(NASA-TM-80012) OAST SPACE THEME WORKSHOP. VOLUME 3: WORKING GROUP SUMMARY. 5: PROPULSION (P-1). A. SUMMARY STATEMENT. B. TECHNOLOGY NEEDS (FORM 1). C. PRIORITY ASSESSMENTS (FORM 2) (NASA) 118 p HC A06/MF G3/12

N79-15124

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42665

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OAST SPACE THEME WORKSHOP

VOLUME III

WORKING GROUP SUMMARY

V. PROPULSION (P-1)

A. SUMMARY STATEMENT

B. TECHNOLOGY NEEDS (FORM I)

C. PRIORITY ASSESSMENTS (FORM II)

HELD AT THE
LANGLEY RESEARCH CENTER

SPONSORED BY NASA-CODE RX

Foreword

The attached material represents the working papers from the OAST Space Theme Workshop held at the Langley Research Center, April 26-30, 1976, and contains a quick-look analysis of the proceedings. The material is unedited and intended for further use by the participants of the workshop and the planning elements of NASA concerned with space mission research and technology. It should be understood that the data do not represent official plans or positions but are part of the process of evolving such plans and positions.

Nearly 100 of the Agency's top technologists and scientists joined with another 35 theme specialists to produce this working document - a document that provides a technical foundation, including research and technology base candidates, for each of the six space themes.

The material in this report is considered essential to the development of Center initiatives in support of these themes. Copies of the report will be made available to the Center Management Board and the individuals at the Centers responsible for the FY'78 program planning cycle. The timing of this planning activity has caused us to distribute this document in this unedited form. Thus, it possibly contains errors, hopefully, more of a typographical rather than a technological nature. Nonetheless, the information contained is of a high professional level, reflecting the efforts of the workshop participants and will be invaluable to the planning and successful execution of the Agency's near- and far-term advanced technology program.

Stanley R. Sadin
OAST Space Theme Workshop
Chairman
NASA Headquarters
Study, Analysis, & Planning Office
Office of Aeronautics and
Space Technology

PROPULSION (WG P-1)

Impact of Theme on Discipline Planning.- All theme requirement documents were reviewed and assessed against ongoing and projected propulsion technology programs. Discussions were held with individual theme teams to review overall theme philosophy and clarify specific theme thrusts. Unique propulsion technology requirements to satisfy theme needs were identified and preliminary program planning was attempted.

It became readily apparent that satisfying theme needs, in many cases, will require augmentation of present available resources.

Propulsion programs were generated reflecting these inputs and the technology planned to meet the schedule goals.

SUMMARY OF THEME NEEDS.- All themes require some form of advanced propulsion capability to achieve their stated objectives. Requirements cover a broad spectrum ranging from a new generation of heavy lift launch vehicles to low thrust, long lift system for on-orbit operations.

The first effort of the group was to establish the commonality extant between propulsive technologies and an attempt to group technologies into vehicle classes by functional capability. The Space Transportation Theme (#12) had identified 5 classes of launch vehicles and a time frame for their availability. These classes were augmented by the working group with a sixth class, encompassing planetary and on-orbit operations. Propulsion technologies in each class were then ranked, and assigned priority numbers.

Finally, prioritized technologies were matched to theme requirements and final discussions held with the Theme Teams.

During this process, it became apparent that some Theme needs could not be satisfied without the generation of New Initiative proposals to initiate new efforts or to augment existing programs. These were identified for later submittal.

The views of the Working Group are summarized on the following figures.

PROPULSION TECHNOLOGY WORKING GROUP FINDINGS

OAST SPACE TECHNOLOGY WORKSHOP

APRIL 30, 1976

LANGLEY RESEARCH CENTER

HAMPTON, VIRGINIA

PROPULSION TECHNOLOGY WORKING GROUP

APPROACH

(1) EXAMINED VEHICLE MATRIX FROM THEME 12

(2) DETERMINE TRANSPORTATION NEEDS OF OTHER SPACE THEMES AGAINST THEME 12 REQUIREMENTS

(3) IDENTIFIED TWO ADDITIONAL PROPULSION FUNCTIONS

(4) IDENTIFIED TOTAL PROPULSION NEEDS AGAINST REVISED MATRIX

(5) PRIORITIZED & EVALUATED ALL PROPULSION "NEEDS" FOR EACH VEHICLE

(6) PROVIDED DOCUMENTATION (Rx FORMS)

PROPULSION NEED REQUIREMENTS FOR THEME SUPPORT

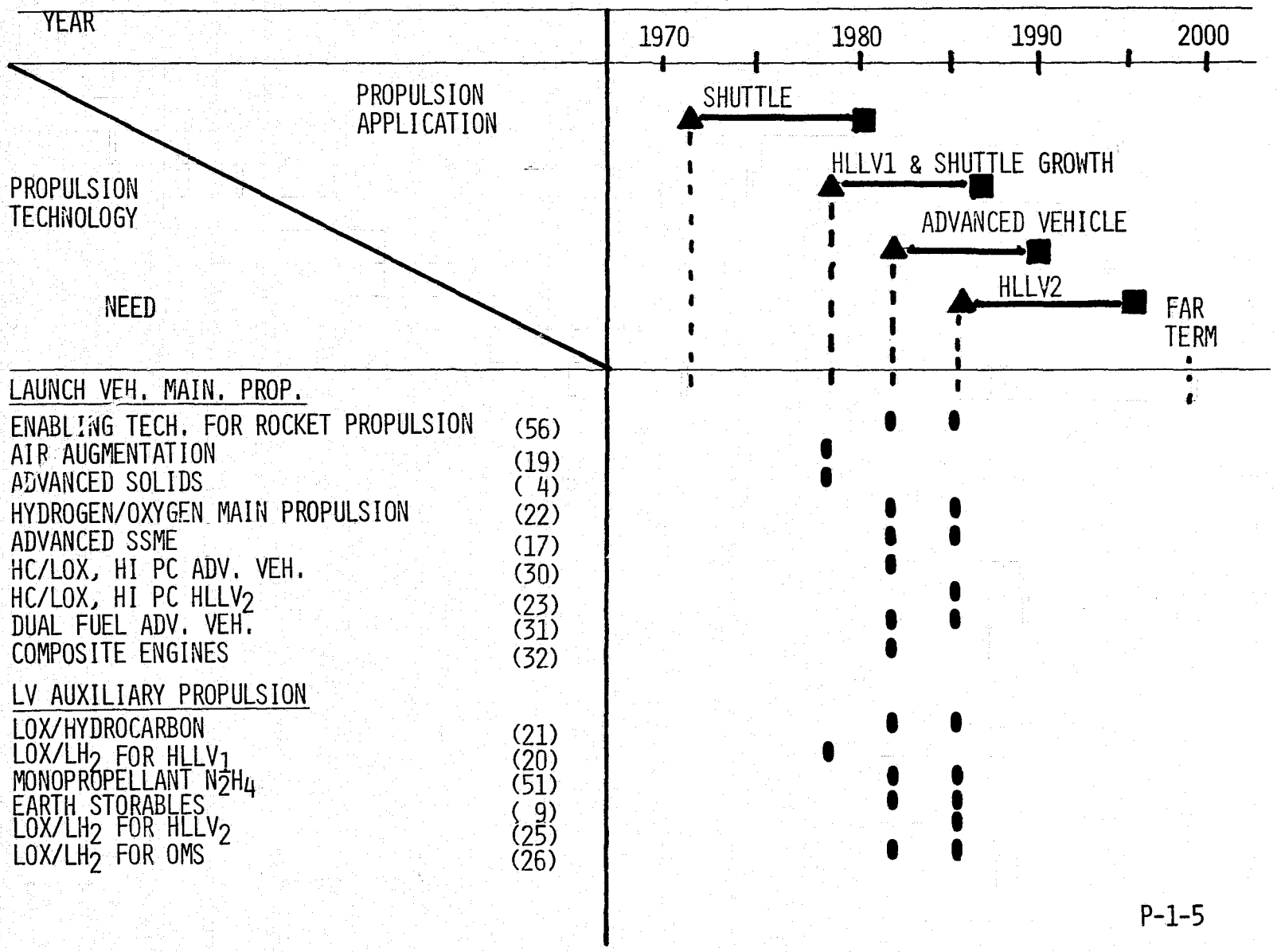
VEHICLE CLASSES \ SPACE THEMES	S.P.	I	SETI	SOLAR SYS.	G. SER.	ATS
	7	8	9	10	11	12
(P) OTV	●	●	●			●
(C) OTV	●	●	●	●	●	●
$HLLV_1$ (1985)		●	●	●		●
$HLLV_2$ (1995)		●	●			●
ADV. VEH.	●	●	●		●	●
PLANETARY				●		
ON-ORBIT STAB.	●	●	●	●	●	

PROPULSION TECHNOLOGY WORKING GROUP

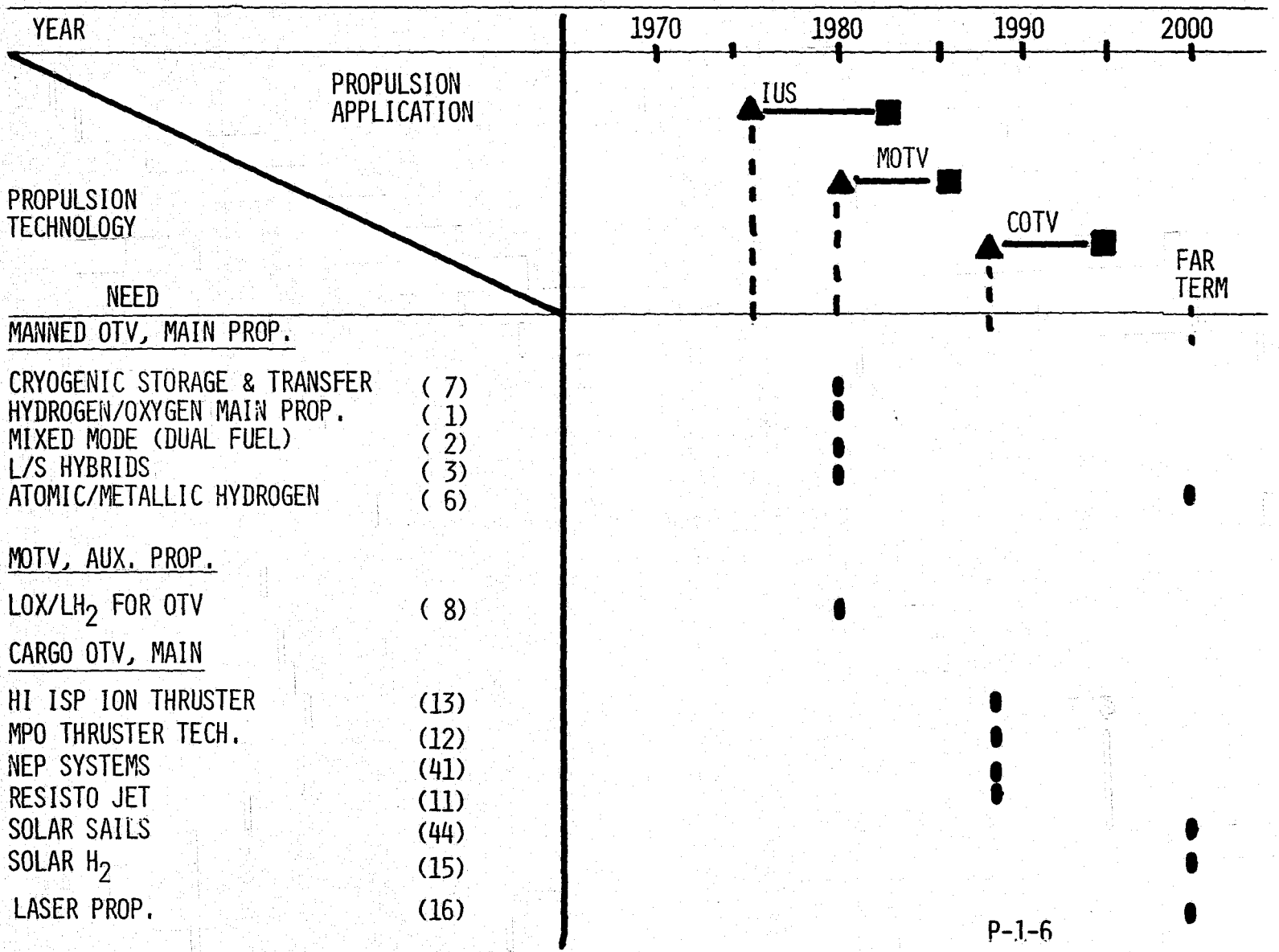
PROPULSION NEED RATING CRITERIA

- USE DATE
- CRITICALITY
  - ENABLING
  - ENHANCING
    - HIGH
    - MEDIUM
    - LOW
- PROBABILITY OF MEETING TECHNOLOGY GOAL

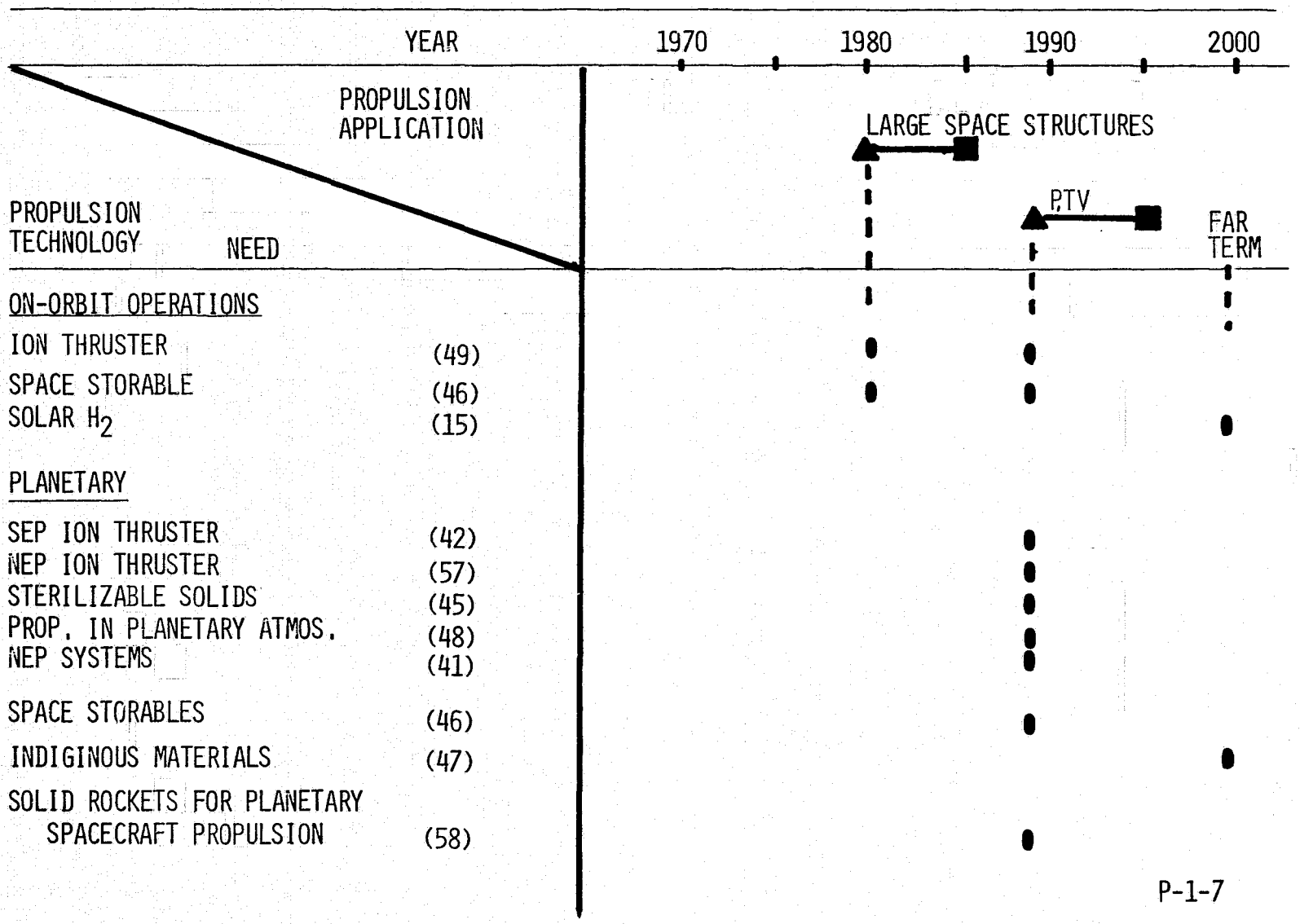
PROPULSION WORKING GROUP SUMMARY



PROPULSION WORKING GROUP SUMMARY



PROPULSION WORKING GROUP SUMMARY



PROPULSION TECHNOLOGY WORKING GROUP

CONCLUSIONS

- THEME 12 UNDERLYING TO ALL OTHERS
- ENABLING PROPULSION TECHNOLOGY AREA KEY TO REDUCED TRANSPORTATION COSTS AND INCREASED SPACE CAPABILITY
- FURTHER OAST EVALUATION OF ALL PROPULSION NEEDS NECESSARY TO ESTABLISH RESOURCE REQUIREMENTS

SPACE TECHNOLOGY NEED — **FORM NO. I** — PAGE 1 OF 3

1. TITLE H_2-O_2 High Performance, Reusable Main Propulsion Systems for Orbit Transfer Vehicles

NO. 1,7,8,12/P-1/1 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE

Develop technology for high performance, reusable H_2-O_2 space propulsion systems, including staged combustion bell nozzle, expander cycle bell nozzle, aerospike, and plug cluster.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1986]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(a) Staged combustion, bell nozzle engine (ASE) - Continue LeRC component technology program on thrust chamber, main fuel and oxidizer turbopumps, preburner, main injector, low cycle thermal fatigue chamber life, turbopump bearings and seals, and boost pump multiroller drive system. Expand program with FY78 now initiative, entitled "Reusable Engine Systems Test (RECEST)" (FY78 new start #119) to obtain data on operation of the powerhead breadboard assembly of the staged combustion cycle engine and the aerospike engine breadboard. (Cont'd on page 3.)

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE H_2-O_2 High Performance, Reusable Main Propulsion Systems for Orbit Transfer Vehicles

NO. 7,8,12/P-11 / 1
THEME / W.G. / TASK

DATE 4/ 27/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

High performance reusable engines are needed to provide maximum payload and low cost through multiple reuses up to 100 missions. High pressure is desirable to provide maximum specific impulse in a small compact package and minimize engine weight. Slush cryogens are needed to reduce tankage volume.

7. ALTERNATIVE APPROACHES/OPTIONS

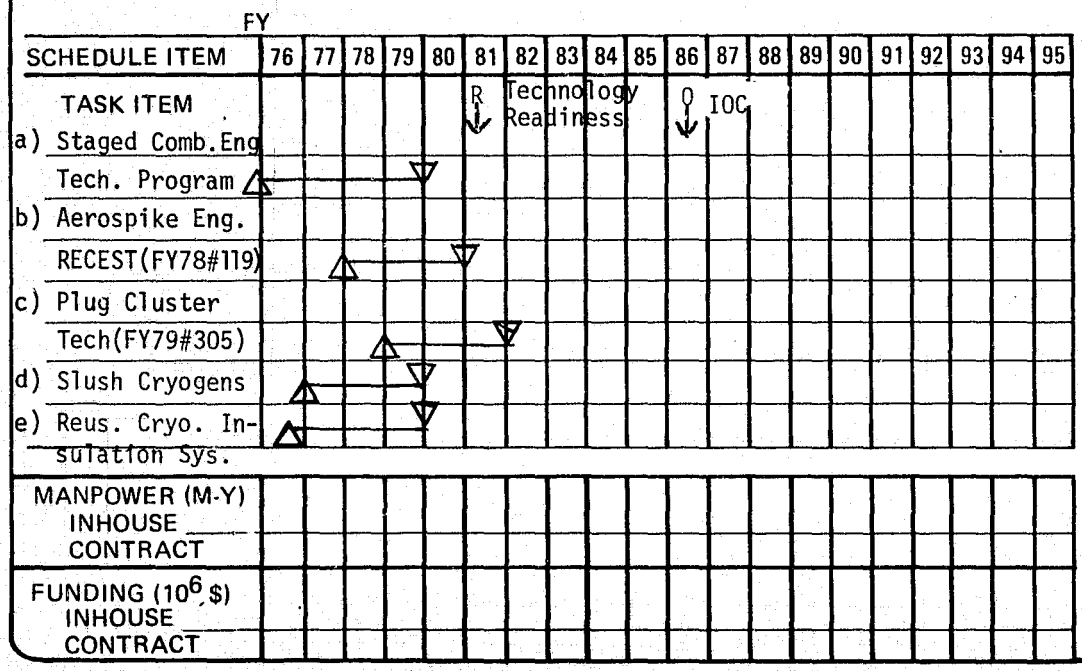
8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11, 506-21-12, 910-03-01

FY78 New Start #119 - RECEST

FY79 New Start #305 - Plug Cluster Nozzle

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. I

1. TITLE H_2-O_2 High Performance Reusable Main Propulsion Systems for Orbit Transfer Vehicles

NO. 7,8,12/P-1/1
THEME / W.G. / TASK

DATE 4 / 27 / 76

( ) CONTINUATION (If Needed)
Block No.

(b) Aerospike expander cycle engine - Complete planned LeRC program on testing of 25K thrust aerospike chamber. Work also needed on thermal fatigue life of segments of chamber and breadboard system test using Mark 48 fuel and oxidizer pumps as part of FY78 new start #119 (RECEST).

(c) Plug cluster nozzle program - Complete present program on studies of plug cluster feasibility and performance. Determine operational constraints and system constraints. Conduct flight test of full scale system as part of FY79 new start #305.

(d) Slush cryogens - Evaluate methods of manufacture, storage, handling, pumping, and cost of applying to a flight system. Demonstrate these technology areas at moderate scale.

(e) Reusable cryogenic insulation systems - Continue LeRC program to provide technology on two approaches: (1) evacuated load bearing insulation system, and (2) purged multilayer insulation system.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

1. TITLE Dual Fuel Engine Technology for Mixed Mode Orbit Transfer Vehicle

NO. 1,7,8,12/P-1 / 2 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE

Develop technology for dual fuel engines burning hydrocarbon or amine fuel and LH_2/LOX in the same engine.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1986]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Perform studies to evaluate use of mixed mode propulsion using dual fuel engine(s) for orbit transfer vehicles. Perform engine system trade-off and parametric studies to determine fuel/oxidizer combinations, engine turbopump drive cycle, cooling method, and component preliminary designs for selected thrust level in the range from 20,000 to 40,000 pounds. Perform component technology programs based on selection of critical components for the engine configuration and propellant combination selected.

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 2 OF 2

TITLE Dual Fuel Engine Technology for Mixed Mode Orbit Transfer Vehicle

NO. 7,8,12/P-1 / 2

THEME / W.G. / TASK

DATE 4/ 27/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

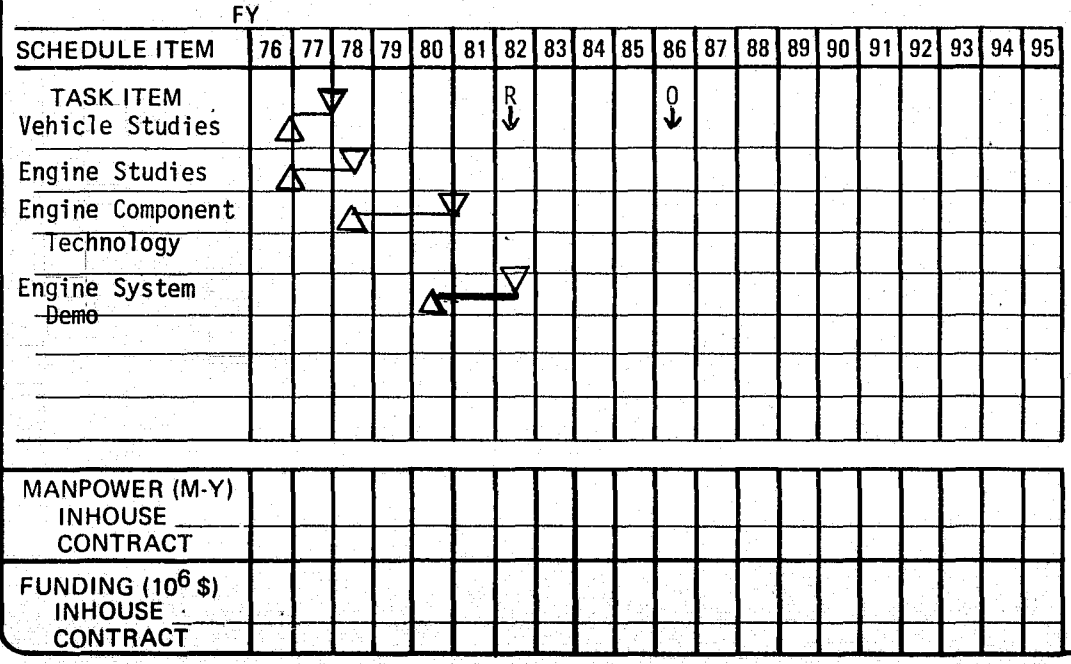
Mixed mode propulsion is attractive for OTV's because it provides payload capability equivalent to H_2-O_2 in a smaller volume stage. Where compact size is important, e.g., to fit in the shuttle cargo bay, mixed mode pays off. A dual fuel engine capable of operating on hydrocarbon fuel/LOX/LH_2 or MMH/LOX/LH_2 is required.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11, 506-21-12, 790-40-12

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED — **FORM NO. 1**

PAGE 1 OF 2

1. TITLE LIQUID/SOLID HYBRID PROPULSION FOR OTV — NO. 7-8-12 P-1 3 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE

A HIGHER PERFORMANCE, HIGHER DENSITY PROPULSION SYSTEM WITH RESTART CAPABILITY WHICH RESULTS IN LOW WEIGHT FOR ABORT LAUNCH VEHICLE LANDINGS WITHOUT ATTENDANT HAZARDS DURING PROPELLANT DUMP OPERATION.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1987]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY DEVELOPMENT OF ENERGETIC SOLID FUEL.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

ANALYSIS AND TEST OF A PROPULSION SYSTEM EMPLOYING A LIQUID OXIDIZER (E.G. LOX) AND A SOLID FUEL. SYSTEM WOULD PROVIDE A HIGH DENSITY MEDIUM ISP COMBINATION, WHICH WOULD HAVE RESTART CPABILITY. IN CASE OF VEHICLE ABORT THE LANDING WEIGHT CAN BE REDUCED WITHOUT THE HAZARDS ASSOCIATED WITH THE DUMPING OF TWO IGNITABLE PROPELLANTS (ONLY LOX WOULD BE DUMPED).

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 2 OF 2

TITLE LIQUID/SOLID HYBRID PROPULSION FOR OTV NO. 7-8-12 P-1 3

THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

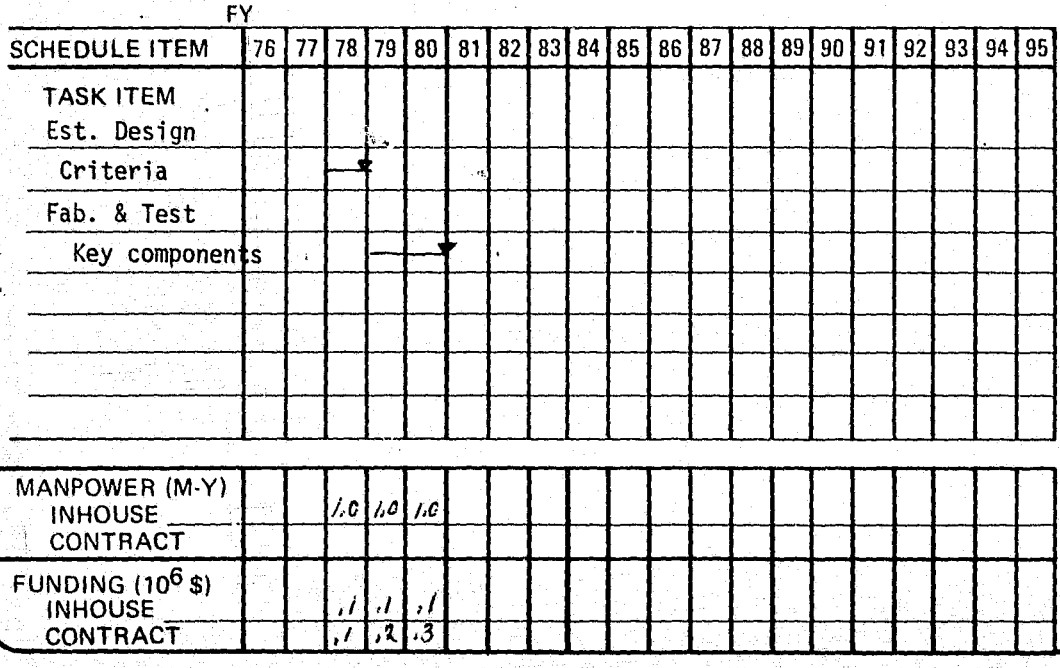
APPLICATION STUDY TO DETERMINE PAY-OFF AND ESTABLISH DESIGN CRITERIA. REVIEW OF PAST TECHNOLOGY RELATED TO LIQUID/SOLID HYBRIDS. DETERMINE THE PROPELLANT COMBINATIONS TO BE EVALUATED. INVESTIGATE BURNING PROPERTIES IN SMALL MOTORS. FABRICATE AND TEST A PROTOTYPE MOTOR.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

NONE

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY ADDITIONAL INITIATIVE — FORM IV

TITLE Liquid/Solid Hybrid Propulsion for OTV — DATE 4 / 29 / 76

TT NO. 7-8-12 OR WORKING GROUP NO. P-1/3

OBJECTIVE

A higher performance, higher density propulsion system with restart capability.

JUSTIFICATION A liquid/solid hybrid system will provide higher lsp than a solid and higher density than a liquid. In case of abort landings, it is lighter than a solid and less hazardous than a liquid.

TECHNICAL APPROACH/PLAN

Application study to determine pay-off and establish design criteria. Review past technology related to liquid/solid hybrids. Determine the propellant combinations to be evaluated. Investigate burning and ballistic properties in small motors. Fabricate & test a prototype.

SCHEDULE

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK																				
Estab. Design Criteria			▼	▼																
Investigate Propellants				▼																
Fab. & Test Components					▼	▼														
Fab. & Test Prototype						▼	▼													
MANPOWER (M-Y) IN-HOUSE			1.0	1.0	2.0	2.0	.5													
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.1	.2	.2	.2	.2													
CONTRACT			.1	.4	.6	.8	.3													

NOTE: FY78 funding in R&T Base

PROPOSED LEAD CENTER MSFC with JPL support.

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Solid Propulsion Advanced Technology Motor

NO 7-8-10-12/P-1 4
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Improve performance, operational flexibility and decrease cost of solid propellant motors used in the advanced space transportation system (launch vehicles and orbital transfer vehicles).

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS. Not approved

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT: Note: Level 5 by 1980
HIGH [ ] MEDIUM [ ] LOW [xx]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [x] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [x]
GRD TEST [x] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Materials suitable for hot gas valve and duct, high strength composites, carbon ablatives, propellant formulations providing high performance.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Hot gas manifold and valve for hot gas bleed TVC system, materials and fabrication techniques for low cost nozzles; stop-restart; low cost, light-weight case designs, improved propellant and insulation formulations; low pollution (mixed oxidizer) propellants; extendable nozzles.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE Solid Propulsion Advanced Technology Motor NO. 7-8-10-12-P-1/4
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

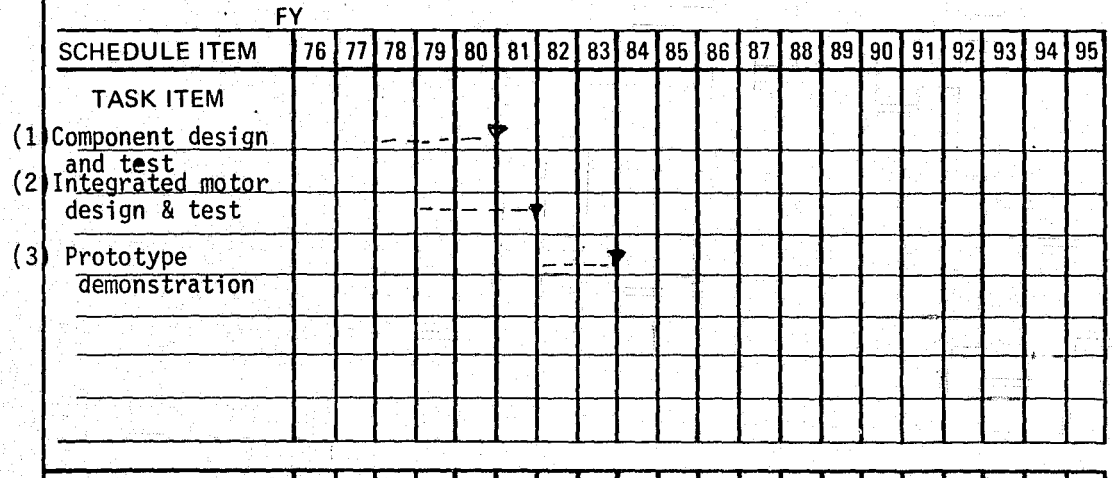
Conduct feasibility design studies and component tests leading to prototype motor demonstration tests including the technology items described above. The plan will be accomplished using appropriately scaled motors depending on whether the application is OTV or launch vehicles.

7. ALTERNATIVE APPROACHES/OPTIONS Liquids and liquid/solid hybrid propulsion systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-21-32 (Advanced solid propulsion concepts)
New initiative has been proposed from JPL-No. 302
New initiative has been proposed from MSFC-No. TBD

9. TECHNOLOGY SCHEDULES



	78	79	80	81	82	83
MANPOWER (M-Y)						
INHOUSE	10	15	15	15	20	10
CONTRACT	5	7	7	8	7	5
FUNDING (10^6 $)						
INHOUSE	1.1	1.3	1.5	1.8	2.3	1.8
CONTRACT	.3	.7	1.0	1.5	2.5	1.5

SPACE TECHNOLOGY NEED **FORM NO. I**

PAGE 1 OF 2

1. TITLE ~~ATOMIC/METALLIC HYDROGEN~~ PROPULSION TECHNOLOGY

NO. 1-7-8-9-10-11-12/P-1/6
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

~~DEVELOP BASIC TECHNOLOGY TO SHOW THE FEASIBILITY OF MANUFACTURING AND STORING ATOMIC OR METALLIC H_2 IN QUANTITIES NEEDED FOR PROPULSION APPLICATIONS.~~

3. NEED ANALYSIS

a) LEVEL NOW [1], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: [2000]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] . SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE YES (FY 78 - 350K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

THEORETICAL STUDIES HAVE SHOWN THAT SIGNIFICANT INCREASES IN ~~PERFORMANCE (1700 ISP) CAN BE ACHIEVED IN PROPULSION SYSTEMS UTILIZING ATOMIC OR METALLIC FORMS OF HYDROGEN. TECHNOLOGY MUST BE DEVELOPED TO PERMIT THE MANUFACTURE AND STORAGE OF THESE PROPELLANTS IN THE QUANTITIES NEEDED IN PROPULSION APPLICATIONS, TO DETERMINE THEIR PHYSICAL PROPERTIES AND ASSESS THEIR APPLICATION TO PROPULSION SYSTEMS.~~

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE ATOMIC & METALLIC HYDROGEN PROPULSION TECHNOLOGY

NO 1-7-8-9-10-11-12/P1/6
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- PRODUCE & MEASURE PROPERTIES OF METALLIC HYDROGEN
- ASSESS FEASIBILITY OF METALLIC HYDROGEN AS A ROCKET PROPELLANT
- PRODUCE & MEASURE PROPERTIES OF ATOMIC HYDROGEN
- ASSESS FEASIBILITY OF PRODUCING LARGE QUANTITIES & ROCKET APPLICATION
- DEVELOP STORAGE CAPABILITY TO STORE ATOMIC & METALLIC FORMS

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RESEARCH ON PRODUCTION OF ATOMIC & METALLIC HYDROGEN INPROGRESS.

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
PRODUCE METALLIC H	—	—	—	—	—	—														
ASSESS FEASIB.						—	—													
PRODUCE ATOMIC H	—	—	—	—	—	—														
QUANTITY ASSESS.						—	—													
DEVELOP STORAGE						—	—													
MANPOWER (M-Y) INHOUSE	8	8	8	8	8	8	8													
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE	.3	.3	.3	.3	.3	.3	.3													
FUNDING (10^6 $) CONTRACT	.25	.35	.35	.5	.5	.5	.5													

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE STORAGE, SUPPLY AND TRANSFER OF CRYOGENIC FLUIDS IN SPACE

NO. 7, 8, 12/P-1/7
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE
Provide a subcritical storage and supply system for cryogenic fluids to minimize system weight and provide the means to replenish fluids on-orbit

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1988]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes (FY 76 ↬200K, FY 78 ↬200K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- Demonstrate reusability of insulation system
- Determine behavior in reduced gravity of LH_2, LO_2 and LHe
- Demonstrate thermal control system performance
- Demonstrate fluid acquisition and control in reduced gravity for cryogens
- Demonstrate outlow and inflow fluid dynamics

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE STORAGE, SUPPLY AND TRANSFER OF CRYOGENIC FLUIDS IN SPACE

NO. 7,8,12/P-1/7
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

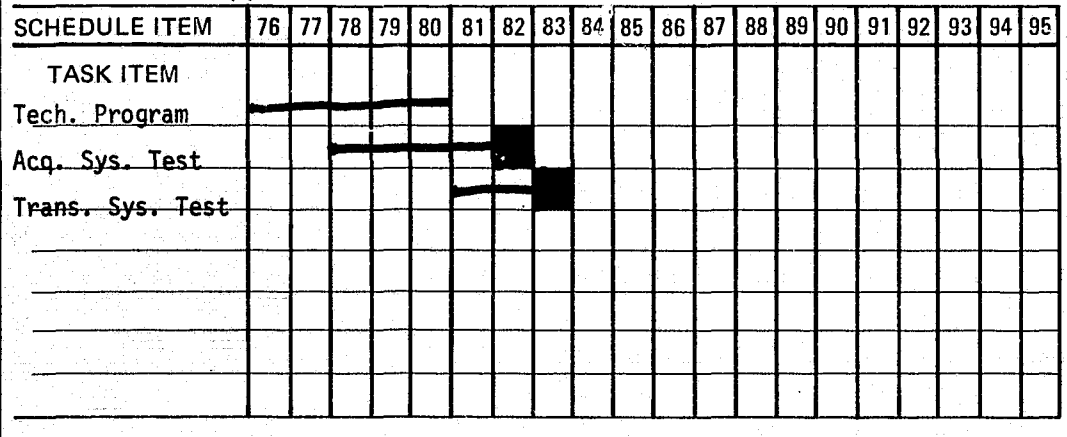
- Continue current technology program
- Flight verification of storage and acquisition system
- Flight verification of complete transfer system

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Technology program on reduce gravity fluid systems, thermal control systems and reuseable insulation systems

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	4	4	6	6	6	4	4	2												
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.2	.2	.2	.2	.2	.2	.2	.2												
CONTRACT	.2	.2	.4	1.0	.5	.7	.4	.1												

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for OTV Application

NO. 1,7,8,12/P-1/8 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE Develop technology for components of a LH_2/LOX APS, such as thrusters, pumps, zero g reservoirs, and accumulators, and perform systems testing.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1986]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Development of technology for LH_2/LOX system for OTV's, including small thrusters (25 to 100 lbs. thrust), small cryogenic positive displacement pumps, accumulators, controls, refillable zero g reservoir, and propellent systems. After component technology is completed, systems testing will be performed to evaluate control requirements and measure heat input effects to thrusters and feed lines. Flight test demonstration as shuttle payload package needed to fully show flight readiness of all aspects of this system technology.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 3

TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for OTV Application

NO. 7,8,12/P-1/8
THEME / W.G. / TASK

DATE 4 / 27/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Cryogenic APS offers advantages of high performance, light total system weight, clean non-toxic exhaust, and commonality of propellants with main propulsion system. Thruster technology has been demonstrated at 1250 lbs. thrust but not at smaller sizes where thermal control problems are more difficult. Small thrust cryogenic engines must be specially designed for accurate thermal control so that rapid start-up is achieved with cryogenic

(See page 3.)

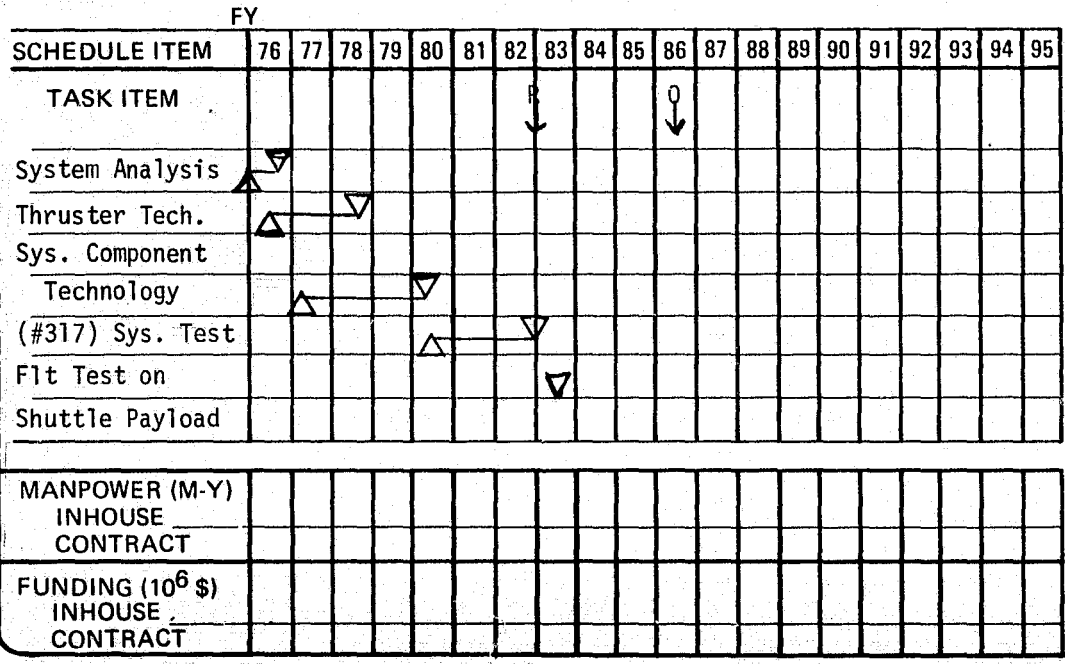
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11

FY80 New Start (#317) - "Functional and Performance Verification of an Integrated LH_2/LOX APS"

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for OTV Applications

NO. 7,8,12/P-1/8
THEME / W.G. / TASK

DATE 4 / 27 / 76

(6) **CONTINUATION (If Needed)**
Block No.

propellants entering a warm engine. Long life and small impulse bits are required to meet OTV requirements. For small pumps, rapid start-up and long life are needed which are difficult requirements for small cryogenic positive displacement pumps.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE Earth Storable Propulsion for Planetary Spacecraft

NO. 10/P-1/9
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Improve lifetime capability and performance level of earth-storable bipropellants.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE:1987

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Improve the lifetime capability of earth storable liquid bipropellants by the development of new materials for thrusters and hard seats for valves. Increase the performance level by the test and evaluation of the bimodal engine technology.

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE Earth Storable Propulsion for Planetary Spacecraft

NO. 10/P-1/9
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct systems studies to identify life-limiting components. Evaluate components and assemble a system for verification testing. Determine interactions and technology readiness. Test and evaluate bimodal engine system operation.

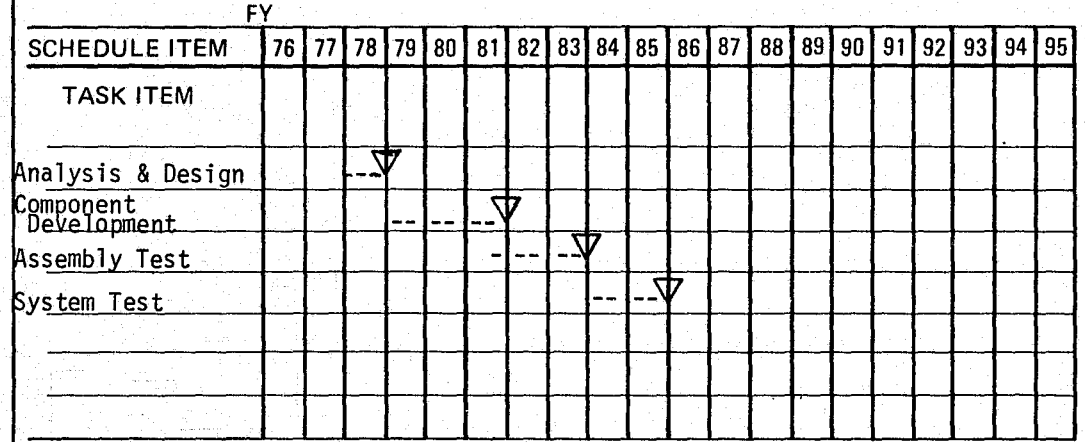
7. ALTERNATIVE APPROACHES/OPTIONS

Monopropellant system, which has lower performance; or live with life-limiting components and replace as necessary.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE			2	3	3	3	4	4	4	3										
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE			.1	.2	.2	.2	4	.2	.2	.2										
CONTRACT			0	0	0	0	.1	.4	.4	.2										

SPACE TECHNOLOGY NEED

FORM NO. I

1. TITLE RESISTOJET FOR (c) OTV MAIN PROPULSION, AUXILIARY PROPULSION SEP-NEP

NO. 7-12 P-1 11
THEME / W.G. / TASK

DATE 4 / 26 / 76

2. OBJECTIVE DEVELOP A LONG LIFE, HIGH PERFORMANCE RESISTOJET CAPABLE OF USING MONOPROPELLANT HYDRAZINE OR LOW FREEZING POINT MONOPROPELLANTS UTILIZING ELECTRICAL HEATER POWER FROM EITHER NEP OR SEP SOURCES

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1984]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE $250K for FY 78

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

RESISTOJET REQUIRES ELECTRICAL HEATER POWER FROM THE NEP OR SEP

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) THRUST LEVELS MUST BE SCALED UP FROM PRESENT LOW LEVELS.

(2) Resistojet utilizing low freezing point propellant (e.g. MMH) must be developed.

(3) Improved long life heaters must be developed for HIPET - LFP propellant application.

(4) Materials improvement program must be initiated.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE RESISTOJET FOR (C) OTV MAIN PROPULSION SEP-NEP NO. 7-12 P-1 11.
THEME / W.G. / TASK

DATE 4 / 26 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Complete hydrazine electrothermal thruster development at 22N thrust level.

(2) Develop a 22N HiPETH

(3) Develop low freezing point full electrothermal thruster to eliminate thermal problem.

(4) Develop HIPET typeheaters for use with carbon based low freezing point fuels.

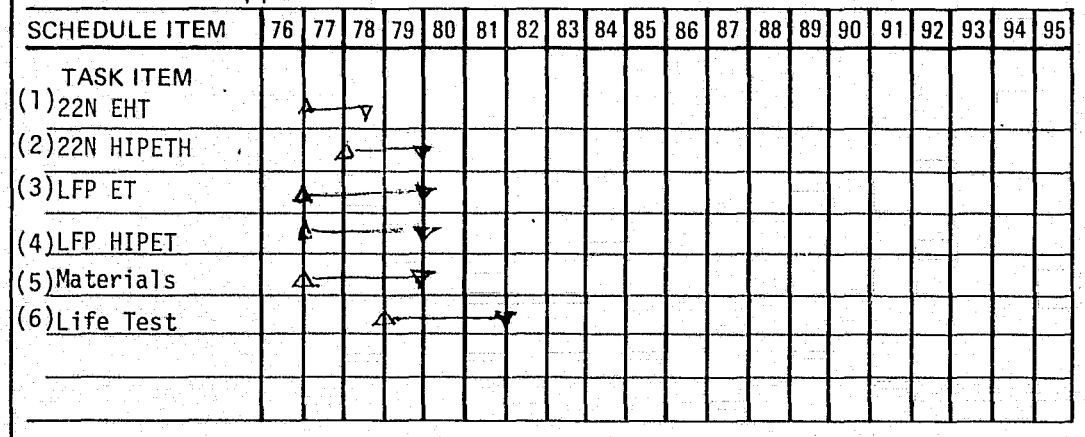
7. ALTERNATIVE APPROACHES/OPTIONS None

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Auxiliary Electric Propulsion Systems

RTOP 506-22-10

9. TECHNOLOGY SCHEDULES



	77	78	79	80	81
MANPOWER (M-Y)					
INHOUSE	1	1	1	1	1
CONTRACT	.5	.5	.5	.2	.2
FUNDING (10^6 $)					
INHOUSE	.05	.05	.05	.02	.02
CONTRACT	.25	.25	.25	.10	.10

SPACE TECHNOLOGY NEED

FORM NO. I

1. TITLE RESISTOJET FOR (C) OTV MAIN PROPULSION
SEP-NEP

NO. 7-12 P-1 11
THEME / W.G. / TASK

DATE 4 / 26 / 76

(6) CONTINUATION (If Needed)
Block No.

(5) Conduct a materials improvement program to prevent nitriding of thruster.

(6) Conduct long life testing of developed hardware in both the pulse and steady state mode of operation.

SPACE TECHNOLOGY ADDITIONAL INITIATIVE **FORM IV**

TITLE Hydrogen Resistojet C(OTV) **DATE** 4 / 29 / 76

TT NO. 7-12 **OR WORKING GROUP NO.** P-1

OBJECTIVE

Develop High ISP moderate thrust resistojet

JUSTIFICATION

Present resistojets utilize hydrazine which provides moderate ISP

TECHNICAL APPROACH/PLAN

1. Design, fabricate, and conduct tests on high temperature H_2 resistojet
2. Conduct development on high temperature heaters
3. Conduct life test program
4. System development and test

SCHEDULE

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK																				
1. Prototype		———			▽															
2. Heater Devel.		———			▽															
3. Life Test					———	▽														
4. System Dev. and Test						———		▽												
MANPOWER (M-Y)																				
INHOUSE			1	1	1	1	1	1												
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE			.01	.01	.01	.01	.01	.01												
CONTRACT			.25	.25	.25	.25	.10	.10												

PROPOSED LEAD CENTER JSC

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE MPD Thruster System Technology Readiness (SEP and NEP)

NO. 7,8,9,10,11,12/P-1/12
THEME / W.G. / TASK

DATE 4 / 27 /76

2. OBJECTIVE

The MPD thruster propulsion system, now seen as essential for economical large cargo earth orbit operations, will be brought to technology readiness.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [5] UNDER EXISTING PLANS (includes new initiative)

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR
ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [x]
GRD TEST [x] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [x]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Nuclear-thermonic power system development or high power lightweight solar arrays.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Incorporate recent research results on pulsed mode operating research devices into a high power level thruster capable of operating at steady state. ~~Determine performance levels & identify promising avenues of~~ thruster improvement. Define an MPD Thruster System and initiate development of critical components.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE MPD Thruster System Technology Readiness (SEP & NEP)

NO. 7,8,9,10,11,12/P-1/12
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

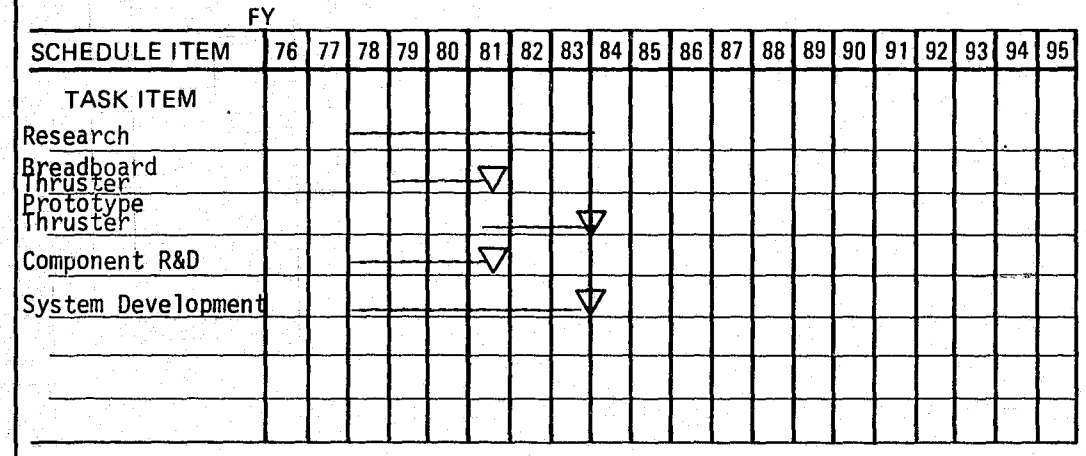
1) Design, fabricate, and conduct tests on a high power MPD thruster.
2) Conduct research into ways of increasing MPD thruster efficiency and lifetime.
3) Develop thrust subsystem concepts.
4) Design, fabricate & test critical system components.

7. ALTERNATIVE APPROACHES/OPTIONS Large size Ion thrusters (~100 cm dia)

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

JPL FY78 new initiative on MPD thruster system technology readiness.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE																				
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE			1.1	1.2	1.3	1.2	1.0	1.0												
CONTRACT			1.4	1.8	2.7	2.8	3.0	1.0												

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE High Specific Impulse Electric Propulsion for Orbital Transfer Vehicle (OTV)

NO. 7,8,9,11,12/P1/13
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Provide the Technology for an Efficient High Specific Impulse Ion Thruster System for Orbit Raising from Low Earth Orbit to a Higher Orbit using Low Cost Inert Fuels

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High power, lightweight solar arrays, N.E.P. Power Source

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Scaling of present thruster systems to required sizes

(2) Efficient operation demonstrated on inert gases

(3) Demonstration of adequate total impulse per thruster module

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF 2

TITLE High Isp Electric Propulsion for Orbital Transfer Vehicle SEP/NEP

NO. 7,8,9,11,12/P1/13 THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

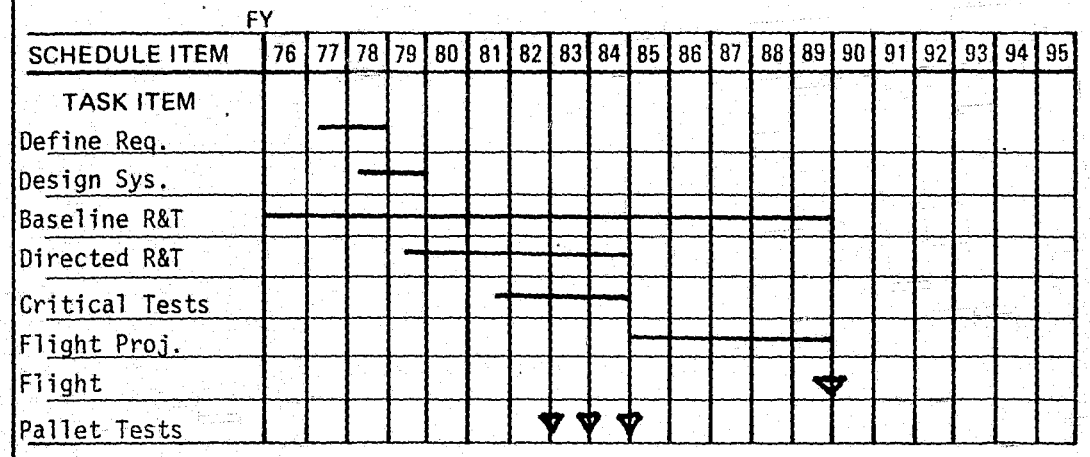
(1) Define System Requirements
(2) Design Thruster System
(3) Incorporate into Existing Technology Program
(4) Perform Directed R&T
(5) Demonstrate Critical Performance Parameters

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-22-30, 506-22-40
Propulsion Pallet Experiment, SPHINX B/C
LeRC '78 New Initiative to develop thrust subsystem technology

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	5	7	10	20	20	20	30	30	20											
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.2	.5	.5	1.0	1.0	1.0	1.0	1.0	1.0											
CONTRACT	.25	.25	.5	1.0	1.0	2.0	3.0	2.0	1.0											

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF 3

1. TITLE Solar Heated Hydrogen Thruster NO. 1,7,8,9, ~~10,11,12/ P1/15~~ THEME/W.G./TASK

DATE 4 /28/ 76

2. OBJECTIVE To provide high specific impulse in a low thrust propulsion system suitable for spacecraft . The use of (Cont)

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [ ] FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [XX] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Long term storage of cryogens in space.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The system is visualized as consisting of a solar energy collector, a form of a solar furnace, a heat exchanger, and a nozzle. The concept is to heat hydrogen (stored as a liquid) and expand it to a high exhaust velocity through a suitable nozzle. Technology is required to provide a lightweight form of a solar furnace suitable for a spacecraft.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE Solar Heated Hydrogen Thruster

1,7,8,9,10
NO. 11, 12/ P-1/ 15
THEME / W.G. / TASK

DATE 4 /28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct total system studies to determine design criteria and interface requirements. Prepare conceptual design. Execute technology demonstration of subsystem elements. Fabricate and test total system. Conduct flight tests in space environment.

7. ALTERNATIVE APPROACHES/OPTIONS Hydrogen/oxygen system, oxygen/hydrocarbon system, SEP, N_2H_4 monopropellant.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

FY / SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
System Study			—	—																
Concept. Design				—																
Test Components					—	—														
Syst. Gnd. Test						—	—	—												
Flight Test									—	—										
MANPOWER (M-Y) INHOUSE			.2	.4	.4	1.0	1.5	1.5	TBD											
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
FUNDING (10^6 $) CONTRACT			.1	.4	.4	.8	1.0	.8	TBD											

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 3 OF 3

1. TITLE Solar Heated Hydrogen Thruster

NO. 1, 7, 8, 9, ~~10, 11, 12/P 1/15~~
THEME / W.G. / TASK

DATE 4 / 28 / 76

(2) CONTINUATION (If Needed)
Block No.

solar energy to heat hydrogen ~~eliminates the need to carry an~~ oxidizer, and provides the potential for Isp values greater than 1000 sec. In addition, the exhaust products are benign and avoid potential contamination of sensors and optical devices.

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Laser Propulsion System for Orbit Transfer Vehicle

NO. 7-8-9-10-11 12/P-1/16
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Provide high Isp (1000 to 2000 sec) laser heated rocket engine for orbit to orbit transfer of unmanned payloads and to provide attitude control capability.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes (FY'76 $200K; FY '78 $1000K)

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Laser power transmitter, large power systems (greater than 1 Mw) in geosync orbit.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

- o Demonstrate absorption of laser radiation in gases to produce Isp between 1000 and 2000 sec
- o Devise practical lightweight laser team collector to focus beam into rocket propellants.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 2 OF 2

TITLE Laser Propulsion System for Orbit Transfer Vehicle.

NO. 7-8-9-10-11 / 12/P1/16 THEME / W.G. / TASK

DATE 4/ / 27/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

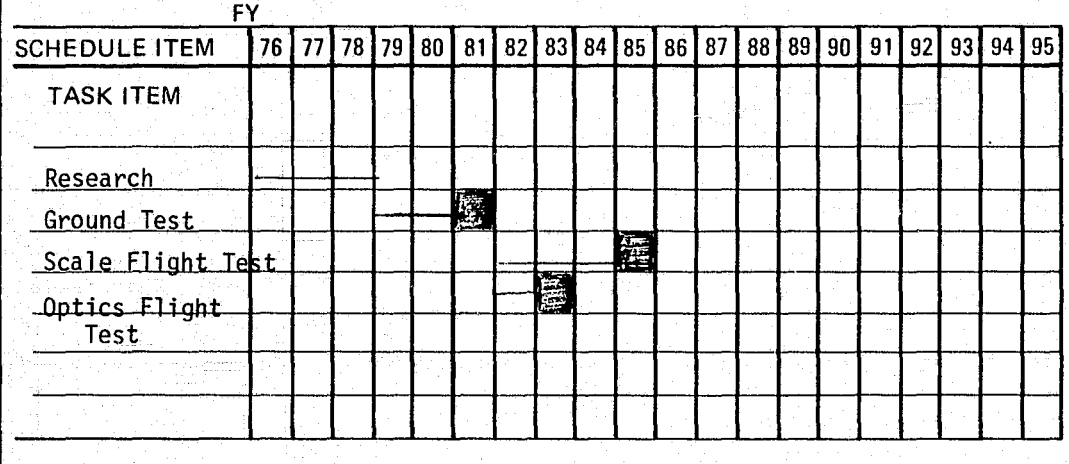
- o Continue current research on laser propulsion
- o Conduct ground demonstration of a laser propulsion system
- o Conduct flight test of a scale model of a laser propulsion system
- o Conduct flight test of lightweight collector and optics system.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Research on laser heated rocket propulsion systems

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	1.5	4	4	5	5	5	5	7	6	6										
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	0	15	15	.2	.2															
CONTRACT	.2	75	75	1.0	2.5	2.5	2.5	3.5	3.0	3.0										

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE H/O BELL NOZZLE ENGINE (ADVANCED SSME) NO. 8-10-12 P-1 17
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE PROVIDE AN ADVANCED SSME FOR HLLV, HLLV$_2$, AND ADVANCED VEHICLE. IMPROVEMENTS WITH INCREASE Isp, EXPAND OPERATIONAL CAPABILITY AND DECREASE ULLAGE & VEHICLE WEIGHT. (Cont'd)

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [XX] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY ZERO NPSH FOR LOX PUMPS, EXTENDIBLE NOZZLES, MATERIALS FOR HIGH TEMPERATURE TURBINE BLADES

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

COMPONENT TESTING FOR ZERO NPSH IN LOX PUMPS (LH_2 ZERO NPSH ALREADY ESTABLISHED); COOLING TECHNIQUES AND MATERIAL ADVANCEMENTS NECESSARY FOR INCREASED CHAMBER PRESSURE; ENGINE SYSTEM TESTS TO EXAMINE TRANSIENT AND STEADY STATE PARAMETERS (SIMILAR TO J2S TESTING); IDLE MORE ANALYSES AND DEMONSTRATION.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE H/O BELL NOZZLE ENGINE (ADVANCED SSME) NO. 8-10-12/P-1 17
THEME / W.G. / TASK

DATE 4 / 29 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Study engine system to quantify potential improvements; acquire component technology; redesign, fabricate and test subsystems; assemble and test experimental engine.

7. ALTERNATIVE APPROACHES/OPTIONS Standard SSME

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP in planning stage

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM \ FY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
System Study		—																		
Tech. Acqui.		—	—																	
Subsyst. Test				—	—															
Exper. Eng. Fab. & Test					—	—	—													
MANPOWER (M-Y)																				
INHOUSE		.5	2.0	2.0	3.0	5.0														
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE																				
CONTRACT		.2	.5	.6	1.5	3.0														

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE H/O BELL NOZZLE ENGINE
(ADVANCED SSME)

NO. 8-10-12 P-1 17
THEME / W.G. / TASK

DATE 4 / 27 / 76

(2) CONTINUATION (If Needed)
Block No.

ADVANCED VEHICLE STUDIES HAVE INDICATED A PRIME NEED FOR EXTENDIBLE NOZZLES. THE SSME EXPERIMENTAL ENGINE IS IDEAL FOR PROVIDING THIS TECHNOLOGY WHICH IS READILY TRANSFERABLE TO OTHER ENGINE CONFIGURATIONS. BY PROVIDING IDLE MODE CAPABILITY IN THE SSME, IT MAY BE POSSIBLE TO ELIMINATE THE NEED FOR AN ORBIT MANEUVERING SYSTEM IN THE ORBITER OR THE 2ND STAGE OF AN HLLV, OR $HLLV_2$. IDLE MODE AND ZERO NPSH ARE ATTRACTIVE METHODS FOR UTILIZING PROPELLANT RESIDUALS. ZERO NPSH ALSO DECREASES THE REQUIRED PROPELLANT ULLAGE PRESSURES, AND CONSEQUENTLY DECREASES VEHICLE WEIGHT. INCREASED Isp CAN BE PROVIDED BY INCREASING EXPANSION RATIO MADE POSSIBLE BY INCREASED CHAMBER PRESSURE. PRELIMINARY STUDIES INDICATE THAT INCREASED PC WILL PROBABLY REQUIRE INCREASED TURBINE INLET TEMPERATURES, WHICH IN TURN REQUIRES ADVANCED MATERIALS FOR TURBINE BLADES.

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE AIR AUGMENTATION OF EARTH TO ORBIT SOLID ROCKET ENGINES

NO. 8-12 P-1 19
THEME / W.G. 7 TASK

DATE 4 /27 /76

2. OBJECTIVE
To provide a 5 to 7 percent increase in booster enginer Isp through air augmentation

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY DATE: 1985

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Air augmentation is currently used in cruise missile applications where essentially steady state operation is achieved. Launch vehicle benefit will be determined where altitude variation results in transient operating conditions. Analysis and preliminary data indicate a 5 to 7 percent increase in Isp may be realized.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE AIR AUGMENTATION OF EARTH TO ORBIT SOLID ROCKET ENGINES

NO. 8-12/P-1/19
THEME / W.G. / TASK

DATE 4 /27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

- Conduct R & T studies to develop concept and verify overall benefit
- Conduct ground based tests and subscale flight test to verify experimentally the performance gains
- Conduct full scale flight verification test

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Concept. Verif.		▬	▬																	
Subscale Flt. Test				▬	■															
Full Scale Flt. Test					▬	▬	■													
MANPOWER (M-Y)																				
INHOUSE		.1	.5	3	3	3	2													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE		0	.1	.1	.2	.2	.1													
CONTRACT		.05	.2	1.5		1.0	1.0													

SPACE TECHNOLOGY NEED — **FORM NO. I**

1. TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for Launch Vehicles ($HLLV_1$)

NO. 1,8,10,12/P-1/20 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

Develop technology for components of a LH_2/LOX APS, such as thrusters, pumps, zero "g" reservoir, and accumulators, and perform systems testing.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR
ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Development of technology for LH_2/LOX system for advanced launch vehicles, including thrusters (800 to 1,500 lbs. thrust), small cryogenic positive displacement pumps, accumulators, controls, refillable zero "g" reservoirs, and propellant systems. After component technology is completed, systems testing will be performed to evaluate control requirements and measure heat input effects to thrusters and feed lines. Flight test demonstration of a subscale system as Shuttle payload package needed to fully show flight readiness of all aspects of this system technology.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I** —

TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for Launch Vehicles

NO. 1,8,10,12/P-1/20 (THEME / W.G. / TASK)

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Cryogenic APS offers advantages of high performance, low total system weight, clean non-toxic exhaust, and commonality of propellants with main propulsion system. Thruster technology has been pursued at 1,250 lbs. thrust which showed that liquid cryogens could be successfully used in a pulsing attitude control thruster. The expected problems of thermal (continued)

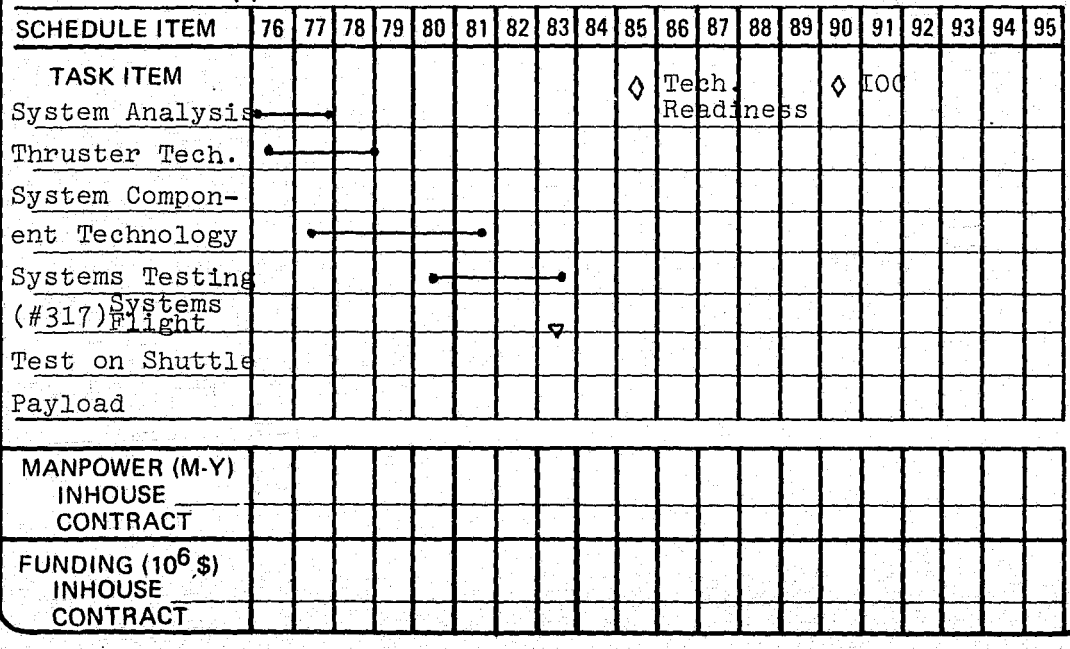
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11

FY 80 New Start (#317) - "Functional and Performance Verification of an Integrated LH_2/LOX APS."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. 1**

1. TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for Launch Vehicles

NO. 1,8,10,12/P-1/20
THEME / W.G. / TASK

DATE 4/28/76

(6) **CONTIN'JATION (If Needed)**
Block No.

control, performance, ignition, and combustion stability were solved. However, additional work is needed on performance, cooling, and thruster life. Additional component work is needed on small cryogenic positive displacement pumps, accumulators, zero "g" refillable tanks, propellant feed lines and manifolds, and system controls.

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE Auxiliary Propulsion, Low Cost Space Propellants for OTV, $HLLV_1$, $HLLV_2$, and Advanced Vehicle

NO. 12 / P-1 / 21 (THEME / W.G. / TASK)

DATE 4 / 27 / 76

2. OBJECTIVE

To evaluate the ignition, combustion, and cooling characteristics of low cost, high density impulse propellants (such as LOX-Propane) under space start, restart, and steady state conditions. This technology is

(Cont'd on page 3.)

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [ ] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [XX] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The following is required: ignition characteristics, performance, cooling capability, and combustion stability.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE Auxiliary Propulsion, Low Cost Space Propellants for OTV, $HLLV_1$, $HLLV_2$, and Advanced Vehicle

NO. 12/P-1/21
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Conduct limited survey of low cost and high density fuels and oxidizers for both pressure-fed and pump-fed systems. Conduct single element and subscale firings over a range of propellant temperatures, pressures, and mixture ratios. Photographic coverage shall be conducted to obtain qualitative understanding of the measured data (C* P_c, Q/P, etc.). Full scale injector firings of a limited number of the most promising propellants shall be con-

(Continued on page 3.)

7. ALTERNATIVE APPROACHES/OPTIONS

Use less dense O-H system with its inherent complexity and packaging problems or pay increased costs of amine fuel, if available.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None.

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM Analysis			—	—	—															
Subscale Design				—																
Fab. & Test.																				
Full Scale Des.,					—															
Fab. & Test																				
MANPOWER (M-Y) INHOUSE			.2	.2	.2															
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT			.150	.2	.5															

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE Auxiliary Propulsion, Low Cost Space Propellants for OTV, $HLLV_1$, $HLLV_2$, and Advanced Vehicle

NO. 12 / P-1 / 21
THEME / W.G. / TASK

DATE 4 / 27 / 76

(2 & 6) **CONTINUATION (If Needed)**
Block No.

Objectives (Cont'd) -

required at this time so that development can be initiated if FY81 to meet the 1985 operational use date.

This technology is required so that the amine fuel presently being used in the shuttle OMS and RCS can be replaced with a more easily available and cheaper fuel. The cost of amine type fuels has risen from the beginning of the shuttle program from approximately $4/lb. to $8/lb. Hydrocarbon fuels can be obtained for less than 50¢/lb. In addition, amine fuels are becoming more difficult to process due to environmental problems, so it is necessary to have a replacement available in event that production is sharply cut back and/or costs increase excessively.

Recommended Approach/Program Plan to Accomplish Need (Cont'd) -

ducted. Vacuum ignition, heat flux, performance and combustion stability shall be investigated.

SPACE TECHNOLOGY ADDITIONAL INITIATIVE **FORM IV**

TITLE Low Cost Propellant Auxiliary Propulsion Technology for Adv. Shuttle **DATE** 4 / 29 / 76

TT NO. _____ **OR WORKING GROUP NO.** P-1/Task 21

OBJECTIVE
To develop technology for low cost hydrocarbon fuels for RCS and OMS propulsion for Shuttle improvements and advanced launch vehicles.

JUSTIFICATION Low cost (and higher performance) propellant combinations, such as LOX-propane, are needed to replace the earth storables now used on Shuttle.

TECHNICAL APPROACH/PLAN
Work will be initiated on both attitude control thrusters of about 1000 lbs. thrust and a pump-fed OMS engine of about 6000 lbs. thrust. Various hydrocarbon fuel/LOX propellant combinations will be evaluated and one selected for experimental work on injectors, thrust chambers, engine cycle studies, and pumps.

SCHEDULE

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK						◇	Tech. Readiness			◇	IOC									
RCS Thruster Tech.		▽				▽														
OMS Injector/Chamb.		▽			▽															
OMS Cycle Study	▽	▽																		
OMS Turbomachinery		▽			▽															
OMS Eng. Breadboard				▽	▽	▽														
MANPOWER (M-Y) INHOUSE		2	4	4	5	4														
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT		.2	.6	.8	1.5	.8														

PROPOSED LEAD CENTER LeRC in consultation with JSC

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE Advanced Hydrogen/Oxygen Propulsion System for Launch Vehicles

NO. 1,7,8,9, 11, 12/P1/22 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

Provide the technology base for large hydrogen/oxygen engines operating at chamber pressures greater than 3000 psi, and employing unconventional configurations.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [ ] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [XX] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Material research to enable higher turbine inlet temperatures and extended low cycle fatigue life for combustor components, improved long-life bearings and seals. Conceptual design studies and subsequent system demonstration programs are required for the geometric configurations being considered. They are: Bell nozzles; linear/aerospike; and plug cluster. The thrust level being considered is 350K to 1000K lbf.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE Advanced Hydrogen/Oxygen Propulsion System for Launch Vehicles

NO. 1,7,8,9, 11,12/P1/22 (THEME / W.G. / TASK)

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

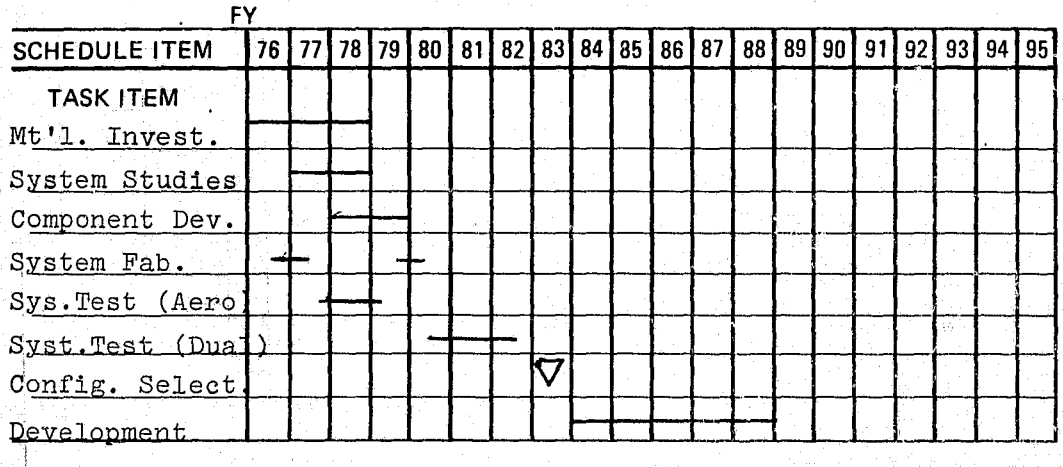
Material investigations should be initiated immediately. For the unconventional configurations, system studies are required to determine design criteria and component operating levels (temp., pressure, etc.). Establishment of component technology base is followed by fabrication & test of breadboard systems.

7. ALTERNATIVE APPROACHES/OPTIONS None

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP's 506-21-11 and 790-40-12.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE		2	2	2	3	3	3													
CONTRACT																				
FUNDING (10^6 $) INHOUSE																				
CONTRACT		.7	1.5	1.5	3	3	2.5													

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications ($HLLV_2$)

NO. 1,8,12/P-1/23
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Develop technology for high performance LOX/hydrocarbon propulsion systems including bell nozzle types, aerospike/linear engines, and plug cluster arrangements for booster applications.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1995]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

High performance LOX/hydrocarbon propulsion systems are needed for future booster applications that provide high specific impulse, compact size, high thrust/weight ratio, reusability, and use high bulk density propellants. A variety of engine cycles and configurations are applicable including high pressure bell nozzle engines, plug cluster, or linear/aerospike (plug nozzle) types that provide high specific impulse at sea level and throughout the flight by the use of altitude compensating nozzles.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED **FORM NO. I**

TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications

NO. 1,8,12/P-1/23
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Technology program should include: engine and vehicle studies; determination of relative advantages of various engine types; thrust chamber cooling studies with fuel, oxidizer, or auxiliary coolant; studies of various candidate hydrocarbon fuels, such as methane, propane, RP-1, RJ-5, and other intermediate density or heavy hydrocarbon fuels to evaluate their performance, cooling capability, and operational problems; engine component tech-

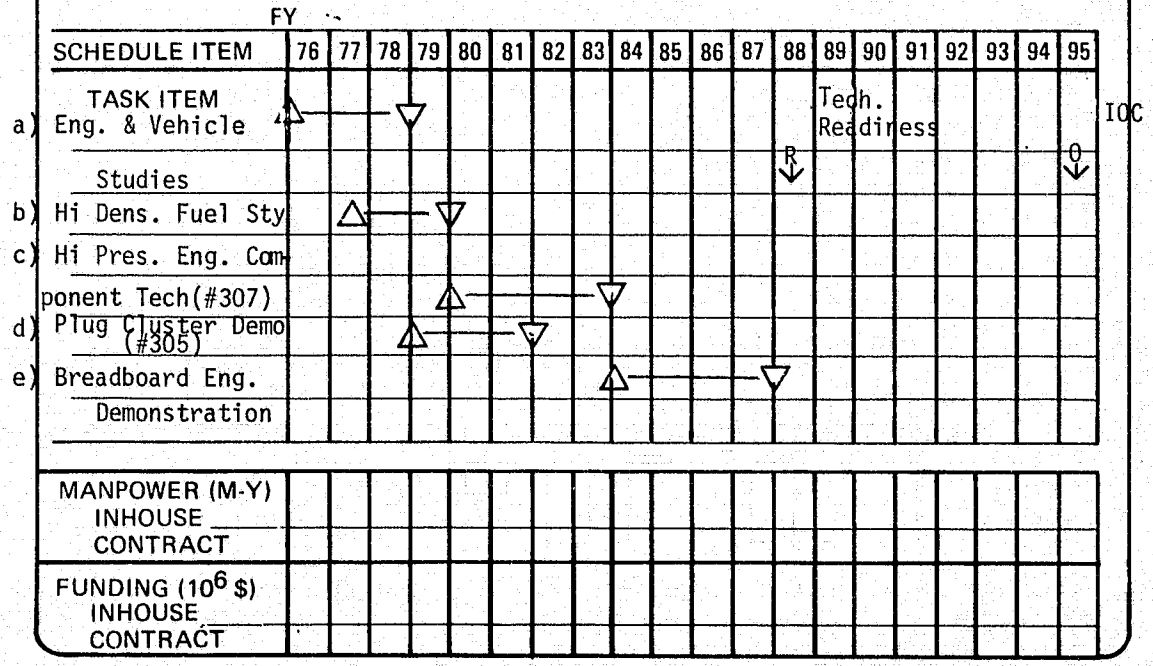
(See page 3.)

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

790-40-12, 506-21-11, 506-21-10
FY79 New Start #305, "Plug Cluster Engine Demonstration"
FY80 New Start #307, "Comp. Tech. for High Press. LOX/Hydrocarbon Booster Engine."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 3 OF 3

1. TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications

NO. 1,8,12/P-1/23
THEME / W.G. / TASK

DATE 4 / 28 / 76

( ) CONTINUATION (If Needed)
Block No.

nology program, including design, fabrication, and testing of selected critical components, such as fuel and oxidizer rich preburners, main injector, thrust chamber and main fuel turbopump; pressure-fed breadboard testing of preburners, main injector, and thrust chamber.

Supporting work is needed on low cycle thermal fatigue life of thrust chambers, turbopump bearings and seals, high temperature turbine materials, and cold and hot flow evaluation of plug cluster arrangements to determine nozzle performance losses.

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE High Performance Dual Fuel Engines for Booster Applications ($HLLV_2$)

NO. 1,8,12/P-1 /24
THEME / W.G. / TASK

DATE 4 /28/76

2. OBJECTIVE

Develop technology for advanced dual fuel engines for hydrocarbon/LOX/hydrogen propellants for use on advanced boosters using mixed mode propulsion.

3. NEED ANALYSIS NOTE: [2] For Dual Throat Config.

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:1995]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR
ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Dual fuel engines are applicable to advanced boosters using mixed mode propulsion. The dual fuel engine burns high density propellants, such as LOX/hydrocarbon early in the flight and switches to LOX/LH_2 later in the flight. Various engine configurations are applicable, including: high pressure staged combustion engines, LOX cooled; high pressure tripropellant engine, H_2 cooled; dual throat engine; split combustor aerospike, etc.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE High Performance Dual Fuel Engines for Booster Applications

NO. 1,8,12/P-1/24
THEME / W.G. / TASK

DATE 4/28/76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

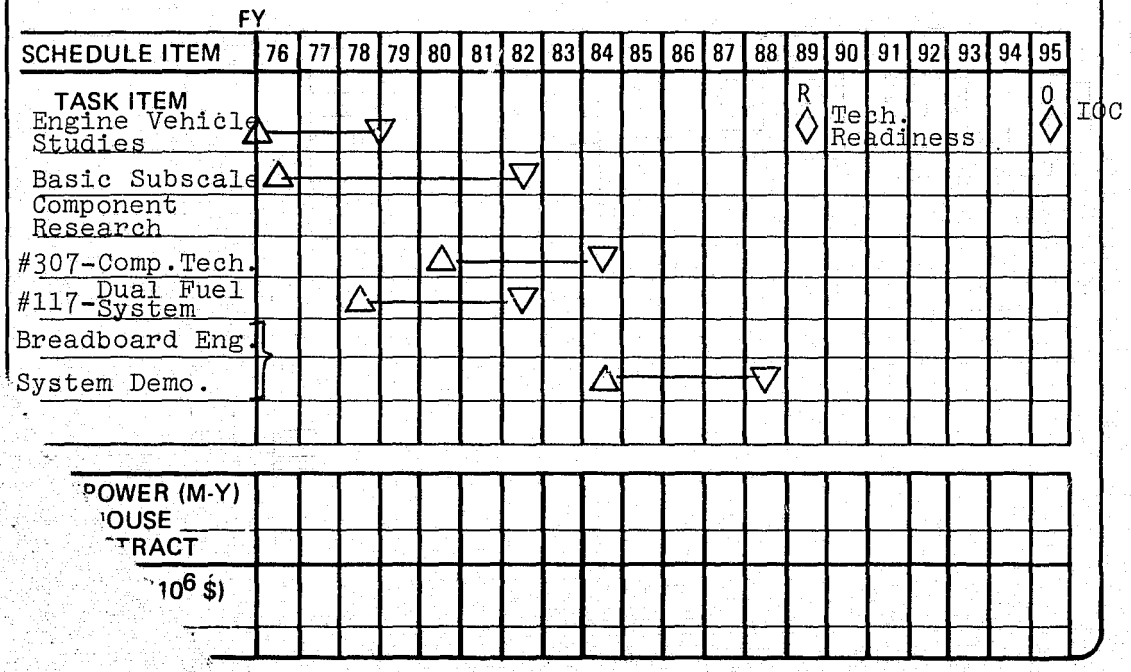
Perform studies to evaluate use of mixed mode propulsion using dual fuel engines for advanced boosters. Perform engine system trade-off and parometric studies to determine fuel and oxidizer combinations, engine turbopump drive cycle, cooling method, and component preliminary design for selected thrust levels in the range from 500,000 to 1,500,000 pounds. Perform (continued)

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11, 790-40-12. FY 79 New Start #305, "Plug Cluster Engine." FY 80 New Start #307, "Comp. Tech. for High Press. LOX/Hydrocarbon Booster Engine." FY 78 New Start #117, "Adv. Dual Fuel Propulsion System."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE High Performance Dual Fuel Engines for Booster Applications

NO. 1,8,12 / P-1 / 24
THEME / W.G. / TASK

DATE 4 / 28 / 76

(6) **CONTINUATION (If Needed)**
Block No.

component technology programs based on selection of critical components for the engine configuration and propellant combination selected.

The technology in this area is supported by work on high pressure H_2-O_2 booster engines and high performance LOX/hydrocarbon engines and also requires additional work on specific problem areas related to the use of two propellant combinations in the same engine.

SPACE TECHNOLOGY NEED FORM NO. 1

PAGE 1 OF 3

1. TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for Launch Vehicles (Adv. Vehicle)

NO. 1,8,10,12/P-1 / 25
THEME / W.G. / TASK

DATE 4/28/76

2. OBJECTIVE
Develop technology for components of a LH_2/LOX APS, such as thrusters, pumps, zero "g" reservoir, and accumulators, and perform systems testing.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Development of technology for LH_2/LOX system for advanced launch vehicles, including thrusters (800 to 1,500 lbs. thrust), small cryogenic positive displacement pumps, accumulators, controls, refillable zero "g" reservoirs, and propellant systems. After component technology is completed, systems testing will be performed to evaluate control requirements and measure heat input effects to thrusters and feed lines. Flight test demonstration of a subscale system as Shuttle payload package needed to fully show flight readiness of all aspects of this system technology.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. 1
PAGE 2 OF 3

TITLE Liquid Hydrogen/Liquid Oxygen Attitude Control Systems for Launch Vehicles

NO. 1, 8,10,12/ P-1/ 25
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

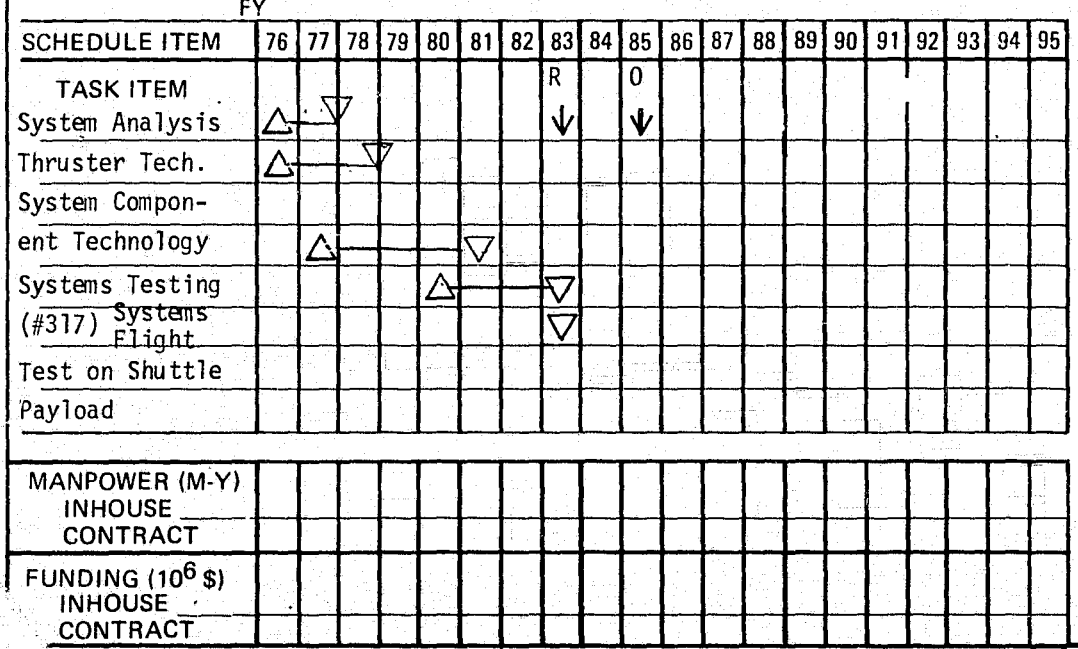
Cryogenic APS offers advantages of high performance, low total system weight, clean non-toxic exhaust, and commonality of propellants with main propulsion system. Thruster technology has been pursued at 1,250 lbs. thrust which showed that liquid cryogens could be successfully used in a pulsing attitude control thruster. The expected problems of thermal (continued)

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11
FY 80 New Start (#317) - "Functional and Performance Verification of an Integrated LH_2/LOX APS."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE High Performance H_2-O_2 Reusable Propulsion Systems for Orbit Maneuvering System (OMS) Applications

NO. 1,7,8,9,11,12/P-1/26 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE Develop technology for high performance, reusable H_2-O_2 space propulsion systems including staged combustion bell nozzle, expander cycle bell nozzle, and aerospike engines.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

a) Staged combustion bell nozzle engine (ASE)- Continue LeRC component technology program on thrust chamber, main fuel and oxidizer turbopumps, preburner, main injector, low cycle thermal fatigue chamber life, turbopump bearings and seals, and boost pump multiroller drive system. Expand program with FY '78 new initiative #119, "Reusable Engine Systems Test (RECEST)," to obtain data on operation of the powerhead breadboard assembly of staged combustion cycle engine and aerospike engine breadboard.

b) Aerospike expander cycle engine - Complete planned LeRC program on testing of 25K thrust aerospike chamber. Work also needed on thermal fatigue life of segments of chamber and breadboard system test using

(Continued on page 3)

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE High Performance H_2-O_2 Reusable Propulsion Systems for Orbit Maneuvering System (OMS) Applications

NO. 1,7,8,9,11,12/P-1/26
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

High performance reusable engines are needed for OMS applications using hydrogen-oxygen propellants to reduce system weight, provide commonality with main propulsion, APS, and fuel cells, thereby reducing cost. H_2-O_2 systems are inherently clean, have non-toxic exhaust, and good reusability aspects. High pressure engines are desirable to provide maximum specific impulse in a small compact package and minimize engine weight. Slush

(Continued on page 3)

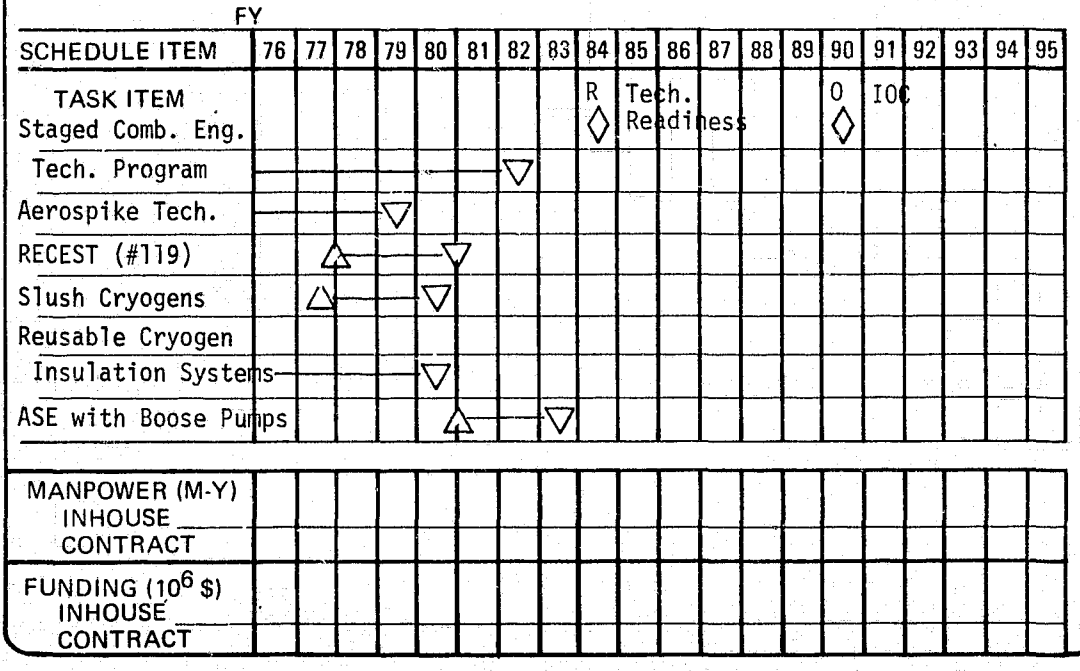
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11, 506-21-12, 910-03-01

FY '78 New Start #119, "RECEST - Reusable Cryogenic Engine Systems Test."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED

FORM NO. I

1. TITLE High Performance H_2-O_2 Reusable Propulsion Systems for Orbit Maneuvering System (OMS) Applications

NO. 1,7,8,9,11,12/P-1/26
THEME / W.G. / TASK

DATE 4 / 28 / 76

(5 & 6) **CONTINUATION (If Needed)**
Block No.

5. b) Mark 48 fuel and oxidizer pumps as part of FY '78 new start #119, RECEST

c) FY '78 new start #119, Reusable Cryogenic Engine Systems Test (RECEST)

d) Slush Cryogens - Evaluate methods of manufacture, storage, handling, pumping, and cost of applying to a flight system. Demonstrate these technology areas at moderate scale

e) Reusable cryogenic insulation systems - Continue LeRC program to provide technology on two approaches: (1) evacuated load bearing insulation systems; and (2) reusable purged multilayer insulation system

f) ASE with boost pumps - Add boost pumps and their drive system to the powerhead breadboard assembly tested under (c), above

6. cryogens are desirable to reduce tankage volume. High performance reusable cryogen insulation systems are needed that are rugged, have low heat leak, and are reusable for up to 50 missions.

SPACE TECHNOLOGY NEED **FORM NO. I**

PAGE 1 OF 3

1. TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications (Adv. Vehicle)

NO. 1,7,8,12/P-1/30
THEME / W.G. / TASK

DATE 4/28/76

2. OBJECTIVE

Develop technology for high performance LOX/hydrocarbon propulsion systems including bell nozzle types, aerospike/linear engines, and plug cluster engines for booster vehicles.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

High performance LOX/hydrocarbon propulsion systems are needed for future booster applications that provide high specific impulse, compact size, high thrust/weight ratio, reusability, and use high bulk density propellants. A variety of engine cycles and configurations are applicable including high pressure bell nozzle engines, plug cluster, or linear/aerospike (plug nozzle) types that provide high specific impulse at sea level and throughout the flight by the use of altitude compensating nozzles.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications

NO. 1,7,8, 9,10,11 / P-1 / 30 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Technology program should include: engine and vehicle studies; determination of relative advantages of various engine types; thrust chamber cooling studies with fuel, oxidizer or auxiliary coolant; studies of various candidate hydrocarbon fuels, such as methane, propane, RP-1, RJ-5 and other intermediate density or heavy hydrocarbon fuels to evaluate their (continued)

7. ALTERNATIVE APPROACHES/OPTIONS

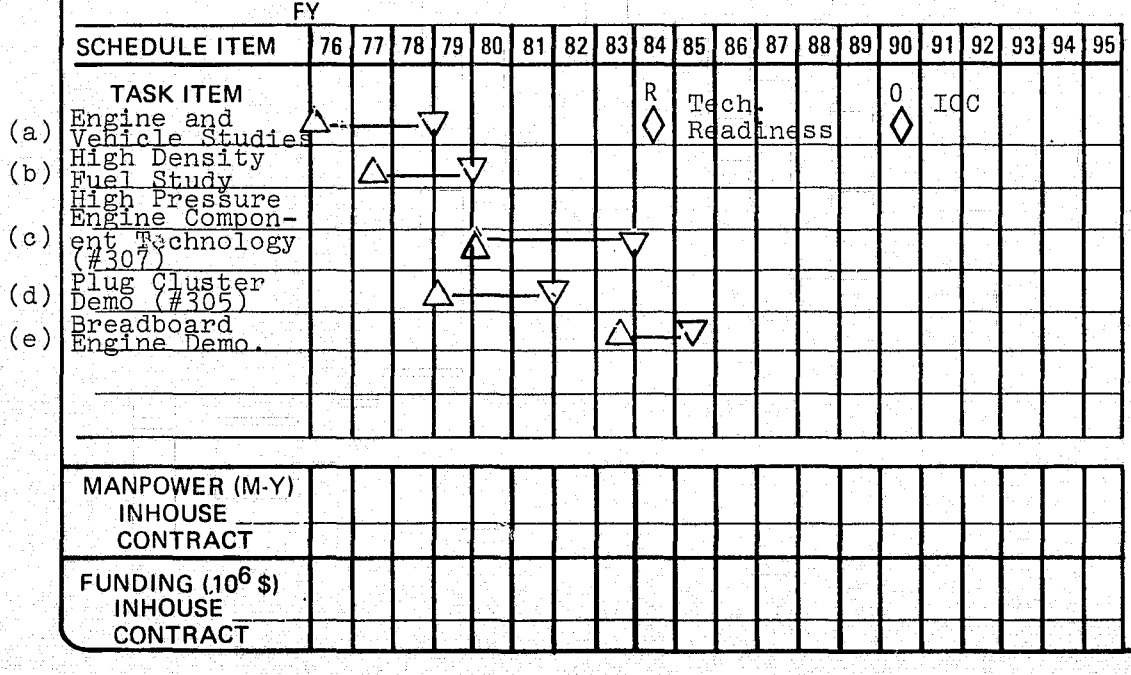
8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

790-40-12, 506-21-11, 506-21-10

FY 79 New Start #305, "Plug Cluster Engine Demonstration"

FY 80 New Start #307, "Comp. Tech. for High Press. LOX/HC Booster Engine."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE High Performance LOX/Hydrocarbon Propulsion Systems for Booster Applications

NO. 1.7.8.9.11.12/P-1/30
THEME / W.G. / TASK

DATE 4 / 28 / 76

(6) **CONTINUATION (If Needed)**
Block No.

performance, cooling capability, and operational problems; engine component technology program, including design, fabrication, and testing of selected critical components, such as fuel and oxidizer rich preburners, main injector, thrust chamber, and main fuel turbopump; pressure-fed breadboard testing of preburner, main injector, and thrust chamber.

Supporting work is needed on low cycle thermal fatigue life of thrust chambers, turbopump bearings and seals, high temperature turbine materials, and cold and hot flow evaluation of plug cluster arrangements to determine nozzle performance losses.

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 3

1. TITLE High Performance Dual Fuel Engines for Booster Applications (Adv. Vehicle)

NO. 9,11,12/P-1/31 (1,7,8,) THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Develop technology for advanced dual fuel engines for hydrocarbon/LOX/hydrogen propellants for use on advanced boosters using mixed mode propulsion.

3. NEED ANALYSIS NOTE: [2] For Dual Throat Config.

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Dual fuel engines are applicable to advanced boosters using mixed mode propulsion. The dual fuel engine burns high density propellants, such as LOX/hydrocarbon early in the flight and switches to LOX/LH_2 later in the flight. Various engine configurations are applicable, including: high pressure tripropellant engine, H_2 cooled; dual throat engine; split combustor aerospike, etc.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE High Performance Dual Fuel Engines for Booster Applications (Adv. Vehicle)

NO. 1,7,8, 9,11,12 / P-1 / 31
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

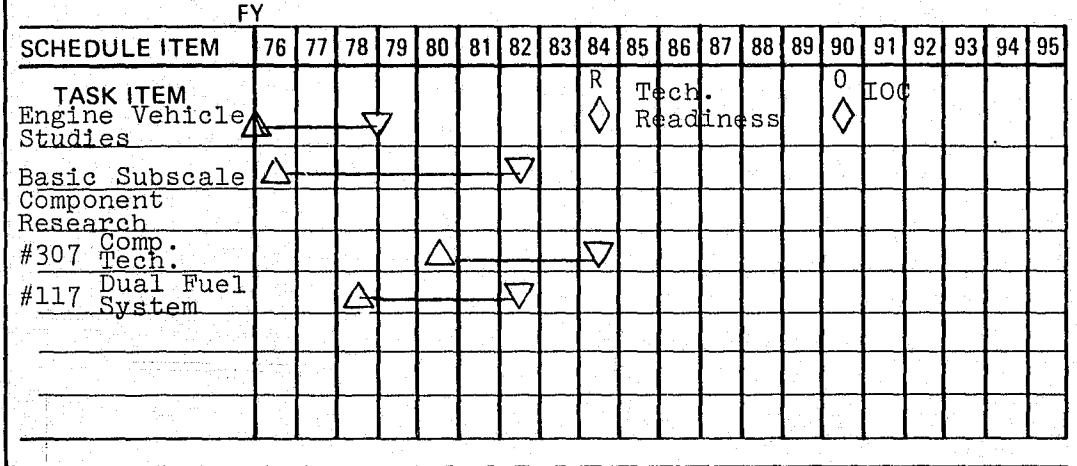
Perform studies to evaluate use of mixed mode propulsion using dual fuel engines for advanced boosters. Perform engine system trade-off and parametric studies to determine fuel and oxidizer combinations, engine turbopump drive cycle, cooling method, and component preliminary design for selected thrust levels in the range from 500,000 to 1,500,000 pounds. (Continued)

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-21-11, 790-40-12. FY 79 New Start #305, "Plug Cluster Engine." FY 80 New Start #307, "Comp. Tech. for High Pressure LOX/Hydrocarbon Booster Engine." FY 78 New Start #117, "Advanced Dual Fuel Propulsion System."

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE High Performance Dual Fuel Engines for Booster Applications (Adv. Vehicle)

NO. 1.7.8 9.11.12/P-1/31
THEME / W.G. / TASK

DATE 4/28/76

(6) **CONTINUATION (If Needed)**
Block No.

Perform component technology programs based on selection of critical components for the engine configuration and propellant combination selector.

The technology in this area is supported by work on high pressure H_2-O_2 booster engines and high performance LOX/hydrocarbon engines and also requires additional work on specific problem areas related to the use of two propellant combinations in the same engine.

SPACE TECHNOLOGY NEED — **FORM NO. I**

PAGE 1 OF 2

1. TITLE Composite Engine Technology — NO. 12 / P-1 / 32 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

Develop technology for composite (rocket/air breathing) engines for advanced horizontal take-off, horizontal landing (HTOHL) shuttle type vehicles.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY DATE: 1990

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

The technology advancements required are dependent upon the engine concept selected (ducted rocket, ejector ramjet, scramjet, air turborocket, lace cycles, and others) but include, for example, engine cooling, afterburner design, and variable area inlet control.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I** — PAGE 2 OF 2

TITLE Composite Engine Technology

NO. 12 / P-1 / 32 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

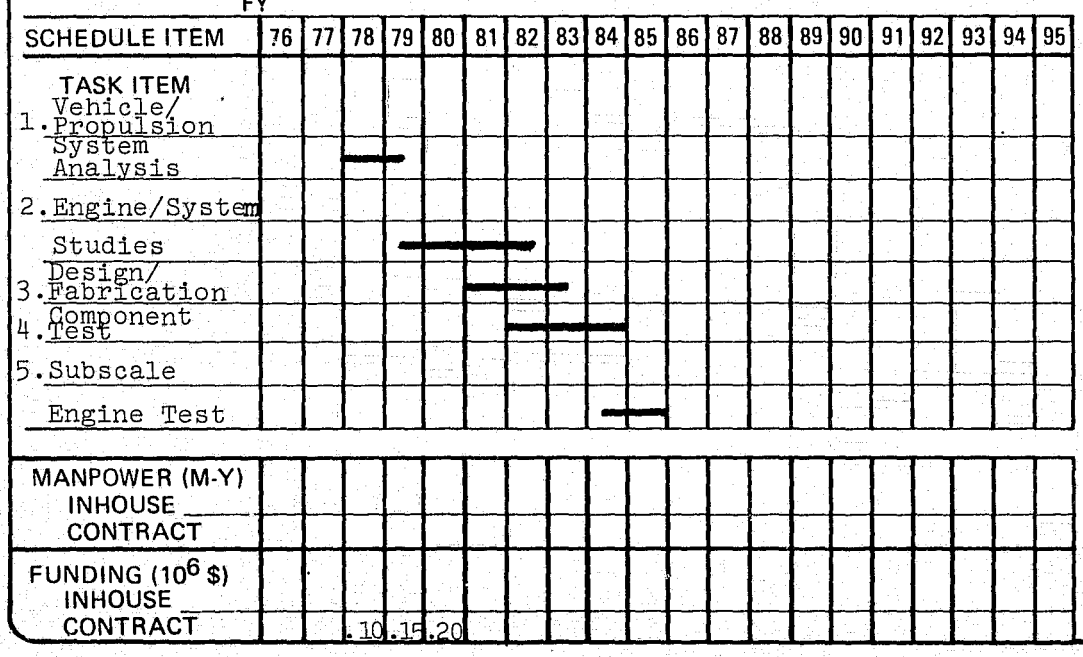
Conduct vehicle/propulsion system analysis of HTOHL fully reusable two-stage-to-orbit shuttle vehicles for the post 1990 time period that utilize composite engines. Select engine concept and perform technology program to bring composite engine technology to maturity by 1985.

7. ALTERNATIVE APPROACHES/OPTIONS Alternative approaches to the HTOHL concept are all rocket vehicles of one or two-stage-to-orbit design which generally have higher gross lift-off weight, higher propellant consumption, and higher launch cost per pound of payload.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF 2

1. TITLE NEP System Technology NO. 12-10/P-1/ 41
THEME / W.G. / TASK

DATE 4 / 27 / 76

2. OBJECTIVE

Develop system technology necessary for integration of thrust and power subsystems into high power level NEP spacecraft. Examine ways of extending lifetimes to 25 years.

3. NEED ANALYSIS

a) LEVEL NOW ☐, WILL BE LEVEL ☐ UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL ☐ FOR OPERATIONAL SYSTEM USE BY DATE: 1995

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH ☐ MEDIUM ☒ LOW ☐

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING ☒ OR ENHANCING: HIGH ☐ MEDIUM ☐ LOW ☐

e) TASKS NEEDED: STUDY ☒ ANALYSIS ☒ RESEARCH ☒
GRD TEST ☐ AIR CRAFT TEST ☐ SPACE FLIGHT TEST ☐
OTHER (Specify) ☐ (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Nuclear-thermonic power system ion thruster technology.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

A single size nuclear reactor of limited lifetime will most probably be developed for space applications. Vehicles that will require increased power levels will require multiple reactors. This effort will determine the interconnection of expected interactions between units. Lifetime limitations of the single reactor design will have to be extended to providelong-lived vehicles. Conduct initial system tests.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE NEP System Technology

NO 12-10/P1/41
THEME / W.G. / TASK

DATE 4 / 27/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

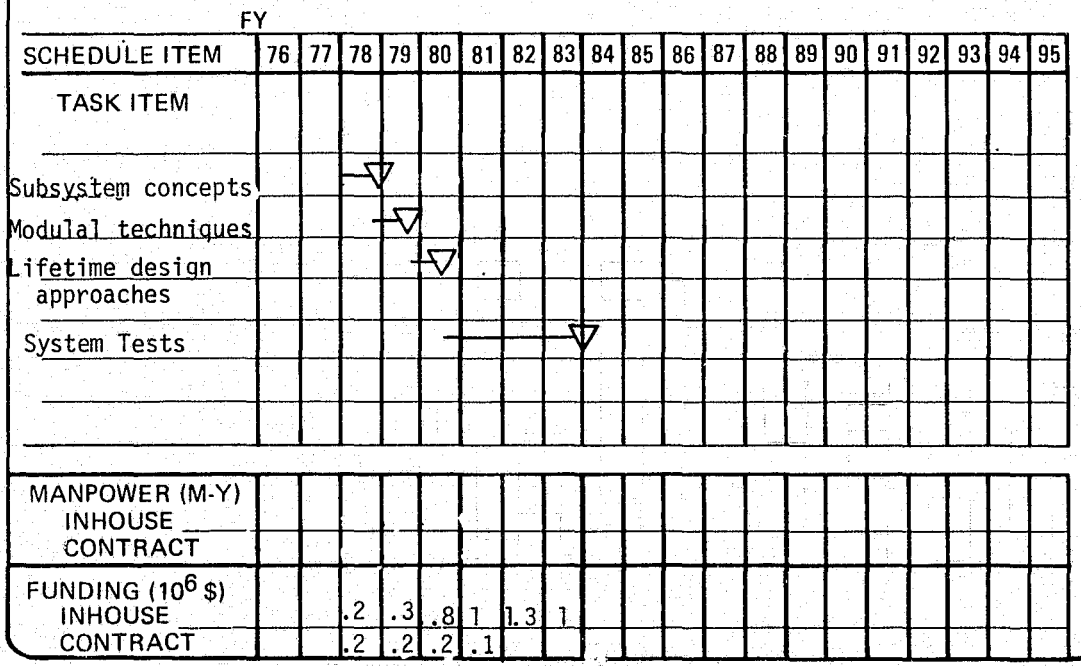
1) ~~Develop thrust subsystem concepts needed for high power NEP vehicles.~~
2) Determine modular techniques for incorporating multiple nuclear reactors in a NEP vehicle
3) ~~Determine lifetime limitations & identify approaches to obtain a long lived system.~~
4) Setup and conduct initial system tests.

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

Nuclear thermonic power subsystem technology.

9. TECHNOLOGY SCHEDULES



SPACE TECHNOLOGY NEED **FORM NO. I**

PAGE 1 OF 2

1. TITLE High Isp Ion Thruster System for Planetary Propulsion

NO. 10/P1/42
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE
Demonstrate the technology for an ion thruster thrust subsystem for planetary propulsion applications

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1984]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY High power lightweight solar arrays.
Lt. wt. high eff. pwr processors

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Ground test of complete systems
(2) Demonstration of system life
(3) Measurement of interactions between system elements and with spacecraft

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE High Isp Ion Thruster System for Planetary Propulsion (SEP)

NO. 10/P1/42
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Maintain Present Technology Program

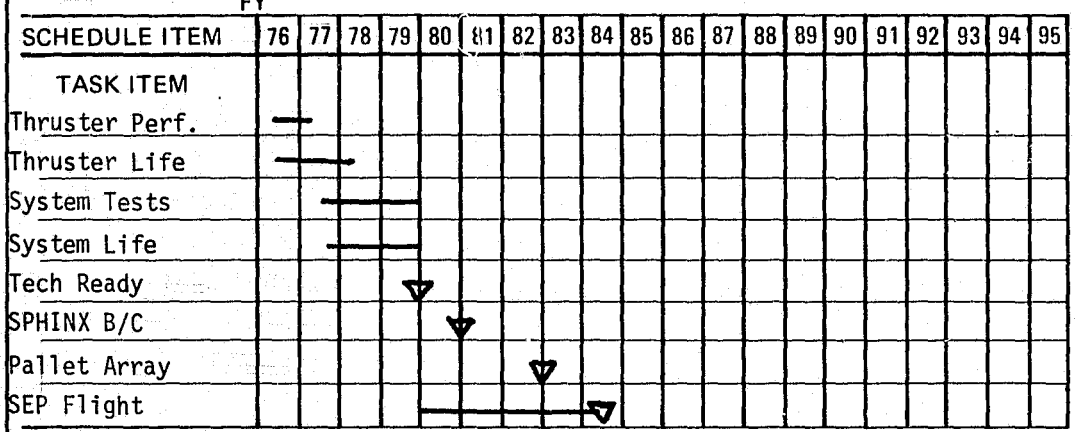
(2) Perform Flight Demonstration of Representative Technology
SPHINX B/C
Propulsion Pallet Experiment w/TSS Array

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-22-30, 506-22-40
SPHINX B/C, Propulsion Pallet Tests

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	44	48	48	24	4	4	4	4	4											
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	1.7	1.5	1.0	1.0	.2	.2	.2	.2	.2											
CONTRACT	1.7	1.5	1.0	1.0	.25	.25	.25	.25	.25											

SPACE TECHNOLOGY NEED — **FORM NO. I**

PAGE 1 OF 2

1. TITLE Solar Sailing Technology Program — NO. 10 /P-1/ 44 (THEME / W.G. / TASK)

DATE 4 /28 / 76

2. OBJECTIVE

Develop and demonstrate the capability to deploy and control a solar sail up to 1 sq km

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990+]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [ ] MEDIUM [X] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Deployment and/or assembly of large-light weight structures; control of large light-weight structures

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

1. Deployment, control of large space structures in space.
2. Development of light-weight, long lifetime solar sail material capable of passing through the earth's radiation belts and be able to travel to within 0.2 AU.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

TITLE Solar Sailing Technology Program

NO. 10 P-1 44
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

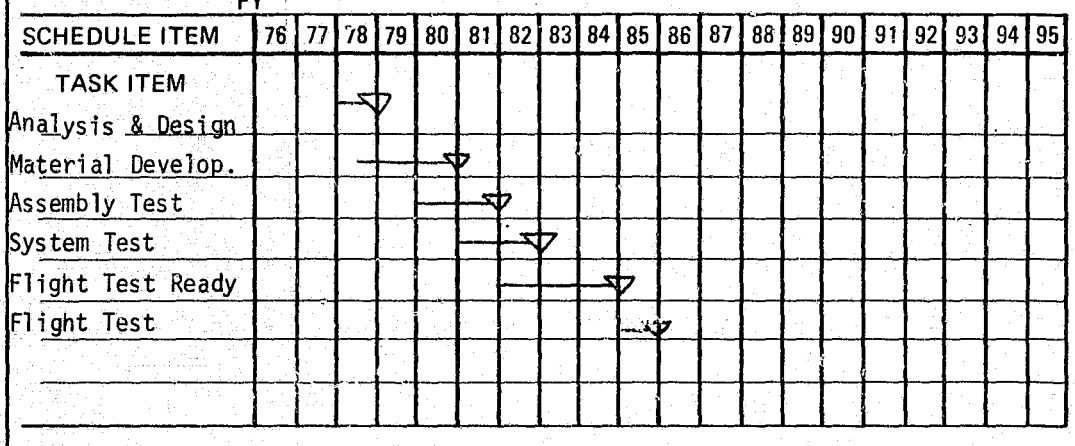
Conduct feasibility design studies and component tests leading to a prototype demonstration flight test.

7. ALTERNATIVE APPROACHES/OPTIONS NEP , SEP

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

NONE

9. TECHNOLOGY SCHEDULES



* Not including launch vehicle

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Sterilizable Solid Propellant Rocket for Sample Return Propulsion

NO. 10/P-1/45
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Demonstrate solid propellant rockets that can withstand heat sterilization cycling to assure planetary quarantine for planetary probes or ascent from planet surfaces.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Formulate and demonstrate propellant with adequate thermal stability to resist degradation during sterilization heat cycling in a motor which has reasonably high mass fraction; demonstrate a propellant charge support system consistent with the mass fraction.

LEVEL OF STATE OF THE ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Sterilizable Solid Propellant Rocket for Sample Return Propulsion

NO. 10/P-1/45
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Evaluate oxidizers and binders with high temperature stability and evaluate charge support designs which do not decrease mass fraction. Heat-cycle propellant charges and complete motor systems, space-age the motors, and conduct verification tests at simulated altitude conditions.

7. ALTERNATIVE APPROACHES/OPTIONS Use higher risk and lower performance chemical systems.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-21-32 (Advanced Solid Propulsion Concepts)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Propellant development			--	--																
Charge Support Test			--	--	--	--														
Full scale motor cycling							--	--												
Aging tests									--	--	--									
Motor test firing												--	--							
MANPOWER (M-Y) INHOUSE			2	2	2	2	2	2	.5	.5	.5	2	2							
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.15	.15	.15	.15	.15	.15	.03	.03	.03	.15	.15							
CONTRACT			0	0	0	.3	.3	.3	0	0	0	0	0							

SPACE TECHNOLOGY NEED

FORM NO. 1

1. TITLE Space Storable Propulsion with Hydrogen Injection

NO 10-12/P-1/46
THEME / W.G. / TASK

DATE 4 /28 /76

2. OBJECTIVE

Demonstrate a flight-weight F_2/H_2 propulsion subsystem applicable to personnel orbital transfer vehicle and planetary spacecraft.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1987]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Demonstration of pumps compatible with F_2/N_2H_4 at engine thrust levels of about 3,000 lb_f; demonstration of components including injector to inject hydrogen as a tripropellant and to use it as an engine coolant; demonstration of increased Isp from 370s to 425s.

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD VALIDATED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Space Storable Propulsion with Hydrogen Injection

NO 10-12/P-1/46
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Complete the currently funded demonstration of F_2/N_2H_4 system for spacecraft and conduct component and subassembly tests to demonstrate the improvement from H_2 used as the third propellant element and as a coolant from H_2 boil-off; demonstrate redundant solenoid valves for reuseable POTV main propulsion (as opposed to pyro-valves for spacecraft propulsion). Conduct system testing at simulated altitude.

7. ALTERNATIVE APPROACHES/OPTIONS

Use currently available propellants.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 525-71-21

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Analysis & Design			--	▼																
Injection Development				--	--	--	▼													
Component Development				--	--	--	--	▼												
Assembly								--	--	▼										
Tests									--	--										
MANPOWER (M-Y) INHOUSE			3	4	4	4	4	3	3	2										
MANPOWER (M-Y) CONTRACT																				
FUNDING (10^6 $) INHOUSE			.2	.3	.3	.4	.4	.3	.3	.2										
FUNDING (10^6 $) CONTRACT			0	.2	.3	.4	.4	.2	.2	0										

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 1 OF 2

1. TITLE Utilization of Indigenous Materials for Propulsion

NO. 10-12/P-1/47
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE Demonstrate the use of the mass of extra-terrestrial surface material, planetary atmosphere, and waste for propulsion.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Adequate verification of the physical and chemical characteristics of the predicated lunar or planetary materials and planetary atmospheres.

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Demonstrate the most applicable concepts for reacting indigenous materials with stored reactants and evaluate their characteristics; devise design criteria.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Utilization of Indigenous Materials for Propulsion

NO. 10-12/P-1/47
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Identify concepts for reacting indigenous materials with stored reactants and evaluate their characteristics. Devise new schemes, compare concepts, test and develop the most applicable technologies.

7. ALTERNATIVE APPROACHES/OPTIONS Carrying mass of propellant from Earth.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-21-43 (New Horizons in Propulsion)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Study			--	--	--	--▽														
Selected Approaches				--▽		--▽														
Lab Tests				--	--	--	--	--▽												
Breadboard tests									--	--▽										
MANPOWER (M-Y) INHOUSE			1.5	2.5	2.5	2.5	2.5	2.5	3.0	2.5										
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.1	.2	.2	.2	.2	.2	.6	.4										
CONTRACT			0	0	0	0	0	0	.3	.2										

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Propulsion in Planetary Atmospheres

NO. 10/P-1/48
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Provide an efficient propulsion system for probe or attitude propulsion operating in very dense planetary atmospheres.

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY Adequate verification of the physical and chemical characteristics of the predicated planetary atmosphere(s).

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Provide prototype detonation propulsion system using small charges of explosive repetitivety detonated in an expanded nozzle to provide an impulse. This impulse is independent of atmosphere to the first order.

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 2

TITLE Propulsion in Planetary Atmospheres

NO. 10/P-1/48
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Complete the component designs and tests and assemble a prototype which can be subjected to space- and planetary-simulated environmental exposure and operated in a simulated desnse planetary atmosphere.

7. ALTERNATIVE APPROACHES/OPTIONS Low efficiency chemical rockets

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-21-32 (Advanced Solid Propulsion Concepts)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Component Tests			--	--	--	--	--	▽												
Prototype assembly								--	▽											
Prototype testing										▽	-- ▽									
MANPOWER (M-Y) INHOUSE			1.5	1.5	1.5	1.5	1.5	3.0	3.0	2.0	2.0									
CONTRACT																				
FUNDING (10^6 $) INHOUSE			.1	.1	.1	.1	.1	.3	.3	.3	.2									
CONTRACT			0	0	0	0	0	0	.2	.2	0									

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Hi Specific Impulse Ion Thrusters for On-Orbit Operations

NO. 7,8,9,10,11/P1/49
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE
To develop Ion Thruster Systems to provide station keeping for orbital systems using low cost inert fuels

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE:1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [ ] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Scaling of present thruster systems to required sizes
(2) Efficient operation demonstration with inert gases
(3) Demonstration of total impulse and cyclic life

LEVEL OF STATE OF ART
1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

TITLE Hi Specific Impulse Ion Thrusters for On-Orbit Operations

NO. 7,8,9,10,11/P1/49
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

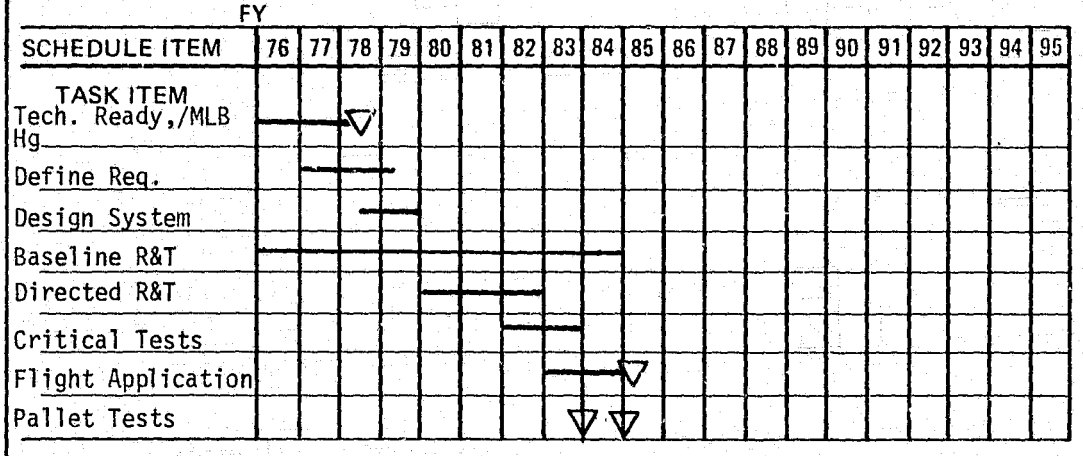
(1) Complete Hg Aux Thruster Program
(2) Define System Operating Requirements
(3) Design Thruster System
(4) Incorporate into Existing Technology Program
(5) Perform Directed R&T
(6) Demonstrate Critical Performance Parameters

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-22-11, 506-22-40, 506-22-30
SPHINX B/C, Propulsion Pallet Experiment
LeRC FY 78 New Initiative for Thrust Sub-System Tech. Dev.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	15	15	15	15	15	15	15	15												
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.4	.4	.4	.5	1	1	.5	.5												
CONTRACT	.43	.46	1	1	1	1	.5	.5												

SPACE TECHNOLOGY NEED **FORM NO. I**

1. TITLE MONOPROPELLANT HYDRAZINE PROPULSION FOR ON-ORBIT STATION-KEEPING

NO. 10-12 P-1 51
THEME / W.G. / TASK

DATE 4 / 27 76

2. OBJECTIVE

INCREASE THE OPERATIONAL LIFE OF N_2H_4 THRUSTERS WITH EMPHASIS ON IMPROVEMENT OF CATALYST BED DESIGNS FOR UNITS WITH THRUSTS RANGING FROM 10^{-3} LBF TO 10^{2} LBF. PROVIDE LOW-GRAVITY ACQUISITION SYSTEM.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1982]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [ ] OR ENHANCING: HIGH [X] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE YES

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY NONE

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

CHARACTERIZE HYDRAZINE CATALYST BEDS WITH RESPECT TO STRUCTURE AND REACTIVITY. DEMONSTRATE LONG LIFE THRUSTER. DEMONSTRATE CAPABILITY OF PROPELLANT ACQUISITION DEVICE TO OPERATE UNDER SIMULATED HIGH "G" ENVIRONMENT.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE MONOPROPELLANT HYDRAZINE PROPULSION FOR ON-ORBIT STATION-KEEPING

NO. 10-12 P-1 51
THEME / W.G. / TASK

DATE 4 / 27 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

UTILIZE GAS GENERATORS TECHNOLOGY FROM SPACE SHUTTLE AND PLANETARY SPACECRAFT. DETERMINE SERVICE LIFE OF A RADIAL FLOW HYDRAZINE THRUSTER. DETERMINE OPTIMUM DESIGN TO MINIMIZE REFURBISHMENT COST AND/OR MAXIMIZE LIFE. DESIGN, FABRICATE & TEST A HYDRAZINE PROPELLANT ACQUISITION SYSTEM EMPLOYING A SURFACE TENSION DEVICE. INTEGRATE THE TWO DEVICES, TEST ON GROUND, AND IN SPACE ENVIRONMENT.

7. ALTERNATIVE APPROACHES/OPTIONS H-O AUXILIARY PROPULSION SYSTEM, BI-PROPELLANT AUXILIARY PROPULSION SYSTEM.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

910-04-01; 910-04-02
506-21-51

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
THRUSTER:																				
Design & Anal.	—																			
Fab. & Test		—																		
ACQUISITION:																				
Design & Anal.	—																			
Fab. & Test		—																		
Gnd Test Integ.			—																	
Space Test						—														
MANPOWER (M-Y)																				
INHOUSE	.5	1	4	4	.5	2	2													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.1	.2	.2	.2		.3	.2													
CONTRACT	.15	.29	.2	.3		TB	D													

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 2

1. TITLE Photochemical Production of Hydrogen and Oxygen for Propellant Application

NO. 12-1/P-1/52
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Demonstrate the feasibility of direct conversion of hydrogen and oxygen from water using solar radiation for propellant applications.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [2] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [4] FOR OPERATIONAL SYSTEM USE BY [DATE: 1995]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [X] MEDIUM [ ] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [X]
GRD TEST [ ] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY None

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Determine the feasibility and economics of direct conversion of water to hydrogen and oxygen without use of fossil fuels or nuclear sources in an energy-conservative method.

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I

PAGE 2 OF 2

TITLE Photochemical Production of Hydrogen and Oxygen for Propellant Application

NO. 12-1/P-1/52

THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Research the direct conversion of water by sea-level solar radiation to H_2 and O_2 via the photo-oxidation and reduction reactions in the presence of inorganic species.

7. ALTERNATIVE APPROACHES/OPTIONS Conversion of coal by gasification methods (dependence on fossil fuel); nuclear powered electrolysis; thermochemical cycles.

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

None. (ERDA sponsoring some thermochemical cycle work at LaRC)

9. TECHNOLOGY SCHEDULES

FY / SCHEDULE ITEM	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Research			--	--	--															
Target for Assessment					▽															
MANPOWER (M-Y) INHOUSE			2	2	2															
CONTRACT			0	0	0															
FUNDING (10^6 $) INHOUSE			.15	.15	.15															
CONTRACT			0	0	0															

C-4

SPACE TECHNOLOGY NEED **FORM NO. 1**

PAGE 1 OF 2

1. TITLE Ion Thruster Baseline R&T NO. 1 / P1 /53
THEME / W.G. / TASK

DATE 4 /28 / 76

2. OBJECTIVE
To Maintain and Explore Advancement in Basic Ion Thruster Technology

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [ ] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Research on Performance Enhancement
(2) Extension of Operating Life
(3) Simplification of Thruster System
(4) Understanding of Basic Phenomena
(5) Reliability Improvement
(6) Plume Definition and Control

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Ion Thruster Baseline R&T

NO. 1 / P1 / 53
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Maintain and/or Augment Present Baseline R&T

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-22-40

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
Base R&T	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
MANPOWER (M-Y) INHOUSE	7	10	10	10	10	10	10	10	10	10	10	10	10	10	10					
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.25	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5					
CONTRACT	.25	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5					

SPACE TECHNOLOGY NEED **FORM NO. I**

PAGE 1 OF 2

1. TITLE Ion Beam Applications Research (IBAR) NO. 1 / P1 / 54
THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE
To Develop Unique Capabilities of Ion Thruster Technology for Non-Propulsive Applications

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR
ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Understanding of Sputter Process

(2) Microscopic Cone Growth for:

Biomedical App., Thermal Control, Adhesion

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Ion Beam Applications Research (IBAR)

NO. 1 / P1 / 54
THEME / W.G. / TASK

DATE 4 / 28/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Source Modification
(2) Applications Investigation
(3) User Involvement
(4) Systems Development
(5) Tech Transfer to User

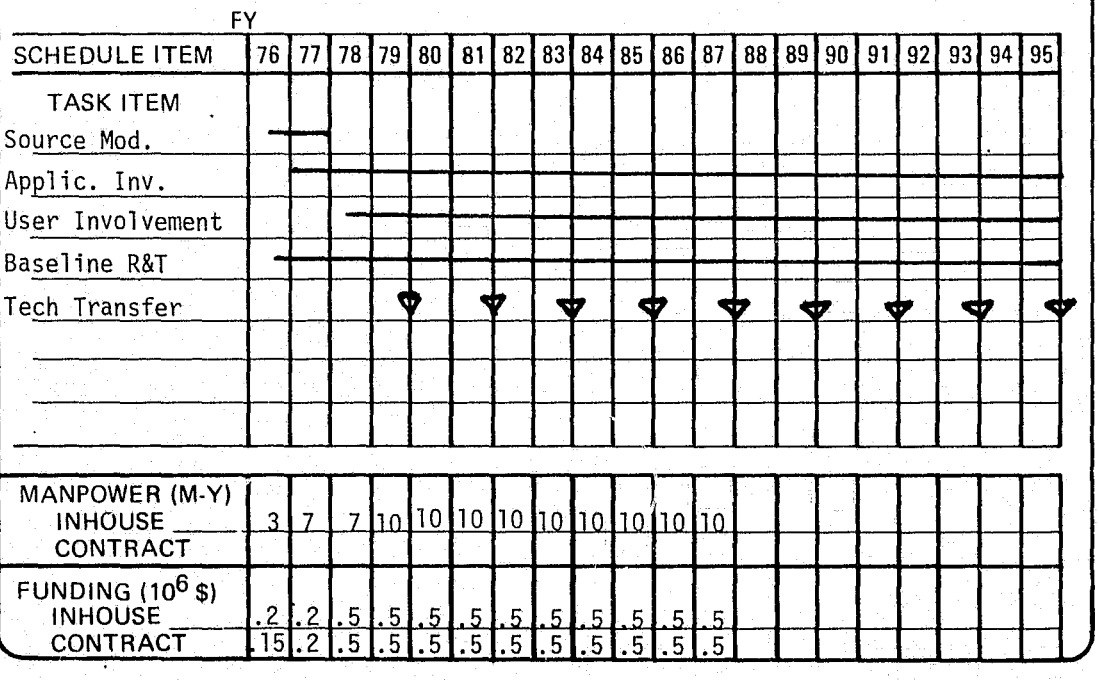
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-22-40, 506-22-43

LeRC FY78 new initiative to expand tech. program.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	3	7	7	10	10	10	10	10	10	10	10	10								
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.2	.2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5								
CONTRACT	.15	.2	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5								

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED — **FORM NO. I**

1. TITLE Ion Beam Application to Space Manufacturing — NO. 8 /P1/55 (THEME / W.G. / TASK)

DATE 4 / 28 / 76

2. OBJECTIVE

To Provide Technology to Fabricate Unique Materials in Space

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE:1982]

c) RISK IN ACHIEVING ADVANCEMENT: HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X] GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ] OTHER (Specify) [ ] (Check one or more)

f) R&T BASE CANDIDATE

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Technology for deposition of large solar reflectors, thermal control surfaces, transparent conductive surfaces, in situ, from space platform.

(2) Zero gravity fabrication of materials; to enhance growth of large crystals.

(3) Deposition of high purity materials for in situ manufacture of thin film solar arrays.

SPACE TECHNOLOGY NEED

FORM NO. I

TITLE Ion Beam Applications to Space Manufacturing

NO. 8 / P1 / 55
THEME / W.G. / TASK

DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

(1) Correlate Unique Capabilities of Ion Beam Manufacturing to Requirements of Space Systems

(2) Breadboard Demonstration on Ground

(3) Shuttle Experiment Verification

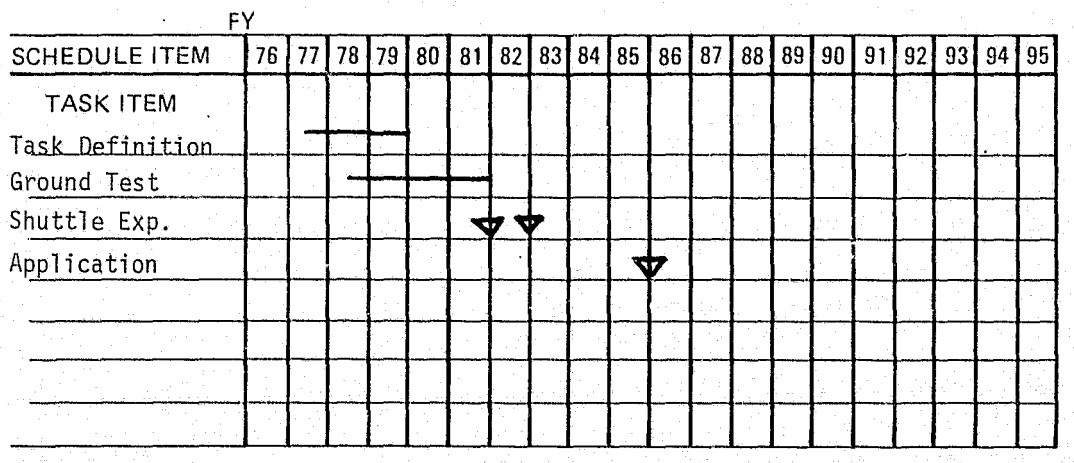
7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

506-22-43, 506-22-40

LeRC FY78 new initiative to develop technology to flight demonstration.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y)																				
INHOUSE	7	10	10	15	15	15	15													
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	.2	.2	.5	1.0	1.0	1.0	1.0													
CONTRACT	.05	.2	.5	1.0	1.0	1.0	1.0													

SPACE TECHNOLOGY NEED

FORM NO. 1

PAGE 1 OF 4

1. TITLE Enabling Technology for Chemical Rocket Systems to Improve Performance, Increase Life, Reduce Cost & Simplify Operations

NO. 1-12 (P-1) 56
THEME / W.G. / TASK

DATE 4/28/76

2. OBJECTIVE

~~Provide constituent and component technology to enable the~~ development of advanced space transportation system chemical propulsion systems.

3. NEED ANALYSIS

a) LEVEL NOW [2], WILL BE LEVEL [3] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [5] FOR OPERATIONAL SYSTEM USE BY [DATE] 1985+

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

Constituent and component technology will be conducted to enable advanced chemical system development. Advancements required are:

1. Reduction of component cost
2. Increase in component life (enhanced reuse)
3. Increase in overall performance
4. Decrease in component weight
5. Easing of component checkout procedures to reduce operational complexity through automation.

LEVEL OF STATE OF ART

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. 1
PAGE 2 OF 4

TITLE Enabling Technology for Chemical Rockets NO. 1-12/P-1/56
THEME / W.G. / TASK

~~Systems to Improve Performance, Increase Life, Reduce Cost & Simplify Operations~~ DATE 4 / 28 / 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

Component technology will be concentrated on improving the overall ~~component performance to achieve the enhancements discussed for each of the following: Combustion Chambers, Nozzles,~~ Injectors, Ignitors, Pumps, Turbine Drives, Valves, Gas Generators, Preburners and Hot Gas Manifolds.

(Continued on next page)

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

9. TECHNOLOGY SCHEDULES

SCHEDULE ITEM (FY)	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK ITEM																				
T. B. D.																				
MANPOWER (M-Y)																				
INHOUSE	10	15	20	20	20	20	20	20	20	20										
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0										
CONTRACT	1.5	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0										

1. TITLE Enabling Technology for Chemical Rocket Systems to Improve Performance, Increase Life, Reduce Cost and Simplify Operations

NO. 1-12/P-1/S-6
THEME / W.G. / TASK

DATE 4 /28 /76

(6) CONTINUATION (If Needed)
Block No.

1. Combustion Chambers - To accomplish the advancements required, efforts will be directed to improvin g thrust chamber wall cooling, development of advanced materials and fabrication techniques. This program should provide the technology to increase chamber life, reduce fabrication cost, decrease chamber weight and ease refurbishment and checkout.

2. Nozzles - Significant performance increases can be realized through high area ratio nozzles in upperstage vehicles and through area ratio variability for launch vehicles. Novel approaches to nozzle design (i.e. external expanding nozzles) can provide improved vehicle/engine integration as well as altitude compensation for launch vehicles.

3. Injectors - Rocket engine combustion efficiency and stability are functions of injector parameters. Faceplate cooling improvements are needed to improve life, as well as new approaches to faceplate fabrication techniques and materials.

4. Ignitors - Materials, cooling and fabrication techniques are known. Work must be directed toward exciter (spark plug and electronics) to extend life beyond present state-of-the-art. New techniques must be developed for ignitor systems in annular combustors such as traveling wave ignition.

5. Pumps and Turbine Drives - Advancements are required for high pressure pumps in the areas of bearings and seals to increase component life and enhance pump reuseability. New fabrication techniques must be developed to ease the manufacturing costs.

6. Valves - Technology must be directed toward improvement in valves to allow significant increase in valve and seat life in an environment where contaminants are present in the working fluid.

SPACE TECHNOLOGY NEED

FORM NO. I

1. TITLE Enabling Technology for Chemical Rocket Systems to Improve Performance, Increase Life, Reduce Cost and Simplify Operation

NO. 1-12/P-1/S-6
THEME / W.G. / TASK

DATE 4 / 28 / 76

(6) CONTINUATION (If Needed)
Block No.

7. Gas Generators - PRB Burners & Hot Gas Manifolds - Materials, Fabrication and fluid flow areas must be studied to realize system improvement. Efforts will lead to ease of fabrication which is a cost reduction and improved life.

Constituent Technology will focus on enhancing chemical rocket engine performance in the areas of acoustic noise and vibrations, operations, checkout and maintenance, and engine vehicle optimization.

1. Acoustic Noise and Vibrations - Identification of sources of noise and vibrations in chemical propulsion systems will be made as a first step in a technology program to reduce levels.

2. Operations, checkout and maintenance - Essential to reducing overall costs, design approaches must be used to ease these functions and provide, where possible, automatic man-free activities.

3. Engine/Vehicle Optimization - Studies to identify engine/vehicle optimum configuration will be conducted which take advantage of engine variability and identify total system constraints and drivers.

SPACE TECHNOLOGY ADDITIONAL INITIATIVE **FORM IV**

TITLE Enabling Technology for Chemical Rocket Systems to Improve Performance, Increase Life, Reduce Cost and Simplify Operations **DATE** 4 / 29 / 76

TT NO. 1 & 12 **OR WORKING GROUP NO.** P-1/56

OBJECTIVE
Provide Constituent and Component Technology to Enable the Development of Advanced Space Transportation System Chemical Propulsion Systems.

JUSTIFICATION Reduced cost and component weight, increased component life and performance, and operational simplicity must be achieved to realize the total benefit in advanced space transportation systems.

TECHNICAL APPROACH/PLAN
Constituent and component technology will be persued focused on the above aspects for the following: thrust chambers, nozzles, injectors, ignitors, pumps and turbine drives, valves, gas generators; acoustic noise and vibration, engine-vehicle optimization, and operations, checkout and maintenance.

SCHEDULE

SCHEDULE ITEM	FY 76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
TASK																				
Thrust Chambers																				
Nozzles																				
Injectors & Ignitors																				
Pumps, Turbodrive																				
Valves																				
Engine-Veh. Opt.																				
Noise & Vibrations																				
Ops/Checkout/ Maint.																				
MANPOWER (M-Y)																				
INHOUSE	10	15	20	20	20	20	20	20	20	20										
CONTRACT																				
FUNDING (10^6 $)																				
INHOUSE	1	1	1	1	1	1	1	1	1	1										
CONTRACT	1.5	2	2	2	2	2	2	2	2	2										

PROPOSED LEAD CENTER Lewis Research Center

RECOMMENDATIONS FOR FULLER DEVELOPMENT OF INITIATIVE STATEMENT

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE High Isp Ion Thrust Subsystem for NEP Planetary Propulsion NO. 10/P1/57 THEME / W.G. / TASK

DATE 4 / 28 / 76

2. OBJECTIVE

Develop the technology for an Ion Thruster Subsystem for Planetary Propulsion Applications with NEP

3. NEED ANALYSIS

a) LEVEL NOW [3], WILL BE LEVEL [5] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1990]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [ ] LOW [X]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [X] ANALYSIS [X] RESEARCH [X]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [X]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE _____

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

Development of Nuclear Electric Power Source

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED

(1) Scaling of present thruster systems to required sizes

(2) Element interaction with power source and spacecraft defines

(3) Demonstrate total impulse required for mission applications

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED FORM NO. I

TITLE High Isp Ion Thrust Subsystem for NEP Planetary Propulsion

NO. 10/P1/57
THEME / W.G. / TASK

DATE 4 /28 /76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

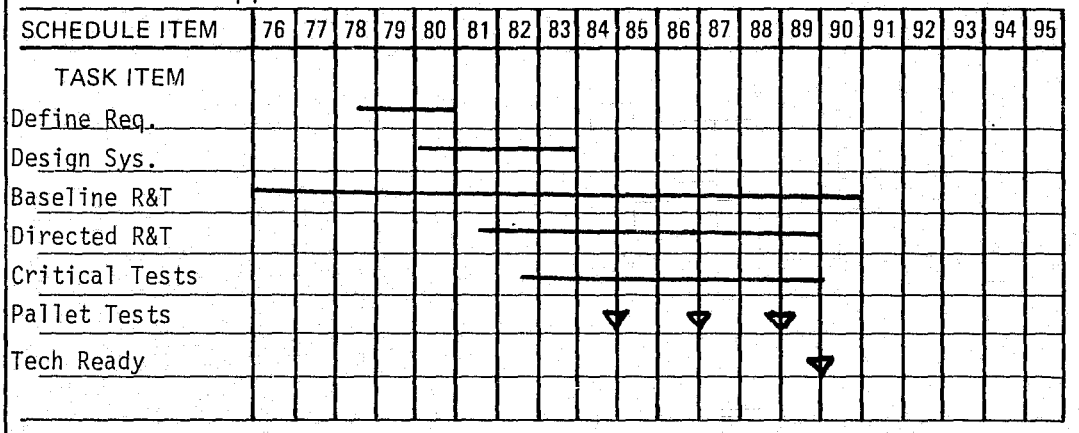
(1) Define System Requirements
(2) Design Thruster System
(3) Incorporate into Existing Technology Program
(4) Perform Directed R&T
(5) Demonstrate Critical Performance Parameters

7. ALTERNATIVE APPROACHES/OPTIONS

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-22-30, 506-22-40
SPHINX B/C, Propulsion Pallet Experiments
LeRC FY79 new initiative to develop thrust subsystem tech.

9. TECHNOLOGY SCHEDULES



	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
MANPOWER (M-Y) INHOUSE	5	7	7	10	10	15	15	20	20	20	20	15	15	10						
CONTRACT																				
FUNDING (10^6 $) INHOUSE	.2	.2	.2	.5	.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0						
CONTRACT	.25	.25	.25	.5	.5	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0						

SPACE TECHNOLOGY NEED FORM NO. I

PAGE 1 OF 2

1. TITLE Solid Rockets for Planetary Spacecraft NO. 10/P-1/58
THEME / W.G. / TASK

DATE 4 / 30 / 76

2. OBJECTIVE
Demonstrate technology of high performance low cost solid propellant motors for use in upper stages or kick stages for planetary spacecraft escape propulsion, and specialized motors for penetrators and probes.

3. NEED ANALYSIS

a) LEVEL NOW [4], WILL BE LEVEL [4] UNDER EXISTING PLANS.

b) REQUIRED ADVANCEMENT – SHOULD BE TECHNOLOGY READY AT LEVEL [7] FOR OPERATIONAL SYSTEM USE BY [DATE: 1985]

c) RISK IN ACHIEVING ADVANCEMENT:
HIGH [ ] MEDIUM [X] LOW [ ]

d) CRITICALITY TO THE ACCOMPLISHMENTS: ENABLING [X] OR ENHANCING: HIGH [ ] MEDIUM [ ] LOW [ ]

e) TASKS NEEDED: STUDY [ ] ANALYSIS [ ] RESEARCH [ ]
GRD TEST [X] AIR CRAFT TEST [ ] SPACE FLIGHT TEST [ ]
OTHER (Specify) [ ] _____ (Check one or more)

f) R&T BASE CANDIDATE Yes. FY78 #750K

4. COMPLEMENTARY TECHNOLOGY ADVANCEMENTS REQUIRED FOR USE OF THIS TECHNOLOGY

5. SPECIFY TECHNOLOGY ADVANCEMENT REQUIRED TO ACCOMPLISH NEED
Chambers using carbon-fiber carbon matrix material so that inert case insulation can be eliminated and propellant placed in the volume that was occupied by the insulation; Class 2 propellants with high performance; thrust vector control system using light-weight moveable nozzles with low actuation power requirements; motors for possible tube-launched penetrators; motors for probes from planetary exploration facility to planets.

LEVEL OF STATE OF ART

1. BASIC PHENOMENA OBSERVED AND REPORTED
2. THEORY FORMULATED TO DESCRIBE PHENOMENA
3. THEORY TESTED BY PHYSICAL EXPERIMENT OR MATHEMATICAL MODEL
4. PERTINENT FUNCTION OR CHARACTERISTIC DEMONSTRATED
5. COMPONENT OR BREADBOARD TESTED IN RELEVANT ENVIRONMENT IN THE LABORATORY
6. MODEL TESTED IN AIRCRAFT ENVIRONMENT
7. MODEL TESTED IN SPACE ENVIRONMENT

SPACE TECHNOLOGY NEED

FORM NO. I
PAGE 2 OF 2

TITLE Solid Rockets for Planetary Spacecraft

NO. 10/P-1/58
THEME / W.G. / TASK

DATE 4 / 30/ 76

6. RECOMMENDED APPROACH/PROGRAM PLAN TO ACCOMPLISH NEED

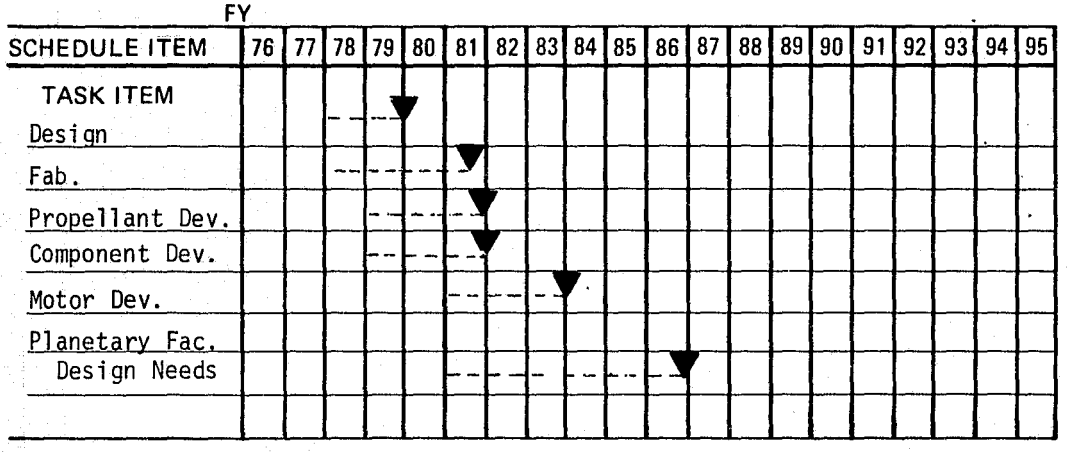
Evolve this program from the on-going R&T program and exploit all DOD technology advancements to minimize cost. Evaluate, design, and test component (nozzles, cases, and insulation) and integrate into complete motor. Explore specialized needs of planetary exploration facility to include designs of capability to replace solid motors in a reusable planetary lander.

7. ALTERNATIVE APPROACHES/OPTIONS Liquid chemical systems, SEP or NEP. (Liquids may not be compatible with AF/IUS and SEP and NEP are not schedule compatible.)

8. CURRENT/PLANNED RELATED ACTIVITIES (RTOP, OTHER)

RTOP 506-21-32 (Advanced Solid Propulsion Concepts)

9. TECHNOLOGY SCHEDULES



	78	79	80	81	82	83	84	85	86
MANPOWER (M-Y) INHOUSE	4	4	6	6	6	4	2	2	2
CONTRACT									
FUNDING (10^6 $) INHOUSE	.4	.4	.4	.4	.4	.3	.1	.1	.1
CONTRACT	.3	.3	.5	.5	.5	0	0	0	0

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-1

DATE 4/28/76 / 4/29/76

TECHNOLOGY NEED NO. \ THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
							Current	R&T Base	WG	TT	OAST DIV.	
1. H_2-O_2 High Perf. Reusable Main Prop. System for OTV	2	2	2			2	✓	✓				
2. Dual Fuel Engine Tech. for Mixed Mode OTV	3	3	3			3		✓				
3. Liquid/Solid Hybrid Prop. for OTV	4	4	4			4		✓				
4. Solid Prop. Advanced Technology Motor		1		1		1	✓	✓				
6. Atomic Metallic H_2 Prop. Technology	6	6	6		6	6	✓	✓				
7. Storage, Supply & Transfer of Cryogenic Fluids in Space	2	2	2			2	✓	✓				
8. Liquid H_2/Liquid O_2 Attitude Control Systems	4	4	4		4	4	✓	✓				
9. Earth Storable Prop. for Planetary Spacecraft	3	3	3			3		✓				
11. Resistojet for C(OTV) Propulsion SEP-NEP	5	5	5	5	5	5	✓	✓				
12. MPD Thrustor System Technology Readiness	1	1	1	1	1	1		✓				
13. High Isp Electric Prop. for OTV	1	1	1	1	1	1	✓	✓				
15. Solar Heated Hydrogen Thruster	5	5	5	5	5	5		✓				
16. Laser Prop. System for OTV	5	5	5	5	5	5	✓	✓				

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-1

DATE 4/28/76

TECHNOLOGY NEED NO. \ THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV.TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
							Current	R&T Base	WG	TT	OAST DIV.	
17. H_2-O_2 Bell Nozzle Engine ADV. SSME		3	3	3		3		✓				
19. Air Augment Earth to Orbit Chem. Rocket Engines		1	1	1		1		✓				
20. Liquid H_2/Liquid O_2 Attitude Control Systems for LV		2	2	2		2		✓				
21. Aux. Prop. Low Cost Prop. for OTV, HLLV, HLLV2 & Adv. Veh.		2	2	2		2		✓				
22. Advance H_2/O_2 Prop. System for Launch Vehicle	2	2	2		2	2		✓				
23. High Perf. LOX/HC Prop. for Boosters		4	4			4	✓	✓				
24. High Perf. Dual Fuel Engines for Boosters		5	5			5	✓	✓				
25. Liquid H_2/Liquid O_2 Attitude Control Systems for L.V.		4	4			4		✓				
26. High Perf. H_2-O_2 Reusable Prop. in Systems for OMS		4	4			4	✓	✓				
30. High Perf. LOX/HC Propulsion for Boosters	3	3	3		3	3	✓	✓				
31. High Perf. Dual Fuel Engines for Boosters	4	4	4		4	4		✓				
32. Composite Engine Technology	5	5	5		5	5		✓				
41. NEP System Technology				4								

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-1

DATE 4/28/76

TECHNOLOGY NEED NO. \ THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
							Current	R&T Base	WG	TT	OAST DIV.	
42. High Isp Ion Thruster for Planetary Prop.				1			✓	✓				
44. Solar Sailing Technology Program			5	5				✓				
45. Sterilizable Solid Rocket for Sample Return				2			✓	✓				
46. Space Storable Propulsion with Hydrogen Injection				3				✓				
47. Utilization of Indigenous Materials for Propulsion				3			✓	✓				
48. Propulsion in Planetary Atmosphere				2			✓	✓				
49. High Isp Ion Thruster for On-Orbit Operations	1	1	1	1	1	1	✓	✓				
51. Monopropellant N_2H_4 Prop. for On-Orbit Station Keeping	3	3	3	3	3	3	✓	✓				
52. Photochemical Production of H_2 & O_2 for Propellants								✓				
53. Ion Thruster Baseline R&T							✓	✓				
54. Ion Beam Application Research (IBAR)							✓	✓				
55. Ion Beam Application to Space Manufacturing							✓	✓				
56. Enabling Tech. for Chemical Rocket Systems						1	✓	✓				

SPACE TECHNOLOGY NEED PRIORITY ASSESSMENT

FORM II
FORM III

(List in numerical order, 1 — Highest Priority)

WORKING GROUP P-1

DATE 4 / 28 / 76

TECHNOLOGY NEED NO. / THEME NO.	7 SPACE POWER	8 SPACE INDUST.	9 SETI	10 SOLAR SYS. EXPL.	11 GLOBAL SERVICE	12 ADV. TRANS. SYS.	NASA R&T		SUMMARY PRIORITY ASSESSMENT			
							Current	R&T Base	WG	TT	OAST DIV.	
57. High Isp Ion Thruster Sys. for NEP Planetary Prop.				✓			✓	✓				
58. Solid Rockets for Planetary Propulsion				✓			✓	✓				