BSATTS #8

SSP

INFORMATION SYSTEMS

CONCEPT DOCUMENT

JULY 7, 1988

DRAFT

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1.0 INTRODUCTION

1.1 IDENTIFICATION OF THIS DOCUMENT

This document is the top level of a hierarchy of concept documents produced under the direction of the Space Station Information Systems Services Program Group (ISSPG). The document set is intended to describe the basic concepts and philosophy of the information systems currently under development within the Space Station Program (SSP). A preliminary view of the total hierarchy is shown below.

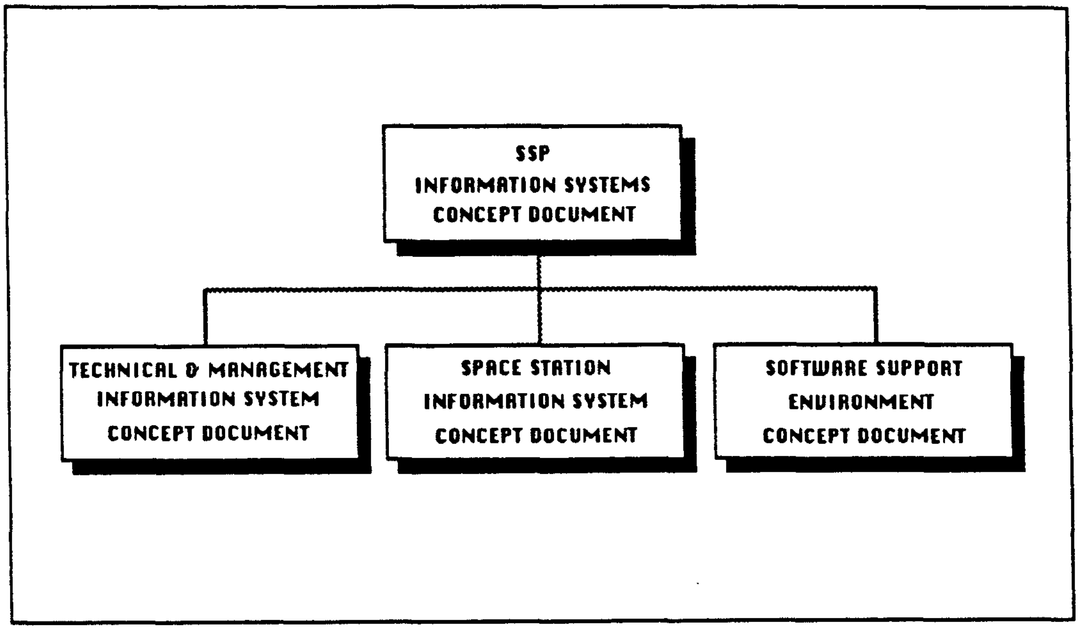

Figure 1.1-1 Documentation Tree - Concept Document Branch

1.2 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide an introduction to the total Information System of the Space Station Program, and to provide a structural description of the system and the relationship between its major components, which are themselves information systems. As the highest member of the concept document hierarchy, this document also provides the context for the lower level, more detailed documents.

1.3 SCOPE OF THIS DOCUMENT

The scope of this document is confined to a conceptual description of the major information systems of the Space Station Program. Since this encompasses a great deal of territory in a limited number of pages, the material is necessarily presented at a relatively high level. Increasing levels of technical detail can be found in the lower levels of the ISSPG concept document hierarchy, and in the existing SSP requirements documents.

1.4 DOCUMENT ORGANIZATION

This document is divided into seven sections. Sections 1 and 2 describe this document and its relationship with other relevant documents.

Section 3 introduces the goals of the Information Systems for Space Station.

Section 4 characterizes various users of the system and discusses their information system needs over the SSP life cycle.

Section 5 contains the kernel of the Information System concept. It describes the major components (the Space Station Information System (SSIS), the Software Support Environment (SSE), and the Technical and Management Information System (TMIS)), and discusses their goals and implementation strategy.

Section 6 illustrates and amplifies the concepts of Section 5 by means of scenarios. In developing these scenarios, emphasis has been placed on showing how the Information System satisfies the needs of representative users over various timeframes of the Space Station Program (some related to the SSP milestones, others of local significance to the user).

Section 7 contains a high-level summary of the document.

Appendices A and B contain a glossary, and a list of acronyms and abbreviations, respectively.

1.5 DOCUMENT STATUS AND SCHEDULE

This document reflects the Information Systems of the program as defined through 5 July 1988. It is planned that this document will be placed under configuration control by the Space Station Program Office.

2.0 DOCUMENTS

2.1 PARENT DOCUMENTS

This is the parent concept document for the major information systems of the Space Station Program.

2.2 APPLICABLE DOCUMENTS

Space Station Program Requirements Document, February 1988.

Space Station Program Definition and Requirements Document, SSP 30000, (various dates) as baselined following PRR, June 1988.

Space Station Program Information Systems Policy Document (Draft), January 15, 1988

SSE System Concept Document, LMSC F255415, Version 1.0, January 15, 1988

TMIS Concept Document, (Draft), date TBD

SSIS Concept Document, (Draft), May 27, 1988

2.3 REFERENCED DOCUMENTS

1 Space Station Information System Architecture Requirements Document, PDRD Section 7, Part 1, April 26, 1988.

3.0 INFORMATION SYSTEM GOALS

The Space Station Program affords NASA a major opportunity for the advancement of space exploration. It also presents a number of unprecedented technical and management challenges. Nowhere are these more apparent than in the field of information systems technology. In this area there are three major challenges in which information systems are, simultaneously, both the problem and the potential solution.

The first is the challenge of **information system transparency**. In comparison with past missions, the information systems of the Space Station era must provide a consistent, homogeneous environment on board and on the ground that is transparent to the user. Information systems that are part of the Space Station Program will provide a greater level of functionality to the users than has been available with past missions, and at the same time will provide this functionality with a greatly expanded base of largely heterogeneous systems. This information system is viewed as a homogeneous environment composed of the major areas of support services required by all software applications and users. The major areas of services are the underlying operating system, the network communications and management functions, database services, user interface services, expert systems, and other areas of artificial intelligence. With the Space Station, we enter a unique period where the operational lifetime of the Station will span more than one generation of information systems; therefore, they must be designed so that the upgrade to the next generation can be made with minimal impact on station operations.

The second challenge is that of **software development**. The Space Station Program requires a software development effort on a scale never before attempted by NASA. It has long been recognized that software development has been a major cost and risk item on most projects, with the cost of sustaining engineering becoming increasingly important as the lifetime of the project is extended. The complexity and duration of the Space Station Program, and the fact that the software will be developed by a widely distributed group composed mainly of contractor personnel, mandate a critical re-examination of past methods. How should NASA most efficiently and effectively develop systems of this size and complexity? Which methodologies are available to ensure their performance and reliability? And, most important of all, how can they be maintained, at reasonable cost, over a multi-year, multi-mission program?

The third challenge is that of **program management** - the challenge of controlling a project of this size and complexity, and of providing the hardware and software developers with a timely, consistent view of program information. How can the information needed to control and continually assess the progress of the development process be collected and processed? And how can a management "window" into the development process be created, so that the efforts of the distributed NASA centers and International Partners involved in SSP development can be coordinated and integrated to fulfill program objectives?

These three challenges are summarized and illustrated in figure 3.0-1 - information management, program management, and software development.

It is clear that to allow NASA and its contractors to meet these challenges will require the help of automated tools and systems. The challenges can then be viewed from a different perspective - as the underlying goals of the program's information systems:

in the **information management** area: to provide for automated information management across the SSP over the full SSP life-cycle;

in the **program management** area: to provide automated tools to facilitate the management of the program development process;

in the **software development** area: to provide automated tools to minimize the cost and risk of program software development.

Clearly, a single phrase is inadequate to express the depth and breadth of the required capabilities. Figure 3.0-2 adds a number of sub-goals to each of these , and also provides some general goals equally applicable to all three areas of activity. While the resulting list is far from exhaustive, it will serve as basis for high-level discussion throughout the remainder of this document.

Later sections will show how the information systems currently under development will combine into a total information system to meet these goals.

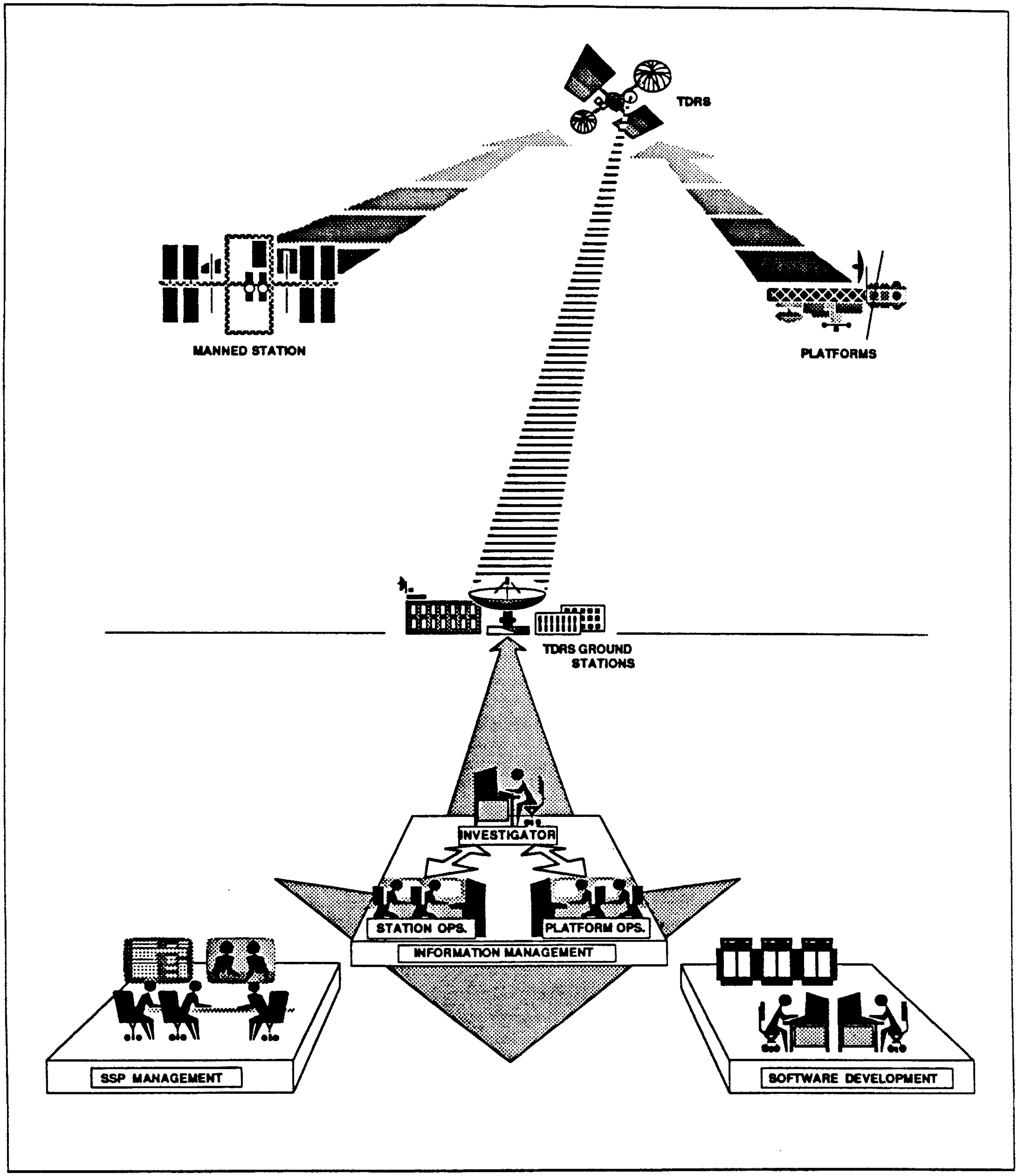

Figure 3.0-1 Information System Challenges

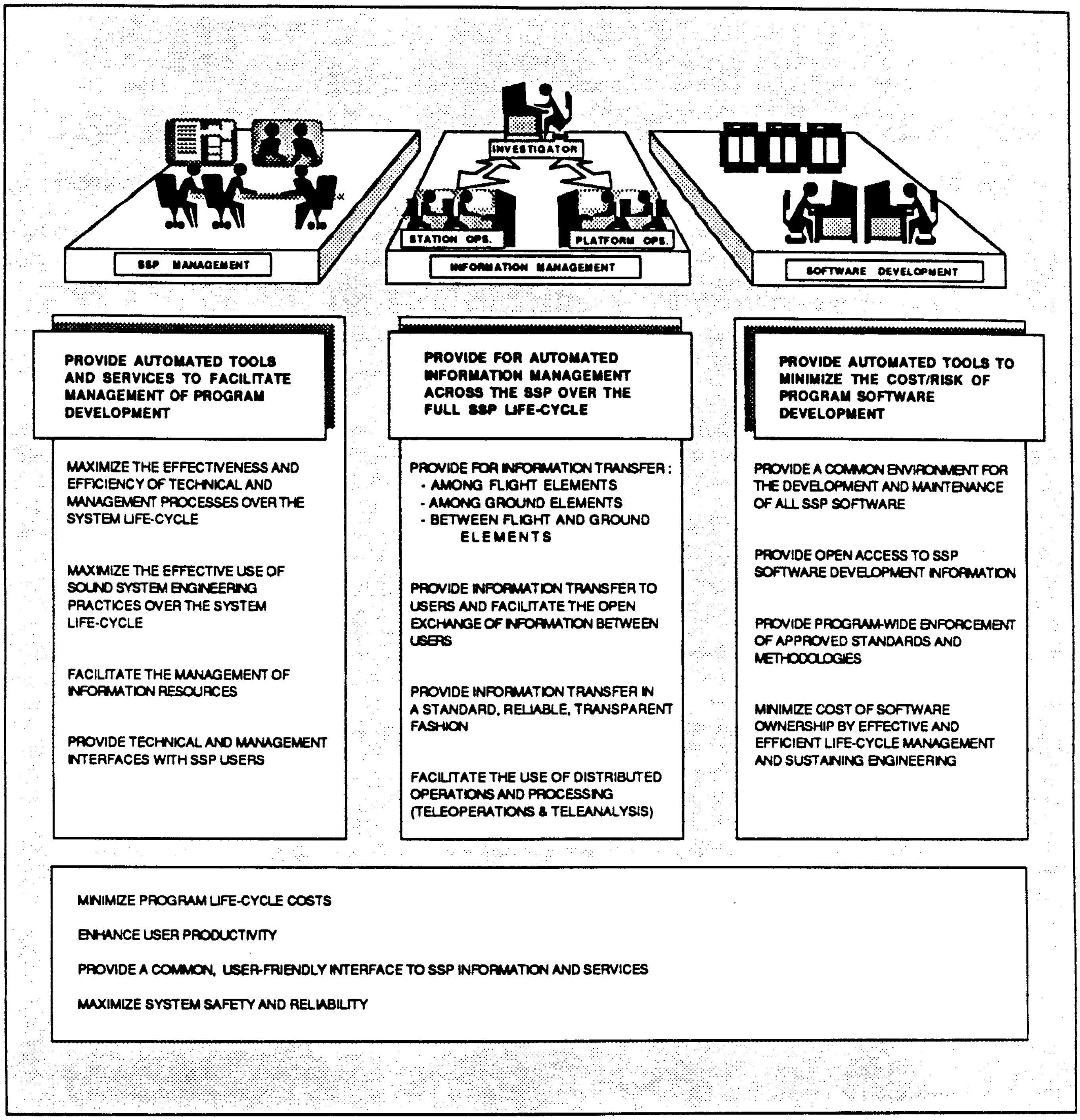

Figure 3.0-2 Information System Goals

4.0 USERS OF THE INFORMATION SYSTEM

In discussing any information system it is important to characterize the eventual users of the system and to understand their needs. The information systems for Space Station will have two distinct classes of user: programmatic users - those concerned with implementing, managing and operating the Space Station, and payload users - mainly concerned with using information system services to develop and operate their instruments. While these two user classes have many information system needs in common, there are also differences in timescale, scope and service needs which make it instructive to consider them separately.

4.1 PROGRAMMATIC USERS

One distinguishing feature of the programmatic users as a class is that their information system (IS) needs are closely tied to the SSP development timescale. At some point in the future (mid-1990s and beyond) the SSP will enter a relatively stable, "mature" operations phase. Between now and then, however, the emphasis will be on the **development** of the space and ground systems, and the management and operations infrastructure, which will eventually lead to the mature operations phase. Figure 4.1-1 shows a greatly simplified view of the SSP development life-cycle.

In identifying their IS needs, programmatic users can be roughly divided into nine distinct groups with corresponding high-level responsibilities:

- administration — concerned with the day to day running of the program, budget control, facilities management, procurement, contract management etc.
- project management — concerned with controlling and coordinating the activities of the various development centers in order to achieve program goals.
- system engineering — concerned with analyzing system-level requirements, performing trade studies to evaluate and select implementation options, and ensuring that common requirements are developed and applied throughout the program.
- operations — concerned with real-time control and monitoring of SSP flight and ground elements, and associated tactical and strategic planning.
- software development — concerned with implementation and testing of program software components.
- hardware development — concerned with implementation and testing of program hardware components.

- system integration /test — concerned with the integration of multiple hardware and software components into working, reliable systems.

- sustaining engineering — concerned with ongoing maintenance and upgrading of systems, including hardware, software and customer payloads.

- support services — concerned with quality assurance and configuration management.

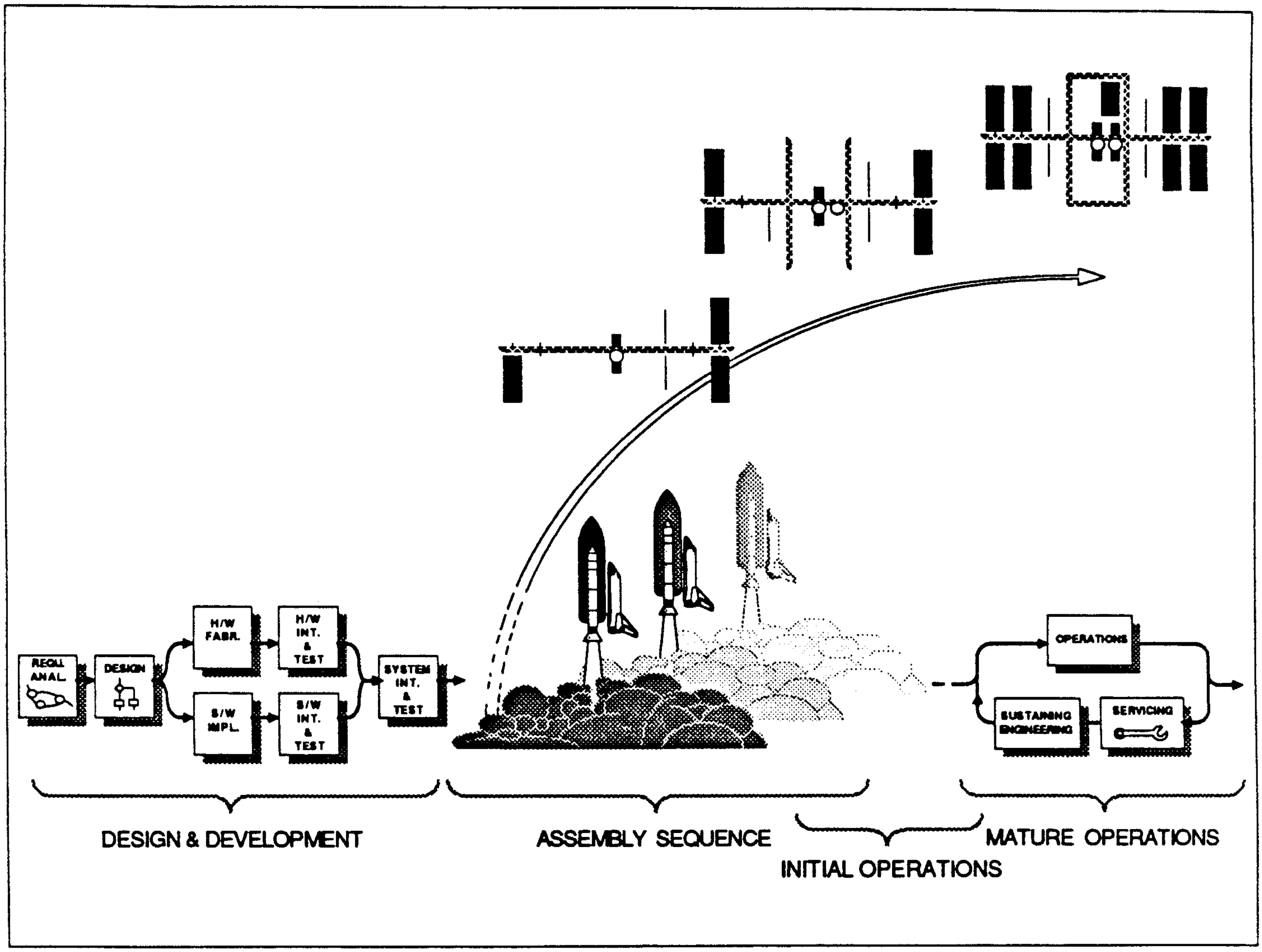

Figure 4.1-1 Space Station Program Development Life-Cycle

The following paragraphs will explore the IS needs of each group in relation to the life-cycle shown in Figure 4.1-1.

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Administration. This user group has a need for a variety of automated tools and information of a general nature: Database Management Systems (DBMS), access to remote computer systems, file transfer to and from remote computer systems, integrated document processing (word processing plus graphics), cost/benefit modeling tools, electronic mail, teleconferencing, spreadsheet capability, scheduling tools, and Computer-Aided Instruction (CAI). The IS needs of the group span the entire SSP life-cycle, from the current day all the way into mature station operations.

Project management. This group has broadly similar needs to the administration group, with an additional need for specialized project management tools and information. The IS needs of this group are already significant and will increase early in 1988 when the implementation contracts begin to take effect, reaching a peak just before the assembly phase, and declining as the program moves into mature operations.

System engineering. The system engineering group will require access to almost all of the program's technical information databases (including requirements, hardware and software specifications, engineering drawings, system configurations, program schedules etc.). Access to simulation and modeling tools will be required to support trade studies. There is an immediate need for IS support for system engineering (a legacy of system engineering data has been left by earlier Space Station definition studies) which will continue throughout the program.

Operations. The IS needs of the operations group are more highly specialized than the previous groups. This group needs access to space element engineering data, systems to process and display that data, voice and video contact with the crew of the manned base, planning and scheduling aids, tools for archiving, retrieval and analysis of engineering data, and access to space element simulators to aid in anomaly analysis. The initial IS needs of this group are for operations planning aids, beginning immediately and increasing until the assembly phase. The need for the other IS services will begin during operations training , again increasing until the assembly phase. Thereafter, they will continue at a more or less constant level throughout the SSP lifetime.

Software development. This is another group with highly specialized IS needs. Beginning in early 1988, the software developers (primarily work package contractors) will need automated tools to assist with: requirements analysis, preliminary and detailed design, High Order Language (HOL) coding and debugging, software system construction, software system testing, configuration management, documentation, and access to databases of requirements, engineering data and reusable software component libraries. Since the development sites are distributed across the country, access to remote computers and databases will also be needed. The activities of this group will peak in the design and development phase, gradually being replaced by sustaining engineering as the program matures.

Hardware development. The hardware development users might be expected to require specialized hardware development tools (such as Computer Aided Design (CAD) and Computer Aided Engineering (CAE)) in the same way as the software development users. In practice however the hardware development contractors will already have these systems in place in their own facilities, so that their needs from Space Station Information Systems are greatly reduced. They will require the means to exchange and access electronic documents and CAD/CAE drawings with remote sites, and automated tools to allow their progress to be monitored and assessed by Space Station Program management. The time scale of these activities roughly parallels that of the software development group - from early 1988 through the assembly phase, then phasing out in favor of sustaining engineering.

System integration and test. This group will primarily require communications services (voice, video and data) and high fidelity hardware and software simulators. Their activities occupy a portion of the Station life-cycle from the end of the development phase to the end of the assembly phase. Although this type of activity will continue for the life of the program, system integration and test responsibilities will gradually be assumed by sustaining engineering.

Sustaining engineering. The sustaining engineering user group will perform all of the activities previously performed by software development, hardware development and system integration and test, though at a lower level, beginning at the end of the assembly sequence and continuing through the life of the program. They will require access to all of the IS tools used by the aforementioned groups.

Support services. In addition to general purpose tools such as communications, document production, and remote system access, the support services users will require access to specialized quality assurance tools and configuration management tools. In particular they will need access to (and control of) QA and CM databases. The IS needs of this group will begin in 1988 and peak sometime during the assembly sequence, but will continue throughout the cycle of the program.

General. In addition to their specialized needs, all of these users will require a consistent, user-friendly interface to programs and data, reliable communications, and access to remote systems and data independent of geographical location.

4.2 PAYLOAD USERS

While the Space Station Program development life-cycle certainly has an effect on payload users, in general, their activities are more closely tied to the development life-cycle of their particular instrument or experiment. A typical instrument life-cycle is illustrated in Figure 4.2-1. In discussing payload user needs for the Space Station information systems, it is more appropriate to consider their needs as a function of the phases of this life-cycle.

Concept definition - proposal preparation. The principal payload user needs during this phase are for the information necessary to determine technical feasibility of the proposed instrument, its compatibility with the proposed station or platform environment, and its approximate cost. Determination of these will require remote access to databases of design information for similar, previously flown instruments, payload accommodation data (power, data interfaces, etc.), information on other payloads with which the proposed instrument may have to co-exist and schedule and manifesting information.

Manifesting and accommodation planning. The information needs here are the same as for the previous phase, but to a much greater level of detail. Additional management information (particularly cost and schedule) will be required.

Design, development, integration and test. Many of the payload user IS needs during this phase are the same as the needs of the programmatic users during the equivalent life-cycle phases. The major difference is that payload users, provided they comply with program safety requirements, are not bound by the standards and methodologies imposed on the programmatic developer. However, the need for electronic access to, and exchange of, technical information will be very similar. Particularly during the integration phase, there will be a need to verify instrument interfaces with the station (or platform) which will require access to the same simulators used during programmatic development.

Operations planning. There are two aspects to this phase. The first is the kind of operations planning which is primarily concerned with the nature of the instrument and its specific targets. Planning of this type will generally be performed by the payload user using his own facilities in conjunction with SSP-provided data. The kind of planning and scheduling which involves Space Station resources and cooperative (or at least non-interfering) operations with other payloads, will require access to SSP planning and scheduling systems of the type also used by SSP operations staff.

Simulations and training. This phase will require remote communications (voice, video and data) and access to SSP simulations facilities. In many cases Space Station crew members will be involved from the point of view of payload installation, operation, and servicing.

Prelaunch operations and flight operations. The payload user IS needs during these phases are focused on communications and data processing. Customers will require access to: instrument quicklook and housekeeping data (possibly in real-time); instrument production data (with all communication artifacts removed); station or platform ancillary data; and voice and/or video communication with involved crew members. In addition they will need to send commands to the payload, and to interact with SSP scheduling systems to arrange for payload resource needs.

Servicing. The IS needs during this phase are largely the same as for the flight operations phase, except that for instruments which normally operate without crew participation, voice and video communication with servicing crew members will be additional requirements. There may also be a need for electronic exchange of engineering information to help in fault diagnosis and resolution.

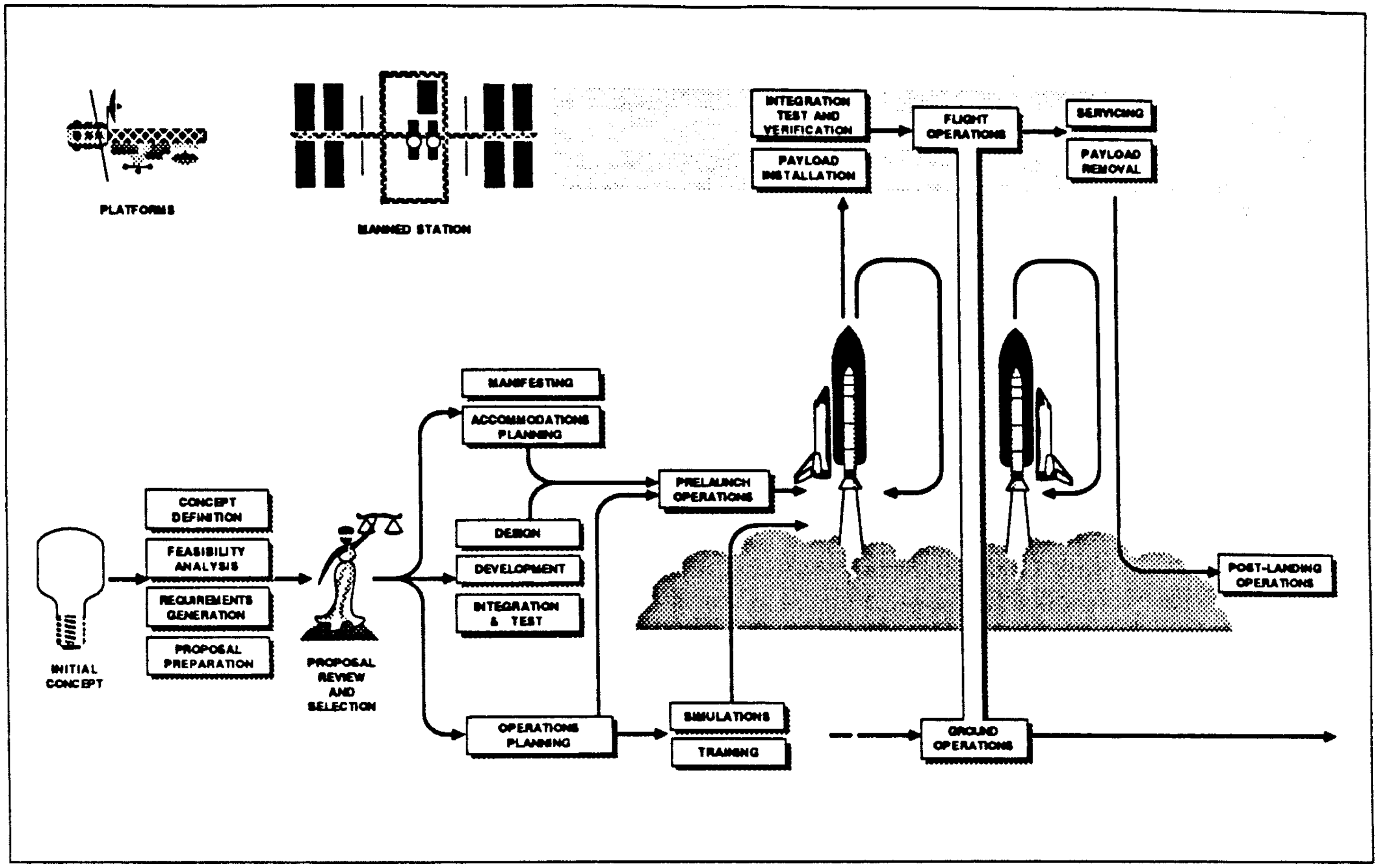

Figure 4.2-1 Instrument Development Life-Cycle

5.0 SSP INFORMATION SYSTEMS CONCEPT

5.1 GOALS OF SSIS, TMIS, SSE

In Section 3, the three outstanding information system challenges facing the Space Station Program were characterized. It was also noted that, if information systems are to provide the basis for a solution, then those challenges must become the basic goals of the information systems. Each of the major goals was augmented by a number of local sub-goals, and by a number of general sub-goals which apply equally to all three - this concept was illustrated in Figure 3.0-2.

Over the past few years of SSP definition, concepts have been developed and refined for three information systems which are directly responsive to these goals. The contribution made by each system toward achieving the goals is briefly explained below, and expanded on in Section 5.3.

The first of these systems is the **Space Station Information System (SSIS).** Its primary purpose is to *provide for information management across the SSP over the full SSP life-cycle.* Secondary goals are to:

Provide for information transfer among flight elements, among ground elements, and between space and ground elements: SSIS is, above all, a communication system, designed to allow the operation and support of flight elements from distributed ground locations.

Provide information transfer to users and facilitate the open exchange of information between users: in addition to providing information transfer for operational elements of the SSP, SSIS is also the primary link between customers and their payloads and on-board crew members supporting their investigations.

Provide information transfer in a standard, reliable, transparent fashion: in contrast to previous systems, SSIS will use standardized protocols which are consistent throughout the program life-cycle, and independent of the user's data formats and contents.

Facilitate the use of distributed operations and processing: the SSIS will allow customers to operate their payloads largely independently of geographical location, throughout all phases of the payload development life-cycle.

The second system is the **Software Support Environment (SSE).** Its primary purpose is to *provide automated rules and tools to minimize the cost and risk associated with program software development.* Secondary goals are to:

Provide a common environment for the development and maintenance of all SSP software: a common environment for software development minimizes the risk involved in a large, extremely complex development effort spread across multiple development centers.

Provide open access to SSP software development information: the benefits here are at the management level where project schedules and status need to be tracked, and also at the developer level where access to reusable components will reduce development effort.

Provide program-wide enforcement of approved standards and methodologies: by encapsulating proven methodologies in 'smart' tools, productivity can be enhanced and risk reduced.

Minimize cost of software ownership by effective and efficient life-cycle management: frequently in large software projects, most of the cost is expended on maintenance - productivity gains in this area through the use of efficient, automated tools can produce a large return on investment.

The third system is the **Technical and Management Information System (TMIS)**. Its primary goal is to *provide automated rules and tools to facilitate management of program development.* Secondary goals are to:

Maximize the effectiveness and efficiency of technical and management processes over the system life-cycle: on-line access to program information from distributed locations has the potential for productivity benefits to both management and engineering staff.

Maximize the effective use of sound system engineering practices over the system life-cycle: sound system engineering judgements require the ready availability of complete, accurate information and automated analysis tools.

Facilitate the management of information resources: configuration control of information resources (interface definitions, requirements, schedules...) will ensure that all users receive consistent and timely access to necessary information.

Provide technical and management interfaces with SSP users: whether engaged primarily in operations or development activities, SSP users will require rapid access to SSP technical and administrative information from a variety of geographical locations.

Finally, the last four sub-goals apply equally to all of the systems:

Minimize program life-cycle costs,

enhance user productivity,

provide a common, user-friendly interface to SSP information and services, and

maximize system safety and reliability.

Figure 5.1-1 summarizes the major contributions of each system.

GOALS OF THE INFORMATION SYSTEMS	SSIS	SSE	TMIS
PROVIDE FOR INFORMATION TRANSFER : AMONG FLIGHT ELEMENTS, AMONG GROUND ELEMENTS, BETWEEN FLIGHT AND GROUND ELEMENTS	●		
PROVIDE INFORMATION TRANSFER TO USERS AND FACILITATE THE OPEN EXCHANGE OF INFORMATION BETWEEN USERS	●		○
PROVIDE INFORMATION TRANSFER IN A STANDARD, RELIABLE, TRANSPARENT FASHION	●		○
FACILITATE THE USE OF DISTRIBUTED OPERATIONS AND PROCESSING (TELEOPERATIONS AND TELEANALYSIS)	●		○
PROVIDE A COMMON ENVIRONMENT FOR THE DEVELOPMENT AND MAINTENANCE OF ALL SSP SOFTWARE		●	
PROVIDE OPEN ACCESS TO SSP SOFTWARE DEVELOPMENT INFORMATION		●	
PROVIDE PROGRAM-WIDE ENFORCEMENT OF APPROVED STANDARDS AND METHODOLOGIES		●	●
MINIMIZE COST OF SOFTWARE OWNERSHIP BY EFFECTIVE AND EFFICIENT LIFE-CYCLE MANAGEMENT AND SUSTAINING ENGINEERING		●	
MAXIMIZE THE EFFECTIVENESS AND EFFICIENCY OF TECHNICAL AND MANAGEMENT PROCESSES OVER THE SYSTEM LIFE-CYCLE			●
MAXIMIZE THE EFFECTIVE USE OF SOUND SYSTEM ENGINEERING PRACTICES OVER THE SYSTEM LIFE-CYCLE			●
FACILITATE THE MANAGEMENT OF INFORMATION RESOURCES	●	●	●
PROVIDE TECHNICAL AND MANAGEMENT INTERFACES WITH SSP USERS			●
MINIMIZE PROGRAM LIFE-CYCLE COSTS	●	●	●
ENHANCE USER PRODUCTIVITY	●	●	●
PROVIDE A COMMON, USER-FRIENDLY INTERFACE TO SSP INFORMATION AND SERVICES	●	●	●
MAXIMIZE SYSTEM SAFETY AND RELIABILITY	●	●	●

● OPERATIONAL ○ SUPPORT

Figure 5.1-1 Goals of SSIS, TMIS, SSE

5.2 SCOPE OF SSIS, TMIS, SSE

Summarizing the previous descriptions of SSIS, TMIS and SSE, the scope of the individual systems can be simply stated as follows:

SSIS — SSP flight operations, spacecraft data management, ground data management, operational data processing and services to experimenters.

TMIS — User services, information, computing and network services in support of management of SSP technical and programmatic information.

SSE SSP mission software development, integration, management and sustaining engineering.

In examining the system descriptions presented in section 5.3, it will be apparent that there are areas of potential overlap of responsibility and functionality. This is not surprising in that the partitioning of functions between the systems was influenced both by NASA programmatic constraints and also by the need for incremental development. Efforts to resolve and clarify these areas are under way and will continue throughout the development process to reduce unnecessary duplication of capabilities. The following list is intended to clarify the current scope of SSIS, TMIS and SSE at a high level:

The Space Station Information System, SSIS, will provide information system support and tools for:

- Operations planning and scheduling (strategic and tactical).
- Space Station flight and ground element operations.
- Short term (tactical) project-level mission analysis.
- Scheduling for on board resource use and conflict avoidance.
- Downlink and uplink management (data, video, voice).
- Payload data processing, storing and distribution.
- Housekeeping data monitoring, analysis and archiving.
- Simulations and training.
- Customer coordination.

The Technical and Management Information System, TMIS, will provide integrated information systems and tools for:

- Long term (strategic) SSP-level or project-level mission analysis and requirements analysis, including allocation of requirements to hardware and software.
- Space Station Program-level project management.
- Design, development, test and evaluation of the SSP.
- Documentation and configuration management.
- Hardware engineering support (requirements analysis, design, development, configuration management, quality assurance).
- Project management support for utilization and operations activities.
- Maintenance, archival and distribution of controlled data developed by SSP management.

The Software Support Environment, SSE, will provide information system support and tools for:

- Software project management.
- Software engineering support (requirements analysis, design, code, unit test, software integration and verification, configuration management, quality assurance).

While the separation of roles and responsibilities may appear clear at this (very simplistic) level, in practice the systems are being developed by different organizations, in different locations, along somewhat different timelines. This raises questions of scope, boundaries of responsibility and interactions between the systems, which are addressed below.

Figure 5.2-1 displays a mapping of the user's needs from Section 4 to the information systems, showing how these needs are satisfied by the SSP Information Systems.

The three systems differ widely in their implementation strategies. SSE has probably the most traditional approach - an implementation contractor has been selected who will establish the SSE rules and procedures, and develop and procure the SSE software tools. In the case of TMIS, a contractor has also been selected, however, the role of the System Integration Contractor (SIC) is focused towards integration of Commercial Off-The Shelf (COTS) products in concert with system development efforts. In contrast to both of these, there is no single contractor charged with implementing the individual SSIS elements. A number of separate development, procurement and facility upgrade efforts will ultimately result in the operational SSIS. It is the responsibility of the SSP Information Systems Services Program Group (ISSPG) to ensure that common requirements are developed and properly applied throughout the SSIS. The ISSPG will be assisted in this task by the services of the Program Support Contractor (PSC). The task of system engineering and managing these disparate projects into a coherent system will clearly be challenging.

Examination of the time-phasing of the development efforts also reveals some essential differences. Since the SSIS is so closely associated with Space Station development and operations, its implementation timescale is necessarily tied to the milestones of the SSP itself. In effect, apart from training and flight readiness exercises, a complete, operational SSIS is not required until First Element Launch (FEL) currently projected for early 1994. Because of their essential roles in supporting SSIS development, SSE and TMIS are required to have operational capabilities in a much more immediate timeframe. SSE for example, provided an interim capability (comprising one host computer and several hundred distributed workstations) in September 1987. The first operational capability (consisting of a number of hosts and approximately one thousand workstations) is scheduled for December 1989. This pace of implementation is necessary to support the needs of the SSP work package contractors who will begin their development efforts early in 1988. The need for TMIS support is even more immediate in that there has already been significant activity in SSP analysis and definition, both technical and programmatic, which has contributed to an already extensive body of engineering and management data, all of which requires program management. For this reason, interim TMIS systems have operated at NASA centers since 1984. The current phase of TMIS development, which began with the selection of the TMIS System Integration Contractor in July 1987, will effect a transition to an integrated, fully functional system through a series of incremental releases.

USERS' NEEDS	SSIS	SSE	TMIS
PROGRAMMATIC USERS			
Administrative			
budget control		●	
contract management		●	
facilities management		●	
document processing		●	
Project Management			
modeling tools		●	●
database access		●	●
System Engineering			
requirements analysis		●	
requirements tracing		●	
evaluation			
trade studies			
Operations			
real-time control	●		
monitoring	●		
planning	●	●	
Software Development			
software implementation			●
software testing			●
technical management		●	●
Hardware Development			
hardware implementation			
hardware testing			
technical management		●	
System Integration and Test			
configuration analysis		●	●
communications	●	●	
simulators (tions)	●		●
Sustaining Engineering			
technical planning	●	●	
system engineering		●	
software development			●
hardware development			
Support Services			
quality assurance		●	
configuration management		●	

● OPERATIONAL ○ SUPPORT

Figure 5.2-1 User Needs Satisfied by SSIS, TMIS, SSE

USERS' NEEDS	SSIS	SSE	TMIS
PAYLOAD USERS			
Concept Definition			
- design information		●	
- interfaces		●	
- schedules		●	
Design, Develop, Integrate, Test			
- requirements analysis		●	●
- evaluation		●	●
- hardware development			
- software development		●	●
- communications	●	●	
- simulators	●		●
- safety		●	
Operations Planning			
- payload planning	●	●	
- SS resources	●	●	
- schedules	●	●	
Simulations and Training			
- communications	●		
- simulations	●		
- operations	●		
Servicing			
- communications	●		
- engineering information	●	●	
- real-time control	●		
- monitoring	●		

● OPERATIONAL ○ SUPPORT

Figure 5.2-1 (con't) User Needs Satisfied by SSIS, TMIS, SSE

5.3 SYSTEM DESCRIPTIONS

5.3.1 THE SPACE STATION INFORMATION SYSTEM - SSIS

At the basic level the SSIS can be viewed as an extensive collection of heterogeneous hardware (computers, networks, facilities) and software, whose primary purpose is to carry data to and from a space-based source and a ground-based user. The data source could be a scientific instrument on the manned base or on a platform; it could be a piece of on-board equipment (such as a Space Station subsystem); or even an on-board crew member. The ground-based user could be an experimenter operating from his home institution; or an operator based in a spacecraft control facility. The data itself might be scientific data; or housekeeping data used to monitor equipment health and safety; a database query; or even audio and video data forming part of a space-ground teleconference. While the situation is not completely symmetrical, most of these dataflows will also occur, simultaneously, from ground to space.

The collection of hardware elements involved in this process is large and varied. One of the foundation documents for the SSIS, The Space Station Information System Architecture Definition Document [1], lists more than ninety space and ground elements which combine to form the SSIS. Some of these elements are new and unique to the SSP while others (such as the Tracking Data Relay Satellite System (TDRSS)) are extended versions of existing NASA institutional capabilities. Some elements are outside of SSP (and even NASA) control, such as customer facilities. However, being connected to the SSIS and using its services, they can be considered to be SSIS elements. Figure 5.3.1-1 depicts a high-level overview of the major SSIS elements.

So far, the rationale for the existence of SSIS has centered around the need for the distribution of enormous quantities of data, both to the customers and to the operations staff of the program. However, data volume is not the only aspect in which Space Station information management differs from current and past practices - the way in which users are connected to, and interact with, the system is fundamentally different from most previous missions. Some of the differences are encapsulated in three terms which are descriptive of a new way of doing business : teleoperations, teleanalysis, and telescience.

The **teleoperations** concept is often described as the ability for a customer to interact with his payload as if that payload were in a laboratory 'next door'. The realization of this concept imposes some stringent requirements on the intervening data systems:

- They must provide constant, standard interfaces so that the payload/user interface looks the same regardless of whether the payload is on a testbench in the manufacturer's facility, in an integration facility at the launch site, or in orbit attached to the station or a platform.

- They must provide data transparency - transporting data with minimum interference or required knowledge of the data networks, regardless of the data content.

- They must transport data with minimum delay so that the investigator can interactively change the course of an observation based on current information.

- They must provide all of the above regardless of the customer's physical location: at his home institution, at a NASA facility, or at an international location.

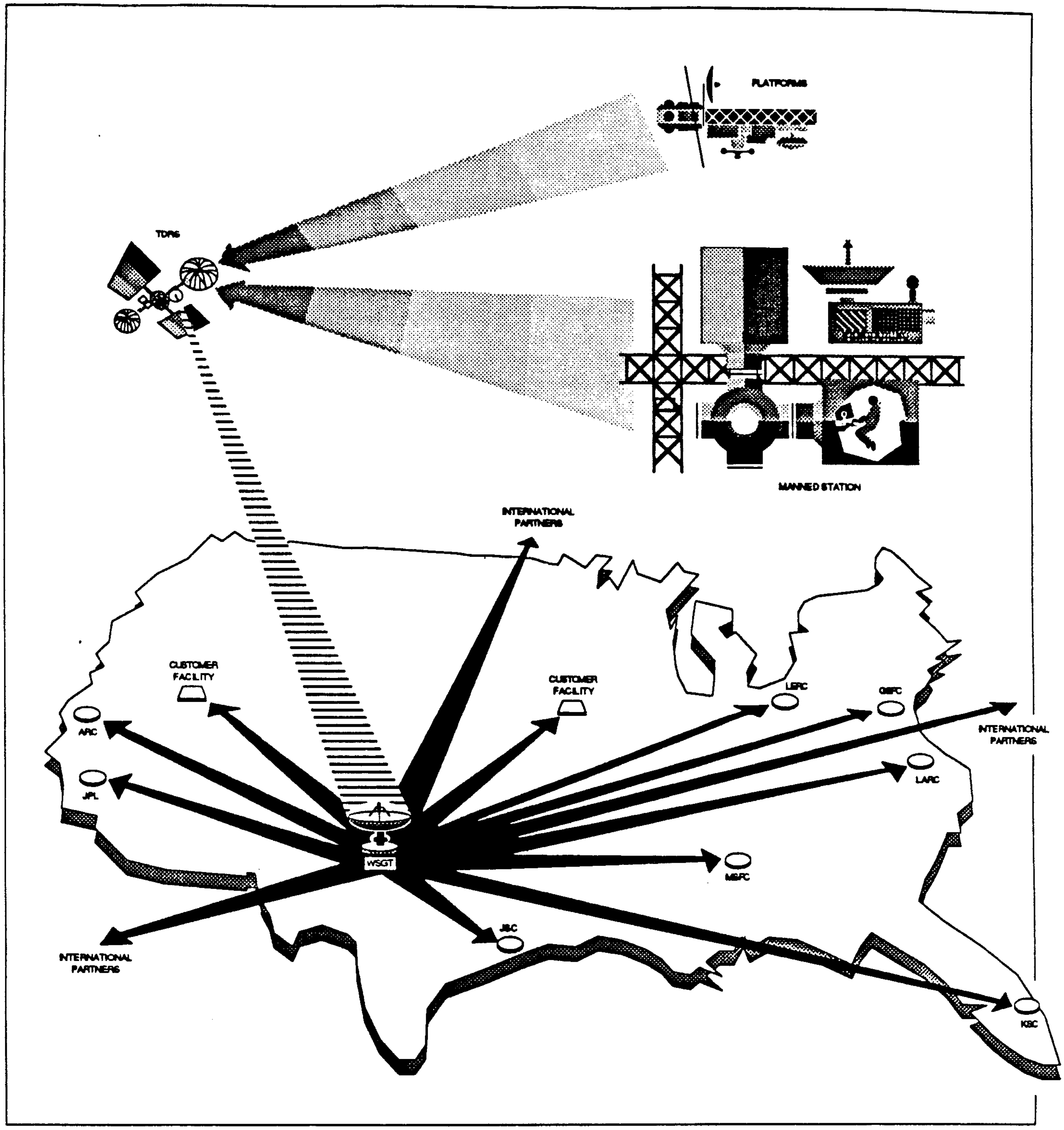

Figure 5.3.1-1 SSIS Flight and Ground Elements

Teleanalysis extends the concept to the ground processing of payload (and other) data. It includes the ability to locate useful data in distributed databases and archives, to extract and receive sub-sets regardless of the physical location of the data, and finally, to combine and reprocess datasets (possibly from different investigations) to produce new datasets of increased utility.

The combination of teleoperations and teleanalysis yields **telescience** - a mode of investigation in which telecommunications resources are used for the most effective division of functions among ground facilities, and between ground and space. It is evident from the preceding discussion that realization of all aspects of the telescience concept will require the cooperation and integration of a multitude of resources, including other information systems such as the Science and Applications Information System (SAIS) and the Earth Observing System Data and Information System (EOSDIS). However, the foundation for these broader concepts, and the vital connection between investigator and payload, are provided by SSIS.

Attractive though the teleoperations concept is, it must be kept in mind that many instruments will operate in a more traditional way - producing large volumes of data, without a great deal of ground intervention, which is processed largely off-line. However, changes in the basic nature of our information systems are necessary here too. In the past, mission data systems tended to be rather inflexible, schedule-driven systems which were labor-intensive to operate. Typically, users' data would be delivered several days (or longer) after reception, usually in formats unique to NASA. The SSIS concept involves some significant improvements :

- The trend is away from schedule-driven and towards data-driven systems - within certain prearranged limits, the system will autonomously accommodate changes in data rates and data destination. This results in operations which are more flexible, less labor-intensive, and give better service to users.

- A necessary building block in the construction of data-driven systems is the autonomous data unit - instead of appearing to the data system as anonymous bit streams, basic data units will be packetized and self-identifying. This allows many of the data system functions in routing data to users, and removing data transport artifacts, to be entirely automated and generic in nature.

- Packetized data can be further packed into 'virtual channels' so that many logically distinct data streams can be multiplexed into the same physical medium (for example, the space-ground link via TDRS).

- In addition to the program benefits of these techniques, the adoption of packetized, data-driven methods has equal benefit to the user community in terms of increased operational flexibility and reduced software development effort.

Discussion of telemetry format standards raises another issue of much broader scope - the issue of communication standards in general. In developing the SSIS, NASA has an opportunity to avoid the unique protocols used in the past in favor of internationally recognized communications standards. There will always be a case for unique solutions to unique problems - the TDRS downlink once again provides a good example, being an unusual combination of high data rates, relatively high noise rate, long round-trip delays and periodic interruptions of service. In this area the Consultative Committee for Space Data Systems is recommending standardized ways of handling these unusual needs. Elsewhere in the information system, however, it is important to recognize that implementation of the

SSIS hinges on the successful assimilation of standards currently under development by international bodies such as the International Standards Organization (ISO). Adoption of these standards, wherever they can be shown to be appropriate, will ensure the benefits to NASA, and to the user community, discussed above.

5.3.2 THE TECHNICAL AND MANAGEMENT INFORMATION SYSTEM - TMIS

In describing the basic concept of TMIS, the focus must be on technical information of primary interest to program developers, management information of primary interest to program managers and administrators, and the tools needed to access and manipulate this information in support of program decision making.

A list of the types of information controlled by TMIS includes the following examples:

- Management data: schedule, budget, contract data ...
- Engineering data: Computer Aided Design (CAD) drawings, Interface Control Documents (ICDs), requirements ...
- Customer relations: payload accommodation data, payload interface definitions ...
- Operations data: planning data, schedules ...

A variety of tools will be provided to enable this data to be captured, controlled and distributed, including the following:

- Management tools: budgeting, planning, project management, cost analysis...
- Engineering tools: CAD, Computer Aided Engineering (CAE), engineering data retrieval, requirements tracking and traceability...
- General tools: spreadsheets, word processing, presentation graphics, electronic mail ...
- Administrative tools: database management, library management, configuration control ...

A survey of all NASA centers, completed in 1987, produced a list of 28 processes performed by the centers in support of their SSP roles, and an initial list of 16 automated tools or capabilities which could be applied to assist in these processes. Figure 5.3.2-1 shows a matrix of processes against applicable automated tools produced in the same survey.

In terms of TMIS implementation, the distributed nature of the SSP development process dictates a distributed approach. At all of the centers, common system capabilities will provide the means to capture, store, transfer, manipulate and archive SSP management and technical data. Program-wide databases and applications, based on information provided by the centers, will be controlled under a TMIS database management system and made available to all authorized users. These data resources will be placed under configuration control so that, at all times, a consistent view is presented to all users regardless of their geographical location. Local databases and applications will be implemented as required, according to TMIS policies, procedures and guideline.

TMIS CAPABILITIES / TOOLS — SSP PROCESSES	CAD / CAM	CAE	COMMON USER INTERFACE	DBMS	REMOTE SYSTEM ACCESS	FILE TRANSFER	IMAGE PROCESSING	COST/PRICE MODELING	WORD PROCESSING	GRAPHICS	ELECTRONIC MAIL	TELECONFERENCING	SPREADSHEETS	PROJECT MANAGEMENT	SCHEDULING	CAI
BUDGETING			●	●	●	●		●	●	●	●	●	●	●	●	●
PLANNING			●	●	●	●			●	●	●	●	●	●	●	●
SCHED. / PROJECT MGMT.			●	●	●	●			●	●	●	●	●	●	●	●
POLICY DEVELOPMENT			●			●			●	●	●	●				●
PERFORMANCE MGMT.			●	●	●	●		●	●	●	●	●	●	●	●	●
TECH. CONTRACT MGMT.		●	●	●	●	●			●	●	●	●			●	●
ADMIN. CONTRACT MGMT.			●	●	●	●			●	●	●	●	●	●	●	●
PROGRAM REVIEW			●	●	●	●	●		●	●	●	●			●	●
PUBLIC RELATIONS			●	●	●	●			●	●	●	●			●	●
INTERNATIONAL RELATIONS			●	●	●	●			●	●	●				●	●
CUSTOMER RELATIONS			●	●	●	●			●	●	●	●				●
REQUIREMENTS ANALYSIS			●	●	●	●			●	●	●	●				●
TECHNICAL ANALYSIS	●	●	●	●	●	●		●	●	●	●	●	●		●	●
INTERFACE CONTROL		●	●	●	●	●	●		●	●	●	●				●
COST/FINANCIAL ANALYSIS			●	●	●	●		●	●	●	●		●	●		●
DESIGN	●	●	●	●	●	●	●	●	●	●	●	●				●
DESIGN REVIEW	●	●	●	●	●	●	●		●	●	●	●	●			●
ACQUISITION			●	●	●	●		●	●	●	●	●	●		●	●
ADMINISTRATION			●	●	●	●			●	●	●		●		●	●
INTEGRATION	●	●	●	●	●	●	●		●	●	●				●	●
TEST & VERIFICATION	●	●	●	●	●	●	●		●	●	●	●	●		●	●
DOCUMENTATION			●	●	●	●	●		●	●	●	●				●
CONFIGURATION MGMT.			●	●	●	●	●		●	●	●	●			●	●
TRAINING	●	●	●	●	●	●			●	●	●	●			●	●
OPERATIONS			●	●	●	●			●	●	●	●	●		●	●
MAINTENANCE		●	●	●	●	●	●		●		●	●	●		●	●
PROTOTYPING			●	●	●	●			●	●	●					●
INVENTORY MGMT.			●	●	●	●			●	●	●		●		●	●

Figure 5.3.2-1 SSP Processes vs. TMIS Automated Tools

The concept discussed above is illustrated in Figure 5.3.2-2. It should be noted that the figure shows communication links only in a generic sense - the bulk of TMIS data traffic will be carried by the Program Support Communication Network (PSCN) - a NASA institutional resource.

Development contractors not based at NASA sites, and international partners in the SSP, will be connected to TMIS via private or commercial networks.

The international community can be divided into two distinct groups, both of which will be supported by TMIS:

- SSP customers: primarily interested in building and operating payloads.
- SSP partners actively developing and operating hardware, software and systems to be incorporated into SSP flight elements

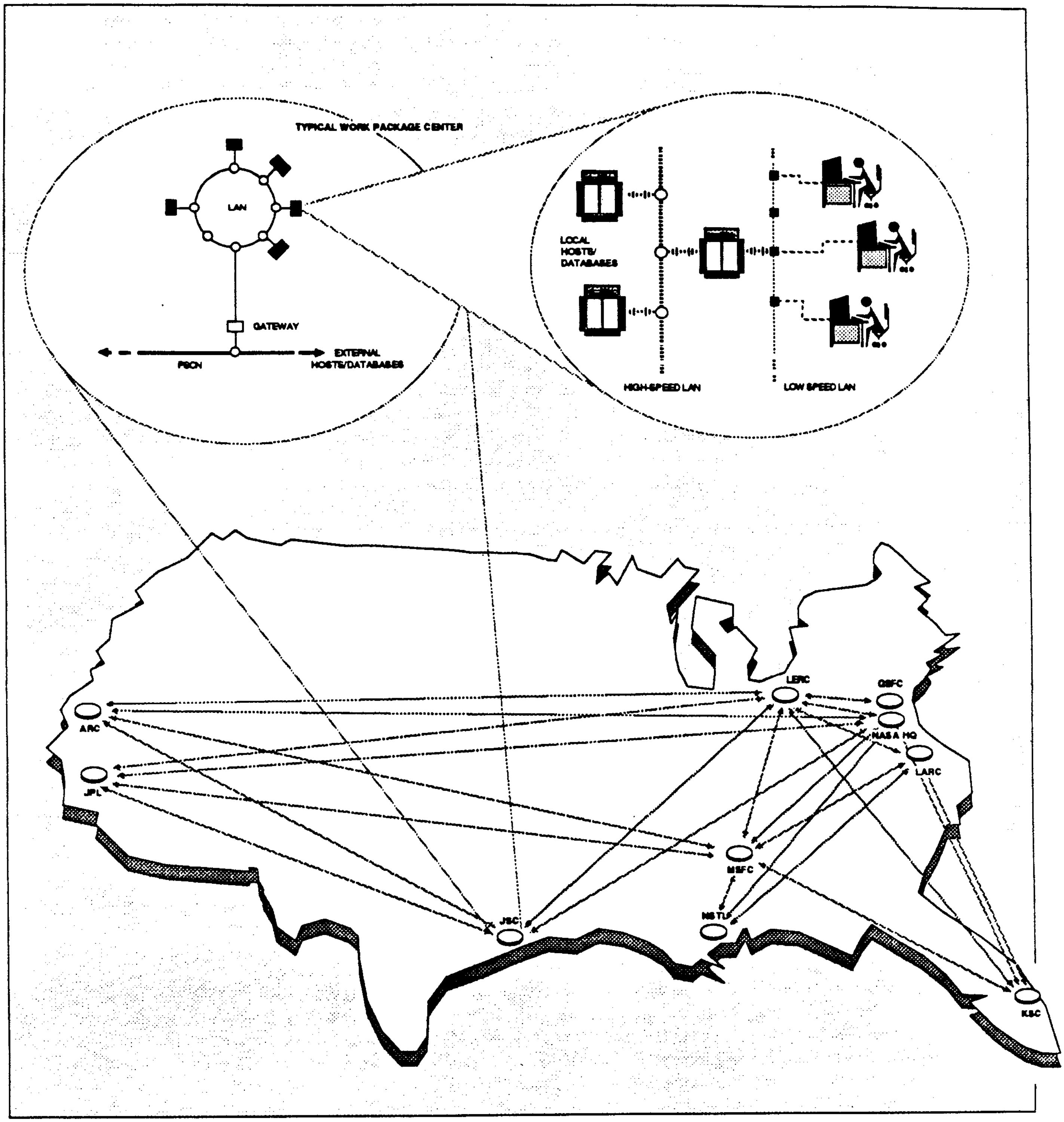

Figure 5.3.2-2 TMIS Elements

While not illustrated in Figure 5.3.2-2 for simplicity, international customers will require the same type of program information as domestic customers. As with the work package contractors, international partners will carry out design and development activities on their in-house facilities, but will require Program-wide requirements data, engineering drawings and design data, program schedules and milestones, and documentation relevant to their interfaces to the Space Station. In turn, they will provide similar data on their own projects for inclusion into TMIS databases.

5.3.3 THE SOFTWARE SUPPORT ENVIRONMENT - SSE

The primary goal of the SSE is to minimize the cost and risk traditionally associated with large, complex software development efforts, and the subsequent sustaining engineering and maintenance of that software. The primary approach of the SSE in meeting this goal is to provide a complete and consistent support environment for the development and maintenance of SSP mission software.

This support environment, as an abstract concept, consists of several components:

- Software Engineering Tools - (covering all phases of the software development life-cycle) including tools for: requirements analysis and tracking, software implementation (design aids, compilers, editors, etc.), configuration management, test-bed generation, test management, test coverage analysis, test-procedure and library management, test results processing, management reporting, problem notification, change control, software and system integration, and product release.

- Hardware Tools - essential hardware components to support test and integration in an environment as close as possible to the target system environment.

- Operating System Interfaces - specifications for the interfaces with the operating system as 'seen' by the application program. These define the context in which the application executes.

- Software Development Rules and Procedures.

- Software Management Plans and Standards - again, covering all aspects of the development life-cycle.

At some point, the abstract SSE concept must be translated into the physical systems on which all phases of software development can be accomplished. There are two distinct aspects to this process. The first is the physical system on which the SSE rules, tools and methodologies are developed and maintained. The second is the set of distributed facilities where the development of actual mission software takes place.

The focus of development for the SSE itself is the SSE Development Facility (SSEDF). This facility is dedicated to the specification, development, maintenance and distribution of all of the SSE components listed above. Essentially the SSEDF is an "SSE factory" - it produces no mission software itself. As the program progresses and experience is gained, the SSE rules and tools will evolve in parallel. The SSEDF will be responsible for life-cycle maintenance and configuration management of the evolving hardware and software tool set. Although the SSEDF is not directly involved in the development of mission software, in time, the tool set will be augmented by the addition of reusable mission software components from other sources.

At the mission software level, since the program development effort is distributed, the implementation of SSE facilities also follows a distributed, layered approach illustrated in figure 5.3.3-1 and described below.

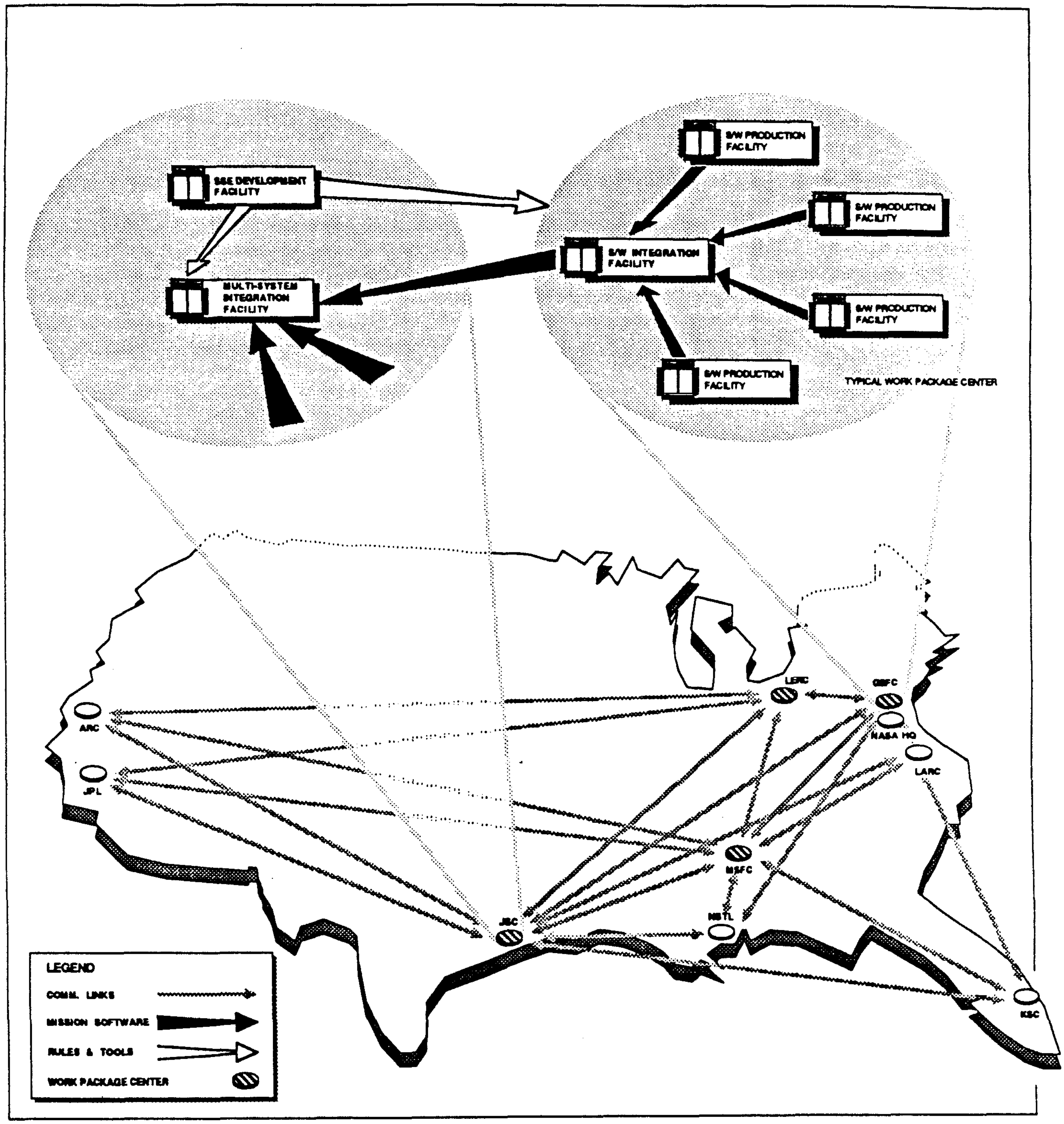

Figure 5.3.3-1 SSE Elements

The lowest level building block of this approach is the Software Production Facility (SPF). An SPF is a physical computer system which hosts a subset of the SSE-defined software and procedures. The SPF can be used, in a local environment, to develop mission software according to the standards, methodologies and guidelines provided by the SSE. SPFs will be located primarily at the sites of the SSP implementation contractors who will be doing the bulk of the software development, however, an SPF can be located anywhere where mission software is being developed.

A typical implementation center consists of a group of SPFs at contractor sites remote from the NASA center controlling that work package. Typically one of the SPFs will be designated as a Software Integration Facility (SIF). The SIF is a specially configured SPF whose job is to integrate and test software from multiple SPFs. The output of the SIF is software integrated at the work package level.

Since the work package centers are distributed, a final level of integration is required to produce program level integrated software systems - this is the job of the Multi-System Integration Facility (MSIF). The MSIF will integrate and test mission software from all sources - work package centers, individual SPFs at other sites, and in some cases, software from non-SSE sources.

5.4 INTEGRATION OF INFORMATION SYSTEMS

These information systems do not operate in isolation. Software developed and tested using SSE can be transferred to the Space Station elements via SSIS both before launch and during operation. SSIS and TMIS will both store information that will be necessary during flight operations. Data of critical importance, such as checklists and procedures, will be stored on-board within SSIS for rapid access. Backup data, such as drawings and design documentation, will be kept in TMIS where it can be accessed as needed either by crewmembers or ground controllers as well as designers of new capabilities. TMIS is the respository of design knowledge; however, detailed information on software will reside within SSE. Reports on the software engineering process will be sent from SSE to the TMIS for management review; schedules, plans and high-level design data will flow from TMIS to SSE as functions are allocated for software development. SSIS will provide the standards and protocols that allow SSE and TMIS to interchange information and for users to access either system in the same manner regardless of location.

The three information systems of the Space Station each have an important role to play in the program. They contribute during different phases of the life-cycle of the SSP from design, development through operations and into sustaining engineering.

The SSE will contribute primarily during development in that all operational software for the Space Station will be developed and tested using the SSE. During integration of all the component elements, SSE will have a significant role in ensuring that a coordinated system results that will fulfill the needs and goals of the Program. The SSE will ensure that the SS continues to fulfill those goals throughout the 30-year lifespan by supporting changes and enhancements to capabilities through software.

The SSIS will be the life-line t hat ties the Space Station into a successful project during operation. As components of SS are developed, SSIS will allow testing of them as a coordinated whole on the ground even though they are distributed across the country and world. Once elements are in orbit, the SSIS will fulfill the goals of telescience by allowing users throughout the world to communicate with and operate their experiments at the same time as controllers monitor and command the distributed systems that comprise the SS.

Layered over the entire program life-cycle, TMIS will allow NASA to control the massive flow of data, both technical and managerial, that will exist during the design, development and operation of this Space Station Program.

6.0 OPERATIONAL SCENARIOS

The scenarios presented in this section are intended to illustrate the roles of SSIS, SSE and TMIS in satisfying the information system needs of representative users. In each case the significant events of the scenario are listed in the left column, while the right column indicates the role of the relevant information system in this event.

More detailed scenarios for each of the systems can be found in the appropriate lower-level concept documents.

6.1 FLIGHT SOFTWARE SUSTAINING ENGINEERING

This scenario depicts the series of events taking place when a possible on-board software problem is detected during a routine orbit adjustment of the space station manned base.

The manned base is scheduled for a routine orbit adjustment - all experiments which might be adversely affected by either attitude or micro-gravity perturbations have been closed down until after the adjustment.	*Management planning and scheduling coordination provided by **TMIS.** Operations-level planning and scheduling provided by **SSIS.***
During the adjustment, numerous sensors record attitude and velocity vector changes, structural stresses and strains, micro-gravity perturbations, and thruster performance. This data is logged on-board and telemetered to the ground for monitoring and archiving.	***SSIS** provides telemetry downlink, processing, distribution and archiving.*
After the adjustment, routine flight dynamics observations and calculations reveal that the final orbit differs slightly from that predicted by the flight software. The difference is too small to require a second orbit adjustment but, nevertheless, a correction is sent to update the on-board orbit model and a problem report is raised.	*Corrections to the orbit model are uplinked via **SSIS.** The problem report is initially filed with SSP program management via **TMIS.***

Detailed engineering telemetry data covering the orbit adjustment period is retrieved from ground engineering archives and analyzed. The analysis shows that the actual orbit correlates very precisely with measurements made during the adjustment and that thruster performance was within specification. The implication is that the "burn" was normal and that the failure was in the on-board orbit-prediction software. The problem report and supporting data are forwarded electronically to SSE management for further analysis.

*Engineering archive data provided electronically by **SSIS.***
***SSE** problem tracking begins.*

The problem tracking organization of the SSE determines the lower level organization responsible for the orbit prediction software and initiates corrective action.

*Internal **SSE** activities.*

At the appropriate SPF the maintenance organization analyzes the problem. To aid diagnosis they request additional information from the Space Station Engineering DataBase (EDB). The analysis shows that during the thruster firing the station structure did not flex exactly according to the properties model in the EDB. A local update to the model is generated and the software is re-run with the new model - the new predicted orbit is within tolerance.

*Access to the EDB provided via **TMIS.***
*Model updates generated and tested at **SSE** SPF.*

A request to update the Space Station EDB is generated. The operational orbit prediction software, with the revised structural model parameters, is re-integrated and regression tested. The revised package is uplinked to the station and replaces the existing software.

*EDB update request made via **TMIS.** Approval of the proposed EDB update request is granted by program CCB. Revised software package created and tested at local SPF, integration tested at **SSE** MSIF. Certified software uplinked via **SSIS. TMIS** and **SSE** problem reports are provisionally closed.*

Finally, after the next orbit adjustment, the orbit predicted by the revised software is found to agree closely with the definitive orbit.

***TMIS** and **SSE** problem reports finally closed.*

6.2 FREE-FLYING SPACECRAFT SERVICING AT MANNED BASE

This scenario depicts the servicing of a free-flying spacecraft which has been retrieved by the Orbital Maneuvering Vehicle (OMV) and is currently located in the Space Station Servicing Facility. Servicing is carried out by a crew member using a work station in a pressurized module. During the operation, the crew member is in audio/video communication with servicing facility personnel on the ground, and with spacecraft engineers operating from the spacecraft Payload Operations Control Center (POCC). The initial portion of the scenario (short-term planning and scheduling phase) takes place prior to the spacecraft retrieval - the retrieval itself is not covered.

Short-term planning and scheduling phase...

Servicing operations personnel confer with the Space Station Operation Management Function (OMF) to schedule the resources required for the servicing period:
• use of the space station servicing facility
• crew time
• data and video channels
• 3-way video teleconference : on-board servicing work station + ground servicing facility + spacecraft POCC
• spacecraft power and thermal control
• spacecraft engineering telemetry downlink (relayed via servicing facility)
• spacecraft command uplink (relayed via servicing facility).

__SSIS__ short-term planning and scheduling facilities used.

Servicing operations personnel confer with spacecraft project personnel for support from the POCC.

Servicing operations personnel retrieve the servicing database for the subject spacecraft.

Retrieved electronically from __TMIS__ database, uplinked via __SSIS__ communication links, stored on-board using __SSIS__ Data Management System (DMS) mass storage.

Servicing operations personnel confer with the Integrated Logistics Support System (ILSS) to coordinate logistics support :
• availability of spares/Orbital Replacement Units (ORUs)
• availability of consumables.

ILSS is a __SSIS__ ground element.

Servicing phase...

At the scheduled time, The space station Operations Management System (OMS) allocates voice, video and data links, also power and thermal control to the subject spacecraft in the servicing bay. OMS will continually monitor resource usage throughout the servicing operation.

*All on-board resources provided by on-board **SSIS** elements. End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The servicing workstation is activated. The servicing operator runs self-tests on the workstation and verifies the voice link with the ground servicing facility.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The spacecraft POCC comes on line, confirms the voice link with the servicing operator, and confirms receipt of spacecraft housekeeping telemetry data.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The servicing operator retrieves the servicing database from SS mass storage.

*On-board **SSIS** functions*

The servicing operator activates the service bay manipulator video cameras and verifies receipt of video.

*On-board video transmission provided by **SSIS** elements.*

The servicing ground facility and the spacecraft POCC confirm receipt of video.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The servicing operator moves the manipulator to the tool storage area and loads the required end-effectors and a replacement for the failed ORU. He then repositions the manipulator to the vicinity of the spacecraft.

*Manipulator commands and force feed-back information transported between workstation and manipulator by **SSIS** on-board elements.*

The operator retrieves an external view of the spacecraft from the servicing database and superimposes it on his video display. Using this, he identifies the position of the suspect ORU and confirms it with the spacecraft engineers in the POCC.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The servicing operator uses the manipulator end-effector to remove the failed ORU. Throughout the operation, the spacecraft engineers monitor the video data and confirm the expected changes in the spacecraft housekeeping telemetry.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The servicing operator stows the failed ORU and inserts the replacement.

*Manipulator commands and force feed-back information transported between workstation and manipulator by **SSIS** on-board elements.*

The spacecraft POCC commands the spacecraft On-Board Computer (OBC) to perform integrity checks on the replacement ORU and confirms the results via housekeeping telemetry. The ORU is pronounced operational.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

The spacecraft POCC commands the spacecraft into a quiescent state and relinquishes voice, video and data links.

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

Ground servicing personnel archive a copy of the video transmission as a record of the operation and for possible use in training exercises. Voice and video links with the on-board operator are relinquished.

***TMIS** logistics, parts and configuration databases updated.*

The on-board servicing operator stows the end-effectors, failed ORU (for diagnosis and possible repair), and manipulator arm. He then shuts down the video cameras, relinquishes the on-board video channels and informs the space station OMS of the termination of the servicing session.

6.3 PAYLOAD USER INSTRUMENT DEVELOPMENT

This scenario depicts the development of a scientific instrument from the payload user perspective. The instrument is assumed to be externally attached to the Space Station manned base. The time flow of the scenario broadly follows the instrument development life-cycle described in Section 4.2, although its timescale is necessarily very compressed - in practice the events depicted would span several years.

Concept definition and proposal preparation...

The payload user accesses technical and customer-liaison databases from a workstation at his home facility. At this time he is interested in :
• technical design data on previously flown instruments with similar operational needs/constraints
• payload accommodation data - particularly on resources available to the payload, operating constraints placed on the payload by the station environment, safety guidelines (since the instrument will be attached to a manned element), and interface definitions
At this stage the design of the instrument is at a rather high level - sufficient to demonstrate technical feasibility.

***TMIS** databases browsed interactively - selected data transmitted electronically.*

Proposal selection...

The customer's proposal is accepted for flight, design and development begin. The hardware development will be carried out by a specialist contractor. The instrument will contain several micro-processors - the customer will develop his own software for these in-house.

Design and development...

The customer's hardware contractor accesses SS databases for more detailed design information. Several different classes of information are required :
• previously performed trade studies which might be helpful in resolving design issues
• simulation models e.g. thermal loading on externally attached payloads throughout the station orbit
• CAD/CAE drawings of standard payload attachments
• design guidelines for possible robotic servicing
• lists and specifications of reusable components e.g. modular, flight-qualified power supplies
• etc.

***TMIS** databases browsed interactively - selected data transmitted electronically.*

As part of his software effort, the customer also accesses SS databases in search of interface specifications to allow his software to use station services. He also checks for the availability of reusable software modules to perform some of the more generic payload functions. The availability of generic packages will speed his development and testing.

TMIS** databases browsed interactively - selected data transmitted electronically. Reusable software components identified and retrieved from **SSE.

Manifesting and accommodations planning...

The customer interacts with NASA through on-line databases and systems to schedule the launch of his instrument. There is an exchange of technical information related to the accommodation of the instrument in the shuttle payload bay, and schedule information related to the availability of launch opportunities. These interactions will continue at increasing levels of detail in parallel with instrument development.

***TMIS** databases browsed interactively - selected data transmitted electronically. Scheduling support provided by **TMIS** and **SSIS** ground elements.*

Integration and test...

At this stage the instrument hardware and software are ready for initial testing. Because of the consistency of SS information system interfaces, most of the testing can be carried out at the customer's facility even though SSP simulators are involved in verifying the instrument + station interfaces.

*End-to-end communication and simulation resources provided by **SSIS** ground elements. Additional support services provided by **TMIS.***

Operations planning, simulation and training...

The customer uses remote SS simulators to verify the operation of his ground equipment with respect to SS communication and data processing services. Using these capabilities to 'close the loop' between his instrument and ground equipment, and to simulate a space station environment for the instrument, realistic scenarios can be played out to verify operational concepts for the instrument.

*End-to-end communication and simulation resources provided by **SSIS** ground elements.*

Payload installation...

Operating from his home facility, the customer receives real-time video during the installation process. A voice link is established with the crew members performing the installation so that the customer can give advice if necessary

*End-to-end communication resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*

Flight operations...

On a day to day basis the customer interacts with SS planning and scheduling systems to arrange for the resources to operate his instrument. During operational periods he can command the instrument and receive 'quick-look' telemetry data at his home location. As long as he remains within prearranged resource guidelines, he is free to interact with the instrument as if it were still on a testbench in his own facility. Apart from the inevitable time delays caused by the round-trip through TDRSS, he is unaware of all the SSP elements cooperating to support this interaction. Production data (high volume) from the instrument is processed to remove any communication artifacts and delivered electronically to the customer site within minutes of reception.

*End-to-end communication and data processing resources provided by a combination of **SSIS** flight, space-to-ground (TDRSS), and ground elements.*
***TMIS** databases updated to reflect new payload complement, resource profiles etc.*

7.0 SUMMARY

The preceding sections have presented a 'broad brush' picture of the Information Systems for Space Station, comprising three major information systems: SSIS, TMIS and SSE. Together, these systems represent a frontal attack on the problems which have traditionally plagued efforts to develop complex, distributed information systems.

Section 3 described the basic nature of the problems, at least as applied to the space system environment, and derived the goals of the automated systems which are intended to provide at least a partial solution.

Section 4 introduced the users of such systems and explored their information needs as a function of time.

In section 5 the abstract goals of Section 3 were embodied in, and allocated to, the three Space Station information systems currently under development.

Finally, the scenarios of Section 6 attempted to show, at a high level, how these individual systems will combine to support the needs of a variety of different users, operating from widely dispersed locations, under greatly differing time constraints.

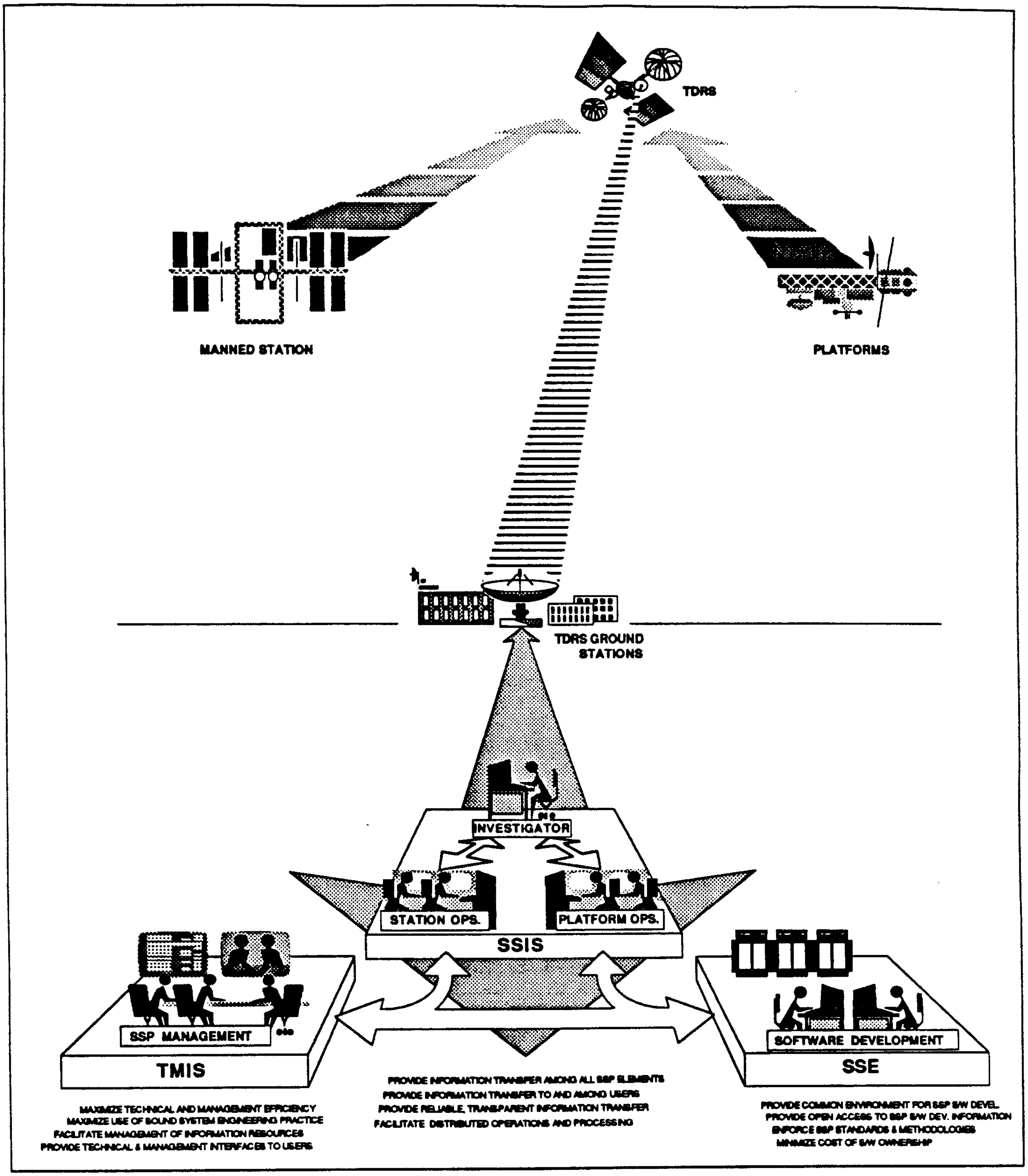

Figure 7.0-1 Information Systems for Space Station

APPENDIX A GLOSSARY

Mission Software — Software executing in a mission data system.

Mission Data System — Computer-based systems which actively participate in the control and/or monitoring of space missions.

Teleanalysis — The ability to locate, access, transport, and analyze data from distributed locations without regard to the physical locations of the data, and to integrate and manage datasets of multiple instruments and investigations.

Teleoperations — The capability for real-time control (to interact with a payload as if the payload were in a nearby laboratory), adaptive operations (changing activities in response to ongoing findings), and coordinated activities across instruments, investigations, and domains of interest, from distributed locations.

Telescience — A mode of investigation, including operations and subsequent analysis, in which telecommunications resources are used synergistically for the most effective division of functions among ground facilities and between ground and space. Telescience includes and implies bidirectional and interactive data flow to support teleoperations and teleanalysis.

APPENDIX B ACRONYMS AND ABBREVIATIONS

÷	To/from
ARC	Ames Research Center
C&T	Communications and Tracking
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAI	Computer Aided Instruction
CCB	Configuration Control Board
CCC	Customer Coordination Center
CCN	Customer Coordination Node
CCSDS	Consultative Committee for Space Data Systems
CDSF	Customer Data Services Facility
CM	Configuration Management
COP	Co-Orbiting Platform
COTS	Commercial Off The Shelf
CSD	Contract Start Date
DBMS	Data Base Management System
DIF	Data Interchange Facility
DMS	Data Management System
EDB	Engineering Data Base
EMU/MMU	Extravehicular Mobility Unit / Manned Maneuvering Unit
EOSDIS	Earth Observing System (EOS) Data and Information System
EVA	Extra-Vehicular Activity
FDF	Flight Dynamics Facility
FEL	First Element Launch
FF	Free Flier
GDMS	Ground Data Management System
GN&C	Guidance, Navigation and Control
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HOL	High Order Language
ICD	Interface Control Document
ILSS	Integrated Logistics Support System
IS	Information Systems
ISO	International Standards Organization
ISSPG	Information Systems Services Program Group
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center

LAN	Local Area Network
LaRC	Langley Research Center
LeRC	Lewis Research Center
MACC	Multiple Application Control Center
MSFC	Marshall Space Flight Center
MSIF	(SSE) Multi-System Integration Facility
NSTL	National Space Technology Laboratory
OBC	On-Board Computer
OMA	Operations Management Application
OMF	Operation Management Function
OMGA	Operations Management Ground Application
OMS	Operations Management System
OMV	Orbital Maneuvering Vehicle
OMVCC	Orbital Maneuvering Vehicle Control Center
ORU	Orbital Replacement Unit
OTV	Orbital Transfer Vehicle
POCC	Payload Operations Control Center
POP	Polar Orbiting Platform
PSC	Platform Support Center
PSCN	Program Support Communications Network
QA	Quality Assurance
SAIS	Science and Applications Information System
SIC	System Integration Contractor (of TMIS)
SIF	Software Integration Facility
SPF	Software Production Facility
SS	Space Station
SSE	Software Support Environment
SSEDF	SSE Development Facility
SSIS	Space Station Information System
SSP	Space Station Program
SSSC	Space Station Support Center
SSTF	Space Station Training Function
TDRS(S)	Tracking Data Relay Satellite (System)
TMIS	Technical and Management Information System
UIL	User Interface Language
USE	User Support Environment (previously UIL)