xenon solar UV simulator, a 19-sample capacity substrate and manipulator system, and a unique computer-controlled spectroreflectometer has been designed and built. At present, environmental tests are being run and will continue to generate the required design data. When the thermal control problem was encountered upon Skylab deployment, this facility was used on an around-the-clock schedule to test the proposed thermal shield materials that were used in the Skylab "fix".

Problems - It has been difficult to obtain samples of candidate thermal control surfaces for testing. Other sources and agreements with present sources are being pursued to alleviate this problem.

Forecast - The present tests will be continued and mission-related tests (such as the Skylab tests) will be run as required.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-51-02	PRIOR NO.: 909-51-02

4. TITLE:

Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Jack D. Loose	205 453-3824	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Transverse Header Heat Pipe; NAS8-27793, Grumman Aerospace Corporation (Note: This task has previously been titled: "Large Variable Conductance Heat Pipe." The header development is a new task, but an extension of the old contract. Final results under the prior heading were reported in the previous progress report. This and future progress reports will address the Transverse Header task only.)

OBJECTIVES: Develop a new heat pipe configuration for achieving variable conductance heat piping action between a heat source and sink. The transverse header invokes non-condensible gas for varying active condenser length, but substantially shortens the liquid return path. The effort was initiated to circumvent gas blockage degradation of arterial wicking systems in gas loaded heat pipes, a problem which has been reported by several investigators of high performance variable conductance heat pipes.

Goals are to understand and analytically characterize the underlying performance factors of the novel configuration, optimize those factors, and propose practical thermal control applications of the device. This is to be done through test and analysis of experimental hardware.

APPROACH: Work scope has 5 phases:

1. Analysis: Analyze data of previously built and tested Transverse Header Heat Pipe (THHP). (This was tested under contractor inhouse funding in support of the initial task of contract NAS8-27793). Use data to analytically model and optimize THHP performance. Define hardware modifications.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
THPR-1	Monthly Progress Report No.1-Jan. 1974	F. Edelstein	2/6/74
THPR-2	Schedule	F. Edelstein	2/6/74
THPM-1	Transverse Header Experimental Results	F. Edelstein	2/27/74

FIRST BENEFITTING PROJECT: Payloads

MSFC - Form 350 (March 1973)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-51-02

PAGE 2 OF 3

APPROACH: (Continued)

2. Fabrication: Design and fabricate modified hardware.

3. Test: Parametrically test modified hardware.

4. Correlation: Use test data to correlate and refine analytical model of THHP.

5. Applications: Define potential thermal control applications of THHP's and show feasibility and performance by simplified analyses.

STATUS:

Technical Progress: The first test unit was an annulus surrounding a fluid line. It had an I.D. of 1.0" (evaporator), O.D. of 2.0" (condenser), and a 22.3" length. Working fluid was ammonia; control gas was nitrogen. The annulus is divided into inner and outer annuli by a thin baffle. Vapor traverses axially along the inner annulus, then turns at one end passing out and back through the outer annulus. Condensate returns through the baffle via radial wicks. Heat transfer was activated by cooling the exterior diameter below the fluid line temperature.

Data was plotted and evaluated. Evaporator and condenser heat transfer coefficients of 1000 and 3200 BTU/hr-ft^2-^{o}F respectively were measured. Loads over 3000 watts were achieved with the control gas introduced, showing no bubble problems. Vapor temperature control was demonstrated over a 400 - 3000 watt load range. Although these values represent good performance, the data evidenced additional performance was possible through design improvements.

Management Progress: Ten month extension for this task signed October 1, 1973. Total extension cost: $40,545. Work initiation delayed to January 1, 1974, by contractor personnel changes. Review at MSFC held March 14, 1974.

Conclusions: None, other than as reported under Technical Progress.

Problems: Three month slip in work initiation may necessitate extension of contract period.

Forecast: Further analysis and testing will define design parameters for even increased heat transport and temperature control performance.

Remarks: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-51-02	909-51-02

4. TITLE:

Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Kenneth E. McCoy	205 453-3824	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Heat Pipe Thermal Conditioning Panel; NAS8-28639 (MDAC)

OBJECTIVE: Develop a proven design concept and working model of a modular heat pipe thermal conditioning panel that has broad application of spacecraft thermal management.

APPROACH: Contractor shall develop the concept and hardware in five major phases as follows: Phase I - Formulation of Specifications: Investigate applications for panel and develop design/performance specifications for panel to provide maximum utility. Phase 2 - Analysis, Design, and Concepts Section: Develop alternative design concepts, analyze performance; and then select and design in detail optimum concept. Phase 3 - Fabrication: Fabricate selected panel of Phase 2. Phase 4 - Testing: Test panel under simulated application environments to verify analyses and achievement of performance specifications. Phase 5 - Second Panel: Repeat Phase 3 and 4 for a second panel built to the selected design or to a modified or alternative design. Both panels, with drawings, manuals, etc., will be delivered to MSFC for additional inhouse tests.

STATUS:

Technical Progress: During the current reporting period the following tasks were completed; fabrication and testing of first panel, design, fabrication and testing of second panel, and both panels delivered to MSFC.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MDC G 3155	"Quarterly Status Report, Heat Pipe Thermal Conditioning Panel"	J.S. Holmgren	October 1972
MDC G 4406	"	"	March 1973
MDC G 4416	"	E.W. Saaski	June 1973
MDC G 4421	"Heat Pipe Thermal Conditioning Panel," Detailed Technical Report	"	Sept. 1973
MDC G4422	"Heat Pipe Thermal Conditioning Panel," Executive Summary Report	"	" "

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-51-02 PAGE 2 OF 3

STATUS: (Continued)

Management Progress: A one year contract with MDC was signed June 28, 1972, for $68,183. The contract was initially partially funded for only $30,000, which was expended by November 15, 1972. Work was stopped awaiting FY73 funds. The balance of fund became available February 15, 1973 and work was resumed after a 3 month delay. Contract was extended to September 12, 1973 on March 19, 1973 to compensate for time lost waiting on balance of funds. This contract was completed with delivery of the second panel and final report in September 1973.

Conclusions: Preliminary evaluation of design concepts indicate it is possible to use same design in both inhabited and uninhabited areas with only a fluid change. Aluminum/ammonia appears optimum in unpressurized areas and aluminum/acetone may be acceptable. Testing of the first panel revealed an excessive source to sink temperature difference at maximum heat load. Investigation revealed that this was caused by excessive gaps at the heat pipe/face sheet interfaces. Design changes incorporated in the second panel included using a square extrusion for the heat pipe, a higher conductivity bonding agent at the heat pipe/face sheet interface and closer heat pipe spacing. These changes reduced the source to sink temperature difference to less than the design goal of 15°F at 300 watts total load.

Problems: None

Remarks: Since completed, will be discontinued in future URS reports.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-51-02	909-51-02

4. TITLE:

Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Glenn Robinson	205 453-3824	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Deployable Heat Pipe Radiator; NAS8-29905, Grumman Aerospace Corporation

OBJECTIVE: Design and fabricate a heat pipe radiator panel and flexible heat pipe header which has deployment capability and can serve as an experimental research tool for investigating the control characteristics of: (1) variable conductance fin heat pipes used with a fluid loop header or single fluid heat pipe header, and (2) a variable conductance heat pipe header used with single fluid or variable condutance fin heat pipes. Panel to be approximately 4' x 6' and reject a heat load of 200 - 400 watts ar nominally 530°R. Heat pipe header to have minimum length of 7 feet and transport capacity of 400 watts.

APPROACH: The effort is divided into 6 phases:

1. Panel concept: Perform parametric studies to define radiator panel design/performance specifications.
2. Flexible header: Develop flexible variable conductance heat pipe.
3. Design: Perform detailed analysis and engineering design.
4. Fabricate: Fabricate and assemble hardware.
5. Test: Prepare test plans/procedures and perform verification test. Ship hardware to MSFC.
6. Test plan: Prepare thermal vacuum test plan for testing in Government facilities.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
DHPM-1	"Design Requirements - Deployable Heat Pipe Radiator"	J. Alario	February 1974
DHPM-2	"Panel Design Selection, Deployable Heat Pipe Radiator"	J. Alario	February 1974
DHPR-1	"Deployable Heat Pipe Radiator Monthly Progress Report No. 1	Fred Edelstein	Oct. 15, 1973
DHPR-2	"Deployable Heat Pipe Radiator Monthly Progress Report No. 2	Fred Edelstein	Jan. 11, 1974
DHPR-3	"Deployable Heat Pipe Radiator Monthly Progress Report No. 3	Fred Edelstein	Feb. 12, 1974

FIRST BENEFITTING PROJECT: Sortie Lab

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-51-02 PAGE 2 OF 3

STATUS:

Technical Progress: The design requirements have been defined and documented in memorandum DHPM-1. A detail analysis has been completed which details the selection of the basic panel design for the deployable radiator. A memorandum documenting this analysis, DHPM-2, has been published.

Analyses have been performed on the design of the artery for the header heat pipe. These results are being evaluated and recommendations will be made shortly.

Management Progress: CPFF contract signed August 20, 1973, with Grumman Aerospace Corporation for 12-month performance period.

On October 4, 1973, a kickoff meeting was held at MSFC. On March 14, 1974, a meeting was held at MSFC to review and approve concept developed by Grumman.

Conclusions: None

Problems: There has been a small delay in receipt of the flexible section necessary for the deployment section of the heat pipe.

Forecast: Progress as scheduled.

Remarks: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-51-05	See Remarks

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. B. Graff	453-4560	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Objective: To develop design concepts, techniques and criteria in the area of Electrical Power Generation by Solar Arrays.

Approach: This program is being conducted under separate tasks which will be individually summarized and discussed. The following tasks are in work:

- o Space Station Solar Array Development
- o Evaluation of Shallow-Diffused (Violet), High Efficiency Solar Cells

Status: Both tasks are contracted efforts using FY-73 and prior year funding. A status report for each task follows:

Remarks: See individual tasks for those previously reported under other numbers or other remarks.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
See individual Tasks.			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-51-05	908-51-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
W. L. Crabtree	453-4566	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Space Station Solar Array Development

Contract No: NAS8-28432, Lockheed Missile & Space Co.

Objective: Develop a long life, retractable, foldout, solar array using flexible substrates and incorporating modularization. Fabricate modules using standard and "violet" cells with welded interconnects and develop acceptance testing criteria.

Approach: The effort will be accomplished in five phases:

I. Establish materials properties and fabrication processes.
II. Establish design requirements; design and fabricate modules.
III. Environmental test and analysis of modules.
IV. Establishment of acceptance test methodology and criteria.
V. Development of array retraction method.

Status: The second iteration of Phase III involving testing of 14 modules utilizing parallel-gap welding and molybdenum and copper interconnects is considerably behind schedule due to test set-up related fabrication and outgassing problems. Phase IV is slightly behind schedule due to the above problems; however, Phase V is on schedule.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

No Reports other than Monthly Status Reports have been written during this reporting period.

First Benefiting Project: LST/Space Station

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-51-05	PRIOR NO.:

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. B. Graff	453-4567	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Evaluation of Shallow-Diffused (Violet), High-Efficiency Solar Cells

Contract No: NAS8-29872, Centralab Inc.

Objective(s): To procure a quantity of the newly developed shallow-diffused, high-efficiency "violet" solar cells for performance evaluation purposes. During evaluation, emphasis will be placed on conversion efficiency, temperature coefficients (power, voltage, and current), and environmental degradation rate.

To gain knowledge of the general mechanism of the cell production line, especially predictions of yield and performance. To identify changes necessary for mass production, and to predict cost per unit in mass quantities. Also, the contractor's views regarding standardization of cells and/or submodules will be obtained.

Approach: A production line will be established, the cells will be tested for specified performance, and changes necessary for mass production will be identified.

Status: Technical Progress: The initial cell production line has been established and cells are being produced. Minor problem areas are being studied in order to establish a mass production line. Areas of possible cost reduction are being studied.

Management Progress: Contract expiration date has been extended to April 15, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Project: All

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-51-05 PAGE 2 OF 2

Conclusions: None to date.

Problem Areas: Problems have been encountered in the fabrication process in trying to scale up production of violet cells. The major problem encountered has been in maintaining the critical diffusion parameters required for large-scale production. These problems have caused a delay in the production of acceptable cells.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-51-07	PRIOR NO.: 908-51-07

4. TITLE:

Communications

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. O. Lowrey, S&E-ASTR-IR	205-453-1578	W.O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Electronically Steerable Phased Array
NAS8-25847, Texas Instruments

Objective: To develop an electronically steerable microwave phased array that is capable of wideband communications and tracking simultaneously from space vehicles. The array will be capable of beam steering and contain transmit, receive, tracking and directional control of S-band and higher frequency signals. The array will be compatible with space relay satellites and ground receiving and transmitting stations.

Approach: The array design and construction utilizes 100 percent usage of active electronic circuits. Required inputs are d.c. power and data bit stream. Outputs are in the form of data and directional tracking information. The array utilizes 100 percent microwave integrated circuitry, microstrip techniques and integrated logic circuitry. Both in-house design and contractual fabrication and development are utilized. The system utilizes highly reliable, lightweight, high efficiency techniques to achieve a long life operational system.

Status: Technical Progress --- The fabrication assembly and checkout of the 48 single layer, active electronic modules for the S-band phased array was begun during this reporting period. Fabrication and assembly of 75 percent of the modules is now complete. Checkout and phase compensation of each module is now in progress. All modules are expected to be completed and ready for final potting and mechanical sealing early in the next reporting period. (Cont'd)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Airborne Electronically Steerable Phased Array, Final Report of Design Phase, Jan. 29, 1971		
	Antenna Array Efficiency and Efficiency Improvements Through Compensation, Technical Report No. 1		
	Airborne Electronically Steerable Phased Array, July 1972.		
	An Evaluation of Ku Band Phased Array Techniques Applicable to Space - To - Space Communications, Feb. 1974		

FIRST BENEFITING PROJECT: CVT/VENUS PIONEER

MSFC - Form 160 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-51-07 PAGE 2 OF 2

Status: (Cont'd) - The Ku-band phased array techniques study and trade-off evaluation has been completed. Critical areas for Ku-band components development have been defined and a trade study of most critical areas have been ranked according to priority for further study. The most critical area for first development and study is the phase shifter. This is the key item that will or will not permit active electronic modular fabrication and operation of a Ku-band electronically steered phased array.

Design study, development and performance specifications for the Ku-band phased array system are now being prepared. Progress is on schedule in this effort.

Management Progress: The specification and procurement action for the extended period of performance of the contractual effort is now in progress.

Conclusion: The progress during this reporting period is now back on schedule after a slight schedule slippage.

Problems: Fabrication of the module circuitry was delayed during this reporting period due to slow delivery of the ceramic circuit substrate materials. The delay in schedule has been recovered and the progress is now on schedule.

Cause of Problems: Late delivery of materials by the supplier.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-52-39	PRIOR NO.: 908-52-39

4. TITLE:

Aerothermodynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AT John D. Warmbrod	205 453-0170	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Booster Aerodynamics Heating Test Support
NAS8-28115, Remtech, Inc.
2603 Artie Street, Suite 21
Huntsville, Alabama 35805

OBJECTIVE(S): To supplement the Space Shuttle contractor Shuttle aerodynamic heating work in the following important areas: (1) Aerodynamic heating test support, (2) develop rarefied flow regime heating rate correlations, and (3) analytical development and model design research for the MSFC Impulse Base Flow Facility.

APPROACH: Provide engineering support for the formulation and conduction of experimental aerodynamic heating programs. Develop and improve aerodynamic heating prediction methods and conduct research in model design for the MSFC Impulse Base Flow Facility. Collect and correlate rarefied flow heating data to be used for Space Shuttle flight thermal environments.

STATUS: Technical Progress - Developed design curves for chamber properties of gaseous oxygen-hydrogen combustors. Analysis and documentation of the IBFF model data was completed. Calculation of flight thermal environments were made on the Space Shuttle ET using the rarefied flow heating method developed under this contract. Shuttle configuration data in the rarefied flow regime will beanalyzed and correlated in the next reporting period.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITING PROJECT: Space Shuttle

STATUS (CONCLUDED)

Management Progress - None

Conclusions - Heating rates for certain areas on the ET during the ascent portion of the Space Shuttle flight are significantly increased when using the rarefied flow heat transfer method developed under this contract as compared to the conventionally used boundary layer methods.

Problems - None

Causes of Problems - None

Suggested Solutions - None

Forecast - None

Publications - Remtech RTR 008-2, Aeroheating Correlations for Non-Continuum Hypersonic Flight, Dr. Carl Engle.

Remtech RM 008-3, An Investigation of Impulse Base Flow Facility Data, Dr. Carl Engle.

Remtech RM 008-5, MINIVER Computer Program Modifications for Rarefield Flow Aeroheating, Dr. Carl Engle.

Remtech RM 008-6, A Simple Recovery Enthalpy Relation for Hypersonic Flight, Dr. Carl Engle.

Remtech RM 008-7, Synopsis for Thermal Environment Predictions of Two Cavity Regions of External Tank, Dr. Carl Engle.

Remtech RM 008-8, MINIVER Computer Program Modifications for Rarefied Flow Aeroheating, Dr. Carl Engle.

Remtech RM 008-9, Saturn 501 Rarefied Flow Heating Data Review, Dr. Carl Engle.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 5

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-52-39	PRIOR NO.: 909-52-39

4. TITLE:

Aerothermodynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AAE Kenneth L. Blackwell	205-453-2517	W. K. Dahm W. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Two-Phase Flow Field Effects on Space Shuttle Plume Simulation
NAS8-29752, Lockheed Missiles & Space Company, Huntsville, AL

Study of the Aerothermodynamic Characterisitics of Shuttle Vehicles During Staging
NAS8-26801, Lockheed Missiles & Space Company, Huntsville, AL

Space Shuttle Plume Simulation Effect on Aerodynamics
NAS8-29751, REMTECH, Inc., Birmingham, AL

OBJECTIVE: To provide technology for wind tunnel simulation of prototype plume flow field and adjacent flow fields for Space Shuttle type vehicles and determine the best cost effective means for accomplishing test programs where plume interactions are significant during ascent flight.

APPROACH: Results of recent plume simulation analyses and wind tunnel tests indicate more extensive studies are required to investigate plume induced effects on ascent vehicle aerodynamics, orbiter aerodynamic control surface torques, engine hinge torques, vehicle base pressure and local impingement loads. A basic approach has been selected to attack the technology questions surrounding plume simulation requirements. A simple body of revolution was selected as the vehicle for the study to allow broader use of results and to make analysis easier. Areas of investigation will include plume simulation sensitivity to free stream mixing parameters, multiple nozzles, mechanical installation methods, Reynolds number sensitivity and two-phase effects on plume impingement loads. Knowledge gained from these investigations will be used to derive a

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LMSC/HREC TM D306631	Pretest Report for a Plume Technology Test Program in the MSFC 14-inch Trisonic Wind Tunnel	C. Donald Andrews C. E. Cooper	N/A
REMTECH RM 016-1	Pretest Report for a Solid Propellant Plume Aerodynamics Test Program in the MSFC 14 x 14-inch Trisonic Wind Tunnel	John E. Readon Carl D. Engel	N/A

FIRST BENEFITING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-52-39 PAGE 2 OF 5

APPROACH (CONCLUDED): set of simulation parameters for use in defining nozzles and test conditions for wind tunnel test models. This will be accomplished through analytical studies and wind tunnel tests in the MSFC 14-inch TWT and the ARC 6 x 6-foot wind tunnels. Basic plume simulation parameters will be investigated using single phase CF_4 and two-phase hot (products of combustion) "prototypes" and air as the simulant gas.

STATUS: Technical Progress -- A test using solid propellant gas generators has been conducted in the MSFC 14-inch TWT. This test was supported by "Experimental Aerodynamic Studies of Space Shuttle Concepts" of this RTOP providing design and fabrication of the gas generator propellant loads. Analysis of the data from this test and the previous Air/CF_4 tests is in progress. Additional tests have been planned and conducted in the MSFC 14-inch TWT during this period to obtain base pressure data for multiple-nozzle, open-wake jet plume cases. An oral presentation was made to the Space Shuttle program personnel defining preliminary simulation procedures for use in Space Shuttle launch vehicle (SSLV) testing.

Management Progress -- Contracts NAS8-29752 and NAS8-29751 to Lockheed and REMTECH were activated during this period.

Conclusions -- For the range of variables thus far investigated, it appears that a useable cold air simulation can be obtained.

Problems -- Because of vastly different flow field environments which influence vehicle base pressure and forebody aerodynamics additional areas of investigation requiring further study have been identified. Additional tests to acquire data for multiple-nozzle bases with open-wake plumes was started during this reporting period. However, the remaining case, that of two-rocket nozzles separated by a third body (such as exists for ET/SRM of Space Shuttle), will be added to the ARC 6 x 6-foot Air/CF_4 tests in April 1974.

Causes of Problems -- See Problems

Suggested Solutions -- See Problems

Forecast -- Two tests at ARC and one at MSFC will be completed. At this point a plume simulation data base will exist for base pressures encompassing aspiration to flow separation on the body, multinozzle and multibase cases. Analysis will be accomplished to determine simulation required for each of these cases and provided to the Space Shuttle program. The next SSLV test supported by this technology will be conducted June 1974. Updated simulation will be provided for later tests. Two-phase flow impingement tests originally included in this task have been deleted. However, study results will be used to provide a detailed study/test plan to the Space Shuttle program.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-52-39	PRIOR NO.: 909-52-39

4. TITLE:

Aerothermodynamics

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AT John D. Warmbrod	205 453-1157	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Wind Tunnel F Occupancy Time for High Mach Number Shock Interference Test on the Shuttle Orbiter/ET Configuration
NASA Defense Purchase Request Number H-99180A
Arnold Air Force Development Center
Arnold Air Force Station, Tennessee 37389

OBJECTIVE(S): Collect interference heating data on the ET for the Space Shuttle orbiter/ET mated configuration at high Mach numbers and low Reynolds numbers.

APPROACH: Conduct a wind tunnel test program at AEDC VKF tunnel F to collect interference heating data on the ET for simulated ascent conditions. Model heat transfer rates will be measured by slug calorimeters, coaxial surface thermocouples, and by a phosphorescent paint technique. Test results will be obtained on the ET for the orbiter/ET configuration at high Mach numbers (16, 19) and for a Reynolds number range of .05 - .15 million per foot. A pretest report for this test has been documented. The test was conducted January 21 - 30, 1974.

STATUS: Technical Progress - Analysis of the data is underway

Management Progress - None

Conclusions - None

Problems - None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-52-39

STATUS (CONCLUDED)

Causes of Problems - None

Suggested Solutions - None

Forecast - None

Publications - S&E-AERO-AT-73-30, "Pretest Report for Test FH-10," Edwin B. Brewer

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-52-46	908-52-46

4. TITLE:

Physical Standards

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
George H. Fichtl, S&E-AERO-YA	205/453-3168	William W. Vaughan, S&E-AERO-Y

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Assessment of Atmospheric Relationships in Support of Space Shuttle Operations Contract No. NAS8-29764, Texas A&M University, Dept. of Meteorology, College Station, Texas 77843

OBJECTIVE(S): Establish and provide analytical models on the relationships between significant features in the detailed ascent design wind profiles including wind speed and direction changes, wind shear and turbulence relative to the integrated ground and inflight wind to assist in the design trade-off status for Space Shuttle System relative to lift-off and ascent flight.

APPROACH: To establish the phase relationships between ground and inflight wind as a function of specific atmospheric conditions with respect to the operational constraints currently established for the Space Shuttle System.

STATUS: Technical Progress: Efforts during the reporting period were concentrated on the analysis of the tower data received from NSSL. A computer program was prepared to read the data from tape for checking purposes. No problems were encountered and the data were found to be in excellent form.

Management Progress: The contractor and the NASA technical COR have been in contact by telephone conversation relative to the management of the contract. It is anticipated that a contract review will be held at MSFC in the next reporting period.

Conclusions: The following tentative results have been obtained from the NSSL data: (1) No marked trends were observed in the variables over the one-hour period. (2) Considerable variation was found to exist between successive 5-min

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Reports			

FIRST BENEFITTING PROJECT: SRB

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-52-46

PAGE 2 OF 3

STATUS: Conclusions: (Continued) mean wind profiles; wind direction tends to be more variable than speed. Little apparent correlation exists between changes in wind speed and direction (similar speed profiles have dissimilar direction profiles).

Problems: None

Cause of Problem: None

Forecast: The work during the coming period will be concerned with continued analysis of the NSSL data set and momentum fluxes, and wind shear will be included in the analyses.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-52-46	PRIOR NO.: 909-52-46

4. TITLE:

Physical Standards

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Orvel E. Smith S&E-AERO-YT	205-453-3144	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Engineering Atmospheric Model for Space Shuttle Re-entry and Return Contract No. NAS8-29753 (Modification 7-23-73). Georgia Tech Institute, Atlanta, Ga.

OBJECTIVE(S): Develop an engineering design model atmosphere for Space Shuttle design and operational analysis from orbital altitudes down to the earth's surface over the entire world. The monthly means and variations of pressure, temperature, and density with respect to monthly reference periods are to be accounted for in the model. The objective(s) were amended 7-21-73 to include annual means and dispersions of pressure, temperature, and density and a derived wind model.

APPROACH: The MSFC 4-D Global Atmospheric Model which gives pressure, temperature, and density versus altitude 0-26 km for any latitude, longitude and monthly reference periods and the MSFC Orbital Model which gives density as a function of time and solar activity for that volume of air above 90 km altitude are connected by a modelling pressure, temperature, and density from available high altitude rocketsonde measurements to form a continuous atmospheric model from orbital altitudes down to the earth's surface for any month, latitude, and longitude. The resulting engineering model will be in the form of a computer program for efficient application to Space Shuttle design and engineering problems. The wind model is derived from basic relationships of mean pressure gradients; i.e., the geostrophic and thermal wind equations.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Contractor's report, "A Global Scale Engineering Atmospheric Model from Surface to Orbital Altitudes," Vol. 1: Technical Description (105P); Vol. 2: Users Manual and Programers Manual (205P)	Justus, C.G., A. Woodrum, & R. G. Roper	March 1974

FIRST BENEFITTING PROGRAM: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-52-46 PAGE 2 OF 3

STATUS: The contractor's reports listed on page 1 will be issued as a NASA publication for broader distribution to assure greater use of this atmospheric model. Although the objectives are met for this effort, there is much work needed to make improvements in the model. For example, the internal consistencies between the variable, pressure, temperature, and density dispersions need to agree with known physical relationships as described the the hydrostatic equation and the equation of state. A follow-on effort is planned for this much needed improvement.

TECHNICAL PROGRESS: The modelling of the atmospheric parameters, pressure, temperature, and density has been completed and most work for the wind model. The computer program will be checked out in November at the MSFC computer facilities.

PROBLEMS: None.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-52-47	PRIOR NO.:

4. TITLE:
Environmental Quality

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
John W. Kaufman JK	453-3159	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study of Space Shuttle Booster Engine Exhaust Chemistry in Controlled Environment

CONTRACTOR: Headquarters, U. S . Air Force
Comptroller Office
Arnold Air Force Development Center
Arnold Air Force Station, Tennessee

U.S. Dept. of Commerce
NOAA
Boulder, Colorado

CONTRACT NO: H-2528B H-92170A

OBJECTIVES: TASK I. The Physical and Chemical Characteristics of Engine Exhaust - Determine the chemical composition and physical characteristics of the exhaust ground cloud based on analytical data and perform controlled chamber tests by burning small rocket motors. Use special sensor/sampler devices to measure solid rocket exhaust constituents especially hydrogen chloride, aluminum oxide, carbon compounds, etc.

TASK II. Study physical and chemical characteristics of the reactions that take place when the rocket exhaust mixes with atmospheric air and moisture.

APPROACH TO TASK I. Initially, a literature search will be conducted to determine what research has been completed, if any, on this and related work. An indepth investigation will be completed to determine best methods to measure the chemistry of the rocket effluents. Establish test procedures to burn small scale rocket motors and raw propellant in controlled environments.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Several monthly progress letters have been received.

FIRST BENEFITTING PROJECT: Space Shuttle

REMARKS: Additional work on the study of the chemistry of solid engine exhaust by-products is anticipated under a planned extension to this effort. The program code is 502-24-80 and under DCN 1-4-75-40035.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-52-47 PAGE 2 OF 3

APPROACH TO TASK II. This effort will be a follow-on of Task I in that particular concern is to be placed on the chemistry of exhaust ground and surface plume phenomena.

STATUS: Dr. Ron Dawbarn, principle investigator of this effort, recently received the small scale rocket motors from JPL. They plan to begin firing the rockets in the 12V chamber the second week of April. The chamber will be available 24 hours a day but the expediency to which the tests will be conducted will depend on wash down, drying, and reinstrumenting the chamber. Sampling of the gaseous and particulate solid rocket exhaust materials is to be done by aerosol bubblers, calorimetric sensors, HCl ph detectors, nuclei counters, particulate impactors, "scotch-tape" impactors, and possibly other devices. It is very likely that the Langley Research Center personnel will participate in the chamber tests as coordination is continuing between the two groups on this matter.

The AEDC people are coordinating closely with the IIT Research Institute people working on the "Atmospheric Scavenging of Hydrochloric Acid" contract in order to continue their cross exchange of information on this work. The AEDC people plan to conduct a few small scale open field propellant burn tests to check out various systems. This approach will save time in that they will not have to clean the chamber.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-52-47	

4. TITLE:

Environmental Quality

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Leonard L. DeVries	205/453-3108	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Potential Environmental Problems Due to Space Shuttle Operations

CONTRACTOR: H. E. Cramer Company, Inc.
P. O. Box 9249
Salt Lake City, Utah 84109
Contract No: NAS8-29033

University of Michigan
Space Physics Research Laboratory
Ann Arbor, Michigan 48105
Contractor No: NAS8-28294

OBJECTIVES: Task I: Update and refine the MSFC Multilayer Diffusion Program. Current MSFC Multilayer Diffusion Models reflect the state-of-the-art in diffusion transport knowledge; however, updating and refinement of the models are needed to more accurately assess the effect of physical depletion factors on the transport and diffusion of material in the atmosphere.

Task II: Study the behavior of aluminum oxide particles in the presence of H_2O and HCl; model the afterburn of H_2 and CO.

APPROACH: Task I: Improve the MSFC Multilayer Diffusion Model by incorporating the latest technical approaches to account for removal of material from the rocket by precipitation, gravitational settling, and other depletion factors. Incorporate the knowledge gained from NASA and USAF sampling programs. Include available up-to-date advances in the science of transport modeling.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Space Shuttle Environmental Impact Study; Interim Report	D. H. Stedman R. S. Stolarski R. J. Cicerone J. K. Williams	

Monthly Progress Reports

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-52-47

PAGE 2 OF 3

Task II: Analyze Al_2O_3 particles for their size, shape, and refractive index. Model the afterburn of H_2 and CO to provide quantitative estimates of the heat input to the ground exhaust cloud.

STATUS: TASK I: A computer program was developed which accepts meteorological data from rawinsonde runs and automatically calculates and prepares input data decks for use with the MSFC Multilayer Diffusion Model. Data from November 1973 and February 1974, launches of Titan III C were analyzed; on the basis of observational data, the MSFC Multilayer Diffusion Model was modified to more closely agree with measurements. Operational computer programs were developed to provide real-time predictions of rocket exhaust by-product concentrations. These programs were tailored to a portable dedicated calculator.

TASK II: Studies of the afterburn of H_2 and CO leave no doubt that these compounds are completely consumed in the afterburn to H_2O and CO_2, whereas HCl remains as HCl and does not become oxidized to Cl_2. There remains some uncertainty in regard to no formation and freezing; however, an absolute upper limit value has been established. Studies of possible chemical reactions between alumina, hydrogen chloride and water indicate that if the cloud consists primarily of alpha phase alumina there is probably little potential chemical reaction with HCl and water; hence, the cloud could be considered "wet" with acid and unreacted alumina. On the other hand, if the molton alumina calcines at an effective temperature in the metastable phase range there is good potential for the formation of an alumina-acid complex. Thus, the effective phase of the alumina present in the ground cloud must be determined before estimates of absorption of water and acid can be made.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-52-47	

4. TITLE:

Environmental Quality

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
John W. Kaufman	453-3159	for William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Atmospheric Scavenging of Hydrochloric Acid

CONTRACTOR: IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616

CONTRACT NO: NAS8-29668

OBJECTIVE: To study hydrochloric acid reaction and combination processes with water vapor, sodium chloride, aluminum oxide, and various other elements and compounds emitted in the exhaust of solid rocket motors. Conduct laboratory studies to determine the degree that hydrochloric acid will be leached out of stabilized solid rocket engine exhaust clouds by rain.

APPROACH: Make a thorough review of past research on rain scavenging of aerospace engine exhaust by-products and other particulates emitted into the atmosphere. Conduct controlled environmental chamber tests to determine the degree of scavenging of HCl, Al_2O_3, CO, CO_2, and other materials by water vapor and droplets. Chemically analyze the gases, particulates, and moisture to assess the reactions, recombinations, acidity, and physical characteristics to lead to a proper determination of rain scavenging coeffients to use in available atmospheric diffusion models.

STATUS: This contract was to be performed within an eight month period beginning on June 4, 1973 and terminating on February 4, 1974. The contract has officially been extended for a two month period, at no cost to the government. The contractor requested this extension to fulfill contractual expectations.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Seven monthly progress reports and several other correspondence and meetings have been accomplished to date.			

FIRST BENEFITTING PROJECT: Space Shuttle

REMARKS: Additional work on atmospheric scavenging of hydrochloric acid is expected to commence as documented in DCN 1-4-75-40041. This is planned to be a six month effort with IIT Research Institute.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 902-52-47

PAGE 2 OF 3

STATUS: (continued)

IIT Research Institute personnel responsible for the work have begun firing small rocket motors in their 5.5 m (18 ft) diameter chamber as planned. Results of these tests will be available in the near future. Water droplets induced to fall through the exhaust cloud show a fair amount of hydrogen chloride absorption. In one test the ph value of the water went from 7.0 (neutral) to 1.53. Aluminum oxide particles that were sampled by optical microscope and other techniques showed particle size range compares well with earlier testsmade from burns of small rockets at JPL.

The Davis Model HCl monitor and bubbler sampler methods to detect HCl seem to be quite favorable. Visual means to look at or photograph the rocket firing events in the chamber failed due to the dense white cloud that is formed as the rocket burns. In another interesting chamber test it was found that a "wet wall" chamber absorbed the HCl gas about 5.0 times faster than the "dry wall" chamber. From these preliminary chamber tests, a great deal of information is being gained on water scavenging of HCl, Al_2O_3, CO_2, CO, and other by-products of solid rocket exhausts. Such information should add significantly to improving the MSFC Multilayer Diffusion Model which treats ambient precipitation scavenging as is the intent of this work. Final results will be documented and sent to this division for review and approval in the near future.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-05	PRIOR NO.:

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Herndon, R. H.	205-453-1508	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Flat Conductor Cable Connector Body
In-House & NAS8-30287 Astro-Space Laboratories, Inc., Huntsville, AL 35806 (Note *)

OBJECTIVE: The major objective of this RTOP is to provide technology (methods, techniques, procedures, tools and equipment) for the fabrication of flat conductor cable (FCC) systems which could be used for future manned or unmanned missions. This specific task is for the development of an FCC connector body and will include the investigation and processing of various molding and potting materials (materials that will be abrasion resistant and meet the necessary requirements in MIL-C-55544A for space environment).

APPROACH: A large in-house effort and a supporting contract are being utilized for this task. The in-house effort will include the investigation of various molding and potting materials, material selection and tests, preliminary design of connector body, prototype fabrication and tests, connector assembly and specifications. The contractor will use the recommended molding and potting materials, MSFC tooling drawings and MSFC connector design drawings during his performance of the contract. The contractual work will be performed in phases: Phase I - Material Selection and Value Analysis (Submission to MSFC for final selection). Phase II - Connector Manufacture and Assembly Tooling (Design and manufacture or procure the tooling required for producing connector parts and for connector receptacle assembly). Phase III - 1.5 inch FCC Plug Termination Tooling (Deliver termination tooling and cable-to-plug assemblies). Phase IV - Manufacture and Assembly of Connector Receptacles (After acceptance testing is completed and approved, deliver required connector receptacles in three sizes - 1.0, 1.5 and 2.0 inch).

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Report (August 16 through September 16, 1973), "Flat Conductor Cable Connectors", Basil W. Wheeler. (Note *)			
(Last Monthly Progress Report Received) Monthly Progress Report (February 1 through February 28, 1974), "Flat Conductor Cable Connectors", Basil W. Wheeler. (Note *)			

(Note * - Contract NAS8-30287 contains a Scope of Work for both the Development of FCC Connector Body and the FCC Connector Spring Contacts Development)

FIRST BENEFITTING PROJECT: Space Shuttle, Tug or Space Systems

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-05 PAGE 2 OF 2

TASK: Electrical Power

STATUS: Technical Progress:

In-House - The selection and testing of materials were completed. A glass filled epoxy material and a moldable polyimide material were selected for further evaluation. A preliminary design of the connector body was completed and discussed with the contractor. Materials, test data and pertinent information supporting the selection of materials were reviewed in accordance with the contract.

Contract - The following progress was reported by the contractor for the period ending February 28, 1974: (1) Assembly tooling for both FCC to FCC and FCC to round conductor cable (RCC) Receptacle Assembly has been completely designed and is now being fabricated. (2) Molds for the seals were completed and are being produced. (3) The blanking and forming dies were completed and are being produced. (4) The die cast die for Shell 95M20508-1 and -5 were completed; samples were made from the dies, inspected, and presented to MSFC for approval. One dimension (the flange holes) were found to be out of tolerance. This discrepancy is being corrected in the die. Once corrected, production will begin. (5) Molds for inserts and plugs are about 50% complete. (6) Silk Screen fixtures have been built for all three sizes of shells and plugs.

Management Progress: After design changes were made, the contract was extended to May 31, 1974 (original completion date was April 16, 1974).

Conclusions: None

Problems: No major problems at this time.

Forecast: The four phases of the contract should be completed on the delivery schedule dates: Phase I - September 27, 1973, Phase II - April 15, 1974, Phase III - April 30, 1974, and Phase IV - May 31, 1974. The in-house effort is expected to be completed in June 1975.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-54-05	908-54-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Herndon, R. H.	205-453-1508	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Shielded Flat Conductor Cable In-House

OBJECTIVE: The major objective of this effort is to provide technology (methods, techniques, procedures, tools and equipment) for the fabrication of shielded flat conductor cable (FCC) systems which would effectively shield against RFI and EMI in applications where these interferences pose a problem in future manned and unmanned missions.

APPROACH: To meet the objective, in-house work must include preparation (stripping) of the cable ends for reliable and inexpensive termination, testing, electrical characteristic measurements, termination hardware and process development, establishment of specifications, and engineering application studies. This effort is being accomplished in five phases: (1) Development of an effectively shielded FCC which can be reliably and inexpensively terminated, (2) Testing and evaluation of prototype cables, (3) Development of processes and termination hardware, (4) Fabrication of prototype cables for engineering application studies, and (5) Prepare final report and documentation.

STATUS: Technical Progress: Basically, two types of shielded FCC have been developed: (a) An insulated copper foil laminated to the outer surface of the FCC. This method reduces the flexibility of the cable and presents a problem in stripping and termination of the cable. (b) A loose overlay of an insulated copper foil. This method requires a tie down of the shield at intervals along the length of the cable and care in handling to prevent damage to the shield. Stripping and termination is also a problem. A supplier is being sought for a ½ oz. copper foil with a 1 mil Kapton film bonded on one side using a chemically strippable adhesive with a heat resistance sufficient to with-

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

No formal in-house report has been issued. In-house accomplishments are reported in the Weekly Notes.

FIRST BENEFITTING PROJECT: Space Shuttle, Tug or Space Systems

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-54-05

PAGE 2 OF 2

TASK: Development of Shielded Flat Conductor Cable

STATUS: Technical Progress: (Continued)

stand the laminating temperature of Kapton/FEP insulated FCC (280°C). One supplier is working on this type of shielding and has promised to send samples for in-house tests and evaluation. A testing program is being performed on prototype shielded FCC that is being developed in-house. A test plan has been formulated and is being used to compare the RFI/EMI characteristics of the developed shielded FCC with that of shielded round wire cable.

Management Progress: Work continues on this in-house effort under a restricted manpower allocation and with no Advanced Development FY-74 approved funding.

Problem: The major problem which exists in the development of shielded FCC is still in the area of stripping and termination.

Cause of Problem: The basic FCC construction is Kapton/FEP insulated. This cable may be stripped quickly, easily and economically using a stripping tool with a sharp steel blade which cuts through the Kapton and into, but not through, the FEP and stripping both away in one quick stroke. When an insulated ½ oz. soft copper foil is added to this construction, stripping becomes a major problem. The shield insulation and adhesive must be removed leaving the foil intact. The adhesive bonding the foil to the FCC, the FCC insulation film and its adhesive must also be removed. At the present time this operation is slow, tedious and quite expensive.

Suggested Solution: Locate a source for a ½ oz. soft copper foil insulated on one side with a 1 mil Kapton film laminated to the foil using a chemically strippable adhesive having a heat resistance capable of withstanding the laminating temperature of Kapton/FEP insulated FCC. This composite would then be laminated to the FCC during fabrication in a single operation. The foil insulation film and its adhesive could be removed chemically, the foil folded back and the Kapton/FEP removed with the cold blade stripper in the same manner as an unshielded cable is presently stripped.

Forecast: In-house work for Phase I should be completed in October 1974. This task should be completed in June 1975 with the delivery of the Final Report.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-05	PRIOR NO.:

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Herndon, R. H.	205-453-1508	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Flat Conductor Cable Connector Spring Contacts Development
In-House & NAS8-30287 Astro-Space Laboratories, Inc., Huntsville, AL 35806 (Note *)

OBJECTIVE: The major objective of this RTOP is to provide technology (methods, techniques, procedures, tools and equipment) for the fabrication of flat conductor cable (FCC) systems which could be used for future manned or unmanned missions. This specific task is for the FCC connector spring contacts development and will include the investigation, analysis and development of spring contacts (BeCu spring investigation, failure analysis, fatigue, redundant contacts, etc.).

APPROACH: An in-house effort and a supporting contract are being utilized for this task. The in-house effort will include the configuration and materials study, preliminary design of contacts, prototype fabrication and tests and specifications. The contractor will use the recommended MSFC drawings for a redundant connector contact, MSFC tooling drawings and MSFC connector design drawings during his performance of the contract. The contractual work will be performed in phases: Phase I - Evaluation of redundant vs single contacts. Phase II - Tooling Design for Connector Parts. Phase III - Contact Manufacture and Tests. Phase IV - Manufacture, Assembly and Delivery of Connectors with drawings and specifications.

STATUS: Technical Progress:

In-House - Prototype redundant Beryllium Copper spring contacts have been fabricated and tested. This design was used to initiate a procurement request for the fabrication

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Report (August 16 through September 16, 1973), "Flat Conductor Cable Connectors", Basil W. Wheeler. (Note*)			
(Last Monthly Progress Report Received) Monthly Progress Report (February 1 through February 28, 1974), "Flat Conductor Cable Connectors", Basil W. Wheeler. (Note *)			

(Note * - Contract NAS8-30287 contains a Scope of Work for both the FCC Connector Spring Contacts Development and the Development of FCC Connector Body)

FIRST BENEFITTING PROJECT: Space Shuttle, Tug or Space Systems

MSFC - Form 350 (March 1973)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-54-05

PAGE 2 OF 2

TASK: Flat Conductor Cable Connector Spring Contacts Development

STATUS: Technical Progress: (Continued)

of a small production quantity of redundant contacts for evaluation tests and use by the contractor. In-house effort has been expended on the configuration and materials study, preliminary design of contacts, prototype fabrication and tests.

Contract - The following progress was reported by the contractor for the period ending February 28, 1974: (1) Material for chem milling all contacts has been sent to the subcontractor for production of contacts (in the flat state). Delivery to Astro-Space Laboratories is expected by April 2, 1974. Forming dies for all contacts are about 85% complete. (2) Spot weld fixture for contacts has been designed and is now in work.

Management Progress: After design changes were made, the contract was extended to May 31, 1974 (original completion date was April 16, 1974).

Conclusions: None

Problems: None

Forecast: The four phases of the contract should be completed on the delivery schedule dates: Phase I - September 27, 1973, Phase II - February 28, 1974, Phase III - April 15, 1974, and Phase IV - May 31, 1974. The in-house effort is expected to be completed in June 1975.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-05	PRIOR NO.: 908-54-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Herndon, R. H.	205-453-1508	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of High Temperature Flat Conductor Cable
In-House & NAS8-29076 Martin Marietta Corporation, Orlando, Florida 32805

OBJECTIVE: To continue in-house development and utilize a supporting contract for the design, development and testing of high temperature flat conductor cable (FCC). The contract effort shall include the design, fabrication, test and delivery of 3000 feet each of two sizes of high temperature (-65°C to 350°C) flat conductor cable having pre-insulated conductors. A process and procedure for stripping shall be developed and documented as part of the contract. The in-house effort will include testing, electrical characteristic measurements, termination hardware and process development, establishment of specifications and engineering application studies.

APPROACH: The contractual effort will be accomplished in two phases: Phase 1 - A prototype FCC using the selected materials and manufacturing method will be fabricated and evaluated to determine if the contract requirements are met and if the stripping method proposed and used is satisfactory. At least 30 feet of continuous FCC will be forwarded for evaluation which will be made simultaneously by the contractor and MSFC. Phase 2 - After the results of the tests have been evaluated and approved by MSFC, the fabrication and production of 3000 feet of each size of FCC will then begin. In-house effort will continue until the objective is accomplished.

STATUS: Technical Progress: After preliminary test and evaluation of various films, adhesives and construction processes; two methods of developing a high temperature FCC were considered. The first method was to prewrap the individual conductors by using

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

Monthly Letter Report No. 14, "Design, Development, Fabrication and Testing of High Temperature Flat Conductor Cable", Walter S. Rigling, 20 September 1973.

(Last Monthly Report Received)
Monthly Technical and Financial Report, 1 February through 28 February 1974, "Design, Development, Fabrication and Testing of High Temperature Flat Conductor Cable", Walter S. Rigling.

FIRST BENEFITTING PROJECT: Space Shuttle or Space Systems

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-54-05

TASK: Development of High Temperature Flat Conductor Cable

STATUS: Technical Progress: (Continued)

polyimide film coated with FEP adhesive on both sides and overcoating with a liquid polyimide. The second method was to laminate the conductors between two layers of polyimide (Kapton) film coated with polyimide (Kerimid) adhesive. The second method was chosen because a FCC of this construction offered higher heat resistance, lower fabrication costs, better strippable characteristics and more compactness. Thirty feet of prototype high temperature (HT) FCC of the 3 conductor and of the 25 conductor sizes were delivered for evaluation and approval. After the results of the tests have been evaluated and approved by MSFC, the fabrication and production of 3000 feet of each size of HT FCC will then begin.

Management Progress: Because of development problems and long delivery of materials and prototypes, Contract NAS8-29076 was extended to August 24, 1974.

Conclusions: Joint in-house and contractual efforts have shown that the Kapton films coated with Kerimid adhesive can be successfully laminated.

Problems: The contractor has reported the following minor problem: "The 3 conductor prototype cable has successfully passed all tests and a summary report is being written. Post curing of this cable has resulted in the appearance of small bubbles in the adhesive layer adjacent to the conductor. Exhaustive testing has been undertaken in an attempt to eliminate these bubbles, however, there appears to be no way to completely avoid the evolution of randomly dispersed 1 mm diameter and smaller bubbles. The bubbles occur on an average of less than one per centimeter, they do not interlock and have no effect on stripping, moisture pick up or electrical properties. While they can be detected using unaided vision under ideal lighting conditions, actual observation must be done at greater than 7X. It should be noted that these bubbles are smaller and less frequent than those in the 30 foot prototype cable previously delivered to MSFC."

Forecast: The contractor completed Phase 1 of the contract in January 1974 and should complete Phase 2 in August 1974. In-house effort should be completed in June 1975.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
Marshall Space Flight Center	01 10 73 - 31 03 74	CURRENT NO.: 909-54-07	PRIOR NO.:

4. TITLE:

Communications

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bobby Hodges	(205) 453-1385	W. K. Polstorff

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Advanced Crew/Computer Communications Techniques

NAS8-25701 McDonnell Douglas Astronautics Company
Huntington Beach, CA 92647

OBJECTIVE(S): Develop techniques, methods and system requirements for effective communications between man and computer. Develop, implement and demonstrate operational crew/computer communications systems. These demonstrations utilize a unique programmable command keyboard and display (PKD) terminal, structured vocabulary and software.

APPROACH: Part I - Definition and development of a crew/computer communications system.

Phase A. Formulation of crew/computer communications system requirements.

Phase B. Requirements specification for crew/computer communications system major components and techniques

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MDC G5312	Crew/Computer Communications Study - Final Report, Volumes I and II.	R. Joslyn G. Montoya	February 1974
MDC G4829	Design and Performance of a Large Vocabulary Discrete Word Recognition System, Volumes I and II		November 1973
	Bi-Monthly Technical Progress Report		

Phase C. Implementation and demonstration of operational crew/computer communications systems.

Part II - Development of crew/computer communications system using speech recognition.

Phase A. Development and demonstration of 25-word Word Recognition System (WRS).

Phase B. Development and delivery of 100-word WRS.

Phase C. Integration of WRS with operational ground computer system.

Phase D. Integration of WRS with operational on-board computer system.

Part III - Development of crew/computer communication system requirements and techniques for specific applications.

Phase A. Development and demonstration of crew/computer communication techniques and system for spacecraft experiment performance.

Phase B. Development and demonstration of crew/computer communication techniques and system for ground checkout and launch system.

STATUS: Part I - All phases have been completed.

Part II - Phase A and Phase B of Part II are complete. Phase C and D were not funded under this RTOP.

Part III - Phase A, the C/CC system for experiment applications, is complete. Phase B was not funded under this RTOP.

This is the final progress report under this RTOP.

RES

PROGRESS REPORT
RCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 to 31 03 74	CURRENT NO.: 909-54-21	PRIOR NO.: 908-51-21

4. TITLE:

Ma facturing and Inspection

5. RESPONSI INDIVIDUAL:	TELEPHONE:	APPROVAL:
Splawn, . L.	205-453-0120	W. Angele

6. ACCOMPL MENTS (Milestones, Problems, Near term activities):

TASK: D elopment of Simulation Techniques and Capabilities In-House

OBJECTIV The major objective of this effort is directed toward the development of simulati equipment and techniques and improvement of simulation techniques for performing gineering studies and evaluations in a simulated zero gravity environment with greater ficiency and safety.

APPROACH: In-house effort is being used to develop and update this simulation equipment, simultane ly conforming to the current space suit configurations, simulation test requireme s and test hardware design. This effort includes work for (1) measurement of metabolic te of space-suited subjects by utilizing different techniques, (2) investigation an development of large mass handling (maneuvering) techniques for the simulated zero grav conditions of space, and (3) development of other underwater simulation techniques for free-flying platforms, rendezvous and docking, solar lighting conditions, etc.

STATUS: chnical Progress: The following in-house work is being performed: (1) Three techniques are being investigated for their application to the Measurement of Metabolic Rate. The Heart-Rate/Respiration Method has been perfected. Thermal Output Method measuremen s have been made and work is being conducted to perfect this method. Work is being perf med on the Gas Analysis Method and the computer software is now available. Effort is ing expended to select a suitable oxygen sensor. (2) Work continues on the investigat on and development of Large Mass Handling Units to move underwater objects

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

No formal n-house report has been issued. In-house accomplishments are reported in the Weekly Not and in news releases to the Press, Radio and Television. Information is also given n the Skylab Technical Crew Debriefing.

FIRST BENE LITTING PROJECT: ATM, Skylab, Space Systems, Space Shuttle

MSFC - Form 350 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-21 PAGE 2 OF 2

TASK: Development of Simulation Techniques and Capabilities

STATUS: Technical Progress: (Continued)

which will simulate typical Space Shuttle Payloads. (3) Work is being performed to add remote (radio transmission) controls to the Free-Flying Platforms to eliminate drag and restriction to free movement. Simulation techniques for Rendezvous and Docking should be completed in FY-75. Techniques for Solar Lighting conditions which would simulate solar illumination of spacecraft (such as Skylab) has been performed on the Skylab Neutral Bouyancy Mockup.

Management Progress: Additional funds and manpower allocation have been requested to maintain this capability for neutral bouyancy simulation.

Conclusions: This improved effectiveness and safety of space simulation testing has resulted in allowing a greater number of astronauts, designers and engineers to gain first-hand information and training with regard to man/machine problems by actually performing tasks in space simulations.

Problems: None

Forecast: This in-house effort should continue until all simulation requirements have been completed. Skylab 4 crewmen (Astronauts Gerald Carr, Ed Gibson and William Pogue) completed their Neutral Buoyancy Training on October 10, 1973 and the backup crew (Astronauts Vance Brand, Don Lind and William Lenoir) completed their training on October 12, 1973.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-21	PRIOR NO.: 908-51-21

4. TITLE:

Manufacturing and Inspection

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Hankins, J. D.	205-453-4877	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Fabrication Technology for Electronic Circuitry Components In-House

OBJECTIVE: To continue development efforts on fabrication technology for electronic circuitry components which would include the development of a plated through-hole process applicable to two or more planes of circuitry for printed wiring boards used in both flight and ground support equipment circuitry.

APPROACH: The approach taken included the investigation and evaluation of various incremental aspects of electronic circuitry fabrication.

STATUS: Technical Progress: Available manpower was utilized on higher priority work during this reporting period. During the past reporting periods, in-house metallurgical evaluation of the first thermal shock samples were completed, additional tests performed and some samples were eliminated from contention after the first thermal shock exposure.

Management Progress: Since no manpower or funding was allocated for this task in FY-74, this task was terminated.

Conclusions: Additional effort must be performed on the evaluation of the thermal shock effects and failure mechanisms before final requirements could be determined.

Problems: None

Forecast: This task is considered to be terminated.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
No formal in-house report was issued. In-house accomplishments were reported in the Weekly Notes.			

FIRST BENEFITTING PROJECT: Space Shuttle or Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-21	PRIOR NO.: 908-51-21

4. TITLE:

Manufacturing and Inspection

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Siler, H. L. (Alt. COR) (*)	205-453-5088	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Analysis of Thermal Stress and Metal Movement During Welding
NAS8-24365 Massachusetts Institute of Technology, Cambridge, MA 02139

OBJECTIVE: The major objective of this effort is to perform studies and a complete analysis of thermal stress and metal movement during welding.

APPROACH: A contract is being utilized to perform (1) mathematical analysis of temperature distribution, (2) analysis of stress distribution, and (3) prediction of metal movement.

STATUS: Technical Progress: Phase Report, 73-16, describes the work performed to June 1973. Appendix A of the report, which is the thesis entitled "Investigation of Thermal Stress and Buckling During Welding of Tantalum and Columbium Sheet" prepared by Mrs. K. Anne S. Hirsch, describes the work performed on Phase B and Phase D of the contract. Appendix B of the report, which is the thesis entitled "Analysis of Two-Dimensional Thermal Strains and Metal Movement During Welding" prepared by LCDR Jon J. Bryan, USN, describes the work performed on Phase E of the contract. Effort is being performed on the balance of the Scope of Work.

Management Progress: The original research contract on "Analysis of Thermal Stresses and Metal Movement during Welding" was initiated on May 15, 1969. The study was completed on October 14, 1970, and the final report of the study was published on December 15, 1970, as the NASA Contractor Report CR-61351. An extension of the contract became effective on October 14, 1970 with an appropriation of addition funds. In June 1973,

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA Contractor Report CR-61351	"Analysis of Thermal Stresses and Metal Movement During Welding"	K. Masubuchi	December 15, 1970.

Technology Utilization Office issued a NASA Tech Brief, B72-10333, "Analysis of Thermal Stress and Metal Movement During Welding", dated July 1972.

Phase Report, 73-16, "Analysis of Thermal Stresses and Metal Movement During Welding", T. Muraki and K. Masubuchi, June 21, 1973.

NOTE (*) Mr. R. M. Poorman, S&E-ASTN-MM, has been designated as COR.

FIRST BENEFITTING PROJECT: Space Shuttle, Space Systems, Space Station

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-21 PAGE 2 OF 2

TASK: Analysis of Thermal Stress and Metal Movement During Welding

STATUS: Management Progress: (Continued)

the contract was again extended until June 30, 1974 with no additional funding and the program was further expanded to include Phase G, "Perform experiments on thermal stresses and metal movement in joining thin cylindrical shells", at no additional cost to the Government.

Conclusions: Although basic equations have been developed to analyze thermal stresses and metal movement in joining thin cylindrical shells, it is important to compare analytical solutions with experimental results. Efforts will be made to generate experimental data on cylindrical shells.

Problems: A major problem in the theoretical study is how to develop a computer program with satisfactory accuracy and reasonable cost. During the entire course of this research, persistent efforts have been made by the contractor to achieve that goal and computer programs have been modified many times.

Forecast: Contractual work is scheduled to be completed by June 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-21	PRIOR NO.: 908-51-21

4. TITLE:

Manufacturing and Inspection

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Splawn, J. L.	205-453-0120	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Maneuvering and Manipulating Units In-House

OBJECTIVE: This effort is directed toward the development of maneuvering vehicles and manipulating units. Items will be used for the purpose of demonstration testing in simulated space environments; such as air bearing surfaces and underwater, with final effort in support of EVA/IVA space activated simulations.

APPROACH: The approach taken to meet the objective included the following areas of work: (1) Develop Air Bearing Lift Pad and manipulating sub-systems. (2) Identify potential application. (3) Test and evaluate to determine technological problems. (4) Upgrade design and hardware. (5) Test and document for future application. (6) Develop multi-purpose Joystick Control for seven-degree-of-freedom master slave manipulator with rate control feature. (7) Develop Extendable Stiff Arm Manipulator (ESAM) for docking experiments. (8) Develop underwater maneuvering Free Flying Platform. (9) Develop analog controls for manipulators. (10) Develop Automatic Cable Management Gantry. (11) Conduct design study for exchanging End Effector Jaws remotely. (12) Develop Joystick/Analog control for ESAM manipulator. (13) In-house tests and evaluation.

STATUS: Technical Progress: The above items (1) through (7) have been completed and reported on in prior reports. Some of the developed items are now being utilized in the work being done for RTOP 970-63-20. Work continued on the following items: (8) Basic unit is complete. Underwater sub-systems (thirteen degrees-of-freedom

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Equipment Contract NAS8-29078	Final Contract Report, "Development of an Automatic Cable Management Gantry,	James R. Allen & Andrew Karchak, Jr.,	September 1973

FIRST BENEFITTING PROJECT: Free Flying Teleoperator/Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-21 PAGE 2 OF 2

TASK: Development of Maneuvering and Manipulating Units

STATUS: Technical Progress: (Continued)

Joystick Controller, control electronics, on-board power supply and circuits, etc.) were tested and operated satisfactory. (9) The analog controls for manipulators were redesigned and necessary modification were completed. (10) Modifications were completed on the Automatic Cable Management Gantry. (11) The design study for exchanging the End Effector Jaws remotely was completed and a working demonstration model was provided. (12) Additional work was completed on the Joystick/Analog control for ESAM Manipulator. (13) In-house testing and evaluation is being performed under a restricted manpower allocation.

Management Progress: Work continues on this in-house effort under a restricted manpower allocation and with no FY-74 approved funding.

Conclusions: The Air Bearing Lift Pad and Underwater Model Maneuverable Units are expected to provide versatile test beds for Free Flying Teleoperator test and simulation studies. The ADAMS manipulator preliminary test indicates improvement of the Servo Control Unit and will provide a valuable manipulator system for various remote manipulator studies and simulation exercises. The 14-channel control and Joystick Analog Proportional Rate Control Unit provided a tool for trade-off studies of control units. The Automatic Cable Management Gantry will improve Free Flying simulation testing. The ESAM manipulators and Joystick/Analog Control will provide the equipment necessary to do simulated remote EVA grappling experiments.

Problems: None

Forecast: The in-house fabrication and testing should be completed by June 1975. This should complete the effort to: (1) Finalize modifications to the controller for the Underwater Model Capture and Maintenance Pilot (U-CAMP), (2) Modify and improve operational characteristics of the Joystick/Analog Controller, (3) Finalize detail design drawings for the Modular Manipulator Kit System for an Elbow Module (an additional control mode is being added to control shoulder, elbow and wrist movements to simulate hand extension), Pitch/Yaw Module (provide Pitch/Yaw wrist movement), and Shoulder Azimuth/Pitch Module, and (4) Modify the Air Bearing Lift Pad Maneuverable Platform by the addition of precision air bearings to reduce friction and provide better performance for operation as a free flyer test vehicle.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-54-21	PRIOR NO.: 908-51-21

4. TITLE:

Manufacturing and Inspection

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Hankins, J. D.	205-453-4877	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Process Development for Electronic Interconnection of Microcircuit Devices In-House

OBJECTIVE: To continue development effort on electrical interconnection techniques for assembly of microminiature devices which included the development of mounting and joining techniques for optimization of reliability for devices and interconnecting systems.

APPROACH: The approach taken included (1) development of mounting and joining concepts, (2) development of lead bending, forming and trimming tooling, (3) assembly and evaluation of assembly techniques, (4) evaluation of concepts for optimum quality and reliability with minimum costs, and (5) prepare test reports and documentation.

STATUS: Technical Progress: Available manpower was utilized on higher priority work during this reporting period.

Management Progress: Since no manpower or funding was allocated for this task in FY-74, this task was terminated.

Conclusions: The developed techniques show much promise for increased reliability and reduction in costs.

Problems: None

Forecast: This task is considered to be terminated.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
No formal in-house report was issued. In-house accomplishments were reported in the Weekly Notes.			

FIRST BENEFITTING PROJECT: ATM, Space System, Space Processing

MSFC - Form 350 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-54-21	

4. TITLE:

MANUFACTURING AND INSPECTION

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-QUAL T. F. Morris	453-4549	R. M. Henritze

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK TITLE: Advanced Remote Visual Inspection Techniques

OBJECTIVE: This work will consist of the development of a remote visual inspection system with a color TV camera system, coherent fiberoptics and illumination sources for inspecting the inside of tubing, small tanks, components, injector plates, etc. The system will have the capability of detecting various defects such as cracks, fatigue stress, electrolytic action, metal transfer, corrosion and heat damage in areas normally inaccessible for direct visual inspection.

APPROACH: A black and white TV portable system has been developed and has been used for inspections of critical hardware and facilities. Progress has been made in the development of color TV's and ultraviolet fiberoptics. These advancements can be made applicable to this advanced remote visual inspection system.

The work is to be accomplished in three phases: (1) Color - development of color presentation; (2) Ultraviolet Light - development of an ultraviolet illumination system, and (3) Techniques - development and refinement of inspection techniques. Phase I will consist of two primary tasks: (a) procuring a low light sensitive color TV camera system; (b) adapting fiberscopes to camera. Phase II will be accomplished concurrently with Phase I and will consist of three tasks: (a) procuring ultraviolet illuminator; (b) procuring non-coherent fiberoptics capable of transmitting ultraviolet light, (c) adapting fiberoptics to an operating system.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-21 PAGE 2 OF 3

STATUS: Technical Progress: An Akai color camera was obtained at no cost for use in this project. Fiberoptics were adapted to the camera and necessary modifications to the camera system were completed. Evaluations of the light sensitivity and resolution of the system were conducted. This system was utilized on two occasions to evaluate defects in the 3K subscale SSME test hardware.

Management Progress: Negotiations are underway to secure a high resolution low light level color TV camera at a reasonable price. It appears that a company demonstrator unit will be a best buy.

Conclusions: Evaluation of the Akai color camera proved it to be of little use in this project. Light sensitivity is rather poor and the resolution is less than 200 lines, whereas, approximately 500 lines are required. The search for a usable system is progressing; however, the projected schedule has been revised. Intermediate portions of the project are being delayed, however, the final completion date still appears valid.

PROBLEMS: No major problems are known at this time

FORECAST: Completion of negotiations for color TV camera systems. Evaluate ultraviolet transmitting fiberoptics and initiate procurement.

PUBLICATIONS: None

REMARKS: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 4

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC Marshall Space Flight Center	01 10 73 . 31 03 74	CURRENT NO.: 909-54-22	PRIOR NO.: 909-54-22

4. TITLE:
Transportation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DIR Jesco von Puttkamer	205-453-1260	J.A. Lovingood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Feasibility and Tradeoff Study of Aeromaneuvering Orbit-to-Orbit Shuttle Contract NAS8-28586, Lockheed Missiles & Space Co., HREC, Huntsville, Alabama

OBJECTIVE: To study and assess the general feasibility and to conduct tradeoff studies of an aeromaneuvering orbit-to-orbit shuttle (AMOOS) vehicle with the goal of identifying one or more promising systems. After identification and selection of a range of appropriate concepts in the first study phase, those systems are now undergoing concept evaluation and concept design. As a highly maneuverable third stage for the Space Shuttle, the AMOOS will utilize atmospheric entry-and-exit passes for synergistic maneuvering, i.e., energy dissipation (braking) and/or orbit-plane rotation (lateral maneuvering) for return from high-energy orbits to Shuttle rendezvous orbits.

APPROACH: During Phase I (Concept Selection) the general feasibility of the AMOOS concept was investigated and substantiated. Tradeoff analyses and vehicle design data studies provided first-cut confirmation of the general feasibility and resulted in a number of promising systems. Results indicated that the use of ablative TPS and one-pass missions may lead to considerable improvements in the payload capability compared to a non-atmospheric Tug-type system. During the current Phase II/Part 1 (Concept Evaluation) the selected concepts are being analyzed in

(Continued)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LMSC-HREC MTR D390041	Feasibility and Tradeoff Study of Aeromaneuvering Orbit-to-Orbit Shuttle (AMOOS). Phase II Midterm Review	C. Donald Andrews	1 February 74
Paper presented at XXIVth I.A. Congress, Baku	Heating Constrained Synergetic Plane Change with Finite Thrust	Ernst D. Dickmanns	7-12 Oct. '73
NASA TN D-7211	The Effect of Finite Thrust and Heating Constraints on the Synergetic Plane Change	E. D. Dickmanns	October '73

FIRST BENEFITTING PROJECT: Payload for Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-22 PAGE 2 OF 4

APPROACH (Concluded):
all problem areas, including aero-thermodynamics, heat shielding, performance, loads, structures, weights, and subsystems. Trade studies are being conducted, and preferred concepts were identified along with their operational and economic aspects. These studies are presently also identifying critical areas requiring additional investigation and deeper penetration, prior to Concept Design (Phase III). In a later study phase, Phase II, Part 2, additional studies - as identified - will be conducted, using the results and vehicle configurations from previous studies with the objective to achieve an extension in scope and depth for data refinement. In Phase III (Concept Design) the system resulting from the preceding Phase will be conceptually designed to subsystem level. In-depth studies of guidance requirements, trajectory optimization, aerodynamics, and flight control will be continued, supported by wind tunnel testing.

STATUS: Technical Progress: During the reporting period, a tradeoff study of the performance and stability characteristics of two of the three concepts under investigation, AMOOS 1 and 5B, has shown that they are very similar, with 5B being the better of the two vehicles. Hence, the AMOOS 1 concept has been eliminated from the study, and the study of AMOOS 5B and HB is being continued. - It was determined that both vehicles are stable for all trim centers of gravity, utilizing a flat-plate flap hinged at the bottom of the vehicle base which operates as an expansion flap. The expansion flap showed no effect on lateral and directional stability but improved the longitudinal stability. A comparable compression flap was found to be stabilizing directionally, but destabilizing laterally and longitudinally. The flap dimensions were determined, along with the additional structural weight required for the trim flap and associated rear struts, and the general design of the two vehicles was finalized. Heating rates were determined for the expansion flap on the HB configuration; alleviation of flap heating is being studied at present. Also determined were shear loads, bending moment, and axial load distributions using windtunnel data determined under Contract NAS8-28608. Trajectories were computed using experimental lift and drag coefficients. Performance and mission analyses were continued, and the TPS study was extended. -- Results thus far indicate the following major conclusions: (1) Both vehicles have sufficient L_{Net}/D to compensate for off-nominal trajectory conditions. (2) AMOOS payload capabilities cover 98% of all Tug missions by weight excluding polar orbit and DOD missions. (3) The AMOOS HB has a lower dry mass than 5B. Use of a graphite-polyimide non-metallic structure would reduce the weight significantly below that of the titanium structure, having a density of 0.80 kg/m^3 as opposed to titanium's 2.56 kg/m^3. Beryllium-38% Aluminum with 1.20 kg/m^3 was also found to be an attractive material for the AMOOS structure which would meet the 588.7^{o}K temperature and strength criteria. (4) Both 5B and HB meet internal packaging and Shuttle packing requirements. (5) Use of a ballute for drag modulation on a one-pass mission is impractical. Application of ballute to multi-pass missions is being studied at present. (6) The leeside of the AMOOS will require a TPS system. Using the Lockheed reusable material LI-900 as TPS would result in at least 50% higher weight penalty than low-density ablative TPS. An additional cost analysis determined that

(continued)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-22 PAGE 3 OF 4

Technical Progress (Concluded):
for one-pass missions and 20-flight reusability, the cost of the ablative TPS is about one-third that of the LI-900 since part of the latter would have to be replaced after each flight due to windward temperatures. (6) Neither the HB or 5B is significantly better overall.

Management Progress: Midterm results of Phase II/Part 1 were reviewed in an oral presentation on February 1, 1974. The Phase II/Part 1 Midterm Report (see 7. page 1) was published on 2/1/74 and distributed. A Modification to the Contract was executed which extends the period of work to July 25, 1974, to allow additional time (at no cost) for preparation of the final report. - The Cooperative Study Project with DFVLR/Germany (Dr. Ernst Dickmanns) is progressing as planned. Two reports were delivered by Dr. Dickmanns which are related to the AMOOS work (see 7., page 1).

Conclusions: The objectives defined for the reporting period in the milestone schedule have been met on time and within budget plans. The tasks specified in a detailed time/task chart were accomplished as planned. Further study in greater depth as well as additional windtunnel testing appear justified by present results.

Problems: None.

Forecast: Work on Phase II/Part 1 of the study will continue on schedule. Missions to and from orbital altitudes other than geosynchronous will be investigated, including high inclination orbits. Additional TPS cost analyses will be made for multi-pass missions, specifically for 2, 3, 5 and 10 passes. Additional TPS material will be considered including carbon/carbon, columbium, and superalloys. These will be compared to each other and to the 1-pass ablator cost on a total program cost basis assuming 20-flight reusability. The loads analysis will be continued. Additional structural materials will be investigated. The Cooperative Study will be continued, with a visit at MSFC of Dr. Dickmanns expected in April '74.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 73	909-54-22	909-54-22

4. TITLE: Transportation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AAE Josh D. Johnson	205-453-2519	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Tasks: Wind Tunnel Testing on the AMOOS Vehicle,
NAS 8-28608: Lockheed Missiles and Space Company, Inc., Huntsville Research and Engineering Center, P. O. Box 1103 West Station, Huntsville, AL 35807

OBJECTIVE: Conduct wind tunnel tests to define the aerodynamic force and static stability characteristics of one or more configurations that have been selected as candidates for the aeromaneuvering orbit-to-orbit Shuttle (AMOOS). Data from this task will be used by Lockheed when they perform another task entitled "Feasibility and Trade-Off study of Aeromaneuvering Orbit-to-Orbit Shuttle."

APPROACH: Lockheed personnel will plan and direct the required wind tunnel tests in the 3.5-foot hypersonic facility at Ames Research Center. They will design and fabricate the necessary models. They will also analyze the resulting data and prepare a data report.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Payload for Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-22 PAGE 2 OF 3

STATUS:

Technical Progress - The required wind tunnel test was performed during November 1973. Two configurations were tested. A total of 32 pitch and sideslip polars were completed. A heat transfer model was fabricated, but, because of limited time in the test facility, this model was not tested.

Management Progress - None

Conclusions - Both configurations that were investigated had longitudinal stability when an expansion flap was deflected. Both were directionally stable at angles of attack near $C_{L_{MAX}}$ when either an expansion flap or a compression flap was deflected.

Problems - Clearances between the model and model support hardware were not adequate; holes for balance leads were small; and fits between parts were too tight.

Causes of Problems - Inadequate communication between Ames personnel and Lockheed designers caused some of the problems.

Suggested Solutions - None

Forecast - None

Publications - Ketter, F. C., Jr., "Pretest Report for Tests to Determine the Aerodynamic Characteristics of Two Potential Aeromaneuvering Orbit- to-Orbit Shuttle (AMOOS) Vehicle Configurations in the NASA-Ames 3.5-Foot Hypersonic Wind Tunnel," Report No. LMSC-HREC TB D 306791, October 10, 1973

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-54-33	909-51-33

4. TITLE:

Information Management System (IMS)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
H. Garrett S&E-ASTR-CF	453-4070	C. N. Swearingen S&E-ASTR-C

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK TITLE: Space Tug Requirements

CONTRACT NO.: NAS8-29749

OBJECTIVE: To determine the functional, storage, physical, environmental, and reliability requirements for the onboard computer system. To provide a reliable mass storage capability for use in application such as Space Tug. To develop a SUMC computer for use in a redundant inertial measuring unit which utilizes state-of-the-art technologies and thereby achieves significant improvements in performance and physical characteristics and one which is extremely reliable. To perform development and qualification testing sufficient to have full confidence in the SUMC design for application to Space Tug. This will be done in cooperation with other on-going related RTOP efforts.

APPROACH: The conceptual design for Space Tug will be thoroughly reviewed and requirements for the onboard computer system determined. In areas where a definition is lacking assumptions will be made based upon Space Tug "type/similar" applications. Included will be the functional, storage, physical, environmental, and reliability requirements.

STATUS: An effort has been initiated under Contract NAS8-29749 to accomplish the objectives stated above. A Space Tug Computer requirements document has been prepared and released. Also the technology impact determined.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
73W-0029	Space Tug Data Management Computer System Hardware Requirements Document	IBM	September 1973
74W-00039	Tug Requirements Impacts on SUMC	IBM	January 1974

First Benefiting Program: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-54-33	909-51-33

4. TITLE:

Information Management System (IMS)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
H. Garrett S&E-ASTR-CF	453-4070	C. N. Swearingen S&E-ASTR-C

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK TITLE: Space Ultrareliable Modular Computer

CONTRACT NO.: NAS8-24909, NAS8-25582, NAS12-2233, NAS8-29072, NAS8-29929, NAS8-30460

OBJECTIVE: To design a computer for Space Application which provides the capability, adaptability, and reliability to accomplish the requirements of the applications. The design shall:

Incorporate state-of-the-art technologies including large scale integration (LSI), complementary metal oxide semiconductor (CMOS), beam lead interconnection, and hybrid packaging.

Have universal application.

Be software compatible with existing commercial computers.

Be cost effective.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
S&E-ASTR-C-001	SUMC Microsimulator	S&E-ASTR-C	October 1972
S&E-ASTR-C-002	SUMC Microinstruction Assembler	S&E-ASTR-C	October 1972
S&E-ASTR-C-003	SUMC-BB Operator Guide	S&E-ASTR-C	Octobter 1972
S&E-ASTR-C-004	SUMC-BB CPU	S&E-ASTR-C	October 1972
S&E-ASTR-C-005	SUMC Computers	S&E-ASTR-C	November 1972
	SUMC-DV System Manual	RCA	May 1972
N70-42890	Advanced Aerospace Computer Technology	H. Garrett	March 1970
IEEE 1971 Proceedings	Space Computer Technology	H. Garrett	March 1971
MSFC-Technology	SUMC an Approach to Flight Computer Systems	H. Garrett	February 1973

First benefiting programs: Tug,. CVT

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-54-33 PAGE 2 OF

APPROACH:

1. Perform System Architecture & Logic Design of a computer commensurate with the objectives.

2. Construction engineering development breadboard for Logic Verification. Develop microprograming and demonstrate compatibility objectives.

3. Construct an engineering development model to demonstrate use of LSI CMOS and design automation techniques.

4. Construct a technology model to demonstrate validity of packaging technology including; beam leads, multilayer substrates, and hybrid subassemblies.

5. Perform development tests sufficient to verify the integrity of design approaches.

6. Construct a prototype model in final selected technology and demonstrate that the objectives of the design have been achieved successfully.

7. Perform design verification testing of the prototype unit.

8. Perform related software and reliability studies.

STATUS:

Technical Progress - The system and logic design of the basic SUMC has been accomplished. An engineering development model was constructed and functional operation fully verified. In addition, compatibility with existing commercial computers has been demonstrated using the breadboard model.

An engineering development model of SUMC in LSI CMOS technology has been constructed and evaluated. This model employed the use of the design automation system developed for LSI CMOS under ongoing technology programs.

A technology model of SUMC has been constructed and fully verified. This model demonstrated the use of beam lead devices, multilayer aluminia substrates and hybrid packaging which are the technologies projected for SUMC use. In addition, this model was designed to be software compatible with a commercial computer (Honeywell 316) to demonstrate the flexibility of the microprograming feature.

Current efforts include the development of a basic memory module (BMM) which can be used to implement main memory units (MMU), technology evaluations for applications in SUMC, partitioning studies, packaging and modularity evaluations, construction of a prototype SUMC in final technology design, evaluation testing and support software development. The prototype SUMC should be completed by July 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:
Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Optimization of Structures Under Multiple Constraints
NCA8-71/72 Pennsylvania State University

OBJECTIVE(S): To develop a small-scale optimization program to demonstrate the feasibility of multiple constrain structural optimization which will serve as a model for a large-scale program.

APPROACH: The proposed work is an extension of the work already carried out at MSFC. The essence of the proposal is development of a computer program specially designed for experimentation with various optimization techniques. It is intended to limit the program to small structures, in order to conserve computational expense, but provide a maximum of flexibility in all other phases of programming. Provision would be made for constraints on stresses, displacements, buckling loads, and natural frequencies, applied either singly or simultaneously. The possibility of including flutter constraints will also be investigated. Some parts of the program have already been completed.

STATUS: Technical Progress--The theoretical basis for handling stress constraints, including local buckling, has been completed. This part still has to be programmed and incorporated in the large-scale optimization program. Work on an out-of-core equation solver has been completed.
Management Progress, Conclusions, Problems, & Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefitting Project: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:
Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Solution Techniques for Nonlinear Structural Analysis
NAS8-29625 The Boeing Company

OBJECTIVE(S): The objective of this effort is to develop effective subroutines and criteria for solution of systems of nonlinear simultaneous equations that contain multiple roots as well as minimum and maximum points.

APPROACH: To accomplish this task, a two-phase program will be initiated. In Phase I, new methods will be developed, new and existing methods will be evaluated on ease of use, cost of solution (i.e., computational speed), and types of problems for which the method is effective. The subroutines developed for this effort will be written to be effective for the solution of problems in structural analysis. In Phase II, techniques will be developed for solution of problems with multiple roots, minimum points, and maximum points. The current techniques for solution of nonlinear equations are extremely inefficient for these types of problems. This phase is most meaningful for solution of buckling problems and nonlinear collapse since equations describing the phenomena can be written directly instead of making many simplifying assumptions which inadequately describe the phenomena as is the current practice.

STATUS: Technical Progress--Detailed analyses have been performed for the nonlinear torus problem, using several finite element meshes. The test problem has proved to be very valuable, both in providing a description of the behavior of a difficult and instructive problem, and in demonstrating and improving our nonlinear solution techniques. The torus problem exhibits extremely nonlinear behavior, with occurrence of two limit points (a maximum and minimum) as well as sharp changes in the path plots of certain of the variables. (See below)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

STATUS: (Continued)
Management Progress--None
Conclusions--None
Problems--None
Forecast--None

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:

Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Ky	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Combined Compression, Bending and Torsion Loads on Skinned and Unskinned Isogrid Cylinders NAS8-29671 McDonnell Douglas

OBJECTIVE(S): To develop an analysis for isogrid cylinders (with and without skins) subjected to combined compression, bending and torsion, and to verify the analysis by testing.

APPROACH: Analysis techniques for stress distribution and critical buckling loads will be developed. The theory developed shall be verified by scale model testing on Lexan isogrid cylinders. The test results and theory shall be summarized and incorporated into the Isogrid Design Handbook as a guide for future designs.

STATUS: Technical Progress--Design and fabrication of the test fixture have been completed. Design and analysis of the two test specimens have been completed. The six panels which will be joined to form two cylinders are currently being fabricated.
Management Progress--None
Conclusions--None
Problems--None
Forecast--None

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFIT PROJECT: Tug

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PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:

Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Structural Test of Isogrid Conical Adapter
NAS8-29859 General Dynamics

OBJECTIVE(S): A 10-foot-diameter isogrid conical adapter will be nondestructively tested for a number of load conditions to obtain structural response data for these types of loads. Upon completion of the nondestructive testing, the most critical loading will be selected and applied to the conical adapter to determine its ultimate strength. The test results will be summarized and incorporated in the Isogrid Design Handbook as a guide for future designs.

STATUS: Technical Progress--The work outlined under Approach has been completed, and the final report described below is available for distribution.
Management Progress--Since this contract is complete, this progress report terminates reporting.
Conclusions--Six potential failure modes were considered in the analysis of the cone; skin buckling, compressive yield stress, stiffener flange crippling, stiffener web crippling, column buckling, and general instability. The skins buckled well below critical loads, but did not constitute a structural failure. The structure failed either as a result of general instability or column buckling. It was impossible to determine which mode actually initiated failure since the predicted strength of the two modes was inseparable.
Problems--None
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
PD 73-0123	Conical Isogrid Adapter Structural Test Results	J. E. Dyer P. Slysh	Feb. 1974

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:
Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. L. McComas	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Orbital Docking Dynamics - Structural Integrity Analysis
NAS8-26159 Martin Marietta Corporation, Denver Division

OBJECTIVE(S): The objective of this funded effort is to complete the development of the Orbital Docking Dynamics Program (A generalized digital computer program to predict preliminary docking loads) and to deliver and implement a working computer program. Demonstration of the program will be accomplished by performing analysis on a furnished Tug structural model and docking mechanism configuration to determine the impact and capture loads to verify the structural integrity.

APPROACH: The program will be developed by generalizing the equations of motion and providing a library of impact mechanisms and a routine that will describe the closing trajectory and predict the impact points until capture has been accomplished. Integration of the equations of motions will be performed to determine the flexible body loads versus time.

STATUS: Technical Progress--The theory and computer coding are complete. The program was demonstrated on the MSFC computers. The demonstration problem was partially successful; however, to extend the accuracy to the desired level, the program is being converted to Double Precision arithmetic.
Management Progress--A no-cost extension was granted to MMC because of the saturation of MSFC computers by Skylab work.
Conclusions--None
Problems--Computer compatibility errors were discovered during the MSFC checkout. These errors are being corrected. Forecast--Program will be ready by June 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:

Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Kay	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Survey and Development of Finite Elements for Nonlinear Structural Analysis NAS8-30626 The Boeing Co.

OBJECTIVE(S): The objective of this task is to survey the literature, collect nonlinear stiffness relationships, and compile a handbook containing these relationships. In addition, a number of needed elements will be developed and tested.

APPROACH: The review would concentrate on nonlinear finite element programs and the literature currently available which address geometric nonlinearities, nonlinear elastic materials, and nonlinear inelastic materials. Each of the sources will be reviewed, and the capabilities and limitations of each will be determined. The nonlinear stiffness relationships for each type of finite element utilized in these programs shall be compiled into a handbook similar to Boeing Report 5-9430-H-1142, "Survey of Structural Finite Elements" which was compiled for linear elements. In addition to the elements available in the literature, a minimum of two elements shall be developed and tested. These elements shall be triangular and quadrilateral in configuration and be capable of handling large, out-of-plane, geometric deformations. For these elements, only Hookean materials need to be considered.

STATUS: Technical Progress--None
Management Progress--Although the contract has been awarded, work has not yet begun.
Conclusions--None
Problems--None
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:
Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. F. Glaser	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Hydroelastic Analysis Verification
NAS8-30270 Southwest Research Institute

OBJECTIVE(S): To verify in-house developed hydroelastic analysis techniques by performing axial vibration tests of simple axisymmetric, partially liquid filled containers.

APPROACH:
1. The test containers shall be modified, where possible, from existing spherical and hemispherical containers and cylindrical containers with hemispherical bulkheads.
2. The tests should be performed with varying fill heights.
3. The experimental conditions shall be realistic, i.e., relatively large amount of liquid and thin membrane-like walls must be considered to efface the effect of the unavoidable variation of wall thickness.
4. The wall material must be elastic so as to follow Hooke's law as much as possible.
5. To avoid any undesired coupling, the support conditions must be appropriate.

STATUS: Technical Progress--None
Management Progress--None
Conclusions--None
Problems--Fabrication difficulties of the first tank.
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE OF	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-01	PRIOR NO.:

4. TITLE:

Structural

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. E. Engler	453-4050	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Lightweight Shell Structures

OBJECTIVE(S): To investigate the optimum designs for thin gage unpressurized structural components that will be representative of those in the Space Tug vehicle. To establish design, analysis, fabrication and inspection techniques to provide reliable, lightweight structural systems, and to demonstrate the application of advanced composite materials in lightweight structural applications.

APPROACH: Design concepts and materials will be evaluated for identification of those that will meet the very low structural density criteria required for mission performance. Test specimens will be designed, fabricated, and tested for verification of the structural performance.

STATUS: Design and analysis studies of a cylindrical shell structure were initiated by the contractor, Martin Marietta Corporation. Candidate structural concepts being considered are honeycomb sandwich, skin-stringer-frame, truss, and isogrid. Evaluation of these concepts includes investigating various combinations of skins, cores, stiffeners, frames, adhesives, and attachments. Materials include those of boron, graphite, glass, epoxy, aluminum, titanium, steel, and beryllium. The most promising structural concepts are in the process of being fabricated and tested as small test specimens.

MANAGEMENT PROGRESS: None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Reports			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-01 PAGE 2 OF 2

PROBLEMS: None

REPORTS: Monthly progress reports issued under contract NAS8-29979

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-02	908-54-02

4. TITLE:

Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Uwe Hueter	(205) 453-3826	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Thermoelectric Thin Film Thermal Coating Systems, NAS8-28519, Ohio Semitronics Inc. (Note: The task was completed satisfactorily by the contractor on 15 Nov. 1973).

OBJECTIVES: Perform comparison studies of proposed spacecraft systems with and without the use of thermoelectric devices to demonstrate both advantages and disadvantages of thin film thermoelectric devices. Generate parametric performance parameters of thermoelectric devices for understanding the performance characteristics of such devices and use as design aids. Determine experimentally the possibilities of utilizing flame-spray techniques for application of thermoelectric materials on various substrates. The goals are to understand the governing design parameters required for incorporation of thermoelectrics into future spacecraft designs and the determination of the advantages of such devices over conventional systems.

APPROACH: The work scope was divided into 4 tasks.

1. Analysis: Analyze a system, Phase B Space Station radiator, and determine performance characteristics of thin film thermoelectric devices in such a system. Use the data to perform a comparison study for determining the advantages of utilizing thermoelectrics. Perform parametric studies to determine what physical design parameters need to be optimized to design an efficient system.

2. Design: Perform a preliminary design analysis on an integrated thermoelectric radiator to determine the engineering aspects of manufacturing a thin-film thermoelectric radiator panel.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Final Report Phase I on Thermoelectric Thin Film Thermal Coating Systems	J. Harpster, W. Bulman A. Middleton, P. Swindhart, F. Braun	28 Aug. '73
	Final Report Phase II on Thermoelectric Thin Film Thermal Coating Systems	J. Harpster, W. Bulman A. Middleton, F. Braun	19 Nov. '73

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-02 PAGE 2 OF 2

APPROACH: (Continued)

3. Testing: Perform flame spray deposition tests utilizing thermoelectrics to determine the feasibility of this technique for applying thermoelectrics on structural surfaces.

4. Application: Define possible utilization of thermoelectric devices for future applications.

STATUS:

Technical Progress: The study concluded that currently the state-of-art of thin-film thermoelectrics is not compatible for use on large surfaces such as radiators. However, use of very thin bulk type thermoelectric device appears possible.

The use of thermoelectrics on radiators of spacecraft in near-earth orbits does not offer any major advantage over use of conventional systems. However, for heat flux environments 1.4 greater than in earth orbit, the thermoelectric approach begins to have advantages (e.g., power savings) over conventional systems.

Parametric analyses conducted showed that thermoelectric can achieve temperature control over large environmental variations. However, control power required by thermoelectric devices may become excessive unless optimized for specific applications. Thus a universal type thermoelectrics device for general application does not appear feasible for spacecraft where power consumption is normally a critical parameter.

The cursory tests conducted on modified flame spray (hot gas) techniques for application of thermoelectric materials on structural surfaces appear to have merit. It has been shown to give adherent layers with a wide variety of shapes and thicknesses and reasonable thermoelectric properties.

Management Progress: The original contract plus the five month extension was completed 15 Nov., 1973, at a total cost of $69,660. The work conducted was satisfactory and no contract overruns occurred. A final overall contract review was held at MSFC 6 November 1973.

Conclusion: None, other than as reported under Technical Progress.

Problems: None

Forecast: None

Remarks: Continued efforts on application techniques and material property improvements should be conducted.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 4

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-02	909-55-02

4. TITLE:

Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Jack D. Loose	205 453-3824	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space Tug Thermal Control; NAS8-29670, Martin Marietta Corp. - Denver Division

OBJECTIVE: Define Space Tug thermal control system hardware requirements and specifications by analyzing Tug thermal environments and requirements and performing preliminary thermal control system design. Product to be recommended justified hardware systems which will be fabricated in a follow on effort and used for breadboard testing by MSFC to obtain advanced evaluation and optimization of Tug thermal control hardware.

APPROACH: Contract is divided into 5 subtasks:

1. Requirements: Catalogue equipment thermal requirements and constraints for all mission phases.
2. Environments: Compute and catalogue thermal environments for all mission phases.
3. Parametrics: Perform parametric thermal studies to define best methods for thermal control.
4. Systems Design: Prepare preliminary hardware systems specifications and designs and analytically demonstrate performance capability.
5. Hardware Plan: Prepare detailed plan including schedules and resources for executing follow on hardware systems fabrication/assembly.

7. REPORT NO.: Issue:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1. MCR-73-220	Monthly Status Letter (MSL) and Program Schedule-July 73.	Terry Ward	6 August 73
2. " " "	MSL-August 73	" "	6 Sept. 73
3. " " "	1st Quarterly Progress Report, July, Aug., Sept. 1973	" "	8 Oct. 73
4. " " "	MSL - October 73	" "	6 Nov. 73
5. " " "	MSL - November 73	" "	6 Dec. 73
6. " " "	2nd Quarterly Progress Report, Oct., Nov., Dec. 1973	" "	15 Jan. 74
7. " " "	MSL - January 74	" "	13 Feb. 73
8. " " "	MSL - February 74	" "	12 Mar. 74

FIRST BENEFITTING PROJECT: Space Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-02 PAGE 2 OF 4

STATUS:

Technical Progress: Subtask 1, Equipment Requirements/Constraints Catalog. Essentially completed. Equipment items identified totalled 109. Data compiled into handbook form and also stored on tape. Computer program, compatible with MSFC computation facilities, written. Users' manual for adding and extracting from the computerized data bank written; in printing at period end.

Subtask 2, Environments. Completed. Orbital environments for geosynchronous, low earth, and transfer orbits calculated and converted to equivalent Tug sink temperatures for various Tug orientations. Hottest and coldest conditions subsequently selected for parametric studies. Shuttle shadowing cases also calculated.

Subtask 3, Parametrics. Tradeoff studies of exterior surface optical studies performed to determine desired coating properties. Coarse Tug temperatures defined using simplified thermal model. Coating selection alone insufficient for temperature control under coldest case conditions. Insulation baffle added to forward end to raise forward skirt compartment temperatures. Perimeter heat pipes were added around forward skirt to balance large circumferential temperature gradients. Study performed to evaluate effect of honeycomb thermal conductance on compartment temperatures. Effect was favorable but small. Study also performed to evaluate thermal effect of internal power dissipation per unit local area for use in component placement.

A component list was baselined. Parametric results and operational constraints were used to locate components in the forward skirt compartment. A comprehensive detailed thermal model of the component/vehicle was compiled. The model is currently being run to verify the overall thermal design and to identify and make localized corrections where required.

Radiators for fuel cell heat rejection (743 watts maximum) were preliminarily sized. Four radiator panels are 90° apart and 6 square feet each in area. A fluid loop model was formulated to evaluate performance and improve design parameters. Cold case transients run.

Subtask 4, Systems Design. Partial specifications for thermal system elements have been prepared in rough form. Updating and completion awaiting final results of Subtask 3.

Subtask 5, Hardware Plan. Not started.

Management Progress: FFP ten month contract was signed July 2, 1973, for $49,000. Technical reviews held at MSFC in October, November, and December 1973, and February 1974. RFP for sole source extension to build and test breadboard elements issued. Proposal received, in evaluation.

Conclusions: Geosynchronous orbit with Tug side solar oriented imposes severe environmental gradients on Tug design. Also large change in environmental heating exists between low and geosynchronous orbit altitudes. Radiator design complicated by large heating environment range. Sizing for Shuttle (low) orbit may be too cold in geosynchronous orbit. However, forward skirt thermal control can be passive using end insulation baffle, perimeter heat pipes, selected coatings, local heaters and insulation, and possibly louvers.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-02 PAGE 3 OF 4

STATUS:

Problems: Contractor had computation facility problems in January - February which significantly slowed analyses of Subtask 3. Schedule is consequently about six weeks behind planning. Radiator sizing as stated in "Conclusions" may be significant technical challenge.

Forecast: Contract may slip 6 weeks, beyond planned May 1 completion though no slip forecast yet by contractor.

Remarks: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-03	113-31-12

4. TITLE:

Propulsion

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. Miller	205-453-3816	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Low Speed Inducers for Cryogenic Upper Stage Engines, NAS8-29189, Rocketdyne

OBJECTIVE: Design, fabricate, test, and demonstrate the concept of using low-speed hydrogen and oxygen inducers for a Tug engine application requiring no tank pressurization. Select, design, and fabricate the optimum inducer drive system and test it with the inducers to demonstrate transient characteristics and mechanical integrity. At the conclusion of testing, refurbish the hardware and deliver to MSFC.

APPROACH: The program is to be accomplished in five phases. Phase I is a preliminary analysis including hydrodynamic analysis and configuration selection.

Phase II is the detailed analysis and design. Detail drawings and assembly drawings will be made.

Phase III is fabrication and includes purchasing, assembly, and inspection of the hardware.

Phase IV is the testing phase. Current plans call for an out-of-house testing laboratory to perform the work. Rocketdyne will monitor the work and analyze the test data.

Phase V is the refurbishment of the hardware as required prior to delivery to MSFC.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1.	Program Plan	J. A. King	6 Dec 1972
2.	Milestone Report Phase I	J. A. King	19 Jan 1973
3.	Milestone Report Phase II	J. A. King	7 Jun 1973

FIRST BENEFITTING PROJECT: Low Cost Cryogenic Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-03 PAGE 2 OF 3

STATUS: Technical Progress: The Phase I Analysis and the Phase II Design efforts have been completed. The Phase I analysis consisted primarily of selecting the optimum drive system from among turbine, hydraulic and electric drive methods. Based upon use with the RL-10 engine, the electric motor drive was optimum. Both oxygen and hydrogen inducers will utilize direct drive submerged motors. The oxygen inducer motor speed is 3000 rpm and hydrogen inducer motor speed is 14,000 rpm.

Phase II detail design consisted of motor/housing design and integration and detailed hydrodynamic calculations.

Phase III fabrication is now in progress. The motor has been subcontracted to Pesco Products Division of Sundstrand Corp. A variable frequency electrical inverter to drive both inducers is being fabricated by the General Electric Corporation.

Both hydrogen inducers are being assembled and completion is expected by April 15, 1974. The motors for oxygen inducers are also scheduled for completion by Sundstrand April 15. Assembly of the complete units is scheduled for mid-April. G. E. has slipped inverter delivery until mid-April.

Management Progress: A detailed design review of phase II was held on May 24, 1973. The test plan was reviewed and approved on August 30, 1973. The test phase has been delayed until May 1974 due to a schedule slippage in the inverters.

Conclusions: An electric drive system was found to be optimum for this particular inducer application.

Problems: Several manufacturing problems have been experienced in fabricating the electric motors.

Cause of Problems: No exact cause of the fabrication problems has been determined. However, several appear to be due simply to carelessness on the part of Pesco Products in machining, welding, and inspection.

Solution of Problems: The manufacturing problems were detected by Rocketdyne and some of the machining problems have been corrected by them. They have also notified Pesco to refrain from further careless errors.

Forecast: Program completion is now scheduled for August 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-03	PRIOR NO.: None.

4. TITLE:

Propulsion

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
F. W. Braam	205-453-3814	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Design Study of RL10 Derivatives, NAS8-28989, Pratt and Whitney Aircraft, West Palm Beach, Florida

OBJECTIVE: Examine a select number of possible RL10 engine derivatives containing various new features to increase performance and reduce vehicle weight. For each engine derivative, define in detail the engine system performance, weight and operational characteristics. Develop program plans and determine the associated development, production, and operational costs for each derivative.

APPROACH: Analyze in detail such performance improvement and vehicle weight reduction concepts as a two-position nozzle, tank head idle mode, and zero tank NPSH identified in study contract NAS8-29314. Conduct detailed design analyses to the component part level for no more than three engine derivatives or configurations selected by NASA. NASA's configuration selection will be based on results of critical design analyses and recommendations from the vehicle study contractors, the engine study contract, and MSFC in-house specialists. Develop detailed program plans for development production, operation, and flight support for each derivative. Based on these detailed plans, develop a cost breakdown for each configuration.

STATUS: Technical Progress: Engine configurations for the study have been defined and selected. Engine derivative IIA has a two-position nozzle, tank head idle mode, zero NPSH capability, and a maneuver thrust option. Engine derivative IIB has a two-position nozzle and tank head and pumped idle modes. These two engine configurations are derived from the current (RL10A-3-3)flight engine.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Design Study of RL10 Derivatives Monthly Progress Report		
FR-5699	No. 1	-	15 April 1973
FR-5756	2	-	15 May 1973
FR-5812	3	-	15 June 1973
FR-5875	4	-	13 July 1973
FR-5934	5	-	15 August 1973
FR-5593A	Program Plan (Revised)	-	30 April 1973
GP 73-114	Briefing Charts - 1st Review	-	1 May 1973
GP 73-161	" " - 2nd Review	-	27 June 1973
GP 73-217	" " - 3rd Review	-	30 August 1973
FR-5951A	Preliminary Interface Control Document		30 August 1973
FR-6011	Design Study of RL10 Derivatives Final Report	-	15 December 1973

FIRST BENEFITTING PROJECT: Space Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-55-03

PAGE 2 OF 3

STATUS: Technical Progress: (Concluded)

A third engine configuration designated category IV is a completely new engine design maximizing the expander power cycle performance. Its features include a two-position nozzle, tank head and pumped idle modes and zero NPSH.

Design and development, production, and flight operation program definitions and cost analyses are complete for all three configurations. The highlights are given below:

Configuration	Isp	Weight	DDT&E
Derivative IIA	459 sec	513 lb	$44.5M
Derivative IIB	459	474	35.7
Category IV	470	424	71.8

Management Progress: Work began on February 15, 1973. Program reviews and data dumps occurred on May 1, 1973, June 27, 1973, and August 30, 1973. All technical work was completed on September 28, 1973. The final report was issued on December 15, 1973.

Conclusions: The program objective was met. The required engine data and costs were produced on schedule to support the Space Tug Vehicle System studies.

Problems: None

Forecast: This is the final URS report that will be issued on this task.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-05	PRIOR NO.: See Remarks Nr. 2

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. B. Graff	453-4560	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Objectives: To initiate and secure advances in the state-of-the-art in the Electrical Power area aimed at specific improvements in performance, weight and reliability of electrical components/sub-systems to permit attainment of performance compatible with TUG requirements.

Approach: This is being accomplished under various tasks and sub-tasks which are discussed and summarized separately. These tasks and sub-tasks are:

- o TUG Fuel Cell
- o TUG Component Development composed of such sub-tasks as Switch Gear & Circuit Protection, Power Conditioning & Analysis, Motors & Controls for Latching & Docking, Lightweight Cables & Connectors
- o Feed-Thru Electrical Connectors

Status: The Task, "Develop Motors & Controls for Latching or Docking" previously reported has been terminated due to uncertainty of a requirement for this item on the TUG.

Remarks: (1) The Task, "Develop Motors & Controls for Latching or Docking" has been terminated; this is the final report on this task.

(2) See individual Task Sheets for prior numbers.

(3) See individual Tasks for Problems & Remarks.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
See individual Tasks.			

First Benefiting Project: TUG

MSFC - Form 350 (March 1973)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-05	PRIOR NO.: 909-55-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. Morgan	453-2461	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: TUG Fuel Cell Development

Contract No: NAS8-30637, Pratt & Whitney (P&W)

Objective: Develop a fuel cell powerplant for Space TUG. Power requirements are 1.0 KW average and 2.0 KW peak. Minimum weight and cost are goals.

Approach: This is a new task directed towards modification of the Space Shuttle fuel cell technology base to meet TUG requirements. Major emphasis is to be on design modifications of Shuttle hardware to operate at the lower power levels of TUG. Low cost and lightweight are also major considerations. Basic R&D will not be addressed with this task as Shuttle program funding will carry this costing.

Status: This is a new contract for this reporting period.

Technical Progress: Technical requirements have been defined and a contract for the design and development effort has been signed. MSFC facilities are being prepared for testing.

Management Progress: A contract covering the work scope for this task through FY76 to accomplish a detailed design of a prototype TUG fuel cell powerplant has been signed with P&W, the Shuttle Fuel Cell vendor.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

First Benefiting Project: TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 2 OF 2

Conclusions: None.

Problems: None.

Forecast: The first test article delivery is expected during July 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-05	909-55-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
B. J. McPeak	453-4652	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Feed-Thru Electrical Connectors

Contract No: N/A - Task 1, 2 & 4 are in-house. Task 3 will be contracted.

Objective(s): The overall objective of this program will be to develop and prove design concepts to establish a set of feed-thru electrical connectors sufficient for Tug LH_2 and LO_2 tanks penetration.

The proposed three-year lifetime Space Tug shows a configuration of thin wall LH_2 and LO_2 tanks. These proposals also show that there must be penetrations thru this material for both coaxial and conventional connectors. We propose an investigation of these connectors since the long life, low leakage requirements will necessitate connectors that can operate over repeated cycles of ambient to cryogenic temperatures.

Maintenance of reliable connectors of electrical circuit penetrations of propellant tanks is aggravated by severe thermal shock and cycling with the cryogenic liquids involved. Pressure vessel integrity must be maintained to assure extremely low leak rates.

Similar electrical feed-thru connectors are used to penetrate the walls of propellant tanks and other pressure vessels of Saturn Vehicle stages. Numerous problems were encountered with the feed-throughs used on Saturn. Difficulties were most severe with coaxial type penetrations.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

First Benefiting Project: Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 2 OF 2

Approach: It is proposed to conduct the investigation in four phases:

Task 1 - Assessment of requirements: Since both Tug structural design and electrical/electronic system design impose requirements on the feed-thru connectors the first task will be to develop for the connector a statement of performance, design requirements, to develop conceptually acceptable feed-thru connector configurations and to write performance-design specifications.

Task 2 - This task will be to carry out a detailed design of configurations selected in Task 1, for further consideration. This task will include screening of already available components for modification to Tug-compatible configurations.

Task 3 - This task will consist of development and fabrication through contracted efforts, of required configurations as designed in Task 2. The resulting hardware will be prototypes sufficiently similar to anticipated flight hardware to permit valid performance testing.

Task 4 - This task will be in-house testing of the prototype hardware to establish performance characteristics and issue test report.

The total effort is expected to require between 30 months and 48 months to complete. Tasks must be conducted, largely, in sequence.

Status: Effort has been completed to research and evaluate available data on cryogenic connector materials, manufacturers, users and problem histories. Many cryogenic connector users and manufacturers have been visited or contacted. Data obtained from users, describes problems and solutions as well as type of connector design used by each. Data obtained during the survey of manufacturers defines design, material, and environmental capabilities of each connector as well as the manufacturer's performance ability. Collected data analysis has been completed. Trades were made to determine extent of modification of existing cryogenic connector designs versus modification of standard multisource connectors to meet cryogenic applications.

A conceptual design approach has been established with modification of standard multisource connectors to meet cryogenic applications. A complete development specification, 40M38294, has been prepared and released. Tasks 1 and 2 are complete. A 404 Procurement Request was submitted in April 1973, to accomplish Task 3 of this effort. The PR was amended September 20, 1973, and $15,000 funding added for new total of $45,000.

The Scope of Work encompassed in the PR cannot be accomplished with $45K. Request for additional Tug funding has proven fruitless to date. Tasks 1 and 2, although major efforts, have required no contract funds being conducted thru in-house efforts. It is anticipated that a contract will be initiated by May 15, 1974, to begin the out-house phase of Task 3.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-05	909-55-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
B. J. McPeak	453-4652	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Lightweight Cable/Connectors

Contract No: N/A – Inhouse except for various procurements of piece parts.

Objective: The objectives of this effort are to review and assess the various methods (flat conductor cables, ribbon cables, etc.) available to provide lightweight, reliable cable and connector systems for Tug use, to identify those areas needing improvement in the state-of-the-art (e.g., connectors, terminations, shields, etc.) and to carry out the tasks necessary to improve the state-of-the-art to a level which will support Tug development.

Approach: This effort will be conducted in-house. Piece parts will be procured.

A program will be initiated in-house to layout electrical wiring harness configurations meeting Tug Configuration Requirements and to assess the design requirements. For each component run of the harness the advantages/disadvantages of the several possible wiring techniques (flat conductor cables, ribbon cables, individual wire cables) will be established in terms of weight, reliability, complexity, etc.

Evaluation testing of hardware and wiring harness layouts will be conducted in-house, and final design specifications prepared. Detailed harness design requirements will be prepared. Harness types not already included in the document "MSFC 40M39582, Harness Design Standard" will be documented for inclusion as applicable.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
N/A			

First Benefiting Project: Space Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 2 OF 2

Status: Investigation has been conducted defining specific methods and hardware available to provide lightweight cable and connector systems. Ribbon cable configurations have been identified. Procurement requests have been submitted to purchase sufficient quantities of ribbon round wire cable for further detailed in-house MSFC test, analysis, and mockup for comparison with other candidate wire and cable systems. Connectors and other devices for terminating candidate wiring systems have been defined and procurement requests have been submitted.

Approximately 85% of hardware on procurement contracts have been received. The test and evaluation program is now scheduled to begin June 1, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 909-55-05	PRIOR NO.:
4. TITLE: Electrical Power			
5. RESPONSIBLE INDIVIDUAL: J. R. Lanier, Jr.	TELEPHONE: 453-4570	APPROVAL: R. M. Aden S&E-ASTR-E	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Develop Motors and Controls for Latching or Docking

Contract No: N/A – In-house

Objective: Define the optimum motor(s) and control scheme(s) to be used for the latching or docking mechanisms required on the Space TUG vehicle. An optimum system will be defined as that system exhibiting the best approach after such parameters as weight, power consumption (efficiency), performance, reliability (maintenance) and cost are considered. Develop motor system; design and breadboard. Test and evaluate.

Approach: This approach will be accomplished in two phases which are broken down into sub-tasks as follows:

Phase 1 – Motor System Development
- (a) Define Motor System Requirements.
- (b) Select Motor Vendor and jointly perform tradeoff analysis of performance versus weight and/or reliability.
- (c) Identify and prepare specifications.

Phase 2 – Motor System Manufacture & Test
- (a) Design Prototype Motor System.
- (b) Manufacture Hardware.
- (c) Test and Evaluate.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Program: Space TUG.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 2 OF 2

Status: This task has been cancelled effective October 30, 1973, for the following reasons:

(1) Lack of design requirement.
(2) Uncertainty over whether there will even be a requirement for Tug Latching and Docking Mechanisms.
(3) Prime responsibility for Tug Management & Development has been taken from MSFC and assigned to the Air Force.

Remarks: This task has been cancelled. This is the final report under the reporting system.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-05	909-51-05

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. R. Lanier, Jr.	453-4570	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Power Conditioning Analysis and Development

Contractor: Teledyne Brown Engineering, NAS8-29770

Objective: This task will be conducted as in-house and contract in sub-tasks whose objectives are as follows:

Sub-Task 1 - Power Conditioning Equipment Dynamics & Stability Analysis: This effort will be to develop the necessary tools and methods to properly determine the stability and dynamic characteristics of switching mode power conditioning devices. Results will be verified by experimental tests with breadboard type circuits.

Sub-Task 2 - Standardization and Modularization of Power Conditioning Equipment: Efforts will be to develop a data base for the standardization and modularization of circuit designs and packaging concepts for power conditioning equipment. Effort will also include development of built-in test circuitry to check power conditioner performance; identify impending failures, or out-of-tolerance or failed conditions; and interface this diagnostic data with a data bus.

Sub-Task 3 - Power Conditioning Subsystem Circuit and Equipment Development: The objective of this effort will be to develop candidate power conditioning circuits and equipment. Power conditioning circuits capable of handling high power (25 to 250 KW) and high voltage (greater than 100 volts dc) or low voltage (3 to 9 volts dc) will be developed. A family of optimum key basic circuits will be developed and generated. This effort will use the developed circuits to produce working prototype equipment.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
No Number	1-Kilowatt SCR Switching Regulator	Sperry Rand Corp.	1/31/73
SP-243-0788	Investigation of Stagger-Phased Regulator	P. Harper	6/19/73
No Number	A Study of Power Conditioning and Power Distribution Components	M. A. Honnell	9/17/73

First Benefiting Project: Sortie Lab/Tug

Objective: (Cont'd)

Sub-Task 3 (Cont'd)

This equipment will then be tested to evaluate and assess their performance under typical ambient environment.

Approach:

Sub-Task 1 — Dynamics & Stability Analysis: An in-house effort will be conducted to develop transfer functions and mathematical models for all types of switching-mode studies to determine criteria, methods and tools for predicting dynamic characteristics and insuring stability of the devices. Results will be verified and demonstrated by experimental tests using in-house breadboard type circuits.

Sub-Task 2 — Standardization and Modularization of Power Conditioning Equipment: This effort will be a contract program conducted in five (5) phases as follows:

Phase 1 — Define power conditioning and built-in test requirements.

Phase 2 — Select candidate circuits meeting requirements, perform trade studies and select preferred circuitry.

Phase 3 — Identify subcircuit elements for thin or thick film microcircuit production.

Phase 4 — Design and develop a standard package and packaging techniques.

Phase 5 — Construct working prototype for testing and evaluation.

Sub-Task 3 — Power Conditioning Subsystem Circuit and Equipment Development: This effort will be accomplished in two phases which are further broken down into subtasks as follows:

Phase 1 — Circuit Development
- (a) Generate functional circuit block diagrams.
- (b) Generate parametric data for circuits.
- (c) Perform tradeoff analysis of performance versus weight and/or reliability.
- (d) Identify specifications for developed circuits.
- (e) Identify requirements for critical piece parts.

Phase 2 — Prototype Equipment Development
- (a) Purchase, analyze, and qualify piece parts as necessary.
- (b) Manufacture candidate prototypes of power conditioning.
- (c) Evaluate equipment by test in laboratory. The new equipment will be tested as separate items under various environmental conditions and then incorporated into a system type test. This testing will allow the use of various power sources and real or simulated so that all candidate power conditioning concepts may be evaluated. Operational response of the equipment will then provide inputs for necessary design modifications.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 3 OF 3

Status:

Technical Progress:

Sub-Task 1 - The final report of Contract NAS8-26752, titled "A Study of Power Conditioning and Power Distribution Components", defines the results of this effort. Therefore, this sub-task is considered completed.

Sub-Task 2 - Work is continuing on construction of the load center type power conditioner (Phase 5). Minor packaging problems (plug-in connectors, heat elimination, etc.) have occurred but each has been solved satisfactorily.

The centralized type power conditioner is in the design and breadboard phase (Phase 2).

Sub-Task 3 - None.

Management Progress:

Sub-Task 1 - Sub-task has been completed.

Sub-Task 2 - None.

Sub-Task 3 - None.

Problems:

Sub-Task 2 - Due to hybrid circuit vendors inability to meet required delivery dates, the fabrication schedule of the load center power conditioner prototype has been slipped by two months.

Sub-Task 3 - Two additional contracts for required piece parts (high voltage transistors, high voltage rectifiers) have been cancelled because vendors could not deliver. This makes a total of five piece part contracts which have been cancelled and means an even more serious delay than previously reported.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-05	

4. TITLE:

Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Donald E. Williams	453-4653	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Switch Gear & Circuit Protection

Contractor: NAS8-29965 - Leach Corporation, Los Angeles, Calif.

Objective(s): Component research and breadboard development of high voltage solid state power controllers. Final results will be the development and MSFC qualification of solid state power controllers capable of flight applications. These devices will optimize current and voltage capabilities as determined by Breadboard development and semiconductor component availability.

Approach: Phase A - Perform research of the availability of semiconductors, etc., that have high voltage, gain and safe operating area (SOA) characteristics. Utilize the research to procure and fabricate a Breadboard model of a high voltage (output stage) power controller.

Phase B - Design, develop and fabricate 4 each solid state power controllers at 5 and 10 amperes. These devices are to meet the technical and functional requirements of the specification included in the contract work scope.

Status: Procurement request prepared and submitted to purchasing in mid-March 1973. Proposal evaluation completed July 1973. Negotiation completed and contract awarded January 1974. Phase A is in process; projected completion date - April 1, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

First Benefiting Project: TUG

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-05	PRIOR NO.:

4. TITLE: Electrical Power

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Herndon, R. H.	205-453-1508	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Light Weight Flat Conductor Cables and Connectors In-House

OBJECTIVE: The objective of this effort is to provide an improved light weight electrical power distribution and interconnect system for the weight-sensitive Space Tug. The effort will provide the necessary advancement in current flat conductor cable (FCC) technology in the areas of shielding methods, thin wall connector designs, high density miniaturized distributors and low-profile cable transitions which will meet specific Space Tug system design and environmental requirements.

APPROACH: This in-house effort will include the necessary tasks for component test and evaluation, full system studies, studies to establish optimum routing of FCC, installation and refurbishment procedures, new component design and hardware specifications which will support the Space Tug development. During FY-74 and FY-75, available funds will be used to purchase materials for in-house research, development, testing and evaluation tasks. These tasks will include any necessary work for the development of an improved light weight connector design, development of multiconnector distributor, FCC/shielding laminating techniques, etc. If additional funds become available, contracts could be utilized to conduct full system studies, prepare mock-ups for routing and installation studies and for the preparation of documentation and specifications.

STATUS: Technical Progress: Two sizes of an improved individually sealed contact connector are under development and are presently being tested and evaluated. The design of a prototype multiconnector distributor has been base-lined. Two types of a low-

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
No formal in-house report has been issued. In-house accomplishments are reported in the Weekly Notes.			

FIRST BENEFITTING PROJECT: Space Tug

MSFC - Form 350 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-05 PAGE 2 OF 2

TASK: Light Weight Flat Conductor Cables and Connectors

STATUS: Technical Progress: (Continued)

profile cable transition are presently being tested and evaluated. The "TermiPoint" method for making terminations is being evaluated. Various types of flat conductor cables are being evaluated for this application. This in-house effort will also utilize information obtained from (1) Review and studies of the SRB Avionic Canister and Interconnect Conceptual Designs. Component and FCC layouts will be made and converted to scale mock-ups in order to establish an optimum design with acceptable volume utilization and weight savings. (2) Monitoring, review, evaluations and assessment of a study by Lockheed Missile and Space Company for the SEPS Solar Array Technology.

Management Progress: FY-75 funds are being requested to start development on light weight aluminum FCC, terminations and connectors.

Conclusions: None

Problems: None

Forecast: This effort should continue through June 1976.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-10	909-55-05

4. TITLE:

Guidance and Navagation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. D. Ellsworth S&E-ASTR-SG	453-4583	J. L. Mack

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Investigate the problems of calculation of the Space Tug's position in an inertial coordinate frame. NAS8-29852 Auburn University Research Foundation, Auburn, Alabama.

OBJECTIVE(S): The objective of this task is to investigate the problems associated with calculating the Space Tug's position in inertial coordinates. The problem areas to be investigated will include periods when little or no measurable accelerations are present. Also to be investigated are the problems associated with updating the vehicle's attitude using onboard measurements in conjunction with ground or onboard computations. Measurement sensors will include sun sensors, star trackers and either gimballed or strapdown inertial measurement units.

APPROACH: The approach to be taken in this study effort will be to first identify the areas of concern. For each of these areas identified potential solutions will be identified and investigated both analytically and numerically. Techniques used to solve the problems will include Kalman Filtering, math modeling of forces etc. Attitude update techniques will be identified and sophisticated numerical procedures used to solve the problem in ground based digital computers. Techniques will then be used to simplify the scheme for onboard implementation. Onboard computer requirements will be established for the navigation and attitude update schemes above.

STATUS: Technical Progress: Two meetings were held at MSFC to discuss the study areas and the approach to be taken in performance of these activities. It was decided that the study effort should be primarily directed toward the periods of low (or zero)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1	Progress Report for 9/19/73 to 10/19/73	Joseph S. Boland III	October 31, 1973
2	Progress Report for 10/19/73 to 11/19/73	Joseph S. Boland III	December 12, 1973
3	Progress Report for 11/19/73 to 12/19/73	Joseph S. Boland III	January 5, 1974
4	Progress Report for 12/19/73 to 1/19/74	Joseph S. Boland III	February 1, 1974
5	Progress Report for 1/19/74 to 2/19/74	Joseph S. Boland III	March 13, 1974

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-10 PAGE 2 OF 2

thrust navigation. Two techniques for navigating during these periods are to be investigated.

The first technique involves modeling the forces that will act on the vehicle to determine accelerations and hence position and velocity. An attempt will then be made to perform navigation updates using celestial measurements (sun sensors, star trackers). Analysis of the proposed scheme will be conducted to determine performance capability.

The second technique involves the use of a horizon sensor to supplement the celestial measurements and the force models. Similiar analysis is planned for this scheme also.

A six-degree-of-freedom digital simulation is being developed to perform parametric studies of the two schemes and also to help determine the effects on measurements of the vehicle rotational dynamics.

Management Progress: Two meetings have been held at MSFC during this reporting period. The contractor is expected to request a no cost contract extension in the next reporting period. The interim review scheduled for this reporting period was not held. It was postponed to better reflect the status of the study activities as shown on the Milestone Schedule Chart.

Conclusions: None

Problems: None

Forecast: More activity in the analysis area will take place in the next reporting period. The six-degree-of-freedom simulation should be completed and Checkout.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 73 31 03 74	CURRENT NO.: 909-55-10	PRIOR NO.: 909-55-05

4. TITLE:

Guidance and Navigation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D.O. Lowrey	205-453-1578	W.O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Space Tug Scanning Laser Radar

The objective of this effort will be to develop a Scanning Laser Radar sensor, which can be space qualified, that will provide range, range rate, angle, angle rate, roll and roll rate data to meet the rendezvous and docking requirements of the Space Tug. Studies, designs, laboratory development and testing will be performed to determine the optimum system design and performance parameters for rendezvous and docking with space targets. A scanning laser radar (SLR) can greatly facilitate Tug rendezvous and docking maneuvers for input into the spacecraft guidance and control system for automatic rendezvous and docking. The SLR will also provide data display information for man-in-the-loop system operation.

Approach: The SLR for Tug applications will be developed by incorporating design improvements and modification into the current SLR prototype model. Better components will be designed, developed and incorporated to enable the system to meet the Tug requirements.

Status: Technical Progress ---- The generation no. 3 laser radar has been set up in the laboratory for test and checkout. The output power from the laser transmitter has considerably degraded in output power level. Investigations will continue to determine if it is due to operational degradation of the laser or pulse power supply.

Investigations and trade-off studies for use of a CO^2 laser source instead of a Gallium (cont'd)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Development of Generation no. 3 Scanning Laser Radar, Final Report of Phase III.		January 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-10 PAGE 2 OF 2

Status :------ Technical Progress -(Cont'd)
arsenide laser source have begun. The effort has not progressed to the point that results can be reported. The study effort was started during the last month of this reporting period.

Management Progress: The contract for the start of the CO2 Laser Source tradeoff study is being negotiated with Norden Division of United Aircraft. The contract for a new laser diode study investigation with IBM has not been finalized. The contract NAS8-20833 with ITT, Gilfillan Division has been completed and all residual components delivered. All ITT contractual effort is now completed.

Conclusion: The progress reported is on schedule.

Problems: None

Cause of Problem: None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
Marshall Space Flight Center	01 10 73 31 03 74	CURRENT NO.: 909-55-37	PRIOR NO.: 908-52-37

4. TITLE:

CRYOGENICS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. E. Stonemetz	453-3854	A. L. Worlund

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space LOX Vent System

CONTRACT: NAS8-26972, General Dynamics/Convair

OBJECTIVES: To design, build, and demonstrate a prototype vent system capable of exhausting only vapor from an all liquid or two-phase mixture of oxygen under low or zero-gravity conditions.

APPROACH: A literature search and an analytical investigation of various liquid-vapor separator concepts will be conducted. The most promising concept, considering separation efficiency, weight, simplicity, and current technology, will be thoroughly analyzed. A system design will be made, including a parametric study showing overall system weight, efficiency, vented mass, etc., for specific design conditions. A prototype of the selected system will be designed, fabricated, and tested.

STATUS: Technical Progress: A compact bulk heat exchanger vent system has been selected and designed as the best overall system to meet the requirements for a zero-gravity LOX tank vent system for 7 to 30-day missions. Individual vent system components have completed LOX compatibility testing. System assembly has been completed and is ready for installation into the test tank.

Management Progress: Current availability date for the test facility is April 19, 1974, following completion of tasks under contract NAS8-27419, "Design and

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
GDC 584-4-716	First Quarterly: Space LOX Vent System	J.A. Stark & J.R. Elliot	Oct 8, 1971
GDC 632-1-17	Second Quarterly Space LOX Vent System	J.R. Elliot, M.D. Walter, J.A. Stark	Jan 21, 1972
GDC 632-1-82	Third Quarterly Space LOX Vent System	J.R. Elliot, J.A. Stark	Apr 18, 1972
GDC 632-3-134	Design Phase Report Space LOX Vent System	J.A. Stark	Aug 10, 1972

FIRST BENEFITING PROJECT: SPACE TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-37 PAGE 2 OF 3

Development of Pressurization and Repressurization Purge Systems for Reusable Space Shuttle Multilayer Insulation Systems." The 240-hour test program is expected to begin June 10, 1974.

Conclusions: Analysis shows that the bulk heat exchanger concept best meets the requirements for a zero-gravity LOX tank vent system for 7 to 30-day missions.

Problems: The contractor is not able to test the prototype system due to an on-going project in the test facility.

Cause of Problem: Extension of contract NAS8-27419 for further testing.

Problem Solution: Delay work on vent system until test facility is free (about June 10, 1974).

Forecast: Expected completion is September 30, 1974.

REMARKS: None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
Marshall Space Flight Center	01 10 73 31 03 74	CURRENT NO.: 909-55-37	PRIOR NO.: 112-30-19

4. TITLE:

CRYOGENICS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Eric H. Hyde	453-3852	A. L. Worlund

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study of Multilayered Pipe Penetration and Long-Term Storage of Cryogenics

CONTRACT: NAS8-26642, Lockheed Missiles & Space Company, Inc., Huntsville, Alabama

OBJECTIVES: The objective of this program is threefold: (1) Provide thermal design data needed for the design of insulated pipe penetrations, both stainless steel and Inconel/fiberglas hybrid penetrations extending through multilayered insulation blankets on cryogen tanks; (2) Analytically model and experimentally verify the thermoacoustic oscillations which spontaneously occur in tubes having an open end exposed to approximately 4°K environment and the closed end to ambient conditions; and (3) Analytically predict the criteria for the design of long-term cryogenic storage containers of minimum mass for future long-term space experiments requiring cryogenic storage without replenishment.

APPROACH: The multilayered pipe penetration is a three-phase program devoted to parametric thermal analyses with the end result the generation of a complex matrix of data, a test program to verify the analytical portion of the program, and a combination of tests to help understand factors that influence the prior tests, such as outgassing, MLI residual pressure and ambient storage.

The thermoacoustic oscillations program includes both analytical predictions and experimental verification of the analytical results to determine the parameter(s) which will

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
D225403	Quarterly Progress Report	G. D. Reny	Sep 27, 1971
D225579	Quarterly Progress Report	G. D. Reny	Dec 23, 1971
D225792	Quarterly Progress Report	G. D. Reny	Apr 5, 1972
D306220	Quarterly Progress Report	G. D. Reny	Sep 27, 1972
D306392	Quarterly Progress Report	G. D. Reny	Jan 4, 1973
D306570	Quarterly Progress Report	G. D. Reny	Apr 2, 1973
D306680	Quarterly Progress Report	G. D. Reny	Jul 5, 1973
D306889	Quarterly Progress Report	J. K. Lovin	Oct 1, 1973
D390053	Quarterly Progress Report	J. K. Lovin	Feb 5, 1974

FIRST BENEFITING PROJECT: Space Tug

result in the required combination of criteria to establish the onset of the thermoacoustic oscillations. This requires the solution of the Navier-Stokes equations in a non-linear form in order to nullify the effects of linearizing certain parameters which are not considered to be of second-order effect.

The design of long-term cryogenic storage containers in order to maximize the effectiveness of space experiments requiring six months to three years duration will necessitate minimizing the mass of the storage system. A systematic variation of storage container configurations, including liquid cryogens, solid subliming cryogens, vapor shields, space radiators and combinations of these will be analytically modeled for maximum efficiencies (or minimum mass requirements).

STATUS: Technical Progress: Analytical modeling of the penetrations analysis, with variables of penetration diameter, wall thickness and insulation length has been completed. The experimental verification of these modeling requirements and variables is well underway. Goldized Kapton is the multilayered insulation being used.

The thermoacoustic analytical modeling requirements have been completed, with computer checkout runs being performed for both total system checkout and prediction of experimental results to be performed. The experimental tasks will begin shortly using liquid helium and liquid nitrogen as cryogenic sources, and aluminum and stainless steel tubes.

The analytical modeling of the long-term storage cryogenic containers has just been initiated.

Management Progress: The basic contract has been amended nine times, with the latest amendment for the purpose of expanding subjects related to thermoacoustic oscillation analytical treatments and to improve testing techniques. The modification will allow the performance of additional studies related to the long-term storage of liquid helium.

Conclusions: The multilayered insulation pipe penetrations tests have confirmed, within reasonable limits, the predictions as made by the analytical modeling techniques. These have been more closely matched through temperature distributions than through net mass flow measurements.

The thermoacoustic oscillation analytical model is operational. The results to date have not clearly defined the criteria for onset of the oscillations, but this is due to the lack of the correlation of parameters which are to be defined during the study.

Problems: Problems were encountered early during the contract upon procurement of the cryostat to be tested. Due to faulty welding techniques, fractures developed requiring fabrication of a new cryostat. An additional flange was required to be fabricated for sealing purposes. Multiple failures in flowmeter sensors required repeated test postponements. The analytical modeling techniques used in the thermoacoustic oscillations computer program required complex scaling techniques in order to reduce the real-time computer requirements, forcing delays in obtaining meaningful oscillation results.

Cause of Problems:

- Cryostat failure - improper welding techniques
- Flange failure - improper seal method

- Flowmeter failures - cause apparently equipment weakness
- Scaling factors - inordinate complex solution technique of non-linear Navier-Stokes equations

Problem Solution: All described problems have been solved with no additional "fixes" anticipated.

Forecast: The multilayered insulation pipe penetrations tests, thermoacoustic oscillations modeling and tests and the long-term cryogenic storage model studies are anticipated to be completed in the second quarter of FY75.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-40	PRIOR NO.:

4. TITLE:
Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. L. McComas	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Curved Shell Finite Element for Space Tug (Continuation of Finite Element Modeling Optimization) NAS8-26284 Bell Aerospace Co.

OBJECTIVE(S): The objective will be to develop a curved shell finite element which will accurately determine antisymmetry shell vibration modes and dynamic response in a solution time effectiveness. The element or elements will be implemented into the MSFC NASTRAN program.

APPROACH: The approach will be to assess the curved shell finite element state-of-the-art and from the assessment results select the most promising element and implement the element into the NASTRAN program. After implementation, the element will be evaluated in its ability to model the Space Tug vehicle and produce accurate modes and responses.

STATUS: Technical Progress--The computer coding for the curved shell element is now being developed for NASTRAN Level 15.5.
Management Progress--The NASTRAN documentation and program tape for the UNIVAC 1108 version was delivered to Bell in December 1973, by the MSFC program monitor. The progress was reviewed and determined to be satisfactory.
Conclusions, Problems, & Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
2523-950002	NASTRAN Implementation of the Transformed Shallow Shell Element for Space Tug Applications	Michael C. Apostal Stephen Jordan	Oct. 73

FIRST BENEFITTING PROJECT: Space Tug & Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-40	909-55-40

4. TITLE:

Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DD, Mario H. Rheinfurth	205 - 453-2470	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study on Space Tug Automatic Docking Control
Contract Number NAS8-29747; Lockheed Missile & Space Co., Inc., P.O. Box 504, Space Systems Division, Sunnyvale, California - 94088

OBJECTIVE(S): The study will be used to generate design requirements for the attitude system for autonomous docking and compare this mode with remote control. In addition, docking sensor and hardware requirements will be specified.

APPROACH: Phase A. Literature Search - The literature search will be accomplished by both manual and computer searching.

Phase B. Terminal Control Strategies and Sensor Requirements - The baseline docking control strategies, sensors, and hardware will be incorporated into the simulation. Data to determine the sensor requirements will then be derived by simulation and analysis.

Phase C. Influence of Docking Mechanism - Docking accuracy specifications for different mechanisms will be derived. The simulation will be run varying the noise, resolution, and bias of the sensors. End conditions of the simulation will then be compared to the specification to ascertain the probability of a first attempt at successful docking.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRST BENEFITTING PROJECT: Space Shuttle-Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-40 PAGE 2 OF 3

APPROACH (CONCLUDED):

Phase D. Effects of a Missed Docking Attempt on Tug Propellant Consumption and on the Payload Control System - The end conditions listed by the previous phase will also include the angular momentum imparted to the payload. In addition to knowing the Tug thrusters attitudes and separation from the payload, the angular momentum caused by impingement would also be calculated.

Phase E. Program Documentation - Complete user's documentation will be provided. In addition a one-day seminar and training session, using the program documentation, will be held.

STATUS:

Technical Progress--The literature search has been completed and a bibliography was prepared.

The docking Mechanism Design Study has been completed. Five docking mechanism designs were analyzed and rated. The International Docking Mechanism (Apollo/Soyuz) was rated highest. Two docking control strategies, (proportional guidance mode and explicit guidance) have been formulated and are being implemented into the simulation. It was also recognized that a realistic docking simulation should incorporate low-g propellant slosh effects. A technical brief is being prepared to simulate propellant slosh.

Management Progress--Docking strategies coordination meeting was held in November 1973. Also discussed were low-g propellant slosh and the Standard Characteristics for Analysis. The Mid-Term Review meeting is scheduled for the end of March.

Conclusions--None

Problem--The Hybrid computer facility at LMSC-Huntsville is in the process of being sold and is not available for use. A request to MSFC for Hybrid Computer Lab Support has been submitted and is being reviewed.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	909-55-40	909-55-40

4. TITLE:

Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DD, Mario H. Rheinfurth	205 - 453-2470	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space Tug Recovery of Spinning Satellite
Contract Number NAS8-29627; Northrop Services, Inc., 6025 Technology Drive, P.O. Box 1484, Huntsville, Alabama

OBJECTIVE(S): Develop techniques for the recovery of free spinning satellites, requiring a minimum of modifications to Tug design. A desirable result would be a single recovery system capable of recovering both spinning and non-spinning satellites.

APPROACH: Phase A. Evaluation of Docking Mechanisms - Several docking mechanisms will be investigated for their applicability for recovery of spinning satellites. One or more mechanisms will be recommended which appears most feasible and requires the least Tug redesign.

Phase B. Capture Boundaries - Establish capture boundaries for retrieving spinning satellites in terms of initial misalignments and dynamic conditions.

Phase C. Stability Analysis and Dynamic Studies - Establish stability limits and perform dynamic simulations of all phases of the docking maneuvers including missed docking attempts.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRST BENEFITTING PROJECT: Space Shuttle-Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 909-55-40

PAGE 2 OF 3

APPROACH (CONCLUDED): Phase D. Sensor Requirements and Control Logic - Investigate requirements for, and implementation of, docking sensors. Establish translational and attitude control logic to accomplish initial capture and subsequent despin and hard docking. Logic includes action to be taken in the event of unsuccessful docking attempt.

STATUS:
Technical Progress--Several docking mechanisms have been investigated. The McDonnell Douglas Docking System was selected as the most suitable for capturing spinning targets. The analytical equations describing the motion of two coupled bodies to be used in the stability analysis were derived and are being programmed for digital simulation.

A model for the round-ring docking mechanism has also been developed, and logic for detecting unsatisfactory docks has been defined.

The stability analysis using the analytical equations of motion is presently continuing. Examination of the nature and requirements for despin torques has begun.

Management Progress--The analytical equations of motion for two rigid bodies connected at a single point have been submitted by the contractor for verification. A midterm meeting is scheduled for April to review past work and discuss planned future activities.

Conclusions--None

Problem--None

Causes of Problems--None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-40	PRIOR NO.:

4. TITLE:

Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DDS Frank M. Bugg	205/453-2526	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Experimental Study of Transient Liquid Motion in Orbiting Spacecraft, Contract No. NAS8-30690, Martin Marietta, Denver, Colorado.

OBJECTIVE: Develop a computer model of propellant in a spacecraft propellant tank during docking. The model must be suitable for use in control studies. Verify the model with experimental results.

APPROACH: Conduct experiments to simulate liquid motion in a spacecraft propellant tank during docking. Use liquid mass density, viscosity, surface tension, and contact angle with tank acceleration and characteristic length as variables for determination of scaling parameters. Develop a computer simulation of the liquid dynamics described above using a point mass representation of the liquid and correlate the experimental and computer results.

STATUS: Technical Progress - A scaling study is underway.

Management Progress - Contract NAS8-30690 was let to Martin Marietta February 20, 1974.

Problems - None

Forecast - Drop test planning and execution should be accomplished during the coming six months.

Conclusions - None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Tug

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-47	PRIOR NO.: 909-55-47

4. TITLE:
Environmental Quality

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Werner K. Dahm S&E-AERO-A	205-453-1092	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study of Space Tug Propellant Dumping During Space Shuttle Abort
NAS8-30379
Combustion & Explosives Research, Inc., 1007 Oliver Building, Pittsburgh, PA 15222

OBJECTIVE(S): To perform a preliminary study of combustion and explosion hazards caused by the dumping of Space Tug propellants during Space Shuttle launch abort; to arrive at a preliminary definition of permissible and nonpermissible times and modes for the dumping of cryogenic or hypergolic propellants.

APPROACH: MSFC provided preliminary flow field estimates for the propellant dump plumes, propulsive jet plumes, and surrounding air flow. Contractor investigated the corresponding hazards.

STATUS: Technical Progress -- The contract has been completed in March 1974. The final report has been received and approved.

Management Progress -- The contract has been signed and completed during this reporting period.

Conclusions -- The objective has been accomplished. The results are being incorporated by MSFC into a preliminary assessment report.

Problem -- None

Forecast -- None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Combustion & Explosives Research, Inc. March 12, 1974	Study of Space Tug Propellant Dumping During Space Shuttle Abort	Dr. Bernard Lewis Mr. Bela Karlovitz	n/a

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 909-55-47	PRIOR NO.: 908-54-22

4. TITLE: Environmental Quality

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Robert E. Smith	205/453-3140	Leonard L. Davis W. W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Dynamic, Three-Dimensional Atmospheric Models
Contract No. NAS8-28248, University of Alabama, Huntsville, AL 35810

OBJECTIVES: To develop dynamic, three-dimensional atmospheric models which are realistic representations of existing conditions. These models will be used for studies on trajectories, guidance, and heating of re-entering space vehicles. Emphasis will be on dynamic aspects of environment.

APPROACH: The short-term approach will be to analyze atmospheric variations in available data and to empirically model these variations to improve the representativeness of current engineering atmospheric models. The longer-term approach is to combine theories and observations to develop global three-dimensional atmospheric models based on available and future data and including all known energy sources, transport effects, and vertical and horizontal motions. Results of studies will provide direct inputs into air braking and related activieies to permit relative assessment of pertinent design trade-off parameters and configurations.

STATUS:

Technical Progress: (a) The lift effect computer program has been modified to employ the lift and drag properties of a flat plate.

(b) A range of gas surface interaction parameters is being used in the dual falling sphere evaluation.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A	Free Molecule Diffusion of Spherical and Cylindrical Particles	G. R. Karr	N/A
N/A	Dual Falling Sphere Determination of Density and Transition Flow Parameter	G. R. Karr	N/A

FIRST BENEFITTING PROJECT: TUG

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 909-55-47 PAGE 2 OF 3

STATUS:

Management Progress: No change.

Conclusions: Falling sphere evaluation is providing data on the transition flow regime and aerodynamic characteristics in that regime. Some temperature data have been retrieved from the falling sphere analysis; however, some additional gas-surface interaction need to be analyzed.

Problems: Limited number of available dual falling sphere data place a limit of the validity of the results derived by this technique. Technique is very promising and may be worthy of making additional falling sphere measurements.

Forecast: Determination of effects of additional vehicle parameters on drag determined densities may become so involved and complicated that establishment of a model atmosphere containing all of the short period fluctuations may not be possible in the current time frame.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-20	970-62-20

4. TITLE:

Food, Atmosphere, Water and Waste Management

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. E. Clonts	205-453-3828	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Analytical Methods for Evaluation and Control of Advanced EC/LSS
NAS8-28982 McDonnell Douglas Astronautics Company, Huntington Beach, CA.

OBJECTIVE: The objective of this study is to produce a mathematical model utilizing the G189A computer program that completely maps and determines the operating conditions and characteristics of the RITE Integrated Waste Management Water System.

APPROACH: For mathematical modeling, the RITE system will be divided into its constituent loops, low temp heating, flush water, air, solid waste, vapor, potable water storage, cooling and high temp heat source. These loops will be investigated to determine the compatibility with G189A. Any incompatibility will be corrected by devising new, or renovating existing subroutines. A mathematical model will be made of each loop, the loops will then be combined to form a cohesive and complete RITE system model. A performance analysis will be made and correlated, with experimental data to ensure model validity. This model will then be made compatibile and operational on MSFC's 1108 EXEC 8 system.

STATUS: Technical Progress - The investigation into the compatibility of the G189A program for use in modeling the RITE system indicated the need for programming of four new subroutines and renovation of one existing subroutine. These subroutines are for the RITE systems evaporator, condenser, pyrolysis unit, incinerator and tank with internal heating or cooling coil and have been checked out and integrated into the G189A computer program. A complete operational envelope including failure mode analysis utilizing this model has been

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1 thru 10	Analytical Methods for Evaluation and Control of Advanced EC/LSS	J. V. Coggi	10 thru 12, 1972 1 thru 7, 1973
MDC G4901	Analytical Methods for Evaluation and Control of Advanced EC/LSS	J. V. Coggi A. V. Loscutoff R. S. Barker	11-73

FIRST BENEFITING PROJECT - Sortie Lab

MSFC - Form 360 (March 1978)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-62-20 PAGE 2 OF 2

Technical Progress - Cont'd

made of the RITE system. This model is completely functional on MSFC's 1108 computer complex.

Conclusions: This contract has been completed. All documentation and final reports have been completed and published.

Problems - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-23	970-62-23

4. TITLE:

Water and Waste Management

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. L. Moses	205-453-3832	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Vacuum Distillation/Vapor Filtration (VD/VF) Water Recovery System NAS8-27467, General American Transportation, Niles, Ill.

OBJECTIVE: To develop a system for reclamation of water from urine in a low gravity environment. System must reclaim 98% of urine, purify to levels prescribed by the National Academy of Science (NAS) and provide means of solids removal. Other design goals are: weight of under 175 lb., power consumption less than 200 w, high reliability and minimum maintenance.

APPROACH: A prototype unit has been designed, built and tested on the ground. Further testing will be accomplished in low "g" aircraft flights. Work was accomplished in phases. First phase provided evaporator/catalyst and subsystem tests, second phase provided condenser/separator and systems tests. Third phase was to provide low gravity testing.

STATUS: Technical Progress - Unit has been designed, built and tested in 1 "g", with production of water that meets NAS requirements, water recovery rates as predicted. Design for low gravity testing was completed and fabrication was begun, fabrication was not completed due to cost overruns.

Management Progress - Contractor under bid by approximately $40K. Funds were not available for completion of Phase III and therefore the project was terminated. This will be the last semi-annual report on this contract.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1528	Design, Manufacture and Checkout Testing of an Evaporator for Water Recovery by Vacuum Distillation - Phase I	Honegger Remus Krug	April 1972
1528	Ditto - Phase II	Honegger Remus Krug	March 1973

FIRST BENEFITING PROJECT - Sortie Lab (Flight Experiment)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 970-62-23

PAGE 2 OF 2

Conclusions - VD/VF unit reclaims water efficiently with high degree of purity, exceeding NAS standards.

Problems - Due to cost overruns the flight portion of the test program was cancelled.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-40	970-62-21

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. C. Clark	205-453-3828	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study/Integration of the Bosch CO_2 Concentrator With the Hydrogen Depolarized Cell CO_2 Concentrator (HDC)
NAS8-29623, Life Systems, Inc. (LSI), Cleveland, Ohio

OBJECTIVE: Determine whether or not the Bosch can be operated satisfactorily at the 1-3 PSIG discharge pressure of the HDC. Resolve pressure fluctuation problems associated with switch-over from one Bosch unit to the other, with resulting operational impacts on the HDC. Determine the amount of instrumentation communication required between the Bosch and the HDC. Confirm data outlined above with testing.

APPROACH: Both the Bosch and HDC will be mathematically modeled and computer analyses made to determine effect of Bosch operating characteristics on HDC. Test program to confirm analytical findings, suggested operating and control modifications to Bosch and HDC will be recommended.

STATUS: Technical Progress - Preferred Bosch operating characteristics were obtained from the Bosch prime contractor, and 200 hour evaluation tests were run with a one man HDC to determine the impact of these conditions on the HDC. The first test was run with the HDC exhaust supplying an H_2/CO_2 ratio of 2, which is favored by the Bosch. No adverse conditions were detected with the HDC, as a matter of fact, efficiency was improved from 78% to 82% by operating in this mode. An additional 100 hour test was run maintaining the exhaust gas H_2/CO_2 ratio mentioned above and increasing the exhaust gas pressure to 4.5 PSI (necessary to supply reacting gasses to the Bosch re-cycle control system). The results of this test indicated that there were no problems associated

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Reports 2 - 8	Monthly Progress and Financial Reports	F. Schubert	Oct. 73 - Mar. 74

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 970-62-40

PAGE 2 OF 2

Technical Progress Cont'd

w operating the HDC at this pressure level. Further studies have been conducted to d mine the impact of the different Bosch system operating modes on operation of the H The Bosch operating modes studied were startup, shutdown, steady state and reactor c t over. It was determined that a pressure relief type dump valve would be required t clude over pressurization of the HDC when the Bosch is shut down. No other con- d n posed any difficulty to the HDC. A failure modes and effects analysis was run o th systems to determine what controls would be required to accommodate anticipated f res. The conclusion which resulted from this study, and which will be used as a g ng principle in future integration effort, is that tolerance limits on interface c al parameters will be established for each system, if these limits are exceeded i ther system, a standby, dump, or shutdown mode will be effected within the other u Controls required to accommodate system fluctuations occurring in failure modes w be excessively complex for the slight system gains effected. A spectrographic a sis of HDC exhaust gas was run to determine potential contaminants which could a t the catalytic reaction of the Bosch system, none were found.

th Management Progress - The procurement request for the FY 74 continuation of effort has been forwarded to procurement, and an RFQ is in progress.

Conclusions - Tentatively; no difficulty in integration between Bosch and HDC.

Problems - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-40	970-62-40

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. W. Littles	205-453-3831	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Aircraft Flight Testing of Fluids in a Zero Gravity Experiment NAS1-11735, General Dynamics, San Diego, CA.

OBJECTIVE: To flight test, at reduced gravity, in an aircraft an experiment in fluid management. The test results, along with results to be obtained at standard gravity on the same hardware, will be used to validate and update analytical models compiled under a previous contract.

APPROACH: Hardware has been fabricated which will be used to provide experimental data from laboratory and KC-135 aircraft tests on the gravity effects associated with the following flow phenomena: (a) two phase flow (b) inertial separation and (c) film transport and stability characteristics. The data will be used to validate analytical models for these fluid flow situations. The hardware is modularized so that the fluid flow sections can be replaced to provide the configuration required for a given flow condition. The power supply and instrumentation packages are in a separate module and are the same for all flow experiments.

STATUS: Technical Progress - Preflight ground tests and KC-135 flight tests have been completed and data are being analyzed.

Management Progress - None

Conclusions - None

Problems - None

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
a. N/A	Sensor Studies	D. Heppher	April 1973
b. N/A	Objectives of the Prototype Experiment Program	J. Burnett	April 1973
c. N/A	Handbook of Instructions - Prototype Experiment System, Vol. II	J. Burnett	April 1973
d. N/A	Management Plan for Hardware Development - Prototype Experiment System	J. Burnett	May 1973

FIRST BENEFITING PROJECT - Sortie Lab (Flight Experiment)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-40	970-62-20

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. L. Moses	205-453-3832	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Advanced Life Support System Cost Study
NAS8-28377, MDAC-WD, Huntington Beach, CA.

OBJECTIVE: To develop and correlate costing and resource relationships to aid in estimating resource requirements for advanced flight type life support systems.

APPROACH: The approach for this phase will be to develop cost estimating relationships (CERs) on subsystems including thermal control, atmosphere pressurization and waste management along the lines of the previous phase of the contract. Additionally the cost estimating relationships for development of flight experiments will be identified. The cost impacts of experiment size/capacity, degree of sophistication of experiment equipment and commonality of experiment equipment will be part of cost estimating relationships to be developed. Ten flight experiments will be cost analyzed. Additional validation of the techniques for arriving at cost estimating relationships will be accomplished by means of cross checking the techniques against equipment that has already been built, but was not used in the establishment of the original CERs. A particular point of interest is in regard to effect of material substitution on the CER.

STATUS: Technical Progress - First phase is complete. Work has begun on second phase described in the Approach.

Management Progress - Proposal has been received, reviewed and approved. Work is under way.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MDC G4031	Cost Analysis of CO_2 Concentrators	M.M. Yakut	June 1973
MDC G4032	Cost Analysis of Water Recovery	M.M. Yakut	June 1973
MDC G4033	Cost Analysis of Oxygen Recovery Systems	M.M. Yakut	June 1973
MDC G4034	Cost Analysis of Atmopshere Monitoring Systems	M.M. Yakut	June 1973
MDC G4030	Summary Report	M.M. Yakut	June 1973

FIRST BENEFITING PROJECT - Sortie Lab

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-62-40 PAGE 1 OF 2

Conclusions - Cost escalates rapidly after construction of a typical non-qualified high fidelity prototype subsystem. Prototype cost is about 10% of the total program cost the rest is integration and qualification costs. In addition, due to changes, etc., design costs rise by 60% after "completion" of the design.

Problems - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-40	970-62-23

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. L. Middleton	205-453-3828	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Radioisotope Water and Waste Management System
H-79269A, General Electric, Valley Forge, PA

OBJECTIVE: Develop a complete system to process all waste products from advanced manned spacecraft with minimum human contact.

APPROACH: The current program is a joint AEC-NASA effort. The system processes the nominal 4 man quantities of waste: urine - 14 lb/day, trash - 1.2 lb/day, feces - 1.2 lb/day, wash water - 24 lb/day and condensate water - 20 lb/day. Using radioisotopes as thermal energy sources, these inputs are processed by evaporation/pyrolysis into distilled potable water and the solids by incineration into dry ash. The processed and stored water is maintained at 160°F until use to preserve sterility. The program has been conducted by means of analysis, component tests short duration (10 day) systems tests and a 180 day system verification test. Following the successful completion of the 180 day test, minor revisions were made to the system in the areas of shaft seal incinerator transport, etc., and a short test performed.

STATUS: Technical Progress - A breadboard and two 10 day system tests were performed to prove the conceptual design of the system. During these tests, the water met all National Academy of Science (NAS) and Johnson Space Center requirements for potable water except during short period (1-2 days) when certain mechanical components failed. When repaired the water quality met NAS and JSC specifications again. Following these successful tests, a 180 day demonstration test was scheduled to show the long term performance of the system. During this test, the water quality once again met NAS and

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Monthly and Quarterly Progress Reports		

IRST BENEFITING PROJECT - Sortie Lab (Flight Experiment)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-62-40 PAGE 2 OF 2

Technical Progress (Cont'd)

JSC standards except when failure of mechanical sub-components caused explainable discrepancies. A slight air leak into the low pressure evaporator around a rotating shaft seal caused the Ph level of the water to be lower than desired. The 180 day test has been completed. System configuration has been modified to show the possibility of no overboard venting from the system. The hardware will be modified to evaluate the system performance (and water quality) in this configuration.

Management Progress - Contract modification to alter design to eliminate overboard venting is in progress.

Conclusions - The basic system concept and component designs accomplished the original performance goals of processing crew and spacecraft waste into potable water and dry ash as well as maintaining acceptable biological sterility of the mechanical components and processed water.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 970-62-40	PRIOR NO.: 970-62-21

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
William M. Langston wml	453-3923	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Design Guidelines for Long-Life Mechanical Components (Pump Failure Anticipator)

OBJECTIVE: Develop sensor that will anticipate a motor or pump failure with sufficient time remaining that repair or replacement can be accomplished before failure.

APPROACH: Analysis of high frequency vibration spectra will be utilized to provide diagnostic information to predict impending pump failures. Two pumps will be utilized in the program. One, a low speed internal gear pump and two, a high speed centrifugal pump will have defects implanted in them that will cause a faulure. The change in vibration spectrum will be observed/analysed to enable one to differentiate or select the problem area in a fluid system pump. With this knowledge, one will be able to anticipate impending failure.

STATUS: Contractor has completed his study of failure modes in various types of pumps and has predicted the expected changes to the vibration spectrum that will result from the various failure modes. A test setup is being constructed to enable testing of the two pumps.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Unnumbered	"Concept Study Report for Pump Failure Anticipator"	J. L. Frarey & D. S. Wilson	2-07-74

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 30 03 74	CURRENT NO.: 970-62-40	PRIOR NO.: 970- 62-21

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bobby R. Elkins	453-4413	G. A. Kroll

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Design Guidelines for Long-Life Mechanical Components (Temperature Control Valve)

OBJECTIVE: To develop a temperature control valve that will have a life of 100,000 cycles of operation and that will be insensitive to particulate contamination.

APPROACH: In the past, problems have been encountered with temperature control valves because of contamination sensitivity. An attempt will be made to solve this problem by designing a valve without the small clearances that are affected by particulate contamination. Obtaining the life cycle goal is not expected to be a problem.

STATUS: The RFQ is being prepared at this time.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

MSFC - Form 350 (March 1973)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-62-40	970-62-21

4. TITLE:

CVT EC/LSS Support Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. C. Clark	205-453-3828	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Bosch CO_2 Reduction System
NAS8-27276 Convair Division, General Dynamics Corp., San Diego, CA.

OBJECTIVE: Optimize operational parameters to effect a 50% reduction in power requirements and a 25% reduction in expendable weight. Conduct an indepth materials evaluation study to isolate materials which are non-reactive in the high temperature reaction zone area in order to preclude carbon precipitation in areas other than the catalyst cartridge. Redesign a power optimized variable speed control system for the re-cycle compressor. Investigation of use of the product carbon block as a filter medium. Investigation of the integration of the Bosch with the hydrogen depolarized cell CO_2 concentrator.

APPROACH: Determine operational parameters which most significantly affect efficiency and optimize for maximum performance capability. Select materials which are non-reactive based on in-depth study of reaction physics and chemistry. Determine filtration efficiency of the product carbon block, in a water system, with a broad spectrum of contaminants to be removed from wash water.

STATUS: Technical Progress - The two new Inconel 625 regenerative heat exchangers were received and have been installed in the units. In reconstructing the units it was decided to separate the reactors, into two independent units, primarily, in order to eliminate cross-over valving, and to allow a more optimum selection of components in the recycle flow loop. Greater power savings result from this approach primarily due to reduced compressor requirements. The reactors were started and todate have a total of

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
ADCA-DBD73-001	Bosch CO_2 Reduction System Development Interim Report	R.F. Holmes C.D. King E.E. Keller	January 1973

FIRST BENEFITING PROJECT - Sortie Lab (Flight Experiment)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-62-40 PAGE 2 OF 2

Technical Progress Cont'd

230 hours of operating time since rework. Some reactor startup problems occurred after re-work but have been overcome.

An in-depth study of a comparison of two methods of re-cycle flow control was made during this period. The two methods studied were, throttling recycle flow by use of a back-pressure regulator, and controlling flow by varying the speed of the compressor which was accomplished by varying the voltage and frequency of the power input to the motor. The results obtained to date indicate that a 30% savings in power consumed for a five (5) day capacity cartridge can be effected by using a variable speed compressor.

Reactor heat losses have been studied and a computer model has been developed which describes and analyses heat flow and losses within the reactor shell. This model will be a valuable tool in accomplishing reactor design improvements.

Materials studies continue in order to isolate non-reactive alloys which could simplify construction techniques. The Bosch unit has been run under conditions which would exist if the unit received feed gasses from an HDC, no difficulties in operating in this mode were found.

Management Progress - The contract for FY 74 effort on this program is presently under negotiation and is expected to be signed by early April 1974.

Problems - Routine

Conclusions - Significant power savings are available through the use of a variable speed recycle gas compressor system. It appears that no significant problems are associated with integration of the Bosch system and the hydrogen depolarized cell CO_2 concentrator. Tests concerning use of the carbon block as a water filter medium have indicated that it is one half to one quarter as effective as activated carbon. It appears possible to use the block as a rough pre-filter in the water system.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-63-10	970-63-10

4. TITLE: Requirements for Work Performance Design

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
P. T. Artis, S&E-ASTN-SMA	205-453-4373	T. P. Isbell
H. H. Watters, S&E-ASTN-SMH	205-453-3747	S&E-ASTN-S

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Laboratory Configuration Development and Evaluation
NASA8-29777 Martin Marietta Corporation, Denver, Colorado
- - Design Criteria for Payload Workstation Accommodations

OBJECTIVES: Continue and consolidate the development, verification, and application of man/system integration criteria for maintainability, accessibility, and the various dimensions of habitability, as well as provide objective man/systems design criteria for guidance of Shuttle payload configuration.

APPROACH: A multilevel man/system assessment will be made during test operations in the Payload Carrier Simulator at MSFC. Man/system design requirements established from Skylab and PCS tests will be documented for distribution to Shuttle Payload participants. Assess Shuttler payload man/system design needs in light of Skylab experience. In instances where payload needs are not addressed supply necessary design criteria.

STATUS: Technical Progress: The NAS8-29777 contract has been completed. A prototype Universal Stowage Module has been delivered to MSFC and a Final Presentation/Demonstration has occurred.

Management Progress: The NAS8-29777 contract has been closed out. The Final Report has been received at MSFC.
The Design Criteria for Payload Workstation Accommodations activity is a competitive procurement. Response to the RFQ is expected March 29, 1974. A contractor has not been selected. Conclusion: A viable program of experiment assessment and man/system assessment for Shuttle payloads continued to be defined and implemented. Problems: None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MCR-74-1	Final Report; Universal Stowage Module for Future Space Exploration	Victor A. DesCamp, Michael W. Hussey, Paul Garber, William Mandras & Don McKinney	January 1974

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-10 PAGE 2 OF 3

Forecast: The above activities will be combined with previously developed techniques to produce an efficient design/development protocol for Space Shuttle payloads. Once established the protocol will be directly applied to payload outfitting.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 970-63-10	PRIOR NO.: 970-63-10

4. TITLE:
Requirements for Work Performance Design

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Jack Stokes, S&E-ASTN-SMH	205-453-3747	T. P. Isbell S&E-ASTN-S

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: On-Orbit Evaluation of Payload Man/Machine Integration Design
NAS8-26558 URS/Matrix Co., Man Systems Div., 4702 Governor's Drive, Huntsville, AL.

OBJECTIVE: Provide a tool with which data on simulated manned systems can be non-intrusively collected and rapidly and effectively reduced and analyzed.

APPROACH: Develop a video tape data collecting system paired with a computer to sample, reduce, and statistically analyze parametes of interest.

STATUS: Technical Progress: The BioEngineering Test Administrator (BETA) hardware has been developed and delivered to MSFC. A computer software program has been developed for data analysis. Technical manuals including a BETA User's Manual has been produced. Management Progress: The contract has been completed. The hardware and final report has been delivered. No further contracted work is contemplated. Conclusions: The BETA system has been and may further be employed for evaluating man/system activities in the Payload Carrier Simulator at MSFC. Problems: None. Forecast: The BETA system will probably be used for experiment integration activities and analysis for future Shuttle payload simulations.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
PRL488	Development of a BioEngineering Test Administrator System	W. S. Woltosz & J. R. Bathurst	28 February 74

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 970-63-10	PRIOR NO.: 970-63-10

4. TITLE:

Requirements for Work Performance Design

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. B. Gardner S&E-ASTN-SM	453-3747	T. P. Isbell S&E-ASTN-S

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Experiment Crew Station Design Criteria
NAS8-25627 URS/Matrix Company, Huntsville, Alabama

OBJECTIVE(S): The development, verification and publication of man/systems design standards and criteria for application to shuttle payload control/display panels and crew stations.

The validation of 1-g simulation methods and techniques for use during the development cycle of payload control/displays, operating procedures, and workstations.

APPROACH: The objectives of this study are being accomplished by an on-orbit and ground evaluation of the ATM man/machine interface to identify design criteria, standards, procedures, and control/display hardware that can be used in the design of shuttle payload controls and displays and crew workstations. This effort is divided into two major phases as follows:

Requirements Analysis. The primary objectives of phase I were (a) prepare the ATM man/machine interface evaluation procedure, including ground data collection requirements, data analysis plan, and a list of the ATM interfaces to be evaluated, (b) prepare a listing of all Skylab on-orbit telemetry data to be used in the analysis.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
PRL-308	Phase I Report An Evaluation of the ATM Man/Machine Interface	E. C. Pruett	2/6/73
PRL-308	Monthly Progress Report	E. C. Pruett	4/10/73
	Monthly Progress Report	E. C. Pruett	5/10/73
	Monthly Progress Report	E. C. Pruett	6/10/73
	Monthly Progress Report	E. C. Pruett	7/10/73
	Monthly Progress Report	E. C. Pruett	8/10/73
	Monthly Progress Report	E. C. Pruett	9/10/73
	Monthly Progress Report	E. C. Pruett	10/10/73
	Monthly Progress Report	E. C. Pruett	11/10/73
	Monthly Progress Report	E. C. Pruett	12/10/73
	Monthly Progress Report	E. C. Pruett	1/10/74
	Monthly Progress Report	E. C. Pruett	2/10/74
	Monthly Progress Report	E. C. Pruett	3/10/74

FIRST BENEFITTING PROJECT: SPACE SHUTTLE

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO. CODE: 970-63-10

PAGE 2 OF 2

APPROACH (CONTINUED): Data Collection. During Phase II baseline ground data was collected on the setup and operation of the ATM experiments using the ATM Dynamic Control/Display simulator located at MSFC. Data collection was accomplished using closed-circuit video cameras, observation, a strip chart recorder and an analog computer. The ground simulation tasks closely duplicated those tasks for which SL-2 telemetry data were available. During the SL-2 mission telemetry data on the operation of the ATM experiments was collected by MSFC. An examination of these on-orbit data has indicated that all requested data were collected.

Data Reduction and Analysis. The SL-2 data collected in phase II has been reduced and analyzed. On-orbit data was compared with baseline ground data for the purpose of validating 1-g simulation techniques and the identification of man/systems design standards, criteria, and control/display hardware that can be used in the design of future payload control/displays and crewstations.

Preparation of Design Criteria. The results of data analysis are being integrated into a control and display panel design criteria handbook for shuttle payload designers. This will include all design criteria developed during this study.

STATUS: Technical Progress. Ground data collection and SL-2 data reduction are complete. Analysis of SL-2 telemetry data has been completed and the findings compared with the one-g baseline data. Design criteria are being prepared from the results of this comparison. Management Progress. The original Scope of Work was expanded to include preparation of a Control and Display Panel design criteria handbook. This modification was incorporated 8/22/73. Conclusion. Analysis of SL-2 data resulted in the identification of deviations between ATM Building Block Procedures and on-orbit ATM panel operations. The effect of these deviations will be described in the final report currently being prepared. Problems. Presently there are no known technical problems that might impede or prohibit successful completion of this effort. Forecast. None. Remarks. None.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 970-63-20	PRIOR NO.: 970-63-20

4. TITLE:

Teleoperator Manipulation and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-MS Wilbur G. Thornton	205/453-5530	G. Barr, S&E-ASTR-M

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Objective: To investigate and establish component and integrated systems technology and define design criteria for free flying teleoperators applicable to shuttle, tug and satellite missions in earth orbit. The goal is to provide design criteria for manipulator, visual, remote vehicle control subsystems and man system interface in 1976 time frame.

Approach:

1. Conduct feasibility studies and design investigations on: advanced manipulators, controllers, end effectors, and their interfaces with supporting systems; remote control of free flying mobility units and interfacing systems; visual system sensors, communications, and displays.

2. Evaluate man-machine integration methods applicable to free flying teleoperators.

3. Define and develop systems for experimental and demonstration flights on early shuttle missions.

4. Investigate advanced methods in manipulators, visual systems, and computer sciences for application to later missions.

Status: This RTOP consists of several tasks. Each will be reported separately.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Free Flying Teleoperator

MSFC - Form 360 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 970-63-20	PRIOR NO.: 970-63-20

4. TITLE: Teleoperator Manipulation & Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Wilbur G. Thornton S&E-ASTR-MS	(205) 453-5530	G. Barr, S&E-ASTR-M

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task 11: Development of Advanced Manipulator Systems.

Reference: This task consists of the following tasks from prior years:

FY-72: RTOP 503-24-01, Terminal Tools for Teleoperators

FY-73: RTOP 970-63-20

Task 10. Manipulator Systems Simulation & Evaluation

Task 11. Study & Development of Remote Manipulators

Task 12. Design Studies in Satellite Retrieval Systems

Contracts:

1. In-House Simulations
2. Ames Research Center, Moffet Field, CA
3. NAS8-27073, University of Mass., Amherst, MA
4. NAS8-29188, Rancho Los Amigos Hospital, Downey, CA
5. NAS8-27013, URS/Matrix Company, Huntsville, AL
6. NAS8-28055, MIT, Cambridge, MA
7. NAS8-29724, Draper Labs, Cambridge, MA
8. NAS8-29631, United Shoe Machinery, Wakefield, MA
9. NAS8-30266, Martin Marietta Company, Denver, CO
10. NAS8-29632, University of Tenn., Knoxville, TE
11. NAS8-28760, URS/Matrix Company, Huntsville, AL

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
URS/Matrix PRB 360	Final Report NAS8-28760	Saenger & Woltosz	6/73
MIT	Final Report NAS8-28055	W. Book	1/74
Martin MCR-73-311	Task 1 Report NAS8-30266	Adams et al	11/73
Martin MCR-73-3/2	Task 2 Report NAS8-30266	Adams et al	1/74
Univ. of Mass	Monthly Progress Reports	F. Crossley	10/73 - 3/74
Univ. of Tenn.	Monthly Progress Reports	J. Hung	10/73 - 3/74
Rancho Los Amigos	Final Report NAS8-29188	J. Allen	1/74
Rancho Los Amigos	TKA, Instruction & Maintenance Manual	J. Allen	1/74

First Benefitting Project: Free Flying Teleoperator

MSFC - Form 360 (March 1973)

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 2 OF 5

Objectives:

1. To identify and apply appropriate aerospace technology to the design of manipulator arms, actuators, end effectors and sensors.
2. To develop viable control schemes which will most effectively utilize the capabilities of man as the primary source of control signals.
3. To evaluate existing and new designs in laboratory conditions and generate requirements for a space design manipulator system.

Approach:

1. Perform trade off analyses and design studies of all design factors and performance functions of the manipulator including actuators, joints, end effectors, and sensors. Design, procure and test an advanced experimental manipulator and components applying space technology.
2. Develop candidate control schemes which offer maximum flexibility and ease of control for the human operator and evaluate these on computer simulations and actual hardware.
3. Using existing hardware where possible prepare a laboratory which will provide a simulated operating environment for the investigation and development of remote controlled manipulator systems. Included will be task boards, communication links, computer, visual equipment, lighting, control and display, etc. Provision will be made for investigating such effects as: manipulator control schemes, manipulator configurations, light, communication link degradation, time delay, etc. Flexibility for use of different manipulator/controller/display combination will be provided. This simulation will provide means of evaluating the man-machine interactions.
4. Utilizing the results of studies performed under contracts NAS8-27021, NAS8-27895, NAS8-29153, NAS8-29024, NAS8-28298, NAS8-28055, and others as appropriate perform a preliminary design of a manipulator system applicable to the free flying teleoperator system. The study would consider configurations, controllers, control modes, and effectors, actuators, sensors, displays and the interaction of the manipulator system with other teleoperator systems.
5. Generate preliminary design criteria.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 3 OF 5

Status:

Technical Progress

1. Manipulator System Simulation & Evaluation

a. The facility change has been completed.

b. The task board for Test 1 with associated hardware has been delivered and installed.

c. Changes in the computer program has resulted in a smooth control of the manipulator. Safety features have been added. The ability to command to return to a known stowed position has been added.

d. Experimenter control station is complete.

2. Manipulator Design & Control

a. Modular Manipulator Kit System

The design study for the semi-anthropomorphic like manipulator was completed. Detail design is complete except for the wrist and elbow. Work on these have been delayed because of limited manpower.

The ADAMS III end effector has been fabricated and is undergoing test.

The ESAM Mechanical Joy Stick Analog Controller has been fabricated and is undergoing test.

The new Harmonic Drive Planetary Gear Assembly has been delivered and installed on an ESAM manipulator. Tests have been good. Steps are being taken to retrofit the three remaining ESAM's with the actuator.

The Terminator Kit Assembly (TKA) was delivered and engineering tests made. The tool storage bin required modification so it was necessary to return the entire system to the manufacturer for the modifications.

b. Advanced Manipulator (In-House) - A preliminary specification for a manipulator based on the concentric tube drive was generated. However, due to manpower limitations this has been shelved for the time being.

c. Advanced Design & Control (NAS8-28055) - A report on: "Modeling Manipulator Arms with Distributed Flexibility for Design and Control" was published. The interactions of control system and distributed flexible structural dynamics was explored for mechanical arms. A modeling process using 4 x 4 transfer matrices was described which permits the closed loop response of many current arm configurations to be evaluated. Root locus, frequency response, modal shapes, and time impulse response were obtained from the digital computer implementation of the model, which is oriented to arm design and allows for easy variation of the arm configuration through data cards. The model corresponds with experimentally observed natural frequencies with an average error of less than 5% in the first three flexible modes in the seven cases considered.

The model was used to explore the limits imposed by structural flexibility on a nondimensionalized two link arm with one and two joints for planar motion. Using simple position and velocity feedback and careful adjustment of control gains adequate damping (damping ration of 0.65) can be imposed on dominant eigenvalues which have a complex modulus of more than one-half the cantilevered frequency of the arm with all joints clamped. The limitations imposed by flexibility are roughly compared to strength limitations to indicate when flexibility will tend to be the more immediate constraint on arm design.

3. Configuration & Design Study of Manipulator Systems Applicable to the Free Flying Teleoperator (NAS8-30266)

a. Task 1. Manipulator System Survey. The results of this task was completed and a report issued (Martin Report MCR-73-311 dated 11/73). A brief survey of existing and developmental manipulator systems used in industrial, hot-lab, undersea, and space applications was presented. Manipulator system physical characteristics and subsystems—controllers, control methods, actuators, and end-effectors— were discussed.

b. Task 2. Preliminary Requirements Analysis. This task was completed and the results published in Martin Report MCR-73-312, January 1974. A preliminary requirements analysis for manipulator systems applicable to a FFT operating in conjunction with the Shuttle and Tug was performed. Two types of manipulators were considered: a general purpose manipulator which as the primary function of on-orbit servicing and maintenance of satellites and a retrieval type manipulator used in support of satellite deployment and retrieval applications.

c. Task 3. Manipulator Conceptual Designs. Design concepts meeting the requirements analysis of Task 2 were generated and presented to NASA in Feb. 1974. As a result the contractor has been given direction to present a plan for the completion of the task together with a proposed simulation.

d. Task 4. Preliminary System Design. In work.

Conclusions:

1. System Simulation & Evaluation

a. The use of a controller with a non-geometric similarity with the manipulator creates problem of singularities and computation.

b. Where a computer is used the computation cycle time is important. New methods were developed for the RAM/TPC system and the manipulator operates smoothly with a 1/15 sec computation cycle in the matrix inversion.

2. Manipulator Design and Control. None. See status above.

3. Configuration & Design Study. The study results show the following requirements for the general purpose manipulator:

Serviceable Modules: Max: 1X1X1 Meter
Min: 0.15X0.15X0.15 meter
Mass: 150Kg

Working Volume: Hemispherical over FFT Docking Interface
Reach Envelope: 2.5 Meters
Tip Force @ Max. Extension: 44.5 Netwon
Tip Torque: 20 Newton - Meter
Tip Veolicty: $\leq$ 0.6 M/S
Mass: $\leq$ 45 Kg

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 5 OF 5

Problems:

No technical problems. The restrictions on manpower and other uncertainties are of concern.

Management Progress: None.

Forecast:

1. Full Scale evaluation of the RAM/TPC has begun and will continue during next reporting period.
2. The Ames Manipulator Delivery has been promised for April 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 970-63-20	PRIOR NO.: 970-63-20

4. TITLE:

TELEOPERATOR MANIPULATION AND CONTROL

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. Dwight Johnston/S&E-ASTR-GC	205-453-0792	R. H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

PRIOR CODE: Task 12, FY-72

TASK 20: INVESTIGATIONS ON REMOTE CONTROL OF TELEOPERATOR MOBILITY UNITS (INHOUSE)

OBJECTIVES: 1. To identify guidance, navigation and control subsystems required for free-flying teleoperator on Space Shuttle payload mission.

2. To determine minimum adequate hardware performance requirements for G, N & C subsystem for a free-flying, remotely controlled teleoperator to affect launch from Shuttle; rendezvous, docking, controlling, and/or operational positioning with respect to an orbiting spacecraft; and the retrieval of the spacecraft.

3. To determine minimum adequate requirements for the remote control and display station applicable to the G, N & C functions.

APPROACH: (Design, Fabricate and Test)

1. Remote controlled vehicle with attitude control systems and reaction wheels or small CMG's necessary for docking. System will be equipped with air bearings to provide low friction rotations about two or three axes and translation in a plane capable of providing information on the G, N & C functions necessary for rendezvous.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
S&E-ASTR-G-WP-7-73	Free-Flying Teleoperator Breadboard Vehicle	W. C. Mastin	July 3, 1973
S&E-ASTR-G-WP-13-73	Phase I Tests and Calculations to Determine the Momentum and Stall Torque Requirements of Reaction Wheels to Control the Free-Flying Teleoperator in Pitch, Yaw & Roll	J. L. Burch	Nov. 20, 1973
Film Serial MSFC-74-405	Free-Flying Teleoperator Experiments	J. L. Burch J. D. Johnston	January 1974

FIRST BENEFITTING PROJECT: Teleoperator

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 2 OF 3

(Approach) (cont.)

2. A test bed of super smoothness (enclosed in a featureless opaque non-reflective black cloth room) to provide low friction operation of the air bearings necessary for flotation of the above vehicle.

3. Control console and station to allow for remote control and monitoring of the above mentioned vehicle and test bed, and will include equipment to enable an in-depth study into the effects of time delays, data processing and handling requirements, communications, image displays, controllers, man-machine interaction, etc.

4. Perform studies on attitude control, docking and retrieval.

STATUS: Technical Progress:

1. The epoxy test bed anomalies were corrected with four coats of epoxy paint, and with the added air supply to the mobility unit the system could operate up to 25 minutes before replenishing the air supply.

2. Following the above corrections and modification, a film documentation was made of the Free-Flying Teleoperator in operation. The film serial is MSFC 74-405 and titled "Free-Flying Teleoperator Experiments".

3. On completion of the above film, Center Management closed bldg. 4752 which housed this test facility and forced its relocation to bldg. 4705.

4. The relocation set the program progress back in excess of 6 months. The following is the status of re-establishment.

(a) The 40' X 40' X 22' high canopy has been relocated in bldg. 4705.

(b) A new control room has been built.

(c) An overhead catwalk for supporting overhead lights and T. V. camera (provides X-Y information for position and attitude system) has been installed.

(d) The new test bed will have approximately 275 more sq. ft. of surface area than the old (1175 sq. ft. vs 900 sq. ft.). This required an enlargement of the canopy and this work is completed.

(e) The floor is presently being prepared for the new epoxy surface. This work should be completed within two weeks.

5. The 12-inch flotation air bearing that was designed in the last reporting period has been delivered.

6. A reaction control wheel has been acquired for evaluation of the mobility unit.

7. Two 10-inch diameter air bearings have also been acquired for possible use in the next prototype mobility unit design.

Conclusions: None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 3 OF 3

Problems: Center Management's decision to relocate the Teleoperator Test Facility has set this phase of the program back in excess of 6 months. Time and effort that should have been spent for productivity of the program has been spent in an effort to get re-established.

Forecast: The program should be in operation in one month.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	970-63-20	970-63-20

4. TITLE:

Teleoperator Manipulation and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. T. Huggins	453-5874	W. O. Frost

5. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task 30: Study and Development of Teleoperator Viewing System
NAS8-29024, Martin Marietta, Denver, Colorado

Objectives: (1) Determine the preferred type viewing system required for remote manipulator operation. (2) To examine and evaluate methods of determining range and range-rate by remote viewing through a television system. (3) Evaluate a combined mono and stereo viewing system. (4) Evaluate the use of color in the remote viewing system. (5) Determine the effect of fixed and variable delays between a video sensor and the display. (6) Perform studies for actual docking of the teleoperator to a target vehicle by remote viewing through a television system. (7) Write system requirements and limitations. (8) Develop a breadboard model and finally an engineering model for design criteria. (9) Apply image enhancement techniques to remote manipulator operations.

Approach: (1) From previous in-house experience, simulations and studies, the system requirements for teleoperator control have been determined and have been used to broadly define a teleoperator viewing system. Based on this definition, simulations are being developed to evaluate the performance capability of the man and the visual system. The Astrionics Visual System Test and Evaluation Laboratory is being used for this testing. Conduction of the tests and analysis of the results are being done by Essex Corporation under Contract NAS8-28298. (2) A contract for conceptual design and preliminary design of a teleoperator viewing system has been completed in 1973 by Martin Marietta under Contract NAS8-29024. The results of the conceptual design phase have been compared with in-house engineering data and a decision, based on both, has been made on the type breadboard system for use in the manipulator/visual system tests. (3) Continue work utilizing concepts from computational linguistics to enhance images by selectively accentuating frequencies of interest.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1. Prog. Report No. 6		R. C. Gonzalez	10/10/73
2. Prog. Report No. 7		R. C. Gonzalez	12/10/73
3. Annual Report		R. C. Gonzalez	02/04/74
Other Publications			
a. Master Thesis	A Minicomputer Implementation of a Compiler for an Image Processing Language	C. S. Wilson	12/1973
b. Master Thesis	A Minicomputer Implementation of the Two-Dimensional Fast Fourier Transform	N. L. Koerner	08/1973
c. Master Thesis	Minicomputer Implementation of a Functional Graphics Package	L. J. Minyard	08/1973
d. Master Thesis	The Design and Implementation of a Digital Video Interface System	W. E. DeWitt	06/1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 2 OF 2

This procedure will be formulated so that it can be used by the operator with minimal insight and experience. This work is being done by Dr. R. C. Gonzalez, University of Tennessee, Knoxville, Tennessee, under Contract NAS8-29271.

Status: Technical Progress: (1) The open loop visual investigations which began in February 1972 are continuing and are described in Task 13. The results have so far indicated, for example, that certain tasks will require the operator to use a 3D TV system, and that brightness ratios will be extremely important where the objects would normally tend to blend without a high brightness difference The use of color may help the brightness problem. Color testing is planned during the first and second quarters of FY 75. (2) Technical support to Essex Corporation is being carried out for visual system design, layout and maintenance for both the visual system test lab and the upcoming manipulator tests. (3) Contract NAS8-29024 with Martin Marietta has been satisfactorily completed. This work took a look at all the following subsystems of a remote manned system's visual system: sensors, illumination, deployment/articulation, displays, telecommunication, and controls and display integration. The basic visual system recommended from this work is a hybrid-monoscopic-stereoscopic TV system. This approach, inherently simple, appears to provide considerable operational flexibility and visual coverage adequate to accomplish all the anticipated RMS activities. (4) The Fresnel stereo visual system was completed in February 1974. Preliminary tests have shown it to be superior to the color separation stereo and the Stereotronics (polarized separation) systems. (5) Phases I and II of the image enhancement contract with University of Tennessee are complete. The development of the necessary basic software for the PDP-11 digital computer, such as the programs to control information transfer and the Fast Fourier Transform programs, have been completed and are operational on the equipment. Initial tests on the effects of filter primitives and lighting on test images have been completed. Test images have been processed through the computer and displayed on the TV monitor. The development of automatic enhancement techniques is underway.

Management Progress: An RFQ has been prepared for a separate support study to determine the anticipated delays which will be encountered between an RMS control station at various locations and a satellite in low and geosync orbits. A computer program will be written to be used in controlling the variable delay between the controller and the RMS as a function of time and orbit position. This will be used in simulations to determine impact on man-machine interface.

Problems: None.

Forecast: (1) The Fresnel stereo visual system will not be installed in the manipulator laboratory before September 1974, due to delays in getting that laboratory operating. (2) Color testing is still delayed. It is now planned for September and October 1974. (3) Motion simulations in the visual lab are now scheduled to be complete by September 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 5

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 970-63-20	PRIOR NO.: 970-63-20

4. TITLE:

Teleoperator Manipulation and Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Wilbur G. Thornton S&E-ASTR-MS	205-453-5530	G. Barr, S&E-ASTR-M

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task 40 RMS Man-Machine Integration Requirements
NAS8-28298 Essex Corporation, Alexandria, VA
NAS8-29914 Essex Corporation, Alexandria, VA
NAS8-30545 Essex Corporation, Alexandria, VA

Objectives:

1. To determine, analyze, and integrate the human factors design requirements for manipulator, remote vehicle, and visual systems.
2. To analytically and empirically develop man-machine interface criteria
3. To investigate perceptual motion cues required for moving base vehicle simulation techniques.

Approach:

1. Plan and conduct open loop visual system tests to determine performance of visual tasks using video systems and display aids.
2. Plan and conduct closed loop visual tests of performance in final approach and docking.
3. Plan and conduct man/machine interface evaluation for manipulator systems including manipulator, effector, controller, and visual subsystems.
4. Plan and conduct man/machine interface evaluation for remotely manned systems maneuvering and docking subsystems.
5. Perform analytic assessment of human factors design requirements to support empirical operator/system performance testing and system design decisions.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
H-4-1	Summary: Man-Machine Interface Evaluation	T. Malone et al	1/74
H-4-2	Test Report: Teleoperator Visual System Evaluation	M. Kirkpatrick et al	1/74
H-4-3	Manipulator System Man-Machine Interface Evaluation	T. Malone et al	1/74
H-4-4	Teleoperator Docking Simulation	M. Kirkpatrick et al	1/74
	Monthly Progress Reports		10/73 - 3/74

First Benefitting Project: Free Flying Teleoperator

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 2 OF 5

Approach: (Continued)

6. Plan and conduct empirical studies of acceleration and deceleration thresholds and changes in thresholds due to visual motion cues.
7. Incorporate threshold data into washout technqiues which minimize detection of invalid platform motion required by moving base system travel constraints.

Status:

Technical Progress:

1. Teleoperator Visual System
   a. Static tests have been completed involving detection, recognition, and discrimination performance as functions of TV parameters.
   b. Dynamic visual judgment tests involving range and range rate detection and estimation are currently in progress.
   c. A base line study of vehicle approach to a nutating large space telescope model has been completed.
   d. The computer is being programmed to calculate maneuvering error data and a study of range/range rate display and video aiding effects is being set up.

2. Manipulator System
   a. MSFC Manipulator Test Laboratory is currently configured to operate the Rancho Anthropomorphic Manipulator and the Matrix Computer-aided Controller.
   b. A task module has been fabricated to measure fine positioning performance this module is currently being integrated with the Manipulator Laboratory Measure.
   c. Test plans were developed to test human performance of remote tasks utilizing the Terminal Kit Assembly (TKA) and the ADAM Manipulator system. Further studies of the TKA with the ESAM are planned.

3. Mobility System
   a. Air bearing floor under construction, no progress.

4. RMS Technology Human Factors Analysis
   a. The effort to define range rate measuring methods and hardware for the visual system is continuing. Estimates in valuing dynamic state estimation, color TV and Fresnel system relative to distance estimation are being defined.

5. Motion Threshold Investigations
   a. Planning was completed for conducting reduced deceleration levels in the ± directions but leaving acceleration at the levels of that of the previous series of tests. In addition, the velocity of travel down the raod was increased from a simulated 100 miles/hour to a simulated 150 miles/hour. The steering parameters were modified to incorporate a 30% increase in the steering sensitivity (from approximately 0%) and approximately three times the noise (which gave the effect of a windy gust in the direction the wheel was turned) level which made the subject concentrate more to maintain his position within the confines of the road.

Five subjects completed the baseline series (1300) and three of these completed the video plus secondary task series (3100).

Analyses of data revealed that overall deceleration detection accuracy was 86% (baseline was 87% and video plus secondary task was 86%) and acceleration detection accuracy was 71% overall (baseline was 75% and video plus secondary task was 68%). However, these data are from a small sample (5 subjects for baseline and three for video plus secondary task) but the trend seems to reinforce the theory of a single threshold rather than separate thresholds for acceleration and deceleration.

b. During December testing began on the motion cue program for the forward/aft directions. Seven subjects were selected and scheduled for the initial base line conditions test program. Tests results showed a 90% accuracy of detection for the deceleration in the aft and forward directions and 76% detection of acceleration in the aft and forward directions. Of these data, deceleration in the aft direction was highest (91%) followed by deceleration in the forward direction (89%), acceleration in the aft direction (80%), and acceleration in the forward direction (73%). Overall accuracy was 83%. It was decided the 0.2 ft/sec initialization ramps could be cueing the subjects as to which interval the signal was present. Therefore the ramps were reduced to 0.1 ft/sec while still maintaining the same "G" levels from the previous test. Eleven subjects (six were replications from the previous test) were tested under these base line conditions and in addition were also tested using a visual scene plus secondary task study. Test data anlyses revealed basically the same pattern for the second base line test with respect to the original base line study. The percent of detection fell slightly in all cases except acceleration in the forward direction which increased slightly. Overall accuracy was 82%.

The subjects were then subjected to a visual scene plus secondary task study using the same conditions and "G" levels from the second base line study. Analyses of test data revealed that deceleration (in both directions) accuracy increased from that of the two base line studies (92% vs. 89%) and acceleration (in both directions) accuracy increased from that of the two base line studies (79% vs. 77%). The overall accuracy increased slightly from that of the base line studies (85% vs. 82.5%).

Conclusions:

1. Visual System Tests

a. The mean visual angle for small target detection or gaps between larger objects varies from 3 to 9 ARC minutes depending on the visual system parameters such as bandwidth and signal-to-noise ratio.

b. Performance is degraded by a reduction of the signal-to-noise ration from 21 DB to 15 DB for a variety of visual tasks. In no test case, however, did an increase in the ratio from 21 DB to 32 DB result in performance gains.

c. Across a number of tasks studies, narrow band and digital transmission modes resulted in performance degradation relative to direct analog TV viewing.

d. For detection of non-alignment of a solid target normal to the camera it appears that lighting systems will be very crucial. Non-alignment angles of 10° were not detected in 65% of the trials where the "available" light source was within 30° of the target axis. When a direct (0°) artificial light source is used to augment "available" light and target markings are employed, the mean angle required for non-alignment detection was reduced to about 8 degrees.

e. Judgments of separation distance along the fore-aft axis yield data that indicate the lowest estimation error is derived using a two mono camera, orthogonal situation, and that the highest mean error is derived when using a split image stereoptic camera system.

f. The range rate (Ft/sec) needed for motion detection of a target 3 feet in diameter at a range of 20 feet was determined to be a .14 - .16 ft/sec with a probability of detection of .95.

g. The probability of motion detection of a target does not appear to be influenced by TV system parameters such as frame rate, signal-to-noise ratio and digital signal vs. analog signal format.

h. The data collected from the docking simulation study during attempts to make a final approach to a nutating large space telescope model supported the following conclusions:

Subjects were unable to complete the final approach when either the nutation angle reached 10 degrees and the nutation rate reached 60 degrees per second.

For the nutation rates and angles which permitted successful final approach, task completion time and propellant consumption were found to be more strongly influenced by nutation angle than nutation rate.

2. Manipulator System Tests - None

3. Mobility System Tests - None

4. RMS Technology Human Factors Analysis - None

5. Motion Threshold Investigations

The conclusions one can infer from these data are rather meager considering the small number of subjects used but three ideas can be advanced in that: (1) acceleration/deceleration threshold levels described in the literature are much lower than originally defined; (2) a visual scene with a secondary task appears to raise the attention level of the subject which in turn lowers his sensory threshold to acceleration/deceleration; and (3) there is no difference in threshold for acceleration/deceleration sensitivity.

Problems: None. The facility changes have been resolved.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 5 OF 5

Management Progress:

1. Contract NAS8-28298 was terminated at end of contract period. Final reports are in review.

2. A new statement of work was negotiated with Essex Corporation and was put into effect November 30, 1973. This is NAS8-30545.

Forecast:

1. Visual System
   a. Complete the B-3 test data collection
   b. Set up range rate estimation test.

2. Computer-Based Visual Simulation
   a. Take data on dynamic state estimation
   b. Complete programming for tracking accuracy statistics with stable satellite

3. Manipulator System
   a. Continue preparation for testing RAM/TPC on minimum position change test.
   b. Set up ESAM and suitable controller for the minimum change test.
   c. Design and fabricate dexterity test module
   d. Conduct human performance testing using the RAM/TPC, ESAM/Analog Controller, ADAMS/TKA, and ESAM/TKA.

4. Mobility System Testing
   a. Dependant on the readiness of the mobility unit simulation docking and maneuvering tests will be conducted to determine the human's performance.

5. Motion Threshold Investigations

A third base line test will be conducted using lower levels of deceleration and test interval times but acceleration levels and times will not be modified. These new levels will also be incorporated into the visual scene plus secondary task study. In addition a higher level of noise (steering parameters) and a higher velocity (150 - 200 miles/hour) will be used to more actively engage the subject's attention.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE OF	
1. CENTER MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 970-63-20	PRIOR NO.:

4. TITLE:

Teleoperator Control & Manipulation

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. G. Perin S&E-ASTR-EA	453-4271	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: #60 Integrated Control Station for Teleoperator & Experiments Development

CONTRACT NO: Not Selected.

OBJECTIVE: (1) To investigate the feasibility of an integrated control station for payloads requiring remotely manned, maneuvering, pointing, attitude and servicing controls.

(2) Determine control function requirements; generate control station requirements and verify by utilizing CVT, Free Flying Teleoperator, Manipulator and Rendezvous and Docking Mockups and Simulators.

Approach: (1) Utilize results of prior studies, simulations and current CVT design requirements.

(2) Conduct feasibility and trade studies in configurations, actuation and display.

(3) Integrate teleoperator and experiment requirements for shared and dedicated controls and displays.

(4) Evaluate design by utilizing CVT and other simulators.

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NONE			

FIRST BENEFITING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 970-63-20 PAGE 2 OF 2

STATUS: This is a new task for this reporting period.

TECHNICAL PROGRESS: Technical statement of work has been defined.

MANAGEMENT PROGRESS: A procurement for a study contract of an Integrated Teleoperator Control and Display Console has been processed thru MSFC Procurement Activity with a requested response of May 31, 1974, from prospective contractors.

CONCLUSIONS: NONE

PROBLEMS: NONE

FORECAST: A contract award for the study is anticipated on or about June 1, 1974.

REMARKS: This is the initial report under this RTOP number.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER: MSFC

2. PERIOD COVERED: 01 10 73 31 03 74

3. CODE

CURRENT NO.: 972-30-00

PRIOR NO.: 972-30-00

4. TITLE: Aeroelasticity

5. RESPONSIBLE INDIVIDUAL: S&E-AERO-AU Robert W. Walker

TELEPHONE: 205-453-0172

APPROVAL: W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Significant work activities):

TASK: Perform the Necessary Hardware Modifications, Checkout and Calibration on Two (2) Existing Electromagnetic Damper Measuring Systems
NAS8-28296; Applied Dynamics Research Corporation, 3313 Memorial Parkway, Huntsville, AL

OBJECTIVE: Determine Skylab unsteady ground wind loads forcing functions from existing aeroelastic wind tunnel test data by dynamically reconstructing the aeroelastic model response. Develop methods of reducing and analyzing the wide-band forcing function data to assess its individual characteristics and modal content, i.e., sinusoidal, random, in phase with response velocity, first or second mode, etc. Verify these methods by conducting response analyses utilizing the individual components of the forcing function.

APPROACH: Experimental dynamic tests will be conducted on the Skylab aeroelastic model to reconstruct the measured wind tunnel model responses for selected test points. Reconstruction of this measured test response will be accomplished by using the recorded wind tunnel response data as a driver signal to the modified electromagnetic damper/force measuring systems. During these dynamic tests, a wide-band unsteady ground wind loads forcing function is measured and recorded as an output from the force measuring system. Methods and procedures of statistical data reduction and analyses will be developed and utilized to determine the character and modal content of the measure wide-band forcing functions.

STATUS: Technical Progress: Experimental dynamic tests were conducted on the Skylab aeroelastic ground wind loads model to reconstruct the measured wind tunnel response for nine selected data points. These tests were conducted in an attenuated mode of

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Skylab

approximately 25-percent because the ground wind forcing function magnitude experienced during wind tunnel testing was very large and because of the limited power capability of the playback force measuring system. The recreated model response and the wide-band forcing function were recorded on magnetic tape during these dynamic tests for subsequent data reduction and analyses to determine the character of the forcing function. In addition, an ensemble averaging technique of determining the total system damping (structural plus aerodynamic) from wind tunnel test data was finalized and programmed. This program was utilized in determining the total damping for the nine selected data points. The aerodynamic damping can therefore be determined by subtracting the pretest structural damping from the total damping.

Management Progress: A no-cost extension was initiated in January 1974, to extend the contractural period of performance through August 1974.

Conclusions: The ensemble averaging technique developed and programmed for computing the total damping is a good method for determining aerodynamic damping. Preliminary spectral analysis of the ground wind load forcing function indicates the forcing function magnitude is very large and the spectra is rather flat and similar for all nine test cases analyzed.

Problems: Delay in setup of model for dynamic testing required a no-cost extension to the contractual period of performance.

Causes of Problems: Accurate determination of model frequency and damping during wind tunnel testing took longer than anticipated. This information was required for setup of model for the playback dynamic tests.

Forecast: Continue data reduction and analysis of wide-band ground wind load forcing function data to determine its character, and publication of the final report.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 972-50-00	PRIOR NO.: 972-50-00

4. TITLE:
Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Richard G. Beranek S&E-AERO-AU	205-453-0179	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Data Reduction of the Saturn IB/LC-39 Wind Tunnel Test Data
NAS8-26703; Baganoff Associates, Inc., St. Louis, Missouri

OBJECTIVE: Provide on-site engineering test support to record and perform on-line quick-look analysis of ground wind loads data obtained during wind tunnel test of an aeroelastically scaled model of the Saturn IB/LC-39 (Skylab 2) launch vehicle. Reduce and extrapolate to full-scale the recorded strain gage and accelerometer data obtained in the first and second bending modes at two vehicle body stations. Present this data in the lift and drag directions as a function of wind velocity for each configuration tested. These data are to be used in the establishment of ground wind loads launch constraints which are used as input to the Launch Operations Manual.

APPROACH: Utilizing the Ground Wind Data Reduction System (GWDRS), transform the recorded data into its lift and drag components. Scale the test results to full-scale using aeroelastic scale factors which are based on final dynamic characteristics of the launch vehicle. For each data run, the final output shall consist of predicted full-scale vehicle static drag, static lift, dynamic drag, dynamic lift and resultant bending moments versus velocity. Also required for each data run, is a plot of vehicle static drag bending moment versus wind tunnel dynamic pressure in order to correct for any zero crossing offset.

STATUS: Technical Progress: During this reporting period, preparation of the final report has been underway.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Baganoff Report #610, Jan. 1974	Skylab 2 Ground Winds Data Reduction & Statistical Analysis.	F. Baganoff	N/A

This is a final report.

FIRST BENEFITTING PROJECT: Skylab

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 972-50-00 PAGE 2 OF 3

Management Progress: The final report has been completed and reviewed for release.

Conclusions: First and second mode strain gage and accelerometer data has been reduced for 112 data points encompassing five simulated fueled vehicle configurations. This data is presented in the form of plots of static lift and drag, dynamic lift and drag, and resultant bending moments versus full-scale wind velocity.

Problems: None

Causes of Problems: None

Forecast: None

Publications:

1. Reduction of Skylab 2 Ground Winds Wind Tunnel Data, BAI Report #605, April 5, 1972.
2. SIB Ground Winds Test Results from Skylab 2 Wind Tunnel Tests, BAI Report #604, April 6, 1972.
3. SIB Ground Winds Test Results from Skylab 2 Wind Tunnel Tests, BAI Report #607, April 9, 1972.
4. SIB Ground Winds Test Results, BAI Report #607-A, April 9, 1973.
5. SIB Ground Winds Test Results from Skylab 2 Wind Tunnel Tests, BAI Report 608, January 8, 1974.

Remarks: None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 975-61-05	PRIOR NO.:

4. TITLE:

Zero-G-Atmospheric Cloud Physics Program

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Robert E. Smith	205 453-3140	Leonard F. Weber William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Analysis of Experimental Concepts Relative to Plasma Physics and Environmental Perturbations Laboratory, Contract No. NAS8-29501 University of Alabama in Huntsville, Alabama 35805

Objective: To theoretically investigate wave propagation through the upper atmosphere.

Approach: Develop theoretical models describing the propagation of VLF and ULF waves through the upper atmosphere and compare results with observational data.

Status: Technical Progress: A VLF wave propagation model was developed during the previous reporting period. It is being modified for ULF waves with completion scheduled for April 30, 1974.

Management Progress: None.

Conclusions: A two-dimensional theoretical model of ULF wave propagation can be developed for use in interpreting observational data.

Problems: None.

Forecast: This effort will be terminated because no FY 74 funds have been made available.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Plasma Physics

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	975-72-01	114-03-52

4. TITLE:

Spacecraft Surfaces

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMT W. T. Powers	453-5619	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Portable Multispectral Reflectometer (PMR)
In-house

OBJECTIVE(S): Spacecraft thermal control is entirely dependent upon radiative heat transfer. The condition of surface coatings of a craft affects the thermal efficiency of the system. No long term spectral reflectometer data has been gathered on coatings while still in space. The PMR is intended to provide a means of acquiring laboratory accuracy multi-spectral reflectance readings on a surface whenever such a reading is desired, while being completely portable, self-contained instrument.

APPROACH: The PMR is to be used to measure surfaces before and during a mission as a means of determining the condition of the thermal control coatings while in use in space. The instrument is an Integrating Sphere Reflectometer with a digital signal processor and memory unit. Reflectance is taken in each of 8 spectral bands.

STATUS: Technical Progress - The development unit has been completed and tested. The project is concluded.
Forecast - none
Conclusions - The project has been terminated. Drawings sufficient for manu-

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 975-72-01 PAGE 2 OF 2

STATUS (CONCLUDED): Conclusions (cont'd) - facturing units are on hand and will be placed into Documentation Repository.

Remarks: Most major parts for up to 4 additional units are on hand. Spheres would require coating and would be the only part giving difficulty since it may be necessary to develop the capability of coating them.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 975-72-39	PRIOR NO.: 975-72-03

4. TITLE:

OPTICAL CONTAMINATION

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Hoyt M. Weathers	205 453-3040	Hoyt M. Weathers Hoyt M. Weathers

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Definition of the separate sensors which comprise the Integrated Real Time Contamination Monitor (IRTCM) System.

Contract No.	Contractor
NAS8-29197	PBR Electronics

OBJECTIVE: To define flight instruments and sensor systems which will be used on the Shuttle and Shuttle payloads to detect the presence and characteristics of an induced environment. This definition phase includes experimental work with pre-prototype equipment in order to develop confidence in the concepts selected to monitor contamination for the protection of the payloads.

APPROACH: Sensors are required which will determine the optical effect of contamination, the amount, its identity, and other factors such as particle sizes, distribution, and velocities. These sensors include Quartz Crystal Microbalances (QCM), Mass Spectrometer, Optical Effects Module, Particle Spectrometer, and Active Cleaning Technique. Other sensor/monitor systems are being developed since the Spacelab payloads require special contamination monitoring equipment.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

SEE LAST REPORT

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 975-72-39 PAGE 2 OF 3

STATUS: Functional laboratory models have been developed of four of the five sensor/monitor concepts. The fifth, the Active Cleaning Technique equipment, will be available in mid-FY74. The Optical Effects Module and the QCMs are being evaluated in the laboratory and were used late in CY73 to instrument simulation tests of the Shuttle Solid Rocket Booster (SRB) separation motor exhaust contamination effects. The Particle Spectrometer has been used in tests at JSC of the Shuttle Thermal Protection System and also in the Shuttle SRB separation motor simulation tests. The above laboratory and operational tests are being used to identify improvements needed in the sensor/monitor systems.

MANAGEMENT PROGRESS: The activities above are being funded from FY-72 funds reprogrammed for FY-74 and are extensions of the approved FY-73 RTOP.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-02	PRIOR NO.:

4. TITLE:
Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

5. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Structural Analysis of Non-Metallic Thermal Protection Systems
H-84825A Naval Ship Research and Development Center

OBJECTIVE(S):
1. To develop a finite element of 3-dimensional structural and thermal analysis of non-metallic thermal protection systems.
2. To correlate structural and thermal analyses based on this finite element to exact solutions and existing test results.
3. To incorporate this finite element into an existing matrix abstraction package such as NASTRAN.

APPROACH: Generate an isoparametric element that will have eight nodes and six sides. The element will be capable of structural and thermal analysis of a single structural model. Correlate structural and thermal analyses based on this finite element to exact solutions and existing test results. Upon completion of the development of this finite element, it shall be incorporated into NASTRAN.

STATUS: Technical Progress--The work outlined under Approach has been completed, and the final report described below is available for distribution.
Management Progress--Since this contract is complete, this progress report terminates reporting.
Conclusions--The thermostructural capability has been added to the NASTRAN structural analysis program. The modifications and additions were made to Level 15.1. UNIVAC 1108 and CDC 6000 versions of the program are available.
Problems and Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
NSRDC 4134	Additions to the NASTRAN User's Manual and Theoretical Manual for a Thermostructural Capability for NASTRAN Using Isoparametric Finite Elements	Myles M. Hurwitz	May 1973

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	976-30-04-01	976-30-04-01

4. TITLE:

Space Shuttle Auxiliary Propulsion System (APS)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
C. Miller	205-453-3816	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Turbopumps for Cryogenic Upper Stage Engines, NAS8-27794, Rocketdyne

OBJECTIVE: Design, fabricate, test, and deliver two liquid hydrogen and two liquid oxygen pump assemblies of an advanced design. These pumps provide broad range, small turbopump system technology applicable to high energy, cryogenic, upper stage engines.

APPROACH: The program task will be accomplished in four phases. Phase I is the general screening analysis to select pump, inducer and turbine type. The combined characteristics of the components will be analyzed in detail.

Phase II consists of making component layout, detail, and assembly drawings.

Phase III consists of procurement, fabrication, and assembly of the hardware.

Phase IV consists of testing the liquid oxygen pump followed by the liquid hydrogen pump. IR&D tests by the contractor on the gas generator, pump bearings and seals, and turbine are also included in this phase.

STATUS: Technical Progress: The program is complete with the exception of issuing the final report. The No. 1 liquid oxygen pump successfully completed 66 tests and 7528 seconds of run time. The No. 2 liquid oxygen pump completed 12 tests for 1050 seconds of operation. The No. 1 liquid hydrogen pump completed 57 tests for 5091 seconds of operation, and the No. 2 liquid hydrogen pump was acceptance tested 13 times for 1260 seconds.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
1.	Program Plan	T. Zachary & J. Laufer	14 July 1971
2.	Milestone Report Phase I	" "	28 Aug 1971
3.	Milestone Report Phase II	" "	19 Nov 1971
4.	Test Plan & Facilities Review	" "	Jan 1972
5.	Test Plan & Facilities Review Amendment 1	" "	Aug 1972
6.	Final Report - Turbopumps for Cryogenic Upper Stage Engines	Zachary, Csomor, and Tignac	Dec 1973

FIRST BENEFITTING PROJECT: Full Capability Tug

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-04-01 PAGE 2 OF 3

STATUS (CONCLUDED):

Management Progress: The program was completed within the budget. The final report was issued in December 1973.

Conclusions: Building of long life, small size pumps is feasible and practical; mechanical reliability is very good. The general technology was demonstrated.

Problems: The liquid hydrogen pumps experienced two problems.

(1) The hydrodynamic efficiency was low compared with predicted values. Specifically, head rise was about 15% low at the design point.

(2) The turbine manifold cracked causing the manifold to deform and rub the turbine blades. This damaged both the wheel and the manifold causing a fire and the termination of one test.

Cause of Problems: The low pump head rise was caused by high diffuser losses which resulted from larger than estimated boundary layer thickness.

The manifold crack was due to a poor quality circumferential weld which was not found during inspection.

Problem Solution: Boundary layers should be calculated rather than estimated. Better quality should be exercised in weld inspection.

Forecast: The final report was issued and distributed in December 1973. This is the final URS report on this task.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-38	PRIOR NO.: 976-30-38

4. TITLE:

Materials

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	W. Angele

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Evaluation of Boron-Aluminum Composites for Space Shuttle Components
NAS8-27735 McDonnell Douglas Astronautics Co.-East, Saint Louis, Missouri

OBJECTIVE: The objective of this program is the development of sufficient technology to permit application of boron-aluminum to Space Shuttle components with high confidence.

APPROACH: This program is being conducted in the following separate phases, several concurrently: (I) Material Evaluation, (II) Design Studies, (III) Process Technology Development, (IV) Fabrication and Assembly, (V) Test and Evaluation, and (VI) Analysis of Structural Test of the Boron-Aluminum Panel. In addition to the acquisition of a significant quantity of mechanical property and process technology data, the realization of this objective will be further demonstrated by the fabrication and test of a 1.22m (48 inch) x 1.83m (72 inch) boron-aluminum compression panel capable of distributing a point load of 1555 kN (350,000 lbs) into a uniform running load within a peaking factor of 1.3 at a temperature of 589°K (600°F).

STATUS: Technical Progress:

Phase I - Material Evaluation - On the basis of a review of material from both Harvey Aluminum and Amercom, Inc., Amercom was selected as a boron-aluminum monolayer and bilayer material supplier and approximately 250 kg (550 lbs) was purchased. Approximately 12% of all material supplied was rejected with the most serious defect being poor diffusion bonds in bilayer material. Over 1000 coupon tension tests were performed to verify monolayer and bilayer strength - of which only 1.2% fell below minimum

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Twenty-one Monthly Progress Reports were received and were dated from 10 August 1971 to 10 April 1973.

First Quarterly Report, MDC E0491, "Design, Process Development, Manufacture, Test and Evaluation of Boron-Aluminum for Space Shuttle Components", R. A. Garrett, 10 Nov 1971.

Second Quarterly Report, MDC E0555, "Design, Process Development, Manufacture, Test and Evaluation of Boron-Aluminum for Space Shuttle Components", R. A. Garrett, 10 Mar 1972.

Third Quarterly Report, MDC E0650, "Design, Process Development, Manufacture, Test and Evaluation of Boron-Aluminum for Space Shuttle Components", R. A. Garrett, 10 Aug 1972.

Fourth Quarterly Report, MDC E0783, "Design, Process Development, Manufacture, Test and Evaluation of Boron-Aluminum for Space Shuttle Components", R. A. Garrett, 10 Mar 1973.

Final Report, MDC E0825, "Design, Process Development, Manufacture, Test and Evaluation of Boron-Aluminum for Space Shuttle Components", R. A. Garrett, 30 July 1973.

FIRST BENEFITTING PROJECT: Space Shuttle

TASK: Evaluation of Boron-Aluminum Composites for Space Shuttle Components

STATUS: Technical Progress: (Continued)

specification filament strength requirements (400 ksi, minimum). The material supplied by Amercom for this program was judged to be of significantly better quality than previously available material. All work required in Phase I has been completed.

Phase II - Design Studies - Components and assemblies representative of full scale hardware were designed and analyzed and included a 1.22m x 1.83m (48 inch x 72 inch) compression panel, a thrust structure beam of truss design, a thrust structure beam of shear web design, representative joint designs and panel components and element designs. Three of these structures designed under Phase II were also fabricated for structural testing. Of the remaining designs, the truss beam and the shear web beam thrust structure configurations were carried far enough to determine an overall structural arrangement, size all elements and calculate structural weights for comparison purposes. For the loading cases considered, the shear web beam design was 37.5 kg (82.8 lbs) or about 8% lighter than the truss beam design. For all design studies, specific analysis techniques tailored for metal matrix composites were developed, based in part on techniques already developed for resin matrix composites and in part for conventional metal structures. These techniques were fully verified by successful testing of the Stringer Test Assembly and the Component Test Assembly conducted at room temperature and 589°K. This effort has been completed.

Phase III - Process Technology Development - This work was concerned with improving the procedures and techniques used to fabricate boron-aluminum structures from monolayer foils. The primary emphasis was placed on the cleaning, coating and bonding thermal cycles associated with the eutectic bonding process and on improving lay-up procedures to reduce fabrication costs. As a result of these studies, the quality and reliability of eutectic bonded parts were improved significantly at the same time that processing costs were reduced. This work was completed with the preparation of process specifications which governed the successful fabrication of test components and the full size compression panel.

Phase IV - This effort included the manufacture of selected joint configurations, the component test specimen, the stringer element test specimen and the complete 1.22m (48 inch) x 1.83m (72 inch) compression panel. These units were successfully fabricated and delivered to the responsible test agencies. Notable in the fabrication achievements were the development of a mechanical forming technique which enabled producing the variable cross section stringers comprised of between 52 to 5 plies with "hard to form" titanium interleaves and the fabrication of the large 1.22m by 1.83m (4 x 6 ft) variable thickness complex skin of 62 to 10 plies, also with titanium interleaves. The successful fabrication of these test articles has demonstrated the present day capability to produce complex boron-aluminum composite assemblies of consistent sound quality.

Phase V - Work performed under the Test and Evaluation Phase included performance of joint tests, the component tests and the stringer element test by MDAC-E. Further, a Test Plan was prepared by MDAC-E for the compression panel test by MSFC followed by a summary report by MDAC-E of all program testing. Under Phase V testing, two significant milestones in panel design verification were achieved: the successful testing to ultimate design load (or equivalent) of the 1.83m (72 inch) Stringer Test Assembly at room temperature and the 0.61m (24 inch) x 1.22m (48 inch) Component Panel Test Assembly at 589°K (600°F). In the test of the Stringer Test Assembly, a maximum load of 100,000 pounds was applied to the test assembly at room temperature; this is equivalent to the

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-38 PAGE 3 OF 3

TASK: Evaluation of Boron-Aluminum Composites for Space Shuttle Components

STATUS: Technical Progress: (Continued)

Stringer Design Ultimate Load (DUL) of 50,000 pounds at 589°K (600°F). In the Component Panel test at 589°K, a maximum load of 400,000 pounds (more than 1.15 times DUL) was achieved at 589°K; subsequent panel inspection revealed only minor structural damage. The results of these tests, coupled with the evaluation of associated test strain and deflection data, fully verified the full size Compression Panel design.

Phase VI - After the completion of the above five phases, a twelve month extension was given to the contractor. This time will allow the contractor to perform analysis of structural test of the boron-aluminum panel.

Management Progress: The contract was extended to June 30, 1974 at no additional cost.

Conclusions: Sufficient technology and test data have been developed to permit application of boron-aluminum to Space Shuttle components with high confidence. Mechanical property data and raw material quality have now stabilized to the point where rational and attractive design allowable data have been developed. The processing required for boron-aluminum fabrication has been clearly transformed from a laboratory operation status to a production shop status with appropriate process specifications developed to provide part quality assurance. The design and fabrication technology have also been significantly advanced. Complex tapered and contoured structures utilizing sophisticated re-inforcement techniques have been successfully designed, fabricated and tested to excess of design ultimate loads at temperatures up to 589°K to provide confirmation of the developed technology. In summary, the boron-aluminum material system has been developed to the point where its use can provide significant weight savings, system performance improvements and increased payload capabilities for the Space Shuttle or other vehicle systems.

Problems: None

Forecast: Contractual work is scheduled to be completed on June 30, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 - 31 03 74	CURRENT NO.: 976-30-40	PRIOR NO.:

4. TITLE:

Dynamics and Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-DYN Larry Kiefling	205/453-2527	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Launch Vehicle Dynamic Loads Optimization
Contract No. NAS8-26352, Lockheed Missiles and Space Co, P. O. Box 504, Sunnyvale, CA

OBJECTIVE: To develop a closed-loop iterative design approach for the minimization of structural weight including all static and dynamic load considerations. Non-structural items such as control and propulsion parameters, both linear and nonlinear, will be included.

APPROACH: First develop an efficient program for the calculation of fully stressed design of a given structure given fixed loads. High efficiency is required in order to make computerized redesign feasible within computational state of the art and economic considerations. Then the relationships between the total loads and the feedback parameters will be developed. A numerical procedure for the solution of the resulting nonlinear equations will be developed.

STATUS:

Technical Progress -- None

Management Progress -- Funds for development of optimization methods were cancelled 20 11 72. Contract remains open for performance of related work funded by Langley Research Center. Work is expected to be completed 30 06 74.

Conclusions -- None Problems -- None

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-40	PRIOR NO.:

4. TITLE:
Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. R. Admire	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Evaluation of Modal Analysis Techniques
NAS8-26750 Martin Marietta Corporation

OBJECTIVE(S): The emphasis on correct analytical prediction of structural loads has been steadily increasing. As a consequence, dynamic models have been improved which results in large models. The heart of most dynamic response problems is the eigenvalue problem providing the modal characteristics of the structure. Thus, as the dynamic models are improved the eigenvalue problem becomes larger, and the time consumed to extract the eigenvalues becomes a major economic factor. Consequently, different and more efficient methods of modal analysis must be developed.

APPROACH: A method of modal analysis has been proposed which shows potential savings in computer time. This method is an iterative application of the Rayleigh-Ritz principle. The method will be thoroughly evaluated to determine its value for modal analysis of aerospace type structures.

STATUS: Technical Progress--The technical objectives of this study have been met. Four modal analysis methods were developed based on the iterative Rayleigh-Ritz technique. These methods were programmed for a digital computer, and the results were compared with other modal analysis programs. The results of this comparison indicate that iterative Rayleigh-Ritz methods are computationally fast and accurate. The theory, numerical results and computer programs are documented in the final report.
Management Progress, Conclusions, & Problems--None
Forecast--This will be the last report submitted on this study.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MMC # MCR-73-310	Final Report "Evaluation of Modal Analysis Techniques"	R. L. Wohlen W. A. Benfield R. A. Philippus	Dec. 1973

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-40	PRIOR NO.:

4. TITLE: Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. L. McComas	453-4387	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Flexible Body/Water Interaction During Water Impact
NAS8-28522 Universal Analytics, Inc.

OBJECTIVE(S): To develop hydroelastic dynamic analysis methods applicable to the Space Shuttle Booster Solid Rocket Motors during water impact and develop a computer program to predict pressure loads and internal loads.

APPROACH: Recommend and develop analytical methods for predicting the rigid and flexible body dynamic response of solid rocket motor resulting from water impact. Then, using the results obtained from the initial study, formulate the equations to represent a rigid SRM vehicle entering the water in a tail-first mode and a broadside mode and to determine the resulting pressure and response. Incorporate the equations into NASTRAN.

STATUS: Technical Progress--The analysis techniques, equations, and computer coding have been completed. Problem demonstration has been accomplished on the JPL computers. The delivery of the program had been scheduled for March 22, 1974.
Management Progress--A no-cost extension to the contract until November 30, 1974 was granted March 21, 1974. This extension will perform Slapdown (Rotation of SRM into water) water impact analyses.
Problems--None
Forecast--None
Conclusions--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Shuttle SRM

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-45	PRIOR NO.: 908-52-40

4. TITLE:

Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AU Jess H. Jones	205-453-0176	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Investigation of the Jet Noise Prediction Theory and Application Utilizing the PAO Formulation

NAS8-28588, University of Alabama at Huntsville, Huntsville, AL

OBJECTIVE(S): The objective of this effort is to specify the critical Shuttle vehicle acoustic environment for a given vehicle configuration and propulsion engine characteristic. It is based on recent developments of an advanced aerodynamical noise theory first formulated by Pao in 1970. As a result of this formulation, important jet noise emission mechanisms in supersonic, high temperature jets relative to overall noise intensity, spectrum, and directivity have been rigorously defined. Computer programs developed using this approach are now available for the determination of nearfield and farfield noise predictions.

APPROACH: This effort includes investigations in two main areas: the existing computer programs shall be refined such that the sound pressure fluctuation environment for given Shuttle vehicle configurations can be predicted; secondly, theoretical analysis shall be performed in areas of fundamental importance to future advancements of technology in the identification of acoustical pressure loadings on the structure of the Space Shuttle and adjacent regions.

STATUS: Technical Progress: Final adjustments to the rocket noise prediction computer program have been made. This program has been written according to the full Phillips-Pao theory of jet noise radiation. Its layout contains four main portions:

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 976-30-45

PAGE 2 OF 3

STATUS (CONCLUDED)

the master program, the WKBJ transformation, self-noise calculation, and shear-noise calculation. In addition, there are subroutines for defining quantities such as turbulence intensity profile, turbulence structure, and special functions.

The calculation of the overall noise radiation from rocket exhaust flows is based on a "slice and segment" scheme. The exhaust flow is divided into 20 or 25 slices along the centerline of the flow. For each slice, characteristic spatial and temporal scales of the turbulence are defined. Each slice is further divided into approximately nine annular segments. Individual convection velocity and temperature are assigned to each segment according to the mean flow properties. For each slice, the WKBJ transformation is defined, and the self-noise and the shear-noise are computed according to the theory. The function of the master program is to execute such calculations for each slice, and to coordinate the bookkeeping and output of the accumulated noise radiation by the entire rocket flow.

In the checkout calculations of this program, the noise radiation characteristics are computed for individual slices. Some interesting trends have been observed. In the downstream quadrant, the noise is governed by both the shear-noise and self-noise, with predominately the contribution of shear noise near the axis of the jet. In the upstream quadrant, however, self-noise dominates. For noise radiation near the axis of the jet, the noise source is located mainly in the outer segments of the jet. Hence, sound intensity at these angles will be underpredicted if only one typical segment of the jet is chosen to represent the entire slice, which is commonly done for jet noise calculations. The directivity pattern as predicted by the current method agrees quite well with experimental results. Adjustments to the input constants have been made to improve the predicted accuracy for practical calculations.

Management Progress: This effort has been terminated due to the lack of funds.

Conclusions: The theoretical results obtained to date are significant because they provide a means to obtain for the first time, a detailed evaluation of the basic noise characteristics of jet/rocket exhaust flows.

Problems: None
Causes of Problems: None
Forecast: None

Publications: "Investigation of the Jet Noise Prediction Theory and Application Utilizing the Pao Formulation", by S. P. Pao, University of Alabama in Huntsville, November 1973. This is the final report.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-45	PRIOR NO.: 976-30-40

4. TITLE:

Space Shuttle Dynamics and Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AU Jess H. Jones	205-453-0176	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Analytical/Experimental Study of Noise Suppression During Holddown of the Space Shuttle

NAS8-28566; Chrysler Corporation, Huntsville, Alabama

OBJECTIVE: High intensity acoustic environments associated with space vehicle launches have long been recognized as a problem. These environments affect the land use around the launch pad, the vehicle structure, and the launch support equipment. To counteract the increase in sound pressure levels with each new generation of boosters it is imperative that improved techniques be developed to suppress these high noise levels. Noise suppressors have been proven effective against ground-runup-noise in jet engine noise abatement programs. Therefore, it is essential that noise suppression techniques be developed to reduce the intense rocket noise environment developed by the Space Shuttle during launch holddown and static testing. The objective of this effort is to perform an analytical/experimental study of possible noise suppression techniques for the Space Shuttle propulsion system.

This effort has been expanded to obtain basic design information that is to be used in the development of the Space Shuttle launch facility deflector design. The Space Shuttle propulsion system presents a unique problem in terms of launch facility design requirements. The three separate exhaust ducting arrangements are of special concern to launch facility design personnel. The two solid motor exhausts are in opposite directions and the Hi Pc exhaust is normal to it. Of particular concern, is the insurance that modification to the existing Launch Complex 39 facility can be made so that the exhaust products can be adequately discharged from the launch facility.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-45 PAGE 2 OF 4

OBJECTIVE (CONCLUDED): It is mandatory that each exhaust duct be designed so that it does not restrict the exhaust flow which will in turn result in pressure buildup within the duct and at the base of the Space Shuttle and possible degradation in the performance of the Space Shuttle propulsion system. Adequate design of the exhaust deflector duct system can only be accomplished by testing.

APPROACH: The current design of the Space Shuttle launch facility with three separate exhaust deflector ducts has necessitated the need for a joint MSFC/KSC Cold Flow Launch Deflector Design and Noise Suppression Test. This joint program will provide basic information with respect to the orbiter and SRB's exhaust flow design requirements and relative effects of potential beneficial noise suppression which can be achieved by covering the exhaust ducts. Specifically, this study will consist of the following:

a. Develop, design and fabricate a cold flow model and implement a cold flow test program (to be conducted at MSFC) to establish basic design information for the Space Shuttle launch facility deflectors.

b. Design, develop and implement a noise suppression program, using a covered duct technique, with optimum launch deflector configurations to provide an assessment of the potential advantage of this approach.

c. Perform an analytical analysis of the diffraction effects caused by the launch facility and SSV configuration so that corrections can be applied to the existing Space Shuttle environmental estimates for the on-pad conditions.

STATUS: Technical Progress: Theoretical analysis of the formulations for diffraction and scattering of the Space Shuttle acoustic field due to the launch facility and vehicle has been conducted. Refinements to the formulations have been made with emphasis on computing the resultant diffracted spectrum assuming a known free field spectrum. A summary of these program developments and some numerical results obtained using these programs has been documented. It has been found that the effect of scattering on the overall pressure level is insignificant with respect to the measurements at the Shuttle surface. The effect on the spectrum levels is significant however.

Acoustic measurements and static pressure measurements have been performed utilizing the 1/60th scale model for the Space Shuttle/Mobile Launcher. These tests were designed to obtain information concerning the (1) effects of Shuttle drift, (2) Shuttle exhaust/mobile launcher - deflector interference effects and (3) noise reduction obtained by covering the exhaust trenches. Data reduction and analytical analysis of the acquired data is in progress.

Management Progress: This effort is presently being extended.

Conclusions: None

Problems: None
Causes of Problems: None
Forecast: Results of this study will be used to provide design information for the modification of the Saturn V Launch Complex 39 facility for use in the Space Shuttle program.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-45 PAGE 3 OF 4

Publications: HSM-R13-73, "Analytical/Experimental Study of Noise Suppression During Holddown of the Space Shuttle, Vol. I, J. Seracki, October 1973. HSM-R13-73, "Effects of Diffraction, Scattering and Reflection of the Launcher on Space Shuttle Acoustic Environments", Vol. II, Tsin N. Lee and T. Sato, February 1, 1974. HSM-R20-73, "Analysis of Scattering of Acoustic Waves by a Cylinder", Vol. III, Tsin N. Lee and T. Sato, February 5, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-45	PRIOR NO.: 976-30-40

4. TITLE:

Space Shuttle Dynamics and Aeroelasticity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AU Jess H. Jones	205-453-0176	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Wave Propagation in Thermoviscous Media
NAS8-26084; Washington University, St. Louis, Missouri

OBJECTIVE: This study effort is directed towards the development of analytical and/or empirical technique for estimating the nonlinear noise field adjacent to jet and rocket exhaust flows.

APPROACH: This effort is a continuation of a theoretical study which was initiated with OART funding. At the present stage of investigation, a solution has been obtained which describes the wave propagation characteristics in thermoviscous media that is valid for one-dimensional and axisymmetric conditions. Specifically, this study will (1) examine in detail the one-dimensional solution, (2) obtain an exact mathematical characterization of the three-dimensional model equations, (3) obtain explicit analytical solutions for the three-dimensional equations for specific regions of interest, (4) develop numerical methods for the computer-aided solution of other three-dimensional problems, and (5) establish the manner and mechanism of energy dissipation.

STATUS: Technical Progress: It is customary to derive a general equation for nonlinear acoustics involving the fluctuations of density and pressure about their equilibrium value. However, by using density and pressure as dependent variables, a general equation can be derived which seems to offer some advantages. This has been done and a resultant three-dimensional equation governing thermoviscous wave propagation has been obtained. This equation is in differential form and an exact solution

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 976-30-45

PAGE 2 OF 3

STATUS (CONTINUED):
Technical Progress (Concluded): for the two-dimensional form has been obtained. The full three-dimensional equation does not appear to be integrable analytically, however, this is still under investigation. Further, this three-dimensional equation can be shown to reduce to Burger's and Kuznetsov's equation and for the case of confined beams to the equations of Zabolotskaya and Khokhlov.

A number of techniques for obtaining approximations are under investigation. The techniques that appear most promising are piston radiation, perturbation solution of Goldberg and parabolic inequalities approaches. The results of the study to date are being documented as an interim report. This report is scheduled to be released in October.

Management Progress: This study has been extended through June 1974.

Conclusions: None

Problems: None
Causes of Problems: None
Forecast: As a result of this study, fundamental advances in the understanding of the three-dimensional propagation characteristics of a nonlinear wave in a viscous medium will be made.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 976-30-50	PRIOR NO.:

4. TITLE:
Eastern Test Range Ocean Wave Statistics for Space Shuttle Booster Design and Recovery Operations

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. C. Brown, S&E-AERO-YT	205 453-3141	Leonard L DeVries for William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Contract No. NAS8-29578, New York University
Contract No. NAS8-29616, The City University of New York, New York

OBJECTIVE: To develop a body of sea-state statistics for use in the design and recovery operation of the Space Shuttle Solid Rocket Booster (SRB). From present indications it appears that the parameters having the greatest effect upon the SRB water entry and recovery operations are the wind speed, wave height, and wave slope. Distributions of these sea-state descriptors at any given instant are applicable to SRB water entry, but for all other operations (afloat, secure, towback recovery) where some considerable time interval is involved exposure period statistics and unfavorable sea-state duration times must be developed.

APPROACH: From a detailed wind analysis of the Atlantic Ocean generate 3-dimensional sea surface spectral data. Each spectrum, computed for several grid points in the SRB water entry and recovery area, will provide sea surface information on all pertinent frequency bands and the direction from which they propagate. From these sea-state spectra develop point statistics, exposure period statistics, and persistency statistics for all phases of the SRB water recovery operations.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Fourteen monthly progress reports have been received.

FIRST BENEFITTING PROGRAM: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 976-30-50

PAGE 2 OF 3

STATUS: Technical Progress: Checkout of the new wave forecasting model has been completed and limited production runs are being attempted.

Management Progress: Contract NAS8-29616 was modified to extend the period of performance for three months to April 1, 1974 with no change in funds.

Conclusions: The wave forecast model will produce better Ocean data for use in SRB attrition studies.

Problems: Difficulty in obtaining sufficient manpower and computer time to generate sea-state statistics from the wave forecasting model were encountered but were overcome in December 1973.

Forecast: Develop one year of ocean wave climatology applicable to the Cape Kennedy SRB recovery area.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-61	PRIOR NO.:

4. TITLE:

Structures

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Incremental Proof Test Feasibility
NAS8-28514 North American Rockwell

OBJECTIVE(S): To study the feasibility of performing low level proof tests at regular intervals over the life of the Shuttle instead of one high level proof test prior to the first flight.

APPROACH: To perform analytical studies to determine the advantages and disadvantages of the incremental approach of proof testing when compared to one high level proof test. Structural weight, cost of damage due to premature failure, etc., shall be considered in this effort.

STATUS: Technical Progress--The work outlined under Approach has been completed, and the final report described below is available for distribution.
Management Progress--Since this contract is complete, this progress report terminates reporting.
Conclusions--Solid Rocket Booster Case - Incremental proof tests between missions would increase the service reliability at the expense of the cost of performing the test and a small increase in the chance of failure during the tests. Orbital Maneuvering Subsystem - The helium bottles offer a substantial weight savings when proof tested incrementally. Power Reactant Subsystem - The expense for removal and reinstallation of these tanks for incremental proof testing is prohibitive.
Problems--None
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
SD 73-SH-0264	Investigation of Incremental Proof Testing	James Noel	Dec. 1973

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-61	PRIOR NO.:

4. TITLE:

Structures

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. E. Key	453-4349	H. R. Coldwater

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of a Method for Elastic Plastic Analysis of Branched Shells
NAS8-28569 Grumman Aerospace Company

OBJECTIVE(S): The objective of this program is to develop theory for plastic analysis of axisymmetric thin shells. This development shall be incorporated into an existing computer program for predicting elastic stresses in shells of revolution subjected to symmetric and unsymmetric loading. In addition to the above extensions, processes that are presently being done by the program user will be automated, and plot routines will be incorporated to facilitate the program user.

APPROACH: A thorough literature search shall be conducted, the theory shall be formulated, and a computer program shall be developed for calculating stresses and displacements in axisymmetric shells that experience plastic deformations.

STATUS: Technical Progress--The work outlined under Approach has been completed, and the final report is forthcoming as a NASA CR.
Management Progress--Since this contract is complete, this progress report terminates reporting.
Conclusions--The programs to accomplish the above objectives are operational on the IBM 360 series and UNIVAC series of computers. The programs performed very well on the selected test problems. Copies of the programs and documentation will be made available to any requester.
Problems--None
Forecast--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA CR	Numerical Nonlinear Inelastic Analysis of Stiffened Shells of Revolution	V. Svalbonas H. Levine	

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-61	PRIOR NO.: 976-30-61

4. TITLE:

Structures

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Kenneth E. McCoy	(205) 453-3824	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Thermal Support for Space Shuttle: NAS8-25569, LMSC

OBJECTIVE: Perform Shuttle TPS analyses in support of the testing program to verify Shuttle TPS designs. In addition, specify test articles, test environments, methods of simulation and instrumentation plans.

APPROACH: Develop a computer model of candidate Shuttle TPS designs including alternate designs. To be included are effects of variation between simulation environments and flight environments such as water vapor pressure, blocking effect, and shear and enthalpy variations. From results of various environments and conditions imposed on these computer models, recommendations will be made as to tests to perform, instrumentation requirements, and methods of simulation.

STATUS:

Technical Progress: The first accomplishment of this task has been in analyzing and correlating data from thermal tests of foam and ablator TPS systems for the External Tank (ET). These ET TPS tests include both Hot Gas Facility (HGF) tests and radiant tests. An analytical thermal model has been developed to predict surface recession and internal foam temperatures in the HGF tests. Also, an analysis was performed on the similarities and differences between the conditions of the HGF tests and those to which the ET TPS will be exposed to in flight. The feasibility of using BX250 on the aft dome, LOX tank and intertank of the ET was investigated. It appears that BX250 may be acceptable as an alternate to ablator in these areas pending better definition of

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LMSC-HREC-D30662	"Thermal Support for Space Shuttle Second Interim Final Report"	W. G. Dean	June 1973

FIRST BENEFFITING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-61 PAGE 2 OF 3

STATUS:

Technical Progress: (Continued) environments and more extensive tests of BX250 foam.

Management Progress: This task is an addition to contract NAS8-25569 (Lockheed Missiles and Space Company). Contract modification was signed March 12, 1974 extending the period of performance to February 28, 1975.

Conclusions: The thermal model developed gives a fair correlation with experimental data over a narrow range of conditions. However, to make the model useful in predicting flight performance, it is being revised as more data becomes available. Although the heating rate is adequately simulated in the HGF, the aerodynamic shear, free stream enthalpy, static pressure and free stream oxygen content are different and additional tests are recommended to determine the exact nature of their effect.

Problems: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-61	PRIOR NO.: 908-54-08

4. TITLE:

Structures

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-D Robert S. Ryan	205/453-2481	Robert S. Ryan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Control Trajectory and Loads Optimization
Contract No. NAS8-28299, Honeywell, Inc., Systems and Research Division, 2345 Walnut Street, St. Paul, MN

OBJECTIVE: Develop and integrate a computer program that simultaneously optimizes vehicle design considering trajectory, control, and structures.

APPROACH:

Phase I - Optimization technique -- Develop an interdiscipline optimization routine; develop basic program using RAGMOP* trajectory and boost six-flight control decks. Tie together these programs in an acceptable manner and make provisions for additional modules, such as structural loads and weight.

Phase II - Structural model -- Develop a structural loads and weight module. Incorporate into program of Phase I.

Phase III - Documentation -- Document and provide computer program.

STATUS:

Technical Progress -- A basic program that meshes RAGMOP, a load module, and pitch plane 3-D control module together has been completed. No optimization between the total loads has been made. Sensitivity of vehicle weight to load relief gains for

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITING PROJECT: Space Shuttle

*RAGMOP is an acronym for: Rocket Ascent G-Limited Moment-Balanced Optimization Program

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-61 PAGE 2 OF 3

STATUS: (CONCLUDED)

a preliminary shuttle vehicle has been made. The results show that even though increasing the load relief gains decreases $q\alpha$, the vehicle weight (total loads) first decreases then increases with increasing gains. This is due to increasing inertial loads faster than decreasing the $q\alpha$.

Management Progress -- The contract is completed with preliminary copies of the final report received.

Conclusions -- This work has been completed.

Problems -- None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-84	PRIOR NO.: 976-30-50

4. TITLE:

Shuttle Development

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AT David C. Seymour	205-453-1157	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: SSME Orbiter Radiation Analysis
NAS8-29270, Remtech, Inc.
2603 Artie Street
Huntsville, Alabama 35805

OBJECTIVE(S): To develop an analytical SSME plume radiation model that can be used to generate SSME plume radiation heating to the base of the Orbiter, ET, and SRB's.

APPROACH: During the development of the Saturn S-II stage, a computer program was developed to calculate the gaseous radiation from the five S-II stage J-2 engines. Since the engines used on the Space Shuttle orbiter utilize the same propellants, i.e., H_2/O_2, this computer program is applicable. It is proposed, therefore, to modify and update this program to include the geometry and plume flow fields of the Space Shuttle and to use this program to generate the SSME radiation contribution to the overall Shuttle base thermal environment.

STATUS: Technical Progress - Since the gaseous radiation computer program developed for the Saturn applies only to rocket engines parallel to each other, a program was developed to transform the plume flow field data for the engines from an uncanted position to a canted position. This program also allows adding together different parts of the flow field obtained from different sources. Several modifications which simplify and specialize the program for the orbiter configuration have reduced the computer time of the radiation program by nearly an

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-84 PAGE 2 OF 3

STATUS (CONCLUDED)

order of magnitude. Preliminary orbiter radiation heating predictions to the external tank and orbiter heat shield have been obtained for sea level conditions and more extensive predictions are planned. High altitude radiation is predominantly from the shock layers formed by the plume interaction of the three engines and an approximation of this three-dimensional flow field is being developed by using S-II flight radiation data.

Management Progress - Contract NAS8-29270 started on January 1, 1973. A $30K extension to April 1, 1975, is expected to begin April 1, 1974.

Conclusions - None

Problems - None

Forecast - None

Publications - None

Remarks - None

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-84 908-52-40*	PRIOR NO.: 908-52-39

4. TITLE:

Shuttle Development

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AAE Josh D. Johnson	205-453-2519	W. K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Tasks: Water Impact Tests of Solid Rocket Motor Booster Models, NAS 8-28985: Chrysler Corporation Space Division, New Orleans, LA 70129

Hydrodynamic Testing and Model Hardware Design for Space Shuttle Water Impact Tests, H-92132A: U. S. Naval Ordnance Laboratory, Silver Spring, MD 20910

OBJECTIVE: Provide part of the water impact data that will serve as a data base to be used to design the solid rocket booster (SRB) structure and the SRB recovery system. Specific parameters to be investigated are pressure scaling effects, vertical impact velocity and impact attitude. Horizontal drift velocity will not be investigated and only tail-first entry will be considered.

APPROACH: This will be a continuation of work that was initiated with other funds; therefore, an existing 0.08-scale model will be modified for use in the tests. This model will be dropped into water at the U. S. Naval Ordnance Laboratory (NOL) Hydroballistics Tank. Accelerometers will be used to record total model impact loads and pressure transducers will be used to record local loads. High speed motion cameras will be used to record visual impact phenomena. Tests will be performed with ambient tank pressures and with reduced tank pressures.

Chrysler Corporation Space Division personnel will prepare for and perform the required water impact tests. They will also analyze the resulting data and prepare a test report. NOL will provide the test facility; NOL personnel will help prepare the test models and they will help perform the tests.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

FIRST BENEFITING PROJECT: Space Shuttle

*Jointly funded by 908-52-70, 908-52-87, and 976-30-40, 908-52-39

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-84 PAGE 2 OF 3

STATUS:

Technical Progress - Tests of an uninstrumented model were performed during October 1972. Results of the tests showed that, for vertical entry with an impact velocity that simulated a full scale impact velocity of 60 feet per second, the penetration depth with a scaled atmospheric pressure was approximately one diameter deeper than for tests with ambient atmospheric pressure. Results also showed that, for entry angles 30 degrees of vertical, the maximum penetration depth did not change when the atmospheric pressure was changed. One interesting result was that, for scaled atmospheric pressure, after each test the model floated in a vertical attitude. In contrast, after tests with ambient atmospheric pressure the model floated in an almost horizontal attitude.

Tests with an instrumented model were performed during February 1973. The model was instrumented with nine accelerometers and thirty-four pressure transducers. Data from these tests have been analyzed and CCSD has completed an analysis report.

Management Progress - The NAS8-28985 contract with CCSD has been completed.

Conclusions - If nozzle-first water impact tests of SRB models are performed in a pressure scaled environment, peak accelerations, peak nozzle internal pressure, and cavity collapse pressures will be greater than the corresponding values that would be measured during tests at standard sea level atmospheric conditions. The peak internal tank pressure will be smaller.

Problems - The first edition of the CCSD-prepared analysis report was not a very good report; therefore, CCSD asked for and received a no-cost extension to their contract so that they could rewrite the report.

Causes of Problems - The first edition of the analysis report was prepared by CCSD personnel who had not helped perform the tests at NOL; therefore, they were not familiar with the test procedures and data acquisition methods that were used during the tests.

Suggested Solutions - Test reports should be prepared by personnel who are familiar with the tests.

Forecast - None

Publications - Braddock, W. F., "Test Results for Space Shuttle Booster Pressure Scaled Water Impact Tests (0.08 Scale Model)," Northrop Services, Inc. Report, January 1973

Hull, J. J. and Kwark, K. C., "Pressure Scaled Water Impact Test and Analysis Report of an 8-Percent Solid Rocket Booster Model," Chrysler Corporation Space Division Report TN-FT-74-5, February 18, 1974

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 976-30-84	PRIOR NO.: 976-30-50

4. TITLE:

Shuttle Development

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-AT Terry F. Greenwood	205 453-1157	Werner K. Dahm

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study on Solid Rocket Motor Plume Flow Field and Radiation Analysis
NAS8-28609, Lockheed Missiles and Space Co., Inc.
Huntsville Research and Engineering Center
P. O. Box 1103, West Station
Huntsville, Alabama 35807

OBJECTIVE(S): To incorporate into existing gaseous plume and plume impingement computer programs the capability to calculate solid rocket motor two-phase plume flow fields and plume impingement effects; and to use these analyses to improve and update existing solid motor radiation calculations.

APPROACH: It is proposed to improve and update existing plume flow field and plume impingement analytical models to account for the effects of solid particles in the flow field. Using this better description of the two-phase flow field, the prediction of solid motor radiation can be improved. Extensive use will be made of existing solid motor radiation data from ground and flight tests of Minuteman, Titan IIIC, Polaris, etc., to develop and improve the radiation analysis. The updated plume impingement analysis will include particle heating, gaseous convective heating, impingement pressure, and particle impingement pressure.

STATUS: Technical Progress - The coupled two-phase solid motor plume flow field analysis has been developed and is being checked out with available experimental data and existing uncoupled programs. Additional work remains to be done in developing adequate "freezing" criteria and in the flow field chemistry analysis.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 976-30-84 PAGE 2 OF 3

STATUS (CONCLUDED)

This program is being incorporated into the plume impingement program (PLIMP). An extensive amount of existing model and full scale solid motor plume radiation data from Polaris, Poseidon and Titan IIIC has been examined and is being used to update our understanding of solid motor plume radiation. The feasibility of using a Monte Carlo Technique for predicting solid motor plume radiation was investigated. This technique will be developed further during the upcoming reporting period.

Management Progress - Negotiations for a follow-on extension to Contract NAS8-28609 are underway.

Conclusions - Preliminary examination of the coupled, two-phase plume analysis indicates that it will be useful in generating the Shuttle design environments.

Problems - None

Forecast - None

Publications - LMSC-HREC TM D306995, "Prediction of Radiation Heat Transfer Characteristics from Solid Rocket Plumes using the Monte Carlo Technique," G. H. Watson, N. A. Logan and J. V. McAnally.

LMSC-HREC TM D390063, "Convective and Solid Particle Plume Impingement Heating Analysis for the SRB Separation Motors Impinging on the Space Shuttle Orbiter and ET," S. D. Smith and J. V. McAnally.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	976-30-93	976-30-61

TITLE:

Structural

RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
&E-AERO-DDD, Gaines L. Watts	205 - 453-2521	Robert S. Ryan

ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Parachute Dynamics & Stability Analysis
Contract Number NAS8-28607; Honeywell Inc., Systems and Research Division, Minneapolis, Minnesota - 55413

OBJECTIVE(S): To provide a data base for the optimization of design of a parachute system for recovery of large vehicles.

APPROACH: To formulate the equations of motion for a Parachute/Vehicle combination (Phase I) then to linearize these equations (Phase II) and use standard linear techniques to analyze parameter sensitivity (Phase III).

STATUS:
Technical Progress--The final refinement of assumptions has been made. The computer programs have been completed and checked out. The linear portion of the programs has been utilized to perform Nyquist and Root-Locus analyses, thus allowing the objective to be achieved.

Management Progress--The contractor gave a final oral progress report in the twelfth month of the contract. Final adjustments to the overall effort were then given to him for incorporation into the final written report. The final written report and computer program documentation are behind schedule but are expected to be received soon.

Conclusions: None Problem: None

REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRST BENEFITTING PROJECT: Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 982-52-03	PRIOR NO.: None

4. TITLE:

Shuttle Main Propulsion Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. A. Gross	205-453-3816	J. A. Lombardo

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: POGO Dynamic Flowmeter Evaluation
In-House S&E-ASTN-PPM

OBJECTIVES: Evaluate and calibrate flowmeters believed to have potential for dynamic flow measurement in SSME testing under simulated operating conditions.

APPROACH: Available flowmeters believed to have potential for dynamic flow measurement in SSME POGO testing will be procured and evaluated in a cryogenic flow facility at MSFC. The 8-inch flowmeters will be evaluated over a frequency range of 2 - 40 Hz with dynamic velocity variations the same as expected in SSME POGO testing. The standards for evaluation will be 2" meters previously calibrated by NBS. The expected results from the program will be recommendations to the SSME contractor for flowmeters to be used in engine POGO testing.

STATUS: Technical Progress: Testing has been completed on two 8-inch Ramapo flowmeters using calibrated Ramapo 2-inch meters as the standard. Testing was performed over the frequency range from 2 to 30 Hz at flows from 10 to 20 lbs/sec. A math model was developed to aid in facility design and data analysis.

Management Progress: Ramapo flowmeters testing has been completed and a report issued.

Conclusions: The Ramapo 8-inch flowmeter does not have the accuracy or resolution required for SSME POGO testing.

Problems: None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
S&E-ASTN-PP(74-36)	Evaluation of RAMAPO Flowmeters for SSME POGO Testing	C. Miller	March 1974

FIRST BENEFITTING PROJECT: SSME

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 982-52-03 PAGE 2 OF 3

STATUS (CONCLUDED):

Forecast: Plans to test the Saratoga flowmeter which has been returned to the manufacturer for repair are indefinite at this time. A decision to test this meter when it is returned will be made on the basis of NBS test results on other promising ultrasonic flowmeters and the MSFC facility status. Therefore, unless the Saratoga flowmeter is tested, this is the final URS report that will be issued on this task.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE: CURRENT NO.: 982-52-61	PRIOR NO.: 976-30-61

4. TITLE: Space Shuttle Engine and Vehicle TPS Review

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. E. Price	205-453-3825	C. C. Wood

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space Vehicle Engine and Heat Shield Review; NAS8-27802, BBCO

OBJECTIVE: (1) Determine the degree of agreement between flight and scale model results and analytical prediction techniques. (2) Identify and implement improvements in the analytical methodology. (3) Identify and evaluate probable errors associated with the flight instrumentation and propose a solution which will correct the errors.

APPROACH: Work scope has four tasks: Task 1 - Adopt the solid rocket plume data previously collected to the present Shuttle SRM configuration through math modeling for capability of assessing the impact of solid rocket plume emission at altitude. The methodology should include incorporation of plume-to-vehicle radiation view factor determination on a rapid turn-around computer run basis. Task 2 - Incorporate in the current operational computer program for flow reversal base heating the effects of cryogenic engine internal boundary layer condensation phenomena which is possible at the reduced power level operation of the Space Shuttle Main Engine (SSME). Task 3 - Evaluate the base region instrumentation requirements of the SRM and ET as dictated by the past and currently available instrumentation design criteria. Task 4 - Prepare a final technical report that describes in detail the results, conclusions, and recommendations of the "Space Vehicle Engine and Heat Shield Review".

STATUS:

Technical Progress: Final report completed. Instrumentation evaluation included in cursory form only. Cryo propellant engine boundary layer condensation effects are included in the flow reversal base heating model.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
July 1971 - June 1972	Monthly -	July, August, Oct, Nov, Jan, Feb, April, May	
933-40-50)		Quarterly - Sept, Dec, March Interim - June	
July 1972 - March 1972 (976-30-61)	Monthly -	July, August, Oct, Nov, Jan, Feb, April, May Quarterly - Sept, Dec, March, June	
July 1972 - March 1973 (976-30-61 and 933-40-50)		Monthly - July, Aug, Oct, Nov, Jan, Feb Quarterly - Sept, Dec, March	
March 1973 - July 1973 -		Postponement of Continuing Effort	
July 1973 - Sept 17, 1973 -		Funding Delay	
Sept 17, 1973 - Dec 14, 1973 (RTOP, 982-52-61)		Final Period of Performance Concluded with Final Report	

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 982-52-61

STATUS: (Continued)

Management Progress: Initial contract signed June 28, 1971. Fifth cost extension covers period from June 30, 1973 to 1 October 1973. Funding delay til 17 September caused schedule shift of period of performance to 17 September through 14 December at no cost to Government. Funding of 1 July 1971 through 30 June 1973 activities under 933-40-50 and 976-30-61 respectively.

Conclusions:

Flight Test Data - Measuring instruments influences the measured parameters rather than being driven by them. Plume radiation characteristics cannot be extrapolated from one vehicle configuration to others as has been previous practice.

Scale Model Test Data - are widely scattered and subject to questionable interpretation and always over predict the base thermal environment for booster stage. Scaling factors remain undefined. Scale model data useful primarily for trend definition but not as a design tool in their present approach.

Engine Cryopropellant Effects influence the overall base thermal environment and have generally been ignored in analyses and model testing.

Base Region Flight Instrumentation not measuring the parameters they were intended to measure and requirement for new instrumentation is evident.

Base Region TPS Materials can significantly influence base region thermal environment if they are highly hygroscopic.

Analytical Models generally force too conservative a design and indicate that the existing empirical correlation for base region heat transfer/flow phenomena are not adequate except in parametric application.

Solid Rocket Motor plume radiation prediction techniques are not adequately developed and require development prior to appplications to Space Shuttle/SRB.

Milestones:

Review of all SATURN I, IB, & V booster vehicle base region flight and base region thermal environment design criteria has been completed and critiqued and impacted on SS design analyses.

Computer programs from previous vehicle programs throughout the Aerospace industry have been reviewed and compacted into a rapid turn around design tool in manual and simplified programming form; convection and radiation heating environment definition capability included in component form.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 982-52-61

PAGE 3 OF 4

STATUS: (Continued)

Problems: Analytical techniques for instrumentation correction not proven and require further analysis beyond scope of work of present extension.

Remarks: On 30 December 1973 a complete final report of 29 month study inclusive of the final extension period, was submitted.

Results of the study will be implemented directly into consideration of of Shuttle TPS and base region heat shield instrumentation design.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	983-15-21	976-30-13

4. TITLE:

Instrumentation for Space Shuttle

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMP H. Harman	453-5620	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: 035 Flange Mounted Preburner Pressure Transducer
Flange Mounted Cryogenic Pressure Transducer

NAS8-27442, Conrac, Inc., Durrant, CA
NAS8-27444, Consolidated Controls Corporation, Bethel, CT
NAS8-27445, Statham Instruments, Oxnard, CA
NAS8-27443, MB Electronics, Gilmore Industries, Cleveland, OH

OBJECTIVE(S): To develop a flange mounted pressure transducer capable of meeting the frequency response and accuracy needed for the Space Shuttle Engine Controller. Reliability and elimination of potential leak problems will be a prime consideration in the development.

APPROACH: A development has been initiated for pressure transducers capable of meeting the environmental restraints of the Shuttle engine preburner and cryogenic pressure measurement. The transducer will be low level strain gage type capable of interfacing with the engine controller. The most logical transduction technique, at this time, appears to be strain gage. The contracts awarded represent four different strain gage approaches: conventional, bonded, deposited film, and piezo resistive.

STATUS: Technical Progress - Composite requirements for flange mounted

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report NAS8-27743		Gilmore Industries	
Final Report NAS8-277445		Statham Instruments	

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 983-15-21 PAGE 2 OF 2

STATUS (CONCLUDED): Technical Progress (cont'd) - and cryogenic pressure transducers have been developed based on information available from the three engine Phase B contractors and MSFC engine working groups. Preliminary design reviews were performed and approved September 9, 1971.
Phase II of the Scope of Work on all contracts has been completed and contractors advised to proceed to Phase III.
Management Progress - Statham Instruments, Inc. and Gilmore Industries, Inc. have delivered hardware and final reports.
Consolidated Controls and Conrac, Inc. were granted additional time to complete hardware and final reports.
Conclusions - Some additional time may be required to complete prototype transducers.
Forecast - The current effort will result in prototype transducers which will allow an evaluation to be conducted for the purpose of defining final unit development. This task is no longer an SRT task and is beingfunded under the engine program. This will be the final report.

Consolidated Controls Co. and Conrac Inc. have been granted additional time at no additional cost to the government to complete prototypes and submit final reports.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 983-15-21	PRIOR NO.: 976-30-13

4. TITLE:

Instrumentation for Space Shuttle

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-ASTR-IMP H. Harman	453-5620	W. O. Frost

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: 035, Low Differential Pressures in High Line Pressures
NAS8-27227, Celesco, Inc. Chatsworth, CA
NAS8-27446, Toroid Corporation, Huntsville, AL

OBJECTIVE(S): To develop a lightweight (12 oz.) dual isolated (wet-wet type) differential pressure transducer having full scale ranges of 0-10 psid and 0-100 psid for line pressures up to 8000 psi.

APPROACH: Two parallel approaches have been chosen for this development; i.e., development of a torus type pressure sensitive element which will generate a force capable of being sensed with conventional strain gage elements and boron doped silicon strain gages bonded inside an integral diaphragm beam.

STATUS: Technical Progress - Celesco will make minor changes in the method of mounting strain gages to the integral beam. Gages will first be applied to a small beam and the small beam will be inserted into the integral beam-diaphragm. This approach eliminates the problem of matching the strain gage to the integral beam-diaphragm material.
Management Progress - Toroid Corporation has delivered final report and hardware. Additional funds were granted Celesco, Inc. in order that the contract might be completed. Celesco, Inc. was given additional time to complete contract.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
Final Report NAS8-27446		Toroid Corporation	

FIRST BENEFITTING PROJECT: Space Shuttle

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 983-15-21

STATUS (CONCLUDED): Management Progress (cont'd) -

Conclusions - Research and development performed indicates that all guideline specifications may not be met.
Problems - Toroid was not able to achieve the required working pressure of 8000 psi.
Forecast - Basic problems associated with low range differential pressure transducer will not be completely solved requiring follow-on contracts in order to meet guideline specifications. This task is no longer an SRT task and is being funded under the engine program. This will be the final report.

Celesco's last approach did not provide a solution to the strain gage problem. Celesco requested additional funds which are not available. Celesco was advised to stop further work and submit a final report.

OFFICE OF APPLICATIONS

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	161-80-01	908-51-02

4. TITLE:

Space Station Thermal Control

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. L. Middleton	205-453-3828	G. D. Hopson

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Evaluation of Absorption Cycles for Space Station Environmental Control NAS8-25986

OBJECTIVE: (a) Evaluate the performance and capabilities of absorption refrigeration cycles for spacecraft thermal control.

(b) Using space system analysis tools evaluate the spin-off application of solar powered cooling and heating systems for residential applications. Using previously developed analytical techniques define, in conjunction with MSFC in-house efforts solar collector, thermal storage, and modifications required for commercially available air conditioners for a full scale demonstration project of solar powered residential heating and cooling.

APPROACH: (a) Computer analysis procedures were developed, system components designed, fabricated and experimentally evaluated. The performance of the space system breadboard components agreed with analytical predictions.

(b) The analytical procedure previously developed were used to support the MSFC designed solar heating and cooling demonstration project.

STATUS: Technical Progress - (a) The space system was analyzed and parametric comparisons made. A conceptual breadboard system was designed, fabricated and tested. This system incorporated all gravity sensitive sub-components, and was successfully operated at design conditions. A detailed final report was written and published.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LMSC D306225	Evaluation of Absorption Cycle for Space Station Environmental Control System Application, LMSC D306225	Sims O'Neal Ried Bisenius	Nov. 1972

FIRST BENEFITING PROJECT -MSFC In-house Solar Heating/Cooling Demonstration Progr

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 161-80-01 PAGE 2 OF 2

Technical Progress Cont'd

This is the final report on the space application of the absorption cycle.

(b) The feasibility study of residential application was completed in November 1972 and a detailed final report published. The contract was amended to permit additional analytical effort in conjunction with the MSFC demonstration program. Design analysis have been completed on the solar collector, thermal storage system, and control system. This effort has been completed and this is the final report.

Management Progress - Final report is being prepared.

Conclusions - (a) Spacecraft thermal control can be accomplished using absorption cycle refrigeration for certain space thermal environment/conditions. Breadboard tests have proven component design adequacy.

(b) Residential heating and cooling utilizing solar powered absorption refrigeration systems is potentially desirable considering increases in conventional fuel cost and decreased availability. Spacecraft technology can make the residential cooling project successful.

Problems - None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	175-21-71	160-44-58

4. TITLE:

Climatological-Statistical Atmospheric and Cloud Cover Models

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-YT S. Clark Brown	(205) 453-3141	Leonard L. Sellers for W. W. Vaughan, S&E-AERO-Y

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: (1) World-Wide Cloud Cover Model
Contract No. NAS8-28721, Environmental Research & Technology, Inc.

(2) Atmospheric Effects on Remote Sensing of Non-Uniform Temperature Sources
Contract No. NAS8-28722, University of South Alabama
Mobile, Ala. 36688

(3) Four-Dimensional Atmospheric Model (World-Wide) Study
Contract No. NAS8-28720, Environmental Research & Technology Inc.
429 Marrett Rd., Lexington, MA 02173
McDonnell Douglas Contract 29663, McDonnell Douglas Corp., Huntington Beach, Calif. 92647

OBJECTIVE: To develop climatological-statistical atmospheric and cloud cover models and to examine the effects of the atmosphere on the transfer of electromagnetic energy. The models (comprised of clouds, pressure, temperature, density, moisture, and winds) are designed for computer simulations of earth oriented space missions.

APPROACH: (1) Compile cloud cover, cloud type, and cloud structure data for homogeneous regions on a global basis. Develop utilization techniques to apply these data to earth viewing missions. (2) Develop atmospheric data (temperature, pressure, density, moisture, and wind) for world-wide grid points from surface to 50 km altitude. Devise techniques to extract from the computer data bank a profile applicable to any specified location. (3) Conduct an analytical investigation of atmospheric effects upon the transfer and sensing of electromagnetic energy.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Monthly progress reports giving informal details of current activities and future plans. Draft copy of final report prepared under Contract NAS8-28721.

FIRST BENEFITING PROJECT: Spacelab.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 175-21-71

PAGE 2 OF 3

STATUS: Technical Progress: Cloud region homogeneity was examined and some region changes were accomplished.

Temporal and spatial conditionality of cloud types was established.

Example calculations to determine the effects of atmospheric emission, absorption, and scattering upon energy emitted by a non-uniform source was begun.

Management Progress: Contract NAS8-28721 was extended to 14 Feb. 1974 at no additional cost.

Contract NAS8-30273, a 12 month contract with Environmental Research and Technology was begun on 22 Feb. 1974.

Conclusions: The atmospheric models and electromagnetic energy attenuation calculations will provide information needed by better earth viewing mission planning.

Problems: None

Forecast: Atmospheric models and operational computer programs to partially analyze these data are presently available. The improved model statistics, the streamlined utilization techniques, and the atmospheric energy attenuation calculations will enhance the utility of the models in mission analysis of earth viewing space missions. The close cooperation of this work with NASA Hq., GSFC, and other MSFC units will insure widest application of the end product.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 - 31 03 74	CURRENT NO.: 175-61-71	PRIOR NO.: 160-44-69

4. TITLE:

Interrelationships Between Atmospheric Motions of Different Scales

5. RESPONSIBLE INDIVIDUAL	TELEPHONE:	APPROVAL:
Robert E. Turner S&E-AERO-YE	(205)-453-3109	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Interrelationships Between Atmospheric Motions of Different Scales
Contract No. NAS8-26751, Texas A&M University, College Station, Texas.

OBJECTIVE(S): The objectives of this effort are (1) to analyze the AVE-I data (Atmospheric Variability Experiment I) and present in a tabular form, (2) to investigate the relationship that exists between mesoscale meteorological phenomena and large-scale averages of the same phenomena, (3) to determine the value of an AVE II experiment, and (4) to determine the use of an AVE II experiment in the SMS project evaluation.

APPROACH: To enhance the applicability of mesoscale analyses, the AVE I data will be documented for use by other research groups. Selected cases of AVE I will be studied to investigate the relationships between mesoscale and larger-scale averages meteorological related phenomena. This relationship will involve parameters such as cloud cover, thunderstorms, precipitation, maximum surface temperature and minimum surface temperature, and the gradients of pressure and temperature. The information obtained above will be used to determine an AVE II experiment for comparative measurements and analysis of satellite and ground-based atmospheric measurements to establish applicability of satellite data from such satellite projects as SMS, Nimbus, NOAA-2, for sensing and predictions.

STATUS: (Continued on following page)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA TMX-2938	Data for First NASA Atmospheric Variability Experiment (AVE I); Data Tabulation	Scoggins, J.R. Smith, O. E.	
NASA TMX-2948	Data for First NASA Atmospheric Variability Experiment (AVE I): Graphical Presentation of Data	Scoggins, J.R. Smith, O.E.	

FIRST BENEFITTING PROJECT: SMS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 175-61-71 PAGE 2 OF 3

STATUS: (Cont'd)

Technical Progress: Software program for the project was developed.

Management Progress: Meeting was held at MSFC and University of Chicago in February to review and discuss our plans for a program to assess the accuracy of satellite derived meteorological data. Briefing was given to Headquarters and Lead Center personnel in March on our plans for obtaining ground-base and satellite data and data reduction techniques to be used.

Conclusions: The project will be conducted with MSFC being the focal point of the coordination effort between NOAA and NASA. The experiment is scheduled for late April or early May 1974.

Problems: None

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	175-61-01	160-75-61

4. TITLE:

Statistical Data Management Methods

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Dr. J. Briscoe Stephens JBS. S&E-AERO-YA	205/453-3159	W. W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Crossed Beam Spectroscopy in Multicomponent Gas Flow

NAS8-30175 University of Oklahoma Research Institute, Norman, Oklahoma

OBJECTIVE: The optical correlation system has been proposed to visualize the three dimensional extent of atmospheric trace constituents such as humid air masses. The visualization and interpretation of the weak trace constituent signals will require new and clever methods, which can only be developed and illustrated in regional application. One such regional project is remote sensing of precipitation and evaporation losses. The utilization of correlation signatures has been proposed since the correlation computations have the potential of separating evaporation loss from total water burden estimates. The objective of this contract is to develop sepectroscopic correlation principles for rejecting interference and for monitoring water vapor without the use of reference signatures. The ultimate objectives are the interpretation of correlation estimates from aircraft and EREP in terms of the concentration, temperature, water vapor and the rejection of background interference, and the evaluation of Shuttle exhaust effects.

APPROACH: Correlation estimates of H_2O: (1) Augment the existing gas calibration cell with a Hg Cd Te detector and a Pb-Se detector, which will be furnished by MSFC to monitor H_2O emission. Prepare the cell for water vapor fillings at temperatures and pressures which simulate the above surveys and scattering interference to the largest practical amount. (2) Repeat for H_2O the static and dynamic absorption measurements which were conducted previously under contract NAS8-30175 for CO_2. Submit selected analog data tapes with the dynamic measurements to S&E-AERO-YA for correlation computatio (3) Evaluate the validity of the conventional (static) and correlation (dynamic) spectra

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Rev. Sci. Inst. 44, 3	An Optical Absorption Cell with Vapor Cross-Flow	P. E. Hendrickson W. L. Falls S. Broersma	March 14, 1973
OURI 12-73	Termodynamic Derivative Spectra of Infrared Absorption, Final Report	S. Broersma P. E. Hendrickson W. L. Falls	February 1974
J. Opt. Soc. Am.	6.3μ Water Vapor Band Derivatives	P. E. Hendrickson W. L. Walls S. Broersma	February 1974

FIRST BENEFITTING PROJECT:
Space Shuttle

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 175-61-71 PAGE 2 OF 3

by comparing the forcing function $\partial K/\partial T$ and $\partial K/\partial P$ that have been obtained from both approahces. (4) Illustrate, for selected examples, the interpretation of the corrected H_2O correlation spectrum in terms of absorber mass concentration and temperatures.

STATUS:

Technical Progress: Static water vapor absorption experiments have been conducted for three temperatures with various concentrations of H_2O over the 5 micron to 8 micron spectral region. These data are being reduced to obtain transmittance as a function of wavelength for a given temperature. Computer programs were developed to convert fine line band model information to broad band information in order to generate a theoretical base for a comparison with the empirical results. These results were presented in the final report.

Management Progress: Final report was reviewed and contract was closed out February 1974.

Forecast: None

Problems: None

Conclusions: Static water vapor experimental results have been obtained. These results suggest that similar model to that obtained for carbon dioxide exists for water vapor; namely, that a thermal "cross-over points" exist at 5.55 micron and 6.95 micron in the 6.3 micron water vapor band. Computer calculation using NOAA fine band model confirm these results. These results agree with the 4.2 micron results obtained for carbon dioxide.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 175-61-73	PRIOR NO.:

4. TITLE: Analysis of the Energy Interactions Between Atmospheric Level and of Solar Terrestrial Relationships

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Robert E. Smith	205 453-3140	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Tidal and Gravity Wave Propagation.
Contract No. NAS8-30616, University of Alabama in Huntsville, AL 35805

Objective: To study wave propagation through the mesosphere and thermosphere in order to understand energy transfer mechanisms.

Approach: Develop a theoretical model of tidal and gravity wave propagation in the mesosphere and lower thermosphere for comparison with C-4 Ionosonde observational data.

Status:

Technical Progress: Ionograms are being analyzed to obtain observational data for use with the CW Doppler array data.

Management Progress: The contract was awarded on Feb. 14, 1974.

Conclusions: None.

Problems: Funds are insufficient to complete the development of a full three-dimensional model.

Forecast: This work will be terminated at the end of the contract since no FY 75 funds will be provided.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Spacelab

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
Marshall Space Flight Center	01 10 73 31 03 74	CURRENT NO.: 177-53-71	PRIOR NO.: 160-75-10

4. TITLE:

Remote Sensing for Geological Resources Survey

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bensko, J.	453-0187	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Preliminary field work was carried out during August. Two contracts to the University of Alabama at Tuscaloosa were initiated on July 1st. High altitude photography and ERTS photography were examined over one test site. Low altitude photography over two other sites is expected during October.

Objectives of one of the university-MSFC studies is to determine the feasibility of utilizing satellites for the detection of geologic hazards. A second project is to relate satellite remote sensing of land and water pollution from several types of strip mining and to study the immediate and long term effects of surface mining activity

ERTS photographs were studied to select a site where large scale non-contour stripping is current whereas other sites were chosen on the basis of ground studies.

Geological studies of site near Cordova and in the Searles quadrangle have been partially completed and a botannical catalog of revegetation over different areas of the site housing different histories and slight changes in the coal composition is in progress. Some aerial photography has been completed over the site but plans for spectral studies of the revegetated areas has been delayed and will have to be postponed because equipment ordered for the study has not been delivered.

The study of Geological hazards by remote sensing techniques is progressing rapidly despite a several months delay in obtaining my low altitude aircraft coverage. ERTS photography proved to be unsuitable for the study. Most of the work has been done by conventional methods to date. Sinkhole hazards along potential highway routes in Shelby County are awaiting the availability of airborne IR equipment.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Annual reports due July 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 177-53-71 PAGE 2 OF 2

6. (Con't)

In-house library search of all current published information on geothermal deposits continues. Contractual efforts are planned in FY 75.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Solidification of Alloys Exhibiting Solid State Immiscibility (179-11-13-01)
NAS8-29725 Washington State University, Pullman, Washington 99163

OBJECTIVE: The objective of this effort is to investigate the effects of low gravity on the solidification, resultant microstructures, and physical properties of binary metal systems having low mutual solubilities and to understand the physics of solidification of materials of this type in a low gravity environment. The results of these studies may be used to design processes for obtaining materials with microstructures and hence properties not achievable under terrestrial gravity.

APPROACH: The contractor shall conduct laboratory studies to determine the effects of varying solidification rates on the crystallographic structures and microstructures in gold-silicon alloys; perform analytical and experimental studies to define specimen sizes, containers where applicable, heating, and cooling rates; prepare specimens of gold-silicon alloys of different compositions for processing by MSFC in the drop tower; and analyze and interpret the processed specimens by using optical microscopy and replica electron microscopy, x-ray diffraction and other techniques.

STATUS: Technical Progress: Contractor has continued work necessary to determine the equilibrium phase diagram for gold-silicon and particularly the eutectic temperature. Drop tower specimens are being prepared for tests during the next quarter. Progress has been made on refining the mathematical theory of gravity segregation which will be used in the evaluation of results on one-g and low-g experiments. The contractor has proposed a new technique for growing crystals from the melt in zero-g.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Eleventh Monthly Progress Report, "The Solidification Under Zero Gravity Conditions of Binary Alloys Exhibiting Solid State Immiscibility", A. A. Johnson, R. P. Anantatmula and R. Vatne, March 1, 1974.			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-10 PAGE 2 OF 2

TASK: Solidification of Alloys Exhibiting Solid State Immiscibility

STATUS: (Continued)

Management Progress: Additional funds are being added to the contract for additional studies on the gold-silicon system and on the feasibility of the proposed technique of growing crystal from the melt. The period of performance is being extended to August 31, 1974.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by August 31, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 975-90-95-47

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Process Development for Immiscible Materials and Alloys (179-11-14-01)
NAS8-28267 TRW Systems Group, TRW Inc., Redondo Beach, CA 90278

OBJECTIVE: The primary objective of this effort is to develop techniques for processing immiscible systems in space and to define process and equipment requirements for space experiments.

APPROACH: This effort will be performed in two phases: Phase I will include studies to define parameters for processing immiscible materials in a low gravity environment; evaluate mixing techniques and devices to obtain complete dispersion of immiscible materials; evaluate techniques and devices to melt the immiscible materials, bring them up to temperature, and to control cooling so as to maintain a homogeneous density distribution upon solidification; and design and build experiments to verify processes on a sub-scale and test system components or models in short duration, low gravity tests. Phase II will continue the above work and will include studies to select immiscible systems suitable for experimental investigations in low gravity research facilities; perform analyses and evaluate processing techniques; and design and develop short duration low gravity experiments to evaluate processing techniques and material properties.

STATUS: Technical Progress: Cooling experiments were conducted on instrumented Bi-Ga cartridges. Based on the results, six experimental heater packages/cartridges with reduced orifices were prepared and shipped to MSFC. An acoustic mixer has been fabricated and successfully tested. Fabrication was initiated on an electromagnetic mixer. Drop tower experiments have been conducted with Bi-Ga samples using two different

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Interim Report, 14725-6010-RU-00, "Study on Processing Immiscible Materials in Zero Gravity", J. L. Reger, May 1973. (For the period 27 April 1972 to 30 April 1973)			
Monthly Progress Report No. 11, 14725-6013-RU-00, "Study on Processing Immiscible Materials in Zero Gravity", J. L. Reger, 18 September 1973.			
Monthly Progress Report No. 17, 14725-6019-RU-00, "Study on Processing Immiscible Materials in Zero Gravity", J. L. Reger, 6 March 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Process Development for Immiscible Materials and Alloys

STATUS: Technical Progress: (Continued)

cooling rates. The samples are presently being tested to determine their super-conducting properties. The acoustic mixer has been utilized for drop tower experiments with the system - calcium - 20% lanthanum.

Management Progress: No contractual changes have been made during this reporting period.

Conclusions: None on this last phase of the study.

Problems: None

Forecast: Contractual work should be completed by June 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Immiscible Materials Selection (179-11-14-03)
NAS8-29748 Battelle Memorial Institute, Columbus, Ohio 43201

OBJECTIVE: The primary objective of this effort is to investigate immiscible materials systems and their potential applications.

APPROACH: The contractor shall conduct studies to develop theoretical relationships and experimental techniques for determining behavior of immiscible systems in a low gravity environment; perform experimental studies including tests in the MSFC drop tower to check out the theories and provide data on effects of low-g on processing immiscible materials; evaluate techniques for synthesizing mixtures of immiscible systems for characterization and assessment of technological potential; and select candidate immiscible systems having the highest potential for each product area.

STATUS: Technical Progress: The study is proceeding in three areas: (1) computer simulation studies of liquid droplets in a miscibility gap, (2) experimental studies in the aluminum-indium system, and (3) analysis of immiscible systems and potential application.

Management Progress: No changes have been made to the management plan.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by August 28, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Ninth Monthly Progress Report, "Investigation of Immiscible Systems and Potential Applications", A. J. Markworth, W. Oldfield, J. Duga and S. H. Gelles, March 15, 1974.			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Berge, L. H.	205-453-1661	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Metal Drop Solidification in Zero-G (179-11-15-02)
NAS8-28604 Grumman Aerospace Corporation, Bethpage, L.I., NY 11714

OBJECTIVE: The primary objective of this task is to demonstrate that unique alloys with superior qualities can be obtain by achieving large undercooling through nucleation control during solidification.

APPROACH: This effort is being performed in two phases: Phase I (Basic Contract) produced drop tower hardware and evaluated specimens solidified during free fall in a drop tower. Phase II (Modification 4 to Contract) will modify the hardware to improve the control and measurement of parameters affecting undercooling through nucleation control. The Phase II effort will include (1) redesign and modification of experiment hardware, (2) selection of materials to demonstrate supercooling and surface evaporation in drop tower tests and (3) drop tower tests and specimen evaluation.

STATUS: Technical Progress: Direct resistance melting of wire specimens has proven to be an effective method to prepare molten metal specimens for limited time zero-g processing. Lack of process control of super heat, cooling rate and accurate temperature measurement reduced supporting process data. Modification 4 to the contract will improve hardware to include lower vacuum, larger specimen size and uniform heating. However, the shadow grains found on several specimens are indicative of the hexagonal grains sought in the Statement of Work.

Management Progress: Contract NAS8-28604 was awarded on June 14, 1972. Modification 4 was awarded on August 2, 1973 for eight more months of performance. A procurement

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

Monthly Progress Report No. 11 (NAS8-28604), "Research of Metal Solidification in Zero-G State", William M. Aubin, May 1973.

Final Report (Interim Report-NAS8-28604), RE-463, "Research of Metal Solidification in Zero-G State", William M. Aubin, Dave Larson, Jr., & Gary I. Geschwind, September 1973.

Monthly Progress Report No. 1 (NAS8-28604 Mod. 4), "Drop Packages for Metal Solidification in Zero-G State", David J. Larson, Jr., September 1973.

Paper to be presented in November 1973 at the NASA/AIAA 7th Space Simulation Conference in Los Angeles, "Sphere Forming in Zero Gravity", W. Aubin, D. Larson, Jr., G. Busch and G. Geschwind.

Monthly Progress Report No. 7 (NAS8-28604 Mod. 4), Drop Packages for Metal Solidification in Zero-G State", David J. Larson, Jr., March 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Metal Drop Solidification in Zero-G

STATUS: (Continued)

Management Progress: (Continued)

action has been written and forwarded to Procurement Office to provide additional funds for the contractor to conduct thirty (30) drop tower tests to generate experimental data on phase transformations caused by solidification in low-g and high vacuum.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by July 2, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Process Development for Fine-Grain Castings in Space (179-11-15-03)
NAS8-29626 Battelle Columbus Laboratories, Columbus, Ohio 43201

OBJECTIVE: The objective of this program is to develop processes for producing fine-grain castings in the weightless environment of space. The objectives of this initial effort are to (1) develop a data base for evaluating use of power metallurgical techniques and processes to produce fine grain castings or dispersion strengthened materials in space and (2) develop requirements and concepts for space processing of beryllium.

APPROACH: This effort will be performed in two phases: Phase I - Aluminum-aluminum oxide powders will be used as a model system. Laboratory experiments will be performed to select powder sizes and compositions, to determine the heating and cooling conditions for powder compact melting and solidification, and to define furnace characteristics and experimental parameters for the experiments in short duration low gravity test facilities. The first phase will also be concerned with developing the analytical tools for characterizing the structure of the melted powder compacts and the distribution of oxide so that quantitative comparisons may be made between compacts melted in 1 g and low-g environments. Phase II - Experiments will be developed for processing in low gravity test facilities or in research rockets. Sealed capsules containing powder compacts of suitable composition, density, and powder size will be fabricated and supplied to MSFC for low g and 1 g processing. A study will be conducted to compare the grain structure and oxide distribution of the low g and 1 g processed samples.

STATUS: Technical Progress: Contractor is performing work in accordance with their scope of work. Phase I experiments with aluminum-aluminum oxide and beryllium-beryllium

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Second Monthly Progress Report, "Process Development for Producing Fine Grain Castings in Space", S. H. Gelles, September 10, 1973.			
Eighth Monthly Progress Report, "Process Development for Producing Fine Grain Castings in Space", S. H. Gelles, March 12, 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Process Development for Fine-Grain Castings in Space

STATUS: Technical Progress: (Continued)

oxide have not yielded the desired grain refinement; therefore, additional studies will be performed to determine grain growth in beryllium at temperatures close to the melting point and to search for effective inoculators for producing a fine grain size in ingot beryllium.

Management Progress: Additional funds are being added to the contract to accomplish additional effort in the amended Scope of Work and to provide additional definition of requirements for low-g experiments suitable for drop tower or sounding rockets. This action will extend the Period of Performance to September 29, 1974.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by September 29, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	975-90-95-89

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Berge, L. H.	205-453-1661	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Containerless Purification of Tungsten (179-11-20-00)
NAS8-29879 General Electric Company, Valley Forge Space Center, Philadelphia PA 19101

OBJECTIVE: The primary objective of this program is to provide a space lab facility to process tungsten x-ray targets having longer operating life and enhanced safety. This effort will extend past laboratory levitation processing experiments and additionally provide drop tower hardware and testing to evaluate influence of low-g on tungsten grain structure.

APPROACH: This effort includes contractual work to (1) investigate improvement of service properties of tungsten, (2) establish the limitations of ground based levitation heating and melting of tungsten, (3) supply the necessary knowledge for conceptual development of a space processing experiment to produce tungsten with improved service qualities, and (4) prepare a final report containing the overall data and evaluation and results of the study.

STATUS: Technical Progress: Contractor is performing work in accordance with the Scope of Work.

Management Progress: Contract NAS8-29879 was awarded on February 7, 1974 for 12 months.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduledto be completed by February 7, 1975.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Development of Techniques for Processing Metal-Metal Oxide Systems (179-11-31-01)
NAS8-29145 Arthur D. Little, Inc., Cambridge, MA 02130

OBJECTIVE: The objective of this effort was to perform theoretical and experimental investigations to determine effects of processing and materials properties such as wetting and density differences on distribution of particles in systems processed in a weightless environment.

APPROACH: The contract was modified and the work limited to the effort completed to select model materials and conduct laboratory experiments to determine the effects of material properties such as wettability and density difference and processing techniques on the grain structure and oxide distribution of a metal-metal oxide system and to propose an experiment for studying the effects of processing such systems in a low gravity environment.

STATUS: Technical Progress: Contractor has completed the work required by the amended contract. Owing to the lack of consistent laboratory results, a meaningful drop tower experiment could not be defined; therefore, a decision was made to terminate the contract at the end of Phase I.

Management Progress: The contract is being amended to include only the Phase I effort. The funding is being reduced and the period of performance is being extended to April 15, 1974 for publication and delivery of the final report.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report Draft,	"Development of Techniques for Processing Metal-Metal Oxide Systems",	P. C. Johnson.	

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-10 PAGE 2 OF 2

TASK: Development of Techniques for Processing Metal-Metal Oxide Systems

STATUS: (Continued)

Conclusions: A satisfactory method to obtain wetting of the oxide particles by the matrix metal was not achieved. Oxide bridging and agglomeration prevents segregation of the particles in the one-g experiments. Some rejection of the non-wetting particles at the solid-liquid interface was noted.

Problems: None

Forecast: Contract has been terminated with the completion of the work required by the amended contract Scope of Work and the final report will be delivered April 15, 1974. This contract is considered to be completed.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yates, I. C., Jr.	205-453-1664	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Process Development for Composite Materials Manufacturing in Space (179-11-31-02) NAS8-29620 General Dynamics Corp., Convair Aerospace Div., San Diego, CA 92111

OBJECTIVE: The major objective of this task is to develop processing specifications for preparation of fiber/particle reinforced metal-matrix composites and controlled density metals in space.

APPROACH: This effort will be divided into three tasks: (1) Establish specific materials compositions, processing requirements, and processing techniques for preparation of aluminum-base fiber/particle reinforced composites and controlled density metals in space and produce prototype composites and controlled density metals by processing in zero-g test facilities. (2) Define expected properties that may be attained in space processed composites based on ground based and short duration zero-g experiments. (3) Define applications potential, users, and the technical and/or economic pay-off for specific products.

STATUS: Technical Progress: Contractor is performing work in accordance with the contractual scope of work. A technique has been developed for the joining of non-wetting reinforcement materials with liquid aluminum. Experiments were carried out with the following reinforcement materials: Bare Pyrolytic Graphite Fibers, Chopped Silicone Carbide Filaments and Chopped Alumina (Sapphire) Filaments. Samples of these materials were sent to the National Bureau of Standards to determine whether their techniques could be used to measure bond strengths between reinforcements and matrix. In the samples consisting of aluminum oxide (Sapphire) filaments in an aluminum matrix, the

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Interim Report, "Space Processing of Composite Materials", W. H. Steurer and S. Kaye, January 15, 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Process Development for Composite Materials Manufacturing in Space

STATUS: Technical Progress: (Continued)

reinforcement matrix interface is excellent. There was a reaction between the aluminum and the other reinforcements (tungsten wires, silicon carbide filaments and chopped graphite fibers) which would degrade their composite properties. All samples had some tungsten impurity from the stirring rod. Additional experiments are planned to refine the process and produce samples suitable for low gravity experimentation. The study of potential applications of space produced composites continues.

Management Progress: The contract will be modified to include the required additional work and the period of performance extended to the end of August 1974.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by August 31, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Production of Unique New Glasses in Space - Analytical Studies (179-14-10-01) NAS8-28991 Rockwell International, Space Division, Downey, CA 90241

OBJECTIVE: The primary objective of this effort is to obtain glass spheres 6 - 8mm in diameter from compositions which do not normally form glasses and to characterize their properties.

APPROACH: Utilizing data obtained from a prior contract, NAS8-28014, the contractor shall select six (6) oxide compositions which appear to be candidate materials for producing glasses during a simulated zero-gravity condition. He shall conduct the experiments required to produce these glasses and analyze the results for percentage of glass obtained. For those samples providing the greatest yield, he shall determine the optical properties obtained in the glass spheres. That compositions considered to give the greatest glass yield shall be selected for further study. Small, but controlled, quantities of an impurity which simulates contamination of the melt by a container material shall be added to the compositions and further tests conducted in a free-fall system to determine the effect of impurities on glass forming ability and glass properties. A study shall be conducted which results in a conceptual design of hardware, monitoring facilities, control mechanisms, and engineering data required for conducting an in-space experiment for producing glasses.

STATUS: Technical Progress: Contractor is performing work in accordance with the contractual scope of work. A wind tunnel air suspension device has been designed, fabricated, and installed at the laser site. Initial tests are being conducted to determine the optimum procedures for suspending the oxides for melting and cooling.

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

(Prior Contract NAS8-28014 Final Report, SD72-SA-0083, "Study of the Production of Unique New Glasses", R. A. Happe, 13 June 1972)

Tenth Monthly Progress Report, "Manufacturing Unique Glasses in Space", R. A. Happe, March 18, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Production of Unique New Glasses in Space - Analytical Studies

STATUS: Technical Progress: (Continued)

The oxide materials to be studied on this program have been received by the contractor and the initial melting tests were conducted. A good quality glass was obtained from the Ga_2O_3 - 20 CaO composition. The laser which is used for melting the glass samples is being modified to increase the power to 5 KW.

Management Progress: Contract NAS8-28991 was awarded on April 30, 1973 for a twelve month Period of Performance and is being amended to add additional effort to the Scope of Work and to extend the time to November 30, 1974.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by November 30, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Theoretical Study of Producing Glasses in Space (179-14-10-02)
NAS8-29850 IIT Research Institute, Chicago, Illinois 60616

OBJECTIVE: The objective of this project is to develop a model of the glass formation phenomena which is based on property data of the composition. It shall be used to predict the tendency to obtain amorphous structure and the conditions required to achieve it.

APPROACH: Contractual effort will be utilized for this task and will include (1) model development, (2) model extension, (3) model evaluation and application, and (4) heterogeneous nucleation study. The contract will be amended to include work to (a) conduct laboratory experiments necessary to provide property data for viscosity, heat of fusion, and other unknown properties as required to complete the model and (b) conduct laboratory experiments necessary to empirically verify the results of computer melting-quenching experiments and to provide firm guidelines regarding the manner in which this project should proceed.

STATUS: Technical Progress: Theoretical relationships for nucleation and crystallization have been developed under steady state conditions for the simple SiO_2 system. This model is being expanded to include non-steady state conditions. During the past month, effort were directed towards (1) incorporating transient effects into the nucleation rate expression, including into computer software, and (2) developing the crystal growth equation.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Eighth Monthly Status Report, "Theoretical Study of Producing Unique Glasses in Space", D. C. Larsen, March 8, 1974.			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-10 PAGE 2 OF 2

TASK: Theoretical Study of Producing Glasses In Space

STATUS: (Continued)

Management Progress: NAS8-29850 was awarded on July 1, 1973 for twelve months of effort and is being amended to add additional effort to the Scope of Work and to extend the Period of Performance to January 31, 1975.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by January 31, 1975.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-10	179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study of Diffusion Coefficient of Glasses Under Zero-G (179-14-20-02)
NAS8-30656 Vanderbilt University, Nashville, Tennessee 37235 and In-House

OBJECTIVE: The primary objective of this effort is to obtain diffusion coefficient data by performing an investigation of diffusion phenomena in glasses while in the liquid state without the effect of convection.

APPROACH: The in-house effort will consist of a plan to develop diffusion experiments for research rocket flights. Glass compositions will be selected and laboratory apparatus fabricated to obtain ground based data on bulk and surface diffusion in liquids. A research rocket experiment will be developed and scheduled for flight. A supporting contract will be utilized to plan and develop experiments for long duration space flight in the area of diffusion in glasses.

STATUS: Technical Progress: In-house work continues in accordance with the project plan and planning for the research rocket lights is proceeding by investigating diffusion experiments previously conducted and by identifying potential materials. The contractual effort should start in April 1974.

Management Progress: The contract is in final negotiation and should be awarded during the first part of April 1974.

Conclusions: None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-10

TASK: Study of Diffusion Coefficient of Glasses Under Zero-G

STATUS (Continued)

Problems: None

Forecast: The in-house effort is expected to continue through FY-76. The first supporting contract is scheduled to be completed in October 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Processes R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Processing of Glass-Ceramics in Space (179-14-20-03)
Contract (To be established - DCN 1-4-65-48002)

OBJECTIVES: The objectives of this effort are to study the effects of low gravity processing on Glass-Ceramic compositions with respect to microstructure and mechanical properties and processing techniques and to define process parameters for recrystallization of Glass-Ceramics in a low gravity environment.

APPROACH: The contractor shall conduct a specific program of Earth experiments which will lead to the development of glass-ceramics material having novel composition, microstructure, or properties by processing in space. The program should utilize the unique features of the zero-gravity environment in space which could provide containerless processing, uniform dispersion of phases, and high temperature crystallization without deformation.

STATUS: Technical Progress: A procurement action was prepared, placed on hold status in October 1973, released with approved funding and sent to Purchasing in March 1974.

Management Progress: Funding has been approved for this procurement action.

Conclusions: None

Problems: None

Forecast: Contract should require twelve months for completion.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Nichols, R. L.	205-453-2005	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space Processing of Chalcogenide Glasses (179-14-20-04)
Contract NAS8-30627 IIT Research Institute, Chicago, Illinois 60616

OBJECTIVES: The objectives of this effort are to (1) develop experiments for producing chalcogenide glasses in low-g for laser transmission uses and (2) produce and characterize the chalcogenide glasses produced in low-g.

APPROACH: Contractual effort will be utilized for the performance of a specific program to determine processing techniques, designing low-g flight experiments, and conducting experiments and evaluating results.

STATUS: Technical Progress: The contractor has designed and fabricated a furnace for experimentation with the proposed materials.

Management Progress: Contract NAS8-30627 was awarded on February 20, 1974 with a Period of Performance of twelve (12) months.

Conclusion: None

Problems: None

Forecast: Contractual work is scheduled for completion by February 20, 1975.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-10	PRIOR NO.: 179-10

4. TITLE:

Materials and Process R&D

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Adams, G. D.	205-453-5084	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Electrohydrodynamic Space Processes (179-15-10-01)
Contract NAS8-30250 Colorado State University, Ft. Collins, CO 80521

OBJECTIVE: The major objective of this effort is to develop methods of applying electrohydrodynamic (EHD) phenomena to processing materials in space.

APPROACH: The most promising applications will be selected from the results of current studies under Contract NAS8-30250. The selected processes will be refined, proven and tested.

STATUS: Technical Progress: The principal investigator for the contract travelled to MSFC during February 1974 and discussed the research program with the contract monitor and other NASA personnel involved in the space processing program. Most of the components for the experimental pressure vessel have been located, priced, and placed on order, so that fabrication of the unit should begin in March 1974.

Management Progress: NAS8-30250 was awarded on 26 November 1973 for a twelve month effort to start on February 1, 1974.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by February 1, 1975

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
First Monthly Progress Letter covering February 1974, "Electrohydrodynamic Space Processing Technology", T. B. Jones, February 28, 1974.			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-11-10	PRIOR NO.: 975-90-95
4. TITLE: Study of Liquid-Solid Transition for Materials Processing in Space			
5. RESPONSIBLE INDIVIDUAL: R. C. Ruff, S&E-SSL-TR	TELEPHONE: 453-3090	APPROVAL: W. C. S. W. C. Snoddy	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Study of Liquid-Solid Transition for Materials Processing in Space
NAS8-28664 The Boeing Co., Huntsville

OBJECTIVES: To develop an increased understanding of the effects of external fields on the solidification process. To develop a mathematical description of the effect of external fields on the distribution of dopant in a solidifying crystal. To better understand the technique of simulating zero-gravity by applying a magnetic field to increase viscosity.

APPROACH: Task 1 - Quantitative values shall be developed for the dependence of convection, diffusion, and internal forces on applied fields for a multicomponent, monoatomic liquid. Data on basic liquid state properties must be gathered. This data will be used in equations developed during the previous year's effort to make the quantitative analysis.

Task 2 - A mathematical description shall be developed for the effects of applied fields on microsegregation of solute atoms and two phase materials during solidification. This analysis will be compared to experimental data as it becomes available.

Task 3 - The foregoing analysis shall be applied to : (A) determine the similarities and differences in diffusion and reduced convection in a liquid when subjected to a high magnetic field or zero gravity; (B) the effects on non-uniform

7. REPORT NO.: TITLE:	AUTHOR(s):	DATE TRANSMITTED
"Solidification in Space: The Liquid State Model Approach" presented at Southeast Section of the American Physical Society (SESAPS)	R. I. Miller R. C. Ruff	Nov. 1971
"The Free Volume Model Equation of State" presented at SESAPS	R. I. Miller D. C. Jerome	Nov. 1972
"A Summary of Liquid State Models for Materials Processing in Space", Interim Report, contract NAS8-28664, Boeing Report No. D5-17268	R. I. Miller	Aug. 1972
"Analysis of Field Effects on Dense Liquid Materials", Interim Report, contract NAS8-28664, Boeing Report No. D5-17254	R. I. Miller	May 1973

continued on page 3

liquids by the application of a RF positioning device; and (C) any possible unique effects in zero-gravity.

STATUS: The search for experimental values of liquid properties for semiconductor elements, their compounds and for liquid metals has encompassed a computer search of NASA and DOD data banks, searches of the Physics Abstracts, the Science Citation Index, and the RSIC book collection, and contacts with Texas Instruments, Inc., Eagle Picher Company, the High Pressure Data Center, the MIT Materials Science Department and the Vanderbilt Materials Science Department. It was found that much of the experimental data for molten semiconductors has been measured by Russian researchers, and that most of the Russian work deals with electrical properties of the melts, and little of it concerns III-V elements or compounds which are of interest in this study.

Calculation of magnetic viscosity and Hartmann numbers has been performed for liquid InSb, InAs, GaAs and liquid Sodium. Calculation of diffusion coefficient and solidification rate changes for liquid InSb, Ge, Hg and Na has been completed. The decay of convection velocity in a magnetic field has been derived and tables of entropy, heat capacity, isothermal compressibility and thermal expansion coefficient have been generated from the Free Volume Model for several liquids. Task 2 was begun with the definition of six subtasks to be accomplished in this task, and the boundary conditions for the magnetic field problems of subtask 1 were determined.

FORECAST: It appears that this thermodynamics and liquid state models approach to the liquid-solid transition problem is no longer profitable to the Space Processing Applications Program. It has been shown that (as has been intuitively guessed) any influence between atomic solidification processes and external fields are second order effects and essentially unmeasurable (except kinetic limited crystal growth rate which may vary 1 to 10% under applied magnetic fields). Therefore, this contract will be concluded during July, 1974.

This is not to imply that such a study should never be continued as a basic research topic. The liquid state is very poorly understood and any work done to clarify this topic would benefit a broad range of researchers.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-11-10 PAGE 3 OF 4

Report:	Author(s):	Date Transmitted:
"External Field Effects on Solidification Rate" presented at SESAPS	R. I. Miller	Nov. 1973
"Qualitative Effects of Oscillating Magnetic Fields on Crystal Melts" in Journal of Crystal Growth	R. I. Miller	Nov. 1973
"Thermodynamic Properties Derived From the Free Volume Model of Liquids" in Metallurgical Transactions	R. I. Miller	Mar. 1974

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-11-11	PRIOR NO.: 975-90-95

4. TITLE:

Single Crystals of Metal Solid Solutions

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL: W.C.S.
R. C. Ruff, S&E-SSL-TR	453-3090	W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Single Crystals of Metal Solid Solutions
Contract NAS8-28749, Battelle Columbus Laboratories

OBJECTIVES: (A) To define the influence of convection and/or gravity on the substructure of a metal solid solution; (B) to define the influence of a magnetic field on the substructure of a metal solid solution; (C) to define requirements for a space flight experiment to verify results of this study.

APPROACH: Task 1: An experimental study shall be run to characterize the role of gravity and/or convection on the chosen system. Quantitative metallography will be used to characterize the substructure of the single crystals of metal solid solutions. This experimental study will consist of crystal growth under various thermal gradients (some inverted if possible) and at different angles to the gravity vector.

Task 2: An experimental study shall be run on the influence of magnetic fields on the substructure of single crystals of chosen metal solid solution system. The study shall be designed to determine: (1) what influence the induced artificial viscosity has on the growth interface shape; (2) if the magnetic field influences the direction or magnitude of diffusion in the liquid; and (3) what similarities growth in a magnetic field would have with growth in zero gravity.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-11-11 PAGE 2 OF 3

STATUS: The alpha silver/zinc alloy system (20 at. % zinc) has been chosen for this study. A metallographic polishing and etching technique has been developed to bring out substructure features. The design and assembly of apparatus for growth both with and without a magnetic field has been completed. Apparatus to measure temperature gradients and fluctuations in the melt has been assembled and tested. Several crystals have been grown under controlled conditions for use in the development of the characterization techniques.

FORECAST: This work is progressing very satisfactorily and all objectives should be met when contract expires in October, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-11-12	PRIOR NO.: 975-90-95

4. TITLE:

Segregation Effects During Solidification in Weightless Melts

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL: W. C. S.
R. C. Ruff, S&E-SSL-TR	205-453-3090	W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Segregation Effects During Solidification in Weightless Melts
Contract NAS8-29662, Grumman Aerospace Corporation

OBJECTIVES: To develop a comprehensive numerical solution for segregation effects during solidification. To incorporate a solution for segregation due to evaporation. To correlate the theoretical analysis with experimental behavior of specific materials and methods of solidification.

APPROACH: A numerical solution was developed to predict segregation effects due to evaporation for Skylab sphere forming experiments. A basic computer model was developed to predict segregation effects for longitudinal solidification. The basic computer model will be improved by considering inherent solidification parameters as a function of temperature and concentration. The improved model will be used to try to explain any anomalous results reported by Skylab principal investigators. The improved model will also be used in predicting effects and explaining anomalies in rocket and ASTP experiments. The model shall be used to analyze different types of crystal growth techniques. Thermal conditions expected on a space flight will be input and an analysis will be made to determine both optimum and critical combinations of thermal and material parameters.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	"Segregation Effects During Solidification in Weightless Melts", Final Report, Jan. 1, 1972 to June 29, 1973, on Contract NAS8-27891	Chou Li	June 29, 1974
	"A New Mechanism for the Formation of Growth Spirals", to be published in Journal of Applied Physics in May, 1974	Chou Li F. Y. Wang K. P. Gupta	

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-11-12 PAGE 2 OF 3

STATUS: As indicated in the approach, the basic computer model for solidification has been written and is working. Converting the material parameters to variables as a function of temperature and concentration is being done. Several instabilities and slow convergence regions are being found and suitably corrected. Grumman is interacting with Battelle (under contract NAS8-28749, "Single Crystals of Metal Solid Solutions") in a mutually beneficial manner. Battelle is experimentally growing crystals of a material with a high concentration of a dopant which also preferentially evaporates. This is an ideal method to check, correct, or improve the computer model. The Skylab crystal growth experimental results are being analyzed as they are becoming available. The computer model will be applied to any which show spurious or anomalous results.

FORECAST: It is planned that the FY-75 effort will bring this effort to a logical conclusion. If appropriate at that time, the FY-76 effort would be a new RFQ with an expanded objective to model solidification and segregation in two dimensions (applicable to symmetrical systems).

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-11-14-02	PRIOR NO.:

4. TITLE:

IMMISCIBLE MATERIALS - GROUND BASED STUDIES

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. Lacy - S&E-SSL-NP	453-5135	R. Decher - S&E-SSL-N

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): This research program will determine the feasibility of producing in space a new class of composite materials for electronic application. The materials are immiscible in the molten state (i.e., the components are mutually insoluble) and separate when mixed together in one-g due to different densities. This effort will consider different techniques for melting and mixing immiscible materials in space and determine the properties and applications of such materials.

APPROACH: The electronic properties of dispersed immiscibles prepared in the laboratory, in the MSFC Droptower and in Skylab are being studied. The physical properties of the materials and their potential applications are being investigated by using electrical, low temperature, magnetic and ultrasonic techniques. The characterization techniques used depend on the particular materials selected and may be used either singularly or in any combination.

STATUS: The initial phases of this work have concentrated on measuring the electrical and superconducting properties of Ga-Bi which was processed in the MSFC Droptower. The results of the initial phase will be presented at the AIAA 12th Aerospace Sciences Meeting on January 1974. The evaluation of the physical properties of AlCu which was processed on SL-3 will be continued, including evaluation of the flight samples. A new non-contacting technique for measuring the electrical resistivity of space process samples has been developed. This non destructive technique can be used to accurately determine the chemical and metallurgical homogeneity of bulk rods (diameters of 3mm and larger). A science demonstration of the behavior and properties of a melting material in zero-gravity was performed on Skylab III. Another science demonstration concerning

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MISC-SSL-73-2	Immiscible Materials - Ground Based Studies. First Quarterly Progress Report	L.L.Lacy G. H. Otto	Aug 1973
AIAA # 74208	The Electrical Properties of Zero Gravity Processed Immisibles AIAA 12th Aerospace Sciences Meeting, Washington, D. C.	L. Lacy G. H. Otto	Jan 1974
	Quick-Look Report on Skylab 4 Science Demonstration TV 102: Immiscible Liquids	L. Lacy G. H. Otto	Mar 1974

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-11-14-02

PAGE 2 OF 3

STATUS: Continued

the behavior of immiscible liquids in zero-gravity is planned for Skylab IV.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 13 74	CURRENT NO.: 179-11-21-00	PRIOR NO.:

4. TITLE:

ZONE REFINING IN A ZERO-GRAVITY ENVIRONMENT

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
M. Davidson, S&E-SSL-TR	453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract No: Not selected
Contractor Not selected

OBJECTIVE(S): Determine the applicability of float zone solidification techniques in zero gravity for producing improved materials of industrial importance.

APPRAOCH: Study possibilities of increased zone diameter and floating liquid zones having lower surface tension to density ratios due to low-gravity environments. Analyze promising candidate materials with respect to maximum diameters possible, zone stability under rotation, and potential cost savings to the industrial community.

STATUS: In contract negotiations.

FORECAST: Contract by December, 1973.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-12-13	PRIOR NO.:

4. TITLE:

Growth of Single Crystal Ribbon in Space

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. C. Ruff, S&E-SSL-TR	453-3090	W. C. S W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Growth of Single Crystal Ribbon in Space

OBJECTIVE(S): To theoretically analyze RF induction and other forces capable of shaping a silicon ribbon in space. To experimentally test any recommended technique to determine if technique is feasible in space. To specify technical requirements on silicon ribbon for economic utilization. To make an economic analysis showing benefits possible if technique is feasible.

APPROACH: A detailed theoretical analysis will be made of RF induction shaping forces for different coil configurations. Simultaneously, other innovative ideas will be studied to determine if ribbons can be shaped in space. This theoretical result shall culminate in a recommendation to continue or to drop this RTOP. If ribbon production appears feasible, an analysis will be made of silicon processing requirements (flatness, perfection, orientation, etc.) for economic utilization. The recommended ribbon growth technique will be simulated as well as possible in the lab to test and check out concept. Periodically, an economic analysis will be made to ensure that if ribbon technique is implemented in space it will be economically worthwhile. If justifiable, a flight experiment will be developed.

REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-12-13 PAGE 2 OF 3

STATUS: The RFQ for the first year effort has been written and approved and is now in the process of being released.

FORECAST: It is expected that the proposals will be received and evaluated in April, May of 1974 and the contract negotiated in June of 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-12-13-06	

4. TITLE:

ANALYTICS OF CRYSTAL GROWTH

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
T. Bannister, S&E-SSL-TR	453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract: NAS8-29847, University of Southern California

OBJECTIVE(S): To analyze mathematically solution crystal growth and float zone crystal growth. To initiate a complementary lab effort.

APPROACH: (1) To develop a set of equations describing each growth system. (2) To solve the set of equations using analytical and computer techniques. (3) Grow crystal in neutrally buoyant solutions.

STATUS: (1) Equations are being set up and studied to obtain a soluble set without making unrealistic simplifying assumptions.

FORECAST: (1) Finalize equations. (2) Initiate analytical solutions. (3) continue lab work.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
One bimonthly report			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-12-15-01	PRIOR NO.:

4. TITLE:

Space Processing Research on Crystal Growth

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
M. Davidson, S&E-SSL-TR	205 453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract No.: NAS8-29542
Contractor: University of Alabama in Huntsville

Objective: Improve existing techniques and develop new techniques for the analysis of crystalline perfection in order to determine the effects of a low-gravity environment on the growth of crystals.

Approach: Study various techniques for determining crystalline perfection. Photovoltaic effects and photoluminescence will be considered. Noncontacting techniques for measuring high frequency resistivity and mobilities in semiconductors will be studied. An effort will be made to reduce the sample area in order to provide better spatial resolution.

Status: Resistivity and Hall effect measurements have been made on GaAs samples. High frequency resistivity measurements have also been made on GaAs.

Forecast: High frequency resistivity and photoluminescence studies will be continued.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Reports January 1972 - Present	Title: Electrical Characterization of GaAs Single Crystal in Direct Support of M555 Flight Experiment		
Final Report December 1972	Title: Investigation of Crystal Growth in Zero Gravity Environment and Investigation of Metallic Whiskers	by: J. H. Davis, H. U. Walters, R. B. Lal, J. G. Castle, Jr.	

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-12-15-02	PRIOR NO.:

4. TITLE:

CRYSTAL GROWTH AND CHARACTERIZATION

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
M. Davidson, S&E-SSL-TR	453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract No.: In-house
Contractor: In-house

OBJECTIVE(S): Conduct in-house studies supplementing contractual efforts in solidification and crystal growth.

APPROACH: Examine various crystal growth methods and characterization methods, including X-ray topography, dc resistivity, Hall mobilities, and photovoltaic scanning. Methods selected for study are those which have application to growth of crystals in low gravity and the evaluation of those crystals.

STATUS: Current studies emphasize photovoltaic scanning of semiconductor crystals with the goal of relating photovoltages to crystal quality. Work continues on growth of metal-doped organic single crystals. A vacuum coater has been modified and techniques developed to apply low resistance contact to GaAs. X-ray defect analysis techniques are being used and topographs of Ge single crystals have been made.

FORECAST: Continue study of photovoltaic characterization of semiconductor crystals. Further studies of epitaxial growth techniques for semiconductor crystals will be conducted. An X-ray transmission topography apparatus is being assembled and should be operational shortly.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
MSFC R&T Review	Crystal Growth Studies	C. F. Schafer	Feb 1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-12-16	PRIOR NO.: 975-90-95

4. TITLE:

Gravitational Effects on Process-Induced Dislocations in Silicon

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL: W.C.S
M. C. Davidson	205-453-3090	W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Gravitational Effects on Process-Induced Dislocations in Silicon
Contract NAS8-29851 Texas A&M University

OBJECTIVES: To characterize the density of dislocations generated and the mode of generation during thermal processing of silicon under the influence of gravity. To characterize the mechanical aspects of the processing and develop an analytic model for dislocation generation. To relate dislocation generation to economics of production for a specific step in the processing of a typical large scale integrated (LSI) circuit. To formulate a space experiment to measure the effect of gravity on process induced defects on silicon devices.

APPROACH: The contractor shall characterize the density of dislocations generated and the mode of generation during high temperature processing (oxidation and diffusion) of silicon under the influence of gravity. This will include a characterization of the mechanical aspects of the processing and development of an analytical model for dislocation generation. The contractor shall demonstrate the economics of gravity induced dislocation generation on a typical LSI circuit by varying the gravitational influence on only one step during the production of the LSI. These results shall be extrapolated to show what economic benefit could be gained by processing of all critical steps in zero-gravity. The contractor shall begin preparations for extending his ground based experiments to higher-g values in a

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

centrifuge. This shall include making the necessary arrangements to use a large centrifuge at JSC and the design and possible fabrication of a small high temperature furnace with appropriate aerodynamic shielding. Space flight experiment definition studies shall continue. This shall include such things as: analysis of open tube (commercial method) and closed ampoule processing conditions; silicon wafer and ampoule design and dimensions and identification and minimization of hazards in space processing.

STATUS: Necessary apparatus for processing silicon wafers in sealed quartz ampoules has been ordered. Preliminary experiments have been done in open tubes to determine generation of dislocations in wafers supported in cantilever fashion from the bottom at 45°. A Berg-Barrett type topographic X-ray camera is being constructed for non-destructive analysis of the wafer defects. Many runs on the open tube system have been made with different insertion, soak, and withdrawal times.

CONCLUSIONS: Different types of defects are generated on silicon wafers during thermal processing depending on whether the polished side of the wafer is up or down. It also appears that plastic flow during the thermal soak period (diffusion steps in processing) is more important in generating defects than thermal shock during insertion or removal.

FORECAST: The people at JSC managing the centrifuge facility have been contacted. No problems associated with using that centrifuge were found. Apparatus design and fabrication for use on the centrifuge will, therefore, begin.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-12-23	975-90-95

4. TITLE:

Crystal Growth in Fused Solvent Systems

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. C. Ruff	205-453-3090	W. C. S W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Crystal Growth in Fused Solvent Systems
Contract NAS8-28114, General Electric Co.

OBJECTIVES: To develop the technique of solution growth of crystals for application in the micro-gravity environment of space. To investigate the relative effects of convection and diffusion on solution grown crystals. To define the requirements for solution growth of certain selected crystal systems for an experiment in space. To make a preliminary design of a solution growth facility for Spacelab. To make an interim economic analysis showing benefits of solution growth in space for selected candidate systems.

APPROACH:

Task 1: The experimental study to define in depth all the variables needed to design a zero-gravity crystal growth experiment shall be continued. This will include, but not be limited to the following: defining the solvent system; determining the temperature and thermal control requirements; determining the solubility characteristics; and determining the need for any mechanical apparatus such as for introducing a seed crystal. Initial material systems to be studied are an aqueous solution of triglycine sulfate and a molten glass solution of both lead and bismuth germanate.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-12-23 PAGE 2 OF 4

Task 2: Experimentally study the basic structural and electro-optic and electro-acoustic properties of solution grown crystals in an effort to isolate and describe the influence of diffusion and convection on these properties. Initially, this task will concentrate on the germanates grown from a glass melt. If appropriate, a low temperature system shall be studied to model the effects of diffusion and convection of high temperature systems.

Task 3: Initiate an experimental study on ceramic oxide crystals needing solution temperatures higher than 1000°C. The same parameters will be studied as are listed in Task I. This class of materials needs to be evaluated since the Shuttle-Spacelab capabilities will not be as restricted as those of Skylab.

PROPOSED TASK: To permit planning for concept verification testing of solution growth systems at MSFC, design of an engineering model of a solution growth facility shall be delivered to MSFC. This facility would be capable of meeting requirements specified in above tasks.

PROPOSED TASK: Because of the rapid expansion of the state-of-the-art of growth of electro-optic and electro-acoustic crystals, it is proposed to make an economic analysis of candidate systems to ensure that crystals are still in economic demand and that terrestrial growth problems are still of sufficient magnitude that expected advantage of space growth is economically worthwhile.

STATUS: Research has centered on the growth of $Bi_{12}GeO_{20}$. Solvent development and seeded growth experiments have been emphasized. Initial solvent development was conducted on the $Bi_{12}GeO_{20}$ - $Bi_2O_3 \cdot 2B_2O_3$ solvent series. Both the temperatures of the spontaneous appearance of crystals in solutions containing 30 to 90 weight percent $Bi_{12}GeO_{20}$ and the nucleation - viscosity relationships were determined. From this a solution of 50 $Bi_{12}GeO_{20}$ and 50 B_2O_3 was determined to be the optimum solvent. Seed solubility, the degree of supersaturation and spontaneous nucleation were evaluated as a function of seed insertion time and temperature. Optimum growth on the seed took place at 670°C. Microprobe analysis showed bismuth and germanium distribution to be uniform with the exception that the growth area immediately next to the seed was depleted of germanium. Detailed X-ray analysis showed the crystal to be $12\ Bi_2O_3 \cdot B_2O_3$ rather than $Bi_{12}GeO_{20}$. Based on differential thermal analysis studies, alumina (Al_2O_3) was added to the solvent and Bi_2O_3 and B_2O_3 reduced to prevent solvent-solute interactions. This has resulted in a solvent consisting of $0.75\ Bi_2O_3 \cdot 0.5\ Al_2O_3 \cdot 1.0B_2O_3$. Solubility data was collected as a function of temperature and a solution consisting of 70 to 80 weight percent $Bi_{12}GeO_{20}$ in 30 to 20 weight percent of $0.75\ Bi_2O_3 \cdot 0.5Al_2O_3 \cdot 1.0\ B_2O_3$ was found to be optimum. Seeded growth experiments have produced single crystal areas of $Bi_{12}GeO_{20}$. Solvents were investigated for the separation of the glass solvent from the single crystal $Bi_{12}GeO_{20}$. Hot basic solutions such as Na OH appear to be satisfactory.

Experiments on the growth of $Pb_5 Ge_3 O_{11}$ from previously developed solvents have been initiated. Optical rotation in a helium-neon laser is being investigated as a tool for characterizing and identifying gravity related defects in $Bi_{12} Ge O_{20}$ and the $Pb_5 Ge_3 O_{11}$. The emphasis is being placed on the change in sense of the optical rotation due to the reversal of the spontaneous polarization. This work has been extended to triglycine sulfate (TGS) which is also being studied under subcontract to Pennsylvania State University. Penn. State has studied defects in TGS and correlated these to Raman spectra, dielectric loss and the pseudo-conductivity which is associated with the pyroelectric characteristics of TGS.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 74 31 03 74	CURRENT NO.: 179-12-23-02	PRIOR NO.:

4. TITLE:

TASK: SOLUTION CRYSTAL GROWTH

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
T. Bannister, S&E-SSL-TR	453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

CONTRACT NAS8-28098, University of Alabama at Tuscaloosa

OBJECTIVE(S): (1) To determine the effects of gravity-induced convection on the quality of solution grown crystals, primarily Rochelle salt. (2) To determine the mechanism of metal ion doping in solution grown organic crystals. (3) To define flight experiment on solution crystal growth for rocket flights, and Space Lab missions.

APPROACH: (1) To evaluate Rochelle salt crystal grown in Skylab IV. (2) To grow crystals from concentrated solutions at varying rates. (3) To characterize the crystals using ferroelectric hysteresis and etching of the crystals. (4) To photograph growth and convection.

STATUS: It has been shown that increased growth rates increase convection and correspondingly cause ferroelectric degradation of Rochelle salt crystals.

FORECAST: (1) To define the nature of metal ion doping. (2) To analyze crystals from the Skylab IV demonstration.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
UAT 28098-1	Investigation of Crystal Growth from Solutions	I. Miyagawa	Feb 1973

10 bimonthly progress reports

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 4	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-15-11-02	PRIOR NO.:

4. TITLE:

CONVECTION ANALYSIS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL: WCS
T. Bannister, S&E-SSL-TR	205 453-3090	W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract Number: NAS8-29610
Contractor: Lockheed Missile and Space Co.

OBJECTIVE(S): (1) To analyze the effects of low gravity on fluid behavior (heat and mass transfer) as applied to the space processing applications program. (2) To determine the effects of convection induced by surface tension, g-jitter, etc., in low gravity. (3) To define flight experiments on convection and diffusion for sounding rocket flights and Spacelab missions.

APPROACH: (1) To develop dimensional analysis techniques on certain fluid problems. (2) To model selected processes on a computer. (3) Initiation of convection criteria for low-g application.

STATUS: (1) Continue a study on heat transfer due to vibrations (g-jitter). (2) Analyze a possible sounding rocket measurement. (3) Initiate analysis of silver crystals grown on Skylab.

FORECAST: (1) Will define g-jitter spectrum effects on fluids. (2) Will continue sounding rocket work. (3) To analyze silver crystals grown on Skylab IV.

7. REPORT NO.: TITLE: AUTHOR(s): DATE TRANSMITTED

NOTE: This is a new contract resulting from the requirement to go RFP for continuation of the convection effort.

The following are reports generated previously which are related to this task:

LMSC-HREC TR D306402	Fluid and Particle Dynamic Effects in Low-g Composite Casting	P. G. Grodzka S. V. Bourgeois	Feb. 1973
LMSC-HREC TR S306350	Types of Natural Convection in Space Manufacturing Processes	P. G. Grodzka	Jan. 1973
LMSC-HREC D306140	A Numerical Solution for Thermoacoustic Convection of Fluids in Low Gravity	L. W. Spradley S. V. Bourgeois C. Fan P. G. Grodzka	Jan. 1973

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-15-11-02

Report No.	Title:	Authors:	Date Transmitted
LMSC-HREC TR D306300	Convection Phenomena in Electrophoresis Separation	C. Fan	Dec. 1972
LMSC-HREC D306065	Convection in Space Processing (M512)	S. V. Bourgeois P. G. Grodzka	July 1972
LMSC-HREC D225365	A Study of Natural Convection in Low Gravity Solution Growth of Rochelle Salt Crystals	L. W. Spradley C. Fan	Oct. 1971
LMSC-HREC D225333	The Apollo 14 Heat Flow and Convection Demonstration Experiments - Final Results of Data Analysis	P. G. Grodzka C. Fan R. O. Heddon	Sept. 1971
LMSC-HREC D162926	Natural Convection in Space Manufacturing Processes	P. G. Grodzka C. Fan	July 1971
LMSC-HREC D225149	Mass Diffusion of Gallium Arsenide in a Gallium Solution	P. G. Grodzka C. Fan	June 1971
LMSC-HREC D148619-A	Zero-Gravity Solidification	P. G. Grodzka	Mar. 1970
UAT 28098-1	Investigation of Crystal Growth from Solutions	I. Miyagawa	Feb. 1973
	Heat Flow and Convection Demonstration Experiments Aboard Apollo 17 (Early Results)	T.C. Bannister	Feb. 1973
	Heat Flow and Convection Demonstration Experiments Aboard Apollo 14	T.C. Bannister	May 1972
	Heat Flow and Convection Demonstration (Apollo 14)	T.C. Bannister	July 1971
	Surface Tension Convection During Floating Zone Refining	P. G. Grodzka T.C. Bannister	May 1970
	A Proposed Crystal Growth Program for Space Processing Including Flight Experiments	T.C. Bannister G. M. Arnett	Jan. 1970

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-15-11-02

REPORT NO.	TITLE		
AIAA Paper #74-156	Natural Convection in Low-g Enivronments	P. G. Grodzka T. C. Bannister	Feb '74
AIAA Paper #74-76	Thermoacoustic Convection of Fluids in Low Gravity	L. W. Spradlen	Jan. '74
AIAA Paper #74-205	Fluid Dynamics & Kinematics of Molten Metals in the Low Gravity Enivronment of Skylab II	S. V. Bourgeois M. R. Brashears	Feb.'74
LMSC-HREC TR D 306955	Convection Effects on Skylab Experiments M551, M552, and M553 Phase 4 Report.	S. V. Bourgeois	Dec, '73
LMSC-HREC TR D390056	Physical Forces Influencing Skylab Experiments M551, M552, and M553, Summary Report.	S. V. Bourgeois	Jan '74

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-15-12-01	PRIOR NO.:

4. TITLE:

SORET SEPARATION IN ZERO GRAVITY

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
B. Facemire, S&E-SSL-TR	205 453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract Number: NAS8-29609
Contractor: Lockheed/Huntsville and In-House

OBJECTIVE(S): (1) Survey literature for important parameters in Soret separations (a paper will be published). (2) Determine whether Soret separation is influenced by the space environment. (3) Determine whether this process will be significantly improved in the space environment.

APPROACH: (1) Perform literature survey. (2) Since convective patterns play a role in these separations, determine optimum flow for good separations (experimentally and analytically). (3) Determine whether the optimum flow (as determined in (2) above) can be achieved in low-g in such a manner as to improve the process - either larger volumes of purified materials (presently only very small samples may be used - about 4cc - with a yield of about 1/4cc) or by decreasing the power requirements required, possibly both of these). (4) Determine materials which would be advantageously separated by the technique in low-g.

STATUS: (1) Contract with Lockheed was signed June 1, 1973, with subcontract to the University of Texas (to study cell rotation effects on Soret separation). Lockheed start date was delayed until July 1. (2) In-house equipment (and equipment to be GFE to Lockheed) ordered. The required water baths have arrived with delivery date of commercially available Soret equipment to be October 9, 1973. Arrived Oct. 9, 1973.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LMSC-HREC PR D 306730	Bimonthly Progress Report	Grodzka/LMSC	Aug 1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-15-12-01 PAGE 2 OF 3

FORECAST: During the next reporting period plans include: (1) Complete literature survey. (2) Determine materials for initial investigations. (3) Determine methods for analyzing effectiveness of separations. (4) Install Soret equipment and initiate testing. (5) Development of models (analytical) of convective patterns in Soret geometry and methods of experimentally determining flow and effects on separation.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-15-12-02	PRIOR NO.:

4. TITLE:

Diffusion Analysis in Low Gravity

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL: WGS
C. F. Schafer, S&E-SSL-TR	205-453-3090	W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract: NAS8-30252

Contractor: Howard University
Washington, D. C.

Principal Investigator: Dr. Anthony O. Ukanwa

OBJECTIVE: To determine the degree to which processes associated with a low gravity environment can be purely diffusion controlled.

APPROACH: Tabulate important parameters affecting mass transport in liquid metals which are candidates for low gravity processing applications. Additionally, measurements will be made on liquid gallium and liquid indium to determine mass diffusion coefficients.

STATUS: Contract was effective on 12/1/73. Work to date has centered on the literature search for data on thermal and electrical properties of liquid metals. In the cases where multiple data points exist for a given property, the least square method of data correlation is being used to determine a best recommended value. Equipment and materials for the laboratory studies have been ordered.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 179-15-12-02 PAGE 2 OF 3

FORECAST: The literature search phase of this effort will be completed by summer. By that time, the laboratory set-up will be complete, and measurements of diffusion coefficients in the liquid gallium-liquid indium system will be made.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-20	PRIOR NO.: 975-90-95-87

4. TITLE:

Space Processing Equipment Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Boese, A.	205-453-1661	H. G. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: M518 Multipurpose Electric Furnace Modification (179-21-10-00)
NAS8-30289 Westinghouse Electric Corporation, Pittsburgh, PA 15235

OBJECTIVE: The objective of this task is to redesign, fabricate, assemble and test a prototype model of the M518 Multipurpose Electric Furnace System.

APPROACH: The contractor shall modify the thermal radiation shields and heater support tubes, modify the heater windings, develop a mechanism for increasing the passive cool-down rate, modify the controlled cool-down circuit, provide system protection and deliver the modified furnace and all associated hardware to MSFC.

STATUS: Technical Progress: Contractor is performing work in accordance with the contractual scope of work for the modification and delivery of hardware.

Management Progress: Contract NAS8-30289 was amended on February 11, 1974 to add funds for additional effort to incorporate certain design changes to the electric furnace.

Conclusions: None

Problems: None

Forecast: Delivery Schedule: Modified furnace and all associated hardware - April 17, 1974. All documentation and Final Report - July 17, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Eighth Monthly Progress Report, "Multipurpose Electric Furnace System",		R. Mazelsky, C. S. Duncan, R. G. Seidensticker and R. A. Johnson,	March 15, 1974.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-20	PRIOR NO.: 179-20

4. TITLE:

Space Processing Equipment Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Aldrich, B. R.	205-453-2010	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Space Processing Furnace System Development (179-21-10-01)
NAS8-29769 ARTCOR, Irvine, CA 92707

OBJECTIVE: The major objective of this task is to develop furnace concepts, fabricate components and test furnace models for space processing facilities to be used on low-g testing facilities. The objective of the first contract will be to design and demonstrate a furnace capable of high temperature with an oxidizing atmosphere.

APPROACH: The contractor shall perform a study of electrically conducting ceramic heating elements for use in high temperature (2200°C) furnaces, design and fabricate a prototype furnace heating element and control system and deliver the prototype system to MSFC for space simulation experiments in the drop tower facility.

STATUS: Technical Progress: The contractor reports that " Fabrication has been completed on the furnace structural components. Ceramic insulator parts were machined. The preheater assembly is being started while the main heater (conducting ceramic) is pending delivery of the needed oxide materials. A model furnace element having an I.D. of 2.6cm and a length of 7cm has been fabricated. The model furnace was operated with manual power controls in two modes. A survey to identify furnace user requirements is continuing with the preparation of a standard questionnaire to relate user requirements to the conducting ceramic furnace concept nearing completion.

Management Progress: The contract was amended on January 3, 1974 to revise and increase the scope of work and to extend the period of performance to December 31, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Tenth Monthly Technical Letter Progress Report, LR 46-164-9, "High Temperature Electrically Conducting Ceramic Heating Element and Control System", C. R. Halbach, for the month of February 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-20

PAGE 2 OF 2

TASK: Space Processing Furnace System Development

STATUS: (Continued)

Conclusions: None

Problems: None

Forecast: The contractor was assigned the following progress schedule: (Mod 1 - signed on and effective on January 3, 1974)

A. Survey to Identify Furnace User Requirements - Twelve (12) weeks from date of Mod 1.
B. Perform Analysis of Chemical Interactions of Materials - Including third month through six and one-half months from date of Mod. 1.
C. Contract Review - Eight months from date of Mod. 1.
D. Study, Design and Fabricate Critical Components - From third month through the ninth month from the date of Mod. 1.
E. Provide Axial Gradient Element Heater System - Tenth month through eleventh month from date of Mod. 1.
F. Performance Testing of Axial Gradient Elements - Tenth and One Half month through twelfth month from date of Mod. 1.
G. Delivery of Axial Gradient Element - Twelve months from date of Mod. 1.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-20	PRIOR NO.: 179-20

4. TITLE:

Space Processing Equipment Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Aldrich, B. R.	205-453-5085	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Furnace Systems for Use on Low "G" Test Facilities (179-21-10-03) In-House

OBJECTIVE: This in-house effort will be utilized to develop furnace systems capable of supporting space processing experiments of sufficient definition to be flown on the initial development flights in the research rocket programs and to be used in the Drop Tower tests. At the present time; the following furnace systems, from design through flight tests of prototype models, are to be developed: (1) Float Zone Stability experiment to obtain the zone shape at various rotation rates. (2) Glass processing furnace. (3) Multipurpose furnace system designed to process samples of the widest possible range of materials and thermal requirements.

APPROACH: A laboratory study of different furnace concepts in conjunction with a users survey will be made. From this study, furnace systems will be developed to provide early processing capabilities for the sounding rockets. These preliminary test furnaces will provide engineering and scientific data with which the instrumented rocket data can be correlated. Each selected furnace system will be designed, fabricated, tested, and made available for flight.

STATUS: Technical Progress: Most of the in-house effort was on the Multipurpose Furnace System and included (a) completion of design and detail drawings, (b) started fabrication of furnace parts for the prototype unit, and (c) continuation of furnace component testing. Design concept for the Float Zone Stability Experiment is continuing and some parts are now on order. Feasibility studies are being performed for Glass Processing Furnace.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
In-House Interim Report, Project Number 8652, "Multipurpose Furnace for Research Rockets", B. R. Aldrich, January 29, 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-20

TASK: Furnace Systems for Use on Low "G" Test Facilities

STATUS: (Continued)

Management Progress: FY-74 funds have been expended for this in-house program.

Conclusions: None

Problems: None

Forecast: This in-house effort is expected to continue through FY-77

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-20	975-90-95-32

4. TITLE:

Space Processing Equipment Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Berge, L. H.	205-453-1661	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Free Suspension System for Space Manufacturing (179-22-10-01)
NAS8-29680 General Electric Co., Space Sciences Laboratory, Philadelphia, PA 19101

OBJECTIVE: The objective of this effort is to build and test free suspension facility to perform containerless processing in zero-g. Heating and positioning will be induced in the material by high frequency fields emanating from multiple coils surrounding the material. This is part of the total effort of a program to obtain an electromagnetic levitation apparatus for space processing experiments.

APPROACH: The contractor will combine data from past contracts with data produced during this contract. This effort will be accomplished with the following tasks: (1) Define levitation system equipment and instrumentation required for space processing of materials and indicate which materials require melting/cooling, transferring, mixing and shaping and other processing activities which an electromagnetic levitation system is associated. (2) Consolidate process variables and facility requirements for material classes to be processed by levitation systems. Material data will be related to process variables effecting the selection of a configuration for further development. (3) Study levitation system elements individually and then combined into systems to select the recommended configurations. (4) Support MSFC for a minimum of four free fall tests of the six coil positioning system. These tests will also verify the performance of modifications made to eliminate "Cross Talk" between coils.

STATUS: Technical Progress: Contractor is performing work in accordance with the scope of work. The effort contained in the first part of the contract for "Electromagnetic

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final Report (Original Scope of Work), "Electromagnetic Containerless Processing Requirements and Recommended Facility Concept and Capabilities for Space Lab", R. T. Frost, H. L. Bloom, L. J. Napaluch, E. H. Stockhoff and G. Wouch, 13 March 1974.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-20

TASK: Free Suspension System for Space Manufacturing

STATUS: Technical Progress: (Continued)

Levitation Systems" was completed and the final report submitted. Work will continue on "Contactless Positioning Technology in Support of Space Processing Payload Systems".

Management Progress: Contract NAS8-29680 was amended and extended to July 2, 1974.

Conclusions: Ground based studies and theory indicate many possibilities for formation of new phases and crystal structures through elimination of gravity and the influence of crucible walls. For many materials, application of positioning forces by means of electromagnetic fields in a Containerless Processing Facility is now feasible.

Problems: None

Forecast: Contractual work is scheduled to be completed by July 2, 1974.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-20	None

4. TITLE:

Containerless Processing System

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Berge, L. H.	205-453-1661	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Containerless Processing System (179-22-10-01)
Contract (To be established - DCN 1-4-65-48019)

OBJECTIVE: The primary objective of this effort is to continue and finalize the "Phase B" effort to develop electromagnetic levitation apparatus which could be used as a Containerless Processing System for space processing experiments to be conducted by various investigators.

APPROACH: The FY-74 funding will be utilized for a contract to use and extend the engineering data generated under contracts NAS8-24683, NAS8-26157, NAS8-27228 and NAS8-29680. The contractor will perform his work in accordance with the scope of work contained in the contract and will develop preliminary process hardware configuration rather than study of processing phenomenon or potential products.

STATUS: Technical Progress: The procurement action was written and forwarded to the Procurement Office.

Management Progress: Funding has been approved for this procurement action.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed within eight months after award of contract.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-20	None

4. TITLE:

Space Processing Equipment Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Berge, L. H.	205-453-1661	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Acoustic Positioning System for Space Processing (179-22-20-02)
NAS8-30471 Intersonics Corporation, Chicago, IL 60611

OBJECTIVE: The objective of this effort is to provide hardware and data analyses for evaluation of a containerless processing facility during a research rocket flight scheduled during first quarter of 1975.

APPROACH: This contract will continue the past team of experts as consultants on glass processing. Intersonics will build a containerless processing system, employing acoustic fields, to process samples of chalcogenide glass. They will furnish two flight units and provide launch support services.

STATUS: Technical Progress: Contractor is performing work in accordance with the scope of work in the contract.

Management Progress: Contract NAS8-30471 was awarded on November 20, 1973 for a seven month period of performance.

Conclusions: None

Problems: None

Forecast: Contractual work is scheduled to be completed by June 20, 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Monthly Progress Report,	"Acoustic Positioning for Space Processing Experiments",	Dr. R. R. Whymark.	

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-21-20	PRIOR NO.: 975-90-95

4. TITLE:

Solar Energy Concentrator System for Crystal Growth and Zone Refining in Space

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. C. Ruff	205-453-3090	W. C. Snoddy

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Solar Energy Concentrator System for Crystal Growth and Zone Refining in Space
Contract NAS8-30268 Lockheed Missiles and Space Co., Huntsville

OBJECTIVES: To define the requirements, benefits, and economics of a solar energy concentrator system. Develop a design for an integrated solar energy concentrator and crystal grower zone refiner. With the design requirements specified, determine feasibility of incorporating facility into Spacelab.

APPROACH:

Task 1 Those particular features unique to solar processing in space shall be defined. In particular, the contractor shall consider the benefits of solar zone refining and crystal growth in addition to the purification and melting of high temperature materials. The feasibility of applying direct solar energy in space for performing such processes will be specified and recommendations made for further study of the most beneficial configuration.

Task 2 Determine the furnace engineering requirements necessary for successful utilization in space. In particular, the contractor shall consider but not be limited to mirror deployment and materials, solar tracking requirements, material outgassing and containment, specimen retrieval, and furnace operating

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

procedure. System limitations will also be clearly defined. A parallel concept will be developed for ground-based feasibility testing.

Task 3 Material systems will be reviewed, considering the unique features of solar processing, and the proposed furnace configuration. This shall include a discussion of proposed processing steps, difficulties and benefits.

Recommendations shall be made of at least five materials whose processing is adaptable to, and benefitted by space manufacturing with solar energy.

Task 4 A detailed design shall be proposed for a space processing solar furnace and an experimental procedure outlined for the processing of two of the materials chosen by the COR from Task 3. A parallel earth based prototype design shall be proposed for testing the concepts in a one-g environment.

PROPOSED TASK: Make an economic comparison of cost of solar concentrator facility to other heating and power systems such as combinations of RF induction and resistance heating with fuel cell or solar cell power generators.

PROPOSED TASK: Determine feasibility of incorporating a solar energy concentrator facility into Spacelab.

STATUS: A list of prime candidate materials for space processing, as recommended in the literature, is being compiled. A list of the physical properties of these materials is being assembled. These properties will be needed for the detailed thermal analysis of the system. A detailed analytical model of the solar energy concentrator system is being formulated. Salient components of the model are as follows. The model will define and analyze reflector contours. It will predict heat flux distributions from prescribed reflectors or define reflector contours that give prescribed heat flux distributions. A solar dish model of non-uniform radiance will be included. The model will attempt to predict process rates and process sizes for specified materials. The model will examine the uncertainties in the ideal design conditions introduced by the following geometrical errors: (1) pointing of the optical axis toward the solar disk; (2) placement of the process material; and (3) optical imperfections in the reflector surfaces.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-24-30-01	PRIOR NO.:

4. TITLE:

CRYSTAL GROWTH TECHNIQUES IN ZERO GRAVITY

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
M. Davidson, S&E-SSL-TR	453-3090	WCS W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Contract No.: Not selected
Contractor: Not selected

OBJECTIVE(S): The objective of this task is to obtain methods of process heating and temperature sensing which do not involve contact with the melt, and to establish the feasibility of such techniques for space processing.

APPROACH: Analyze and test heating and temperature sensing methods not involving contact with the melt. Develop designs for working systems which are applicable to space processing applications.

STATUS: Funds not yet available.

FORECAST: Release RFQ when funds become available.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 179-26-11-01	PRIOR NO.:

4. TITLE:

ACOUSTIC MIXING FOR SPACE PROCESSED MATERIALS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. L. Lacy, S&E-SSL-NP	453-5135	R. Decher, S&E-SSL-N

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): To determine the optimum conditions for achieving a dispersion or mixing of small particles in a molten metal using acoustic processing in space. This research will determine the best acoustic technique for the production of composite castings in the Shuttle Space Laboratory.

APPROACH: The influence of various acoustic and liquid parameters on acoustic mixing will be determined by laboratory simulation of space processing conditions. Several techniques will be investigated in order to define the necessary design parameters for acoustic mixing motors and chambers to be used for the production of composite castings in space. Molten metals will be simulated by using liquids of various densities and viscosities along with particles of different densities and diameters. The amount of dispersion obtained will be determined in real time by optical and acoustic means.

STATUS: Although this program was only approved in September, a great deal of work has been accomplished. For example, a novel technique of counting particles suspended in a fluid by using acoustics was developed, and a government patent has been applied for. This new technique will not only be valuable to space processing but also to such fields as pollution measurements in water and cavitation detection in liquid rocket fuels. A NASA Technical Report is in the preparation stage.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NASA Technical Report is being prepared.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 179-30	PRIOR NO.: 975-90-95-33

4. TITLE:
Ground Based Space Processing Tests

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yost, V. H.	205-453-2013	W. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Drop Tower Program Support (179-31-99-01)
In-House

OBJECTIVE: The primary objective of this in-house effort is to maintain and improve necessary equipment and facilities to provide short periods of near zero-g environment for space processing experiments and to continue the design, development, test and evaluation of systems for processing materials and detecting and measuring experiment parameters.

APPROACH: In-house work and supporting contracts will be utilized to provide experimenters with a readily available low cost means of testing and evaluating experiments and to provide universal packages to experiments which can be used in either the drop tower or KC-135 tests.

STATUS: Technical Progress: During this reporting period the following work was completed:

A 3000 psig air manifold, reported as a problem last period, was manufactured, installed and checked out in January 1974. The principal cause of the delay was obtained AISI 304 material. Most of the fittings had to be machined from bar stock to avoid 180 day delivery periods.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
No formal report issued during this reporting period.			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 179-30

TASK: Drop Tower Program Support

STATUS: Technical Progress: (Continued)

Of the 143 drops scheduled for CY 1974 32 were made. Four of these had to be run over because the near zero-g times were inadequate. Two one-g tests were also conducted. The 28 good drops were distributed as follows: Cloud Physics -- 17 drops; Immiscible Materials (TRW, NAS8-28267) -- 7 drops and 1 one-g test, Finary Alloy Exhibiting Immiscibility (WSU, NAS8-29725) -- 1 drop and 1 one-g, and Metal Drop Solidification (Grumman NAS8-28604) -- 3 drops.

Management Progress: FY-74 funding has been approved for this task.

Conclusions: This task is providing experimenters with a readily available low cost means of testing and evaluating their Space Processing experiments.

Problems: The Drop Tower is located in the Saturn V Dynamic Test Stand at MSFC. In January 1975 modifications of this stand for Shuttle Dynamic Testing is scheduled to begin. This will take one to two years to complete. During most of this period MSFC Drop Tower will be out of operation. An effort is being made to get the Drop Tower relocated in the Stand first so we can conduct drops while the remainder of the Stand is being completed. We are also investigating the possibility of conducting drops at the Lewis Research Center during this period. They can do about 20 drops a year in addition to what they had planned for their own work.

Forecast: Drop tower tests and KC-135 flights are planned and scheduled at least 90 days in advance. This in-house effort is scheduled to continue through FY-77.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	179-40	975-90-95-79

4. TITLE:

Space Processing Flight Systems

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Yost, V. H.	205-453-2013	H. F. Wuenscher

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Rocket Payload Non-Spin System (179-42-22-01)
NAS8-30528 Astro-Space Laboratories, Inc., Huntsville, AL 35806 and In-House

OBJECTIVE: The objective of this effort is to provide a rocket payload non-spin system which will have a platform to mount Space Processing experiments on it and will produce near zero-g in the roll planes by greatly reducing radial acceleration on the payload produced by the spin stabilization of the rocket.

APPROACH: The data obtained from in-house studies and investigations were utilized in developing the scope of work for a contract to fabricate and deliver two Non-Spin Platforms for Research Rockets. After the platforms are received, tested and evaluated, a procurement action will be initiated for Rocket Payload Non-Spin Systems.

STATUS: Technical Progress: During this reporting period, a scope of work and procurement action was prepared and a contract was obtained for the "Design, develop, fabricate, test, evaluate and deliver two (2) each non-spin platforms for research rockets". A technical review meeting was held with the contractor on March 18, 1974.

Management Progress: Contract NAS8-30528 was awarded on March 15, 1974 for six months.

Conclusions: None

Problems: None

Forecast: Contract completion September 15, 1974. In-house work through FY-76.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None			

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	645-10-01	645-40-05

4. TITLE:

Zero-G Cloud Physics Experiments

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-Y William W. Vaughan	205/453-3106	William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Zero-G Cloud Physics Experiments

Contract No. NAS8-30247 University of Alabama - Huntsville, Alabama
NAS8-30272 McDonnell Douglas - Huntington Beach, California
NAS8-28606 American Meteorological Society, Boston, MA

OBJECTIVE(S): The Zero-G Cloud Physics Program objective is to significantly increase the level of atmospheric cloud microphysical processes. This will be accomplished by: (1) complement and supplement terrestrial cloud physics research, (2) provide scientific community with general purpose orbital laboratory, (3) laboratory capability to encompass largest feasible range of research and beneficial applications experimentation, (4) establish experiment program accommodation, (5) formulate and implement efficient and effective method for scientific community participation, and (6) implement cost laboratory by continual assessment of usage value.

APPROACH: The experiment definition effort will include engineering definition studies of the preliminary multi-experiment laboratory concept(s) and approaches developed as a result of the scientific experiment feasibility activity. Furthermore, the approach will include selected detailed analysis and limited subcomponent breadboard and testing necessary to assess and define an acceptable zero-gravity cloud physics experiment facility and related carrier interface plus operational concepts.

STATUS: Technical Progress--During this reporting period the following milestones were accomplished:

(1) Summary report covering work period between April 1973 and August 1973. This report was distributed as a NASA CR report.

(2) Programmatic data on laboratory costs, schedules, and other estimates

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED
NASA CR 129013	Zero-G Cloud Physics Laboratory-Experiment Program Definition and Preliminary Laboratory Concept Studies	L. R. Eaton, R. V. Greco McDonnell Douglas Astronautics Co.	Sept. 1973

FIRST BENEFITTING PROJECT: Shuttle Spacelab

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 645-10-01

PAGE 2 OF 3

STATUS (CONCLUDED): relative to 1981 flights were completed and sent to OA, NASA Headquarters, (3) contract negotiated now in process for FY-74 effort relative to indepth laboratory concept and subsystem definition (Phase A effort). The scope covers: 1. Experiment Laboratory Technology Development Task, 2. Experiment Laboratory Subsystem Definition Task, 3. Experiment Facilty Subsystem Requirements Task, 4. Cloud Chamber Subsystem Evaluation Task, 5. Ancillary Subsystems Evaluation Task, 6. Experimental Laboratory Definition Trade-Off Task, 7. Data Management, and 8. Cost, Schedules, and SRT Requirements for Laboratory. Program development plan has been rewritten to reflect latest programmatic information. Work has continued on the proposed carry-on experiment, the NaCl Break-Up proposed for the ASTP flight. Although not selected for the ASTP flight, prototype hardware was fabricated and tested. Some simple cloud physics demonstration experiments were performed by Skylab crews 2, 3, and 4. Inhouse work on small cloud chamber has been accomplished using the CVT (Concept Verification Test) facility at MSFC to acquire engineering interface data applicable to future laboratory development efforts.

Management Progress--Briefings were given to MSFC personnel in March. This briefing covered a review of the past efforts covering revised laboratory definition and chamber concept, experiment classes, laboratory concept features, and critical data sampling requirements, funding estimates, etc. Relative to the current study activity, MSFC management has established a study team for management and review of the contract efforts in this new phase of effort. Increased inhouse manpower has been authorized for more indepth penetration into the contractor's efforts. Astronautics Laboratory will have the engineering responsibility in the forthcoming contract while Aero-Astrodynamics will maintain overall management, as well as science responsibility. A separate contract has now been established to support the Senior Science Activity and it is planned to increase the number of members and/or use other consultants to provide a more critical view of the overall Cloud Physics Program and a more independent assessment on the contractors effort.

Forecast: The Zero-G Cloud Physics Program is proceeding as scheduled toward the projected flight schedule of experimental hardware and experiments for the 1981 Shuttle flight schedule. As new experiments are identified they will be added to the experiment class list and trade-off studies will be performed to establish how they could be incorporated into the present laboratory design or in revised laboratory designs for future flights. Simple carry-on experiments will continue to be studied and identified for development. These experiments could provide engineering data and could take advantage of any flight opportunities prior to that main Shuttle flight. A program development plan will be submitted to OA, NASA Headquarters, in April 1974 so that necessary actions can be taken at the OA, Headquarters level to establish authority for the FY-75 Phase B effort and the FY-76/77 Phase C/D effort.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 684-30-90	PRIOR NO.:
4. TITLE:			
5. RESPONSIBLE INDIVIDUAL: S&E-AERO-GA J. R. Duncan, Jr.	TELEPHONE: 205-453-0442	APPROVAL: James C. Blair	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Terminal Guidance and Navigation for Comet and Asteroid Rendezvous
NAS8-30248, Auburn University
Engineering and Experiment Station
Auburn, Alabama 36830

OBJECTIVE(S): Algorithms for an on-board guidance and navigation scheme for rendezvous with comets and asteroids will be developed. These algorithms will be applicable to any mission; however, detailed analysis will be made only for missions to comet Encke in the late 1970's and early 1980's. Additionally, instrument types and accuracies necessary to obtain varying levels of rendezvous precision and on-board computer requirements necessary to implement the developed guidance and navigation scheme will be identified.

APPROACH: Various separate tasks will be undertaken in order to meet the objectives outlined above. A study will be conducted of the accuracy of state determination and rendezvous attainment employing on-board, relative measurements. The practical restriction that thrust be constrained at a constant level and direction over certain intervals will be satisfied by matching a stair step approximation to the continuously varying thrust of the theoretical guidance algorithm. Thrust error management will be investigated. The problem of avoiding unattainable thrust levels near the rendezvous point will be examined. A study of overall system performance will be conducted. A survey of possible instrument and computer types will be made, and on-board guidance and navigation schemes will be developed, tested and delivered.

REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 684-30-90 PAGE 2 OF 3

STATUS: Technical Progress: A description of work required to determine on-board radar equipment characteristics has been prepared. New analytical work on the guidance algorithm has been started. This investigation will include initially the possible improvement of the algorithm by modification to include linear sun terms and also the incorporation of thrust level constraints.

Management Progress: This contractual effort was initiated on December 16, 1973.

Conclusions: None

Problems: None

Causes of Problems: None

Suggested Solutions: None

Forecast: The objectives outlined above will be reached on schedule.

OFFICE OF SPACE SCIENCES

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-50	180-17-50

4. TITLE:
System Performance & Technology Assessment for Unmanned Missions

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-MFT Gerald Wittenstein	205-453-0359	J. P. Lindberg

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: System Performance and Technology Assessment for Unmanned Missions

Contract Number: NAS8-26491
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

OBJECTIVES: Our primary objectives for the year were to identify and assess future performance requirements for OSS launch vehicles and also for astrionics/avionics systems. One other objective was to obtain copies of the already developed programs for use inhouse.

APPROACH: OSS-SV will establish the priority of mission - launch vehicle combinations. Based on these priorities, tasks will be defined by the COR and issued to the contractor who performs the assessments. The resulting data will be reviewed by MSFC specialists and the data, including specialists' comments, submitted to OSS-SV for their use.

STATUS:

1. The conversion and operation of these computer programs (EOMP-I and II) was accomplished, and we presently have this capability inhouse. These programs basically generate L/V trajectory and dispersion analysis in extremely rapid fashion, using the concept of linear propagation of errors.

2. Due to the potential (earlier in the year) of having to look at a SATS class of missions, a study was initiated and completed which defined what orbital constraints would occur for a SATS size payload flying on a Scout vehicle. The results were published in

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
VSPR-IM-73-1	Matrix Routines Used in EOMP	Fred Rea	1-29-73
VSPR-IM-73-2	EOMP TBHS Prog	Fred Rea	1-29-73
VSPR-IM-73-3	- -		
VSPR-IM-73-4	- -		
VSPR-IM-73-5	Ann. of a Number of Pot'l Scout Missions (SATS)	Fred Rea	6-5-73
VSPR-IM-73-6	Scout Vel. Vernier System	Fred Rea	6-6-73
VSPR-IM-73-7	Rate Generation for EOMP Traj.	Fred Rea	6-6-73
VSPR-IM-73-8	Error Anal. of Lageos Mission	Fred Rea	6-8-73
VSPR-IM-73-9	Payload Weight to Perigee Sensitivity to Scout D	Fred Rea	6-20-73
VSPR-IM-73	Third Interim Scientific Report on Vehicle System Eval. Requirement	Fred Rea	10-1973
VSPRE-MM-73-6	ARMMS Phase Review Meeting Report	J. D. Allen	12/11/73
VSPRE-MM-73-7	Recent VSPRE Meetings (Interim Review)	F. G. Rea	12-13-73

(Cont'd)

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 180-17-50

PAGE 2 OF 3

Item 6. (cont'd):
VSPR-IM-73-5, on June 5, 1973. Briefly circular orbits up to 200 n. mi. through 80° inclination were available on Scout and through 100° of inclination for approximately circular orbits less than 250 n. mi. Another analysis concerning the Delta L/V assessing the Delta guidance errors was made concerning the Lageos Mission. These data were published on June 18, 1973, and were used to identify some problem areas in the orbital sensitivity for this mission. Major result was that the Delta could assure errors less than .01, 99.7% of the time.

3. Investigation concerning the improvement of overall mission reliability and orbital achievement accuracy was made on the Scout Vehicle. This study resulted in a potential improvement for the Scout in the form of a velocity vernier system in order to cut off the Scout more closely to the desired velocity. This study is still continuing with respect to other low cost, systems which could be added to the velocity vernier system to further improve the mission attainment reliability for Scout.

4. A computer system which allocates hardware as a function of task priority, and available resources and computes the overall probability of mission success, task completion and final probability of each module was built (Feb 1974). The purpose of this system is to design or analyze a mission using an onboard computer system such as ARMMS (Automatically Reconfigurable Modular Multiprocessor System). Evaluation of such systems will be made as required.

5. Redshift studies were performed analyzing spin coning and spin damping of a Scout fourth stage. A report documenting these data is due this quarter.

6. An investigation of the mission planning and reliability assessments required for Earth observations experiments has begun, with a literature search initiated and an Earth observations injection accuracy orbital program written. This effort is continuing and is expected to provide a series of Mission Requirements Models, and an analysis of all unmanned, small L/V missions for L/V/payload matching and the corresponding L/V injection accuracies required to satisfy mission objectives.

Management Progress --- The FY-74 purchase requirement is being developed.
Conclusions --- Studies are being carried out as planned.
Problems --- None
Cause of Problems --- Not Applicable
Suggested Solutions --- Not Applicable
Forecast --- With inputs from NASA Headquarters to define missions and launch vehicle configurations, efforts will proceed as planned.

Item 7. (cont'd):

VSPRE-IM-73-10	Introduction to ARMMS Concepts	J. D. Allen	12-14-73
BMI-VSPRE-TC-74-1	Lageos Mission Design Consideration	J. D. Allen	1-18-74
VSPRE-IL-74-1	Letter (Bi-Monthly Report)	F. A. Rea	2-25-74

FIRST BENEFITING PROJECT: SPACE SHUTTLE UTILIZATION AND SPACELAB

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-52	PRIOR NO.:

4. TITLE:

System and Trajectory Analysis

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. R. Parker - S&E-ASTR-GDA	453-4276	R. H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Investigation of Strapdown Sensor Rebalance Loops and System Redundancy Concepts NAS8-27296 The University of Tennessee

OBJECTIVES:

(1) To develop a high reliability strapdown navigation platform using two-degree-of-freedom sensors and redundancy concept.

(2) To develop a width-modulated rebalance electronics loop for strapdown gyroscopes.

APPROACH:

(1) In a previous study, a technique has been proposed to use the concept of sensor redundancy to improve the reliability of a strapdown platform employing two-degree-of-freedom (TDF) sensors. Three important parts involved in the development of the sensor are the optimum configuration for sensor arrangement, data reduction, and the sensor performance management method. In the previous study, it is assumed that when a TDF sensor fails, measurement from both of its output axes are erroneous. The validity of this assumption is debatable.

This study proposes a solution to the same problem, but developed under the assumption that each axis of a TDF sensor can fail without affecting the other axis. Although the basic concepts used in this development are similar to the aforementioned development, the details are different. System reliability based on present assumption is studied, the optimum redundancy configuration is developed, associated measurement

(SEE ATTACHED SHEET)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
S-27	"Investigation of Time Sharing of Rebalance Electronics for Sensors in Strapdown Navigation Platforms"	Hung, Coffman	3-15-74

FIRST BENEFITTING PROJECT: Large Space Telescope

equations are given, data reduction methods are presented and discussed, and one concept of sensor performance management is presented.

(2) A new width-modulated pulse rebalance electronics loop was developed for use with strapdown gyroscopes. The decision to develop a width-modulated binary loop was based on the study reported last year in which a width-modulated and a ternary loop were compared, and also on additional results obtained in the first phase of the work reported here. The salient advantages of the width-modulated binary over the ternary loop which strongly influenced our decision are the following: (1) the H-switch is easier to implement, (2) torque is applied in finely quantized increments. (3) the analog-to-digital conversion for data generation is inside the loop and is directly determined by the torque pulse, (4) no part of the loop compensation network bypasses the gyroscope, and (5) the torquer is fed constant power.

The basic design goals for the new rebalance loop were (1) versatility for accomodating a number of different gyros with minimum change in loop parameters, (2) minimization of required number of power supply voltages, (3) at least a factor-of-two increase in error signal sampling rate, (4) improved performance with special emphasis on reduction of uncertainties in data output due to all sources of noise, (5) a wide range of available scale factors, (6) reduction of system complexity for improved reliability, and (7) amenability to microcircuit implementation.

The design theory needed to synthesize the rebalance loop is developed, details of the implementation of each part of the loop are discussed, and some experimental evaluation of a breadboard of the rebalance loop are reported.

STATUS: Technical Progress--

Investigation of the time sharing of electronics is complete. The results of this effort indicate time sharing to be impractical for width-modulated pulse rebalance electronics.

Modeling of the TDF gyro is nearing completion. Verification of the model and stabilization will not be completed without additional funding.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-52	

4. TITLE:

System and Trajectory Analysis

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bobby J. Gaines S&E-ASTR-GC	205-453-0795	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Experimental Studies of Body-Mounted Gyroscope Design
NAS12-2033 MIT Draper Laboratory
NAS8-30255 MIT Draper Laboratory

OBJECTIVES: To devise and perform experiments to verify analytically derived error models for strapdown sensors.

APPROACH: The program intent is to conduct dynamic performance tests of strapdown gyros operating in a rebalanced mode. These tests include single-axis, constant and oscillatory and two-axis oscillatory inputs.

STATUS: Technical Progress - The tasks defined in contract NAS12-2033 have been completed. A final report covering this contract effort is in publication at MIT. A new contract, NAS8-30255, has been signed and will cover dynamic testing a pendulous accelerometer and a laser gyro. Interfacing electronics and preliminary testing of the accelerometer is in process.

Management Progress - A Kearfott 2401 pendulous accelerometer has been GFEd to MIT.

CONCLUSIONS: The final report will summarize static and dynamic tests of gyros with different suspension systems and torque rebalance schemes.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

NOTE: Monthly letter-type progress reports have been received during this reporting period.

FIRST BENEFITTING PROJECT: Non-Project Oriented

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-52 PAGE 2 OF 2

FORECAST: Dynamic testing of the pendulous accelerometer should be completed in four months. Testing of the laser gyro will commence after delivery to MSFC. Additional tests on tuned rotor gyros with digital electronics are being discussed.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-53	

4. TITLE:

Dynamic Test of Inertial Sensors

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bobby J. Gaines S&E-ASTR-GS	205-453-0795	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Procurement and Evaluation of Advanced Gyroscopes for Modular System
NAS12-687 Hamilton Standard

OBJECTIVES: The objective of this task is the design, fabrication, and testing of gyroscopes specifically designed for the environment inherent in strapdown systems.

APPROACH: The results of studies funded by NASA/ERC under contract NAS12-508 and other studies defining the inter-relation between gyroscope design parameters, strapdown system environment, and system errors have been used in the design and fabrication and will be used in testing of gyroscopes for strapdown application. The major phases of this work are: (1) compiling existing studies and initiating studies where needed, (2) design and fabrication of gyroscopes as a result of the studies, (3) testing the resulting gyroscopes for conformance to the design goals, and (4) based on the results of (3), the gyro system will be refined and/or the technology developed will be assessed and applied to suitable gyroscopes which have a production base.

STATUS: Technical Progress - The active magnetic suspension system has been replaced with a precision ball bearing suspension system for the final gyro. Integration of the hybrid is in process, however, circuit component failures continue to plague the system. The final report rough draft has been completed and is currently in review.

Management Progress: A no-cost extension to NAS12-687 has been granted.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: Non-Projected Oriented

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-53 PAGE 2 OF 2

CONCLUSIONS: The ball bearing output axis will not maintain output axis definition to the accuracy of the design goals; however, tests on similar output axis suspension suggest that it will be adequate for evaluation.

PROBLEMS: 1. Ceramics - The problem area will be addressed during gyro refinement.

2. Electronics - The large number of power supplies contribute to the total noise in electronics. An effort is being made to limit the noise.

3. A severe problem involving integration of the hybrid electronics has surfaced and is being worked.

CAUSE OF PROBLEMS: 1. Ceramics - This appears to be due to improper handling that causes hairline fractures. DOD programs that utilize ceramics suggest that proper care in handling will correct ceramics cracking.

2. The gyro requires a large number of dc supplies to operate. Ground loops occur and require care in test setup.

3. The hybrid circuit components appear to be aging and electrical connections are of poor quality.

FORECAST: The final report should be published during this report period. The pulse torquing technology developed in this program has been applied to an effort at the University of Tennessee (funded under 180-17-52) and is being considered for application to tuned rotor gyros.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-53	

4. TITLE:

Dynamic Tests of Inertial Sensors

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Bobby J. Gaines S&E-ASTR-GC	205-453-0795	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Dry Gyro for Strapdown Systems

NAS8-27452 Teledyne Systems Corporation

OBJECTIVES: The need exists for a low cost, reliable, normalized gyro for strapdown system for launch vehicles. New techniques in gyro suspension systems have reduced the cost of platform gyros and this technology has the potential for reducing cost, reducing parts count, and increasing reliability of a strapdown gyro.

APPROACH: The technology developed inthe dry gyro program for platforms has been applied in the design of a strapdown gyro. Two of these instruments have been procured and will be evaluated for use in the launch environment. This evaluation will be both analytical and experimental. Qualification of this type instrument for strapdown systems would allow NASA to meet the needs for inertial reference sensors from a large production base with potential for reduced cost. Two more of these instruments will be procured and characterized in an effort to better assess the gyro applicability to low cost system.

STATUS: Both tuned rotor gyros puchased from Teledyne have been tested. One gyro has been tested at MIT (contract NAS12-2033) in a static and dynamic environment. Dynamic testing has been limited due to the analogue rebalance loop readout limitations. Efforts will be directed toward defining and demonstrating a digital rebalance loop which will allow this dry gyro and other dry gyros to operate in a dynamic environment.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

NOTE: Report covering static and dynamic testing at MIT is in publication.

FIRST BENEFITTING PROJECT: Non-Project Oriented

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-53 PAGE 2 OF 2

CONCLUSIONS: The limited testing accomplished to date indicate this type gyro can be made applicable to a low cost per axis system. The successful application of a digital torquing loop will enhance its applicability to low cost systems.

FORECAST: One (from a large production based) will be modified for launch vehicle environments. Digital electronic loops will be interfaced with this gyro and the Teledyne gyros.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-53	180-17-53

TITLE:

Dynamic Tests of Inertial Sensors

RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
K. Kissel - S&E-ASTR-GDA	453-4276	R. H. Tutt

ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Strapdown Gyro and Accelerometer Test Methods
NAS12-678 The Analytic Sciences Corporation (TASC)

OBJECTIVE(S): To define and evaluate test methods and techniques for evaluation of strapdown gyros and investigate the vibration effects on strapdown navigation accuracy.

APPROACH: Take the fundamental laws of physics and apply them to different types of strapdown gyros in order to develop error models. Then note especially those error terms peculiar to strapdown application. New procedures and methods for evaluating these unique error terms can then be developed and evaluated.

STATUS: Technical Progress--Work has resumed under the redirected effort. The Teledyne dry gyro has been completely modeled and various analyses of output error have been made using several values of measurement and environmental noise.

Management Progress--Effort has been redirected to investigate the design of torque rebalance loops for the Teledyne dry gyro using modern estimation and control theory. Some effort will be devoted to assessing the feasibility of an all digital control loop.

Conclusions--None

Problems--Not enough effort will be available to adequately study the all digital loop.

Forecast--Work on this contract is due to end on June 30, 1974, with publication of the final report.

Publications--None this period

Remarks--None

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
TR-147-4	Strapdown Sensor Test Simulation and Test Plan Recommendations	Bard S. Crawford	1 June 72
TR-147-5	Dynamic Errors in a Tuned Flexure-Mounted Strapdown Gyro	John E. Bortz, Sr.	Sept. 72

FIRST BENEFITTING PROJECT: Non-Project Oriented

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	30 09 73 31 03 74	CURRENT NO.: 180-17-54	PRIOR NO.:

4. TITLE:

GUIDANCE COMPUTER TECHNOLOGY

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Mr. J. B. White, S&E-ASTR-CA	453-4129	C. N. Swearingen Chief, Computers Div.

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Reconfigurable Modular Digital Computer Development, NAS8-27926, Hughes Aircraft Co., and NAS8-26930, Auburn University

OBJECTIVE: To develop a highly reliable modular computer system which is adaptive to various mission requirements. The system is to be capable of configuring itself into various modes of operation, including those which require automatic masking of errors (such as triple modular redundancy), of parallel processing for extremely high computational requirements, and into a standby redundancy mode where failed modules are isolated and automatically replaced with a working module. The various modes are compromises between system reliability and computational capacity. In the mode of automatically masking errors, computational capacity is sacrificed for maximum system reliability. In the mode of parallel processing, a lesser reliability is accepted to obtain maximum computing capability. One objective is to design the system logically and mechanically such that, for a particular mission, a system configuration can be provided that satisfies the requirements of that mission without undue penalty of hardware that is not needed. The system is to be known as an "Automatically Reconfigurable Modular System" (ARMS). The reliability goal for the system is 0.99 for a five year mission, having at least one processor functioning correctly at the end of that time. The goal for computational capability is several million operations per second.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
FR 73-11-998,	"Design of a Modular Digital Computer System, DRL 4 and 5, Final and Phase III Report"	R. A. Easton W. L. Martin W. G. Tees D. W. Kuyper S. A. Simpson B. Cohen R. Radys J. L. Bricker	Dec. 21, 1973 Author(s) Cont'd: J. H. Englemen T. T. Schansman K. H. Schonrock
New Technology Report	"Design of a Modular Digital Computer System, DRL 7"		Dec. 21, 1973

First benefitting project: Possible application on SEPS, LST, TUG, or other long life missions.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-54 PAGE 2 OF 4

APPROACH: Phase I, Preliminary Design - During this phase the system architecture was defined. Such items as how many processors will be in the system, how many switchable modules there will be within each processor, what type of system controller there will be, and how all these various modules are to be interconnected was defined in this phase. Also, specific problem areas were investigated in detail. This included error detection and correction (with special emphasis given to detecting intermittent failures), system reconfiguration, the system controller, and the switches between modules. The Central Processor Unit (CPU) was defined as the Space Ultrareliable Modular Computer (SUMC) which was designed in-house at MSFC. This allows major emphasis to be placed on the system architecture and not have to spend time and money designing another CPU. During this phase the software requirements related to error detection, error correction, reconfiguration, and system reinitialization were identified. Also, the mechanical requirements as they relate to making the system adaptable to various mission requirements were investigated.

Phase II, Breadboard Design and Fabrication - The system architecture as defined in Phase I is being implemented in a breadboard model to enable the investigation of problems in both hardware and software. The technology utilized will be one which will permit changes to be installed without undue expense or time delay. To conserve cost of the breadboard unit, the designs of the Central Processor and input/output units were furnished to the contractor to be modified as required to fit the system architecture. Software to exercise the system is being developed.

PHASE III, Flight Prototype Design and Fabrication - The necessary design changes for both hardware and software resulting from Phase II will be incorporated into the system. The flight prototype will be implemented with the total logic design and technology that would be utilized in the flight unit. This system would be used to verify the total system, including the fabrication technique of the technology chosen.

STATUS: Technical Progress - The Phase I effort has been completed and the final report has been delivered. Detailed design and fabrication is proceeding on the Phase II breadboard. The breadboard shall consist of a Central Control Element (CCE), four CPU's, one Input/Output Processor (IOP), four Memory Modules, four Memory to Processor Busses, and four Processor to Memory Busses. Each Memory Module will be four thousand words by thirty nine bits, including single error correction, multiple error detection coding. The system will be capable of only single stream processing in simplex, duplex, and TMR modes. Multicomputing (multiple dedicated streams) will be added later as an option if required.

Management Progress - Contract NAS8-27926 with Hughes Aircraft has been extended for one year with funding for design of the breadboard system and construction of one copy of each of the module types (CPU, IOP, CCE, Memory). FY 75 funds will be used to purchase the additional required modules, integrate the system and generate the software necessary to test the system.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-54 PAGE 3 OF 4

CONCLUSIONS: The large memory required for executive software associated with multiprocessing coupled with cost and a lack of any defined requirements for multiprocessing on candidate missions has led to the decision not to implement multiprocessing in the system. Multicomputing capability (multiple dedicated processing streams) is being retained as an option and can be added to the breadboard with very little design effort or hardware impact if a requirement becomes defined. The breadboard will be known as the Automatically Reconfigurable Modular System (ARMS).

PROBLEMS: Problem areas are being investigated in more detail as they are identified. None have yet been identified that indicate the approach is not feasible.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-55	PRIOR NO.: NA

4. TITLE:

Contamination Control in Hybrid Microelectronic Modules

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S. V. Caruso, S&E-ASTR-RMH	205-453-1505	J. C. Taylor

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Contamination and Process Control in Hybrid Microcircuit Modules

OBJECTIVE: To develop, test and evaluate coating materials, processes, and process controls for protection of hybrid microelectronic modules from contamination.

APPROACH: Perform investigations to select and test passivation coating materials and processes for applications in particulate contamination control.

Develop process controls for critical operations that effect the reliability of hybrid microcircuits as related to contamination control.

Continue in-house research to supplement contract efforts in these areas.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
NA			

FIRST BENEFITTING PROJECT: NA

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 180-17-55

PAGE 2 OF 2

STATUS: Technical Progress: Two requests for proposals have been submitted for this task. One is a request to develop contamination controls and processes for hybrid microelectronic modules. The second is a study program to develop high reliability processes and methods for ultrasonic bonding using small diameter aluminum wire. Proposals have been received for both requests and are currently being evaluated.

In-house Activities: Research studies are being conducted in-house on contamination control and wire bonding in order to supplement proposed contract studies.

Management Progress: Contract proposals are being evaluated for two research efforts. It is anticipated that contracts will be awarded this month and work will begin by April 1, 1974.

Conclusions: NA

Forecast: The investigations being conducted under these tasks will provide guidelines and procedures for protection of hybrid microcircuits for contamination. In addition, processes and procedures will be developed to provide more reliable bonding techniques for hybrid circuits used in NASA programs.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-56	

4. TITLE:

Low Cost Computer for SEPS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
H. Garrett S&E-ASTR-CF	453-4070	C. N. Swearingen

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK TITLE: Low Cost Computer for SEPS.

OBJECTIVE :- The Solar Electric Propulsion Stage (SEPS) application places very stringent requirements upon the onboard computer system. To meet the needs it is necessary to perform research and development in a number of important areas leading to a low cost highly reliable computer system for a SEPS type applications. Performance characteristics can be traded for cost and reliability to arrive at an acceptable configuration forSEPS with minimum payload penalties. It is vital to the existance of low budget projects such as SEPS that the onboard computer function be accomplished low cost.

APPROACH - It is necessary however, to do additional development for a SEPS type application wherein high reliability over a significant time period is required. This will most likely necessitate the use of redundancy to achieve the reliability goals. Two specific areas will be addressed under this task as follows: (1) The configuration and definition of a low cost SEPS computer system. (2) The qualification of low cost computer for SEPS type application. This will be performed in conjunction with ongoing research and development efforts. SEPS will benefit from the ongoing efforts and duplication will be minimized.

PROGRESS - Significant progress has been made in defining and developing a computer system which can be configured to meet the performance objectives of SEPS within reasonable costs. The flexibility and adaptability inherent in the design permits its use to configure low cost systems. A procurement request has been processed to cover the expected FY 74 effort.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Program: SEPS

PROGRESS REPORT ESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
	2. PERIOD COVERED:	3. CODE	
	01 10 73 31 03 74	CURRENT NO.: 180-17-56	PRIOR NO.:

ation of SEPS Control System

BLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
e	453-1565	

SHMENTS (Milestones, Problems, Near term activities):

Simulation of SEPS Control System

ACTOR NO: Not Negotiated

TIVE: Develop control schemes, suitable for the SEPS stage, which provide le attitude and translational control using low-thrust-level RCS and TVC s.

ACH: The SEPS simulation will be performed on a computer currently being used turn control system verification. The Saturn simulator will be modified to m Solar Electric Propulsion Stage rendezvous and docking, guidance and tion, and pointing control functions requiring both attitude and translational l of the vehicle. In addition to these functions, guidance navigation and l system definition studies to recommend a low-thrust-level reaction control will be performed. The simulation hardware will be used to integrate and flight hardware at a later date. By means of simulations, control schemes investigated in a realistic disturbance environment including the simulation mic effect of the solar panels and other on-board moving masses.

S

: A Procurement Request was initiated February 21, 1974, soliciting a proposal tract negotiation.

7. REPO

	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

FIRS

NEFITING PROGRAM: SEPS

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-56	

4. TITLE:

Solar Electric Propulsion Stage (SEPS) Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-GG W. E. Causey	205-453-0447	James C. Blair

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: SEPS Guidance and Navigation Autonomy Analysis
NAS8-30271, International Business Machines Corporation
150 Sparkman Drive
Huntsville, Alabama 35805

OBJECTIVE(S): An analysis for the selection of a feasible, reliable, low cost SEPS Guidance and Navigation Subsystem will be provided. Three missions will be evaluated.- two geosynchronous and one low earth orbit. The cost analysis will be outlined in manpower, facilities, hardware, and software functions. Both lowest and highest feasible levels of autonomy will be evaluated and costing will be done on the guidance and navigation subsystem for each level.

APPROACH: An initial requirements definition phase will be undertaken. During this phase, study groundrules will be laid baseline trajectories will be generated, and candidate configurations will be identified. Then using the information generated during the first phase of operation, navigation error analyses of the SEPS missions to determine which navigation configurations could meet mission requirements for each of the two levels of autonomy will be performed and the best configuration for each level will be determined. The selected configuration for each level will then be sized and in each case, ground control functional responsibilities will be established. Communication, command, tracking, display and telemetry requirements and/or processing will be determined. A thorough cost analysis will be done at each level as relates to manpower, facility and communications, hardware, and software. Costing of the two levels of autonomy will then be compared and a recommendation will be made between the two levels.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITING PROJECT: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-56 PAGE 2 OF 3

STATUS: Technical Progress: The initial requirements definition phase has been completed. Guidance philosophies, navigation sensors, and performance criteria were selected. In addition, the guidance and navigation evaluation tools (ANS - Autonomous Navigation Analysis Program and MOLTOP - Multiple Orbit Low Thrust Optimization Program) have been modified and are working in conjunction with each other. Navigation analyses are well underway for the high autonomy level (10K circular to synch circular mission) using various combinations of navigation sensors. Groundrules and requirements are being established and evaluated as relates to the low autonomy level.

Management Progress: This contractual effort was initiated on November 30, 1973.

Conclusions: Work is progressing well towards the scheduled meeting of the objectives outlined above.

Problems: None

Causes of Problems: None

Suggested Solutions: None

Forecast: The objectives outlined above will be reached on schedule.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-56	180-17-56

4. TITLE:

Solar Electric Propulsion Stage (SEPS) Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-SA J. R. Duncan, Jr.	205-453-0442	James C. Blair

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Interplanetary Low Thrust Guidance and Performance Error Analysis
NAS8-29666, Martin Marietta Corporation
P. O. Box 179
Denver, CO 80201

OBJECTIVE(S): Effort to date on this contract has produced a computer program (MAPSEP) which can be used to evaluate guidance, navigation and performance requirements to the degree necessary for SEPS studies and interplanetary mission design work. Thus, previously listed objectives have been met. Under contract extension and expansion, modifications and extensions of this program will be made which will provide for increased efficiency of operation and the additional capability of performing guidance and navigation analysis for low thrust earth orbital missions.

APPROACH: The expanded objectives outlined above will be met by the successful completion of the following four tasks. (1) The computer program (MAPSEP) previously developed and documented under this contract will be improved in efficiency and its capability to evaluate planetary missions will be increased. (2) A separate program will be developed which will perform the same functions as MAPSEP but which will be oriented towards earth orbital mission applications. (3) Test case data and verification methods for the programs created under (1) and (2) above will be defined and applied. (4) The finalized programs will be completely documented and this documentation, along with a source deck or tape of the program, will be provided to MSFC. Concurrently with the development of the program, the contractor will communicate

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

FIRST BENEFITTING PROJECT: SEPS

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 180-17-56

APPROACH: (Continued)

with the MSFC Computation Laboratory and provide them with the information needed to facilitate the program conversions which are necessary for operation on MSFC computer systems.

STATUS: Technical Progress: Development of a mission analysis program for solar electric propulsion (MAPSEP) was completed. This program contains three basic modes: TOPSEP (trajectory generation), GODSEP (linear error analysis), and SIMSEP (simulation). These modes and their various options give the user sufficient flexibility to analyze any low thrust mission with respect to trajectory performance, guidance and navigation, and to provide meaningful system related requirements for the purpose of vehicle design. The developed program was completely documented in a three volume report including an analytical or functional description document, a User's Manual and a volume containing a description of the internal structure of MAPSEP including logical flow.

Management Progress: The original contractual effort with one expansion was brought to a successful completion on March 10, 1974. A contract extension for approximately 65K and covering a one year period is presently in the last stages of negotiation. This extension will cover the completion of all the objectives outlined above.

Conclusions: The original objectives of this contractual effort have been reached. Upon completion of negotiations for contract extension, work will begin on the objectives currently listed.

Problems: None

Causes of Problems: None

Suggested Solutions: None

Forecast: The objectives as outlined above will be reached on schedule.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-56	180-17-56

4. TITLE:

Solar Electric Propulsion Stage (SEPS) Technology

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
S&E-AERO-GA J. R. Duncan, Jr.	205-453-0442	James C. Blair

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Conversion of HILTOP and ASTOP Computer Programs
NAS8-29945, Analytical Mechanics Associates, Inc.
50 Jericho Turnpike
Jericho, New York 11753

OBJECTIVE(S): The Heliocentric Interplanetary Low Thrust Trajectory Optimization Program (HILTOP) and the Arbitrary Space Trajectory Optimization Program (ASTOP) will be transferred to MSFC for operation on the MSFC UNIVAC 1108 computer. In addition, various proposed program modifications to HILTOP will be investigated and, where applicable, included in the program.

APPROACH: The HILTOP and ASTOP programs will be transferred to MSFC for use on its UNIVAC 1108 computer. In this regard, test cases will be run and evaluated for all program options; the existing User's Guide will be updated and expanded; and training sessions on the use of the programs will be provided for interested MSFC personnel. The following program modifications to HILTOP will be investigated: (1) generalization of fixed thrust angle capability; (2) inclusion of the coupling between the solar array pointing angle and the thrust vector; (3) revision of the iterator; (4) better model of the radiation degradation effects upon the solar arrays; (5) account for throttling effects, and (6) revise logic of program to handle cases where the switch function and its derivative both go to zero. Where program modifications are actually made, they will be documented as addendums or inclusions into the original documentation.

7. REPORT NO.:	TITLE:	AUTHOR(S):	DATE TRANSMITTED

FIRST BENEFITING PROJECT: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-56 PAGE 2 OF 3

STATUS: Technical Progress: None

Management Progress: This contractual effort was initiated on February 21, 1974.

Conclusions: None

Problems: None

Causes of Problems: None

Suggested Solutions: None

Forecast: The objectives outlined above will be reached on schedule.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57 502-24-17	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. E. Young	453-4566	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Objective(s): To insure the availability and adequacy of technology to support the Solar Electric Propulsion Stage (SEPS) Solar Array.

Approach: The approach is to perform a preliminary design in order to identify the solar array technology required by the SEPS. This technology will be compared with the state-of-the-art to identify areas where demonstration or futher development of technology is needed. These areas will be worked as specific tasks with results being fed back into the design effort. The availability of overall array technology will be demonstrated by fabricating and testing a full-scale wing. The approach is divided into major task areas as follows:

- o Preliminary Design
- o Technology Development
- o Fabrication and Test of Full-Scale Wing

These tasks are illustrated in the attached milestone schedule.

Status: Technical Progress: The Preliminary Design Task is over 60% complete with the following areas of technology having been identified as sub-tasks to be worked under the Technology Development Task.

(1) Solar Cell to Solar Cell Interconnect Bonding

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Project: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-57 502-24-17 PAGE 2 OF 2

(2) Materials Tests and Demonstration
(3) Non-Destructive Inspection and Test Methods for Solar Cell Modules
(4) Illumination and Thermal Cycling Testing of Solar Cell Modules
(5) Aluminum Flat Conductor Cable Development & Cable Termination

Remarks: (1) Additional sub-tasks may be identified as the Preliminary Design Task processes. The various tasks and sub-tasks will be reported separately.

(2) See individual tasks and sub-tasks for management progress, problems, and remarks.

(3) All current effort involving the OAST (502-) portion of this RTOP is reported under the Task "Preliminary Design". This is a joint effort with OSS (180-).

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57 502-24-17	PRIOR NO.:

4. TITLE:
Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. E. Young	453-4566	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Preliminary Design

Contract No: NAS8-30315 - Lockheed Missiles & Space Co.

Objective(s): Insure that all SEPS Solar Array Technology requirements are identified and characterized as to their availability. To demonstrate the feasibility of a lightweight array which meets these requirements.

Approach: A preliminary design will be performed to identify the required technology which will compare to that considered state-of-the-art. The technology will then be characterized I, II, or III in accordance with its availability. A working model of the solar array wing-root will be fabricated and tested to demonstrate the feasibility of meeting the requirements.

Status: Technical Progress: A design concept has been developed and most of the areas of technology have been characterized.

Management Progress: A contract (NAS8-30315) has been signed with Lockheed Missiles and Space Co. to perform the preliminary assignment.

Conclusions: None
Problems: None
Causes of Problems: N/A

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
L. E. Young	453-4566	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Task: Technology Development

Contracts: See related sub-tasks.

Objective(s): To demonstrate or develop the technology identified under the Preliminary Design Task.

Approach: Areas of technology identified under the Preliminary Design Task will be worked in-house and on contract in accordance with the plans and schedules depicted in related sub-tasks.

Status: Technical Progress: Some technology development areas have already been initiated. See related sub-tasks.

Remarks: See related sub-tasks for Management Progress, Conclusions, Problems, etc.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE OF

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
G. L. Filip, S&E-ASTR-RMH	453-1505	R. M. Aden/S&E-ASTR-E J. C. Taylor/S&E-ASTR-R

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Sub-Task: Solar Cell to Solar Cell Interconnect Bonding

to Task: Technology Development (In-House and on Contract - TBD)

Objective: To select materials and develop interconnect technology including process controls for attaching solar cells to large flexible printed circuits.

Approach: Perform investigations to select and test materials and processes for attaching solar cells to flexible printed circuits so that mechanical and electrical integrity is not degraded beyond acceptable limits. Test assemblies are to be made and tested to ascertain mechanical and electrical performance.

Status: Technical Progress: A procurement request has been submitted for this task.

Management Progress: None.

Conclusions: None.

Problems: None.

Causes of Problems: N/A.

7. REPORT NO.	TITLE:	AUTHOR(s):	DATE TRANSMITTED
N/A			

First Benefiting Project: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
F. Uptagrafft/S&E-ASTN-MX	453-1275	R. M. Aden/S&E-ASTR-E R. Schwinghamer/S&E-ASTN-M

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Sub-Task: Materials Tests & Demonstration

to Task: Technology Development (In-House & on Contract - TBD)

Objective(s): To obtain data on the combined effects of UV, penetrating radiation and vacuum on structural, thermal-optical and electrical properties of the candidate solar array materials.

Approach: Through a combination of an in-house and contract effort, a program will be initiated which will identify candidate solar array materials to be tested and evaluated against the SEPS environment. Tests will be conducted to provide creep, tear, tensile data, and UV effects on candidate substrate materials. Particle radiation tests will be conducted to determine their effects. Results of these tests will be used to select materials capable of meeting SEPS requirements.

Status: Technical Progress: A list of candidate materials has been prepared and a scope of work is presently being generated.

Management Progress: None
Conclusions: None
Problems: None
Causes of Problems: N/A

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 03 31 74	CURRENT NO.: 180-17-57	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Ken Woodis	453-4519	R. M. Aden/S&E-ASTR-E R. Henritze/S&E-QUAL-A

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Sub-Task: Non-Destructive Inspection and Test Methods for Solar Cell Modules (In-House)

to Task: Technology Development

Objective: To insure the availability and adequacy of nondestructive testing technology to support the solar array development program. Two areas of this program will be researched and developed: (1) Electrical interconnection integrity and (2) Solar Array output verification. The electrical interconnection portion will consist of: (a) The development of an optimum test method for determining the adequacy of electrical interconnections, (b) Testing solar modules after fabrication, and (c) The disassembly/teardown analysis on test samples. The solar array output verification will consist of nondestructive evaluation techniques for verification of solar array module outputs.

Approach: Illumination, Dark IV and infrared techniques will all be investigated to determine an optimum test method to determine not only cell integrity but also interconnect integrity. Close coordination with ASTR, as well as the contractor will be maintained to prevent undesirable conditions from appearing in the consequent solar design, especially in the area of interconnect materials and method of bonding.

Status: Technical Progress: Test fixtures have been fabricated and equipment obtained to illuminate and hold test solar cells. Preliminary tests have been performed. A procurement request has been prepared to refurbish an existing infrared scanner. This scanner has the sensitivity needed to plot thermal profiles of the cell and interconnects.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Project: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-57 PAGE 2 OF 2

Management Progress: None.

Conclusions: None.

Problems: None.

Cause of Problems: N/A.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 180-17-57	PRIOR NO.:

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
D. W. Alexander	453-4567	R. M. Aden S&E-ASTR-E

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Sub-Task: Illumination and Thermal-Cycle Testing of Solar Cell Modules
To Task: Technology Development

Objective(s): To determine the I-V characteristics and the solar cell interconnect integrity of the solar cell modules to be delivered under the preliminary design task, the technology development task, and the fabrication and tests of a full-scale wing task.

Approach: I-V characteristics of the solar cell modules will be determined using a flash-lamp solar simulator calibrated to AM-O conditions using standard solar cells calibrated by JPL's high altitude balloon flight calibration program. The electrical and mechanical integrity of the solar cell interconnect designs will be verified by comprehensive thermal-cycle testing.

Status: Technical Progress: Two of the four standard solar cells were calibrated by JPL on February 16, 1974, under Sub-Auth. No. 82, dated Dec. 19, 1973. The other two cells will be flown on balloon flights between March and June 1974.

Management Progress: The large area solar simulation facility is ready for occupancy. An RFQ has been submitted for development of solar cell interconnect bonding techniques which will result in the fabrication and delivery of eight experimental solar cell modules.

Conclusions: None. Problem Areas: None. Causes of Problems: N/A.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
None.			

First Benefiting Project: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	180-17-57	

4. TITLE:

Solar Array Technology for Solar Electric Propulsion Stage (SEPS)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
James M. Willis	453-1509	R. M. Aden/S&E-ASTR-E W. Angele/S&E-PE-M

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

Sub-Task: Aluminum Flat Conductor Cable Development & Cable Termination (In-House and on Contract - TBD)

to Task: Technology Development

Objective: The objective of this effort is to develop and substantiate the necessary technology for the development of an ultimate lightweight, highly flexible Aluminum Conductor Flat Cable (FCC) and to establish a reliable method(s) for terminating. The developed technology shall be readily adaptable to the initial manufacture, rework and refurbishment of large, flexible, flat-fold solar arrays.

Approach: Both in-house effort and supporting contracts will be utilized to develop the required lightweight cable and termination technology. The in-house effort shall include the evaluation of prototype designs, using candidate materials and methods. Contractor submitted cables and termination procedures will be subjected to verification testing and assessed for program application. Through contract support, the manufacturing procedures, materials selection and preparation and the required process controls shall be established.

Status: Technical Progress: A procurement request for materials to support the in-house effort has been prepared. A program plan to update aluminum conductor flat cable fabrication and to establish the base parameters for terminating aluminum conductors is under investigation.

Management Progress: The procurement of materials was issued during Feb-

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

First Benefiting Project: SEPS

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 180-17-57 PAGE 2 OF 2

Management Progress (Cont'd)

ruary 1974, for the support of the in-house effort.

Conclusions: None.

Problems: None.

Cause of Problems: N/A.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	186-68-64	186-68-64

4. TITLE:

Comet and Asteriod Rendezvous and Docking (CARD)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
J. D. Ellsworth/H. Waites S&E-ASTR-S	453-4584/4717	J. L. Mack

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: a) Autonomous Target Relative Navigation
b) Stability and Dynamic Analysis of a Control System Insensitivity to Parameter and Environmental Variations

OBJECTIVES: a) The purpose of the study effort under Task (a) was to develop an autonomous or ground supplemented target-relative navigation system capable of use on spacecraft which would fly by, orbit/land on a plante, a comet, or an asteroid.

b) The study effort under Task (b) was to develop techniques, analysis, and synthesis tools to aid in the design and development of a simulation plan for stability and dynamic analysis of a control system insensitivity to the variations encountered in unmanned rendezvous and docking in the CARD mission.

STATUS: The study contracts on the above tasks have been completed and final reports delivered.

This is the final progress report on this RTOP.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Scientific Report #S-24	Autonomous Target Relative Navigation Final Report Contract NAS8-28251	James C. Hung	May 1, 1973
Vol I, II, III	Dynamic Analysis of and synthesis of an Attitude Control System for a Spacecraft to Rendezvous with Comet and Asteroids Final Report Contract NAS8-28110		July 31, 1973

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 3

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 188-36-56	PRIOR NO.:

4. TITLE:

Magnetospheric-Physics-Particle and Particle/Photon Interactions

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
G. Swenson, S&E-AERO-YS	205 453-3140	Leonard L Lockhart for William W. Vaughan

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Airglow Research, Contract No. NAS8-29543
University of Alabama in Huntsville, Huntsville, AL 35810

OBJECTIVE: To obtain a better understanding of the effects of wave propagation in airglow emissions.

APPROACH: 1) Develop a model of wave propagation through the ionosphere.
2) Combine with an already developed static model of the 6300 Å OI emission.
3) Adjust model parameters until agreement is reached with observational data recorded by MSFC Airglow Observatory System.

STATUS: Technical Progress: 1) A theoretical model of a three fluid ionosphere is approximately 90% complete.
2) A set of governing equations for a quiet magnetosphere has been developed and work has started on developing a model which can be used to study the evolution of the magnetosphere.
3) Development of a dynamic model of the 6300 Å OI emission has been delayed due to observational equipment problems. The data required to verify the theoretical studies has not been available.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Short Period Geomagnetic Variations During Storm		
	Thermospheric Heating and Movements During Geomagnetic Disturbances	S. T. Wu	
	Wind Shear Effect on Acoustic-Gravity Wave Propagation in the Thermosphere	S. T. Wu, R. J. Hung, and G. L. Rao	

FIRST BENEFITTING PROGRAM: Atmospheric Science and Space Plasma Physics Laboratory

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-36-56 PAGE 2 OF 3

STATUS: Management Progress: The period of performance has been extended and work will continue at a much lower level of effort during the remainder of the contract.

Conclusions: Objectives are technically feasible; however, three-dimensional model appears to be far downstream.

Problems: Length and level of effort of contract will not permit the indepth work needed to develop the full scale model originally envisioned.

Forecast: This effort will be terminated because no FY 74 funds have been provided.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 5

1. CENTER:	2. PERIOD COVERED:	3. CODE	
MSFC	01 10 73 31 03 74	CURRENT NO.: 188-38-52	PRIOR NO.: 188-38-01

4. TITLE:

REAL TIME SOLAR MAGNETOGRAPH (RTSM)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
W. C. Snoddy, S&E-SSL-T	453-3103	E R Miller for W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Real Time Solar Magnetograph

GO #H-45646A

OBJECTIVE(S): To develop a solar magnetograph capable of real time, high-resolution measurements having a field of view of several arc minutes. Such instrumentation will be used to study small-scale, rapid variations of the solar magnetic fields. This information is needed, for example, to support the scientific data evaluation of the ATM and to aid in the prediction of flares in connection with such manned missions. It will provide a capability of the Space Sciences Laboratory of MSFC to support solar astronomical missions.

APPROACH: The RTSM is representative of magnetograph systems which use a narrow-band birefringent filter plus an assembly of polarizing optics to uniquely determine the state of polarization of a narrow wavelength interval of the light emerging from a small element of the sun's surface by measuring the Zeeman effect in chromospheric absorption lines. The specific problems to which the RTSM is addressed are (1) to establish the relationship between measured polarization and solar magnetic fields, and (2) to correlate measured magnetic field distributions with distributions calculated theoretically from various assumptions concerning the solar plasma. In regard to the first problem, calibration is approached by solving the radiative transfer equations for the line profiles of the Stokes parameters and computing the percentage of linear and circular polarization across the line profiles. Correspondingly, if it is assumed that the polarization of the light is caused solely by the presence of a homogeneous magnetic field in

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
TMX-53984	Calculations of Astrophysical Partition Functions	M. J. Hagyard	Feb 1970
TMX-64556	The Continuous Absorption Coefficient Per Gram of Stellar Matter with Neutral Hydrogen & the Negative Hydrogen Ion as Sources of Opacity	M. J. Hagyard	Sept 1970
TMX-64541	Calculations of the Stokes Parameters and the Degree of Line Polarization: An Application of the Solutions of Moe to the Unno Transfer Equations	M. J. Hagyard	Aug 1970
NAS8-30148	Two Solar Intensity Calculations	A. R. Dunn	July 1970

FIRST BENEFITTING PROJECT: SKYLAB/ATM Data Reduction

APPROACH: Cont'd

the process of formation of the absorption line in the relevant layers of the sun's atmosphere, this magnetic field can be determined both in magnitude and direction from measurements of the degrees of linear and circular polarization of the light transmitted by the narrow-band filter. In connection with the second problem, the shock calculation for infalling prominence material in the infall-impact model of a solar flare yields appropriate conditions for hydrogen-alpha emission. As an extension of the infall-impact theory, a theoretical model for type II and type IV solar radio bursts has been developed and numerical calculations made.

The 30.48cm (12-in.) Cassegrainian telescope collects light for the RTSM optics, Zeiss filter, and secondary electron conduction (SEC) vidicon detector. The data is digitized and processed on a real time basis by a UNIVAC 1108 third generation computer. Results are immediately displayed on a digital to television (D/TV) system and on high-speed printers, and plotters. The Zeiss filter is a specially built birefringent filter designed to have a bandpass of about 0.01nm (0.125Å) at the 525.02nm (5250.2-Å) iron line wavelength. Magnetogrpah measurements are made by using polarizing optics consisting of two $\lambda/4$ plates, two potassium-deuterium-phosphorus (KD*P) crystals, and a linear polarizer. The analysis of the polarized light is accomplished with six combinations of these elements with the retardance of the KD*P crystals being electrically controlled by varying the plate voltage. The effect of each of these six combinations on a beam of partially polarized light can be described in terms of the Stokes parameters and Mueller calculus.

STATUS: Technical Progress - The system became operational in the longitudinal mode on May 30, 1973. Magnetograms were taken 45 percent of the time during the Skylab mission. Because the RTSM was the most eartern ground-based facility, it had the capability of providing the earliest magnetograms for ATM planning for the next day's execution. Since August 15, 1973, magnetograms were transmitted via wirephoto to the NOAA forecaster in the Science Room at JSC. A capability for taping and processing of raw digital data was developed by the Computation Laboratory.

MANAGEMENT PROGRESS - Contract Number NAS8-28456 has been signed under which Electro-Mechanical Research, Inc. (EMR) will provide field engineering and technical support services for the RTSM.

PROBLEMS: No serious problems exist at this time.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-38-52 PAGE 3 OF 5

CONCLUSIONS: The system appears to have the desired capability and flexibility required for initial measurements of solar magnetic fields on a continuing real time basis.

7. REPORT NO.:	Continued TITLE	AUTHOR(S)	DATE TRANSMITTED
NAS8-20166	Corrections to Observations of Intensities on the Sun(Tech. Note).	A. R. Dunn	Apr 1970
NAS8-20166	Corrections of Observed Umbral Spectral Lines,(Interim Report).	A. R. Dunn	Dec 1969
NAS8-20166	Umbral Line Profile Corrections Interim Report.	A. R. Dunn	Mar 1970
	Analytic Solutions to the Unno Transfer equations for the Stokes Parameters in a Milne-Eddington Atmosphere, Solar Physics.	M. J. Hagyard	(In Press)
	Profile & Polarization of the Zeeman Triplet 5250.22 Å, O.K. Moe, G.E. Brueckner, and M.J. Hagyard, 132nd meeting of the American Astronomical Society, Boulder, Colo.	M. J. Hagyard	June 1970
	A Compressible MHD Model of the Development of a Sunspot, 1st meeting of the Solar Physics Division of the American Astronomical Society.	M. J. Hagyard Y. Nakagawa S. T. Wu	Nov 1970
NAS8-25101	Electro-Magnetohydrodynamic Description of the Infall-Impact Model of the Solar Flares. Final Report	S. T. Wu	Nov 1970
	On the Prediction of the Magnetic Field Strength Associated with Solar Flares. Information Zur Kernforchung & Kerntechnik.	S. T. Wu K. O. Thompson	(In Press)
	Real Time Solar Magnetograph (First Ceneration) Edited by J. R. Watkins, MISC-3SL-70-5	M. J. Hagyard E. J. Reichman N. P. Cumings W. C. Snoddy J. R. Watkins	Dec 1970

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN
(Continuation Sheet)

CURRENT NO./CODE: 88-38-52

PAGE 4 OF 5

7. REPORTS Continued

NAS8-26376	Analysis of Sunspot Spectral Data, Interim Report SE-SSL-1428	A. R. Dunn	Oct 1971
	H_2 Flares: The Response of the Chromosphere to a Downward Shock Wave. Meeting of the Solar Physics Divison of the American Astronomical Society, University of Maryland.	S. T. Wu S. M. Han Y. Nakagawa	Apr 1972
	Calculation of 5250.216 Å Line Profiles in Sunspots; Meeting of the Solar Physics Division of the American Astronomical Society, University of Maryland.	A. R. Dunn	Apr 1972
	Non-Linear Study of the Dynamical Behavior of a Force-Free Magnetic Field; Meeting of the Solar Physics Division of the American Astronomical Society, University of Maryland.	M. J. Hagyard Y. Nakagawa S. T. Wu	Apr 1972

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	188-41-51	188-41-01

4. TITLE:

UV and OPTICAL ASTRONOMY

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. R. Miller, S&E-SSL-TE	453-3103	W. C. Snoddy, S&E-SSL-T

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

RTOP TITLE: UV and Optical Astronomy - The objectives of this RTOP are to perform ground-based visible and infrared observations on selected objects. The overall objective is to perform astronomical publishable research that has bearing on MSFC projects, both on-going and future. For instance, the latest observations of eclipsing binary stars were chosen such that the planned observation by S-183 on Skylab would include these objects; and the studies of optical and infrared emissions from energetic processes will benefit HEAO.

Also, the overall effort will provide MSFC with active knowledge of observational and theoretical problems, thereby contributing to MSFC's role in producing payloads to carry out such observations from space.

TASK: Visible and IR Photometry of Variable Stars and Other Stellar Objects in Support of MSFC Astronomy Flight Projects

OBJECTIVE(S): To provide ground-based photometric data in support of S-183 (Skylab) and other MSFC projects such as HEAO and CVT on selected objects. Cost of such a ground-based program is negligible compared to a flight experiment and can add greatly to the scientific return of the experiment, such as obtaining near IR data on objects observed in the UV.

APPROACH: Optical and infrared narrow-band photometric observations are performed on such stellar sources as a) binary stars, b) long period mira variables, and c) Seyfert galaxies. Such data establish periodicity, mass ratios, limb darkening and magnitudes.

7. REPORT NO.: TITLE:	AUTHOR(s):	DATE TRANSMITTED
PASP, Vol 79, 74. The Period of HD 10783	Hardie, Lieberman, Reichmann	
The Development of Two Photoelectric and Two Infrared Photometers and the Reduction of the Photoelectric Light Curve of the Eclipsing Variable Star VV Orionis Uof Georgia Masters Thesis, 1971	H. Atkins	
IAU Circular 2407, 1972e Supernova	Wisnieski, Lee, Wdowiak, and Michlovic	
Photometry of Supernova 1972 in NGC 5253 The Astrophysical Journal Vol 177, No. 2 Part 2, October 1972	Lee, Wamsteker, Wisnieski and Wdowiak	
Recent Supernova in NGC 5253 and the Supernova Rate, Nature-Physical Science, Vol. 241, January 1, 1973	Wamsteker, Wisnieski, Lee, and Wdowiak	

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-41-51 PAGE 2 OF 4

STATUS: A lead-sulphide JHKL infrared photometer and a dual-channel UBV optical photometer have been built. Data have been obtained on several binary star systems including HS Hercules, VV Orionis and Beta Lyrae. In addition, data have been taken from OAO tapes to supplement above data. Data reduction and analysis on the above observations is essentially completed and papers are in writing. However, due to commitments on Skylab, final publication will be delayed until several months after Skylab is completed. No funds are being expended on this task during Skylab activities.

Conclusions - Flight projects can be aided by ground-based observations by both determining magnitude to be expected and obtaining additional spectral data needed for better interpretation of the object. The above can be accomplished by coordinated programs in which the ground-based effort can produce independently publishable research.

Problems - Active participation in Skylab prevents observation during its flight to obtain simultaneous measurements.

Forecast - Begin publications and resume observations after Skylab.

TASK: Photoelectric Photometry of Magnetic Variable Stars

OBJECTIVE(S): To establish, by photometric measurements in the UBV narrow bands, variability in light intensity and to check for correlation of light variability with magnetic field strength and with radial velocity variations.

APPROACH: Optical (UBV, H-alpha, and Stromgren) narrow-band photometry will be used to examine selected magnetic variable stars to establish light curves, metal line indices, and Balmer-discontinuity indices.

STATUS: Instrumentation and optical components, being used currently in support of ATM, have been obtained and will eventually (after Skylab) be used on this program. No observations have been performed since the work on HD10783 in concert with Dyer Observatory. Funds are not being expended on this effort until after Skylab.

Conclusions - Data from HD10783 observations have been produced and reported.

Problems - None

Forecast - Resume observation after Skylab.

TASK: The Relationship of Certain Celestial Optical and Infrared Emitting Objects and High Energy Radiation

OBJECTIVE(S): To perform optical and infrared observations and theoretical studies of galactic and extragalactic steady state and transient energetic processes on such objects as novae, supernovae, x-ray sources, and galactic H II regions.

APPROACH: The work is carried out with the 1.5-meter NASA(GSFC/MSFC) telescope located on Mt. Lemmon, Tucson, Arizona, and 0.4-meter telescope at MSFC. Joint work is being done at Vanderbilt (Dyer Observatory) and Case Western Reserve. All components of the instrumentation are on hand and the TV systems will be put into use in the winter of 1973.

STATUS: Continued

Extensive work on Supernova 1972 e has been carried out in optical and infrared photometric observations. The IR measurements are believed to be the first ever attempted on such an event and resulted in several publications. A program to observe peculiar galaxies is under way with the goal of detecting energetic events. Measurements of galaxy 1c/62 indicate an infrared excess. Joint programs with Vanderbilt and Case are under way to study IR emissions from Seyfert-type galaxies and to look for UV excess sources, respectively.

Instrumentation to date consists of low and high dispersion spectrographs modified to use image tubes and low-light-level TV systems, infrared radiometer and polarimeter using both photo and bolometer infrared detectors.

Conclusion - Some ideas on supernovae events and rates were published (see publications). Also, from this work with electronic detection systems such as image tubes and low-light-level TV systems even moderately sized telescopes (40-90cm) become suitable for 17th and 18th magnitude objects, and techniques such as video subtraction can be used to enhance signal differences such as caused by polarization.

Problems - Conference attendance is extremely limited by budget constraints, making scientific interchanges difficult.

Forecast - Continue observations, including using more electronic techniques, and continue publication in the literature.

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7. REPORTS: Continued

A Video Data Acquisition System for Ground-Based Astronomy ASEE-NASA Summer Faculty Fellowship Program, MSFC	K. Honeycutt	Aug. 1973

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 2

1. CENTER:	2. PERIOD COVERED:	3. CODE CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	188-41-54	188-41-01

4. TITLE:

SUPPORTING STUDIES FOR RELATIVITY EXPERIMENT

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
R. Decher, S&E-SSL-N	453-5130	R. Decher, S&E-SSL-N

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

OBJECTIVE(S): To develop techniques and methods for the implementation of the Gyroscope Relativity Experiment in collaboration with the principal and co-investigators at Stanford University. To perform theoretical analysis for various aspects of this experiment and to set up a laboratory experiment to test the different components of this experiment.

APPROACH: In-house experimental and theoretical work is performed in several laboratories (PE, SSL, ASTR), including support from contractors (UAH), to develop the technology and to solve instrumentation problems. Development activities include: (1) design and precision manufacturing of a quartz rotor and quartz gyro housing; (2) development of more accurate measuring techniques for quartz gyro parts; (3) thin film coating of quartz gyro parts with titanium and niobium; (4) development of a London Moment readout system for the gyro, including a highly sensitive squid-type magnetometer; (5) suspension, spin, and readout testing of the gyro at room and liquid helium temperatures; (6) optical contacting of quartz parts for the gyro assembly; (7) development of a low temperature microelectronic amplifier for the gyro signal. In addition, a continuous error analysis is being performed to investigate error sources causing gyro drift and to optimize gyro design parameters.

STATUS: Technical Management - Following successful spin tests with a hollow aluminum ball, a solid beryllium ball was suspended in the quartz housing. Spin-up could not be accomplished because the beryllium ball was too heavy for the present electrode design. An improved gyro housing with recessed and enlarged electrodes is being manufactured and should be available by the middle of 1974.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
G. R. Karr and J. B. Hendricks, Third Quarterly Progress Report (Contract NAS8-29316), February 11, 1974. (An analysis of the gas spin-up system is included in this report).			

low temperature apparatus for gyro tests at liquid helium temperature has been ›signed and is under construction. Testing of the apparatus will start in the ımmer of 1974.

quartz enclosure for two gyros has been designed. The quartz structure will lso serve as a support for the magnetic shields.

ıe technique to generate reproducible thin superconducting niobium films (down › 50Å) has been developed. Superconducting microbridges (less than 1 micron ide) have been made. Work will continue to reduce the critical current in the icrobridge (the microbridge is the critical element of the readout magnetometer).

puttering techniques for uniform coating of the quartz rotor have been improved. niformity in thickness of the thin film coating of less than 10% has been achieved.

anagement Progress - A phase A study for flight missions of this experiment one before 1980 and one after 1980) is planned for FY 75.

onclusions - Progress during the last 12 months at Stanford University and at ISFC indicates that a first flight of the experiment (with reduced accuracy goals) ›ould be accomplished before 1980.

roblems - There are still several technical problems which have to be solved. The experiment requires very difficult instrumentation development which pushes the state-of-the-art.

Forecast - Work will continue on the subjects indicated above. A first low temperature test of the new MSFC gyro model is anticipated during the fall of 1974. A prototype gyro design combining the best features of the Stanford/Honeywell and MSFC gyro can be expected early in 1975. The design of the prototype gyro model will be based on tests to be performed at Stanford and MSFC.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 3	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 . 31 03 74	3. CODE CURRENT NO.: 188-45-52	PRIOR NO.:
4. TITLE: Meteor Astronomy			
5. RESPONSIBLE INDIVIDUAL: S. Clifton, S&E-SSL-PA	TELEPHONE: 453-0183	APPROVAL: R. J. Naumann, S&E-SSL-P	

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: 1 Electro-Optical Support
TASK: 2 LLL TV Meteor Spectral Analysis

OBJECTIVES: Task 1: (a) To give electro-optical support of NASA airborne observations. (b) Improved definition and analysis of astronomical and atmospheric phenomena.
Task 2: (a) To determine the composition of shower and sporadic meteors. (b) To relate this data to the overall knowledge of meteor streams. (c) To develop techniques for the automated analysis of spectra.

APPROACH: Task 1: (a) To make observations with LLL TV systems aboard Convair 990 expeditions. (b) To use closed-circuit TV systems to transmit the data to other experimenters, expedition personnel, and pilots. (c) To video tape data for possible analysis and correlation with other experimenters.
Task 2: (a) LLL Sec vidicon systems will be used to record meteor spectra to as faint a magnitude as possible. (b) Analysis of spectra will be attempted both in-house and with a working agreement with the National Research Council of Canada. (c) Analysis techniques will be tested and developed to provide automated analysis of meteor spectra to be correlated with manual techniques. (d) Data from spectral studies will be correlated with photometric, orbital and other data pertaining to any shower.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	Television Studies of Faint Meteors, Journal of Geophysical Research, October, 1973.	K. S. Clifton	1973

Other reports are listed in previous progress reports.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-45-52 PAGE 2 OF 3

STATUS: Task 1: LLL TV systems have been utilized aboard the 1969 NASA Airborne Auroral Expedition, the 1971 Barium Ion Cloud Expedition, and the 1972 Giacobinid Shower Expedition. Auroral tapes from the 1972 mission have been sent to ARC for redubbing and transmission to the University of Alaska. With the temporary loss of a Convair 990, efforts have been directed into the development of a video data processing unit for extended analysis capability. At present the unit consists of a video analyzer, for relative intensity information beneath a set of cross hairs, a video processor for sync and signal improvement, a scan converter for single frame read out, an XY indicator for read out of positional data, a video quantizer for equal brightness contouring, a special effects generator for adding a frame counter to video-taped data, a bandwidth compressor for computer interfacing, a shading generator for shading compensation, a moving target indicator for determination of the light curves of transient events, a video hard copy unit for reproduction of video data, and a color encoder for color video.

Task 2: (a) 150 Perseid meteors have been obtained of which at least 30 should be analyzable. (b) Analysis of the Perseid spectra is presently being accomplished by Dr. P. Millman of the National Research Council of Canada. (c) Spectral tapes obtained during the Orionid, Quadrantid, and Giacobinid meteor showers are being logged and analyzed (d) Five methods have been identified and isolated in order to electronically analyze spectral profiles.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 5	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 188-46-64	PRIOR NO.:

4. TITLE:

COSMIC-RAY AND GAMMA-RAY ASTRONOMY INVESTIGATIONS

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Thomas A. Parnell	453-5130	R. Decher, S&E-SSL-N

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Cosmic-Ray Astronomy

OBJECTIVE(S): To perform high resolution charge composition measurements of the cosmic-ray flux in the Z greater than 15 range; to develop instrumentation, methods and data analysis techniques for very large area detector systems for use in the Z greater than 30 range; to develop low cost, large area proportional counter hodoscopes; to perform calculations and analyses of particle energy deposition in thin dE/dx detectors; and to continue theoretical work on the energy loss of highly charged relativistic particles. A study will also be made of the feasibility of extending this class of detector systems to very large areas ($\approx 25\ m^2$) for use in the Shuttle era experiments for high charge resolution measurements in the Z greater than 30 range. The balloon flight experiment will also be used in the CVT program.

APPROACH: Using detectors developed for the HEAO, a large area ($0.25\ m^2$) multi dE/dx Cerenkov counter system will be assembled and flown on a balloon to perform a high resolution measurement of the iron group nuclei. The goal will be the determination of individual abundances from Z = 22 to Z = 30. Work will be continued to examine the energy deposition distributions (vice energy loss distributions) for high Z particles in very thin detector systems (such as ion chambers). These calculations will treat the statistical fluctuations (Vavillov distribution) and the transport of high energy delta rays with completeness so that accurate energy loss distributions will be available for use with data analysis techniques such as likelihood-ratio methods.

7. REPORT NO.: TITLE:	AUTHOR(S):	DATE TRANSMITTED
"Corrections to the Bethe-Block Formula for Average Ionization Energy Loss of Relativistic Heavy Nuclei-Close Collisions," Nuclear Instruments & Methods.	Peter B. Eby Samuel H. Morgan, Jr.	Mar 1973
"Nuclear Gamma Rays from Li^7 in the Galactic Cosmic Radiation," The Astrophysical Journal.	G. J. Fishman D. D. Clayton	Dec 1972
"Measurements of Cosmic-Ray Trajectories with a Proportional Counter Hodoscope," presented at 13th International Cosmic-Ray Conference, Denver, Colorado.	T. A. Parnell Godehard Guenther Udo Pollvogt	Aug 1973
"Predicted Intensities of Cosmic-Ray-Produced Gamma-Ray Lines," presented at 13th International Cosmic-Ray Conference, Denver, Colorado.	T. A. Rygg G. J. Fishman	Aug 1973

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-46-64 PAGE 2 OF 5

STATUS: Technical Progress

1. A detector system for investigating the Fe group CR has been prepared for a balloon flight and has been flown on a balloon in October 1973 from Palestine, Texas.

2. A study of appropriate gas mixture for high resolution parallel plate ion chambers has been made. The present balloon instrument uses an 8-cm dual gap with a 93% Xenon/7% methane mixture.

3. Calculations have been continued on the energy loss and energy deposition of trans iron cosmic rays. A computer code has been developed to calculate energy deposition as a radial function of distance from the track of a very, very high (VVH) cosmic ray in emulsion, etc. This calculation has been completed resulting in the thesis listed below.

4. Publications for this 6 months are listed below.

Management Progress -- Contract NAS8-24953 with the Research Institute, University of Alabama, Huntsville, will be extended.

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7. (Continued)

"Calculation of Energy Loss by Highly Charged Particles and the Interpretation of Cosmic-Ray Data," presented at 13th International Cosmic-Ray Conference, Denver, Colorado.	Peter B. Eby Samuel H. Morgan, Jr. T. A. Parnell	Aug 1973
Large Volume, High Efficiency Scintillation Detectors using Multiple NaI (Tl) Crystal Pieces, "Nuclear Instruments and Methods"	G. J. Fishman D. M. Walker	Mar 1973
Induced Radioactivity Contributions to Diffuse Gamma-Ray Measurements, "NASA SP Publication" (in progress).	G. J. Fishman	May 1973
"Spatial Distribution of Ionization Energy for Relativistic Heavy Nuclei" MS Thesis UAH	F. Roberts	Mar 1974
"Secondary Electron Background Produced by Heavy Nuclei in a Multiwire Proportional Counter Hodoscope" NASA TN D7591	S. H. Morgan et al	Feb 1974

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-46-64 PAGE 3 OF 5

TASK: Gamma-Ray Astronomy

OBJECTIVE(S): To implement a program to increase the sensitivity of gamma-ray astronomy experiments and to incorporate these advances in a balloon-borne detector system. The results of this investigation will be used in the definition of future space shuttle gamma-ray astronomy experiments. The program will include; the development and balloon flight testing of lower cost, large area crystal scintillation detectors; testing of active shielding systems; calculations and measurements of cosmic-ray-induced background; development of an on-board spectral memory and analysis system for telemetry rate reduction; and a continuation of theoretical calculations in gamma-ray astrophysics.

APPROACH: Large Area Detector Development - A new technique for producing large volume, high efficiency scintillation detectors using NaI (Tl) crystal pieces will be evaluated for use as a large area gamma-ray astronomy detector. By combining this type of detector with large plastic scintillators and using the pulse shape discrimination, it is believed that high gamma-ray efficiency as well as good charged particle rejection could be obtained. This concept will be utilized in the design of a balloon-borne detector system which will also include several new data compression schemes to preserve high spectral and time resolution with a large counting rate while maintaining a reasonable telemetry rate. The detector will then be used in a gamma-ray astronomy program to determine the spectral characteristics of various celestial objects and the galactic plane. Of special interest will be the measurement of a gamma-ray line feature near 470 keV from the galactic center region reported recently by the Rice University group. An attempt to measure the nuclear excitation lines from carbon and oxygen will also be made. Other scientific objectives of the balloon flight program will include the measurement of gamma-ray pulses for the objects Her X-1, NP0532, and PSR0833.

The present plan of research will continue the analytical and experimental investigation of the local background radiation. Of particular importance for low altitude orbiting experiments is the activation of spacecraft materials during passes through the trapped radiation belts. The spectral and time characteristics of the activation radiation will be computed using codes developed at Oak Ridge National Laboratories (ORNL) and MSFC. The experimental work on this program will consist of gamma-ray spectral measurements of spacecraft materials which have been irradiated by protons. This experimental work is already in progress.

STATUS: 1. A successful balloon flight experiment was conducted August 11, 1973, from Palestine, Texas. The sun and the Crab Nebula were observed in the energy range from 50 keV to 6 MeV. The payload was at float altitude for 9 hours and landed in good condition near El Paso, Texas. Data analysis is now in progress.

2. Measurements of induced radioactivity by neutrons and protons are continuing using a recently acquired high efficiency Ge(Li) detector. Several samples from Skylab are scheduled to be measured as well as artificially irradiated samples from particle accelerators and nuclear reactors. Computer programs used in calculating induced radioactivity have been written and debugged.

3. A neutron activation experiment for the SL-4 mission has been tentatively accepted by the Flight Management Team (FMT) meeting in Houston. Experiment integration is now under way.

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-46-64 PAGE 4 OF 5

4. A new large area detector is being designed for balloon flight use. A prime objective of this detector is to search the entire sky for low intensity gamma-ray bursts. The detector will also be used for studying other time-varying gamma-ray phenomena such as solar flares and pulsars.

5. The feasibility of flying a small Ge(Li) detector on a superpressure balloon for at least 2 months is being studied.

6. The application of recently developed gamma-ray astronomy (instrumentation and data handling) techniques for Shuttle payloads is continuing.

Management Progress - Contract NAS8-26343 has been extended with Brown Engineering Company, Inc., Huntsville, Alabama.

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 to 31 03 74	188-48-51	188-48-51

4. TITLE:

Interdisciplinary Space Research

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
E. Stuhlinger	205-453-3033	E. Stuhlinger

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Interdisciplinary Space Research

OBJECTIVE: To conduct space research in various scientific disciplines with a capability of directing "quick reaction" efforts toward significant problems or promising areas of research. Such research is related to the space physics and astronomy programs of NASA.

APPROACH: Under the direction of the Associate Director for Science, Dr. Ernst Stuhlinger, research is initiated in scientific and technical areas which influence Center scientific missions. Projects are selected which, within available resources, contribute significantly to in-house scientific capabilities and state-of-the-art advancement. Three new projects were funded in FY-74: (1) development of experiments/techniques for plasma wake and sheath measurements, (2) development of a sector spectrophotometer, (3) development of a gain control for scintillator photomultiplier systems. Continuing support was furnished to five other projects: (4) lightweight optical telescope blanks, (5) gamma-ray astronomy, (6) three-dimensional holographic motion picture system, (7) mechanical properties of graphite/epoxy materials, and (8) support to a phased array laser system.

STATUS: Technical Progress: (1) Plasma Wake and Sheath Measurements - In-house research now setting up laboratory apparatus to investigate wake characteristics associated with streaming plasma, developing experiment techniques for the investigation of plasma wakes and plasma sheaths, (2) Sector Spectrometer - Study of aurora-induced atmospheric emissions

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Project 6,	Three Dimensional Holographic Motion Picture System		
NASA TR R-424	Optical Holographical Applications for the Zero-G Atmospheric Cloud Physics Laboratory	Dr. Robert L. Kurtz	(Not yet published)
N. A.	Real-Time Holographic Motion Picture Capable of Recording Front Surface Detail from a Random Velocity Vector	Dr. Robert L. Kurtz	Applied Optics, Volume 12, No. 12, December 1973

requires simultaneous monitoring of emissions from several constituents at different wave lengths. Instrument sensitivity at different wavelengths requires detectors more sensitive to these wavelengths. A scheme to do multiple scans with multiple detectors using a single scanning spiral has been formulated; funds are provided to verify this hypothesis, (3) Gain Control for Scintillator Photomultiplier - A multipurpose automatically compensating gain control is needed for long-duration space experiments. Research is just under way to develop a stabilization circuit to compensate for gain changes in the phototube, amplifier or high voltage power supply, (4) Lightweight Optical Telescope Blanks - Past efforts were unsuccessful to acquire a mirror of low expansion glass with a low expansion glass foam core as this combination has been beyond the state of the art. A carbon fiber-epoxy design, 25% of the weight of the solid composite blank, is being built. Front and back surfaces made of cross-ply carbon fiber composites are separated and held in place by composite unidirectional fiber tubings spaced by two perforated discs. Front and rear surfaces are to be plated for final finish and figuring, (5) Gamma-Ray Astronomy - Preliminary design has been initiated on a gamma-ray spectrometer to detect gamma-ray bursts with test flight in first part of FY-75 on a standard balloon. It is planned for the detector to be borne by a super-pressure balloon which offers possibilities of staying up 3 to 4 months, (6) Three-Dimensional Holographic Motion Picture System - Further development of the real-time large scene camera is waiting procurement of a higher intensity laser source. A modification applicable to the atmospheric physics program is being considered as an on-board flight instrument. A NASA Technical Report was written on this; additionally, a feature article was published in Applied Optics on the basic system, (7) Graphite-Epoxy Research - Evaluation of graphite-epoxy materials as possible components for the LST program continues; these are analyses relative to their physical and mechanical properties after exposure to environments anticipated in actual LST orbit conditions. For example, preliminary data on exposure to long term vacuum/ultraviolet indicates no significant effects, (8) Phased Array Laser Radar System Support - A thick-film logarithmic amplifier circuit and accompanying subsidiary circuits are being designed and fabricated, with AD-S providing funds for component procurement.

Management Progress - Not applicable

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 1	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 30 03 74	3. CODE CURRENT NO.: 188-78-57	PRIOR NO.:

4. TITLE:
Large Space Telescope (LST)

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
G. S. Nurre, S&E-ASTR-A	453-4718	Hans H. Hosenthien

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Fine Pointing Control System, NAS8-28983, Bendix

OBJECTIVE: The objective is to show the feasibility of achieving the required pointing accuracy (~ .005 sec) for the LST of body-pointing as opposed to an image motion controller within the telescope itself.

APPROACH: A baseline system will finally be selected that is based on the results of previous studies. The system characteristics and disturbances will be accurately modeled, and a large scale digital simulation will be developed to solve the nonlinear equations. This work will be supported by a simplified single axis system analysis and analytical work. Computer runs will be made to show pointing accuracies for realistic system characteristics and to determine system sensitivities to control parameters. These results will show whether or not the required accuracies can be achieved by body-pointing.

STATUS: All simulation work under the basic work statement has been completed, and the final reports are due to be completed by April 1. Presently an extension is being planned to carry the work through the end of this fiscal year. During this time the performance of double gimbal CMG's will be investigated.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
LST-PC-201	Imbalanced Double Gimbaled CMG	S.C. Rybak	Dec. 19, 1972
LST-PCS-204	Nonlinear Model for Reaction Wheel	S. C. Rybak	Dec. 19, 1972
LSC-PCS-205	Sensor Noise	S. C. Rybak	Dec. 19, 1972
LST-PCS-204	RW Actuator Model for Fine Pointing	S. C. Rybak	Dec. 19, 1972
LST-PCS-200	Imbalanced SGCMG	R. A. Mayo	Jan. 1973
LST-PCS-202	Verification of Model for SGCMG	R. P. Headley	Jan. 1973
LST-PCS-203	Verification of Model for DGCMG	R. P. Headley	Jan. 1973
LST-PCS-206	Reaction Wheel Actuator Model	R. P. Headley	Jan. 1973

FIRST BENEFITTING PROJECT: LST

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE 1 OF 1

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	188-78-57	188-78-57

4. TITLE:

Large Space Telescope

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Paul T. Golley S&E-ASTR-GM	205-453-5755	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Dual-Spin Gas Bearing Reaction Wheel
NAS8-29013 Martin-Marietta; Denver, Colorado

OBJECTIVE: To provide a bi-directional momentum exchange device which has sufficient torque resolution and produces sufficiently little noise and vibration that it can be used to provide the extremely precise pointing control required for astronomical observations.

APPROACH: This task consists of development, fabrication, and test of +5 ft-lb-sec reaction wheel in which the rotor is supported by hydrodynamic pressure generated by a small self-pumping inner spin-structure concentric with the inertia rotor axis. The inner spin-structure is driven by a constant speed ac motor. The inertia rotor is driven by a variable speed ac motor. Speed will be measured by an optical tachometer. The motors and speed transducer are all brushless to minimize frictional effects.

STATUS: Technical Progress - The unit has been delivered to MSFC, acceptance tested, and the final report published. Further in-house testing at MSFC is being delayed until protective circuitry can be developed to permit leaving the unit running but unattended overnight and on weekends. This will avoid starting and stopping the rotor each day, which could deteriorate the gas bearing surface lubricants before all testing is completed. Speed control circuitry is also being developed.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
Final report:	"The Fabrication and Test of a Dual Spin Gas Bearing Reaction Wheel", No. MCR-73-322, Nov. 1973, Martin-Marietta Corp., P. O. Box 179, Denver, CO		

Note: There are errors in this report, particularly regarding the gas bearing stiffness. Corrected numbers will be included in the following paper which will be presented at the ASME/ASLE Joint Conference in Atlanta in October 1974 .

"Gas Bearing Dual Spin Reaction Wheel" by J. T. McCabe, A. Gu, B. Geren, and S.C. Wright.

FIRST BENEFITTING PROJECT: Large Space Telescope

PROGRESS REPORT
RESEARCH AND TECHNOLOGY OPERATING PLAN

PAGE OF

1. CENTER:	2. PERIOD COVERED:	3. CODE	
		CURRENT NO.:	PRIOR NO.:
MSFC	01 10 73 31 03 74	188-78-57	188-78-57

4. TITLE:

Large Space Telescope

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
Paul T. Golley S&E-ASTR-GM	205-453-5755	Richard H. Tutt

6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Secondary Mirror Articulation, Contract NAS8-29723 Perkin-Elmer; plus in-house MSFC testing.

OBJECTIVE: To develop a laboratory prototype secondary mirror articulation mechanism which proves the feasibility of at least one scheme for accomplishing image stabilization and focus and alignment.

APPROACH: Prototype hardware will be conceived, designed and fabricated. More than one actuation technique will be evaluated if multiple concepts appear feasible. Hardware testing will progress through three phases.

(1) In-house (MSFC) closed-loop testing with electronic position sensors, to determine gains and stability.
(2) Threshold and noise testing at Martin-Marietta/Denver.
(3) Dynamic interaction testing in the Boeing graphite-epoxy truss.

STATUS: Management Progress - Perkin-Elmer won a competitive award to fabricate the secondary mirror articulation mechanism.

Technical Progress - The hardware has been built and acceptance testing is in progress. Preliminary results indicate that two different actuation schemes can provide resolution of 0.001 arc second for image stabilization.

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED

Only fragmented, letter-type monthly progress reports are available at present. A final report will become available in the near future.

FIRST BENEFITTING PROJECT: Large Space Telescope

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN		PAGE 1 OF 2	
1. CENTER: MSFC	2. PERIOD COVERED: 01 10 73 31 03 74	3. CODE CURRENT NO.: 188-78-57	PRIOR NO.:

4. TITLE:

Large Space Telescope

5. RESPONSIBLE INDIVIDUAL:	TELEPHONE:	APPROVAL:
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6. ACCOMPLISHMENTS (Milestones, Problems, Near term activities):

TASK: Fine Guidance Sensor
NAS8-29918 ITT Gilfillan

OBJECTIVE(S): The LST requirements are ±5 microradians, pointing, and 0.024 micoradian rms, stabilization, over a 40-hour observation period. From this a 0.012 microradian error for stability, based on 2 Hz. control gain crossover frequency, is allocated to the fine guidance sensor. This task will investigate ways of obtaining the desired accuracy and develop a sensor to perform to the given specifications.

APPROACH: (1) Investigate electromagnetic and electrostatic image dissector tube performance as potential candidates for the sensing element. Under contract make modifications to the ITT 4012RP image dissector tube to improve linearity, resolution and uniformity across the photocathode. (2) Investigate charge coupled device (CCD) technology for possible implementation into the fine guidance sensor. CCD's are in the development stage but appear to have great possibilities as the sensing element. (3) Design, in-house, a stable current regulator and drift tube voltage regulator that have regulation of 200 parts per million or better. (4) Build and test a breadboard configuration of a fine guidance sensor.

STATUS: Technical Progress--(In-house) A breadboard has been constructed for a complete set of electronics for a 4012-RP image dissector tube. Preliminary tests are underway to evaluate the system stability.

Tests on an EMR 574 electrostatic tube are complete. A report on the test results is 80% complete. Overall the electrostatic tube appears to be inferior (See Page 2)

7. REPORT NO.:	TITLE:	AUTHOR(s):	DATE TRANSMITTED
	"Monthly Progress Report" For Period 1 October 1973 to 31 December 1973	ITT Gilfillan	

FIRST BENEFITTING PROJECT: Large Space Telescope

PROGRESS REPORT RESEARCH AND TECHNOLOGY OPERATING PLAN (Continuation Sheet)	CURRENT NO./CODE: 188-78-57 PAGE 2 OF 2

to the electromagnetic tube.

Management Progress--Contract NAS8-29918 for the improved image dissector is running behind schedule. Two tubes are being fabricated and should produce at least one good tube.

Problems--Potting compound outgassing above specifications on the deflection coil and production problems in the face plate for the tube.

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