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STI/E-TR-25066
May 1983

TRACKING AND DATA ACQUISITION SYSTEM
FOR THE 1990's

VOLUME II

USER COMMUNITY CHARACTERISTICS

DRAFT FINAL REPORT

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(NASA-CR-175194) STUDY OF A TRACKING AND
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16. Abstract This report is the Draft Final Report for Task 1, User Community Characteristics. It will be re-issued as part of the contract final report, and will then contain updated material based on inputs obtained from subsequent tasks. For example, navigation forecasting will reflect TDAS capabilities derived from Task 5 "TDAS System Architecture". This report is intended to develop the scenarios of experiments that will form the basis for generating alternative sets of mission models covering the TDAS time frame of approximately 1994 to 2004. It covers 5 areas of study activities: (1) Estimate what is projected for 1990's experiments through literature, surveys, and interviews with NASA managers; (2) Survey navigation requirements and potentials; (3) Determine communications requirements associated with space experiments; (4) Develop alternative forecast options; (5) Investigate operational impacts on experiments. This report generates a baseline of plans for the TDAS User Community, including a set of generic experiments developed to supplement existing planning for the 1990's time frame. It includes extensive summaries of collected data, and a bibliography. The data are representative of inputs obtained from NASA planning sources through September 1981.			
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PREFACE

OBJECTIVE

The objective of this report is to document the scientific and engineering results obtained as a result of completing Task Assignment 1, TDAS User Community Characteristics, on Contract NAS5-26546, "Tracking and Data Acquisition (TDAS) Study." The report is a draft report which will be part of the final report on the contract.

SCOPE OF WORK

This contract represents a two-year pre-Phase A concept definition study for the proposed Tracking and Data Acquisition Satellite System (TDAS), which will be the follow-on to Tracking and Data Relay Satellite System (TDRSS) which is currently in development. The TDRSS is contracted for through about 1994. This TDAS study, therefore, covers a ten-year planning period starting in the early 1990's.

The types of carriers for experiments flown during the TDAS time frame are grouped into three classes:

- Free Flyers
- Platforms
- Space Stations

In general, the platforms provide means to group experiments together in an unmanned vehicle, while the space stations provide a manned facility which may carry one or more experiments. The space shuttle is expected to be active well past the year 2000, with 5 to 7 vehicles flying in the study period.

Much of the TDAS requirement will be to support low earth orbit (LEO) missions in terms of communications, navigation, and TT&C. Additional requirements could stem from user mission activities in higher (e.g., synchronous) orbits, and in support of inter-orbital transfers of materials and men for maintenance and repair in space, or for retrieval of platforms and experiments.

A critical area in the development of TDAS requirements involves the handling of earth resource observations, since large-capacities (e.g., Multispectral Linear Array-MLA) are needed for certain types of observations. Such sensors may require downlink data rates in excess of most other TDAS users combined. Some other activities, such as PUP (Power Utilization Platform) may also have large data requirements.

Task 1, "TDAS User Community Characteristics," involves interviewing NASA program managers and mission planners, and reviewing existing literature, to develop a baseline of plans for the TDAS time frame. Since NASA planning and budgeting does not extend this far into the future on a formalized basis, there is significant uncertainty in the available planning information. This will, of course, be gradually obtained as the successive Phase A and B studies are performed in later years. However, a recommendation is included in this report for a review and update of the Task 1 results in the second year of this contract in order to provide the strongest possible study results.

CONCLUSIONS

Results of this task activity are summarized in Section 3.0. Collected data on experiments are tabulated in Appendix B.

There are two conclusions which stem from the work under T/A #1, "User Community Characteristic":

- Planning Uncertainty - There is significant uncertainty in the Task 1 mission planning data, since NASA budgeting processes do not extend this far into the future (the 1990's). Later Phase A and Phase B studies will narrow the range of uncertainty.
- Operational Mission Sensitivity - The TDAS requirements are extremely sensitive to inclusion of support for operational missions such as earth observation, due to high data rate requirements which may be encountered.

RECOMMENDATIONS

There is one recommendation which arises from the work under T/A #1, "User Community Characteristics":

- It is recommended that Task 1 results be updated in the second year of the contract. This will take advantage of a 1 year advance by NASA into the normal planning cycles, and will thereby lead to the strongest possible study results.

TABLE OF CONTENTS

<u>SECTION</u>		<u>PAGE</u>
1.0	INTRODUCTION	1-1
1.1	Task Assignment	1-1
1.2	Summary of TDAS User Community Characteristics	1-2
1.3	Overview of Methodology	1-2
1.3.1	Terminology	1-2
1.3.2	Work Flow	1-5
1.4	Synopsis	1-5
1.5	New Technology	1-7
2.0	TASK METHODOLOGY	2-1
2.1	TDAS User Community	2-1
2.2	Baseline of Plans	2-3
2.2.1	Data Sources	2-3
2.2.2	Generic Experiments	2-3
2.2.3	Results	2-3
2.3	Screening of Plans for TDAS	2-4
2.3.1	Location	2-10
2.3.2	Non-TDRSS Capable	2-10
2.3.3	Shuttle Based Experiments	2-14
2.3.4	Schedule	2-14
2.3.5	Power Utilization Program	2-15
2.3.6	Miscellaneous	2-15
2.4	Forecast Options	2-16
2.4.1	Budget Options	2-16
2.4.2	Vehicle Options	2-17
2.5	Scenarios of Experiments	2-17
2.5.1	Historical Analysis	2-19
2.5.2	Increased Budget	2-20
2.5.3	Results	2-23
2.5.4	Characteristics of Generic Experiments	2-23
2.5.4.1	Astrophysics	2-23
2.5.4.2	Solar Terrestrial	2-23
2.5.4.3	Resource Observation	2-23
2.5.4.4	Global Environment	2-27

TABLE OF CONTENTS (CONT'D)

<u>SECTION</u>		<u>PAGE</u>
2.6	Navigation	2-27
2.6.1	Navigation Requirements	2-27
2.6.2	Navigation Systems	2-28
2.6.2.1	Background	2-28
2.6.2.1.1	Global Positioning System	2-28
2.6.2.1.2	Tracking and Data Relay Satellite System	2-29
2.6.2.1.3	Space Sextant	2-30
2.6.2.2	Orbit Determination	2-31
2.6.2.2.1	Current Systems	2-31
2.6.2.2.2	Autonomous Navigation with GPS	2-33
2.6.2.2.3	Semi-Autonomous	2-33
2.6.2.2.4	Autonomous Navigation with TDRSS	2-33
2.6.2.2.5	Laser Ranging Systems	2-34
2.6.2.3	Time Determination [20.5].	2-35
2.6.2.3.1	Current Systems	2-36
2.6.2.3.2	Autonomous Spacecraft Clock	2-37
2.6.2.3.3	Time Transfer via TDRSS	2-37
2.6.2.3.4	GPS Timing	2-38
2.6.2.4	Attitude Determination	2-38
2.6.2.4.1	Current Systems	2-38
2.6.2.4.2	Autonomous Attitude Determination	2-29
2.6.2.5	Capabilities Summary	2-41
2.7	Communication Requirements	2-41
2.8	User Data Requirements	2-43
2.9	Operational Impacts	2-43
2.9.1	Shuttle	2-44
2.9.2	Power Utilization Platform	2-44
2.9.3	Space Operations Center	2-45
3.0	USER COMMUNITY CHARACTERISTICS	3-1
3.1	Navigation	3-1
3.1.1	Evaluation of Suitability	3-1
3.2	Communications	3-10
3.3	Physical	3-11

TABLE OF CONTENTS (CONT'D)

<u>SECTION</u>		<u>PAGE</u>
Appendix A	BASELINE OF PLANS	A-1
Appendix B	USER COMMUNITY CHARACTERISTICS DATA	B-1
Appendix C	BIBLIOGRAPHY	C-1

LIST OF ILLUSTRATIONS

<u>FIGURE</u>		<u>PAGE</u>
1.3-1:	Terminology	1-4
1.3-2:	Task 1 - TDAS User Community Characteristics Methodology	1-6
3.1-1:	Summary of System Accuracy Capabilities to Meet Experiment/Mission Navigation Requirements	3-9

LIST OF TABLES

<u>TABLE</u>		<u>PAGE</u>
1.2-1:	TDAS User Community Characteristics	1-3
2.1-1:	TDAS User Community Classification	2-2
2.2-1:	Baseline of Plans	2-5
2.3-2:	Screened Baseline of Plans	2-11
2.5.3-1:	Scenario of Experiments - Constraint Budget	2-21
2.5.3-2:	Scenario of Experiments - Increased Budget	2-24
3.1-1:	TDAS User Community Navigation Requirements	3-2
3.1-2:	Navigation Capability Summary	3-4
3.1-3:	Comparison of Experiment/Mission Accuracy Requirements with Navigation System Capabilities	
	A) Orbit Determination	3-6
	B) Time Determination	3-7
	C) Attitude Determination	3-8
3.2-1:	TDAS User Community Communication Characteristics	3-12
3.3-1:	TDAS User Community Physical Characteristics	3-14
B-16.1	Attitude Control Performance Capability	B-36
B-39.1	Shuttle Data Communication Capability	B-81

SECTION 1

INTRODUCTION

This report is the final report on Task 1, "TDAS User Community Characteristics," under Contract NAS5-26546. Documented herein is the methodology used to accomplish the task as well as the detailed results of the effort. The Scenarios of Experiments for the 1990's time frame and the associated User Community characteristics are presented below.

1.1 TASK ASSIGNMENT

The contractor shall develop at least two scenarios of experiments that will form the basis of generating alternative sets of mission models. To do this, the contractor shall carry out, to the extent necessary to define or develop this scenario, the following goals or objectives:

- a) Conduct sufficient surveys of the existing literature, contact with NASA organizations with applicable studies in progress and interviews with NASA science and application program managers to establish a baseline of plans within the Aerospace community which will lead to an estimate of what is projected for the 1990's time frame with respect to experimental programs. In particular, weather observation, earth observations, oceanographic observation and space science programs will be examined to determine experimental programs that can benefit the TDAS planning baseline.
- b) Navigation requirements of these programs will be surveyed and the potential of the various navigation systems to satisfy these requirements will be estimated.
- c) Communications requirements associated with space experiments should be determined.

- d) Develop a set of alternative forecast options which depend upon budget changes in experimental requirements and options on space vehicles (i.e., minimal free-flyers vs space stations, etc.).
- e) Investigate the impact of operational aspects on experiments such as the impact of Shuttle operations.

1.2 SUMMARY OF TDAS USER COMMUNITY CHARACTERISTICS

Table 1.2-1 presents the TDAS User Community characteristics identified during the execution of this task. This information was collected from existing literature and discussions with NASA personnel. Since information could not be obtained on many experiments, the missing information was estimated and is indicated by asterisks. Generic experiments were formulated where planning information did not exist and are indicated as AG- ,SG- , RG- or EG-1 representing astrophysics, solar terrestrial, resource observation and global environment, respectively.

1.3 OVERVIEW OF METHODOLOGY

The methodology used to satisfy the Task Assignment defined above was based upon establishing a data base of potential TDAS user characteristics and screening and refining this data base to arrive at the TDAS User Community characteristics. Before describing the work flow involved in this process, the terminology associated with the user community is first defined.

1.3.1 Terminology

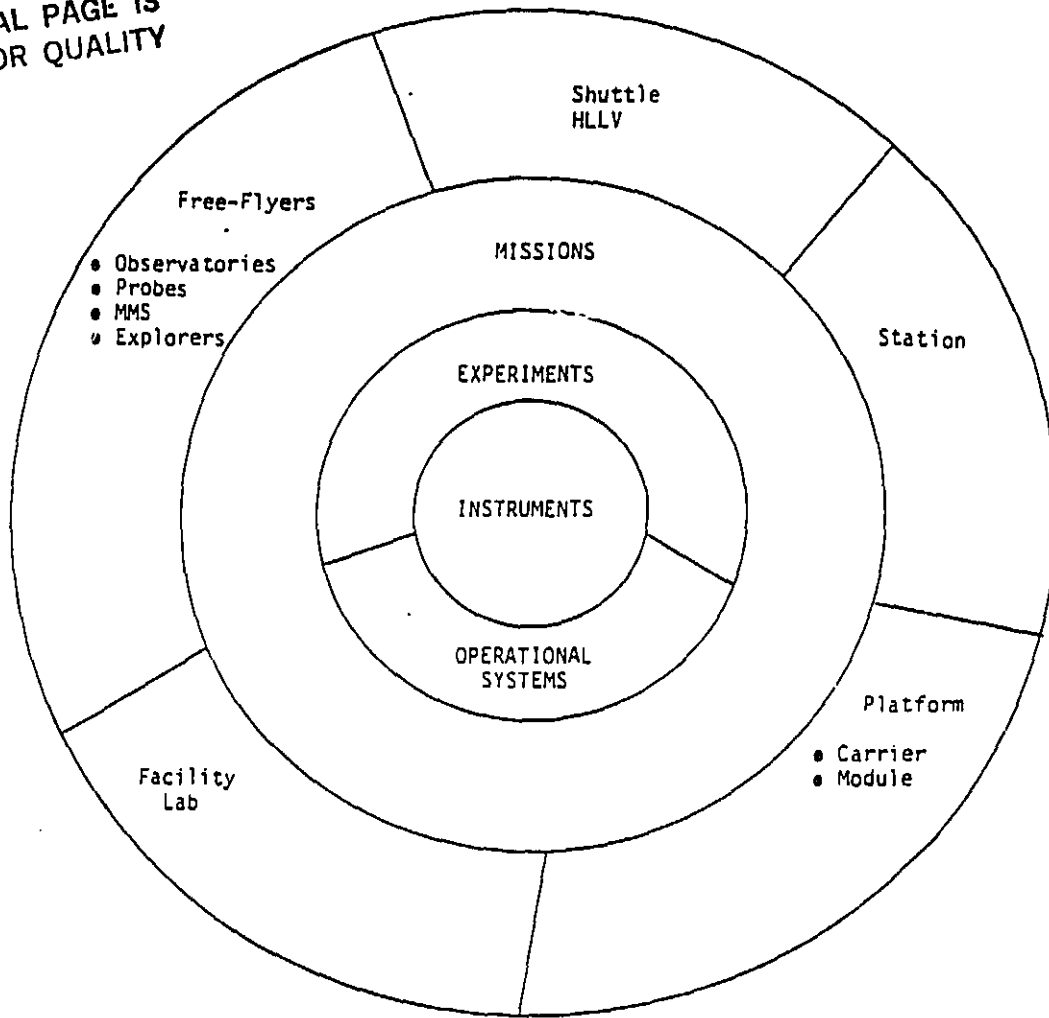
Various terminology is used throughout the existing literature to describe aspects of the NASA Space Program. Figure 1.3-1 illustrates the interrelationship among this terminology. At the lowest level, an instrument is a device which measures certain characteristics of a phenomenon. Then, an experiment represents a set (or one) of instruments and processes for their use, while a mission represents a collection (or one) of experiments and flight objectives. A mission can be flown on any one of several vehicles including the Shuttle,

EXPERIMENT/MISSION	NAVIGATION				COMMUNICATIONS				PHYSICAL														
	FILE NO.	POSITION ACCURACY (METERS)	POINTING ACCURACY (METERS)	POINTING STABILITY (METERS)	ASPECT ANGLE (DEG)	TIME (S)	EXPERIMENT TEC (1)		EXPERIMENT INIA		SPACECRAFT TEC		ORBIT										
							COMMAND RATE (Hz)	CONTACTS/DAY	REAL TIME (HOURS)	CONTACTS/PER DAY	CONTACTS/PER DAY	CONTACTS/PER DAY	CONTACTS/PER DAY	CONTACTS/PER DAY	PERIOD (HOURS)	PERIOD (HOURS)	PERIOD (HOURS)	PERIOD (HOURS)					
ARAI	5	0.15	0.15	2x10 ³			1*	4*	0.2*	40	1*	2.8*	1.0	4*	0.2*	4*	0.2*	456	20.5	1/000	31.4x3.1	10000	All-sky
X-RAY OBS.	106	GPS	0.28	0.01	0.05	GPS	1	4*	0.2*	8	10*	0.1*	1.024				100	20.5	900	2.9x3.6	700	All-sky	
LAMAR	35	GPS	0.28	0.14		GPS	1	4*	0.2*	8	7*	0.1*	2.048				400	20.5	1050	6x4	5000	All-sky	
LADAR TELESCOPE	34		5x10 ⁴	5x10 ⁻⁵			1	4*	0.2*		3.3*	0.1*	7.0				400-700	28.5	3000	15x11*	17000	All-sky	
INFRARED INTER.	30		1.0*	3x10 ⁻⁵			1	4*	0.2*		1*	24*	1.0				400-700	28.5	25000	100x15	25000	All-sky	
SPACE TELESCOPE	92		1.0	3x10 ⁻⁵			1	4*	0.2*		4	3*	0.8*	1.024			600	28.8	2100	3.6x4.3	11070	All-sky	
COSMIC	8		1.0*	2x10 ⁻⁶			1	4*	0.2*		1*	0.03*	100				500	28.5	25000	12x4	67000	All-sky	
100-m. IRIM. APER. TELE.	56		1.0*	2x10 ⁻⁶			1	4*	0.2*		1*	0.03*	100				500	28.5	25000	100(dia)	85000	All-sky	
LARGE OPT./RAY TELE.	37		0.005	10 ⁻⁵			1	4*	0.2*		1*	0.03*	100				500	28.5	25000	100(dia)	85000	All-sky	
GRAVITY WAVE INT.	23		1.0*	3x10 ⁻³			1	4*	0.2*		1*	24*	1.0*				250	Any	1000	1000	16000	All-sky	
VIBRI	104	1000	0.01	0.0*		HYDROGEN LASER	1*	4*	0.2*	270000	1	24					100-5000	45	1200	10-60(dia)	6000	All-sky	
INFR. SPECTRO. TELE.	61		0.01	0.01			1*	4*	0.2*	1	1*	0.01*	0.01				1000	SUN-SYME	500	10-15(dia)	1000	All-sky	
SLEPH	74		0.005	0.002			1	4*	0.2*	16	7.5*	0.5*	1.024				575	28 or 98	800	6x2	2600	Sum	
SOC	89	GPS	5.8*	2.9*		GPS	300*	1	24	50*	24*	0.3*	300*				400	28	25000	31.4x19.5	19700-19500	All-sky	
MAG SUR B	40	30	0.017	0.017*		10.6*	1	4	0.2*	12	4	0.2*	0.064				300	97	150	1x1	800		
DEFS	57	10	0.175	2x10 ⁻⁵		GPS	25	14*	0.2*	270000	1	24					705	99	1200	8x4.5	4214	Earth	
ADV. THERMAL MAP.	4	50*	0.05	0.05*		3x10 ⁻³	1	16	0.3	700	16	0.1					620	97.8	630*	3.2x3.5	300	Earth	
SOIL PRIS. & ASS. MISS.	73	100	0.17	0.1		10.6*	1	14	0.2*	500	14	0.2					400-700	60-98	1200	11x10	2000	Earth	
OPER. METEOR. SAI.	58	500	1.7	0.26		1	1	12.14	0.2	665	10.11	0.2	2.66				830	98.7	420	3.7x1.9	740	Earth	
UCERIN RESEARCH (SAR)	55	50*	13.1*	0.17*		10.6*	2*	14*	0.3*	270000	14*	0.1*					790	Polar	1000	2x10	2000	Earth	
TOPLE	53	0.1 ALL	87.5			0.1	1	13	0.3	8	11	0.1	0.05				1334	63.4	500	2x3	1350	Earth	
SHORTLE	93	100	6.7	0.014		GPS	36719215 22221618	1	24	12772 (3) 192750000 (1)	1	24					85-1110	28.5-57 70-104	7000	31x17	86000	All-sky	
MRS	46	175	0.17	0.17x10 ⁻³		10.6	2	***	***	1.64	***	***							1200	2.9x3.6	4048		
HANDED GEO. SORTIE	42						1	1	24	1500	1	24					370	Pa. Ions		20x20	6000	All-sky	
IMS	98	100	4.4	1.7		GPS											1000	Var Ions	550	1.3x3.2	6500	All-sky	
PIIP	67	GPS	5.8	2.9		GPS	100	1	24	50	24	0.3	300				400	20-57 CHLIP	25000	3.4x19.5 25000	19700-19500	All-sky	
ILIV	25	100*	8.7*	0.014*		GPS*											200-500	Var Ions			53	1.9x10 ⁶	
OLV	59	4500	8.7	0.014*		GPS											1100	Var Ions					
AG-1,2,3,4			0.15	0.15			1	4	0.2	4	2.5	0.05	1.024				110	28.5	200	1.6x1.6	1000	All-sky	
AG-5,6,7			0.28	0.28			1	4	0.2	8	7	0.01	1.024				400	28.5	900	3.6x1.6	3500	All-sky	
SG-1,3,5			0.005	0.007			1	4	0.2	16	2.5	0.5	1.024				575	28	800	6x2	2600	Sum	
SG-2,4			1	0.005			1	4	0.2	17000	1	24					400	57	10500			Sum	
RG-1,2,3,4		10	0.175	2x10 ⁻⁵		GPS	1	14	0.3	80000	1	24					700	98	1200	8x5	4214	Earth	
EG-1,3,4,7		50	13.1				2	14	0.3	200000	14	0.3					790	98	1000	2x10	2000	Earth	
EG-2,5,6		2.7 ALL	87.5			0.1	1	13	0.3	8	13	0.3	0.05				1334	63	500	2x3	1350	Earth	

(1) Experiment Telemetry included with data
* Estimated
** Included with experiment data
*** Depends on experiment

TABLE 1.2-1: TDAS USER COMMUNITY CHARACTERISTICS

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VEHICLE SUPPORT SYSTEMS

- MANNED GEO SORTIE
- IUS, SSUS

FIGURE 1.3-1:
TERMINOLOGY

Heavy Lift Launch Vehicle (HLLV), free-flying satellite including the Multi-mission Spacecraft (MMS), observatories or probes, platforms or stations. The facilities and labs used as vehicles typically provide access to special devices needed to accomplish the mission (e.g., the Advanced X-Ray Astrophysics Facility or the Space Lab). Additionally, platforms are also called modules or carriers. Support for the various vehicles are provided by other elements including the Orbital Transfer Vehicle and the Manned GEO Sorties, among others.

1.3.2 Work Flow

The methodology used to determine the TDAS User Community characteristics is illustrated in Figure 1.3-2. The data base was developed based upon surveys of the existing literature and discussions with various NASA organizations and program managers. This data base was formulated into a planning baseline for the 1990's time frame with generic experiments being added as appropriate. This baseline of plans was then screened to determine the experiments/missions of concern to TDAS. This screening was based upon the flight schedule, orbit parameters, TDRSS compatibility and whether the Shuttle is the vehicle. Forecast options were then formulated to reflect budget options and vehicle options (i.e., free-flyers vs platforms). The scenarios of experiments were then developed from this information. For each experiment in the scenarios, information was collected on the data distribution requirements, communication requirements and navigation requirements. In order to complete the TDAS User Community characteristics, the suitability of various navigation systems to satisfy the navigation requirements was determined, the impact of the NASA End-to-End Data Systems (NEEDS) and the Application Data System (ADS) on data distribution was assessed, and the impact of operational aspects of the Shuttle, space platforms and space stations determined.

1.4 SYNOPSIS

NASA has manifested TDRSS satellites for early shuttle flights. From a contractual viewpoint, TDRSS services will be available until about 1994. Thereafter, a new family of satellites, called "Tracking and Data Acquisition System" (TDAS), is planned to meet requirements of the 1990's and beyond.

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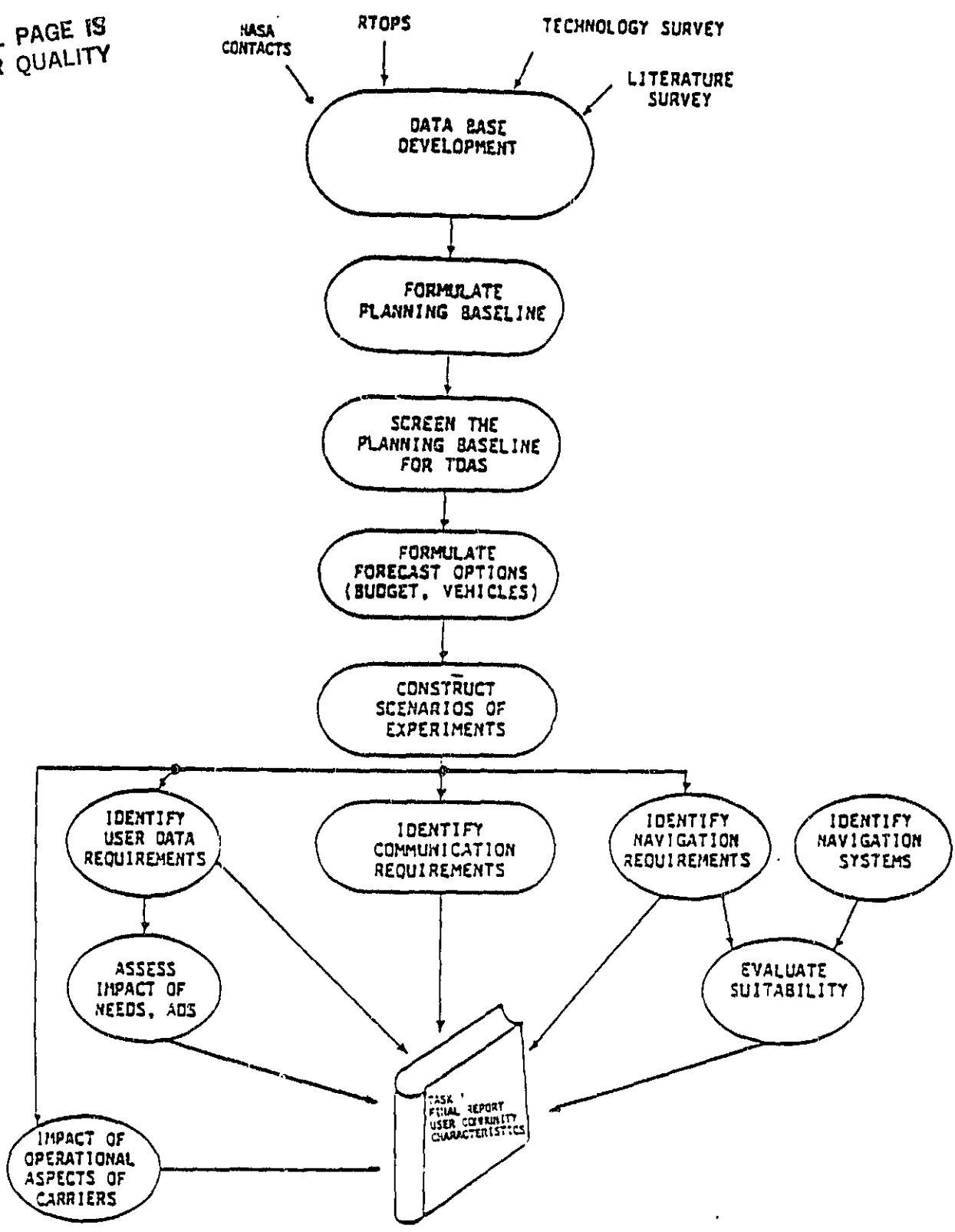


FIGURE 1.3-2:
TASK 1 - TDAS USER COMMUNITY CHARACTERISTICS METHODOLOGY

This study is intended to develop at least two scenarios of experiments that will form the basis for generating alternative sets of mission models for the first decade of the TDAS time frame. It develops a baseline of plans for the User community leading to an estimate of experimental programs. Results include alternative forecast options based on budgetary and space vehicle options. Impact of operational considerations (e.g., shuttle operations) is also included.

Section 2 of this final report presents the details of the methodology used to arrive at the TDAS User Community characteristics including the assumptions made, details of the data base and details of the requirements identified. Due to the lack of firm planning for the 1990's time frame, the assumptions made are critical and, consequently, considerable discussions are included. Section 3 presents the TDAS User Community Characteristics as identified during this effort.

The planning baseline for the 1990's is included as Appendix A to this final report. In the text, numbers in parentheses, e.g., (21), refer to experiments, missions, or programs listed in Appendix A.

Appendix B, User Community Characteristics Data presents detailed data obtained on each of the experiments/mission expected to be active during the TDAS time frame. Numbers following a "B-", e.g., B-3, refer to sections given in Appendix B.

Numbers in square brackets, e.g., [37.0], are references to documents listed in Appendix C, Bibliography.

1.5 NEW TECHNOLOGY

There were no new technology developments under this task activity.

SECTION 2

TASK METHODOLOGY

This section presents the details of the methodology used to develop the scenarios of experiments for the 1990's time frame and the associated TDAS User Community characteristics. The sources of data used to develop the baseline of plans are identified, as are the assumptions invoked and procedures used to develop the scenarios of experiments from this data. Intermediate results are presented in order to illustrate the impact of the various assumptions. The final results of this effort are presented and discussed in the next section.

2.1 TDAS USER COMMUNITY

The TDAS User Community consists of those NASA programs and associated experiments which operate on orbital vehicles with less than geosynchronous altitude. This User Community has been classified as detailed in Table 2.1-1. The sub-classifications were developed to allow the identification of generic experiments.

The major classifications in Table 2.1-1 are related to those defined in the task assignments as follows:

<u>TASK ASSIGNMENT</u>	<u>TABLE 2.1-1</u>
Weather Observation	Global Environment (A, B, C)
Earth Observation	Resource Observation
Oceanographic Observation	Global Environment (D)
Space Science Programs	Astrophysics
Space Science Programs	Solar Terrestrial
Space Science Programs	Life Sciences
Space Science Programs	Communications
Space Science Programs	Transportation
Space Science Programs	Utilization of Space Environment

The data presented on the following pages is grouped according to the classifications defined in Table 2.1-1.

TABLE 2.1-1

TDAS USER COMMUNITY CLASSIFICATION

ASTROPHYSICS

- A. X-Ray/Gamma Ray
- B. Infrared
- C. Optical/Ultraviolet
- D. Cosmic Ray
- E. Gravity
- F. Radio
- G. Misc.

GLOBAL ENVIRONMENT

- A. Upper Atmosphere
- B. Radiation
- C. Weather
- D. Ocean

COMMUNICATIONS

SOLAR TERRESTRIAL

- A. Sun Observations
- B. Earth/Sun Interactions

TRANSPORTATION

- A. Earth to LEO
- B. Multi-Mission Spacecraft
- C. LEO-GEO
- D. Placement/Retrieval

LIFE SCIENCES

- A. Biological
- B. Extraterrestrial

UTILIZATION OF SPACE ENVIRONMENT

- A. Material Processing
- B. Platforms/Stations
- C. Power
- D. Structures
- E. Misc.

RESOURCE OBSERVATION

- A. Magnetic
- B. Gravity
- C. Landsat
- D. Crustal Dynamics

2.2 BASELINE OF PLANS

The baseline of plans for the TDAS User Community was developed as a list of potential experiments/missions ranging from approved missions to imaginative (speculative) missions. The potential experiments were identified by surveying the existing literature and by conducting discussions with various NASA personnel. Where planning data for the 1990's time frame were unavailable, generic experiments/missions were developed based upon trends established in the 1980's planning data. These are listed in Appendix A, and numbered there for reference in other portions of this report.

2.2.1 Data Sources

Mission planning data collected for the TDAS time frame is documented in Appendix B. A listing of the existing literature surveyed as part of this task is provided as Appendix C to this report. The NASA Space Systems Technology Model (May 1980) provided the bulk of the potential experiments/mission. The information contained in the Technology Model was supplemented and updated by contacts with NASA personnel.

2.2.2 Generic Experiments

A set of generic experiments was developed to supplement the planning for the 1990's time frame. As discussed below, historical trends were used to determine a launch schedule for the potential experiments/missions. When a launch was scheduled and no experiment was available, a generic experiment was defined. The characteristics of the generic experiments were based upon the trends established in the particular classification by the available planning data. Details on the various generic experiments are presented below.

2.2.3 Results

Table 2.2-1 presents the baseline of plans extending from the present into the distant future using the classifications given in Table 2.2-1. The descriptions along the top of the table are defined as:

Approved - Missions which have been funded and authorized for implementation.

Planned - Missions designated as possible new starts within the next five years.

Candidate - Missions considered for possible initiation within ten years.

Opportunity - Potential missions for start beyond ten years and/or missions of a speculative nature.

Imaginative - Potential missions for start beyond ten years from non-NASA sources.

Communication experiments/missions which do not use a TDAS relay capability are not included. Also, space transportation systems which do not use a relay capability are not included. Finally, planetary missions are not included.

The numbers in parenthesis in Table 2.2-1 refer to the file number of the experiments/missions as defined in Appendix A. Data collected on TDAS experiments/missions are tabulated in Appendix B.

2.3 SCREENING OF PLANS FOR TDAS

The baseline of plans presented in Table 2.2-1 includes many experiments/missions which will not impact the TDAS design directly. These experiments were screened from the baseline of plans based upon the location (beyond geosynchronous) of the experiment, the planned use of a relay satellite and the planned schedule of the experiment. All experiments classified as "Imaginative" were removed due to lack of information sources. Additionally, experiments/missions planning to use the facilities of its carrier were screened from the baseline of plans. The rationale for this is that TDAS will be supporting the carrier (e.g., Shuttle, PUP, SOC) and experiments utilizing the carrier's facilities will impose no additional requirements on TDAS. The screened baseline of plans for TDAS is presented in Table 2.3-1.

	APPROVED	PLANNED	CANDIDATE ASTROPHYSICS	OPPORTUNITY	IMAGINATIVE
A	High Energy Astronomy Observatory - C (26)	Gamma Ray Observatory (13) Advanced X-Ray Astrophysics Facility (5) X-Ray Timing Explorer (107)	X-Ray Observatory (106) Large Area Modular Array of Reflectors (35)		
B	Infrared Astronomical Satellite (29)	Shuttle Infrared Telescope Facility (71)	Large Ambient Deployable IR Telescope (34)	Infrared Interferometer (30)	
C	Space Telescope (92)	STARLAB (94)		Coherent Optical System of Modular Imaging Collectors (8) 100-Meter Thinned Aperture Telescope (56) Large Optical/UV Telescope (37)	10-Meter Optical Interferometer (99)
D	Cosmic Background Explorer (9)	Extreme Ultraviolet Explorer (17)	Cosmic Ray Observatory (10)		
E		Gravity Probe B (22)		Gravity Wave Interferometer (23)	Doppler Millihertz Gravity Wave (13)
F			Very Long Baseline Radio Interferometer (104)		

NOTE: Numbers in Parentheses refer to Appendix A

TABLE 2.2-1: BASELINE OF PLANS

	APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
	ASTROPHYSICS (CONT)				
G			Orbiting Submillimeter Telescope (61)		Space based Astro-Physics Research Facility (84) Detection of other Planetary Systems (12)
H					
	SOLAR TERRESTRIAL				
A	Solar Maximum Mission (76) International Solar Polar Mission (31) Solar Optical Telescope (78)	Solar Soft X-Ray Telescope Facility (82) Solar Probe (81)	Solar Cycle and Dynamics Mission (74)	Pinhole Satellite (64) Close Solar Orbiter (7)	Solar Penetrator (79)
B	Dynamics Explorer (14) Chemical Release Module Facility (6)	Active Magnetosphere Particle Tracer Exp. (1) Origin of Plasma in the Earth's Neighborhood (62) Plasma Turbulence Experiment (65) Subsatellite Facility (96)	Solar Terrestrial Observatory (53)		
	LIFE SCIENCES				
A		Spacelab Biological Experiments (88)			Space Based Health Care Research Facility (86)

NOTE: Numbers in Parentheses refer to Appendix A

TABLE 2.2-1: BASELINE OF PLANS (CONT)

	APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
			LIFE SCIENCES (CUMI)		
B		Space Sciences Platform (91)		Search for Extra-terrestrial Intelligence (70)	
C					
RESOURCE OBSERVATION					
A	MAGSAT (41)	Magnetic Field Survey B (40)			
B	LANDSAT D (32)	GRAVSAT A (24) Operational Earth Resources System (57)	Soil Moisture Research Assessment Mission (73)		LANDSAT H (33) Advanced Resources/Pollution Observatory (3) High Resolution Earth Mapping Radar (105) Water Level and Fault Movement Indicator (105)
C		Advanced Thermal Mapping Satellite (4)			
D	Crustal Dynamics Program (1)				
GLOBAL ENVIRONMENT					
A	Stratospheric Aerosol and Gas Experiment (95) Solar Mesosphere Explorer (77)	Upper Atmospheric Research Satellite (103)			Space-based Atmospheric Research Facility (85)
B	Earth Radiation Budget Satellite (15)				
C	NOAA A-G/TIROS-N (50) GOES D,E,F (19)	Operation Meteorology Satellite (58)			Synchronous Meteorological satellite (47)

NOTE: Numbers in Parentheses refer to Appendix A

TABLE 2.2-1: BASELINE OF PLANS (CONT)

APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
		GLOBAL ENVIRONMENT (CONT)		
	National Oceanic Satellite System (49) NOSS Research Program (51) Ocean Circulation Mission (TOPEX) (53)	Ocean Research (SAR) (55)		Ocean Exploration System (54)

COMMUNICATIONS

Search and Rescue Mission (69)			Multi-Service Thin Route Narrowband Program (47)	Global Search and Rescue Locator (20) Orbiting Civil Command and Control System (60)
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TRANSPORTATION

Space Transportation System (Shuttle) (93)			Heavy Lift Launch Vehicle (25)	Single Stage to Orbit Shuttle (72)
Multi-mission Modular Spacecraft (46)			Advanced Electric Propulsion (2)	
	Solar Electric Propulsion Stage (75) Orbital Transfer Vehicle (59)	Manned GEO Sortie (42) Teleoperator Maneuvering System (98)		

UTILIZATION OF SPACE ENVIRONMENT

National Materials Laboratory (48)	Material Experimentation Carrier (43)		Materials Experimentation Module (45)	
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NOTE: Numbers in Parentheses refer to Appendix A

TABLE 2.2-1: BASELINE OF PLANS (CONT)

	APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
UTILIZATION OF SPACE ENVIRONMENT (CONT'D)					
B	Extraterrestrial Material Processing Program (16)	Material Experimentation Carrier II (44)			
C	Spacelab (87)	Science and Application Space Platform (68)		Space Operational Center (89)	Permanent Orbiting Outpost (63)
D		Power Extension Package (66)		Space Power Technology Demonstration (90)	Solar Power Satellite (80)
E		Large Power Module (102)			Highly Autonomous Telerobot (28)
F		Tethered Satellite System (100)			Nuclear Waste Disposal (52)
		Large Space Structure Technology and Development Program (39)			

NOTE: Numbers in Parentheses refer to Appendix A

TABLE 2.2-1: BASELINE OF PLANS (CONT)

2.3.1 Location

The experiments/missions included in the 'Baseline of Plans (Table 2.2-1) which are beyond geosynchronous orbit were screened out of the baseline. These experiments/missions* included:

- International Solar Polar Mission (31)
- Solar Probe (81)
- Origin of Plasma in the Earth's Neighborhood (62)
- Plasma Turbulence Experiment (65)
- Close Solar Orbiter (7)
- Solar Penetrator (79)
- Search for Extra-terrestrial Intelligence (70)

All of the planetary missions were previously removed using this same criteria.

2.3.2 Non-TDRSS Capable

The experiments/missions included in the baseline of plans (Table 2.2-1) which do not have the capability of utilizing a relay satellite were screened out of the baseline. These experiments/missions included:

- High Energy Astronomy Observatory - C (26)
- Infrared Astronomical Satellite (29)
- Magsat (41)
- Stratospheric Aerosol and Gas Experiment (95)
- NOAA A-G/TIROS-N (50)
- GOES D,E,F (19)
- Search and Rescue Mission (69)

Communication experiments/missions as well as space transportations systems which do not have a relay capability were previously screened.

* NOTE: Numbers in paranthesis refer to Appendix A.

APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
		ASTRO PHYSICS		
A	Advanced X-Ray Astro Physics facility (5)	X-Ray Observatory (106)		
B		Large Area Modular Array of Reflectors (35)	Infrared Interferometer (30)	
C		Large Ambient Deployable IR Telescope (34)	Coherent Optical System of Modular Imaging Coll (8)	
D			100-Meter Thinned Aperature Telescope (56)	
E			Large Optical/UW Telescopes (37)	
F		Very Long Baseline (104) Radio Interferometer	Gravity Wave Interferometer (23)	
G		Orbiting Submillimeter Telescope (61)		
H				
		SOLAR TERRESTRIAL		
A	Solar Optical Telescope (78)	Solar Cycle and Dynamics Mission (74)		
B		Solar Terrestrial Observatory (83)		

NOTE: Numbers in parentheses refer to Appendix A

TABLE 2.3-2: SCREENED BASELINE OF PLANS

APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
LIFE SCIENCES				
A				
B				
C				
RESOURCE OBSERVATION				
A	Magnetic Field Survey B (40)			
B				
C	Operational Earth Resources Satellite (57) Advanced Thermal Mapping Satellite (4)	Soil Moisture Research & Assessment Mission (73)		
D				
GLOBAL ENVIRONMENT				
A				
B				
C	Operational Meteorology Satellite (58) National Oceanic Satellite System (47) Ocean Circulation Mission (TOPEX) (53)	Ocean Research (SAR) (55)		
D				
COMMUNICATIONS				
A				

NOTE: Numbers in parentheses refer to Appendix A

TABLE 2.3-2: SCREENSED BASELINE OF PLANS (CONT)

	APPROVED	PLANNED	CANDIDATE	OPPORTUNITY	IMAGINATIVE
A	Space Transportation System (Shuttle) (93)		SPACE TRANSPORTATION	Heavy Lift Launch Vehicle (25)	
B	Multi-Mission Modular Spacecraft (46)				
C			Manned GEO Sortie (42)		
D		Orbital Transfer Vehicle (59)	Teleoperator Maneuvering System (98)		
A			Utilization of Space Environment		
B					
C		Power Utilization Program (67)		Space Operational Center (89)	
D					
E					
F					

NOTE: Numbers in parentheses refer to Appendix A

TABLE 2.3-2: SCREENED BASELINE OF PLANS (CONT)

2.3.3 Shuttle Based Experiments

The Shuttle based experiments/missions included in the baseline of plans are:

- Shuttle Infrared Telescope Facility (71)
- Starlab (94)
- Solar Optical Telescope (78)
- Solar Soft X-Ray Telescope Facility (82)
- Subsatellite Facility (96)
- Pinhole Satellite (64)
- Spacelab Biological Experiments (88)
- Spacelab (87)
- Power Extension Package (66)
- Tethered Satellite System (100)
- Large Space Structure Technology & Development Program (39)

The basis for screening the shuttle-based experiments/missions from the baseline of plans is that TDAS will be required to support the Shuttle. Thus, experiments/missions utilizing the Shuttle capabilities will impose no additional requirements on TDAS.

2.3.4 Schedule

Any experiment/mission which is planned for completion prior to 1990 was screened from the baseline of plans. These experiments/missions include:

- Gamma Ray Observatory (18)
- X-Ray Timing Explorer (107)
- Extreme Ultraviolet Explorer (17)
- Cosmic Background Explorer (9)
- Gravity Probe B (22)
- Cosmic Ray Observatory (10)
- Solar Maximum Mission (76)
- Dynamics Explorer (14)
- Chemical Release Module Facility (6)
- GravSat A (24)

- LANDSAT D (32)
- Crustal Dynamics Program (11)
- Upper Atmospheric Research Satellite (103)
- Earth Radiation Budget Satellite (15)
- National Materials Laboratory (48)
- Active Magnetospheric Particle Tracer Experiment (1)

These experiments/mission were used in the formulation of the generic experiments.

2.3.5 Power Utilization Platform Program

The Power Utilization Platform (PUP) Program will provide a space platform which will carry various experiments. Several of the potential experiments/missions included in the Baseline of Plans have been combined to form the PUP Program. These include:

- 25 kW Power System (102)
- Materials Experimentation Carrier (43)
- Materials Experimentation Carrier II (44)
- Science and Applications Space Platform (68)
- Space Sciences Platform (91)

These experiments/mission have been removed from the Baseline of Plans.

2.3.6 Miscellaneous

Several potential experiments/missions were removed from the Baseline of Plans based upon information uncovered during the contacts with NASA personnel. These include:

- Large Power Module (38)
 - The program will not be flown until well after the year 2000.
- Solar Electric Propulsion Stage (75)
 - The program is in a technology "keep alive" status.

- Advanced Electric Propulsion (2)
 - The program will not be flown until well after the year 2000.
- Space Power Technology Demonstration (90)
 - The program will not be flown until well after the year 2000.
- NOSS Research Program (51)
 - The program is cancelled in current NASA planning. The experiments will be carried on other experiments/missions.

Little information is available for the imaginative experiments/missions beyond a few sentence description. Since NASA contacts could not be found for the experiments/missions, identification of requirements could not be accomplished. As a result, all imaginative experiments/missions were removed from the baseline of plans.

2.4 FORECAST OPTIONS

Whether or not the potential experiments/missions are conducted will depend on the NASA budget during the TDAS time frame. The other major option considered was the allocation of the potential experiments/missions to vehicles. Due to the long range nature of the forecast (10-25 years), the baseline of plans will change as a result of refined agency goals, refined experiment objectives, identifying experiments of opportunity, etc. However, the implicit assumption is that the basic characteristics of the experiments will be reasonably valid. For most of the potential experiments/missions this assumption is not critical. For the experiments driving the TDAS requirements (high data rate, accurate navigation, etc.), this assumption is critical and considerable effort was devoted to research these experiments to mitigate against this assumption.

2.4.1 Activity Level Options

The activity level options considered included a constant level of activity based on recent history, and an increased level. The major impacts of the activity level options were:

- For a constant level, one space platform would be available for launch in 1987 with expansion in 1989. For the increased level, a second platform would be available for launch in 1989.
- An increased level would result in additional shuttle flights.
- An increased level would accelerate the schedule for the Space Operations Centers.
- An increased level would result in an acceleration of the schedules for the potential experiments/missions.

For the purposes of this study, the increased activity level was assumed to be 20% above the constant level.

2.4.2 Vehicle Options

The vehicles that will be available for use by the potential experiments/missions in the 1990's time frame are:

- Shuttle
- Space Platform (PUP)
- Space Station (SOC)
- Free Flyers (Multi-mission Modular Spacecraft)
- Facilities (Space Telescope, AXAF, etc.)

Due to the commitment to space platforms and stations, it appears that the use of free-flyers will be minimized with experiments/missions using the other available vehicles if at all possible. During other tasks under this contract, the potential experiments/missions will be assigned to these vehicles.

2.5 SCENARIOS OF EXPERIMENTS

The screened baseline of plans identified above was used to generate the Scenarios of Experiments: one for a constant activity level and one for an increased activity level. As discussed below, additional Scenarios of Experiments can be easily generated

to reflect additional activity level options. The procedure used to develop the Scenarios of Experiments was:

- a) The vehicles/carriers were removed from the baseline of plans and provided the vehicle options discussed above.
- b) The support systems (OTV, TMS, etc.) were removed from the baseline of plans and form a separate category.
- c) It was assumed that experiments/missions planned for the shuttle would never be free-flyers and would never be on another carrier.
- d) An historical analysis of the remaining classifications (astrophysics, solar terrestrial, resource observation and environmental observation) was conducted to determine the number of new experiments launched each year and the distribution of lifetimes of these experiments. (See 2.5.1).
- e) The results of the historical analysis were assumed to be valid throughout the TDAS time frame for a constant activity level.
- f) The results of the historical analysis were used to develop a schedule of new experiments through 2005.
- g) The experiments/missions in the baseline of plans were assigned to the schedule with planned missions assigned earliest, followed by candidate and opportunity. The experiment lifetime was used if available. If not available, it was obtained from the distribution of lifetimes.
- h) The blanks in the schedule were defined as generic experiments. The lifetimes of the generic experiments were drawn from the distribution of lifetimes.
- i) It was assumed that a 20% increase in the activity level would result in the launch of 20% more experiments.

Additional details of this procedure are provided in the following paragraphs.

2.5.1 Historical Analysis

The data base collected on the potential experiments/missions usually lacked schedule data for the candidate and opportunity missions. To arrive at a schedule, a historical analysis of the related programs was performed. The following information was derived:

- Astrophysics
 - Historically (and approved through 1985) one new experiment is flown each year. Due to the increasing lifetime of experiments, the following distribution of lifetimes is appropriate:
 - 20% - 1 year lifetime (historically 40%)
 - 40% - 2-5 year lifetime (historically 20%)
 - 20% - 15 year lifetime
 - 20% - Shuttle based experiments

- Solar Terrestrial
 - Historically one new experiment is launched each year of which half are beyond geosynchronous. Of the one LEO launch every other year:
 - 40% - Shuttle
 - 60% - 2-4 year lifetime

- Resource Observation
 - Historically one new experiment is launched every three years. Due to the increasing lifetime of experiments, the following distribution of lifetimes is appropriate:
 - 50% - 3 year lifetime
 - 50% - 5 year lifetime

- Environment Observation
 - Historically one new experiment is launched every two years. Due to the increasing lifetime of experiments each has a three year lifetime (historically each had a two year lifetime). In addition, the operational meteorology system will have two polar experiments and a geostationary experiment.

The above information was used to determine an estimated flight schedule for the potential experiments/missions. The assignment of the experiments to the schedule was accomplished by first assigning the planned experiments, then the candidate and finally the opportunity experiments. The blanks left over were defined as generic experiments.

Table 2.5.3-1 shows the schedule for the potential experiments/missions in the screened baseline of plans.

2.5.2 Increased Activity Level

The impact of an increased activity level was assumed to be an increase in the number of flights in lieu of increasing the complexity or duration. Increasing the number of simultaneous experiments would be the same as increasing the number of new experiments from the TDAS point of view.

To generate the Scenario of Experiment for the increased activity option, a 20% increase will be used. Based upon the assumptions made, this will result in a 20% increase in the number of flights with the same distribution of lifetime. The impact on the various classifications are:

- Astrophysics
 - 1.2 launches per year. Presently, 10 launches in 10 years is estimated for the constant level whereas 12 launches in 10 years will result from the increased level. The launches will be scheduled in the third and seventh year and will have a five year lifetime.
- Solar Terrestrial
 - 0.6 launches per year
- Resource Observation
 - 0.4 launches per year
- Environmental/Observation
 - 0.6 launches per year

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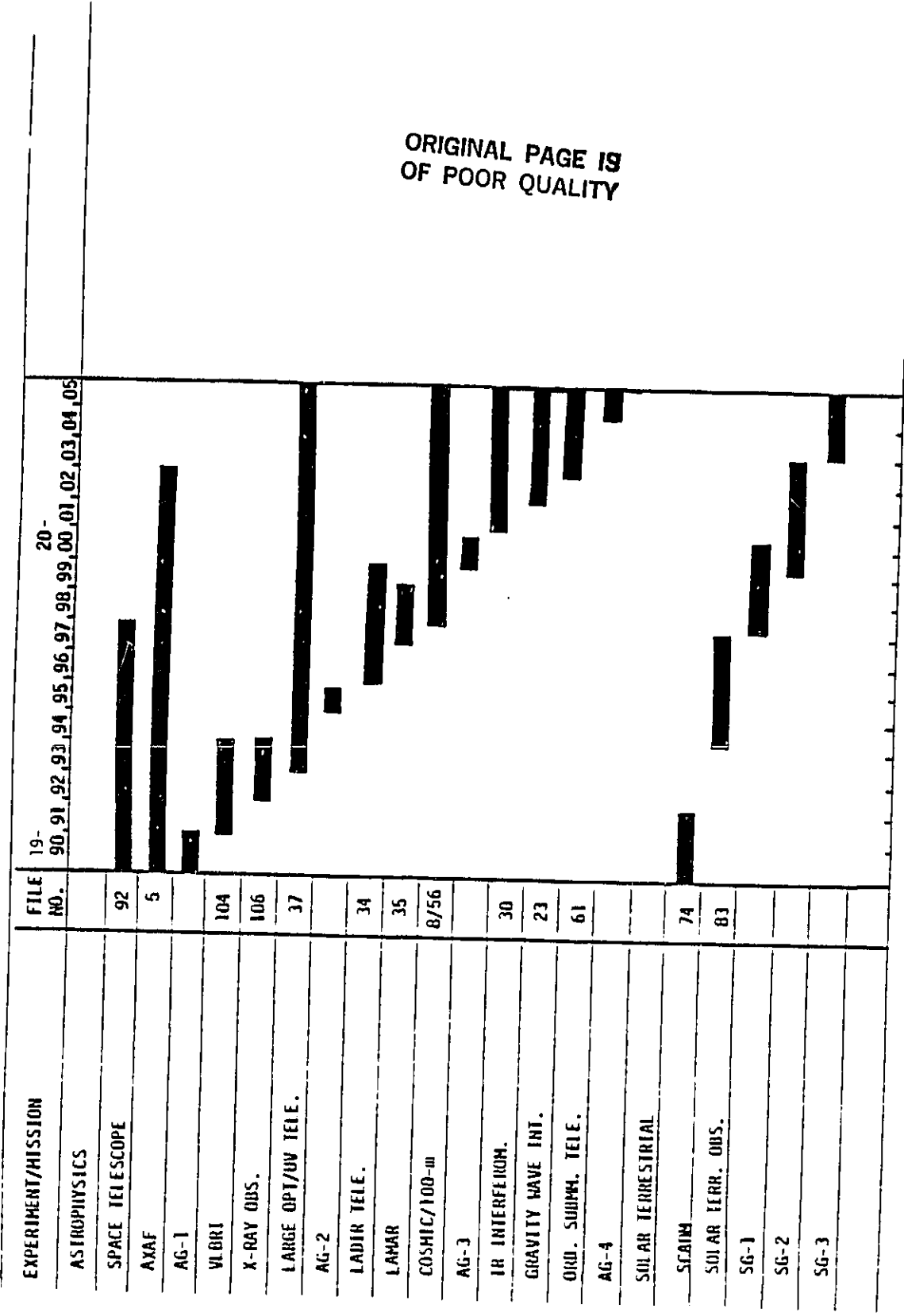


TABLE 2.5.3-1: SCENARIO OF EXPERIMENTS - CONSTANT ACTIVITY

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EXPERIMENT/MISSION	FILE NO.	19- 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 00, 01, 02, 03, 04, 05	20- 00, 01, 02, 03, 04, 05
RESOURCE OUS.			
MAG SAT B	40		
OERS	57		
SOIL MOISTURE	73		
ADV. TIER. MAP	4		
RG-1			
RG-2			
RG-3			
GLOBAL ENVIRON.			
TOPEX	53		
OSAR	55		
EG-1			
EG-2			
EG-3			
EG-4			
EG-5			
METEOROLOGY			
EG-6	58		

TABLE 2.5.3-1: CON'T

The same technique of assigning the baseline of plans to the resulting schedule was used. Table 2.5.3-2 shows the schedule for the potential experiments/missions in the screened baseline of plans.

2.5.3 Result

The Scenario of Experiments for the constant activity options is shown in Table 2.5.3-1. The Scenario of Experiments for the increased activity option is shown in Table 2.5.3-2.

2.5.4 Characteristics of Generic Experiments

As discussed above, generic experiments were defined to fill out the Scenarios of Experiments. The characteristics of the generic experiments were determined by selecting a model for the generic experiment from the same classification and using the characteristics of the model experiment for the generic experiment. The criteria for selecting the model was that the model have a similar lifetime to the generic experiment, that the characteristics of the model be well known, and the model not be a TDAS driving requirement.

2.5.4.1 Astrophysics. For the one year experiments (AG-1,2,3,4), the Infrared Astronomical Satellite was used as the model and for the three year experiments (AG-5,6,7), the X-ray Observatory was used as the model.

2.5.4.2 Solar Terrestrial. For the generic solar terrestrial experiments, (SG-1,-3, and-5), the Solar Cycle and Dynamics Mission was used as the model. For generic experiments, (SG-2 and -4), the Solar Terrestrial Observatory was used as the model.

2.5.4.3 Resource Observatory. For the generic resource observation experiments (RG-1,2, 3 and 4), the Advanced Land Observing System (ALOS) was used as the model and the experiment lifetime adjusted to provide an operational system starting in 1999 for the constant activity level and 1997 for the increased activity level.

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EXPERIMENT/MISSION	FILE NO.	19- 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 00, 01, 02, 03, 04, 05	20-
ASTROPHYSICS			
SPACE TELESCOPE	92		
AXAF	5		
AG-1			
VLDRI	104		
X-RAY OBS.	106		
LADIR TELE.	34		
LARGE OPT./UV TELE.	37		
AG-2			
LAMAR	35		
IR INTERFER.	30		
GRAVITY WAVE INT.	23		
COSMIC/100-m	8/56		
AG-3			
AG-5			
AG-6			
AG-7			
ORBITING SUB-mm TELESC.	61		
AG-4			

TABLE 2.5.3-2: SCENARIO OF EXPERIMENTS - INCREASED ACTIVITY

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EXPERIMENT/MISSION	FILE NO.	19- 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 00, 01, 02, 03, 04, 05	20- 96, 97, 98, 99, 00, 01, 02, 03, 04, 05
SOLAR TERRESTRIAL			
SCADH	74		
SOLAR TERR. OBS.	83		
SG-1			
SG-2			
SG-3			
SG-4			
SG-5			
RESOURCE OBS.			
MAG SAT B	40		
OERS	57		
SOIL HUMIDITY	73		
ADV. THERMAL MAP	4		
RG-1			
RG-2			
RG-3			
RG-4			

TABLE 2.5.3-2: CONT'D

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EXPERIMENT/MISSION	FILE NO.	19- 20 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 00, 01, 02, 03, 04, 05
GLOBAL ENVIRONMENT		
TOPEX	53	
EG-2		
OSAR	55	
EG-5		
EG-1		
EG-3		
EG-6		
EG-4		
EG-8		
EG-7		
METEOROLOGY	58	

TABLE 2.5.3-2: CONT'D

2.5.4.4 Global Environment. For the generic global environment experiments (EG-1, 3, 4, and 7), the Oceanic Synthetic Aperature Radar (OSAR) was used as the model and the experiment flight times adjusted slightly to form an operational system starting in 1994 for the constant activity level and 1993 for the increased activity level. For the generic global environmental experiments (EG-2, 5, 6, and 8), TOPEX was used as the model.

2.6 NAVIGATION

As part of the data collection effort for the TDAS User Community, the navigation requirements of the experiments/missions in the scenario of experiments were surveyed and the capabilities of the various navigation systems determined. A brief analysis was then conducted in order to determine the suitability of the navigation systems for satisfying the navigation requirements in the TDAS time frame. The results of this effort are presented in Section 3 of this report. Presented herein is a discussion of the methods used to survey the navigation requirements including the assumptions made; a brief description of the various existing and planned navigation systems; and a discussion of the methodology used in the suitability analysis.

2.6.1 Navigation Requirements

The data defining the navigation requirements for the experiments/missions in the scenarios of experiments surveyed during this effort included:

- Position Accuracy - defined in terms of track, cross track and altitude.
- Pointing Accuracy - the accuracy to which the experiment can be pointed with respect to the commanded angles.
- Pointing Stability - motion about the pointing angles.

- Aspect Knowledge - measurement of where the experiment is pointing.
- Time - the accuracy of experiment time to UTC.

The data collected is summarized in a later table (see paragraph 3.1.1)

2.6.2 Navigation Systems

Presented below are brief descriptions of current and planned navigation systems which may be used for orbit, time and attitude determination of NASA spacecraft. The capabilities of these navigation systems are summarized at the end of this section. The navigation services provided to user spacecraft by the TDRSS are also described since the TDAS may provide the same services. The material has been extracted primarily from various NASA publications.

2.6.2.1 Background.

2.6.2.1.1 Global Positioning System [20.5]. The NAVSTAR Global Positioning System (GPS) is a satellite-based navigation system that will provide extremely accurate position and timing information to users on or near the Earth. In its operational configuration, the GPS satellite constellation will consist of 18 satellites in circular, 12-hour orbits (10,900 nautical miles) with inclinations of 55 degrees. This configuration ensures that at least four GPS satellites (NAVSTARS) will usually be within the user satellite's field of view with the user satellite at less than 10,000 km.

Each NAVSTAR carries an atomic clock that is used to generate pseudo-random noise (PN) spread spectrum navigation signals on two L-band carriers. The basic navigation signal is at 1575 megahertz (L1) while a secondary signal is at 1225 megahertz (L2). Processing of phase information from the two signals allows the user to correct for ionospheric propagation delay if necessary.

The basic navigation signal is transmitted in two separate codes: the coarse/acquisition (C/A) code with a 1.023-megabit-per-second chip rate and the precision (P) code with a 10.23-megabit-per-second chip rate. Each NAVSTAR

has unique codes. The C/A code is transmitted only on the L1 frequency and is used to rapidly acquire the GPS signal and perform the transition to the P code. The P code is transmitted on both frequencies and is intended for high-precision users.

A navigation message is modulated onto the PN sequence at a rate of 50 bits per second. The entire message is contained in a data frame 1500 bits long and is repeated every 30 seconds. The data in the navigation message includes a precision ephemeris for the NAVSTAR, the NAVSTAR clock time, the NAVSTAR clock correction relative to the master clock, almanacs, and other information about the other NAVSTARS. The almanac allows the user to select which NAVSTAR signals to receive and aids in the acquisition of the signals. Measurements to four NAVSTARS allow the user to uniquely solve for three-dimensional position and velocity vectors plus a timing correction due to the imprecise user clock.

2.6.2.1.2 Tracking and Data Relay Satellite System (TDRSS) [27.0]. TDRSS will be added to the STDN in the early 1980's and evolve to the TDAS in the 1990s. This system will allow NASA to accommodate high data rates from user spacecraft; allow a user real-time data flow between the spacecraft and the ground system; and will provide near global coverage to user spacecraft. The TDRSS will consist of a ground station at White Sands, New Mexico and two operational Tracking and Data Relay Satellite (TDRS) located in geosynchronous orbits 41 degrees and 171 degrees west longitude.

TDRSS is a communication service, and as such, does not need to know the content of the data being transmitted. The interface point between TDRSS and the NASA ground communication system, NASCOM, is at the White Sands station. Four types of operational information flow across the TDRSS/NASCOM interfaces.

- 1) data from NASCOM to be transmitted to user satellites
- 2) data from user satellites to be transmitted by NASCOM to user control centers
- 3) schedules and control orders from the NASA TDRSS control center telling TDRSS where to point antennas and when to provide certain types of service, and

- 4) TDRSS reports and status data to notify NASA of the current condition of TDRSS.

TDRSS generates modulated radio signals at the White Sands station for transmission through a TDRS to user satellites, and demodulates radio signals which have passed through TDRS from user satellites. The TDRS does no processing of user satellite traffic, in either direction, other than reception, frequency translation, amplification and radiation through the appropriate antennas. Thus, the TDRSS operates as a "bent pipe" repeater, and all of the signal processing equipment is in the ground station.

TDRSS will also support onboard navigation functions for user satellites equipped to process TDRSS ranging and/or doppler data. TDRS time and ephemeris information is transmitted via White Sands and combined with the ranging/doppler data to derive user position, velocity, clock updates and modeling parameters.

2.6.2.1.3 Space Sextant [28.0]. The Space Sextant - Autonomous Navigation Attitude Reference System (SS-ANARS) being developed by Martin Marietta Aerospace with sponsorship by the USAF is a spacecraft subsystem that has the integrated capability of onboard orbit determination with onboard attitude determination. An instrument called the Space Sextant is a gimbaled-two telescope included angle measurement device that is driven by an onboard computer to measure the angles between celestial bodies, as seen from a spacecraft, to an accuracy of 1 arc-second.

Orbit determination with the system is achieved by measuring the included angles between brighter stars and the limbs of the moon and earth, and processing these angle measurements through a Kalman filter with an onboard digital computer. Spacecraft position to 800 ft. (250 m) accuracy is achieved for any earth orbit.

Attitude determination relative to the celestial sphere is determined with the same device to an accuracy of less than 1-arc second by measuring the included angles between the brighter stars and a reference platform consisting of a mirror and a Porro prism.

The SS-ANARS has been under development since 1973 and has progressed through critical technology development, a proof of concept model, a laboratory model and a flight demonstration system. This flight demonstration system is to be flown as a sortie payload on the Space Transportation System (Space Shuttle) to prove its autonomous integrated orbit and attitude determination capability.

2.6.2.2 Orbit Determination [20.5].

2.6.2.2.1 Current System. The current system for orbit determination includes the following steps: generation of tracking data, input data processing, ephemeris data computation, acquisition data computation, and scheduling and planning data computation.

- Tracking Data
 - Tracking data are generated by the GSTDN, which consists of 14 ground stations and a laser system. The ground stations receive telemetry from the spacecraft, transmit commands to the spacecraft, and provide tracking data for orbit determination. Normally, data passing through a ground station undergo a formatting or data handling processing before being sent to the NASA Communications Network (NASCOM). These data can be transmitted by means of Teletype, high-speed, or wideband transmission equipment.
- Input Data
 - Input data processing consists of receiving, processing, and archiving tracking data. Raw metric data are received from NASCOM and are edited, converted to engineering units, sorted, and stored

so that they may be retrieved when needed. Data also are sampled and the results maintained on a processed data file. The system reports the activities of the network and the errors found in the data, and it archives data for long-term storage.

- Ephemeris Data
 - Ephemeris data computation consists of generating sets of current and predicted ephemerides (time and vector pairs), validating these ephemerides, and refining them according to mission requirements. Predicted ephemerides are used for acquisition data computation and scheduling and planning data computation. Both predicted and definitive ephemerides are used in attitude determination and data processing.

- Acquisition Data
 - Production of acquisition data involves determining time periods during which a station will be able to view a spacecraft. Input to this step consists of acquisition requirements and the ephemerides described above. Major outputs from this step include acquisition data messages that are sent to the stations via NASCOM.

- Scheduling and Planning Data
 - Scheduling and planning data are various sets of spacecraft orbital information that allow the development of future mission and mission support schedules. These data are based on the predicted ephemerides described above. The output from this step includes station pass summaries and orbit event predictions.

A great disadvantage of the current orbit determination system is the time required to complete the steps outlined above. It can take up to 2 weeks from the time that the tracking data are generated by the GSTDN until ephemerides are available for data processing and attitude determination.

2.6.2.2.2 Autonomous Navigation with GPS. The user satellite acquires navigation signals from a number of GPS satellites (NAVSTARS) and generates range and Doppler observations. Each NAVSTAR transmits its own position and time with high precision. From repeated use of these data, the user is able to determine its state (three-dimensional position, velocity and timing corrections) and other modeling parameters involved in propagating its state between measurements.

2.6.2.2.3 Semi-Autonomous Navigation with TDRSS. A two-way navigation technique is utilized based on signals uplinked from the WSTF via the TDRS to the user satellite. The spacecraft transponder returns the signal to the TDRS, which relays it back to the WSTF. The two-way Doppler shift, the shift in frequency of the round-trip signal, is measured at WSTF. In addition, the two-way range measurement, the round-trip signal propagation time, is also extracted. These two-way measurements, along with TDRS ephemerides, accurate time tags and frequency reference provided by the standard clock at WSTF, are sent to the Payload Operations Control Center (POCC), placed in the command stream, and transmitted to the user via TDRSS. This is processed onboard to derive user position, velocity and modeling parameters (e.g., drag factor).

TDRSS can also measure range and range rate in the loop from White Sands through one TDRS to the user satellite, and back through a different TDRS to White Sands. This may provide better position accuracy for those user satellites whose antenna allow this operating mode.

2.6.2.2.4 Autonomous Navigation with TDRSS. A one-way navigation technique is utilized based on Doppler data extracted onboard the spacecraft and combined with the TDRS ephemerides to derive the user position, velocity and modeling parameters. The one-way Doppler measurement is extracted from the shift in frequency of a signal emanating from the White Sands Tracking Facility (WSTF).

Standard TDRSS user equipment includes TDRSS-compatible antenna and transponder elements. Addition of the onboard orbit determination function will require

modification of the standard TDRSS user transponder to permit Doppler extraction, and the addition of an onboard microprocessor assembly to perform the navigation computations. It is anticipated that the transponder modification will be incorporated in all TDRSS user equipment so that the only operational navigation user expenses will be those associated with the user processor and software. Other elements of the TDRSS user systems (such as the oscillator, timing module, telemetry components and onboard computer) are standard spacecraft equipment.

2.6.2.2.5 Laser Ranging Systems. Short pulses from a laser are transmitted to retroreflectors located onboard a satellite (ground-based-system) or at surveyed ground sites (space-based-system). Ranging data for orbit determination are derived from the roundtrip travel time between the transmitter and retroreflectors. Corrections are made for the time delay due to the atmosphere, which is roughly 7 meters (linear equivalent) at sea level for a 20° elevation angle. Calibration measurements are used to correct for any time delay differences in the electronics or photodetectors between the transmitted and received pulses.

With these systems the ranging errors are typically only a few centimeters. Consequently, the main present limitations for orbit determination are availability of sufficient ground sites and errors in the modeling of satellite orbits due to the gravity field uncertainties, solar radiation pressure effects, and atmospheric drag.

Ground-based Laser Systems

Currently, about 15 "second-generation" laser ranging systems (LRS) with ranging accuracies of approximately 10 cm have been used in certain GSTDN operations. The laser pulse length generally is a few nanoseconds, and the largest source of uncertainty usually is associated with the electronic circuitry used to pick out the center of gravity of the returned pulse. Many of these systems are mobile, so that they can be moved from site to site.

Three "third-generation" systems with pulse lengths of the order of 0.2 nsec and energies per pulse of about 200 mJ are also in operation. The transportable Laser Ranging System (TLRS) is a "third-generation" laser system currently under development. This system, capable of single photoelectron detection, should have a normal point accuracy better than two centimeters for a three-minute average during a satellite pass.

Potential (LRS) applications to support semi-autonomous orbit determination would require uplinking the laser ranging data to a user satellite for onboard processing. This could be implemented by adding a communication link from appropriate LRS sites to the TDRS (or TDAS) satellites.

Spaced-based Laser Ranging System

The Spaceborne Laser System (SLS) was planned initially for implementation on an orbiting spacecraft carrying a pulsed laser range measurement device that sequentially measures the distance to a number of retroreflector arrays on the ground. Once in orbit the spacecraft ranges to corner reflectors on the earth's surface as it passes overhead. The measurement objective of the system is relative positioning of the reflectors to ± 1 cm precision or better for separations of reflectors as large as 1200 to 1500 km. The specifications are such that it should meet this measurement accuracy for a mission to be launched in the early mid-1980's. The proposed laser system would use a Nd YAG laser with 0.2 nsec pulses at a repetition rate of 10 pulses/sec and provide an rms range uncertainty for a single pulse at 5 to 10 photoelectrons of 1 to 2 cm with a bias of a few millimeters. Potential SLS applications to autonomous orbit determination would involve onboard processing of the laser ranging data.

2.6.2.3 Time Determination [20,5]. In early space applications, observations of events were recorded on magnetic tape, stored in a computer memory and transmitted to the ground in real time. These data were time tagged by time codes generated onboard the spacecraft. The time codes were not necessarily related to any standard time scale. When real-time data were transmitted from

the satellite to a ground station, they were time tagged by means of the ground station clock. From the two sets of time tags, the spacecraft clock could be calibrated if the equipment and propagation delays were known. One of the major difficulties in ground data processing has been to calibrate the spacecraft clock.

2.6.2.3.1 Current Systems. There are frequently two oscillators onboard a spacecraft: one is used to generate clock pulses in a time counting system, and the other is used to generate data samples and telemetry timing functions, e.g., the time division multiplex bit streams, words, frames, etc. Telemetry frames are divided into two categories: major and minor frames. In a NASA standard spacecraft, a minor frame may contain from 1024 bits to 8192 bits. At the start of each minor frame is a frame synchronization word typically 24 bits in length. The trailing edge of the last bit of this word is the standard reference mark for the onboard clock time code. If the two oscillators are asynchronous, whether because of a differential aging rate or an offset frequency, time interpolation problems in data reduction can be anticipated. In actual operation, data stored on the spacecraft are often transmitted to the ground in reverse order because the spacecraft magnetic tape is in rewind mode for data playback. The ground station clock is synchronized to a national standard clock such as the National Bureau of Standards UT-2 times via WWV. The data recorded at the ground tracking station are sent by mail or communication links to the data processing facilities at GSFC.

The data reduction problem becomes obvious in attempting to calibrate the satellite clock. This is because calibration of the satellite clock requires the transmission of the clock word to the ground station in real time and the removal of the equipment delay and the propagation path delay. The propagation path delay can be removed only after the refined orbital data have been computed and sufficient data on the performance of the onboard clock over an extended period of time (typically days or weeks) are available for accurate interpolation of clock correction parameters. This procedure causes a delay that is between 2 to 4 weeks at present. Thus, correlation and correction of the time codes generated onboard the spacecraft with, and relative to, the time codes generated by the ground station clock are a major task and contribute to throughput problems.

2.6.2.3.2 Autonomous Spacecraft Clock. An autonomous spacecraft clock (ASC) has been devised to meet the needs of spacecraft and data autonomy. It will generate a standard space-applicable time code to the accuracy needed by the various users. The ASC and the time code are in coordinated universal time (UTC). The term "autonomous spacecraft clock" implies that the clock is synchronized to an accuracy requirement and to a standard time scale without the need for additional calibration and validation. The time code distribution to the users is handled through onboard computers. Similar to the current spacecraft clock, the ASC consists of an oscillator and its associated circuitry. In addition, the ASC is designed to include hardware that will provide capabilities to correct for clock drift and to remove clock errors to within the user's requirement using standard time reference signals, which could be transmitted to the ASC by the Tracking and Data Relay Satellite System (TDRSS) or the Global Positioning System (GPS).

2.6.2.3.3 Time Transfer via TDRSS. NASA satellites will carry TDRSS transponders with which the satellite can communicate through a TDRS to the ground station at White Sands, New Mexico. It is by using this system that the ground station master clock time signal can be transmitted to the near-Earth orbiting satellite in which a clock may be maintained independently to the accuracy required by the experimenters.

The philosophy of operation is directed towards automation; that is, the clock time will be transferred from the White Sands terminal via a TDRS to a user satellite by a command sent from the Payload Operations Control Center (POCC). The propagation delay may be measured by a two-way time transfer technique or may be calculated based on the position information of the ground terminal and the two predicted satellite positions, if the calculated delay accuracy meets the time accuracy requirement. The received time signal in the user satellite is measured relative to the onboard clock by a time interval unit. After correction for the signal propagation path delay, the clock error is transmitted via the TDRS to the ground for monitoring and verification. The satellite clock is free running up to a preset maximum clock error at which time, by onboard computer program action, a step-time or a step-frequency correction is made. If the correction is deleted, a command signal is needed to override the automatic clock correction. After such a command, a new

value of the maximum clock error must be reset if the automatic clock correction feature is to be maintained.

TDRSS can be used as an operational service to transfer precise time by a two-way or a one-way technique. Using the two-way technique to measure the propagation path delay, the precision of time transfer, without corrections, can be of the order of nanoseconds. The precision of the one-way time transfer technique is limited by the accuracy of the path delay calculations. This is generally in the order of microseconds.

2.6.2.3.4 GPS Timing. For GPS timing operations, a GPS Receiver/Processor can supply the UTC-synchronized reference for the onboard time computation. GPS time is maintained on the NAVSTAR satellites each of which carries an atomic clock that generates pseudo-random noise (PN) spread spectrum navigation signals. Since GPS signals are provided on two L-band carriers, any ionospheric propagation delay between the NAVSTAR satellites and the user spacecraft can also be determined by processing of phase information from the two signals. The propagation delay may be needed for the time correlation, time validation, or both.

2.6.2.4 Attitude Determination [20.5]. Attitude determination is the process of computing the orientation of a spacecraft with respect to an appropriate frame of reference.

2.6.2.4.1 Current Systems. Typically, data gathered by attitude sensors have been processed by ground-based software for this purpose and usually involves the following basic functions:

- Real-time or near-real-time determination--computation of attitude solutions in real-time or within several hours in support of attitude control or for verification purposes.
- Attitude control--generation of command data to maintain or modify the orientation of the spacecraft based upon current and desired attitudes.

- Definitive attitude determination--computation of post facto attitude solution for annotation of user experiment data.
- Attitude prediction--generation of future attitude trajectories. Frequently this function uses mathematical models for spacecraft dynamics and disturbance torques.
- Bias determination--estimation of calibration parameters and systematic biases of attitude sensors so that more accurate attitudes can be calculated from their data.

Because of a variety of mission requirements, the extent to which the functions are performed will vary widely from mission to mission. Most current ground attitude determination systems have attitude control and definitive support as primary requirements, with the other functions playing supporting roles.

For attitude control purposes, telemetry data are received from the command and control function, which is typically accomplished by a POCC. A near-real-time attitude solution is obtained using computers in an offline processing mode. The attitude solutions, as well as possible reorientation and correlation commands, are conveyed to the command and control function, which creates command data for uplink to the spacecraft. This type of open-loop processing has inherent drawbacks, such as high cost and time delays due to the large number of operations personnel in the loop and the number of manual interfaces involved.

The current scheme for definitive support also has drawbacks due to the data processing and communications delays.

2.6.2.4.2 Autonomous Attitude Determination. The concept of onboard attitude determination autonomy is being examined because it will allow real-time annotation of experiment data and improve system throughput by eliminating the need for definitive attitude determination.

In addition, one of the major reasons for determining attitude onboard the spacecraft is to enable more efficient and accurate attitude control concepts, since open-loop control systems include human intervention and relatively long response times.

Additional benefits from autonomous attitude determination are also expected to arise. For example, onboard autonomy could reduce the frequency of the ground attitude computations required for spacecraft control. It could also eliminate the need to store long attitude history tapes for experimenters, since attitude would be directly available in telemetry for the experimenter. A greater degree of standardization of ground attitude support systems would also result if onboard autonomous systems were standardized.

Onboard autonomy does not completely eliminate the requirement of a functional capability on the ground for attitude determination and sensor calibration because these capabilities will be required for validation and maintenance of onboard systems. Depending upon onboard implementation details, autonomy may not eliminate the requirement of initial attitude acquisition by the ground. It also may not eliminate ground activities associated with maneuver planning.

Complete automation of some onboard attitude prediction and filtering schemes requires either simple and accurate models of spacecraft dynamics and sensor behavior or the addition of more sophisticated measuring schemes. This is likely to pose formidable challenges because with the advent of high-accuracy missions, complex and lengthy modeling problems such as flexible dynamics might not be easily included in the onboard software. Moreover, the models used in attitude computations are highly mission dependent and are not easy to standardize for onboard usage. More sophisticated measurement devices would, however, add additional weight and cost.

A conceptual design for Onboard Attitude Determination System (OADS) was completed in 1978 by Martin Marietta Aerospace. This design was based largely upon the Multi-mission Modular Spacecraft (MMS).

The OADS consists of one NASA Standard IRU (DRIRU-II) as the primary attitude

determination sensor, two improved NASA standard star trackers (SSTs) for periodic update of attitude information, and a multiple microcomputer system or an NSSC-1 with a microcomputer system to provide the computing power needed to support enhanced onboard automation.

2.6.2.5 Capabilities Summary. Systems which could potentially support the navigation functions of the TDAS user community have been described above. A summary of expected accuracies for the orbit, time and attitude determination functions expected to be available by the 1990's are presented in Section 3.1.

2.7 COMMUNICATION REQUIREMENTS

The characteristics of the data transmitted to and from the experiments/missions which was collected during this effort included:

- Experiment Data Rate - the return link data rate (real-time and dump) for the science data
- Experiment Control Data Rate - the forward link data rate for control of the science package.
- Spacecraft Data Rate - the forward link data rate for control of the spacecraft
- On-board Storage - the number of bits of storage available for the experiment
- Data Volume - the bits/day of data generated by the experiment
- Contact Time Profile - the user requirements for contacts/day and hours/contact.

The communication data required for the other tasks as well as their relationship to the collected data are:

Experiment T&C (Telemetry & Command)

Contacts/day	}	Contact Time Profile
Hours/contact		
C Rate		Experiment Control Data Rate
T Rate		Usually included with data

Experiment Data

Real Time Data Rate		Experiment Data Rate
Contacts/day	}	Contact Time Profile
Hours/contact		
Dump Rate		Experiment Data Rate

Spacecraft T&C (Telemetry & Command)

Contacts/day	}	Contact Time Profile
Hours/contact		
C Rate		Spacecraft Data Rate
T Rate		Usually included with data

Spacecraft data is only included for the experiments/missions known to be free-flyers (e.g. Space Telescope) and of course for the vehicles. Most of the experiments/missions have not defined the characteristics of the forward link for control of the experiment.

Data which was not available from the existing literature or from the discussions with NASA personnel were estimated using the following procedures:

Contact Time Profile - When data was not available, formulas relating data rates, storage and data volume were used to compute contacts per day and hours per contact. This will tend to overestimate both the contacts per day and hours per contact. The formulas are:

$$\text{Contacts/Day} = \frac{\text{Data Volume}}{\text{Bits of On-board Storage}}$$

$$\text{Hours/Contact} = \frac{\text{Bits of On-board Storage}}{\text{Dump Rate} \times 3600}$$

Experiment Control Rate - When data was not available for a particular experiment, 1 kbps was used.

Experiment Telemetry Rate - In all cases, the housekeeping data for the experiment was included with the experiment data.

Experiment Data Rate (Real Time) - When data was not available, a similar experiment was identified and the data rate used.

Experiment Data Rate (Dump) - When data was not available, 1.024 Mbps was used.

Resulting communication requirements for TDAS are shown in a subsequent Table (see subsection 3.2). The parameter values marked with an asterisk have been estimated.

2.8 USER DATA REQUIREMENTS

A brief survey of the user data requirements was conducted concurrently with this effort. In some cases, delivery requirements were identified. In the remaining cases, the existing literature and NASA contacts assumed that the data would be processed through the TDRSS ground station as it exists in current planning. Discussions with NASA contacts of the concepts of direct delivery of the data to the user or mission center indicated that this concept has not been incorporated or considered in the NASA planning. Consequently, in future efforts (most notably Tasks 4 & 5) in depth discussions with the potential users will be required to uncover the advantages (if any), of this approach.

2.9 OPERATIONAL IMPACTS

During this effort, the operational impact of the shuttle, power utilization platform and space operations center on the various experiments and TDAS was

investigated. The assumptions involved in assessing the operational impacts are discussed below.

2.9.1 Shuttle

Since the shuttle experiments utilizing the shuttle's communication system were not included in the scenarios of experiments, only the Shuttle's flight schedule will impact the TDAS architecture. This impact will be assessed during subsequent Task 3 (Communications Mission Model) efforts. As discussed previously, five shuttles will be procured with the constant activity level and seven shuttles with the increased level.

2.9.2 Power Utilization Platform

The first platform available in 1990 will be a second-order Science and Applications Platform (SASP), having 6 berthing ports for experiment pallets. The choice of orbit inclinations for the 1990's will be either 28.5°, 57°, or 98°. For an increased activity level, two second order platforms will be available, each having 6 berthing ports.

During the SASP Payload Accomodation Study, payloads were deemed unsuitable for the platform for the following reasons:

- Experiment is too large
- Experiment requires all-sky coverage
- Experiment operation is too complicated
- Experiment requires low accelerations
- Experiment requires multiple orbits

Using this same criteria, the following experiments were declared free-flyers:

- Space Telescope (already a free-flyer)
- AXAF (already a free-flyer)
- TOPEX (low acceleration)
- Gravity Wave Interferometer (too large)

VLBRI (too large)
COSMIC/100M (too large)
MAGSAT (low accelerations)
Infrared Interferometer (too complicated/too large)

The remaining experiments/missions are considered candidates for the PUP. One berthing port will be dedicated to materials experimentation, leaving 5 ports available for instruments.

2.9.3 Space Operations Center (SOC)

As discussed previously, the SOC will be used to fly shuttle experiments for longer periods of time. As a result, the only operational impact of SOC is then the flight schedule.

SECTION 3

USER COMMUNITY CHARACTERISTICS

The TDAS User Community characteristics identified during this effort are summarized below. The tabulation of the characteristics has been segregated into communication, navigation, and physical characteristics for all experiments/missions. The characteristics which have been estimated are indicated by an asterisk. The raw data collected are presented in Appendix B along with the source of the data.

3.1 NAVIGATION

Table 3.1-1 provides the user community navigation characteristics as identified during this effort.

A summary of expected accuracies for the orbit, time and attitude determination functions expected to be available by the 1990s is presented in Tables 3.1-2a, b, and c. Semi-autonomous system options are included for all functions except attitude determination. The ground support is considered to be substantially less frequent and demanding than for orbit and time determination. The attitude accuracies pertaining to the Autonomous Attitude Determination System (AADS) assume the use of 10 \sec (1σ) star trackers. However, this could change up or down depending on the sensor complement for a particular application.

3.1.1 Evaluation of Suitability

This section addresses the suitability of the various navigation systems to potentially support the navigation functions of the user community in terms of an accuracy capability vs requirements comparisons. Requirements to be compared pertain only to normal orbit operational modes, since no special requirement during launch or orbit modification modes have been identified.

Table 3.1-3 lists the experiments/mission identified previously in Section 2 and the corresponding accuracy requirements for each function (to the extent

EXPERIMENT/MISSION	FILE NO.	POSITION ACCURACY (METERS)	POINTING ACCURACY (mr)	POINTING STABILITY (mr)	ASPECT KNOWLEDGE (mr)	TIME μ SEC
AXAF	5	>1000	0.15	0.15	2x10 ⁻³	1-10
X-RAY OBS.	106	ST ⁺	0.28	0.01	0.05	10 ³
LAMAR	35	ST ⁺	0.28	0.14	-	-
LADIR TELESCOPE	34	ST ⁺	5x10 ⁻⁴	5x10 ⁻⁵	-	-
INFRARED INTER.	30	ST ⁺	1.0*	3x10 ⁻⁵	-	TBD
SPACE TELESCOPE	92	200/1000*	1.0	3x10 ⁻⁵	-	1
COSMIC	8	ST ⁺	1.0*	2x10 ⁻⁶	-	1*
100-m THIN. APER. TELE.	56	ST ⁺	1.0*	2x10 ⁻⁶	-	1*
LARGE OPT./UV TELE.	37	ST ⁺	0.005	10 ⁻⁵	-	1*
GRAVITY WAVE INT.	23	>1000	1.0*	3x10 ⁻⁵ *	-	TBD
VLBRI	104		0.01	0.01	-	10**
ORB. SUB-mm TELE.	61	ST ⁺	0.01	0.01	-	10 ⁶
SCDM	74	>1000	0.005	0.002	-	1
SOC	89	15-30	5.8*	2.9*	-	1
MAG FIELD SURVEY B	40	30	0.017	0.017*	-	1
OERS	57	10	0.175	2x10 ⁻⁵	-	10 ³
ADV. THERMAL MAP.	4	50*	0.05	0.05*	-	3x10 ⁺³
SOIL MOIS. & ASS. MISS.	73	100	0.17	0.1	-	1*
OPER. METEOR. SAT.	58	500	1.7	0.26	-	10 ⁶
OCEAN RESEARCH (SAR)	55	50*	13.1*	0.17*	-	1*

NOTE: File Numbers refer to Appendix A

* ST Accuracy Requirements (200m - 10% of time, >1000m - 90% of time) are used for analogous missions

** For initial clock synchronization only; Need onboard clock stability of 10 ps/day

*ESTIMATED

TABLE 3.1-1: TDAS USER COMMUNITY NAVIGATION REQUIREMENTS

EXPERIMENT/MISSION	FILE NO.	POSITION ACCURACY (METERS)	POINTING ACCURACY (mr)	POINTING STABILITY (mr)	ASPECT KNOWLEDGE (mr)	TIME μ SEC
TOPEX	53	2-3 (0.1 Alt)	87.5	-	-	10 ⁵
SHUTTLE	93	100	8.7	0.034	-	1
MMS	46	175	0.17	0.17x10 ⁻⁴	-	1
MANNED GEO. SORTIE	42	100	8.7	0.03	-	TBD
TMS	98	100	4.4	1.7	-	TBD
PUP	67	10-30	5.8	2.9	-	0.01-0.1
HLLV	25	100*	8.7*	0.034*	-	TBD
OTV	59	4500	8.7	0.034*	-	TBD
AG-1,2,3,4	-	>1000	0.15	0.15	-	TBD
AG-5,6,7	-	ST*	0.28	0.28	-	10 ³
SG-1,3,5	-	>1000	0.005	0.002	-	1
SG-2,4	-	>1000	3	0.005	-	1
RG-1,2,3,4	-	10	0.175	2x10 ⁻⁵	-	1
EG-1,3,4,7	-	50	13.1	-	-	1
EG-2,5,6	-	2-3 (0.1 Alt)	87.5	-	-	10 ⁵

NOTE: File Numbers refer to Appendix A

*ESTIMATED

TABLE 3.1-1: TDAS USER COMMUNITY NAVIGATION REQUIREMENTS (CONT)

A) ORBIT DETERMINATION

SYSTEM	POSITION ACCURACY (1 σ) (METERS)	NOTES
SEMI-AUTONOMOUS*	TDRSS	SENSITIVE TO TDRSS TRACKING SCHEDULE
	TLRS	DEPENDENT ON RANGING DATA AVAILABILITY & USER PROXIMITY TO OBSERVATION REGION
AUTONOMOUS**	TDRSS (1 WAY)	SENSITIVE TO TDRSS TRACKING SCHEDULE
	GPS	DEPENDENT ON P SIGNAL AVAILABILITY & 18 - 24 SATELLITE CONSTELLATION
	SS-ANARS	SENSITIVE TO TIME BETWEEN MEASUREMENTS & IRU GYRO DRIFT CHARACTERISTICS
	SLS	DEPENDENT ON RANGING DATA AVAILABILITY & USER PROXIMITY TO OBSERVATION REGION

* MEASUREMENT DATA OBTAINED AT GROUND STATIONS(S)

** MEASUREMENT DATA OBTAINED ONBOARD USER SPACECRAFT

TABLE 3.1-2: NAVIGATION CAPABILITY SUMMARY

B) ATTITUDE DETERMINATION

SYSTEM	ATTITUDE ACCURACY (1σ) mrad (sec)	SENSOR COMPLEMENT
AUTONOMOUS*	0.05 (10)	2 NASA STD. STAR TRACKERS & IRU PACKAGE (THREE 2 AXIS GYROS)
	2×10^{-4} (0.4)	2 FOLDED OPTICS TELESCOPES & IRU PACKAGE (TWO 2 AXIS GYROS)

* GROUND-SUPPORT ONLY FOR VERIFICATION & STAR TABLE UPDATE

C) TIME DETERMINATION

SYSTEM	TIME ACCURACY (1σ) (μsec)	NOTES
SEMI-AUTONOMOUS	≤ 0.1	DEPENDENT ON EQUIPMENT CALIBRATION AND BIAS UNCERTAINTIES
AUTONOMOUS	0.005 - 0.01*	DEPENDENT ON P SIGNAL AVAILABILITY
	0.1 - 1.0	DEPENDENT ON TDRS & USER SATELLITE EPHEMERIS UNCERTAINTY

* RELATIVE TO GPS TIME

TABLE 3.1-2: NAVIGATION CAPABILITY SUMMARY (CONT)

TABLE 3.1-3: COMPARISON OF EXPERIMENT/MISSION ACCURACY REQUIREMENTS
WITH NAVIGATION SYSTEM CAPABILITIES

A) ORBIT DETERMINATION

EXPERIMENTS/MISSIONS	ACCURACY REQT. (METERS)	SEMI-AUTONOMOUS		AUTONOMOUS			
		TDRSS- 2 WAY (30 - 100 m)	TLRS (0.1-15 m)	TDRSS- 1 WAY (30 - 100 m)	GPS (5-15 m)	SS-ANARS (200 - 250 m)	SLS (0.1- 15 m)
AXAF (5)	>1000	X	X	X		X	X
X-RAY OBSERVATORY (106)	ST*	X	X	X	X	Y	X
LAMAR (35)	ST*	X	X	X	X	?	X
LADIR TELESCOPE (34)	ST*						
INFRARED INTERFEROMETER (30)	ST*						
SPACE TELESCOPE (92)	200/100						
COSMIC (8)	ST*						
100 m THEM. APER. TELE. (56)	ST*						
LARGE OPT./UV TELESCOPE (37)	ST*						
GRAVITY WAVE INTERFER. (23)	>1000						
VLRBI (104)	1000	X	X	X	X	X	X
ORB. SUB-M TELESCOPE (61)	ST*						
SCDM (74)	>1000						
SOC (89)	15-30				X		
MAG. FIELD SURVEY B (40)	30	X	X	X	X		X
OERS (57)	10				X		
ADV. THERMAL MAP (4)	50	X	X	X	X		X
SOIL MOIS. & ASS. MISS. (73)	100	X	X	X	X		X
OPER. METEOR. SAT. (52)	500	X	X	X	X	X	X
OCEAN RESEARCH (SAR) (55)	50	X	X	X	X		X
TOPEX (53)	3(0.1 ALT)		Y				Y
SHUTTLE (93)	100	X	X	X	X		X
MMS (46)	175	X	X	X	X		X
MANNED GEO. SORTIE (42)	100						
TELEOP. MAN. SYSTEM (38)	100	X	X	X	X		X
PUP (67)	10-30		X		X		X
HLLV (25)	100	X	X	X	X		X
OTV (59)	4500	X	X	X	X	X	X
AG - 1,2,3,4	>1000						
AG - 5,6,7	ST*						
SG - 1,3,5	>1000						
SG - 2,4	>1000						
RG - 1,2,3,4	10				X		
EG - 1,3,4,7	50	X	X	X	X		X
EG - 2,5,6	3(0.1 ALT)		Y				Y

NOTE: Numbers in parentheses refer to Appendix A

* X implies requirements should be met

Y implies requirements may be met at intervals

TABLE 3.1-3: COMPARISON OF EXPERIMENT/MISSION ACCURACY REQUIREMENTS
WITH NAVIGATION SYSTEM CAPABILITIES (CONT)

B) TIME DETERMINATION

EXPERIMENTS/MISSIONS	ACCURACY REQT. (μ sec)	SEMI-AUTONOMOUS	AUTONOMOUS	
		TDRSS - 2-WAY ($\leq 0.1 \mu$ s)	GPS ($\leq .01 \mu$ s)	TDRSS-1-WAY ($< 0.1-1.0 \mu$ s)
AXAF (5)	-			
X-RAY OBSERVATORY (106)	GPS		X	
LAMAR (35)	GPS		X	
LADIR TELESCOPE (34)	-			
INFRARED INTERFEROMETER (30)	-			
SPACE TELESCOPE (92)	-			
COSMIC (8)	-			
100 m THEM. APER. TELE. (56)	-			
LARGE OPT./UV TELESCOPE (37)	-			
GRAVITY WAVE INTERFER. (23)	-			
VLRBI (104)	10	X	X	X
ORB SUB-M. TELESCOPE (61)	-			
SCDM (74)	-			
SOC (89)	GPS		X	
MAG. FIELD SURVEY B (40)	1	X	X	X
OERS (57)	GPS		X	
ADV. THERMAL MAP. (4)	3000	X	X	X
SOIL MOIS. & ASS. MISS (73)	1	X	X	X
OPER. METEOR. SAT. (52)	10^6	X	X	X
OCEAN RESEARCH (SAR) (55)	1	X	X	X
TOPEX (53)	10^5	X	X	X
SHUTTLE (33)	GPS		X	
MMS (46)	1	X	X	X
MANNED GEO. SORTIE (42)	-			
TELEOP. MAN. SYSTEM (98)	GPS		X	
PIJP (67)	GPS		X	
HLLV (25)	GPS		X	
OTV (59)	GPS		X	
AG - 1,2,3,4	-			
AG - 5,6,7	-			
SG - 1,3,5	-			
SG - 2,4	-			
RG - 1,2,3,4	GPS		X	
EG - 1,3,4,7	1	X	X	X
EG - 2,5,6	10^5	X	X	X

NOTE: Numbers in parentheses refer to Appendix A.

* X Implies requirements should be met

TABLE 3.1-3: COMPARISON OF EXPERIMENT/MISSION ACCURACY REQUIREMENTS
WITH NAVIGATION SYSTEM CAPABILITIES (CONT)

C) ATTITUDE DETERMINATION

EXPERIMENTS/MISSIONS	ACCURACY REQT. (mrad)	AUTONOMOUS	
		AADS (.05 mrad)	SS-ANARS (.002 mrad)
AXAF (5)	0.15	X	X
X-RAY OBSERVATORY (106)	0.28	X	X
LAMAR (35)	0.28	X	X
LADIR TELESCOPE (34)	5×10^{-4}		
INFRARED INTERFEROMETER (30)	1.0	X	X
SPACE TELESCOPE (92)	1.0	X	X
COSMIC (8)	1.0	X	X
100 m THEM. APER. TELE. (56)	1.0	X	X
LARGE OPT./UV TELESCOPE (37)	0.005		X
GRAVITY WAVE INTERFER (23)	1.0	X	X
VLBI (104)	0.01		X
ORB. SUB-M. TELESCOPE (61)	0.01		X
SCDM (74)	0.005		X
SOC (89)	5.8	X	X
MAG. FIELD SURVEY B (40)	0.017		X
OERS (57)	0.175	X	X
ADV. THERMAL MAP (4)	0.05	X	X
SOIL MOIS & ASS. MISS. (73)	0.17	X	X
OPER. METEOR. SAT (52)	1.7	X	X
OCEAN RESEARCH (SAR) (55)	13.1	X	X
TOPEX (53)	87.5	X	X
SHUTTLE (33)	8.7	X	X
MMS (46)	0.17	X	X
MANNED GEO. SORTIE (42)	-		
TELEOP. MAN. SYSTEM (98)	4.4	X	X
PUP (67)	5.3	X	X
HLLV (25)	3.7	X	X
OTV (59)	8.7	X	X
AG - 1,2,3,4	0.15	X	X
AG - 5,6,7	0.28	X	X
SG - 1,3,5	0.005		X
SG - 2,4	3.0	X	X
RG - 1,2,3,4	0.175	X	X
EG - 1,3,4,7	13.1	X	X
EG - 2,5,6	87.5	X	X

NOTE: Numbers in parentheses refer to Appendix A

* X Implies requirements should be met

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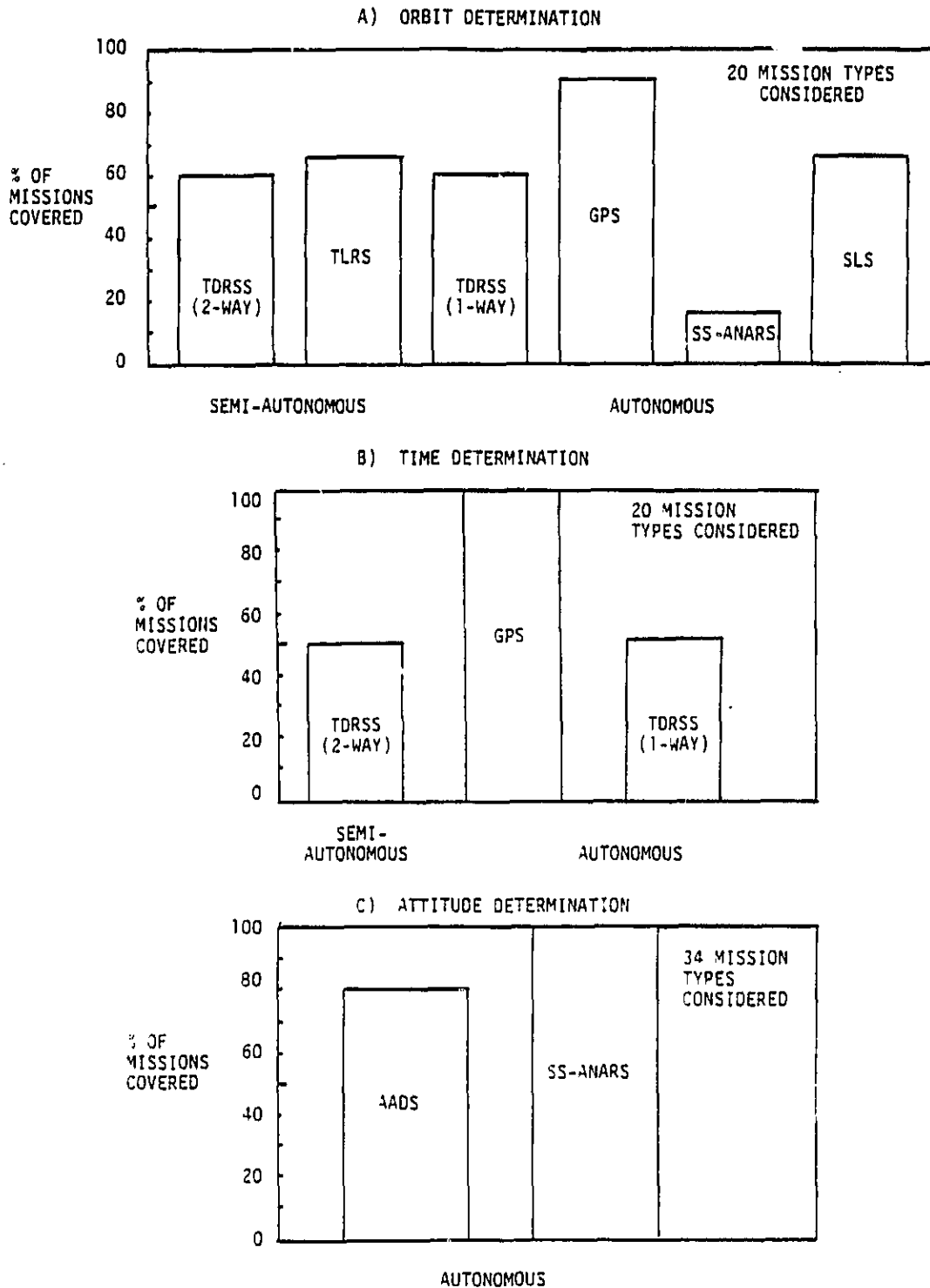


FIGURE 3.1-1: SUMMARY OF SYSTEM ACCURACY CAPABILITIES
TO MEET EXPERIMENT/MISSION NAVIGATION REQUIREMENTS

known or estimated). Dashes indicate that no requirement exists or can be defined at this time. Each of the systems surveyed for providing the navigation function are also listed with their corresponding accuracies. An x appears in the array wherever the system accuracy capability is deemed compatible with the experiment requirement.

For orbit determination only TOPEX and EG-2,5,6 and B have accuracy requirements which cannot be met continuously. The laser systems could potentially meet the requirements over orbit segments where retro-reflectors are located. A comparison of the various system capabilities to meet the orbit determination requirements is given in Figure 3.1-1. GPS appears to be the most applicable and the space sextant the least applicable among all alternatives considered.

For time determination an on-board clock is assumed to be updated to the accuracy requirements shown in Table 3.1-3. As indicated in Figure 3.1-1, GPS meets all accuracy requirements, while TDRSS (2 way) and TDRSS (1 way) meet about half. It should also be observed that with GPS the user clock oscillator long term stability requirements would be less than with the TDRSS alternatives, since GPS updates occur almost continuously. TDRSS updates would likely occur at longer intervals and thus requires a more stable clock oscillator to maintain the same overall timing accuracy.

For attitude determination all mission accuracy requirements except for the LADIR telescope mission are met with at least one of the alternatives considered. Meeting the LADIR requirement could potentially be done with a secondary, fine pointing payload sensor such as the Telescope Boresight Sensor demonstrated on OAO-C. Figure 3.1-1 shows that 80% of the requirements could be met with a .05 m μ r accuracy capability such as the AADS is planned to provide.

3.2 COMMUNICATIONS

Table 3.2-1 provides the TDAS User Community communication characteristics. Only those experiments/missions which are definitely free-flyers have spacecraft T&C characteristics. The experiment T&C characteristics have been

estimated for most of the experiments/missions since this function is typically not included or discussed in the planning documents.

3.3 PHYSICAL

Table 3.3-1 provides the TDAS user community physical characteristics. These are considered to be self-explanatory and will not be discussed further.

EXPERIMENT/MISSION	EXPERIMENT T&C (1)			EXPERIMENT DATA				SPACECRAFT T&C			
	FILE NO.	COMMAND RATE (kbps)	CONTACTS/DAY	HOURS/CONTACT	REAL TIME DATA RATE (kbps)	CONTACTS PER DAY	HOURS/CONTACT	TELE DATA RATE (Mbps)	CONTACTS PER DAY	HOURS/CONTACT	COM RATE (kbps)
AXAF	5	1*	4*	0.2*	40	1*	2.8*	1.0	4*	0.2*	2/**
X-RAY OBS.	106	1	4*	0.2*	8	10*	0.1*	1.024			
LAHAR	35	1	4*	0.2*	8	7*	0.1*	2.048			
LADIR TELESCOPE	34	1	4*	0.2*	-	3.3*	0.1*	7.0			
INFRARED INTL.	30	1	4*	0.2*	-	1*	24*	1.0			
SPACE TELESCOPE	92	1	4*	0.2*	4	3*	0.8*	1.024	4*	0.2*	2/**
COSMIC	6	1*	4*	0.2*	100	1*	0.03*	100			
100-m IRR. APER. TELE.	56	1*	4*	0.2*	100	1*	0.03*	100			
LARGE OPT./UV TELE.	17	1	4*	0.2*	4	3*	0.8*	1.024			
GRAVITY WAVE INT.	23	1	4*	0.2*	-	1*	24*	1.0*			
VI BRI	104	1*	4*	0.2*	120 Mbps	1	24	-			
ORB. SHIPH. TELE.	61	1*	4*	0.2*	1	1*	0.03*	0.01			
SCIM	74	1	4*	0.2*	16	2.5*	0.5*	1.024			
SOC	89	300*	1	24	50*	24*	0.3*	300*			
HAG SUR B	40	1	4	0.2*	12	4	0.2*	0.064			
OILS	57	25	14*	0.2*	700 Mbps	1	24	-			
ADV. THERMAL MAP	4	1	16	0.3	200	16	0.3	-			
SOIL MOIS. & ASS. MISS.	73	1	14	0.2*	500	14	0.2	-			
OPER. ALTOR. SAT.	58	1	12-14	0.2	665	10-11	0.2	2.66			
OCEAN RESEARCH (SAR)	55	2*	14*	0.3*	200 Mbps	14*	0.3*	-			

NOTE: File Numbers refer to Appendix A

(1) Experiment Telemetry is included in Experiment Data.

* Estimated
** Included with experiment data

TABLE 3.2-1: TDAS USER COMMUNITY COMMUNICATION CHARACTERISTICS

EXPERIMENT/MISSION	FILE NO.	EXPERIMENT IBC (1)			EXPERIMENT DATA			SPACECRAFT IBC		COM RATE/ TELE RATE (kbps)
		COMMAND RATE (kbps)	CONTACTS/DAY	HOURS/CONTACT	REAL TIME DATA RATE (kbps)	CONTACTS PER DAY	HOURS/CONTACT	DUMP DATA RATE (Mbps)	CONTACTS PER DAY	
TOPEX	53	1	13	0.3	8	13	0.3	0.05		
SHUTTLE	93	96/192 (s) 72/216 (k)	1	24	32/72 (s) 192/50000 (k)	1	24	4*	0.2*	**/**
HMS	46	2	***	***	1-64	***	***	2.048		
MAUNED GLO. SORTIE	42	1	1	24	1.5 Mbps	1	24	-		
IHS	98	1	4	0.2	15 Mbps	1	24	15	24	2/15000
PUP	67	300	1	24	50	24	0.3	300	24	1/15000
HITV	25	1*	***	***	16	***	***	-	1/flight	**/**
OTV	59	1*	1-12	0.75	6 Mbps	1-12	0.75	-	1/flight	2/16
AG-1,2,3,4	-	1	4	0.2	4	2.5	0.05	1.024		
AG-5,6,7	-	1	4	0.2	8	7	0.03	1.024		
SG-1,3,5	-	1	4	0.2	16	2.5	0.5	1.024		
SG-2,4	-	1	4	0.2	32 Mbps	1	24	-		
RG-1,2,3,4	-	1	14	0.3	800 Mbps	1	24	-		
EG-1,3,4,7	-	2	14	0.3	200 Mbps	14	0.3	-		
EG-2,5,6	-	1	13	0.3	8	13	0.3	0.05		

NOTE: File Numbers refer to Appendix A

(1) Experiment telemetry is included in Experiment Data.

*Estimated

TABLE 3.2-1: TDAS USER COMMUNITY COMMUNICATION CHARACTERISTICS (CONT)

EXPERIMENT/MISSION	FILE NO.	ORBIT		SPACECRAFT/EXPERIMENT					
		APOGEE (km)	INCLINATION (°)	POWER WATTS	SIZE (m)	MASS (kg)	FIELD OF VIEW		
AXAF	5	450	28.5	1200	11.4x3.1	10000	All-sky		
X-RAY OBS.	106	300	28.5	900	2.9x3.6	3500	All-sky		
LAMAR	35	400	28.5	1050	6x4	5200	All-sky		
LADAR TELESCOPE	34	400-700	28-50	3000	15x12	16000	All-sky		
INFRARED INTER.	30	400-700	28-57	25000	100x15	22500	All-sky		
SPACE TELESCOPE	92	600	28.8	2100	3.6x4.3	11070	All-sky		
COSMIC	8	500	28.5	25000	12x4	67000	All-sky		
100-m THIN. APER. TELE.	56	500	28.5	25000	100(dia)	85000	All-sky		
LARGE OPT./UV TELE.	37	450	28.5	6000	28.5x8.4	22800	All-sky		
GRAVITY WAVE INT.	23	250	Any	1000	1000	16000	All-sky		
VI DRI	104	300-5000	45	1200	30-60(dia)	6000	All-sky		
DIR. SHIPW. TELE.	61	1000	SUN-SYNC	500	10-15(dia)	1000	All-sky		
SCDH	74	575	28 or 98	800	6x2	2600	Sun		
SOC	89	400	28	25000	13.4x19.5	19700-49600	All-sky		
MAG SUR B	40	300	97	150	1x1	800			
OIRS	57	705	99	1200	8x4.5	4214	Earth		
AUV. ILLUMIN. MAP.	4	620	97.8	630*	1.7x3.5	300	Earth		
SOLR WINDS. & ASS. MISS.	73	400-700	60-98	1200	11x10	2000	Earth		
UPLR. REFLOR. SAT.	58	830	98.7	420	3.7x1.9	740	Earth		
OCEAN RESEARCH (SAR)	55	790	Polar	1000	2x10	2000	Earth		

* ESTIMATED

NOTE: File Numbers refer to Appendix A

(1) Experiment Telemetry is included in Experiment Data.

TABLE 3.3-1: TDAS USER COMMUNITY PHYSICAL CHARACTERISTICS

EXPERIMENT/MISSION	FILE NO.	ORBIT		INCLINATION (°)	POWER WATTS	SIZE (m)	MASS (kg)	SPACECRAFT/EXPERIMENT	
		APOGEE (km)	PERIGEE (km)					FIELD OF VIEW	
TOPEX	53	1334		63.4	500	2x3	1350	Earth	
SHUTTLE	93	185-1110		28.5-57 70-104	7000	37x17	86000	All-sky	
MHS	46	500-1600		Various	1200	2.9x3.6	4048	All-sky Earth	
HARNED GLO. SORTIE	42	370		Various	1000*	20x20	6000	All-sky	
IHS	98	1000		Various	550	3.3x3.2	6500	All-sky	
PUP	67	400		28.57 Polar	25000	13.4x19.5	19700- 49600	All-sky	
IIIIV	25	200-500		Various	1000*	53	1.9x10 ⁶	All-sky	
OTV	59	100-600		Various	500*	4-10x6.5	37000	All-sky	
AG-1,2,3,4	-	100		28.5	200	3.6x1.6	1000	All-sky	
AG-5,6,7	-	400		28.5	900	3.6x1.6	3500	All-sky	
SG-1,3,5	-	575		28	800	6x2	2600	Sun	
SG-2,4	-	400		57	10500			Sun	
IG-1,2,3,4	-	700		98	1200	8x5	4214	Earth	
EG-1,3,4,7	-	790		98	1000	2x10	2000	Earth	
EG-2,5,6	-	1334		63	500	2x3	1350	Earth	

NOTE: File Numbers refer to Appendix A
(1) Experiment Telemetry is included in Experiment Data.

*ESTIMATED

TABLE 3.3-1: TDAS USER COMMUNITY PHYSICAL CHARACTERISTICS (CONT)

APPENDIX A

BASELINE OF PLANS

APPENDIX
INTRODUCTION

The following list shows the baseline of plans used to develop information related to the period of the 1990's during which TDAS would be active. A number of items in the list were found to be non-drivers relative to TDAS architectural considerations. Those items marked (*) were dropped from consideration in accordance with reasons presented in the main text. See subsection 2.3 for additional details.

In addition, a set of generic experiments was defined to reflect special considerations as defined in sub-section 2.2 of the main text. These are identified as follows:

- Astrophysics-Generic
 - AG - 1, 2, 3, 4, (29. IRASS type)
 - AG - 5, 6, 7 (106. XRO type)

- Solar Terrestrial-Generic
 - SG - 1, 3, 5 (74. SCDM type)
 - SG - 2, 4 (83. STO type)

- Resource Observation-Generic
 - RG - 1, 2, 3, 4 (57. Advance Land Observing System)

- Global Environment-Generic
 - EG - 1, 3, 4, 7 (55. OSAR)
 - EG - 2, 5, 6 (53. TOPEX)

APPENDIX A

BASELINE OF PLANS

<u>FILE NO.</u>	<u>STATUS</u>	<u>EXPERIMENTS - MISSIONS - PROGRAMS</u>
1	Planned*	Active Magnetospheric Particle Tracer Experiment
2	Opportunity	Advanced Electric Propulsion (B-1)
3	Imaginative*	Advanced Resources/Pollution Observatory
4	Planned	Advanced Thermal Mapping Applications Satellite (B-2)
5	Planned	Advanced X-Ray Astrophysics Facility (B-3)
6	*	Chemical Release Module Facility
7	Opportunity*	Close Solar Orbiter
8	Opportunity	Coherent Optical System of Modular Imaging Collectors (B-4)
9	Approved*	Cosmic Background Explorer - COBE
10	Planned*	Cosmic Ray Observatory
11	Approved*	Crustal Dynamics Program
12	Imaginative*	Detection of Other Planetary Systems
13	Imaginative*	Doppler Millihertz Gravity Wave
14	Approved*	Dynamics Explorer
15	Approved*	Earth Radiation Budget Satellite
16	Approved*	Extraterrestrial Materials Processing Program
17	Planned*	Extreme Ultraviolet Explorer
18	Planned*	Gamma Ray Observatory - GRO
19	Approved*	Geostationary Orbiting Environmental Satellite (GOES)
20	Imaginative*	Global Search and Rescue Locator
21	Imaginative*	Gravity Gradiometer
22	Planned*	Gravity Probe - GP-B
23	Opportunity	Gravity Wave Interferometer (B-5)
24	Planned*	GravSat A
25	Opportunity	Heavy-Lift Launch Vehicle - HLLV (B-6)
26	Approved*	High Energy Astronomical Observatory-C
27	*	High Resolution Earth Mapping Radar
28	*	Highly Autonomous Tele-Robot

* Dropped. See sub-section 2.3 of main text.

NOTE: Numbers in parentheses refer to Appendix B.

APPENDIX A

BASELINE OF PLANS (CONT)

<u>FILE NO.</u>	<u>STATUS</u>	<u>EXPERIMENTS - MISSIONS - PROGRAMS</u>
29	Approved*	Infrared Astronomical Satellite (IRAS)
30	Opportunity	Infrared Interferometer (B-7)
31	Approved*	International Solar Polar Mission
32	Approved*	Landsat D
33	Imaginative*	Landsat H
34	Candidate	Large Ambient Deployable IR Telescope (B-8)
35	Candidate	Large Area Modular Array of Reflectors (B-9)
36	Planned*	Large Format Camera
37	Opportunity	Large Optical/UV Telescope (B-10)
38	Planned*	Large Power Module (B-11)
39	Planned*	Large Space Structures Technology and Development
40	Planned	Magnetic Field Survey B (B-12)
41	Approved*	Magsat
42	Candidate	Manned GEO Sortie (B-13)
43	Planned	Materials Experimentation Carrier (B-14)
44	Planned	Materials Experimentation Carrier II (B-15)
45	Opportunity*	Materials Experimentation Module
46	Approved	Multi-mission Modular Spacecraft - MMS (B-16)
47	Opportunity*	Multi-Service Thin Route Narrowband Program
48	Approved*	National Materials Laboratory Program
49	Planned	National Oceanic Satellite System - NOSS (B-17)
50	Approved*	NOAA A-G Satellites
51	Planned*	NOSS Research Program (B-18)
52	Imaginative*	Nuclear Waste Disposal
53	Planned	Ocean Circulation Mission-Topography Experiment - TOPEX (B-19)
54	Imaginative*	Ocean Exploration System
55	Candidate	Ocean Research - Synthetic Aperture Radar - SAR (B-20)

* Dropped. See sub-section 2.3 of main text.

NOTE: Numbers in parentheses refer to Appendix B.

APPENDIX A

BASELINE OF PLANS (CONT)

<u>FILE NO.</u>	<u>STATUS</u>	<u>EXPERIMENTS - MISSIONS - PROGRAMS</u>
56	Opportunity	100-m Thinned Aperture Telescope (B-21)
57	Planned	Operational Earth Resources System -OERS (B-21)
58	Planned	Operational Meteorology Satellites(s) (B-23)
59	Planned	Orbital Transfer Vehicle (B-24)
60	Imaginative*	Orbiting Civil Command and Control Station
61	Candidate	Orbiting Submillimeter Telescope (B-25)
62	Planned*	Origins of Plasmas in the Earth's Neighborhood
63	Imaginative*	Permanent Orbiting Output
64	Opportunity	Pinhole Satellite (B-26)
65	Planned*	Plasma Turbulence Explorer
66	Planned*	Power Extension Package
67	Planned	Power Utilization Program - PUP (B-27)
68	Planned	Science and Applications Space Platform (B-28)
69	Approved*	Search and Rescue Mission
70	Opportunity*	Search for Extraterrestrial Intelligence - SETI
71	Planned*	Shuttle Infrared Telescope Facility - SIRIF
72	Imaginative*	Single-Stage-to-Orbit Shuttle
73	Candidate	Soil Moisture Research and Assessment Mission (B-29)
74	Candidate	Solar Cycle and Dynamics Mission-SCD11 (B-30)
75	Planned*	Solar Electric Propulsion Stage (B-31)
76	Approved*	Solar Maximum Mission
77	Approved*	Solar Mesosphere Explorer
78	Approved*	Solar Optical Telescope - SOT (B-32)
79	Imaginative*	Solar Penetrator
80	Imaginative*	Solar Power Satellite
81	Planned*	Solar Probe
82	Planned	Solar Soft X-Ray Telescope Facility (B-33)
83	Candidate	Solar Terrestrial Observatory-STO (B-34)

* Dropped. See sub-section 2.3 of Main Text

NOTE: Numbers in parentheses refer to Appendix B.

APPENDIX A

BASELINE OF PLANS (CONT)

<u>FILE NO.</u>	<u>STATUS</u>	<u>EXPERIMENTS - MISSIONS - PROGRAMS</u>
84	Imaginative*	Space-Based Astrophysics Research Facility
85	Imaginative*	Space-Based Atmospheric Research Facility
86	Imaginative*	Space-Based Health Care Research Facility
87	Approved*	Spacelab
88	Planned*	Spacelab Biological Experiments
89	Opportunity	Space Operations Center - SOC (B-35)
90	Opportunity*	Space Power Technology Demonstration (B-36)
91	Planned	Space Sciences Platform (B-37)
92	Approved	Space Telescope (B-38)
93	Approved	Space Transportation System -STS (B-39)
94	Planned	Starlab (B-40)
95	Approved*	Stratospheric Aerosol and Gas Experiment
96	Planned*	Subsatellite Facility
97	Imaginative*	Synchronous Meteorological Satellite
98	Candidate	Teleoperator Maneuvering System
99	Imaginative*	10-m Optical Interferometer
100	Planned*	Tethered Satellite System
101	Planned*	Time and Frequency Transfer Experiment
102	Planned	25-kW Power System (B-42)
103	Planned*	Upper Atmospheric Research Satellite - UARS
104	Candidate	Very Long Base-Line Radio Interferometer (B-43)
105	Imaginative*	Water Level and Fault Movement Indicator
106	Planned	X-Ray Observatory - XRO (B-44)
107	Planned*	X-Ray Explorer
AG - 1,2,3,4		Astrophysics - Generic (B-45)
AG - 5,6,7		Astrophysics - Generic (B-46)
SG - 1,3,5		Solar Terrestrial - Generic (B-47)
SG - 2,4		Solar Terrestrial - Generic (B-48)
RG - 1,2,3,4		Resource Observation - Generic (B-49)
EG - 1,3,4,7		Global Environment - Generic (B-50)
EG - 2,5,6,8		Global Environment - Generic (B-51)

* Dropped. See sub-section 2.3 of main text.

NOTE: Numbers in parentheses refer to Appendix B.

APPENDIX B

USER COMMUNITY CHARACTERISTICS DATA

APPENDIX B

CONTENTS

<u>APPENDIX SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
	<u>INTRODUCTION</u>	B-4
	<u>QUESTIONNAIRE - TDAS USER COMMUNITY CHARACTERISTICS</u>	B-5
B-1	Advanced Electric Propulsion (2)	B-8
B-2	Advanced Thermal Mapping Applications Satellite (4)	B-9
B-3	Advanced X-Ray Astrophysics Facility (5)	B-11
B-4	Coherent Optical System of Modular Imaging Collectors (8)	B-13
B-5	Gravity Wave Interferometer (23)	B-15
B-6	Heavy-Lift Launch Vehicle (25)	B-17
B-7	Infrared Interferometer (23)	B-19
B-8	Large Ambient Deployable IR Telescope (34)	B-21
B-9	Large Area Modular Array of Reflectors (35)	B-23
B-10	Large Optical/UV Telescope (37)	B-25
B-11	Large Power Module (38)	B-27
B-12	Magnetic Field Survey B (40)	B-28
B-13	Manned GEO Sortie (42)	B-30
B-14	Materials Experimentation Carrier (43)	B-32
B-15	Materials Experimentation Carrier II (44)	B-33
B-16	Multi-Mission Modular Spacecraft - MMS (46)	B-34
B-17	National Oceanic Satellite System (NOSS) (49)	B-37
B-18	NOSS Research Program (51)	B-39
B-19	Ocean Circulation Mission-Topography Experiment - TOPEX (53)	B-40
B-20	Ocean Research-Synthetic Aperture Radar - SAR (55)	B-42
B-21	100-m Thinned Aperture Telescope (56)	B-44
B-22	Operational Earth Resources System - OERS (57)	B-46
B-23	Operational Meteorology Satellite(s) (58)	B-48
B-24	Orbital Transfer Vehicle (59)	B-50
B-25	Orbiting Submillimeter Telescope (61)	B-52

APPENDIX B

CONTENTS (CONT)

<u>APPENDIX SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
B-26	Pinhole Satellite (64)	B-54
B-27	Power Utilization Program - PUP (67)	B-57
B-28	Science and Applications Space Platform (68)	B-60
B-29	Soil Moisture Research and Assessment Mission (73)	B-61
B-30	Solar Cycle and Dynamics Mission - SCDM (74)	B-63
B-31	Solar Electric Propulsion Stage (75)	B-65
B-32	Solar Optical Telescope (78)	B-66
B-33	Solar Soft X-Ray Telescope Facility (82)	B-69
B-34	Solar Terrestrial Observatory - STO (83)	B-72
B-35	Space Operations Center (SOC) (89)	B-73
B-36	Space Power Technology Demonstration (90)	B-75
B-37	Space Sciences Platform (91)	B-76
B-38	Space Telescope (92)	B-77
B-39	Space Transportation System - STS (93)	B-79
B-40	Starlab (94)	B-85
B-41	Teleoperator Maneuvering System (98)	B-87
B-42	25-KW Power System (102)	B-89
B-43	Very Long Base-Line Radio Interferometer	B-90
B-44	X-Ray Observatory - XRO (106)	B-92
B-45	Astrophysics - Generic (AG - 1,2,3,4)	B-94
B-46	Astrophysics - Generic (AG - 5,6,7)	B-96
B-47	Solar Terrestrial - Generic (SG - 1,3,5)	B-98
B-48	Solar Terrestrial - Generic (SG - 2,4)	B-100
B-49	Resource Observation - Generic (RG - 1,2,3,4)	B-102
B-50	Global Environment - Generic (EG - 1,3,4,7)	B-104
B-51	Global Environment - Generic (EG - 2,5,6,8)	B-106

NOTE: Numbers in parenthesis refer to Appendix A

APPENDIX B

INTRODUCTION

In accordance with the Task 1 planned approach, information was collected by interviewing NASA management personnel, and by review of published documentation, relative to planning for the TDAS time frame. The resulting information was processed and summarized by mission, as documented in the following pages of this appendix.

The initial questionnaire guidance to the study team is shown below, followed by the resulting data. The data entries are generally self-explanatory.

In many cases desired information was not available or could not be found during the study period. Since such missing information could become available at a later date, the entry space is preserved and "TBD" (To be determined) is entered for brevity.

For example, this is used in appendix section B-3, under "Orbit Parameters-Flight Activity Profile". The "description" in Section B-3 indicates the AXAF spacecraft will be recovered for ground refurbishments and re-flight. The Flight Activity Profile should indicate planning data such as time periods in-orbit (full TDAS loading), in transfer (TT&C loads only), and on the ground (no TDAS requirement) over the 10 to 15 year lifetime. In this example, such information is TBD.

In other cases, "NA" is used for "not applicable". Thus, for example, in Section B-2, NA is used under "Data Characteristics - Processed D/L Data Rate" because of the previous indication of no on-board data processing. In this case later cost-trade off study results could conceivably indicated desirability of adding on-board data processing, but it is not clear that this would happen. NA is the entry of choice.

APPENDIX B

QUESTIONNAIRE - TDAS USER COMMUNITY CHARACTERISTICS

The purpose of this questionnaire is to provide guidance to the Task team personnel in collecting the information required to establish the TDAS planning baseline. The information collected for each experimental program will be submitted to the Task Manager for incorporation in the Final Report. Quantitative information is, of course, desired, however, if only qualitative information is available it should be refined as much as possible.

Most of the experimental programs will have a status of O (opportunity).* During the interview, attempts should be made to assess the likelihood of the experimental program eventually being approved or conducted.

Experimental Program Characteristics

Here the objectives of the experimental program along with a brief description are required, with references. Information at the program level should include:

- Program definition and areas of uncertainty including funding and timing constraints.
- Identification of technology dependencies and preferred options
- Ties, actual or potential, to other programs, and any interactive benefits potentially available.
- At least two program size options, such as planned and smallest feasible programs.
- List of expert personnel, and bibliography, for the experiment.

*NOTE: Other possible categories are:

- A - Approved
- P - Planned
- C - Candidate

QUESTIONNAIRE (CONTINUED)

Orbit Parameters:

The desired altitude and inclination for the experimental program is required to allow combinations of experiments to be established for the Spacecraft Data System Architecture tasks. Also of importance is the planned carrier for the experiment characterized as STS (the shuttle), free-flyer, platform, or Space Station. The desired launch date and flight duration and frequency is required to allow determination of the loading of the TDAS. The description of simultaneous or associated experiments is required for this same determination.

Spacecraft Requirements

Define special requirements to be imposed on the spacecraft by the experiments, such as field of view, power, stability, thermal, interactive anomalies, special vehicle-vehicle or vehicle-earth cooperative actions, and orbital maneuvering. Also show physical characteristics (size, weight) in orbit (and at launch if different), for the two program levels (e.g., as planned and minimal program). Include operational considerations, such as impact of shuttle operations.

Data Characteristics

The required data rate of the forward (to the experiment) and return data links will be used to derive the communication mission model. The use of on-board storage should be determined and the impact on the continuity of service (e.g., contacts per day, time per contact) assessed. Obtain data transfer characteristics for mission data, mission command, control and telemetry (CC&T), and user experiment CC&T. This information will be used to size the TDAS. Any limitations on the communication frequency band should be identified.

Data Distribution/Processing

The requirements for ground data distribution and delivery (including timeliness) as well as data processing and pre-processing requirements need to be identified to support the Ground System Architecture task. Any advantages or disadvantages to on-board processing of the data either on the user vehicle or on TDAS should be determined. The advantages and disadvantages of direct delivery of the data to a user site from TDAS should be determined.

QUESTIONNAIRE (CONTINUED)

Navigation Requirements

The navigation requirements of the experimental programs are needed as part of the User Community Characteristics task. In particular, for each experiment, the pointing accuracy and stability/jitter, position accuracy and precise time requirements should be identified.

Items include:

- Orbit and Ephemeris
- Timing Accuracy
- Attitude (Roll, Pitch, Yaw)

Also indicate navigation frame of reference, proposed sensor techniques or TDAS support, and secondary (backup) navigation requirements, including any potential 1990's systems in planning or development stages.

The need for user tracking services for user orbit determination should be identified. The destination of the tracking data should be identified as well as the required accuracy.

Miscellaneous

As part of the development of the scenarios of experiments, the expected budget requirements for each experimental program should be determined. This information should be such that the amount per year can be determined. (Note: sufficient information could not be collected to be useful, in nearly all cases, so none is reported in this study.)

Since the use of manned platforms is being considered, any advantages of manning the particular experiment should be identified.

The utility of a relay at greater than synchronous orbit including a deep space relay needs to be determined. If the experimental program would accrue benefits from this type of relay, the details of its use should be identified. (Note: this question is deferred to a later Task. No data is available for this report).

Any unique or unusual support requirements for each experimental program should be identified. This would include the use of special waveforms as well as other items.

B-1: Advanced Electric Propulsion (2)

NASA Headquarters indicated that this is no longer a viable program. If it is ever flown it will be well beyond the time frame of TDAS.

B-2: Advanced Thermal Mapping Satellite (4)

OBJECTIVE: Investigate remote sensing potential of narrow spectral band imagery in thermal spectral region.

DESCRIPTION: Explorer-class mission with high sensitivity photodetectors in narrow spectral bands of the thermal IR region. Advanced version of Heat Capacity Mapping Mission (HCMM), with multi-channel and microwave radiometer capabilities.

ORBIT PARAMETERS:

Altitude: 620km circular
Inclination: 97.86°
Carrier: Free-Flyer
Launch Date: 1988
Flight Duration: 2 - 3 years
Flight Activity Profile: One Flight

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
Power: 630 Watts*
Size: 1.7 x 1.7 x 3.5 m*
Mass: 300 kg*

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 200 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: NO
Daily Data Volume: 3 x 10⁹ bits
On-Board Processing: NA
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS: **

Position Accuracy: ± 50 Meters
Pointing Accuracy: 10 arc. sec.
Stability: 0.05 mr
Time Requirement: ± 3 ms
Techniques: GPS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 1 Contact/Revolution
Forward Link - Hours/Contact: < 17 minutes
Return Link - Contacts/Day: 1 Contact/Revolution
Return Link - Hours/Contact: 17 minutes

* Estimated From Heat Capacity Mapping Mission (HCMM)
** LANDSAT D

DATA DISTRIBUTION/PROCESSING FLOW: *

Image data is recorded at tracking stations on analog tapes, which are mailed to Image Processing Facility (IPF) for processing. IPF generates high density tapes, computer compatible tapes, and film products. After validation, data is sent to NSSDC for archiving. NSSDC will furnish data to qualified users without charge.

NASA CONTACTS:

W. Plotrowski, NASA HQ. (202) 755-6038

REFERENCES:

OSTA NASA Technology Model [15.0]

B-3: Advanced X-Ray Astrophysics Facility (5)

OBJECTIVE: The Advanced X-ray Astrophysics Facility (AXAF) will serve as an X-ray astrophysics facility to complement visual and radio observations made from the ground and from space observatories such as the Space Telescope. The basic objectives are to determine the positions of X-ray sources, their physical properties as composition and structure, and the processes involved in x-ray photon production.

DESCRIPTION: AXAF is a free-flying, Shuttle launched spacecraft designed to view celestial X-ray sources. The facility has a 1.2 meter diameter Wolter type I mirror assembly which has a 0.5 arc sec resolution goal. Instruments using this mirror assembly are mounted in a rotating carousel at the focal plane. AXAF is being designed for on-orbit repair and instrument changeouts. Recovery for ground refurbishment and avionics redundancy are planned to achieve a 10 to 15 year lifetime. NASA's Astrophysics Program is considering AXAF as a candidate new project for FY 83 with launch in 1987.

ORBIT PARAMETERS:

Altitude: 450 km
 Inclination: 28.5°
 Carrier: Free Flyer
 Launch Date: 1987
 Flight Duration: 10-15 years
 Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 1200 W
 Size: 11.5 x 3.1 (dia)m
 Mass: 10,000 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 40 kbps/1Mbps
 Experiment Control Data Rate: 1 kbps*
 Mission TT&C Data Rate: 2 kbps*
 On-Board Data Storage: 10¹⁰ bits
 Daily Data Volume: 10⁹ - 10¹¹ bits/day
 On-Board Processing: NSSC-1 32K

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 0.15 mr
 Stability: 0.15 mr
 Time Requirement: TBD
 Techniques: Startrackers, inertial reference unit,
 sun sensor, magnetometer

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4***
Forward Link - Hours/Contact: 0.2***
Return Link - Contacts/Day: 1**
Return Link - Hours/Contact: 2.8**

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

B.G. Davis, MSFC

REFERENCES:

Space Systems Technology Model [15.0]

* MMS
** Computed based on data volume, storage and dump rate
*** Estimated

B-4: Coherent Optical System of Modular Imaging Collectors (8)

OBJECTIVE: The overall objective of the Coherent Optical System of Modular Imaging Collectors (COSMIC) is to increase the capabilities of UV/Optical/IR astronomy by several orders of magnitude more than Space Telescope. Typical science investigations are calibration of the distance scale beyond Virgo out to the Coma cluster, high resolution studies of quasars, search for planetary systems.

DESCRIPTION: Cosmic could be developed by NASA in the 1990's as a long-lived international observatory analogous to Space Telescope. A large coherent array of optical collectors is deployed in orbit by assembly of modules carried into orbit inside the Shuttle Orbiter bay. Initially only one module consisting of a 10 m baseline array is sufficient to prove the concept and at the same time significantly increase the angular resolution capability over Space Telescope. Several array geometries are under consideration which minimize the number of elements. An evolutionary development starting with a two-four element interferometer and evolving to a two dimensional array is proposed. The ultimate limit of such an approach depends upon the ability to manage the buildup of tolerance. The 100 Meter Thinned Aperture Telescope is an alternate method for providing significant advances for optical astronomy.

ORBIT PARAMETERS:

Altitude: 500 km (eventually GEO)
 Inclination: 28.5°
 Carrier: Free Flyer
 Launch Date: 1990
 Flight Duration: 10 years
 Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 25,000 W
 Size: 12 x 4 (dia)m
 Mass: 67,000

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 100 kbps/100 Mbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 10^{11} bits
 Daily Data Volume: 10^{11} bits/day
 On-Board Processing:

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 1.0 mr*
 Stability: 2×10^{-6} mr
 Time Requirement: TBD
 Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4***
Forward Link - Hours/Contact: 0.2***
Return Link - Contacts/Day: 1**
Return Link - Hours/Contact: 0.03**

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

M. Nein, MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

-
- * Space Telescope
 - ** Computed using data volume, storage and dump rate
 - *** Estimated

B-5: Gravity Wave Interferometer (23,

OBJECTIVE: The Gravity Wave Interferometer searches for gravitational radiation from astrophysical sources such as binaries, pulsars and black holes. The characteristics to be determined are the amplitude, the frequency bandwidth, polarization and, for transient events, time history of amplitude and phase.

DESCRIPTION: A Shuttle based beam manufacturing machine is used to fabricate the large antenna structure. The antenna has arm dimensions of about 1 km and has a 1000 kg test mass at each tip. Inside the antenna is a Michelson interferometer which is used to measure the strain ($\Delta\lambda/\lambda$) caused by the interaction of gravity waves with the antenna. An alternative is to measure with great accuracy the range between two "drag free" spacecraft. It is desirable to have coordinated observations with other observatories, e.g., Space Telescope and Advanced X-ray Astrophysics Facility.

ORBIT PARAMETERS:

Altitude: > 250 km
 Inclination: any
 Carrier: Free-Flyer
 Launch Date: 1990
 Flight Duration: 5 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 1000 watts**
 Size: 1000 m
 Mass: 16,000 kg

DATA CHARACTERISTICS:*

Experiment Sensor Data Rate: 1 Mbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 10" bits
 Daily Data Volume: 10" bits/day
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS: *

Position Accuracy: TBD
 Pointing Accuracy: 1 mrad
 Stability: 3×10^{-5}
 Time Requirement: TBD
 Techniques: TBD

* based upon Infrared Interferometer

** Estimate

TDAS CONTACT TIME PROFILE:*

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2
Return Link - Contacts/Day: 1
Return Link - Hours/Contact: 24

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

M. Nein, MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

B-6: Heavy Lift Launch Vehicle - HLLV (25)

OBJECTIVE: To identify requirements and develop specifications for launch vehicles capable of carrying unmanned payloads into low-earth orbit which are heavier (60 to 450 metrics tons) than Shuttle payloads.

DESCRIPTION: Studies indicate that up to 84,000 kg payloads can be accommodated by an unmanned HLLV configuration that employs the present External Tank, a recoverable capsule with three SSMEs, and an expendable payload shroud/strongback. Liquid rockets in lieu of the present SRBs would be required. Heavier payloads would require a new HLLV stage having little in common with the present STS.

ORBIT PARAMETERS:

Altitude: 200 - 500 km
 Inclination: Various
 Carrier: It is a launch Vehicle
 Launch Date: TBD
 Flight Activity Profile: see note (1)

NOTES (1): Although no flight activity profile has yet been drawn by NASA, the organization is contemplating many candidate payloads and missions. It is projected that activity will be taking place in TDAS era.

SPACECRAFT REQUIREMENTS:

Field of View: Full Sky
 Power: 1000 (1)
 Size: 53 m (2)
 Mass: 1.9×10^6 kg (3)

NOTES (1): Estimated
 (2): No individual dimensions have yet been defined. No overall dimension will be greater than 53 m.
 (3): This is the lift-off weight including payload. The payload capability is 84000 kg.

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 16 kbps	} (1), (2)
Experiment Control Data Rate: 1 kbps (3)	
Mission TT&C Data Rate: 2 kbps (3)	
On-Board Storage: No (3)	
Data Volume: Small (3)	
On-Board Processing: No (3)	
Processed D/L Data Rate: NA	

NOTES (1): As a result of talking to W. Finnell MSFC it was gathered that HLLV will have data rate requirement typical of any of today's launch vehicles.
 (2): Talking to R. White of MSFC it was found that HLLV will not have strong data rate requirements.
 (3): Although not specifically defined by NASA, these appear to be likely characteristics based upon the function of the vehicle and low data rate requirement.

NAVIGATION REQUIREMENTS (1):

Position Accuracy: 100 m (1)
Pointing Accuracy: 8.7 mr (1)
Stability: 0.034 mr (1)
Time Req: GPS
Techniques: GPS eventually (2)

NOTES (1): No requirements have yet been defined by NASA, but after talking to W. Finnell MSFC, it was gathered that for HLLV the requirements will be typically the same as those of any launch vehicles today.
(2): It is a reasonable assumption.

TDAS CONTACT TIME PROFILE:

Contacts/Day (forward link): see note (1)
Hours/Contact: 0.33 (2)
Contacts/Day (return link): see note (1)
Hours/Contact: 0.33 (2)
Schedule Type: see note (3)

NOTES: (1) Since the vehicle is used mainly for expendable launch to LEO, contact will be required only for the duration of the flight.
(2) This is the expected contact time to cover launch.
(3) No launch schedules have been worked out by NASA according to W. Finnell of MSFC. Also the number of launch vehicles to be produced has not been defined.

DATA DISTRIBUTION FLOW:

TBD

NASA CONTACTS:

W. Finnell MSFC
R. White MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

B-7: Infrared Interferometer (30)

OBJECTIVE: An infrared interferometer is able to make observations with higher angular resolution than a single mirror telescope. High resolution studies of galactic nuclei, protostars, young stellar objects, circumstellar shells and binary systems are intended to elucidate the physical processes in galactic cores, the dynamics of stellar formation and the interaction of gas and radiation in planetary nebulae.

DESCRIPTION: Three cooled IR telescopes are positioned on a 100 m deployable boom to form a sensitive interferometer. Two telescopes have movement capability along the baseline to change separation distance. Operations commence after the boom is deployed and the telescopes are locked in their vertical viewing position. Data is transmitted to the ground science team. Annual Shuttle revisits are used to replenish cryogenics; a five-year mission permits study of a significant number of astronomical objects. Other options to be evaluated are two element interferometers using one Shuttle-based telescope in place of the cooled IR telescope. Concept needs further study and demonstrations of the preferred options.

ORBIT PARAMETERS:

Altitude: 400 - 700 (km)
Inclination: 28-57°
Carrier: Free Flyer
Launch Date: TBD
Flight Duration: 5 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
Power: 25000 Watts***
Size: 100 x 15 x 9 (m)
Mass: 22,500 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 1 Mbps
Experiment Control Data Rate: 1 kbps ***
Mission TT&C Data Rate: 2 kbps ***
On-Board Data Storage: 10^{11} bits
Daily Data Volume: 10^{11} bits/day
On-Board Processing: TBD
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 1 m⁺
Stability: 3 x 10⁻⁵⁺
Time Requirement: TBD
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4***
Forward Link - Hours/Contact: 0.2***
Return Link - Contacts/Day: 1**
Return Link - Hours/Contact: 24**

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

J. Murphy, ARC

REFERENCES:

NASA Space Systems Technology Model (15.0]

-
- ⁺ Space Telescope
 - ^{**} Computed from data volume, storage and dump rate
 - ^{***} Estimate

B-8: Large Ambient Deployable IR Telescope (34)

OBJECTIVE: Investigations are conducted outside the Earth's atmosphere using an infrared astronomical telescope with a large aperture (10 to 30 meters diameter) which provides improved spatial resolution and energy collecting capability for the study of a wide variety of astrophysical phenomena throughout the infrared spectral region.

DESCRIPTION: The baseline design has a 12-meter aperture which can be placed in orbit by one Shuttle mission. The collector consists of segmented sections deployed in orbit. A variety of instruments would be included to permit a wide range of scientific studies. Instrument cryogenics are resupplied and instrument changeout are accomplished through periodic visits by the Shuttle to the free-flying satellite.

ORBIT PARAMETERS:

Altitude: 400 - 700 km
 Inclination 28-50°
 Carrier: Free-Flyer
 Launch Date: 1990
 Flight Duration: 5 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 3000 W
 Size: 15 x 12 m
 Mass: 16,000 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 7 Mbps (Dump)
 Experiment Control Data Rate: 1 kbps***
 Mission TT&C Data Rate: 2 kbps***
 On-Board Data Storage: 3×10^9 bits*
 Daily Data Volume: 10^{10} bits*
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 5×10^{-4} mr
 Stability: 5×10^{-5} mr
 Time Requirement: TBD
 Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4***
Forward Link - Hours/Contact: 0.2***
Return Link - Contacts/Day: 3.3**
Return Link - Hours/Contact: 0.1**

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

J.P. Murphy, ARC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Space Telescope
** Computed based on data volume, storage and dump rate
*** Estimate

B-9: Large Area Modular Array of Reflectors (35)

OBJECTIVE: The primary objective of the Large Area Modular Array of Reflectors (LAMAR) Mission is to conduct a full-sky survey for x-ray sources with at least as much sensitivity as the Einstein Observatory has provided for very limited areas. Additional objectives are observations of extended diffuse sources and of faint time variable objects.

DESCRIPTION: The LAMAR spacecraft will consist of an instrument module plus a spacecraft bus similar to the Multimission Modular Spacecraft. Because of its large size and mass, the instrument module will be the major structural element to which the other systems are attached. The instrument module contains multiple coaligned x-ray concentrators each of which produces an image on a detector. The data system combines the image information into a single image for transmission via TDRSS. It is intended that LAMAR be utilized as a national observatory. The large collecting area and moderate angular resolution of LAMAR complement the properties of the Advanced X-ray Astrophysics Facility (AXAF). Thus, LAMAR is a mission which NASA is considering for in the early 1990's when AXAF would be operational. The Shuttle is used for launch, deployment, and checkout. Retrieval in the event of a spacecraft failure or at the end of the mission is possible.

ORBIT PARAMETERS:

Altitude: 400 km
 Inclination: 28.5°
 Carrier: Multi-mission Modular Spacecraft
 Launch Date: Early 1990's
 Flight Duration: 2 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 1050 W
 Size: 6 x 4 (dia)m
 Mass: S/C bus 1450 kg
 Total 5200 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 8 kbps/2048 kbps
 Experiment Control Data Rate: 1 kbps**
 Mission TT&C Data Rate: 2 kbps**
 On-Board Data Storage: 10^8
 Daily Data Volume: 7×10^8 bits/day
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: GPS 10 m
Pointing Accuracy: 0.28 mr
Stability: 0.14 mr
Time Requirement: GPS
Techniques: Star trackers, sun sensor, gyro, GPS
receiver/processor for position and velocity

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 7*
Return Link - Hours/Contact: 0.1*

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

E. Mercanti, GSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Computed based on data volume, storage and dump rate
** Estimate

B-10: Large Optical/UV Telescope (37)

OBJECTIVE: The Large Optical/UV Telescope, Diffraction Limited, is to have a tenfold increase in sensitivity over the Space Telescope (ST) presently under development. Thus, it can extend the distance scales for astronomical observations. This is especially important for such areas as detection of extrasolar planetary systems, extragalactic astronomy and observational cosmology.

DESCRIPTION: The telescope concept which is presently considered feasible consists of a Ritchey-Chretien all reflective system with an 8 m aperture. The telescope components are carried into orbit in the Shuttle orbiter cargo bay and a modified external tank, (primary structure and mirror cell, etc.). On-orbit deployment and assembly are required. The mission profile projects permanent operation in orbit with periodic maintenance and instrument change-outs. Study activity is currently limited to assessment of overall feasibility and concept options.

ORBIT PARAMETERS:

Altitude: 450 km
 Inclination: 28.5°
 Carrier: Free-Flyer
 Launch Date: 1990
 Flight Duration: 10 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 6,000 W
 Size: 28.5 x 8.4 (dia)m
 Mass: 22,800 kg

DATA CHARACTERISTICS:*

Experiment Sensor Data Rate: 4/1024 kbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 3×10^9
 Daily Data Volume: 10^{10}
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 0.005 mr
 Stability: 10^{-5} mr
 Time Requirement: TBD
 Techniques: Star trackers, gyros, image motion compensation

*based upon space telescope

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4***
Forward Link - Hours/Contact: 0.2***
Return Link - Contacts/Day: TBD 3**
Return Link - Hours/Contact: TBD 0.8**

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

M. Nein, MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

** Computed based on data volume, storage and dump rate
*** Estimated

STATUS: PLANNED

B-11: Large Power Module (38)

NASA Headquarters indicated that the Large Power Module would not be flown within the time frame of TDAS.

B-12: Magnetic Field Survey B (40)

OBJECTIVE: Improve understanding of solid earth and processes leading to the decay of the Earth's magnetic field. Increase resolution of mapped magnetic anomalies.

DESCRIPTION: The primary option being considered for the Magnetic Field Survey B is a small spacecraft carrying a vector and scalar magnetometer. The satellite will be shuttle retrievable and serviced.

ORBIT PARAMETERS:

Altitude: 300 km
Inclination: 97°
Carrier: Free-flyer
Launch Date: Early 1990s
Flight Duration: 5 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: NA
Power: 150 Watts
Size: 1 cubic meter with 8 meter boom
Mass: 800 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 12 kbps/64 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 10^8 bits
Daily Data Volume: 1.5×10^8 bits
On-Board Processing: No
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 30 Meters
Pointing Accuracy: 0.017 mrad
Stability: 0.017 mrad
Time Requirement: 10^{-6} *
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 4
Return Link - Hours/Contact: 0.2**

* MMS

** based upon bits/day and contacts/day

DATA DISTRIBUTION/PROCESSING FLOW:

Data delivery 6 weeks after acquisition ***

NASA CONTACTS:

T. Elchetti, NASA HQ (202) 755-3848

REFERENCES:

NASA Space Systems Technology Model [15.0]
Data Systems Survey, A. Villasenor, GSFC, 8/22/79 [11.0]

*** MAGSAT Data

B-13: Manned GEO Sortie (42)

OBJECTIVE: A manned orbital transfer vehicle (MOTV) primarily to be used for service of spacecraft at GEO.

DESCRIPTION: The vehicle is comprised of a crew capsule, which houses the crew and mounts external cargo and mission equipment, and a propulsion module. The MOTV is capable of deploying and returning the manned capsule and 1-2,000 kg of servicing equipment.

ORBIT PARAMETERS:

Altitude: 370 km
 Inclination: variable (1)
 Carrier: Free-flyer
 Launch Date: TBD (2)
 Flight Activity Profile: Flight activity to start about year 2000 (3)

- NOTES: (1) This is estimated based upon the operational and functional considerations.
 (2) No launch data has yet been defined. The studies are going on as of 1980, but have slowed down due to budget cuts.
 (3) No flight activity profile has yet been defined by NASA as it was found out from M. Nolan of NASA HQ. The present projections made during TDAS study indicate that first launch may take place in 2000. It is estimated that there will be various reflights.

SPACECRAFT REQUIREMENTS:

Field of View: Full Sky
 Power: 1000 W
 Size: 20 m (1)
 Mass: 5000 - 6000 kg (2)

- NOTES: (1) Estimates derived from the sketch of the vehicle indicate that no dimension is expected to increase 20 m.
 (2) This is the operational mass at operational location (see NASA Space Systems Technology model Vol. I P. B-467).

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 15 Mbps (1)
 Experiment Control Data Rate: 1 kbps (2)
 Mission TT&C Data Rate: 2 kbps*
 On-Board Data Storage: No (3)
 Daily Data Volume: $*10^{12}$ bits/day
 On-Board Processing: Yes (4)
 Processed D/L Data Rate: 5 Mbps (5)

NOTE: Voice and Data in Forward Link is 20 kbps.

- NOTES: (1) This is an estimate based upon the equipment which is assumed to be necessary for this mission. The equipment is assumed to include two slow scan, slow frame rate, tv sensors.

* Estimate

NOTES (CONT.):

- (2) This is assumed typical value.
- (3) Mission might dictate real time monitoring of operations; thus Onboard Storage does not appear to be a possibility.
- (4) TV data compression might be an Onboard processing function.
- (5) Based upon the assumption that experiment data is compressed by a factor of 3.

NAVIGATION REQUIREMENTS: (1)

Position Accuracy: 100 m
Pointing Accuracy: 8.7 mr
Stability: 0.03 mr
Time Requirement: GPS (2)
Techniques: GPS eventually (2)

- NOTES: (1) As a result of talking to L. Edwards of NASA HQ it was learned that no navigation requirements have yet been defined. The stated parameters have been estimated.
- (2) It is a reasonable assumption.

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: Continuous (1)
Forward Link - Hours/Contact: Continuous (1)
Return Link - Contacts/Day: Continuous (1)
Return Link - Hours/Contact: Continuous (1)
Schedule Type: Repeat flights, with no contact time requirements during refurbishment periods.

- NOTES: (1) Continuous Contact with the vehicle will be necessary for the duration of the mission during which mission operations will monitored via TV.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS

L. Edwards NASA HQ
M. Nolan NASA HQ

REFERENCES:

NASA Space Systems Technology Model [15.0]

STATUS: PLANNED

B-14: Materials Experimentation Carrier (43)

This is part of the Power Utilization Platform Program. See B-27.

B-15: Materials Experimentation Carrier II (44)

This is part of the Power Utilization Platform Program. See B-27.

B-16: Multimission Modular Spacecraft - MMS (46)

OBJECTIVE: Provides a standard spacecraft bus that can be used for a range of missions.

DESCRIPTION: The Multimission Modular Spacecraft (MMS) will support a variety of earth orbiting missions requiring solar, stellar, or earth pointing. Additionally, it can support special purpose programs such as space manufacturing or low-G biological missions. It can be launched by the Delta or the Space Transportation System (STS). It can also be accommodated on the Atlas-Agena with an 8-ft diameter or larger fairing, or the Titan. It can be used at orbital altitudes from low earth to geosynchronous. It is available to support US Government, foreign government, and commercial space programs. It presents a standardized telemetry and command interface both for integration, test and on-orbit operations with the Ground Space Tracking and Data Network (GSTDN) and the Tracking and Data Relay Satellite System (TDRSS). The multimission versatility of the MMS is accomplished by combining the baseline MMS with mission options and mission-unique equipment to meet the specific requirements of the user.

ORBIT PARAMETERS:

Altitude: 500 - 1,600 km
 Inclination: Variable
 Carrier: Free-flyer
 Launch Date: 14 Feb 1980
 Flight Duration: 2 years
 Flight Activity Profile: See Note (1)

NOTES (1): As a result of talking to W. Schindler (Program Manager of MMS activity at FSEC) it was learned that the present NASA MMS activity is directed towards Landsat 1 and 2 which will be launched respectively in 1982 and 1983. According to him, although there are no firm commitments, hope certainly prevails that MMS S/C will be present in TDAS era. But at any time there will not be more than one MMS in orbit. So it may be assumed that one MMS will always be in orbit from 1980 to 2000.

SPACECRAFT REQUIREMENTS:

Field of View: Full sky and earth
 Power: 1200 W (Average operational power)
 Size: Height x Diameter
 1.70 m x 2.0 m Mark-I (1)
 2.90 m x 3.60 m Mark-II (2)
 Mass: 1,200 kg, 4048 kg without payload (3)

NOTES (1): These are the dimensions of Mark-I MMS without propulsion modules.
 (2): These are the dimensions of Mark-II MMS.
 (3): The masses are for Mark-I and Mark-II respectively.

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 1-64 kbps payload telemetry
2.048 Mbps Max: stored data dump rate (1)
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 Kbps Max: Command Rate
On-Board Data Storage: 3 x 10⁸ bits: Tape Recorder (2)
2 x 10⁹ bits: Tape Recorder
Daily Data Volume: See note (3)
On-Board Processing: Data Formatting
Processing D/L Data Rate: See note (3)

- NOTES: (1) This provides capability to handle stored data dump/mission data source at a rate of 2.048 Mbps maximum (1.024 Mbps for coded data).
(2) Data Storage is optional. These standard 10⁸ bit or the standard 10⁹ bit tape recorders may be employed.
(3) The characteristics depend upon the mission which is being served.

NAVIGATION REQUIREMENTS:

Position Accuracy: 175 m
Pointing Accuracy: 0.17 m rad (1)
Stability: 0.17 x 10⁻⁴ m rad
Time Requirement: Time Accuracy (parts) 10⁻⁶
Time Stability (parts) 2 x 10⁻⁸
Techniques: Eventually GPS

- NOTES: (1) This pointing accuracy is without payload sensor. For detailed attitude control performance capability see Table B-16.1.

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: See note (1)
Forward Link - Hours/Contact: See note (1)
Return Link - Contacts/Day: See note (1)
Return Link - Hours/ Day: See note (1)

- NOTES: (1) Contacts per day and hours per contact depend upon the mission which is being served.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

None. (Extensive discussions however took place with W. Schindler, Program Manager of MMS activity at Fairchild Space and Electronics Company, Germantown, MD).

REFERENCES:

MMS External interface specification and User's Guide. NASA GSFC, S-700-11, April 1978 [61.0].

TABLE B-16.1
ATTITUDE CONTROL PERFORMANCE
CAPABILITY

	Stellar and Solar Mission		Earth Pointing Mission
	w/Payload Sensor ^(a)	w/o Payload Sensor	
Pointing Accuracy (Degrees - 1σ)	$< \pm 10^{-5}$	$< \pm 10^{-2}$	$< \pm 10^{-2}$
Pointing Stability ^(b) Average Rate Deviation (Deg/Sec)	$< \pm 10^{-6}$	$< \pm 10^{-6}$	$< \pm 10^{-6}$
Pointing Stability ^(c) Attitude Jitter (Degrees)	$< \pm 10^{-6(d)}$	$< \pm 0.0006^{(d)}$ (20 min)	$< \pm 0.0003^{(d)}$ (≤ 30 sec) $< \pm 0.0006^{(d)}$ (≤ 20 min)
Slew Scale Factor Stability		0.01% (30 days)	
Slew Rate (Deg/Sec)		0 to 0.2 ^(e)	
<p>NOTES (a): ACS (Attitude Control System) performance limit with ideal sensor (applies only to axes normal to line-of-sight of payload sensor)</p> <p>(b): Based on 30 minute intervals</p> <p>(c): Relative to average rate deviation as baseline</p> <p>(d): Based on no disturbance torques internal to spacecraft</p> <p>(e): IRU (Inertial Reference Unit) coarse mode can accommodate slew rates up to 1.6 degrees/sec.</p>			

STATUS: PLANNED

B-17: National Oceanic Satellite System - NOSS (49)

OBJECTIVE: To measure oceanic parameters required to improve and sustain operational oceanic analysis and prediction programs.

DESCRIPTION: NOSS Mission is cancelled in current NASA planning.

ORBIT PARAMETERS:

Altitude: 700 km
Inclination: 87°
Carrier: Free-flyer
Launch Date: TBD
Flight Duration: 2 - 3 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: Earth under NADIR
Power: 2,200 W
Size: 10.7 x 4.5 m
Mass: 3,816 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 10 Mbps
Experiment Control Data Rate: 50 kbps
Mission TT&C Data Rate: 50 kbps
On-Board Data Storage: Yes
Daily Data Volume: 5×10^{11} bits/day
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 10 cm
Pointing Accuracy: 1.7 mr
Stability: 8.7 mr
Time Requirement: TBD
Techniques: GPS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: TBD
Forward Link - Hours/Contact: TBD
Return Link - Contacts/Day: TBD
Return Link - Hours/Contact: TBD

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

TBD

REFERENCES:

TBD

STATUS: PLANNED

B-18: NOSS Research Program (51)

The NOSS Research Program has been cancelled and the experiments carried on other missions.

B-19: Ocean Circulation Mission - Topography Experiment - TOPEX (53)

OBJECTIVE: Map the surface topography of the ocean to determine the absolute value of the surface geostrophic current. Measure surface roughness under nadir to determine waveheight and surface wind speed.

DESCRIPTION: MMS free-flyer (see B-16) or equivalent with radar altimeter and two-channel microwave radiometer.

ORBIT PARAMETERS:

Altitude: 1334 km circular
Inclination: 63.4°
Carrier: Free-flyer
Launch Date: Late 1987
Flight Duration: 5 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
Power: 500 W.
Size: 2 m DIA x 3 m
Mass: 1,350 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 8 kbps/50 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 3 x 10⁸ bits
Daily Data Volume: 7 x 10⁸ bits*
On-Board Processing: No
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 10 cm Altitude, 2 - 3 meters
Pointing Accuracy: 5°
Stability: TBD
Time Requirement: 0.1 seconds
Techniques: Laser for pointing; internal clock for time

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 13
Forward Link - Hours/Contact: 0.3
Return Link - Contacts/Day: 13
Return Link - Hours/Contact: 0.3

* Estimate based on sensor data rate

DATA DISTRIBUTION/PROCESSING FLOW:

Data Delivery in 4 months from acquisition

NASA CONTACTS:

Bob Neilson, JPL: (213)354-3324
W. Townsend, NASA HQ.

REFERENCES:

OSTA NASA Technology Model [15.0]

B-20: Ocean Research - Synthetic Aperture Radar - SAR (55)

OBJECTIVE: In Oceanic Research the Synthetic Aperture Radar is used to map the surface topography of the ocean; measure waveheight surface windspeeds, and roughness.

DESCRIPTION: The FIREX mission has been chosen to fly a SAR for Ocean Research in the 1990s. Other instruments proposed to be flown on the FIREX mission include a microwave radiometer, and a scatterometer.

ORBIT PARAMETERS:

Altitude: 700 km*
 Inclination: 98°
 Carrier: Free-flyer
 Launch Date: Early 1990's
 Flight Duration: 1 year*
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
 Power: 1 kw*
 Size: 2 x 10 m**
 Mass: 2000 kg**

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 200 Mbps
 Experiment Control Data Rate: 2 kbps*
 Mission TT&C Data Rate: 25 kbps*
 On-Board Data Storage: 3.5×10^8 bits*
 Daily Data Volume: 2×10^{12} bits***
 On-Board Processing: Yes
 Processed D/L Data Rate: TBD

NAVIGATION REQUIREMENTS

Position Accuracy: 50 meters
 Pointing Accuracy: 0.75°*
 Stability: 0.17**
 Time Requirement: 10^{-6} **
 Techniques: GPS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 14**
 Forward Link - Hours/Contact: .3**
 Return Link - Contacts/Day: 14**
 Return Link - Hours/Contact: .3**

-
- * SEASAT
 - ** Estimate
 - *** Computed based upon sensor data rate

DATA DISTRIBUTION/PROCESSING FLOW:

Optical, Survey Processing -24 hrs.*

NASA CONTACTS:

W. Piotrowski, NASA HQ. (202)755-6038
K. Carver, NASA HQ
J. Granger, JPL
L. McGoldrich, NASA HQ

REFERENCES:

OSTA NASA Technology Model [15.0]

B-21: 100-Meter Thinned Aperture Telescope (56)

OBJECTIVE: The 100 Meter Thinned Aperture Telescope (TAT) has as its basic objectives a 30-fold increase in image resolution and a 1000-fold increase in astrometric precision over that afforded by the Space Telescope. Typical science investigations are calibration of the distance scale beyond Virgo and out to the Coma cluster of galaxies, high resolution studies of quasars, and a search for planetary systems.

DESCRIPTION: The TAT could be developed by NASA in the 1990's and managed as a long-lived international observatory analogous to Space Telescope. The large aperture telescope is deployed in low earth orbit using advanced assembly techniques. Several Shuttle flights provide for assembly of the initial structure including fabrication of structural components, attachment of the equipment and instrument sections and the solar arrays. Addition of the primary and secondary mirror segments proceeds in an incremental fashion to provide an early initial capability to obtain high resolution observations of brighter sources. Eventual filling in of sections of the annular mirrors will provide the full capability for faint object detection.

ORBIT PARAMETERS:

Altitude: 500 km (eventually GEO)
 Inclination: 28.5°
 Carrier: Free-flyer
 Launch Date: 1990
 Flight Duration: 10 years
 Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS

Field of View: All-sky
 Power: 25,000 W
 Size: 100 m (Dia)
 Mass: 85,000 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 100 kbps/100 Mbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 10^{11} bits
 Daily Data Volume: 10^{11} bits/day
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 1.0 mr
 Stability: 2×10^{-6} mr
 Time Requirement: TBD
 Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 1*
Return Link - Hours/Contact: 0.03*

DATA DISTRIBUTION/PROCESSING FLOW:

NASA CONTACTS:

M. Nein, MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Computed based on data volume, storage, and dump rate
** Estimated

B-22: Operational Earth Resources Satellite - OERS/ALOS (57)

OBJECTIVE: Operational land remote sensing mission for providing improved user services.

DESCRIPTION: The ALOS mission is a renamed OERS mission. As an experimental system, it is considered part of the NASA mission complement. An MLA (multi-spectral linear array) free-flyer is being considered.

ORBIT PARAMETERS:

Altitude: 705 km circular
Inclination: 98.95°
Carrier: Free-flyer
Launch Date: 1989
Flight Duration: 3 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: off nadir
Power: 1,200 W
Size: 8 m x 4.5 x 3 m
Mass: 4,214 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 700 Mbps
Experiment Control Data Rate: TBD
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: Yes
Daily Data Volume: 5×10^{12} bits
On-Board Processing: Yes
Processed D/L Data Rate: 150 Mbps

NAVIGATION REQUIREMENTS:

Position Accuracy: 10 m geolocation
Pointing Accuracy: 0.01°
Stability: 10^6 dg./sec.
Time Requirement: GPS
Techniques: GPS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 14*
Forward Link - Hours/Contact: 0.2*
Return Link - Contacts/Day: 1
Return Link - Hours/Contact: 24

* LANDSAT-D

DATA DISTRIBUTION/PROCESSING FLOW:

Data Delivery: 6-12 hrs. Quick-Look Product
48 hrs. Standard Products
1 week Archive Products

NASA CONTACTS:

K. Ando, NASA HQ.
J. Welsh, NASA HQ.

REFERENCES:

NASA Space Systems Technology Model [15.0]

Application of Solid-State Array Technology to an Operational Land
Observing System (JPL Document 715-82) [62.0].

B-23: Operational Meteorology Satellite(s) (58)

OBJECTIVE: The Satellite(s) will provide improved capabilities for long-range weather prediction, balloon and buoy tracking capability, cloud cover temperatures and imaging and ozone monitoring.

DESCRIPTION: "NOAA Next" is the current name of the NOAA series follow-on program. The mission baseline here describes the NOAA operational program which meets the stated requirements of the National Operational Environmental Satellite System (NOESS).

ORBIT PARAMETERS:

Altitude: 833 km/98.74°, 870 km/98.9°
Inclination:
Carrier: Free-flyer
Launch Date: One S/C per year average
Flight Duration: 2 years
Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
Power: 420 Watts
Size: 3.71 x 1.88 (Dia) meters
Mass: 740 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 665 kbps/2.66 & 1.33 Mbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 8.32 kbps
On-Board Data Storage: Yes
Daily Data Volume: 6×10^{10} bits
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: ± 500 m
Pointing Accuracy: $\pm 0.1^\circ$
Stability: $0.015^\circ/\text{sec}$
Time Requirement: 1 sec
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 12 - 14
Forward Link - Hours/Contact: 10 minutes
Return Link - Contacts/Day: 10 - 11
Return Link - Hours/Contact: 10 minutes

DATA DISTRIBUTION/PROCESSING FLOW:

Data is relayed to White Sands for processing, where it is correlated with the Thematic Mapper Scenes and then archived. Archived data will be available and produced in 48 hrs for user requests.

NASA CONTACTS:

J. Blue, SpaceCom (301) 258-6800

REFERENCES:

NASA Space Systems Technology Model [15.0]

Data Systems Survey, A. Villasenor, GSFC 8/22/79 [11.0]

Programming and Control Handbook for TIROS-N Spacecraft
Vol. I 6/30/78 [2.9].

B-24: Orbital Transfer Vehicle (59)

OBJECTIVE: Provide a large cryogenic recoverable/refurbishable transfer vehicle to place spacecraft and/or assemblies into higher energy orbits.

DESCRIPTION: A reusable advanced LO₂/LH₂ stage occupying one shuttle bay capable of placing 8,000 kg into GEO and other payloads into various high-energy orbits including earth escape.

ORBIT PARAMETERS:

Altitude: variable from LEO to GEO
Inclination: variable
Carrier: Free-Flyer
Launch Date: TBD
Flight Activity Profile: See Note (1)

NOTES: (1) No flight activity profile has yet been worked out by NASA. Only information which is known at present is that the flights will initiate in the 1990's. Based upon this information it can safely be assumed that the activity will prevail during the TDAS era.

SPACECRAFT REQUIREMENTS:

Field of View: Full Sky (1)
Power: less than 500 W (2)
Size: 6.5 m (Dia), 4 - 10 m length
Mass: 37000 kg (3)

NOTES: (1) Based upon the projected functional capabilities it appears desirable that the vehicle have full Sky field of view.
(2) Power requirements will depend upon the application but as estimated by NASA (NASA Space Systems Technology Model Vol. I p. B-460) they will be typical of an unsophisticated upper stage.
(3) This includes dry mass, maximum usable propellant mass and maximum payload.

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 6 Mbps (1)
Experiment Control Data Rate: 1 kbps*
Mission CC&T Data Rate: 2 bkps*
On-Board Storage: Yes (2)
Data Volume: Application Dependent
On-Board Processing: Yes (3)
Processed D/L Data Rate: 2 Mbps (4)

* Estimate

- NOTES: (1) This is estimated value based upon technical discussions with K. Hinckle of MSFC. In particular he stated that advanced OTV will employ reduced scan rate compressed bandwidth TV. For such a TV, it is unlikely that data rate will exceed 6 Mbps.
- (2) Intended application of the vehicle may dictate On-Board Storage.
- (3) TV bandwidth compression will be done On-Board.
- (4) Based upon the assumption that data can be compressed by a factor of 3.

NAVIGATION REQUIREMENTS:

Position Accuracy: 45 km (1)
Pointing Accuracy: 8.7 mr (1)
Stability: *0.034 mr
Time Req: GPS (2)
Techniques: GPS (2)

- NOTES: (1) According to present concepts OTV requirements are typically the same as those of IUS. The values which are applicable strictly to IUS and are extracted from NASA Space Systems Technology Model Vol. I, p. B-450, are stated here as provisional requirements for OTV.
- (2) Eventually GPS may be used for Navigation.

TDAS CONTACT TIME PROFILE:

Contacts/Day (Forward Link): 1 to 12
Hours/Contact: 0.75 (LEO) (2)
Contact/Day (Return Link):
Hours/Contact: 0.75 (LEO) (2)
Schedule Type: *Multiple flights scheduled to fit shuttle flights.

- NOTES: (1) As a result of talking to K. Hinkle MSFC it was gathered that OTV orbit will span the range from LEO to GEO and a contact will be required during each orbit. Thus for GEO one contact per day will be required and for LEO one contact/2 hours will be required if it is assumed that the orbital period is 2 hours.
- (2) K. Hinckle of MSFC further provided that the hours/contact will be approximately 0.75 for LEO.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

K. Hinckle MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Estimated

B-25: Orbiting Submillimeter Telescope (61)

OBJECTIVE: The Orbiting Submillimeter Telescope can carry out a wide range of astrophysical observations in a spectral region that is not accessible to ground-based observatories because of the absorption by the terrestrial atmosphere.

DESCRIPTION: The Orbiting Submillimeter Telescope (OST) is to be launched by the Shuttle into a low-earth orbit. A 10 to 15 meter reflecting antenna would be deployed in orbit; it would collect the submillimeter waves from celestial sources for detection by one of several instruments. During its operational lifetime of about 10 years, the OST can be revisited to resupply cryogen and to replace instruments and subsystems. It could be operated as a major facility (like Space Telescope) with international participation.

ORBIT PARAMETERS:

Altitude: 1,000 km
 Inclination: (Sun synchronous)
 Carrier: Free-flyer
 Launch Date: 1990
 Flight Duration: 10 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 500 W
 Size: 10 - 15 (dia)m
 Mass: 1,000 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 1/10 kbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: Tape Recorder
 Daily Data Volume: 10^5 - 10^6 bits/day
 On-Board Processing: Microprocessor
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 0.01 mr
 Stability: 0.01 mr
 Time Requirement: TBD
 Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
 Forward Link - Hours/Contact: 0.2**
 Return Link - Contacts/Day: 1*
 Return Link - Hours/Contact: 0.03*

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

P. Swanson, JPL

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Computed based on data volume, storage and dump rate
** Estimated

B-26: Pinhole Satellite (64)

OBJECTIVE: One of the outstanding questions of solar atmospheric physics concerns the transport of energy and mass in the corona. To understand this transport, one needs, among other data, high spatial-resolution information, both at X-ray wavelengths and in the UV and Optical domains. The availability of such X-ray data, which can be secured with a pinhole satellite system, will help clarify crucial questions concerning the energy budget in the solar atmosphere.

DESCRIPTION: For this NASA Solar Terrestrial Physics mission a large random array pinhole mask of lead or tungsten is deployed from the orbiter cargo bay. An X-ray detector mounted on a maneuverable subsatellite is launched from the orbiter into a co-planar orbit 1 km from the mask and aligned to detect solar X-ray images formed by the pinholes of the mask. The pinhole mask is stabilized by the orbiter attitude control system. Laser alignment beams emanating from the mask-mounted aspect sensing system are reflected from the detector spacecraft to provide a position history of the detector with respect to the occulting mask. Post-flight deconvolution of the images in conjunction with the very accurate mask/detector position information will result in resolution of X-ray images (10 to 100 keV) of better than 1 arc sec. (0.2 - 1 arc sec.). Other concepts for separating the pinhole array and the detectors have been defined.

ORBIT PARAMETERS:

Altitude: 370 km
 Inclination: 970(1)
 Carrier: Pinhole mask on Shuttle and X-ray
 detector on a satellite
 Launch Date: After 1984(2)
 Flight Duration: 7 days
 Flight Activity Profile: See Note (3)

- NOTES (1): Normal shuttle orbit plane is always perpendicular to the sun - earth line. Subsatellite orbit is coplanar with 1 km offset. (In the initial flights, detector will be mounted on a boom instead of in a subsatellite).
- (2): Although no launch date has yet been defined by NASA a reasonable estimate is 5 years after date which is say 1990.
- (3) a. It is estimated that at least 2 flights will take place per year over a period of at least 5 years. Each flight will have a duration of 7 days.
- b. According to NASA TM-82413 "The pinhole/occultor facility" by H. S. Hudson, et. al., NASA MSFC, March 1981, Spacelab versions of the pinhole satellite will lead into more advanced systems with new scientific objectives. Based upon this future it is estimated that the lifetime will easily extend to year 2000. It is therefore projected that from 1990 to 2000, at the rate of 2 flights per year, a total of 20 flights can be expected.

SPACECRAFT REQUIREMENTS:

Field of View: 0.5 (1)
Power: *1000 W
Size: 37 x 24 x 25 (2)
Mass: 9,100 kg (3)

NOTES (1): FOV should be enough to view the sun.
(2): Shuttle dimensions with deployed pinhole mask.
(3): The mass breakdown is as follows:
Pinhole mask 2,900 kg
Detector Subsatellite 2,800 kg
Spacelab Systems 3,400 kg
Mass of spacelab systems includes about 1,000 kg for solar physics instruments on spacelab pallet.

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 1 Mbps
Experiment Control Data Rate: *1 kbps
Mission TT&C Data Rate: *2 kbps
On-Board Data Storage: * 2.5×10^9
Daily Data Volume: * 4×10^{10} bits/day
On-Board Processing: No
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 10^{-4} km
Pointing Accuracy: 0.002 m rad
Stability: 0.002 m rad
Time Requirement: *GPS
Techniques: *GPS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: *4
Forward Link - Hours/Contact: *0.2
Return Link - Contacts/Day: 16
Return Link - Hours/Contact: 0.75

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

* Estimated

NASA CONTACTS:

J. Dabbs MSFC

REFERENCES:

1. The Pinhole/Occulter facility
by H.S. Hudson et. al; NASA MSFC, TM-82413 [63.0]
2. NASA Space Systems Technology Model [15.0]

B-27: Power Utilization Program - PUP (67)

OBJECTIVE: A permanent operational base and laboratory to support or enable several missions perceived to be of value: solar power system development, zero-g manufacturing, earth observation/communication/navigation, life sciences, and celestial/solar observation.

DESCRIPTION: A modular approach to space platform configuration is taken. These include a power module, platform support modules (one is pressurizable for life sciences operations), deployable structural elements, antennae, rotary joints, and payload carriers. These building blocks can be assembled in various configurations depending upon the mission requirements. The deployable structural elements are themselves modular and can be added to or deleted from the platform to make the arms shorter or longer. Each platform can therefore be configured on the ground or on orbit depending upon the individual payload element or discipline viewing requirements. The arms of these platforms can be either fixed or rotatable, depending on the payload viewing requirements.

ORBIT PARAMETERS:

Altitude: 400 km
Inclination: 57°
Carrier: Free-flyer
Launch Date: 1987
Flight Duration: 10 years
Flight Activity Profile: See Notes

SPACECRAFT REQUIREMENTS:

Field of View: All-Sky
Power: 25 kW
Size: 13.4 m x 19.5 m
Mass: 19,770 kg to 49,640 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 300 Mbps
Experiment Control Data Rate: 300 kbps
Mission TT&C Data Rate: Included
On-board Data Storage: Yes
Daily Data Volume: Up to 10^{13} bits/day
On-Board Processing: Yes
Processed D/L Data Rate: TBD

NAVIGATION REQUIREMENTS

Position Accuracy: GPS Eventually
Pointing Accuracy: 20 min
Stability: 10 min
Time Requirement: GPS Eventually
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 1*
Forward Link - Hours/Contact: 24*
Return Link - Contacts/Day: 24
Return Link - Hours/Contact: 0.3

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

F. Wulff, NASA HQ

REFERENCES:

SASP Study documents [47.0, 48.0, 50.0, 51.0, 57.0]

* Estimate

NOTES: The Power Utilization Program is a combination of the following programs:

- . 25 kW Power System (102)
- . Space Sciences Platform (91)
- . Science and Applications Space Platform (68)
- . Material Experiment Carrier (43)
- . Material Experiment Carrier II (44)

The basic space platform is scheduled for launch in 1987 and may be extended to a second order platform by 1989. At the same time a second space platform may be launched depending on budget considerations and user community support.

STATUS: PLANNED

B-28: Science and Applications Space Platform (68)

This is part of the Power Utilization Platform Program. See B-27.

B-29: Soil Moisture Research and Assessment (73)

OBJECTIVE: Perform multispectral data acquisition to provide synoptic, repetitive measurements of soil moisture in support of agriculture, water resources, and climatic information needs.

DESCRIPTION: Large sensor structures for passive microwave radiometer, active microwave sensor, and thermal IR sensor.

ORBIT PARAMETERS:

Altitude: 400 - 700 km
Inclination: 60°
Carrier: Platform candidate
Launch Date: 1989
Flight Duration: 3 years
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
Power: 1.2 kw
Size: 11 mx 10 m parabolic sensor antennas
Mass: 2000 kg*

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 500 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: No
Daily Data Volume: 1×10^7 *
On-Board Processing: No
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 100 m
Pointing Accuracy: 0.175 mrad
Stability: 0.10 mrad
Time Requirement: 10^{-6} Sec*
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 14**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 14**
Return Link - Hours/Contact: 0.2**

* Estimated
** LANDSAT-D

DATA DISTRIBUTION/PROCESSING FLOW:

Experimental Data delivered to NASA, Goddard

NASA CONTACTS:

L. King, GSFC
W. Piotrowski, NASA HQ.

REFERENCES:

OSTA NASA Space Systems Technology [15.0]

B-30: Solar Cycle and Dynamics Mission - SCADM (74)

OBJECTIVE: The scientific objectives of the Solar Cycle and Dynamics (SCADM) Mission are to measure the large-scale solar magnetic field, its structure and long-term variations; to observe in detail the solar corona, and its time-varying temperature, velocity patterns and density structures; to study global and local oscillations of the solar surface, as a probe of the convection zone; to continue monitoring of the solar constant over a wide spectral range; and to investigate the relationship of these phenomena to each other, to the mechanism of the solar cycle and to events at the earth.

DESCRIPTION: The SCADM spacecraft will be launched by Shuttle into a standard 300 km orbit, then inserted by on-board propulsion into a 575 km circular orbit. This altitude minimizes effects from the radiation belts, yet is above significant extreme ultraviolet (EUV) attenuation. After the two-year mission, enough fuel will remain to allow return to the standard Shuttle orbit for retrieval. The Multimission Spacecraft (MMS - see B-16) can be utilized to support the SCADM instruments. The SCADM mission is intended as a follow-on to the approved Solar Maximum Mission. It would be desirable for SCADM to be operational when the International Solar Polar Mission is above the sun's poles in 1986 and 1987. However, this cannot be done because SCADM is being considered for a new start in 1985 at the earliest with launch about three years later.

ORBIT PARAMETERS:

Altitude: 575 km
 Inclination: 28° or 98°
 Carrier: Multimission Modular Spacecraft
 Launch Date: 1991 (Est)
 Flight Duration: 2 years or longer with resupply
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: Sun
 Power: 800 W
 Size: 6 x 2 (dia)m
 Mass: 2,600 kg total
 1,000 kg instruments

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 16 kbps/1024 kbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: Included
 On-Board Data Storage: 2×10^9
 Daily Data Volume: 5×10^9
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 0.005 mr
Stability: 0.002 mr⁻⁶
Time Requirement: 10⁻⁶
Techniques: Fine sun sensor, gyros, star trackers,
coarse sun sensor

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 2.5*
Return Link - Hours/Contact: 0.5*

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

D. Suddeth, GSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Computed based on data volume, storage, and dump rate
** Estimate

STATUS: PLANNED

B-31: Solar Electric Propulsion Stage - SEPS (75)

NASA Headquarters indicated that this program is in a technology "keep alive" status. The viability of this program is in doubt and will not be used for TDAS planning. The TDAS support to the other upper stage vehicles would be similar if SEPS is flown.

B-32: Solar Optical Telescope - SOT (78)

OBJECTIVE: The scientific objective of the SOT is to obtain high resolution data which are required to solve many fundamental problems in solar physics. These problems include the energy and mass transports in the solar atmosphere in the presence of magnetic fields, the origin and evolution of the surface magnetic fields, the nature of sunspots and prominence, and many phenomena known to occur in laboratory plasmas, believed to be present on the sun (fluxes), but, heretofore not yielding to instruments of coarser resolution than the SOT.

DESCRIPTION: SOT is being developed for NASA's Solar Terrestrial Programs and is to be integrated with the NASA European Space Agency (ESA) Spacelab Program and will utilize the ESA Instrument Pointing System (IPS) for arc-second pointing and stability. A parabolic primary mirror, 1.25m aperture f/3.6, will provide diffraction limited solar imaging in the spectral region 115 nm to 1000 nm. An articulated primary mirror actuator assembly will provide active alignment, focus, sub-arc second pointing, rastering, and up to + 1/2 degree offset. SOT as the baseline facility, will accomodate various Science Instruments (SIs) at its focal plane. First flight is planned after 1984. The basic telescope with additional and/or modified instruments is expected to be used for many Shuttle/Spacelab missions. An interactive interface will be provided between the SOT and the trained observers. Control and operation of the SOT will conform to an established mission operations plan; however, targets of opportunity will arise and the interactive control will allow decisions by the observers to be implemented. The observers include the Mission/Payload Specialists (crew) and the scientists in the Payload Operations Control Center (POCC).

ORBIT PARAMETERS:

Altitude: 460 km
Inclination: 57 deg (1)
Carrier: Shuttle/Spacelab
Launch Date: several launches (2)
Flight Activity Profile: see note (3)

- NOTES:
- (1) High inclination orbits are desirable for continuous solar observations.
 - (2) No launch date has yet been defined, but several launches will be made (about 10) with the first one expected after 1984.
 - (3) Each Spacelab/SOT mission lasts 7 to 21 days. SOT is returned, refurbished and reflown about 1 year later. A useful life of 10 years is planned (NASA Space Systems Technology Model Vol. I p. B-166). Only one SOT is planned. Since budget cuts have slowed down the SOT activity it is estimated that first flight may take place after 1985. Based upon this estimate, the flights will last beyond 1995.

SPACECRAFT REQUIREMENTS:

Field of View: enough to view the Sun
 Power: 935 W (Average operational power)
 Size: Length = 7.3 m / Diameter = 3.9 m
 Mass: 3100 kg

NAVIGATION REQUIREMENTS:

Position Accuracy: 0.1 km (1)
 Pointing Accuracy: 10^{-4} m rad (2)
 Stability: 10^{-4} m rad
 Time Req: GPS
 Technique: Eventually GPS (3)

- NOTES: (1) Position accuracy is the same as that of Shuttle.
 (2) It is assumed that the orbiter and instrument pointing system serve as coarse pointing System and that an internal SOT pointing system will achieve the necessary fine pointing (NASA Space Systems Technology Model Vol. I, p. B-167).
 (3) It is a reasonable assumption.

DATA CHARACTERISTICS:

Experiment Data Rate: 12 Mbps (1)
 Experiment Control Data Rate: *1 kbps
 Mission CC&T Data Rate: *2 kbps
 On-Board Storage: Yes (2) * 6×10^9 bits
 Data Volume: * 10^{10} bits/day
 On-Board Processing: Yes (3)
 Processed D/L Data Rate: *2.8 Mbps (4)

- NOTES: (1) Digital and TV displays from SOT-provided camera are required (NASA, Solar Terrestrial Mission Concept: Solar Optical Telescope (SOT-1), July 1979). From this information it is estimated that total data rate will be approximately 12 Mbps.
 (2) From page 13 of reference listed in Note (1) above it is planned that engineering test and housekeeping data will be monitored on board, recorded and transmitted to the ground at convenient intervals. TV images will be sent as operationally convenient.
 (3) TV bandwidth may have to be compressed.
 (4) Derived from on-board storage and contact time.

TDAS CONTACT TIME PROFILE:

Contacts/Day (Forward Link): *4
 Hours/Contact: *0.2
 Contacts/Day (Return Link) *16
 Hours/Contact: 0.6 (1)
 Schedule Type: *Multiple flights

NOTES: (1) Based upon the data presently available (Solar Optical Telescope System Analysis and Interface Study, Final Report F78-06, Oct. 78 Bell Aerospace Systems Division) relative to mission planning a total of 9.5 hours of Contact time per day is required. This yields 0.6 hours/contact.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

E. Schmidt GSFC

REFERENCES:

1. Solar Optical Telescope System Analysis and Interface Study Final Report: Bell Aerosystems Division, F78-06, Oct. 78 [64.0]
2. NASA Space Systems Technology Model [15.0]

B-33: Solar Soft X-Ray Telescope Facility (82)

OBJECTIVE: The Solar Soft X-ray Telescope Facility has as its purpose fundamental observations of the outer solar atmosphere. Specific objectives are to determine the mass flow and energy deposition in the corona, to understand the formation and evolution of coronal features and their relationship to changes in the photosphere and chromosphere, to identify the sites and processes that produce solar flares, and to assess the relationship between the large scale structures of the corona and solar magnetic fields and the interplanetary solar wind and magnetic sector structure.

DESCRIPTION: The Solar Soft X-ray Telescope Facility is being studied as a candidate Shuttle/Spacelab payload to be launched after 1987 (approx.); a new start after FY 84 is assumed. Instruments for the telescope facility are to be selected by the Announcement of Opportunity process. The telescope consists of a set of confocal mirrors of the Wolter type I configuration for observations from 0.175 to 10 nm. A smaller telescope, coaxial and confocal with the larger telescope, will provide imaging at short wavelengths. A spatial resolution of 0.5 arc sec is desired. An evolutionary program of Shuttle flights is planned for the Facility using increasingly sophisticated focal plane instrumentation. The Facility will be mounted on pallets in the Shuttle bay and pointed to the Sun by the ESA Instrument Pointing System (IPS). Data from the observations will either be recorded on film or telemetered to Earth via the Shuttle/Spacelab Command and Data Management System (COMS) and the Tracking and Data Relay Satellite System (TDRSS).

ORBIT PARAMETER:

Altitude: 430 Km
 Inclination: 56°
 Carrier: Shuttle/Spacelab
 Launch Date: After 1987
 Flight Duration: 7 - 30 days
 Flight Activity Profile: See Note (1)

NOTE (1): As informed by C. Stouffer GSFC, an evolutionary plan of Shuttle flights is planned for the facility at the rate of 2 flights per year for a period of 10 years. Thus, the lifetime will extend into TDAS era. A total of 20 flights over a period of 1990 to 2000 will take place. The experimental setup may not go in the same shuttle orbiter each time.

SPACECRAFT REQUIREMENTS:

Field of View: Full disc coverage of the sun
 Power: 240 W (Average consumption)
 360 W (Peak consumption)
 Size: 6 m long x 1.2 m dia
 Mass: 1,300 (total mass at operational location)

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 60 kbps (min), 15 Mbps (max)(1)
Experiment Control Data Rate: 1 kbps (3)
Mission TT&C Data Rate: 2 kbps (3)
On-Board Data Storage: 6×10^9 bits.
Daily Data Volume: 10^{11} bits/day
On-Board Processing: Yes (4)
Processed D/L Data Rate: 4 Mbps (1)

- NOTES (1): The experiment provides imaging data. Two imagers are considered for the experiment; these are (1) photon analyzing imager and (2) energy integrating imager. Their respective data rates (max. buffered data rates) are 60 kbps and 15 Mbps (Transmission rate 4 Mbps.
- (2): This value is estimated based upon similar experiments.
- (3): This value is estimated based upon similar missions.
- (4): Following on-board processing functions are required
- a. Energy Integrating Imager requires on-board data compression
 - b. Both imagers require on-board data buffering and on-board TV display generation.

NAVIGATION REQUIREMENTS:

Position Accuracy: 0.1 km
Pointing Accuracy: 0.005 mrad
Stability: 0.001 mrad
Time Requirement: *GPS
Techniques: GPS Eventually

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: *4
Forward Link - Hours/Contact: *0.2
Return Link - Contacts/Day: *16
Return Link - Hours/Contact: *0.4

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

C. Stouffer GSFC

* Estimated

REFERENCES:

1. Minutes of 1980 EUV, XUV Soft X-ray FDT meeting, Jan. 23, 1981
Center for Astrophysics, Harvard College Observatory
Smithsonian Astrophysical Observatory, Cambridge, Mass. 02138 [65.0]
2. NASA Space Systems Technology Model [15.0]

B-34: Solar Terrestrial Observatory (83)

The Solar Terrestrial Observatory has been formulated based upon the 25 dW Power Module which is now part of the Power Utilization Platform Program. It has been concluded that this experiment/mission would be flown on the space platform being developed under PUP. See B-27.

B-35: Space Operations Center - SOC (89)*

OBJECTIVE: The Space Operations Center is a Shuttle-serviced, permanently manned facility in near space for operational support of space activities in the 1990s.

DESCRIPTION: The SOC is planned to evolve from the PUP space platform with the addition of habitability modules. The approach is to have the SOC as a permanent manned facility in LEO and to transfer extended time-line missions from the shuttle to the SOC. Additionally the SOC will be used for satellite and platform servicing as well as staging for high energy missions. Launch is currently planned for late 1990.

NOTE: Since little information was available on the characteristics of the SOC, the characteristics of the PUP are assumed to adequately reflect the characteristics of the SOC, with a few exceptions (See B-27).

ORBIT PARAMETERS:

Altitude: 400 km
Inclination: 28°
Carrier: Free-Flyer
Launch Date: 1994
Flight Duration: 10 - 15 years
Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: All-Sky
Power: 25 W
Size: 13.4 x 19.5 m
Mass: 19,770 to 49,640 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 300 Mbps
Experiment Control Data Rate: 300 kbps
Mission TT&C Data Rate: Included
On-Board Data Storage: Yes
Daily Data Volume: Up to 10^{13} bits/day
On-Board Processing: Yes
Processing D/L Data Rate: TBD

NAVIGATION REQUIREMENTS:

Position Accuracy: GPS
Pointing Accuracy: 5.8 mr
Stability: 2.9 mr
Time Requirement: GPS
Techniques: GPS

* All Characteristics based upon PUP

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 1
Forward Link - Hours/Contact: 24
Return Link - Contacts/Day: 24
Return Link - Hours/Contact: 0.3

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

Mark Nolan, NASA HQ

REFERENCES:

NASA Space Systems Technology Model [15.0]
OSTS Ten Year Plan 1983-1992 [46.0]

STATUS: OPPORTUNITY

B-36: Space Power Technology Demonstration (90)

NASA Headquarters indicated that this is no longer a viable program. If it is ever flown it will be well beyond the time frame of TDAS.

STATUS: PLANNED

B-37: Space Sciences Platform (91)

This is part of the Power Utilization Platform Program. See B-27.

B-38: Space Telescope (92)

OBJECTIVE: The ST is a large light-gathering instrument with optical performance near the diffraction limit. Scientists will be able to observe the universe with a clarity and to distances never before attained. It will be used to attack a wide variety of frontier problems in atmospheric particularly the areas of extragalactic astronomy and observational cosmology.

DESCRIPTION: The optical systems of the NASA Space Telescope consist of a 2.4 meter primary mirror and a 0.3 meter secondary mirror. The Telescope's Ritchey-Chretien optical system will produce an image 1.5 meters behind the front surface of the primary mirror. To achieve the high spatial resolution objective of the ST (10 times better than now possible with ground-based telescopes) will require extremely smooth and precisely shaped mirror surfaces. ST is to be launched in December 1983; it is designed for on-orbit maintenance, (requires astronaut EVA) and for Shuttle recovery and ground refurbishment. Operation of the ST is to be done through the ST Science Institute and an ST Operations Control Center. ESA is providing the photovoltaic power source and the Faint Object Camera and is participating in the observing program.

ORBIT PARAMETERS:

Altitude: 600 km
 Inclination: 28.8°
 Carrier: Free-flyer
 Launch Date: 1983
 Flight Duration: 15 years
 Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 2,100 W
 Size: 13.6 x 4.3 (dia)m
 Mass: 11,070 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 4/1024 kbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 3 x 10⁹ bits
 Daily Data Volume: 10¹⁰ bits/day
 On-Board Processing: Microprocessors
 Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
 Pointing Accuracy: 1.0 mr
 Stability: 3 x 10⁻⁵ mr
 Time Requirement: TBD
 Techniques: Fine guidance sensor, rate gyro, star tracker, magnetometer, sun sensor.

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 3*
Return Link - Hours/Contact: 0.8*

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

F.A. Speer, MSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

* Computed based on data volume, storage and dump rate
** Estimate

B-39: Space Transportation System - Shuttle (93)

OBJECTIVE: A partially reusable space transportation system designed to reduce the cost and increase the effectiveness of using space for commercial, and defense needs.

DESCRIPTION: The Shuttle flight systems is composed of the orbiter, an external tank (ET) that contains the ascent propellant used by the three orbiter main engines, and two solid rocket boosters (SRBs). The orbiter and SRBs are reusable; the external tank is expended on each launch. The orbiter is designed to carry a crew of up to seven and the payloads. The smaller engines of the orbital maneuvering system (OMS) provide propulsive energy for orbit insertion, retrograde, and maneuvering capability during space flight. A reaction control system provides for precision velocity adjustments and attitude control. During atmospheric flight, the orbiter is controlled by its aerodynamic surfaces. A turnaround time as short as two weeks is planned between touchdown and relaunch.

ORBIT PARAMETERS:

Altitude: 185 - 1110 km⁽¹⁾
 Inclination: 28.5 to 57°, KSC: Launch AZ 35 to 120°
 Carrier: Free-flyer
 Launch Date: 12 April 1981⁽²⁾
 Flight Duration: 7 - 30 days
 Flight Activity Profile: See Note (3)

- NOTES (1): Range of possible orbital altitudes.
 (2): Date of first test flight launch.
 (3): In connection with the longevity of Shuttle flights, the following information has been obtained on telephone from D. Turner of STS operations branch of NASA HQ.
- a. NASA will continue to research the Shuttle problem and Shuttle flights will continue into the 21st century (at least up to 2010).
 - b. Any advanced replacement for Shuttle will not be contemplated before 1995. Assuming 10 year development period replacement of the present Shuttle with an advanced version can not be expected before 2005 (one candidate is Heavy Lift Launch Vehicle, HLLV).
 - c. The number of orbiters in the fleet will be as shown below.
 - 5 to accommodate projected demand. Two out of these are dedicated for DOD.
 - 1 to take peak loads.
 - 1 to replace loss by attrition.
 - Total = 7.
 (The funding for the 5th orbiter, which has been reduced, is expected to be resumed in FY 85).
 - d. The total flights are as shown below:
 10 flights/orbiter/year which will be increased to 50 flights/orbiter/year with refurbishment.

SPACECRAFT REQUIREMENTS:

Field of View: Full-sky
Power: 7 kW (Average operational)
Size: 37 x 17 x 24 (L, H, Wing Span)⁽¹⁾
Mass: 86,000⁽²⁾

- NOTES (1): These are orbiter dimensions.
(2): This does not include the following
a. Usable propellant 14,750 kg
b. Payload 29,500 kg (max.).

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: For complete data communication capability
see attached Table B-39.1
Experiment Control Data Rate: For complete data communication capability
see attached Table B-39.1
Mission TT&C Data Rate: For complete data communication capability see
attached Table B-39.1
On-Board Data Storage: No
Daily Data Volume: TBD
On-Board Processing: No
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 0.1 km⁽¹⁾
Pointing Accuracy: 8.7 mrad⁽²⁾
Stability: 0.034 mrad
Time Requirement: GPS; see note (3)
Techniques: GPS; see note (3)

- NOTES (1): Initial errors (during first 40 minutes of flight)
will be higher up to 1 Km.
(2): This is 3 axis, 3σ , accuracy using orbiter Inertial Measuring
Unit and it will be 7.6 mrad with Star Sensor updating. Pointing
accuracy degrades at the rate of 1.7 mrad/hr (1 axis, 3σ , no star
sensor updates).
(3) Presently STDN network is being used. GPS may be used in future.

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: *4
Forward Link - Hours/Contact: *0.2
Return Link - Contacts/Day: *1
Return Link - Hours/Contact: *24

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

* Estimate

NASA CONTACTS:

D. Turner NASA HQ

REFERENCES:

1. NASA Space Systems Technology Model [15.0]
2. Space Shuttle (TRW Brochure)
3. STDN in the TDRSS and Shuttle Era [10.0]
4. Special Issue on Space Shuttle Communications and Tracking [16.0]

SHUTTLE COMMUNICATION SERVICES	LINK FUNCTIONS	RF DATA		CHANNEL RATE		A			B			C			
		RF BAND	MODU- LATION	HIGH RATE	LOW RATE	2-32 kbps Delta Mod Voice	128 kbps Telemetry	1-32 kbps Delta Mod Voice	64 kbps Telemetry	Up to 5 Mbps Attached Payload Dig. Data	Up to 4 Mlig Attached Payload Analog Data	2-32 kbps Delta Mod Voice	128 Mbps Telemetry	64 kbps Telemetry	128 Mbps Telemetry
1. GSTDN	DOWNLINK	S	PM	192 kbps HIGH POWER	96 kbps LOW POWER	2-32 kbps Delta Mod Voice	128 kbps Telemetry	1-32 kbps Delta Mod Voice	64 kbps Telemetry	Up to 5 Mbps Attached Payload Dig. Data	Up to 4 Mlig Attached Payload Analog Data	2-32 kbps Delta Mod Voice	128 Mbps Telemetry	64 kbps Telemetry	
	DOWNLINK	S	PM	SAME	SAME	128 kbps Telemetry		64 kbps Telemetry							
	DOWNLINK	S	FM	192 kbps ENCODED TO 576 kbps		Up to 1.024 Mbps Tele- metry & MSS Data		Up to 5 Mbps Attached Payload Dig. Data							
2. TDRSS	RETURN LINK	S	PM	192 kbps ENCODED TO 576 kbps	96 kbps ENCODED TO 288 kbps	2-32 kbps Delta Mod Voice		1-32 kbps Delta Mod Voice				2-32 kbps Delta Mod Voice	128 Mbps Telemetry	64 kbps Telemetry	
	RETURN LINK	S	PM (PSK)	SAME	SAME	128 Mbps Telemetry		64 kbps Telemetry							

TABLE B-39.1: SHUTTLE DATA COMMUNICATIONS CAPABILITY-SELECTED SUBSET

	LINK FUNCTION	RF DATA		CHANNEL RATE		USED FOR		
		RF BAND	MODI- FICATION			A	B	C
3. TORSS	RETURN LINK MODE 1	Ku	PH			2-32 kbps DELTA MOD. VOICE	128 Kbps TELEMETRY & UP TO 2 Mbps DIGITAL DATA	2 TO 50 Mbps DIGITAL PAYLOAD DATA
4. TORSS	RETURN LINK MODE 2	Ku	PH			2-32 Kbps DELTA MOD. VOICE	128 Kbps TELEMETRY & UP TO 2 Mbps DIGITAL DATA	4.5 Mhz TV/ ANALOG OR UP TO 4 Mbps DIGITAL DATA

TABLE B-39.1: SHUTTLE DATA COMMUNICATIONS CAPABILITY-SELECTED SUBSET (CONT)

SHUTTLE COMMUNICATION SERVICES	LINK CONFIGURATION	RF DATA		CHANNEL RATE		USED FOR		
		RF BAND	MODU- LATION	HIGH RATE	LOW RATE	A	B	C
5. GSTDN	UPLINK	S	PH	72 Kbps	32 Kbps	2-32 Kbps DELTA MOD. VOICE	1-24 Kbps DELTA MOD. VOICE	2400 bps COMMAND CHANNEL
6. TDRSS	FORWARD LINK	S	PH (PSK)	72 Kbps	32 Kbps	2-32 Kbps DELTA MOD. VOICE	1-24 Kbps DELTA MOD. VOICE	2400 bps COMMAND CHANNEL
7. TDRSS	FORWARD LINK MODE 1	Ku		216 Kbps 1/3 RATE CODED	96 Kbps 1/3 RATE CODED	2-32 Kbps DELTA MOD. VOICE	2400 bps COMMAND CHANNEL	128 Kbps DATA CHANNEL
TDRSS	FORWARD LINK MODE 2	Ku		72 Kbps		2-32 Kbps DELTA MOD. VOICE	2400 bps COMMAND CHANNEL	

TABLE B-39.1: SHUTTLE DATA COMMUNICATIONS CAPABILITY-SELECTED SUBSET (CONT)

B-40: Starlab (94)

OBJECTIVE: Starlab is a platform facility for astronomical observations in the visual and ultraviolet portion of the spectrum. Scientific investigations that can be conducted include high resolution, wide field imaging, far ultraviolet spectroscopy, precise spectrophotometry and polarimetry, and synoptic planetary observations. A Starlab mission can have unique scientific objectives and an appropriate instrument complement.

DESCRIPTION: Starlab is a 1-meter aperture f/15 telescope which will accommodate a wide variety of principal investigator-furnished focal plane instruments. New instruments are readily accommodated. Starlab is flown in the platform attached mode. Mission durations are to 30 days in an orbit at 400 km altitudes. The mission uses the following Spacelab hardware: two pallets, the Instrument Pointing System and an igloo. Starlab is being considered by NASA's Astrophysics Program office for a new project start in FY 84 with launch possible in 1987.

ORBIT PARAMETERS:

Altitude: 400 km Circular (1)
 Inclination: 57°
 Carrier: Shuttle or Platform
 Launch Date: Several launches (2)
 Flight Duration: 10 - 15 years
 Flight Activity Profile: 1 year useful lifetime
 See Note (3)

- NOTES (1): Orbit with maximum solar occultations is preferred.
 (2): Several launches are envisioned. Different instruments will be launched each time. The flight duration is expected to be from 7 to 30 days. The first launch is expected to be in 1987.
 (3): Based upon the data presented in the table and annexed explanatory notes, the Starlab lifetime is expected to extend to year 2002. Two flights per year are planned over the time 1987 to 2002 with a total of 30 flights.

SPACECRAFT REQUIREMENTS:

Field of View: Full-sky⁽¹⁾
 Power: *1000 W
 Size: Length = 5 m
 Diameter = 1.5 m
 Mass: 2000 kg⁽²⁾

- NOTES (1): Full sky FOV is required to enable Starlab to view various celestial objects.
 (2): Mass breakdown is as follows:
- | | |
|---------------------|--------|
| Science Instruments | 500 kg |
| Optics | 350 |
| Structure | 400 |
| Miscellaneous | 300 |
| Margin | 450 |

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 10 - 6000 kbps (1)
Experiment Control Data Rate: *1 kbps
Mission TT&C Data Rate: *2 kbps
On-Board Data Storage: 25×10^6 bits
Daily Data Volume: $10^9 - 10^{11}$ bits/day
On-Board Processing: No
Processed D/L Data Rate: 1 Mbps (1)

NOTES: (1) Typical Value of donwlink experiment data rate is 1000 kbps
(2) Film will not be used for storage.

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 5.4×10^{-3} mrad
Stability: 1.5×10^{-4} mrad
Time Requirement: TBD
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: *4
Forward Link - Hours/Contact: *0.2
Return Link - Contacts/Day: *1 (1)
Return Link - Hours/Contact: *24 (1)

NOTES: (1) It is assumed that continuous contact for each day of the flight duration will be required.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

T. Stecher GSFC

REFERENCES:

1. STARLAB, Rainbow Series booklet [66.0]
2. NASA Space Systems Technology Model [15.0]

* Estimated

B-41: Teleoperator Maneuvering System - TMS (98)

OBJECTIVE: To provide remotely manned placement and retrieval of satellites, maintenance and repair of satellites, and perform subsatellite operations.

DESCRIPTION: The TMS core vehicle, without hydrazine performance kits, can perform all known LEO payload retrieval missions within one-half mile range of the Shuttle. This includes the capability to rendezvous and dock with equipped spacecraft and return it within the Orbiter RMS range. It also enables the monitoring and viewing of free-flying spacecraft, orbiter payload bay operations, and exterior surfaces/components of the orbiter. By using 2 or 4 hydrazine or bipropellant add-on kits, the TMS can deliver and retrieve payloads to higher orbits beyond those attainable by the orbiter. With specific mission-front end kits the TMS can perform remote maintenance and repair.

ORBIT PARAMETERS:

Altitude: 1000 km
Inclination: variable (28.5° to Polar)
Carrier: Free-Flyer
Launch Date: see note (1)
Flight Activity Profile: see note (2)

- NOTES: (1) The Launch data has not yet been firmly defined, but first launch is not expected to take place before 1985. (Teleoperator Maneuvering System Study, Dec. 10, 1980, Report No: 10, Dec. 1980, Vought Corporation)
- (2) Although detailed activity profile has not yet been defined by NASA, the flights will last for ten (10) years period. The TMS's which will be built and launched is not known at this time, but applications might dictate more than one TMS to stage payloads from single orbiter. The activity consisting of several flights is expected to continue beyond 1985.

SPACECRAFT REQUIREMENTS:

Field of View: Full Sky
Power: 550 W (average operational)
Size: 3.3 x 3.2 x 3.4 M (L x W x H)
Mass: 5600 - 6500 kg

DATA CHARACTERISTICS:

Experiment Data Rate: 15 Mbps (1)
Experiment Control Data Rate: 2 kbps (2)
Mission CC&T Data Rate: 8 kbps (2)
On-Board Storage: see note (3)
Data Volume: $*10^{11}$ bits/day
On-Board Processing: Yes (3)
Processed D/L Data Rate: 5 Mbps (4)

- NOTES: (1) This is an estimate based upon the equipment which will be on-board TMS. There will be two operational slow scan, slow framerate, black and white TV sensors and one radar to measure range to the object. The information about equipment was obtained from R. Cortez of NASA HQ. No experiment data rates have yet been estimated by NASA.
- (2) This is assumed typical value.
- (3) TV data compression is an on-board processing function.
- (4) Based upon factor of 3 data compression.

NAVIGATION REQUIREMENTS:

Position Accuracy: *0.1 km
Pointing Accuracy: 4.4 m rad
Stability: 1.7 m rad
Time Req: GPS (1)
Technique: GPS eventually (1)

- NOTES: (1) It is a reasonable assumption

TDAS CONTACT TIME PROFILE:

Contacts/Day (Forward Link): *4
Hours/Contact: *0.2
Contacts/Day (Return Link): Continuous (1)
Hours/Contact: Continuous (1)
Schedule Type: TBD

- NOTES: (1) Monitoring of TMS functions is a key requirement to ensure that the functions are being adequately performed. Continuous Contact capability is therefore necessary.

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

E. Cortez NASA HQ
F. Wulff NASA HQ

REFERENCES:

Teleoperator Maneuvering System Study, Vought Corporation
Report # 2-30400/OR-52611, Dec. 10, 1980; prepared for NASA MSFC [54.0]

* Estimated

B-42: 25 kW Power System (102)

This is part of the Power Utilization Platform Program. See B-27.

B-43: Very Long Baseline Radio Interferometer (104)

OBJECTIVE: Radio interferometry over very long baselines provides maps of compact celestial radio sources with finer resolution, less ambiguity, and more efficiency than Earth-bound techniques.

DESCRIPTION: The Very Long Baseline Interferometer (VLBI) observatory is taken to low-Earth orbit by the Shuttle. A parabolic antenna with a diameter of 30 to 60 m is deployed. Celestial radio sources are observed simultaneously by the free-flying VLBI observatory and by one or more ground based observatories. Two orbiting VLBI observatories with larger orbit sizes could be used together to provide maps with even finer angular resolution.

ORBIT PARAMETERS:

Altitude: 400-5000 km
Inclination: 45°
Carrier: Free-flyer
Launch Date: 1990
Flight Duration: 3 years (possibly 10)
Flight Activity Profile: TBD

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
Power: 1200 W**
Size: 30 - 60 m(dia)
Mass: 6000 (based upon orbiting submillimeter telescope)

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 120 Mbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: TBD
Daily Data Volume: TBD
On-Board Processing: Yes
Processed D/L Data Rate: TBD

NAVIGATION REQUIREMENTS:

Position Accuracy: 1 km
Pointing Accuracy: 0.01 mr
Stability: 0.01 mr
Time Requirement: TBD
Techniques: TBD, Hydrogen Maser

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4*
Forward Link - Hours/Contact: 0.2*
Return Link - Contacts/Day: 1*
Return Link - Hours/Contact: 24*

* Estimate

** MMS

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

R. Preston, JPL

REFERENCES:

NASA Space Systems Technology Model [15.0]

B-44: X-Ray Observatory - XRO (106)

OBJECTIVE: It is intended that the X-ray Observatory mission make scientific observations with broad bandwidth X-ray instruments which are needed to resolve problems in the areas of large-scale galactic phenomena, stellar structure and evolution, the nature of the active galaxies, clusters of galaxies and cosmology.

DESCRIPTION: The X-ray Observatory mission is designed to extend the previous observations in X-ray astronomy made by Uhuru, ANS, Ariel 5, SAS-3, and the HEAO series of satellites by providing more sensitive and time-correlated measurements over a broad spectral range (potentially as great as 40 eV to 300 keV). XRO could also support the AXAF mission. XRO will be launched from the Kennedy Space Center (KSC) on the Space Shuttle and placed in a 300 km, 28.5 deg. inclination orbit. The instruments, with the exception of the all-sky monitor, will be pointed with 1 arc min. accuracy to any area of interest in the sky. The XRO concept is based upon the support capabilities that can be provided by the Multimission Modular Spacecraft (MMS - see B-16). The XRO mission is being considered by NASA's Astrophysics Program as a candidate for a new project start after FY 85.

ORBIT PARAMETERS:

Altitude: 300 km
 Inclination: 28.5°
 Carrier: Multimission Modular Spacecraft
 Launch Date: 1990
 Flight Duration: 2 years
 Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
 Power: 900 W
 Size: 2.9 x 3.6 (dia)m*
 Mass: 1300-1800 kg Instruments
 3500 kg Total

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 8 kbps/1024 kbps
 Experiment Control Data Rate: 1 kbps
 Mission TT&C Data Rate: 2 kbps**
 On-Board Data Storage: 10^8 bits
 Daily Data Volume: 10^9 bits/day
 On-Board Processing: Yes
 Processed D/L Data Rate: NA

* data is based upon Multi-mission Modular Spacecraft capabilities (Mark II version)
 Further information is not available on this experiment/mission.

NAVIGATION REQUIREMENTS:

Position Accuracy: GPS
Pointing Accuracy: 0.28 mr
Stability: 10^{-2} mr
Time Requirement: GPS*
Techniques: inertial reference unit, magnetometer, star trackers,
sun sensor*

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4**
Forward Link - Hours/Contact: 0.2**
Return Link - Contacts/Day: 10***
Return Link - Hours/Contact: 0.1***

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

J. Gitelman, GSFC

REFERENCES:

NASA Space Systems Technology Model [15.0]

** Estimated
*** Computed based on data volume, storage, and dump rate.

B-45: Astrophysics-Generic (AG-1, 2, 3, 4)

OBJECTIVE: The objective of these generic experiments is to fill out the NASA planning in the TDAS time frame.

DESCRIPTION: The basis for these experiments is the Infrared Astronomical Satellite - IRAS. (29). The characteristics of the IRAS except for orbit parameters are used for the generic experiments.

ORBIT PARAMETERS:

Altitude: LEO
Inclination: 28.5°
Carrier: MMS
Launch Date: TBD
Flight Duration: 1 year
Flight Activity Profile: Single launch

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
Power: 200 W
Size: 3.6 x 1.6 (dia)
Mass: 1,000 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 4/1024 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 2×10^8 bits
Daily Data Volume: 5×10^8
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 0.15 mr
Stability: 0.15 m
Time Requirement: TBD
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2
Return Link - Contacts/Day: 2.5
Return Link - Hours/Contact: 0.05

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

NA

REFERENCES:

NA

B-46: Astrophysics-Generic (AG-5, 6, 7)

OBJECTIVE: The objective of these generic experiments is to fill out the NASA planning in the TDAS time frame.

DESCRIPTION: The basis for these experiments is the X-ray Observatory - XRO (106). The characteristics of the XRO are used for the generic experiments.

ORBIT PARAMETERS:

Altitude: 400 km
Inclination: 28.5°
Carrier: MMS
Launch Date: unscheduled
Flight Duration: 3 years
Flight Activity Profile: one flight

SPACECRAFT REQUIREMENTS:

Field of View: All-sky
Power: 900 W
Size: 3.6 x 1.6 (dia)
Mass: 3,500 kg

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 8/1024 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 10^8 bits
Daily Data Volume: 7×10^8
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 0.28 mr
Stability: 0.28 mr
Time Requirement: TBD
Techniques: MMS

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2
Return Link - Contacts/Day: 7
Return Link - Hours/Contact: 0.03

DATA DISTRIBUTION/PROCESSING FLOW.

TBD

NASA CONTACTS:

None

REFERENCES:

None

B-47: Solar Terrestrial-Generic (SG-1, 3, 5)

OBJECTIVE: The objective of these generic experiments is to fill out the NASA planning in the TDAS time frame.

DESCRIPTION: The basis for these experiments is the Solar Cycle and Dynamics Mission - SCADM (see B-30). The characteristics of the SCADM are used for the generic experiments.

ORBIT PARAMETERS:

Altitude: 575 km
Inclination: 28°
Carrier: MMS
Launch Date: unscheduled
Flight Duration: 2 years
Flight Activity Profile: one flight

SPACECRAFT REQUIREMENTS:

Field of View: Sun
Power: 800 W
Size: 6 x 2 (dia)m
Mass: 2,600 kg

DATA CHARACTERISTICS

Experiment Sensor Data Rate: 16/1024 kbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 2×10^9
Daily Data Volume: 5×10^9
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: TBD
Pointing Accuracy: 0.005 mr
Stability: 0.002 mr
Time Requirement: TBD
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2
Return Link - Contacts/Day: 2.5
Return Link - Hours/Contact: 0.5

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

None

REFERENCES:

None

B-48: Solar Terrestrial-Generic (SG-2, 4)

OBJECTIVE: The objective of these generic experiments is to fill out the NASA planning in the TDAS time frame.

DESCRIPTION: The basis for these experiments is the Solar Terrestrial Observatory - STO (see B-34). The carrier would be MMS (see B-16). The characteristics of the STO are used for the generic experiments.

ORBIT PARAMETERS:

Altitude: 400 km
Inclination: 57°
Carrier: MMS
Launch Date: Unscheduled
Flight Duration: 5 years
Flight Activity Profile: One Flight

SPACECRAFT REQUIREMENTS:

Field of View: Sun/nadir/limb
Power: 10,500 W
Size: 4 pallets
Mass: TBD

DATA CHARACTERISTICS:

Experiment Sensor Data Rate: 32 Mbps
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 2×10^9
Daily Data Volume: 3×10^{12}
On-Board Processing: Yes
Processed D/L Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 1 km
Pointing Accuracy: 3 mr
Stability: 0.005 mr
Time Requirement: TBD
Techniques: TBD

TDAS CONTACT TIME PROFILE:

Forward Link - Contacts/Day: 4
Forward Link - Hours/Contact: 0.2
Return Link - Contacts/Day: 1
Return Link - Hours/Contact: 24

DATA DISTRIBUTION/PROCESSING FLOW:

TBD

NASA CONTACTS:

None

REFERENCES:

None

B-49: Resource Observation Generic (RG-1, 2, 3, and 4)

OBJECTIVE: Improve Earth remote sensing services to users.

DESCRIPTION: Visible imager with on-board Processing (similar to SAR, B-20).

ORBIT PARAMETERS:

Altitude: 700 km
Inclination: 98° Polar
Carrier Type: Fre-flyer
Launch Date: unscheduled
Duration: 3 years
Flight Activity Profile: one flight

SPACECRAFT REQUIREMENTS:

Field of View: Earth under nadir
Power: 1200 W
Size: 8m x 5m x 3m
Mass: 4214 kg

DATA CHARACTERISTICS:

Experiment D/L Data Rate: 800 Mbps
Experiment Control Data Rate: 1 Kbps
Mission TT&C Data Rate: 2 Kbps
On-Board Data Storage: Yes
Daily Data Volume: 5×10^{12} bits
On-Board Processing: Yes
Processed Data Rate: 150 Mbps

NAVIGATION REQUIREMENTS:

Position Accuracy: 10m
Pointing Accuracy: .01°
Stability: 10^{-6} /sec
Time Accuracy: GPS
Techniques: GPS

TDAS CONTACT TIME PROFILE:

Experiment TT&C - Contacts/Day: 14
Experiment TT&C - Hours/Contact: 0.3
Spacecraft TT&C - Contacts/Day: 14
Spacecraft TT&C - Hours/Contact: 0.3
Experiment Data(1)- Contacts/Day: TBD
Experiment Data(1)- Hours/Contact: TBD
Experiment Data(2)- Contacts/Day: 1
Experiment Data(2)- Hours/Contact: 24

NOTES: 1. Unprocessed "Raw" Data
2. Processed Salient Data

DISTRIBUTION/PROCESSING FLOW:

Direct to users; encoded

CONTACTS:

None

REFERENCES:

None

B-50: Global Environment Generic (EG-1, 3, 4, 7)

OBJECTIVE: In Oceanic Research the Synthetic Aperture Radar is used to map the surface topography of the ocean; measure waveheight surface windspeeds, and roughness.

DESCRIPTION: Synthetic Aperture Radar

ORBIT PARAMETERS:

Altitude: 790 km
 Inclination: 98°
 Carrier Type: Free-flyer
 Launch Date: unscheduled
 Duration: 3 years
 Flight Activity Profile: one flight

SPACECRAFT REQUIREMENTS:

Field of View: Earth under Nadir
 Power: 1 KW
 Size: 2m x 10m
 Mass: 2000 Kg

DATA CHARACTERISTICS:

Experiment D/L Data Rate: 200 Mbps
 Experiment Control Data Rate: 2 kbps
 Mission TT&C Data Rate: 2 kbps
 On-Board Data Storage: 3.5×10^8 bits
 Daily Data Volume: 2×10^{12} bits
 On-Board Processing: Yes
 Processed Data Rate: NA

NAVIGATION REQUIREMENTS

Position Accuracy: 50 m
 Pointing Accuracy: 0.75°
 Stability: 0.17
 Time Accuracy: 10^{-6}
 Techniques: TBD

TDAS CONTACT TIME PROFILE:

Experiment TT&C - Contacts/Day: 14
 Experiment TT&C - Hours/Contact: 0.3
 Spacecraft TT&C - Contacts/Day: 14
 Spacecraft TT&C - Hours/Contact: 0.3
 Experiment Data(1)- Contacts/ Day: 14
 Experiment (1)- Hours/Contact: 0.3

NOTES: 1. Unprocessed "Raw" Data

DISTRIBUTION/PROCESSING FLOW:

Optical, Survey Processing - 24 hrs.

CONTACTS:

None

REFERENCES:

None

B-51: Global Environment Generic (EG-2, 5, 6 and 8)

OBJECTIVE: Map the surface topography of the ocean to determine the absolute value of the surface geostrophic current. Measure surface roughness under nadir to determine waveheight and surface wind speed.

DESCRIPTION: MMS Freeflyer or equivalent with radar altimeter and two-channel microwave radiometer. (See B-16).

ORBIT PARAMETERS:

Altitude: 1334 km circular
Inclination: 63°
Carrier Type: Free-flyer
Launch Type: unscheduled
Duration: 5 years
Flight Activity Profile: one flight

SPACECRAFT REQUIREMENTS:

Field of view: Earth under nadir
Power: 500 W
Size: 2m x 3m w/o solar array
Mass: 1350 kg

DATA CHARACTERISTICS:

Experiment D/L Data Rate: 8 kbps/50 kbps (realtime/dump)
Experiment Control Data Rate: 1 kbps
Mission TT&C Data Rate: 2 kbps
On-Board Data Storage: 3×10^8 bits
Daily Data Volume: 7×10^8 bits
On-Board Processing: No
Processed Data Rate: NA

NAVIGATION REQUIREMENTS:

Position Accuracy: 2 to 3m, in the radial direction
Pointing Accuracy: 5°
Stability: TBD
Time Accuracy: 0.1 sec
Techniques: Altitude knowledge accurate to 10cm. needed.

TDAS CONTACT TIME PROFILE:

Experiment TT&C - Contacts/Day:	Included
Experiment TT&C - Hours/Contact:	Included
Spacecraft TT&C - Contacts/Day:	Included
Spacecraft TT&C - Hours/Contact:	Included
Experiment Data (1) - Contacts/Day:	13
Experiment Data (1) - Hours/Contact:	0.3

NOTES: 1. Unprocessed "Raw" Data

DISTRIBUTION/PROCESSING FLOW:

Data Delivery within 4 months from acquisition

CONTACTS:

None

REFERENCES:

None

Appendix C

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