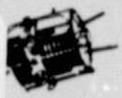
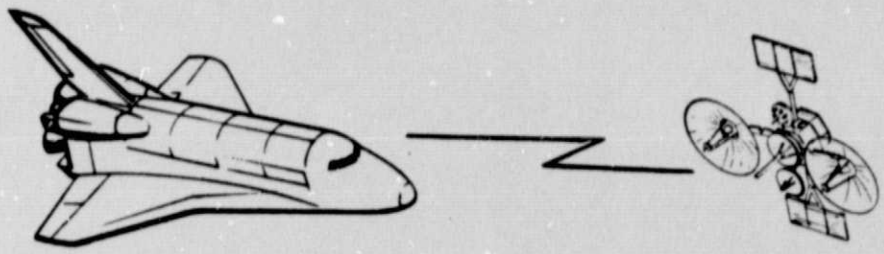
SPACE TRANSPORTATION SYSTEM PAYLOADS MISSION CONTROL STUDY PHASE A-1

NASA CR-151168

VOLUME I





VOLUME 1 OF
FINAL STUDY REPORT

FINAL SUMMARY REPORT

PHASES A AND A-1

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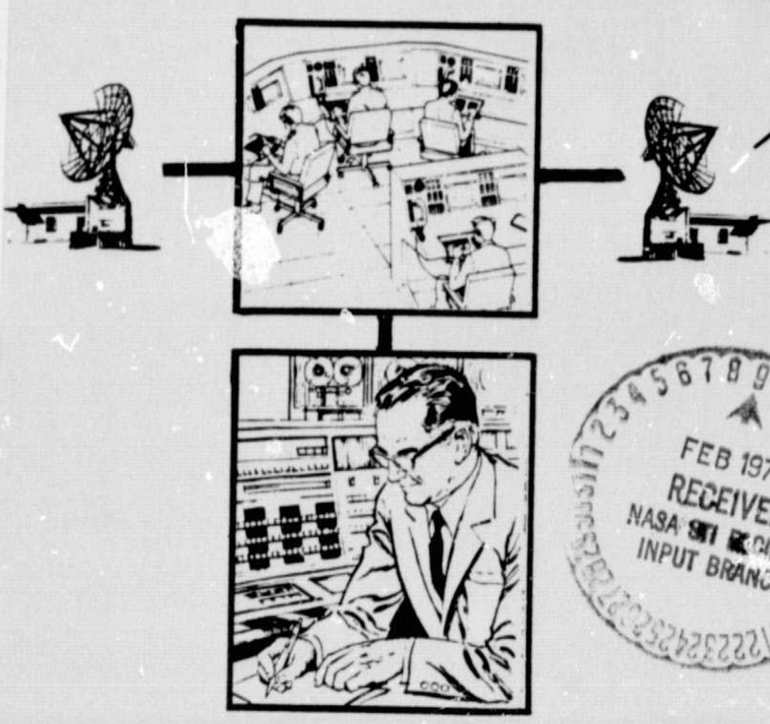

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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December 1976

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FINAL REPORT
FOR
STS PAYLOADS MISSION CONTROL STUDY PHASE A-1

FINAL SUMMARY REPORT, PHASES A AND A-1

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FOREWORD

This Final Summary Report summarizes the Space Transportation System (STS) Payloads Mission Control Phase A-1 Study results combined with key results from the basic Phase A Study, References 2 and 11. A major purpose of the Phase A-1 Study was to determine the Composite Resources required to accomplish Joint STS-Payload preflight preparation for joint flight operations, including flight planning, training, and simulations. These results are presented in Section 4. The major output of the Phase A Study was the introduction of the Standard Payload Operations Control Center (POCC) concept, Reference 11. This concept was developed further in the Phase A-1 Study. A combined Standardized POCC concept has been summarize in Section 3.

This document represents one section of the FINAL REPORT for the STS PAYLOADS MISSION CONTROL STUDY, PHASE A-1. It was prepared by TRW Defense and Space Systems Group under Contract NAS9-14484 with NASA, Lyndon B. Johnson Space Center. The complete set of documents that comprise the FINAL REPORT of Study Phase A-1, the Study Plan and Key Study Briefings are listed below. Documentation of the basic study (Phase A) is listed under "References" herein.

- TRW 26904-H016-RO-00: Phase A-1 Study Plan, dated January 19, 1976, and Study Plan Rev A, dated April 30, 1976
- *TRW 26904-H021-RO-00: Phase A-1 Volume I, "Final Summary Report"
- TRW 26904-H018-RO-00: Phase A-1 Volume II-A, Study Task 1 - 1.0 Joint Products and Functions for Preflight Planning of Flight Operations, Training and Simulations
- TRW 26904-H019-RO-00: Phase A-1 Volume II-B, Study Task 2 - 2.0 Evaluation and Refinement of Implementation Guidelines for the Selected STS Payload Operator Concept
- TRW 26904-H020-RO-00: Phase A-1 Volume II-C, Study Task 3 - 3.0 Identification of Joint Activities and Estimation of Resources in Preparation for Joint Flight Operations
- TRW Document Dated April 1976, Initial Progress Review, Continuation Phase A-1
- TRW Document Dated June 3, 1976, Summary Review of Past (Phase A), Present (Phase A-1) and Future (Quarterly Review Document, Phase A-1)
- TRW Document Dated October 1976, Mid-Term Progess Review (Phase A-1)
- TRW Document Dated December 1976, Executive Summary Review (Phase A-1)

*This document.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

KEY DEFINITIONS

The following "Key Definitions" are pertinent for a clear understanding of the content of this document and other Study documentation.

POCC VERSUS POC

POCC = PAYLOAD OPERATIONS CONTROL CENTER

- FOCAL POINT OF PAYLOAD FLIGHT OPERATIONS
- CONTROL ROOM EQUIPPED WITH CONTROLS, DISPLAYS, ETC.
- ONE ELEMENT OF A POC

POC = PAYLOAD OPERATIONS CENTER

- NASA CENTER ASSIGNED TO HOST/PERFORM OPERATIONS FOR GIVEN PAYLOAD CATEGORY
  - GSFC - AUTOMATED EARTH ORBIT
  - JSC - SPACELAB
  - JPL - PLANETARY
- PROVIDES SEVERAL CAPABILITIES
  - POCC'S
  - ORBIT DETERMINATION
  - FLIGHT MANEUVER COMPUTATIONS
  - EXPERIMENT DATA PROCESSING
  - OTHERS

PAYLOAD OPERATOR

ORGANIZATION ASSIGNED PRIME RESPONSIBILITY FOR OPERATIONS OF TOTAL CARGO/PAYLOAD ONBOARD FOR A GIVEN FLIGHT.

NOTE: FOR NASA PAYLOADS, THE PAYLOAD DEVELOPMENT CENTER WOULD NORMALLY BE THE "PAYLOAD OPERATOR"; HOWEVER, ONE OF THE THREE DESIGNATED HOST CENTERS COULD ALSO SERVE AS PAYLOAD OPERATOR BY MUTUAL AGREEMENT WITH THE PAYLOAD DEVELOPMENT CENTER INVOLVED.

STS FLIGHT OPERATOR

MCC-H

STS GROUND OPERATIONS

KSC/VAFB

1.0 SUMMARY RECOMMENDATIONS

The results of the Phase A and Phase A-1 Studies, as described in this Summary Report, lead to the recommendations shown in Table 1-1.

Table 1-1. Summary Recommendations

1. *INITIATE STANDARDIZATION IMPLEMENTATION AT THE EARLIEST POSSIBLE DATE FOR THE FOLLOWING:
    - PAYLOAD COMMUNICATIONS AND DATA HANDLING
    - POCC'S
    - DATA MANAGEMENT
    - OPERATIONAL PROCEDURES
    - PREFLIGHT PLANNING, TRAINING AND SIMULATION METHODS
    - OPERATING INTERFACES
2. *RECOMMEND IMMEDIATE IMPLEMENTATION OF THE STANDARD POCC CONCEPT AND THE ACCOMPANYING SYSTEM ENHANCEMENT TO INSURE THE ULTIMATE CAPABILITY REQUIRED BY THE TRAFFIC MODEL.
3. UTILIZE STUDY METHODOLOGY TO DETERMINE RESOURCES REQUIRED OF THE STS OPERATOR AND PAYLOAD OPERATOR. THIS WILL ASSIST IN IDENTIFYING ANY GAPS OR OVERLAPS IN THE ACTIVITIES AND TASKS.
4. A COST ANALYSIS OF THE STANDARD POCC NETWORK DEVELOPMENT CONCEPT SHOULD BE UNDERTAKEN NOW TO QUANTIFY THE COST OF IMPLEMENTATION AND THE SAVINGS WHICH WOULD ACCRUE.
5. SINCE MANPOWER IS THE MAJOR RESOURCE IN OPERATIONAL PLANNING, RESOURCES SHOULD BE CONSERVED THROUGH:
    - AUTOMATION
    - ELIMINATION OF REDUNDANCY
    - CENTRALIZED FUNCTIONAL CAPABILITIES FOR SIMILAR EFFORTS
    - PRODUCTION LINE TECHNIQUES FOR REPETITIVE ACTIVITIES
    - USE OF STANDARD MODULES - FOR FLIGHT PLANNING
    - CROSS-TRAINING BETWEEN SPECIALIZED PERFORMER GROUPS
6. IT IS RECOMMENDED THAT THE RESOURCES ESTIMATES FOR THE JOINT PREFLIGHT PREPARATION ACTIVITIES BE ASSESSED FOR IMPACT ON THE USER CHARGE ALLOCATIONS.
7. RECOMMEND EARLY PROGRAM BE CONSIDERED TO ESTABLISH STANDARDS FOR STS PAYLOADS. ADVANTAGES INCLUDE:
    - WILL PERMIT USE OF PROCESSING FIRMWARE
    - WILL MINIMIZE UNIQUE SOFTWARE
    - WILL SIMPLIFY PROCEDURES AND DOCUMENTATION
    - WILL REDUCE TRAINING TIME

*NOTE: A SYSTEM WHICH MAXIMIZES STANDARDIZATION OF POCC'S:

- ALLOWS USE OF STANDARD SOFTWARE
- PROMOTES SYSTEM VERSATILITY
- ACCOMMODATES FAST TURNAROUND
- SIMPLIFIES SPARES AND MAINTENANCE PROGRAM

2.0 STUDY DESCRIPTION AND BACKGROUND

2.1 STUDY OBJECTIVES

The goal of the Phase A and Phase A-1 Studies was to develop and expand STS Payload Mission Control concepts associated with ground flight control support and preflight planning including personnel resource requirements.

The objectives of each study were:

PHASE A

- Identify flight control ground functions for representative STS Payloads.
- Investigate present/planned NASA-wide facilities (capabilities) for STS Payload Flight Control.
- Determine feasible cost-effective system concept options for flight control of STS Payloads.
- Develop implementation guidelines for proposed system concept options.

PHASE A-1

- Refine concepts from basic study including:

  1. Approaches to POCC implementation
  2. Definition of Interfaces, Payload Operator/STS Flight Operator.

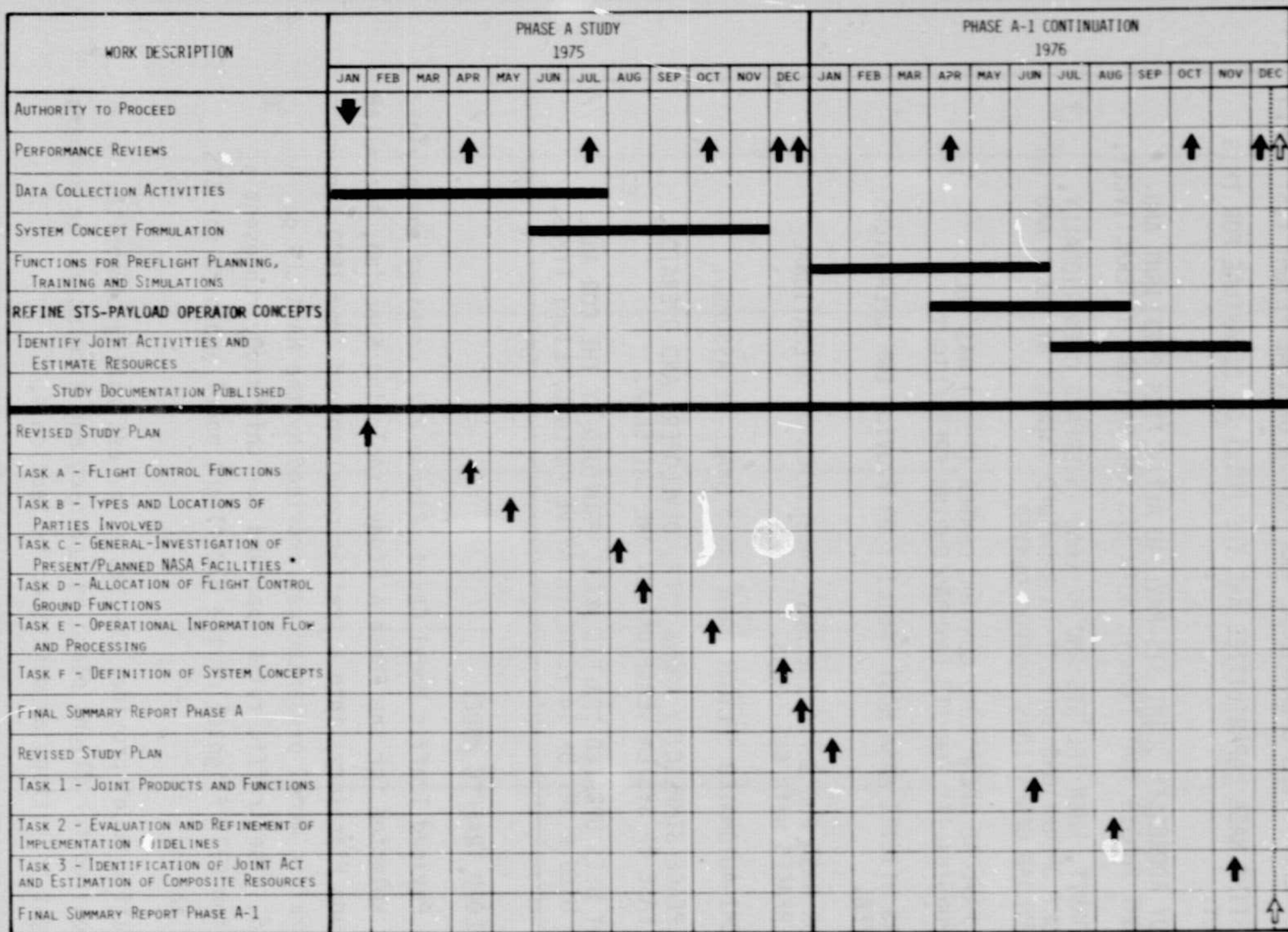
- Identify joint preflight activities and estimate composite joint resources.

2.2 STUDY SCHEDULE

The STS Payload Mission Control Study extended over a period of two years, twelve months each for the Phase A Study and the Phase A-1 Continuation effort (see Figure 2-1).

2.3 SELECTED STUDY GUIDELINES

The Phase A-1 Follow-on Study was based on the nine guidelines shown in Table 2-1.



*PRESENTED IN GENERAL (SUMMARY) DOCUMENT AND FOLLOWING APPENDICES:

A - NASA/ARC CAPABILITIES
B - NASA/GSFC CAPABILITIES
C - NASA/JPL CAPABILITIES
D - NASA/JSC CAPABILITIES
E - NASA/KSC CAPABILITIES
F - NASA/LARC CAPABILITIES
G - NASA/MSFC CAPABILITIES

Figure 2-1. Study Schedule

Table 2-1 Phase A-1 Study Guidelines

1.	STUDY EMPHASIZES OPERATIONAL ERA (AFTER ORBITAL FLIGHT TEST [OFT])
2.	EXISTING NASA CAPABILITIES ARE THE POINT OF DEPARTURE FOR THIS STUDY.
3.	STUDY ADDRESSES JOINT STS-PAYLOAD ACTIVITIES PREFLIGHT AND FLIGHT PHASES THAT INVOLVE BOTH STS AND PAYLOAD INTERACTIVELY.
4.	ON-ORBIT, WHEN THE STS AND PAYLOAD INTERFACE OPERATIONALLY, FLIGHT OPERATIONS SUPPORT IS PROVIDED JOINTLY BY MCC-H AND A PAYLOAD OPERATIONS CONTROL CENTER.
5.	THE PAYLOAD OPERATIONS CONTROL CENTER (POCC) HAS FULL RESPONSIBILITY FOR ITS PAYLOAD DURING FREE-FLIGHT.
6.	USERS UTILIZE NASA HOST FACILITY OR PROVIDE OWN OPERATIONS CENTER.
7.	MAJOR NASA POC'S PROVIDE HOST FACILITIES OR OPERATIONAL INTERFACES WITH CUSTOMERS.
8.	A SEMI-AUTOMATED "FLIGHT DATA BASE" SHALL BE ASSUMED.
9.	INTERFACE SIMPLICITY AMONG USER, DEVELOPER, AND OPERATOR, AND EASE OF SYSTEM VERIFICATION ARE CRITERIA.
10.	STUDY USES UPDATED TRAFFIC MODEL PROVIDED BY THE COR AND ALSO USES A SET OF 14 REPRESENTATIVE PAYLOAD/FLIGHT TYPES.

2.4 STS PAYLOAD TRAFFIC MODEL

The STS Payload Traffic Model Chart, Figure 2-2, combines the payload flight types selected for the Phase A Study (including Spacelab, Automated Earth Orbit and Planetary) into a traffic model spread from 1980 through 1991. The traffic model presented was provided by the NASA COR on 30 April 1976. The traffic rates approved for this study represent a reduced version (371 flights) of the 572-flight model approved for STS Operations Planning.

This traffic model provides the basis for estimating composite resources required for flight planning training and simulations in preparation for flight operations as described in Section 4.

2.5 REVIEW OF SYSTEM CONCEPTS DERIVED FROM PHASE A STUDY

This section presents the rationale used in developing the system concepts and describes the three system concepts selected.

Flight Type - Payload			Lead PL Center	Calendar Year												Total
	I.D.	Description		80	81	82	83	84	85	86	87	88	89	90	91	
SPACELAB	A	M+P, DC - ATL	LaRC	-	1	1	1	2	3	3	4	4	4	5	5	33
	A'	M+P, DC - OP	GSFC	-	1	1	1	2	2	2	2	2	2	2	2	19
	B	M+P, MD - AMPS, SP	GSFC	-	1	1	2	2	2	2	2	2	2	2	2	20
	B'	M+P, MD - OTHER	GSFC	1	-	-	-	1	1	2	3	3	4	5	6	26
	C	P ONLY, DC - SO	GSFC	-	-	1	1	2	3	5	6	6	5	6	6	41
	C'	P ONLY, DC - STELLAR	GSFC	-	-	-	1	1	1	1	1	1	1	1	1	9
	D	P ONLY, MD - HEA, SEOPS, SO	MSFC	1	1	1	2	3	4	4	4	4	4	4	5	37
	J_1	M ONLY, DD - LS	JSC	-	-	1	1	1	1	1	1	1	1	1	1	10
AUTO EARTH ORBIT	J_2	DELIVERY, MC - EXP, STP (DOD)	GSFC	-	1	1	1	1	1	1	1	1	1	1	1	11
	E	DELIVER - EOS	GSFC	-	1	1	1	-	1	1	1	-	1	-	1	8
	F	DELIVER - ST, RETRIEVE HEAO-C	MSFC	-	-	-	2	2	3	4	3	3	3	4	3	27
	G	REVISIT W/O EVA - EOS	GSFC	-	-	-	-	1	1	-	-	1	-	1	-	4
	H	REVISIT W/EVA - ST	MSFC	-	-	-	1	1	-	1	1	1	1	-	1	7
	I	DELIVER MC - BESS, SEOPS, 2 MINI-LAGEOS, FFTO	ARC	-	-	-	1	1	2	2	2	2	2	1	1	14
	K	MS, IUS - DW, COMSAT	GSFC	-	1	2	3	1	-	-	-	-	-	-	-	7
	M	MS, TUG - TM, INTEL/SAT	GSFC	-	-	-	-	3	5	7	7	10	12	13	11	68
PLANETARY	L	MARINER	JPL	-	1	2	2	2	-	-	-	-	-	-	-	7
	N	PIONEER	JPL	-	-	-	-	-	4	5	6	2	3	1	2	23
SUBTOTAL, 7-DAY FLIGHTS				2	8	11	19	25	32	38	41	39	41	42	43	341
SUBTOTAL, 30-DAY FLIGHTS (INCLUDES J_1)				-	-	1	1	1	2	3	3	4	5	5	5	30
TOTALS				2	8	12	20	26	34	41	44	43	46	47	48	371

LEGEND:

AMPS - Atmospheric, Magnetospheric, Plasmas-in-Space
ATL - Advanced Technology Laboratory
BESS - Biomedical Experiments Scientific Satellite
DC - Dedicated Center
DD - Dedicated Discipline
DW - Disaster Warning
EOS - Earth Observation Satellite
EVA - Extravehicular Activity
EXP - Explorer
FFTO - Freeflyer Teleoperator
HEA - High Energy Astrophysics
HEAO - High Energy Astrophysics Observatory
IUS - Interim Upper Stage
LAGEOS - Laser Geodynamic Satellite
LS - Life Science
M - Module
MC - Multi-Cargo
MD - Multi-Discipline
OP - Earth and Ocean Physics
P - Pallet
PL - Payload
SEOPS - Standard Earth Observations Package for Shuttle
SO - Solar Physics
SP - Space Processing
ST - Space Telescope
STP - Space Test Program (DOD Payloads)
TM - Traffic Management

Figure 2-2. STS Payload Traffic Model

2.5.1 Definition of System Concept

The Centers identified as POC candidates in Figure 2-3 were considered from the standpoint of present capabilities and historical involvement in STS or Payload operational-type activities and on the basis of difficulty/expense anticipated in augmenting present capabilities to develop a cost-effective capability for flight control. The alternatives in Figure 2-3 were used as a point of departure for the development of system concepts.

The POC alternatives were based on three distinct precept categories:

a. Utilize an existing single POC for each class of STS Payloads; Automated Earth Orbiting, Planetary and Spacelab Payloads.

b. Use multiple POC's for each class of STS Payload.

c. Provide alternative in which each NASA Payload Development Center is the POC for flight control of its payloads.

2.5.2 Selected System Concept Options

The three system concept options for Joint STS-Payload Flight Control, as derived from considerations in Section 2.5.1 and Figure 2-3, are shown in Figures 2-4, 2-5 and 2-6.

Figure 2-4, Concept Option No. 1, provides these features:

1.	It meets initial requirements for control of STS-Payloads at minimum cost.
2.	It makes maximum use of Centers' existing capabilities and experience.
3.	It requires minimum changes to the present mode of payload operations.
4.	It provides a solid baseline for future expansion and for system enhancements.
5.	It will provide for easy transition from present payload operations to STS-Payload operations.

MISSION TYPES	EXISTING SINGLE POC	MULTIPLE POC'S	EACH DEVELOPMENT CENTER IS POC
AUTOMATED EARTH ORBIT	GSFC JSC	GSFC / JSC GSFC / MSFC / ARC JSC / MSFC / GSFC	GSFC / MSFC / JSC / ARC / JPL
AUTOMATED PLANETARY	JPL ARC * *REMOTE POC FOR PIONEER	JPL / ARC	JPL / ARC / LaRC
SPACELAB	JSC JPL GSFC	JSC / MSFC JSC / JPL JSC / GSFC JSC / JPL / GSFC JSC / JPL / GSFC / MSFC	JSC / JPL / MSFC / GSFC / ARC / LaRC

Figure 2-3. Alternatives for POC Locations

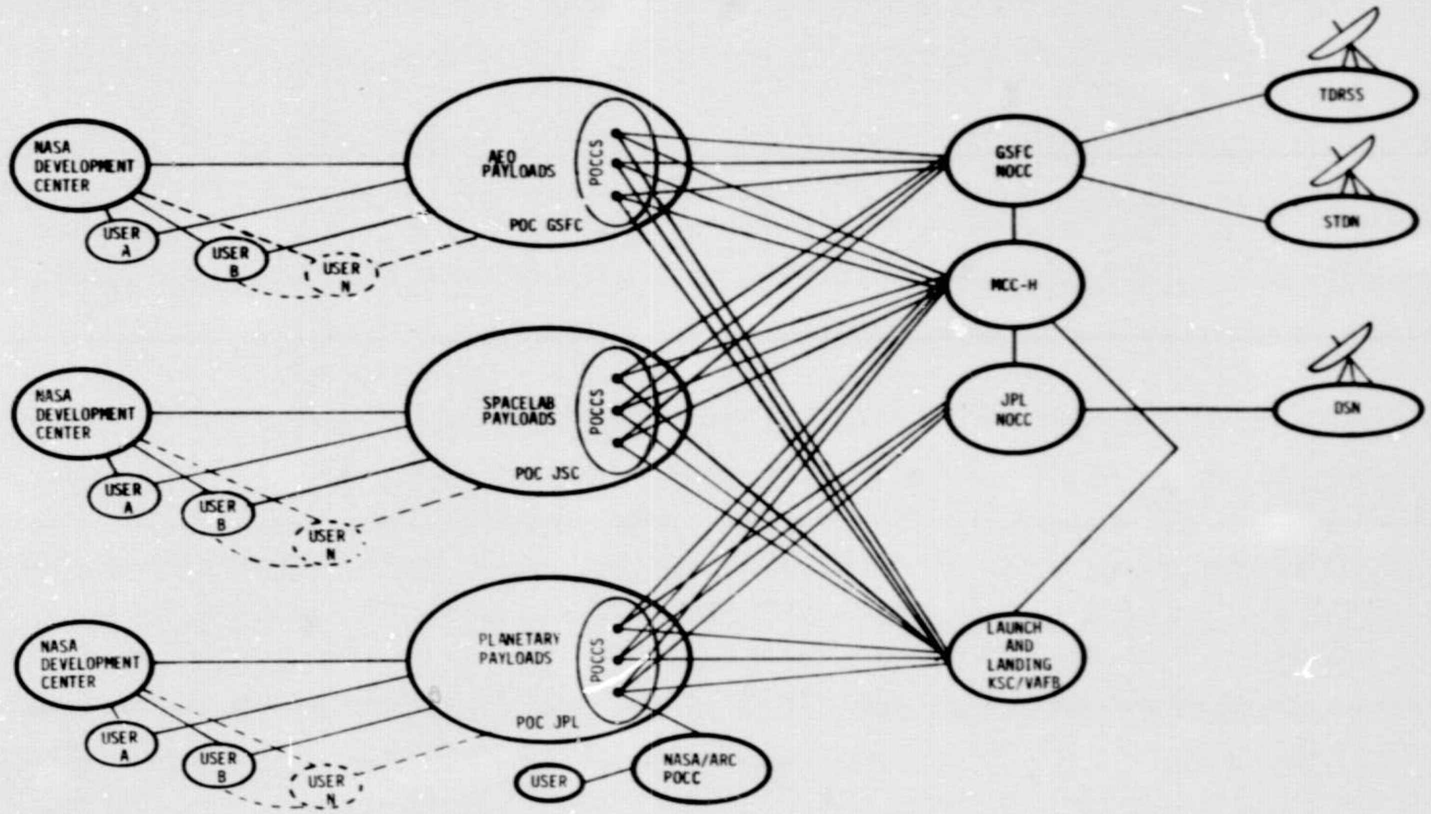
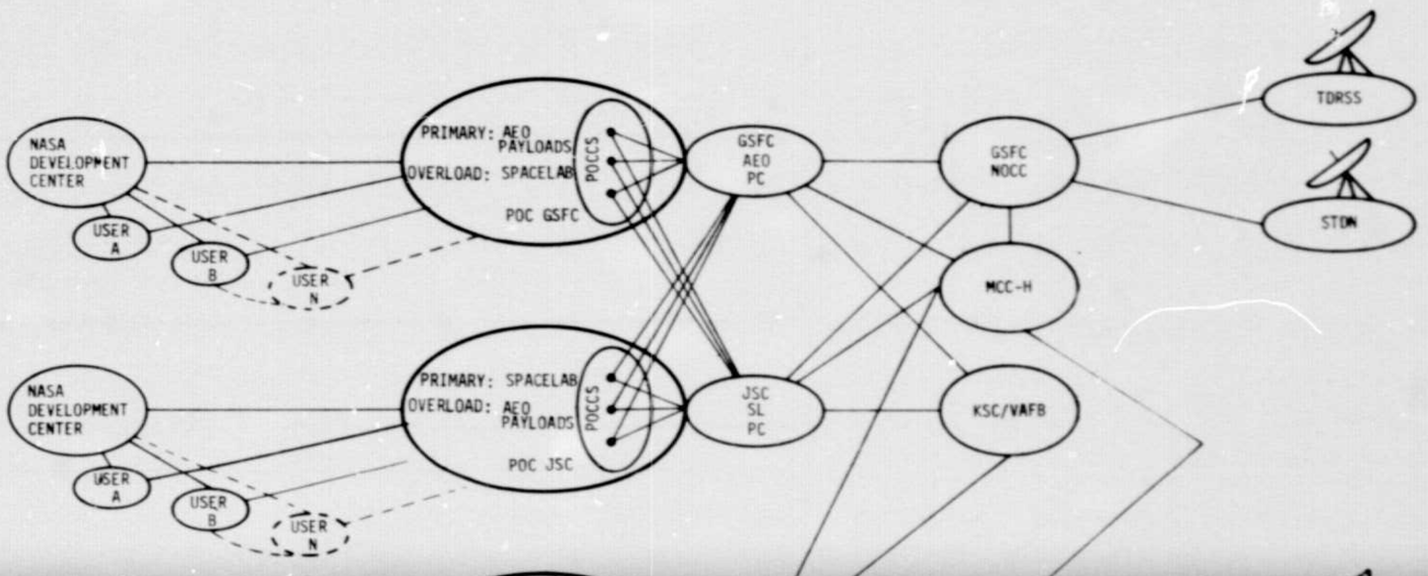


Figure 2-4. Joint STS-Payload Flight Control System Concept Option No. 1



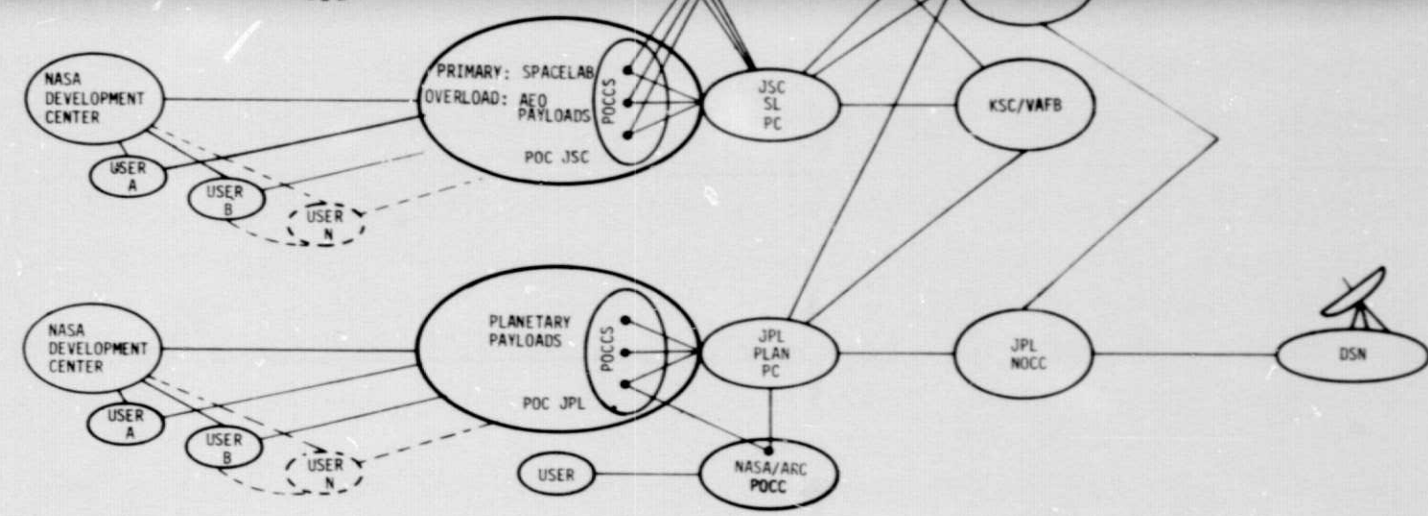


Figure 2-5. Joint STS-Payload Flight Control System Concept Option No. 2

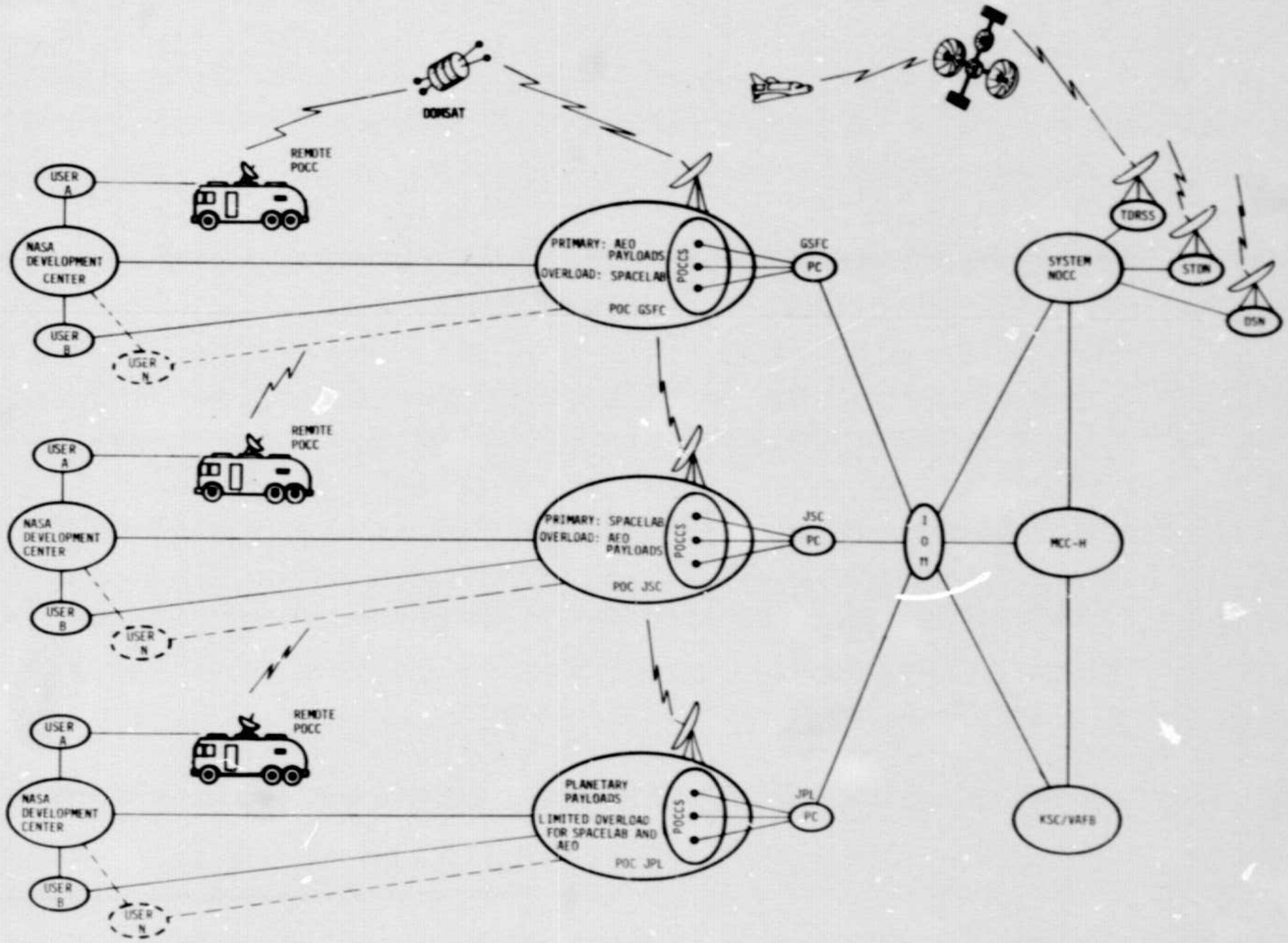


Figure 2-6. Joint STS-Payload Flight Control System Concept Option No. 3

Figure 2-5, Concept Option No. 2, provides these additional features beyond those of Option No. 1.

1.	A Payload Coordinator has been added to coordinate payload operations within each class of payloads. This reduces the number of operational interfaces between the STS Operator and the payload projects when problems arise which affect STS Joint Operations requiring resolution among the payload projects.
2.	A higher level of standardization of operational procedures among the payloads of a given class can be achieved with this concept.
3.	Increased versatility for Spacelab and AEO Payload operation is achieved.

Figure 2-6, Concept Option No. 3, is used during the period of mature STS Operations, when the Payload Traffic Model reaches its maximum level of activity. Additional features include:

1.	Provision for use of efficient remote POCC's.
2.	Operation in conjunction with an integrated network control (Network Operations Control Center (NOCC), combining STDN and DSN.
3.	Addition of an Integrated Operations Manager (IOM), provides a single payload interface for all payloads to MCC-H, System NOCC and the Launch/Landing Sites for resolution of certain payload problems involving more than one Payload Class.
4.	Accommodation of standard operational procedures/conventions in an optimum way.

3.0 STANDARDIZED PAYLOAD OPERATIONS CONTROL CENTER (POCC)

3.1 RELATED PHASE A STANDARD POCC CONCEPT

The Standard POCC concept was conceived during the performance of the Phase A Study. This section summarizes the ideas contributing to the Standard POCC concepts as derived during Phase A which led the way to the sophisticated implementation developed during the Phase A-1 Study.

3.1.1 Typical POC Functional Flow

Figure 3-1 shows the typical functions to be performed by a POC regardless of the class of payload being supported.

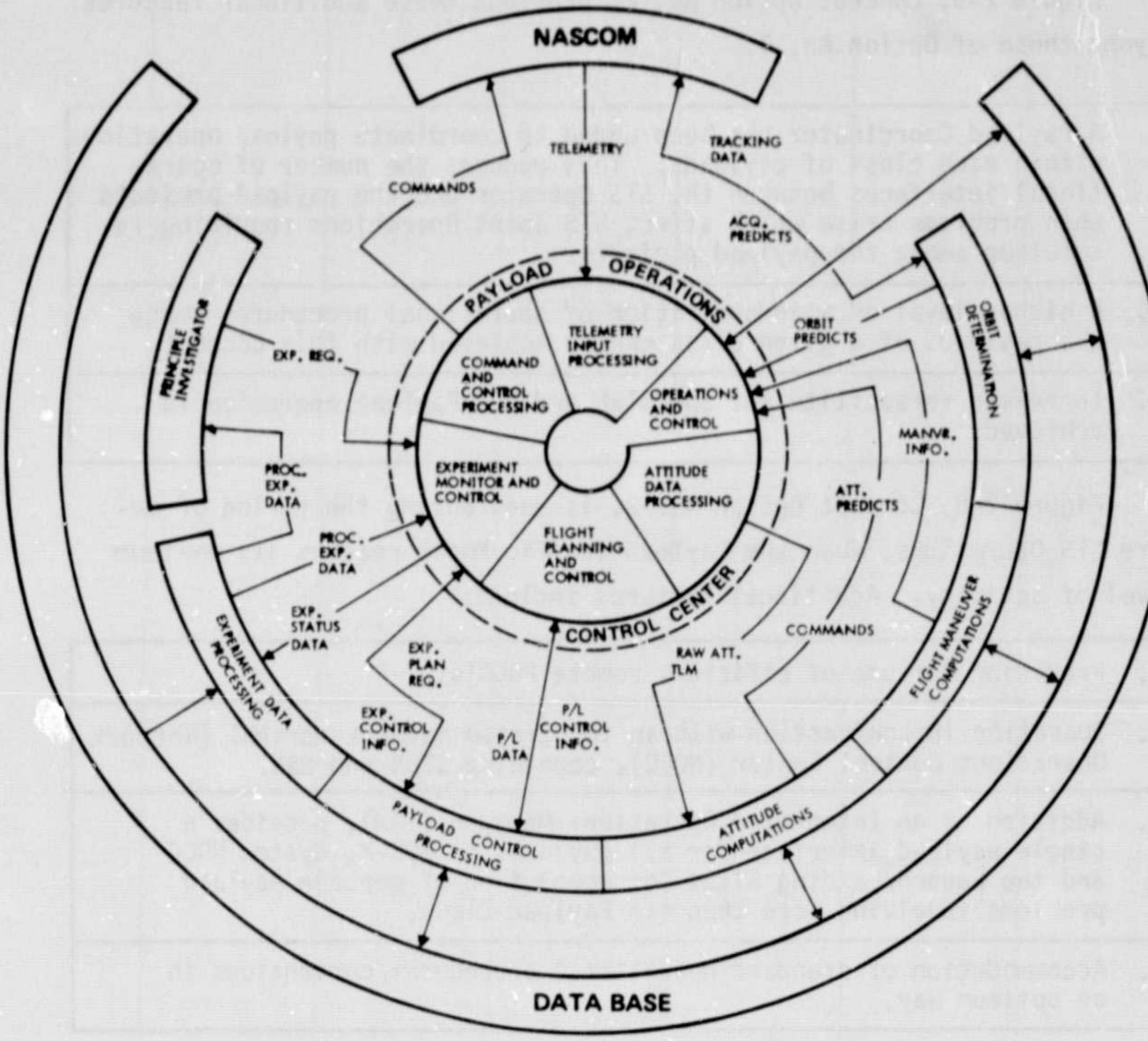


Figure 3-1. Typical POCC Functional Flow

The inner circle depicts the functions performed by a POCC, whereas, the center circle identifies the functions which might normally be supported from the institutional capabilities of the NASA Payloads Operations Center (POC), in support of all POCC's located at the POC. The arrows indicate data flow between the POCC's, the POC and the common data base in support of all functions.

3.1.2 Phase A Summary Conclusions

The primary conclusions reached during the Phase A Study were:

1.	An evolutionary approach to an integrated, standardized multicenter system for STS Payloads was indicated for Joint STS-Payload Operational Flight Phases, which permits pooling of resources, eliminates unnecessary redundancy, and reduces costs.
2.	The ultimate system optimizes standardization of POCC's for all payloads. It allows use of standard software, promotes system versatility, accommodates fast turnaround, and simplifies spares/maintenance.
3.	A decision should be made early in the program to establish standards for STS Payloads which will permit use of processing firmware, minimize unique software, simplify procedures and documentation, and reduce training time.
4.	A key decision should be made as early as possible whether to expand the initial capabilities of GSFC/JSC/JPL Payloads Operations Centers or add Payload Operations Centers to accommodate increasing loads as the flight traffic increases. This decision will affect long-range system architecture and influence User interfaces.
5.	A portable, interactive POCC/DOMSAT Terminal is a practical alternative for specific Users in that it enhances User involvement, improves system utility for Users, and moves data, not people.

3.2 EXPANSION OF POCC AND SYSTEM STANDARDIZATION

An approach to POCC and system design and development is presented in this section using practical standardization of system architecture, software and hardware leading to consideration of "common" and "unique" functions.

3.2.1 Approaches to Standardization

A key concept formulated during the Phase A Study was to implement a cost-effective, NASA-wide POCC System for STS Payloads: this idea triggered the idea of POCC and system standardization. The concept becomes more attractive for operations during the later years of the STS era when payloads are launched more frequently, are of a longer duration, and require a greater extent of processing capability and interface control. POCC and system standardization offer the advantages of a simple, efficient, cost-effective approach for POCC and system development to meet increased loading and releaving overloads.

The primary ways of achieving POCC and system standardization are:

1. Functional standardization where an attempt is made to standardize functions within the POCC and system operational interfaces.

2. Procedural standardization where operational procedures to monitor, command and control the payload and experiments are standardized.

3. Hardware configuration standardization where the processing hardware and peripherals, hardware interfaces and essentially the POCC architecture are standardized.

4. Communication standardization where an attempt is made to standardize all external interfaces to the NASA Centers as much as practially possible, leading to a common communication network, with standards for communications, transfer protocols and data formats.

3.2.2 Functional Standardization

During the analysis of requirements to standardize POCC's/POC Systems, it became apparent that backup capability for each POC will be needed to support another POC whenever a Payload operation overloaded condition arises (for example, more Spacelab flights than JSC can handle within schedule constraints).

Figure 3-2 relates POCC versus Flight Phase Activities so as to include not only the support of primary payload classes assigned, but secondary or backup POCC/system support to another Center.

3.3 POCC INTERFACES

In conjunction with the developing and implementing of Standard POCC/POC system concepts in Phase A-1, POCC interfaces were established which provided an interface philosophy for both prelaunch and operational phases for end-to-end POCC to Payload operation. This was accomplished by:

- Assimilating the Phase A results and also the Mission Control Communications Interface Requirements Study Results, References 3 through 15 and 22 through 27.

- Developing POCC to Payload end-to-end communication diagrams for each typical POCC at GSFC, JPL, JSC and DOD (STC), respectively.

FLIGHT TYPE	SPACELAB					AUTOMATED EARTH ORBIT								AUTOMATED IUS/SSUS/TUG								
FLIGHT PHASE / PRIMARY POCC LOCATIONS	ASCENT	ON-ORBIT ACTIVATION OF CHECKOUT	ON-ORBIT OPERATIONS	PAYLOAD DEACTIVATION	REENTRY	ORBITER ASCENT	ORBITER ON-ORBIT ACTIVATION OF CHECKOUT	PAYLOAD DEPLOYMENT	PAYLOAD OPERATIONS	PAYLOAD RENDEZVOUS & SERVICING	PAYLOAD RETRIEVAL	PAYLOAD DEACTIVATION	ORBITER REENTRY	IUS/SSUS/TUG - PAYLOAD DEPLOYMENT	IUS/SSUS/TUG - ASCENT	IUS/SSUS/TUG ORBIT ACTIVATION & CHECKOUT	PAYLOAD DEPLOYMENT	PAYLOAD INJECTION	PAYLOAD OPERATION	TUG DEORBIT	TUG RETRIEVAL	TUG/SSUS/IUS DEACTIVATION
JSC	P	P	P	P	P	B	B	B	B	B	B	B	B									
GSFC	B	B	B	B	B	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
														(AUTO EO/GEOSYNC ONLY)								
JPL		B	B	B				B	B					P	P	P	P	P	P/B	P	P	P
														(P FOR PLANETARY, B FOR AEO)								
NON-NASA		P	P	P			P	P	P			P					P	P	P			

LEGEND: P = PRIMARY, B = BACKUP POCC FOR OVERLOAD

Figure 3-2. Primary and Backup POC Support versus Flight Phases for NASA and Non-NASA Payloads

- Describing the communications flows in the diagrams for Commands, Payload Health Telemetry, and Payload Science Telemetry during both prelaunch and operational phases.

During the study, 26 interface diagrams were generated using the following interface nodes in the various links connecting the POCC's and the associated Payloads.

Table 3-1. Interface Nodes Between POCC's and Payloads

1. Remote POCC
2. POCC
3. NASCOM (including the switching center)
4. DOMSAT Ground Station
5. DOMSAT
6. MCC-H
7. Satellite Tracking Center (DOD)
8. Satellite Control Facility (DOD)
9. TDRS
10. TDRSS Ground Station
11. GSTDN
12. KSC (including) - Mobile Launch Platform and GSE - Various Launch Support Facilities - Orbiter, Spacelab, IUS, and Payload (at Launch Pad)
13. Orbiter, Spacelab, IUS and Payload (inflight operation)

The following is a recap of the more salient features which were delineated in the interface diagrams:

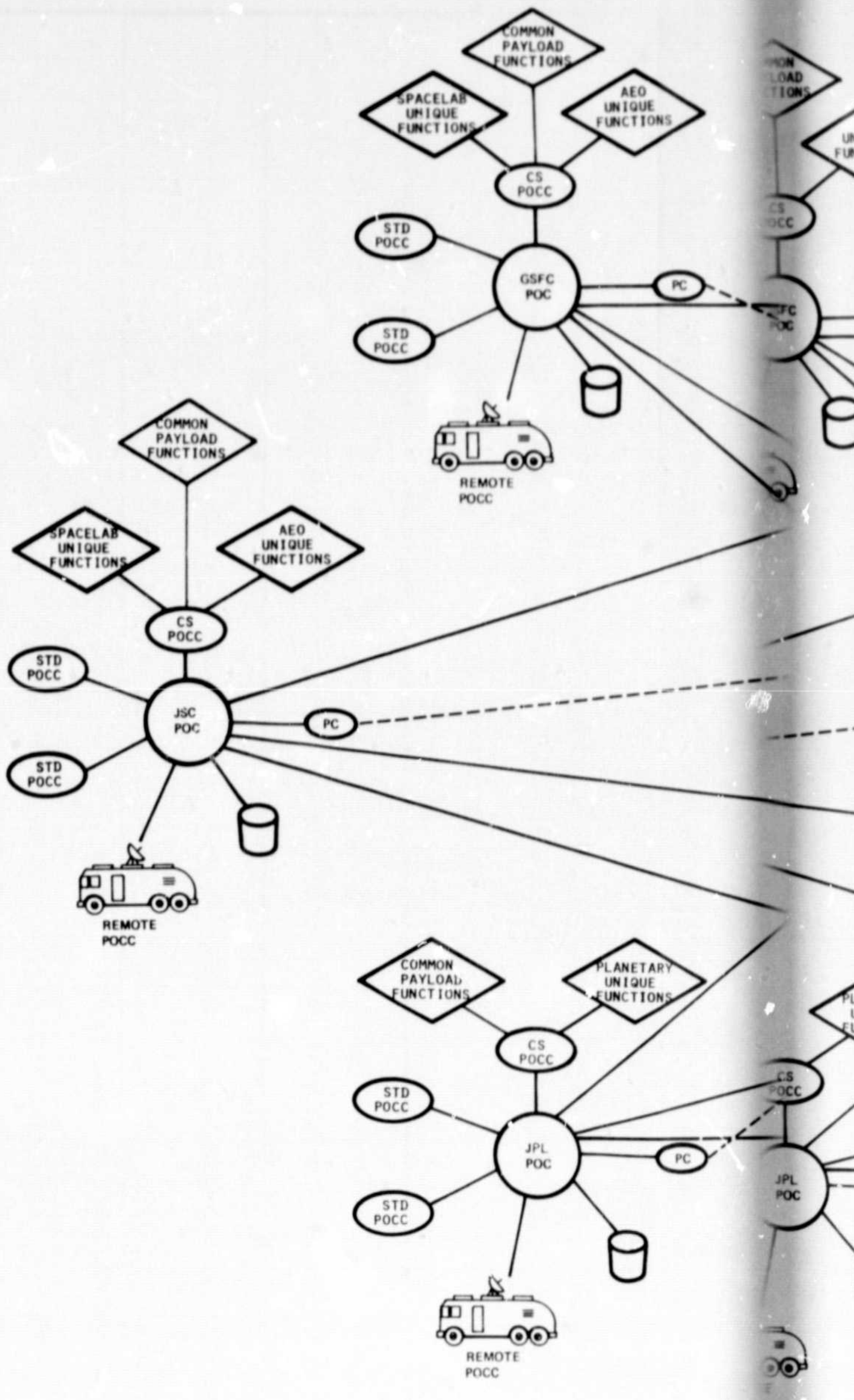
- End-to-End Command Verification Links
  - Standardized command validity logic at MCC-H and KSC (LPS)
  - MCC Processes Command telemetry response
  - Remote POCC command capability.
- Standardization of GSTDN and TDRSS for command data handling transparency.
- MCC-H provides hazardous command protection.
- Remote POCC command capability is accommodated.
- Command verification and logging is provided at both MCC-H and POCC. Master log at MCC-H. Command validation at MCC-H only.
- For launch pad operations, payload and IUS connections via Orbiter and also direct to MILA Ground Station. Primary checkout path is via Mobile Launch Platform GSE.
- Prelaunch End-to-End Payload Health Telemetry Links
  - Via TDRSS and NASCOM Ground Link
  - To POCC via MCC-H
  - Use Remote POCC Link.
- Prelaunch End-to-End Science Telemetry Links
  - Via TDRSS and NASCOM ground links
  - Spacelab, IUS and Free-Flyer Prelaunch checkout links muxed with Orbiter data
  - Planetary payloads link to MILA, MIL-71, GSE and Bldg AO. (at KSC)
- Operational End-to-End Payload Health Telemetry Link
  - Payloads use Orbiter and IUS for communication until free-flight
  - MCC-H demultiplexes and processes payload health telemetry from both Orbiter and IUS
  - Free-flight payload telemetry bypasses MCC-H
  - Use of Remote POCC link.
- Operational End-to-End Science Telemetry Link
  - Payload uses Orbiter and IUS communications until free-flight
  - Anticipated bandwidth requires use of DOMSAT for JSC and GSFC payloads.
- DOD Payloads
  - Use Orbiter and IUS multiplexed links until free-flight
  - Telemetry data handled and processed by NASA the same as NASA data
  - Use unclassified data for NASA integrated operations.

3.4 POCC STANDARDIZATION AND INTERFACE STUDY CONCLUSIONS

The conclusions arrived at as a result of performing the Standard POCC development/implementation and the POCC interface studies are:

- The analysis of Flight Control Functions and Sub-Functions performed from a POCC for each of the representative payloads and the subsequent classification of POCC functions into common and unique categories has permitted definition of a reasonable level of standardization which in turn will increase POCC efficiency.
- The Standard POCC concept should be implemented and ready for support of payloads by the time the payload traffic model reaches 50% of the maximum level, which is mid-1982.
- The implementation of the Standard POCC should evolve through augmentation of existing POCC systems and grow toward standardization as present systems are phased out due to obsolescence.
- Provide end-to-end command verification link from the Orbiter to the POCC. This should permit standardization of data handling throughout the data system.
- Fully utilize the TDRSS and GSTDN during pre-launch checkout to verify end-to-end checkout and to assure end-to-end compatibility.
- Standardize the GSTDN and TDRSS for command data handling transparency. This standardization should serve to eliminate the costly changes which must be implemented at the several link junctions for each new payload or payload change.
- Provide for the demultiplexing of the composite IUS/payload data stream at MCC-H. This will minimize the number of Orbiter interfaces and will serve to standardize the Orbiter interfaces to the payload and to MCC.

As a result of the Standard POCC Study, Figure 3-3 provides a conclusion for a conceptual baseline NASA Network of Standard POCC's. The Prime Centers and their Standard POCC's including common functions with other POCC's and specific unique functions for payload types are shown. The main external interfaces consisting of STDN, TDRSS, and DSN, are depicted under a Common Network Operational Control Center (NOCC) whose function is to perform all support functions of tracking and data acquisition by a single responsible authority. The MCC-H works directly with the IOM, the NOCC, and the KSC/VAFB. Standard remote portable POCC's operate with each host POC via DOMSAT links. All POCC's of a Center can communicate directly with each other through resources of the POC. POCC's of different centers communicate through NASCOM facilities.



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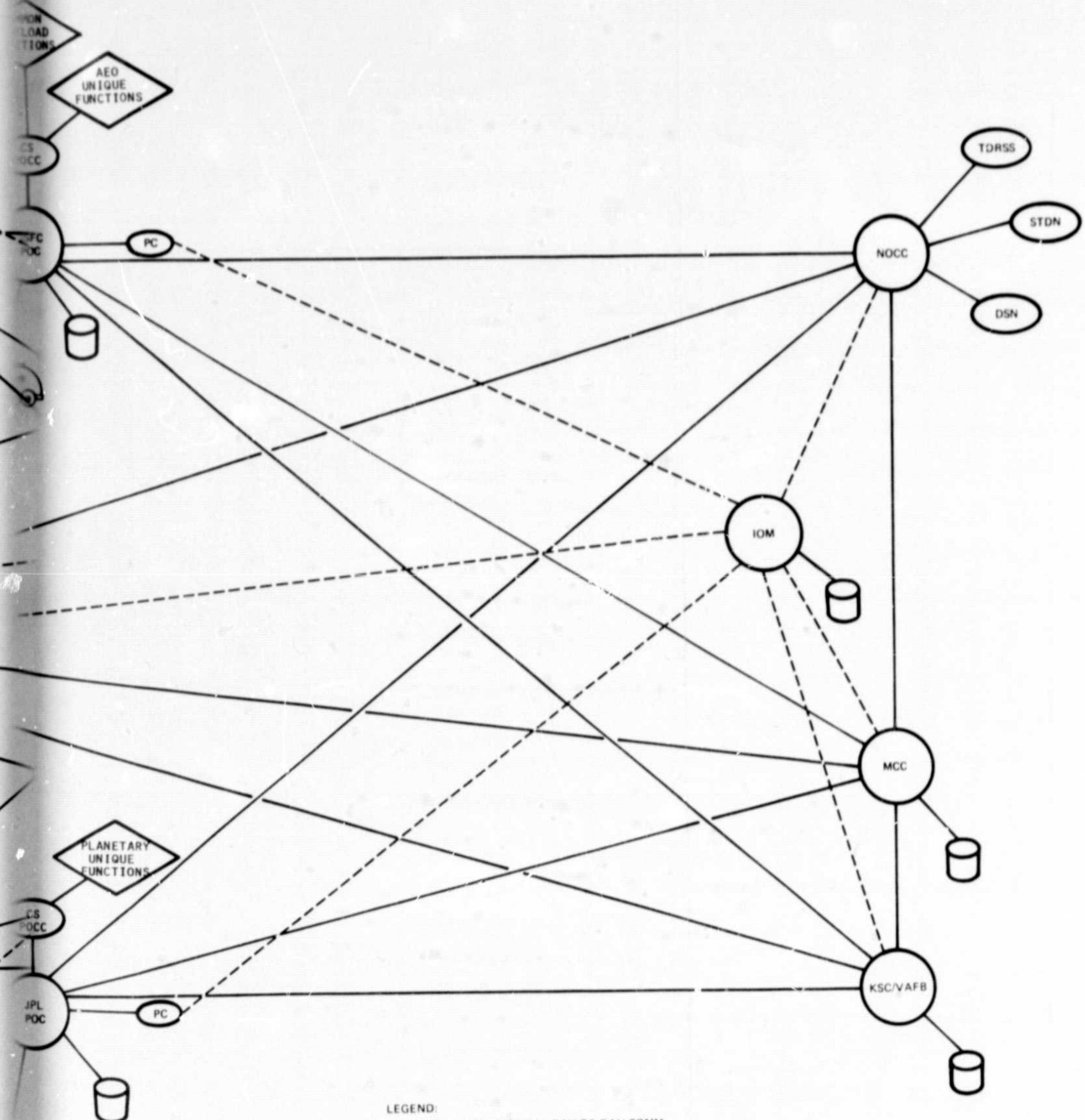

LEGEND:

SOLID LINES = NORMAL DAY TO DAY COMM CHANNELS

DASHED LINES = OPS COORDINATION BETWEEN POC'S

CS POCC = COMMON STANDARD POCC

FOLDOUT FRAME 2

Figure 3-3. NASA Network of Standardized POCC's

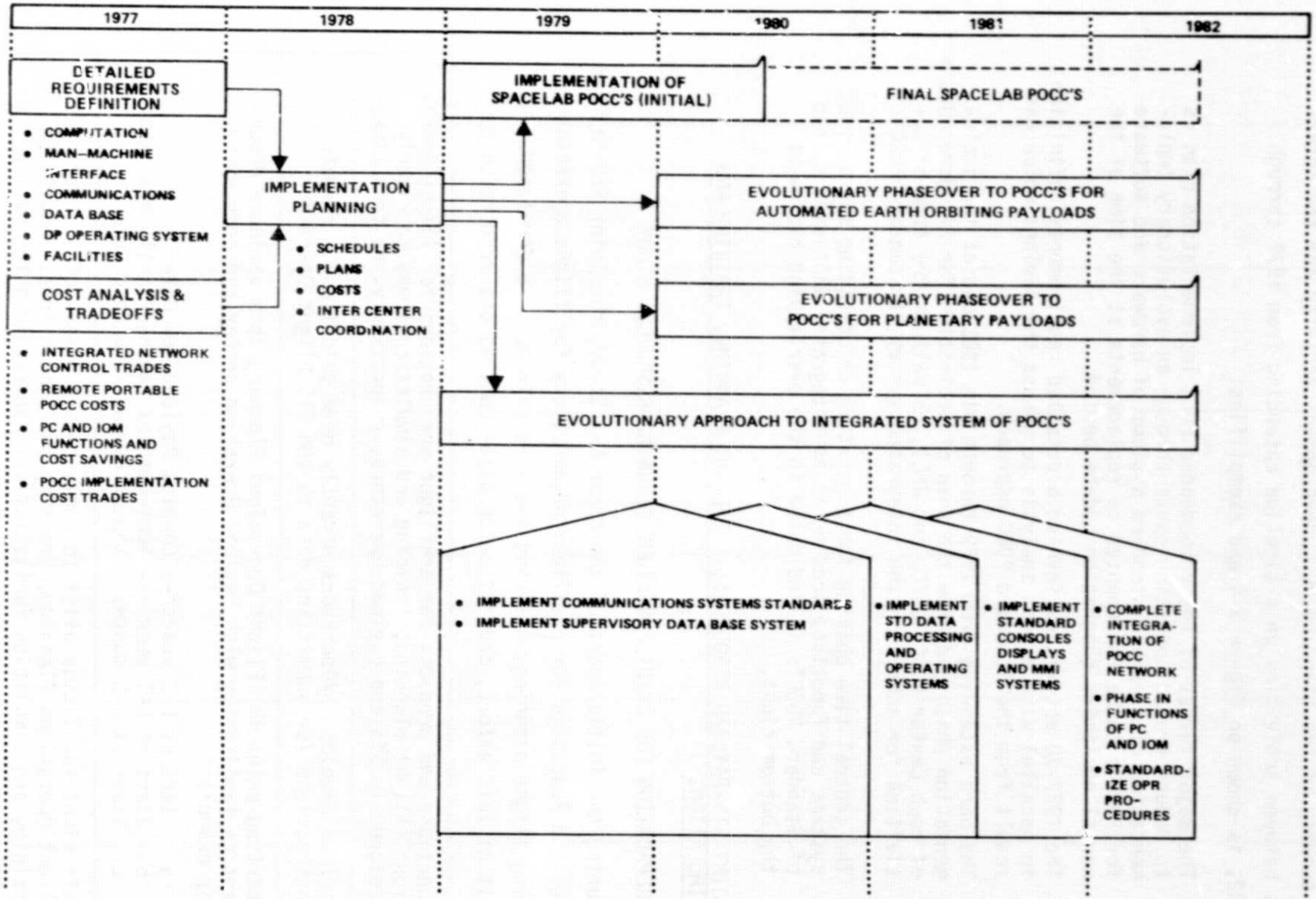

Figure 3-4. POCC System Development Activity Network

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A summary of the Standard POCC development activity and the interactions between activities on a timeline extending from 1977 through Mid-1982, is shown on Figure 3-4 and exemplifies:

- The major thrust of the recommended POCC implementation plan is to reduce ground operating costs through an evolutionary implementation of flexible standard systems of hardware and software for POCC's to be implemented as replacements at the time of the normal equipment generation update period.
- The 1977-78 activities involve a detailed requirements definition in parallel with a cost analysis to assess the savings which can result from the Standard POCC approach.
- The bars extending from 1979 through Mid-1982 depict the implementation phase and show the span of activities for Standard POCC's of each Center (JSC, GSFC, and JPL), as well as the span of activities for achieving the integrated system of Standard POCC's.
- The general time phasing for augmenting or upgrading the various systems and functions leading to an integrated NASA-wide system of Standard POCC's is indicated in the overlapping blocks at the bottom right.

4.0 JOINT STS-PAYLOAD RESOURCES, PREFLIGHT PLANNING, TRAINING AND SIMULATIONS

4.1 PREPARATION FOR JOINT PREFLIGHT PLANNING RESOURCES STUDY

During the initial part of the Phase A-1 Study, the joint STS-Payload products and functions for preflight preparations for flight operations including flight planning, training and simulations, were developed. As a result of this effort, the following major conclusions were reached:

1. Functions and products for preflight preparations for flight operations (flight planning, training and simulations) may be clearly assigned to STS and Payload Operators, respectively, at this time.
2. Payload Developers/Operators urgently need guidelines - formats - instructions for submitting data to the STS Flight Operator.
3. Starting point for Flight Operations Planning is a variable dependent on familiarity with Payload Operation or Payload complexity, for example: a. Start at L-2 years*-- Complex Payload/New Data b. Start at L-1 year --- Semi-Complex Payload/Partly New Data c. Start at L-6 months - Repeat Payload/Standard Data.
4. Sufficient facilities exist to commence all phases of STS-Payload Flight Operations Planning, Training and Simulations. Additional Training and Simulation Facilities will be required for some payloads.

*L-2 = Launch Minus Two Years.

4.2 APPROACH TO ESTABLISHING THE JOINT PREFLIGHT PLANNING RESOURCES

The objectives of this Resources Planning Study were to identify joint STS-Payload preflight activities, develop the methodology and estimate composite joint resources required to accomplish preflight activities in preparation for STS Payload Flight Operations, Training and Simulations based on given flight traffic and payload assignment models.

Figure 4-1 is an activity flow which defines the technical approach to the Joint Preflight Planning Resources Study.

For complex detailed descriptions of the tasks delineated in Figure 4-1, refer to Section 3.3 in the Final Report for Task 3, Phase A-1.

Figure 4-2 shows pictorially the steps involved in the final estimation of composite resources. These tasks consisted of:

- A Resources Estimating Structure.
- Composite Task and Subtask Estimates and Experience Factors for Each Activity and Payload Category.
- Summations of Composite Resources.

A resources estimating structure was developed as shown in Figure 4-3, to facilitate computing the composite resources by month and year. This diagram assigns unique code numbers to each payload category activity, and organizes these elements into a hierarchy for use in computing the composite resources. In addition to the structure shown in this figure, additional structures were used to assign a specific flight number to each of the activities under each flight type.

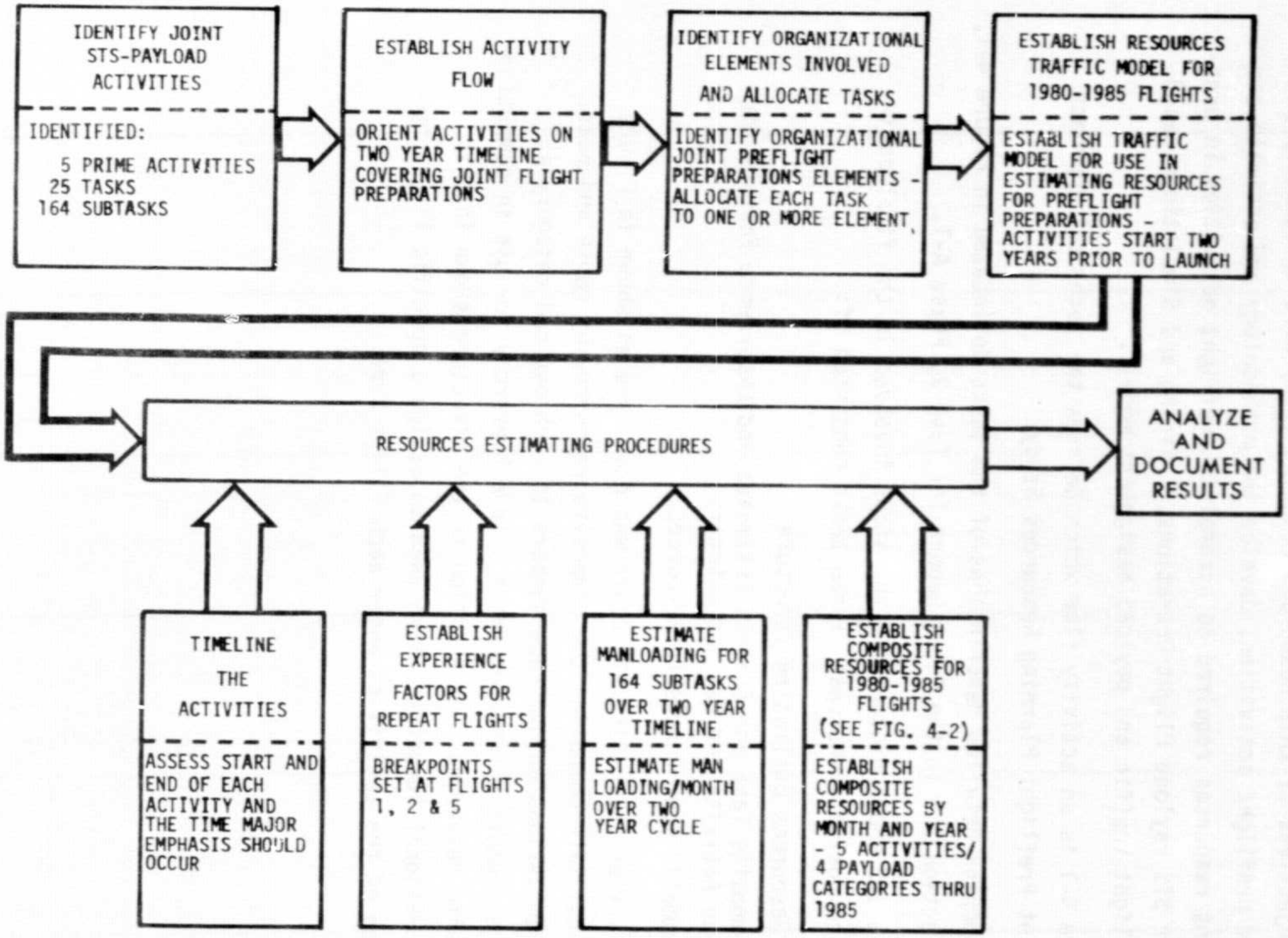

Figure 4-1. Activity Flow for Establishing Joint Preflight Planning Resources

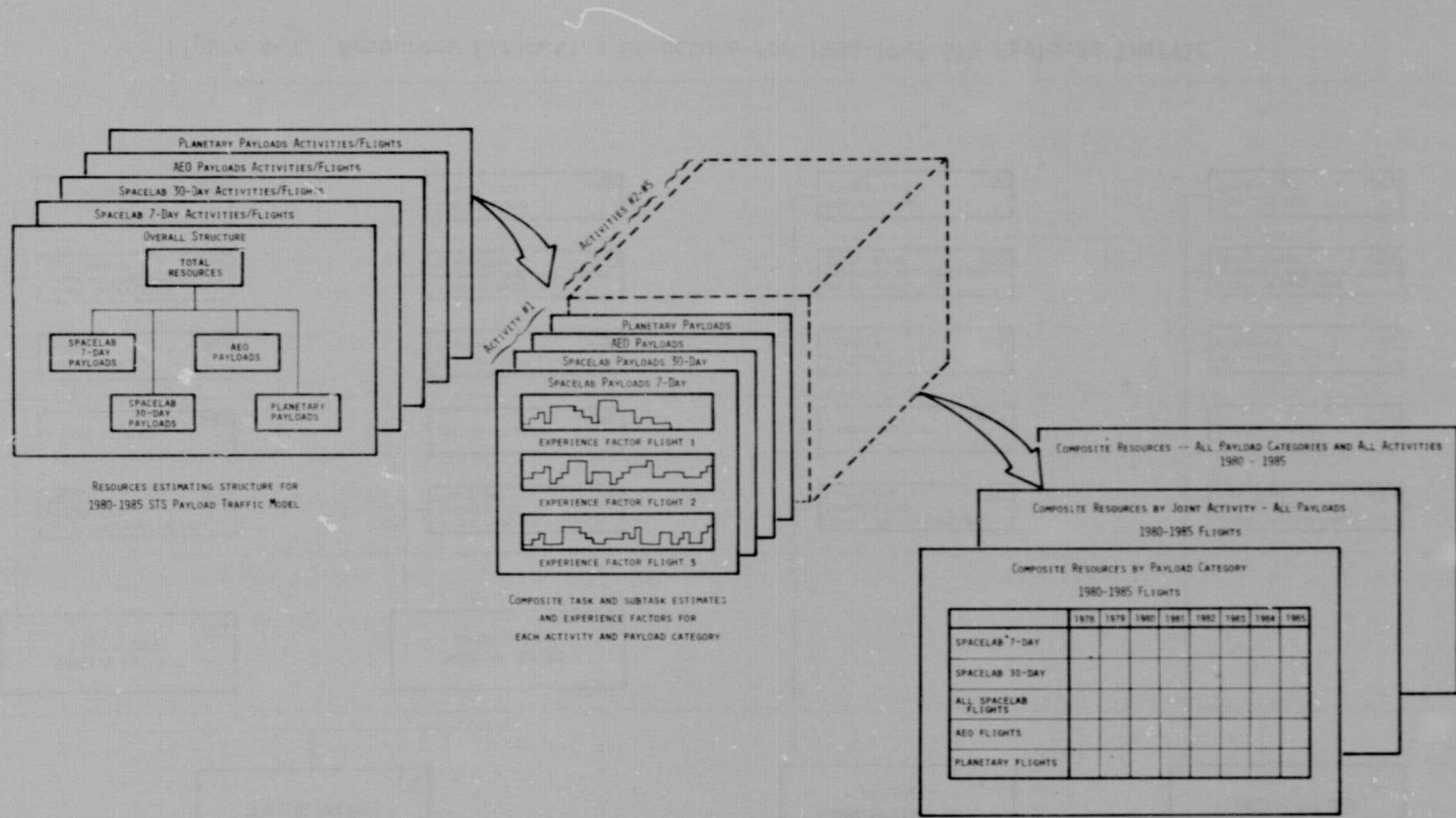

Figure 4-2. Approach to Summarizing Composite Resources Estimates

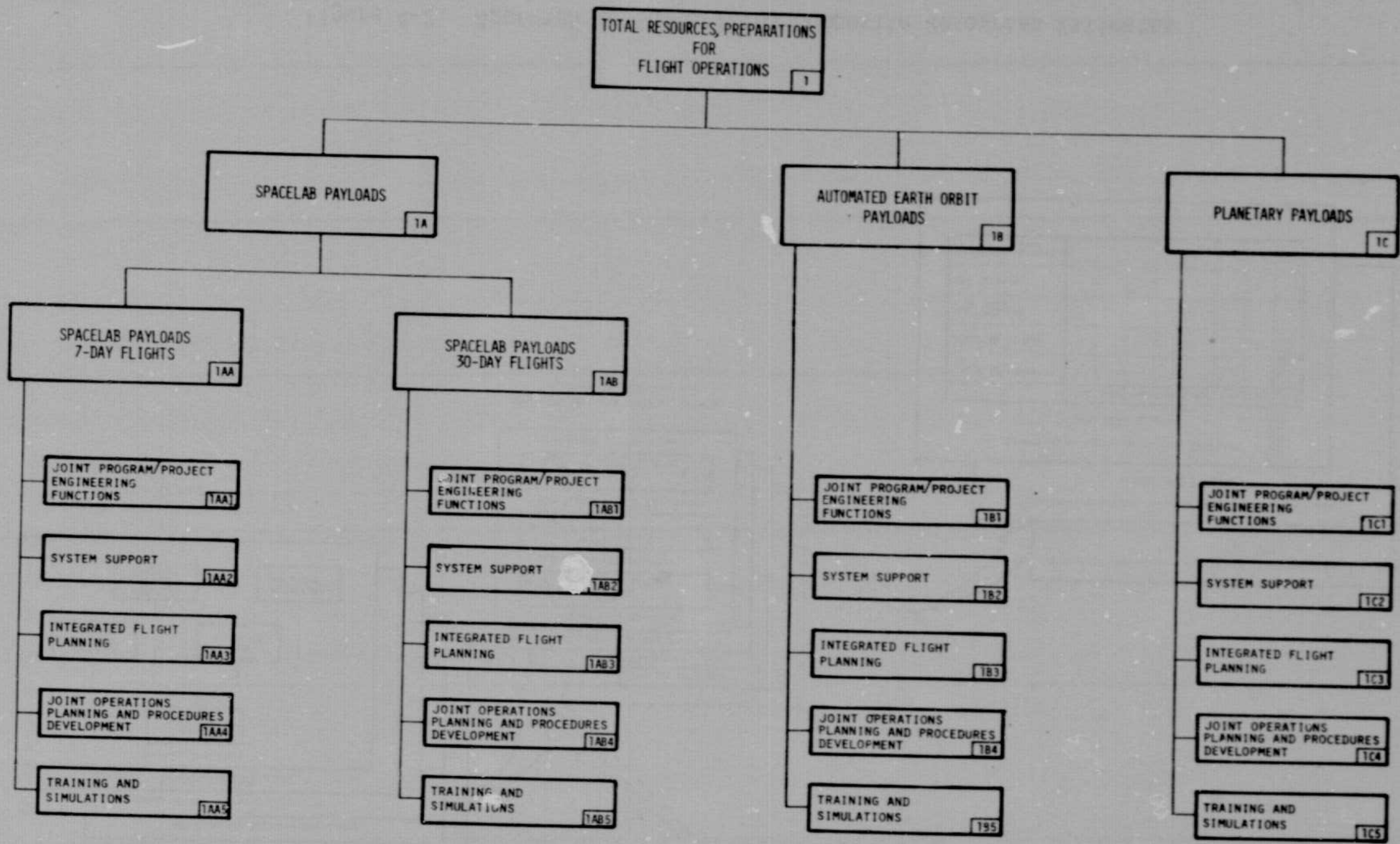

Figure 4-3. Resources Estimating Structure for 1980-1985 STS Payloads Traffic

4.3 CONCLUSIONS OF THE JOINT PREFLIGHT PLANNING RESOURCES STUDY

The following summarizes the conclusions reached during the performance of this study with respect to an analysis of the study results and the summary charts shown on Figures 4-4 through 4-6.

- There are five principal activity areas that involve Joint STS and Payload participation to prepare for STS-Payload Joint Flight Operations phases - JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS, SYSTEM SUPPORT, INTEGRATED FLIGHT PLANNING, JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT, and TRAINING AND SIMULATIONS.
- Major breakpoints were identified for applying experience factors to the five principal activities; these were judged to be at Flights 1, 2 and 5 in this study.
- In allocating prime responsibility for the 25 Joint Flight Preparation Tasks to organizations and functional groups, the assignment of all but one task appeared logically to belong to either the STS Payload Integration and Development Program Office (SPIDPO), (five tasks) or the MCC-H (19 tasks). The other task, Flight Requirements Development, was assigned to a Payload Project Office.
- Figure 4-4, Summary of Resources Requirements, Flights 1, 2 and 5, allows a direct numerical comparison of the difference in resources required for Flights 1, 2 and 5, for each joint activity and each flight type. The last column on this figure provides the average manpower for each activity and each experience factor among all the flight types.
- Figure 4-5, Composite Resources by Joint Activity, All Payloads, 1980-1983 Flights, shows the relative manpower for each activity by month and year as well as the direct comparison between support requirements for each activity. Note that personnel resources for training and simulation are not required until ten months later than activation of the activities for Joint Program/Project Engineering Functions.
- Figure 4-6, Total Resources, All Flight Types, All Activities, shows a fairly linear build-up in the total manpower resources required for all preflight planning, training and simluations activities after 1978. The dashed portion of the curve represents an extrapolation of the solid curve information based on an average growth of the Traffic Model.

  From 1979 through 1983:

  a. Total manpower required = 17,809 manmonths.
  b. Average number of personnel is approximately 300 per year.
  c. Average personnel rate of increase per year is approximately 110 per year.

ACTIVITY	STS PAYLOAD CATEGORY												AVERAGE FOR ALL PAYLOAD CATEGORIES TOTAL MAN-MONTHS		
	SPACELAB 7-DAY FLIGHTS TOTAL MAN-MONTHS			SPACELAB 30-DAY FLIGHTS TOTAL MAN-MONTHS			AEO FLIGHTS TOTAL MAN-MONTHS			PLANETARY FLIGHTS TOTAL MAN-MONTHS					
	EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR			EXPERIENCE FACTOR		
	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5	FLIGHT 1	FLIGHT 2	FLIGHT 5
1. JOINT PROGRAM/PROJECT ENGINEERING FUNCTIONS	1AA101 102	1AA102 78	1AA105 55	1AB101 123	1AB102 100	1AB105 65	1B101 99	1B102 80	1B105 57	1C101 90	1C102 71	1C105 51	104	82	57
2. SYSTEM SUPPORT	1AA201 121	1AA202 106	1AA205 81	1AB201 138	1AB202 115	1AB205 92	1B201 123	1B202 105	1B205 84	1C201 115	1C202 97	1C205 81	124	106	85
3. INTEGRATED FLIGHT PLANNING	1AA301 93	1AA302 82	1AA305 62	1AB301 120	1AB302 100	1AB305 81	1B301 65	1B302 55	1B305 38	1C301 71	1C302 58	1C305 42	87	74	56
4. JOINT OPERATIONS PLANNING AND PROCEDURES DEVELOPMENT	1AA401 65	1AA402 51	1AA405 36	1AB401 74	1AB402 62	1AB405 45	1B401 55	1B402 40	1B405 29	1C401 57	1C402 42	1C405 30	63	49	25
5. TRAINING AND SIMULATIONS	1AA501 50	1AA502 39	1AA505 28	1AB501 58	1AB502 47	1AB505 36	1B501 23	1B502 18	1B505 15	1C501 23	1C502 18	1C505 15	39	31	24
SUM, ALL ACTIVITIES PER FLIGHT	431	356	262	513	424	319	365	298	223	356	286	219	417	342	257

Figure 4-4. Summary of Resource Requirements, Flights 1, 2 and 5

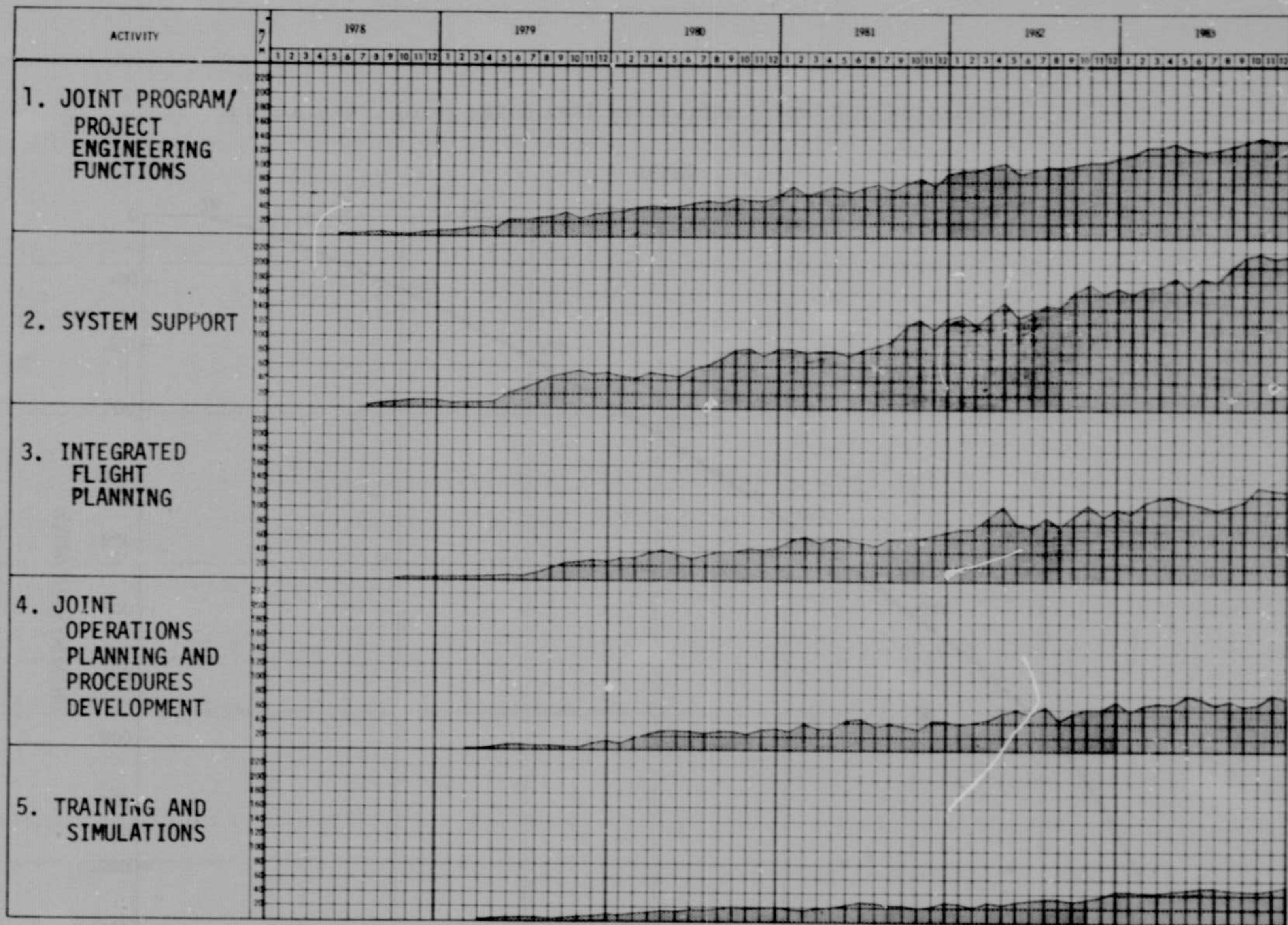

Figure 4-5. Composite Resources by Joint Activities

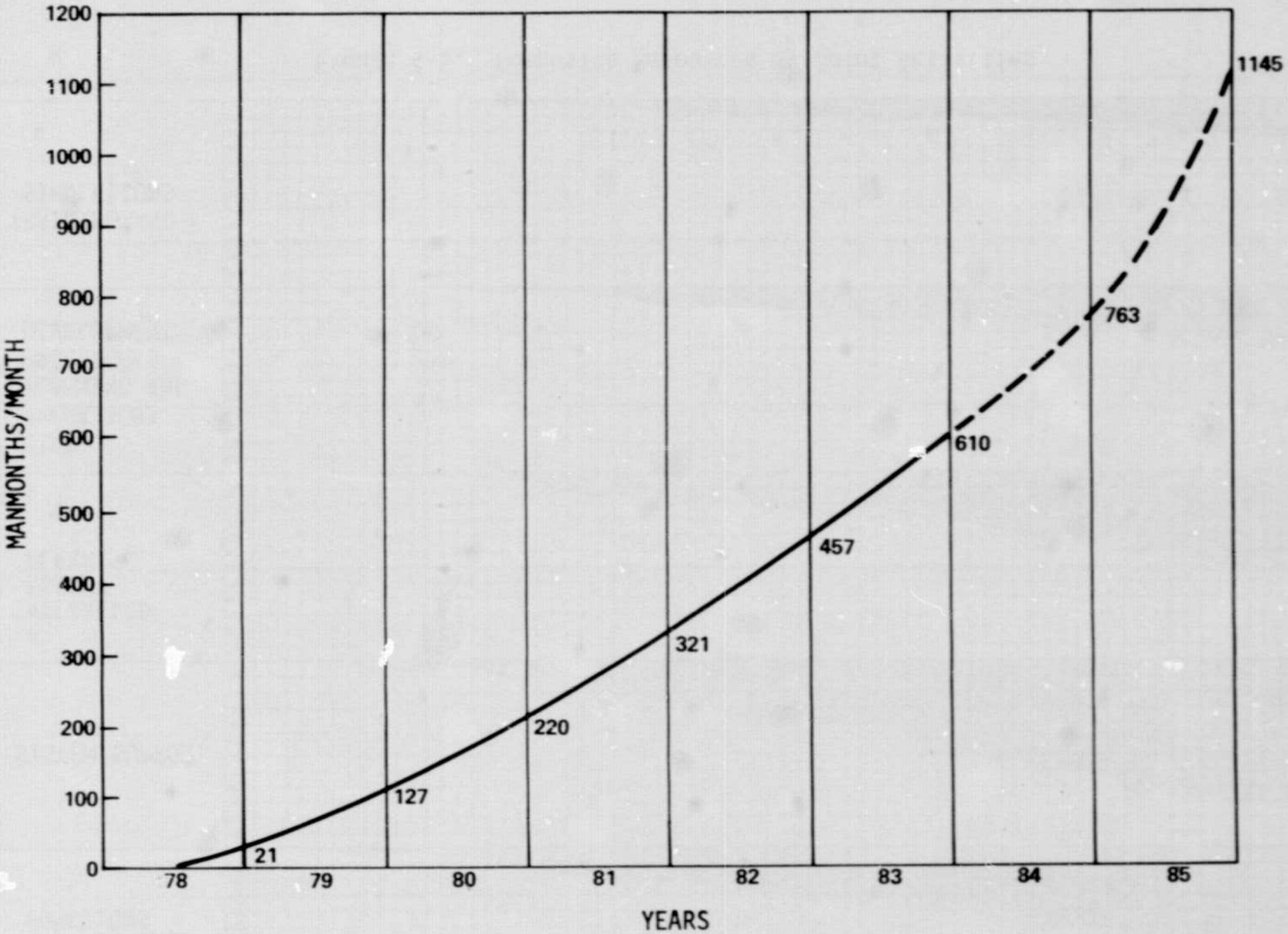

Figure 4-6. Total Resources, All Flight Types, All Activities

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4. TRW 26904-H003-RO-00, Volume II-B - Study Task b - 2.0 Types and Locations of Parties Involved
5. TRW 26904-H004-RO-00, Volume II-C - Study Task c - 3.0 Investigation of Present/Planned NASA-Wide Facilities Available
6. TRW 26904-H005-RO-00, Volume II-C - Study Task c - Appendix A - NASA/ARC Capabilities
7. TRW 26904-H006-RO-00, Volume II-C - Study Task c - Appendix B - NASA/GSFC Capabilities
8. TRW 26904-H007-RO-00, Volume II-C - Study Task c - Appendix C - NASA/JPL Capabilities
9. TRW 26904-H008-RO-00, Volume II-C - Study Task c - Appendix D - NASA/JSC Capabilities
10. TRW 26904-H009-RO-00, Volume II-C - Study Task c - Appendix E - NASA/KSC Capabilities
11. TRW 26904-H010-RO-00, Volume II-C - Study Task c - Appendix F - NASA/LaRC Capabilities
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