SPACE CONSTRUCTION AND UTILITY DISTRIBUTION

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A summary of the Rockwell International activities for FY 1979 relating to Large Space Structures Technology, with emphasis primarily on space construction and utility distribution for erectable and deployable platforms.

SPACE SCIENCES AND APPLICATIONS PLATFORM

Derivation of near-term space platform technology requirements was the primary objective of the Space Sciences and Applications Platform Study. Technology advancement to effect an orderly development program leading to construction of space platforms in the 1985 time period was defined, in a program that utilized a viable platform and service module concept with concise OSS/OAST mission ard payload models. Consideration was given to concepts for alternate platform servicing of the payloads described in the model. One of these concepts was selected (Figure 1) for detailed definition and for provision to act as a baseline for technology requirements study.

Using the baseline configuration, issues pertinent to platform development as well as orbit emplacement and operation and on-orbit construction methodology were analyzed. These analyses provided the following data: (a) payload definitions and installation options, (b) identified structural and subsystems options, (c) developed integrated platform system concepts, and (d) identified technology deficiencies and recommended technology development timelines.

SCIENCE AND APPLICATIONS PLATFORM

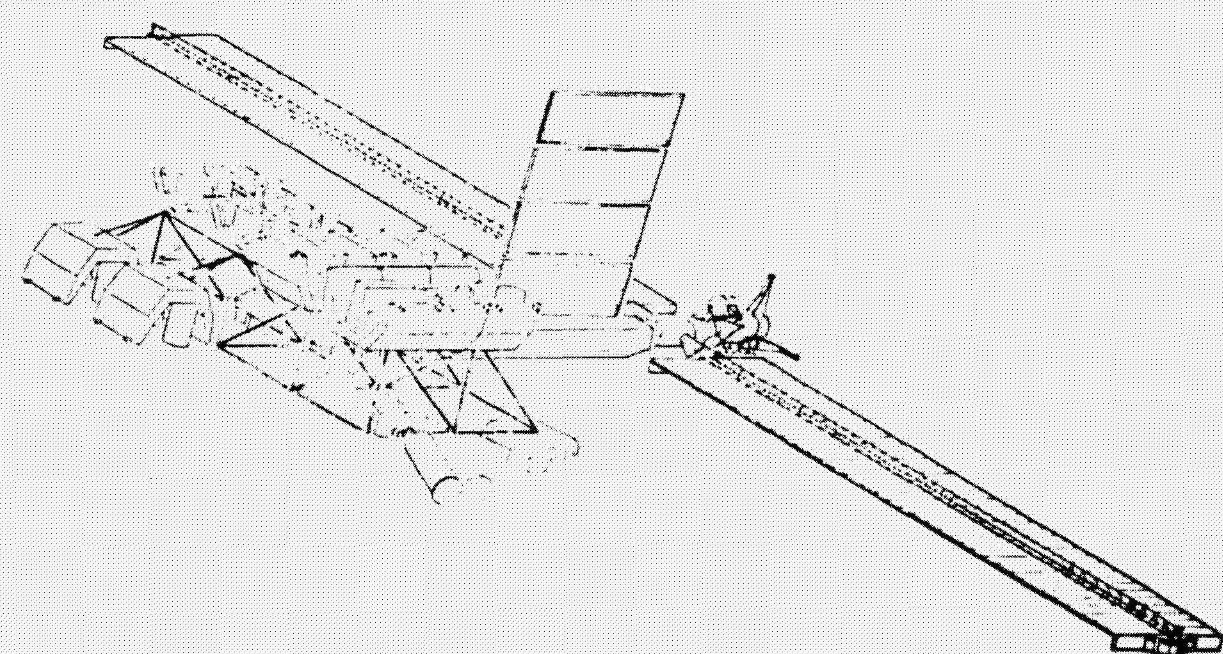


Figure 1

SCIENCE AND APPLICATIONS PLATFORM
TECHNOLOGY DEVELOPMENT PLANNING

Utilizing the data obtained from the Science and Applications Platform Study a generalized technique was established for estimating technology development requirements. The schedule period (fifty-eight months for the development program) extended from the determination of the system requirements through the completion of a systems integrated ground test. Major subsystems applicable to a platform such as would be used in the science and applications mission were defined as well as the interaction of these systems with the structure and associated construction equipment. Scheduling and development requirements encompassed the activities/tasks relevant only to the construction of the platform (i.e., individual subsystems would be completed only to the extent of their effect upon the design of the platform structure and construction equipment). Figure 2 depicts a portion of the development planning schedule done in chart form that incorporates the data used in developing the PERT type program (i.e., the interrelationship between each system and the tasks within each system, including task durations).

It was during the Space Sciences and Applications Platform Study and the subsequent development planning that it became apparent that two major challenges exist in large space systems (LSS) construction. These are: (a) the installation of utility distribution systems and (b) the design/development of construction fixtures required for construction of the space platform.

SCIENCE AND APPLICATIONS PLATFORM
TECHNOLOGY DEVELOPMENT PLANNING

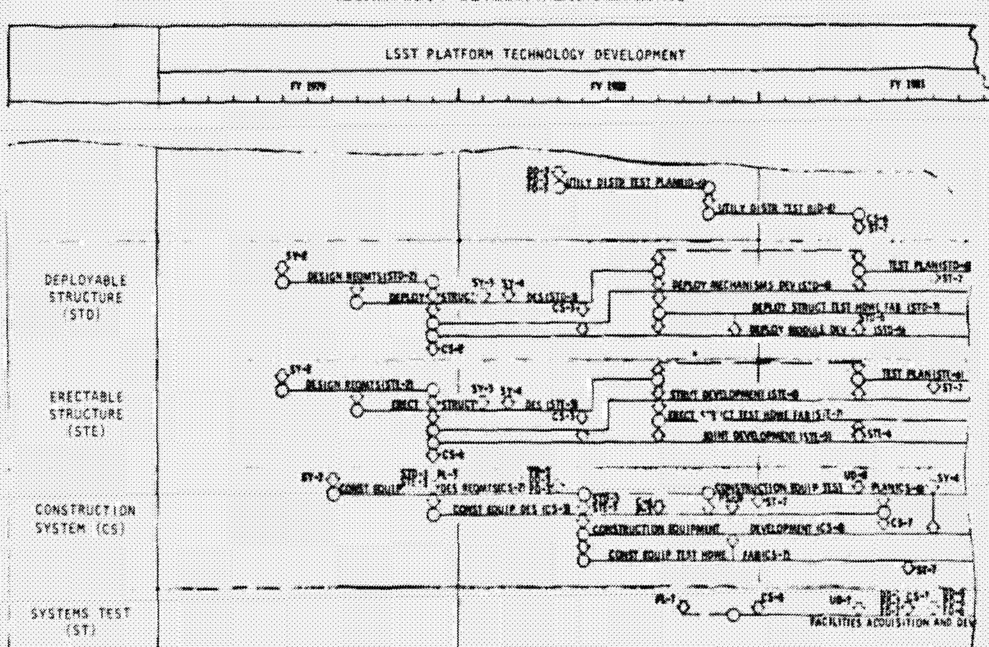


Figure 2

UTILITIES DISTRIBUTION

The technique of distributing power and data lines and fluid (e.g., cooling, if necessary) lines to and from the various payloads on a large space system is an important consideration in the design and development of the system. It is as significant as the platform structure design. Some of the more important factors to consider when designing the utility distribution system are shown in Figure 3. Options that must be considered in implementing the distribution of utilities, range from the methods by which the system is installed, or integrated, to the actual form the utility is to take. A thorough study and tradeoff analysis are required to arrive at an optimum configuration.

The options are subject to the influence of many drivers. The physical design of the structure and its construction process have a great influence on the distribution system design. Variations in the platform design, and construction sequence would in many cases provide more impact than variations in the magnitude of the utilities. The entire scenario of stowage, installation, servicing, etc., establishes a basis for the design of the distribution system.

Detail problems associated with utility distributions are similar to those encountered in earth-bound systems; however, the solutions are not necessarily the same. Considerable research and development is necessary to resolve the problems associated with space environment and to bring them into state-of-the-art.

UTILITIES DISTRIBUTION

OPTIONS

- LAY-ON/PREASSEMBLED/STRUCTURE-INTEGRATED
- DUCTED/SEPARATED
- COAX/FIBER-OPTICS
- HIGH-VOLTAGE/LOW-VOLTAGE

DRIVERS

- PLATFORM CONFIGURATION
- LOAD LOCATION
- FAB/ASSY/DEPLOY SEQUENCE
- RMS/EVA/FIXTURE INSTALLATION
- STRUCTURAL INTERFACES
- UTILITIES MAGNITUDES

PROBLEMS

- RFI/THERMAL ISOLATION
- THERMAL EXPANSION STRESS
- CONNECTORS/JOINTS
- ATTACHMENTS

Figure 3

DEPLOYABLE/ERECTABLE UTILITY DISTRIBUTION CONCEPT

A concept for a utilities distribution system was developed utilizing the Space Sciences and Applications Platform as a model. The concept provides power, cooling and data service to various payload pallets mounted on the node points of a tetrahedral truss structure. This concept is shown in Figure 4. Utilities, originating at the side-mounted power module, are routed underneath the node points, to preserve the pallet access and follow the path of the surface columns. High/low voltage regulators are incorporated into the distribution runs to minimize the cable size in the sections that must transmit higher power.

Pallet interface points are located near the centers of the surface columns to service each pallet location. The upper ends of these lines would interface with standard payload connectors such as those proposed for standard mounted payload pallets. Shut-off and selection valves would interface the coolant line runs to a standardized connector plate in the vicinity of the payload.

DEPLOYABLE/ERECTABLE UTILITY DISTRIBUTION CONCEPT

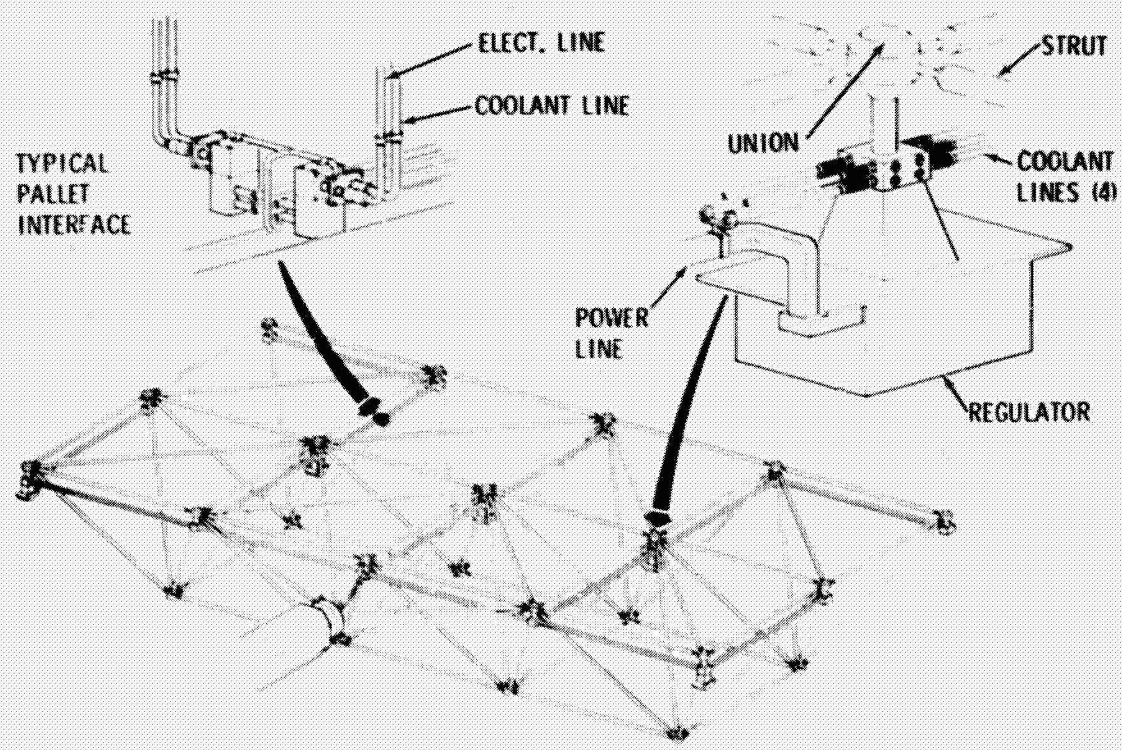


Figure 4

SPACE FABRICATED ELECTRICAL POWER AND DATA DISTRIBUTION CONCEPT

In contrast to the semi-rigid/rigid line installation shown in Figure 4, a flexible line concept for a space fabricated platform shown in Figure 5 has been defined in a space construction system analysis study. This concept allows for continuous installation of electrical power and data lines during beam fabrication. A fabricated utility bundle, complete with branch connectors, would be attached to the space fabricated structure as one of the automated operations of the platform construction fixture. Interconnection of the utility lines on the longitudinal beam with similar lines on the cross beams may require Astronaut Extravehicular Activity (EVA).

SPACE FABRICATION
ELECTRICAL POWER AND DATA DISTRIBUTION CONCEPT

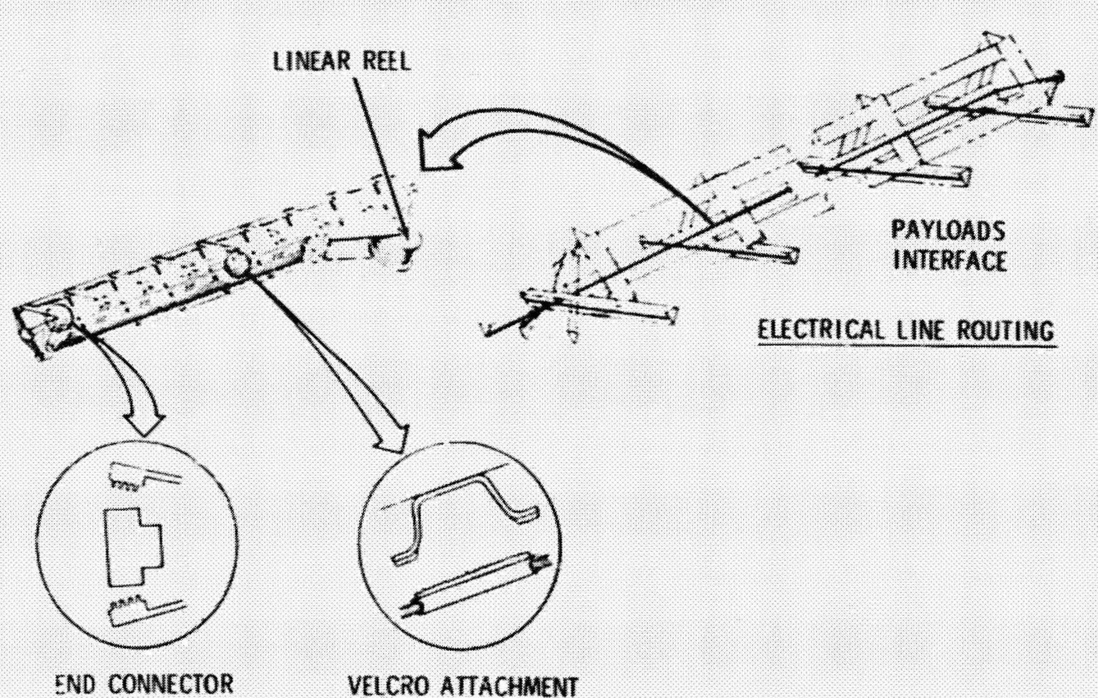
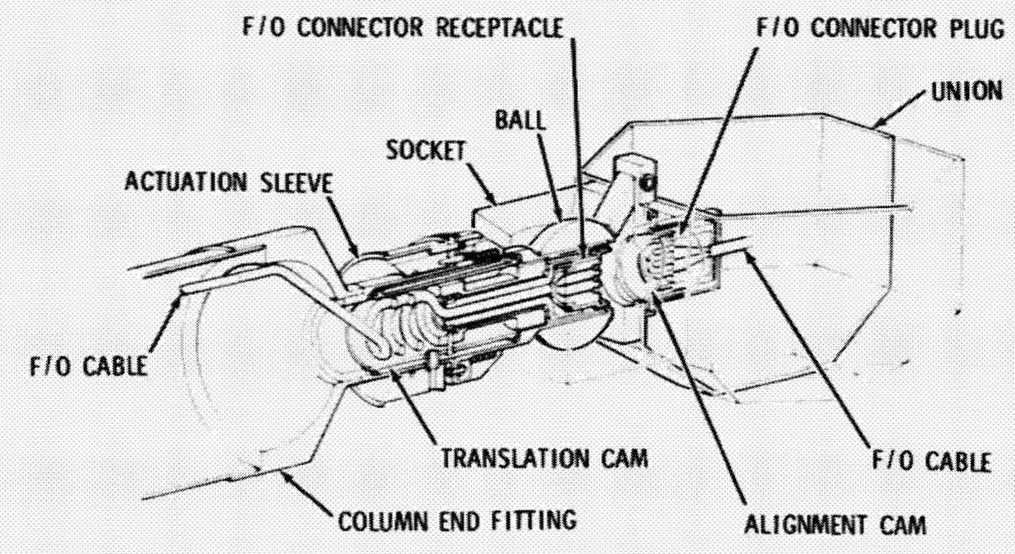


Figure 5

INTEGRATED FIBER-OPTIC CONNECTOR

Data transmission through fiber optics (F/O) for LSS applications has additionally been concluded as acceptable for use in relay satellites for digital transmission of mail, control and regulation of power status, etc.. A design study was conducted to determine a feasible method to integrate the F/O capability into the space platform construction. The objective of the study was to develop methods for connecting erectable structure type unions and struts that have F/O connectors as an integral part of the assembly. Specifically, the design objective was to provide a mechanism that would mate and align a F/O connector plug/receptacle set during a strut/union on-orbit assembly operation using the Remote Manipulator System (RMS) or Astronaut Extravehicular Activity (EVA). From a comprehensive set of mechanism concepts the design shown in Figure 6 was selected. Subsequently, design of the concept was generated in sufficient detail to permit fabrication of a test article. Tests will be performed using the test article to assess the contributions of the mechanism toward the overall attenuation of the optical path.

INTEGRATED FIBER-OPTIC CONNECTOR



- EVALUATE OPTICAL LOSSES DUE TO ALIGNMENT
- TESTS TO START 12/79

Figure 6

ERECTABLE STRUCTURE ASSEMBLY SIMULATION

The utilities distribution system is not solely comprised of lines and connections. A significant item for installation of the utilities is the installation/attachment of such items as regulator boxes, systems modules and payloads after the platform has been assembled. Figure 7 illustrates one method by which such attachments could be made. The device is an adaptor that interfaces with the union socket assembly on one end with provision for module attachment at the other end. When inserted into the union it is self-aligning and mechanically activates a mechanism which drives an acme threaded screw into a receiving nut in the union; a rigid joint is thereby provided. The energy source for the adaptor is a set of two clock springs. A test article was fabricated and successfully tested in the Neutral Buoyancy Simulator (NBS) at Marshall Space Flight Center (MSFC) by pressure-suited subjects in a simulated EVA mode. Installation time for the adaptor was under three minutes.

LARGE SPACE SYSTEMS
ERECTABLE STRUCTURE ASSEMBLY SIMULATION
AT MSFC'S NEUTRAL BUOYANCY SIMULATOR

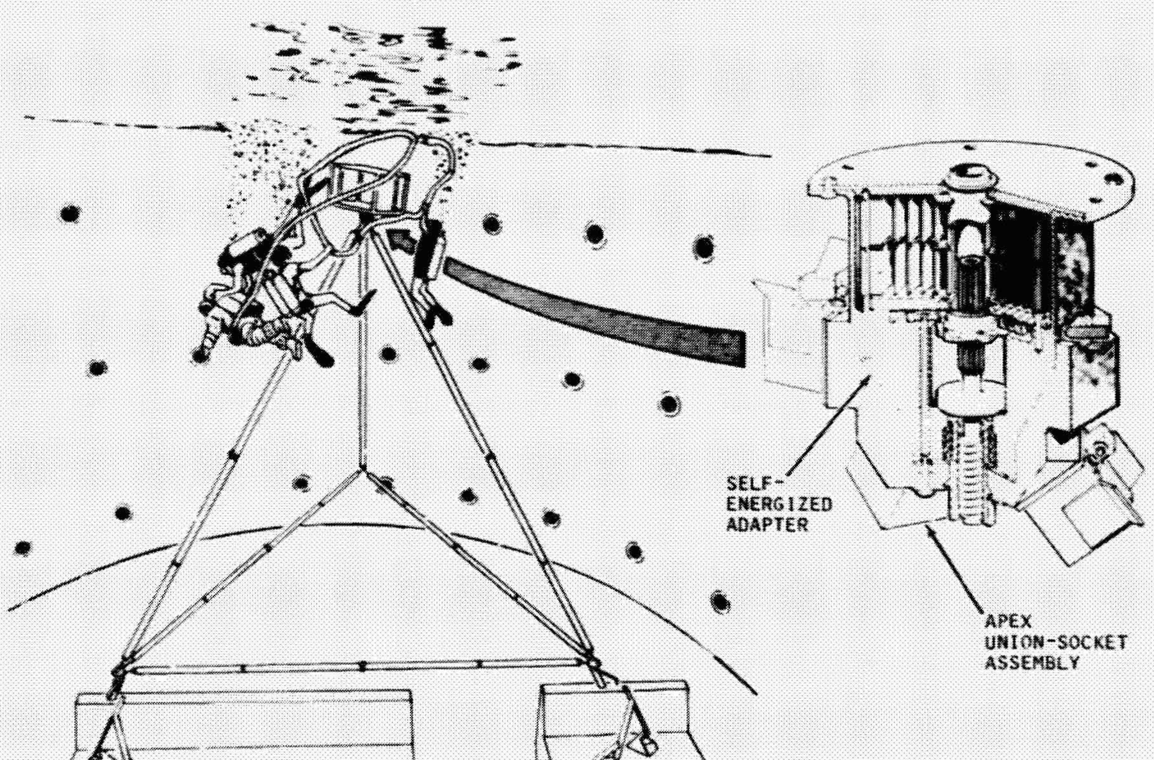


Figure 7

ERECTABLE STRUCTURES ASSEMBLY SIMULATION
PRELIMINARY TEST RESULTS

During 1979, other LSS tests of interest were performed at the MSFC/NBS by pressure-suited subjects to investigate operational procedures and techniques for the assembly of large erectable space structures. Timeline data for assembly of a repeating cell of a tetrahedral truss platform was obtained for varied parameters. The test variables included:

(a) Assembly Techniques
- Manual - Subjects performed assembly tasks as well as transportation tasks.
- Augmented - Subjects performed assembly tasks but transportation tasks were performed by RMS simulations.

(b) Column Lengths
- 30 Foot tubular column, hinged in center (NB-18B Assy. Test)
- 18 Foot nestable column (NB-18C Assembly Test)

(c) Hinged Design (30 Foot Column Only)
- Sleeve Lock (S)
- Latch Lock (L)

(d) Deployment Methods
- Manual
- Anchor - Manual with one column end anchored
- Anchor + Fulcrum - Manual with one column end anchored and a fulcrum used as a deployment aid.

Preliminary test results are shown in Figure 8.

LSS ERECTABLE STRUCTURES ASSEMBLY SIMULATION
PRELIMINARY TEST RESULTS

TEST			NO. OF TRIALS	AVG (RMS) TIME (MIN:SEC)
NB-18B ASSEMBLY	MANUAL		4	22:40
	AUGMENTED		4	14:54
NB-18C ASSEMBLY	MANUAL		2	13:38
	AUGMENTED		2	10:40
NB-18B COLUMN DEPLOYMENT	MANUAL	S	5	1:16
		L	5	1:09
	ANCHOR + FULCRUM	S	2	1:21
		L	2	1:05
	ANCHOR ONLY	S	2	0:39
		L	2	0:42

Figure 8

LSS CONSTRUCTION FIXTURES

Methods/processes for constructing large space systems, using the Shuttle Orbiter as the construction base, range from the erectable assembly of structure from components pre-fabricated on the ground to pre-assembled deployable structure to fully automated in-space fabrication using beam machine facilities. Figure 9 illustrates several types of construction fixtures that would accommodate various configurations of platforms.

Erectable Platforms - Assembled on-orbit from unions and struts by RMS and/or EVA.

(a) Small Area Erectable - A platform similar to the Science and Applications Platform that can be assembled in one orbiter flight.

(b) Large Area Erectable - Similar to a small area erectable but much larger and would require multiple orbiter flights to assemble with orbiter return capability.

(c) Linear Erectable - A long slender platform 200 meters or greater in length with width no greater than the length of a strut. It also would require multiple orbiter flights to assembly with return capability.

Deployable platforms - Pre-assembled on the ground and folded for packaging in the orbiter payload bay. When in orbit the platform is removed from the orbiter, and deployed to form the platform either by RMS or by a self-contained deployment mechanism. The platform size is generally dependent on one orbiter mission transportation capability.

Space Fabrication - On-orbit fabrication of the main structure of LSS platforms using a beam fabricating machine. Beam material is brought to orbit in the orbiter in an unformed stage (e.g., flat stock on reel) where it is formed and welded together to produce a platform structure. Multiple orbiter flights are required for assembly completion, thus requiring orbiter return capability.

Assembly Fixture and Aids - This study presently being performed will derive concepts and requirements for assembly fixtures and aids necessary to the assembly and maintenance of the erectable and deployable space platforms. The results of the study are necessary for the initiation and definition of planning to develop cost effective, Shuttle compatible space systems for the 1985-2000 time frame. Initial tasks of the study included literature search of previous studies to summarize the construction equipment requirements previously defined and to use this information as a data base for further construction definition.

LSS CONSTRUCTION FIXTURES

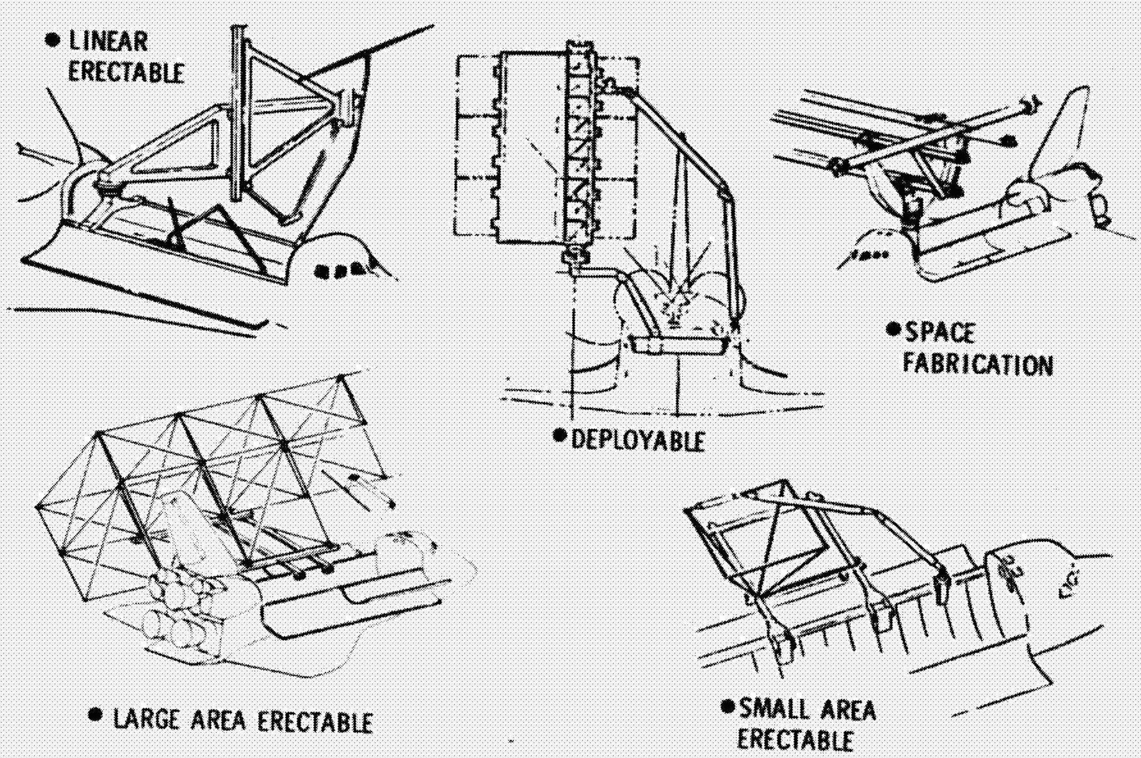


Figure 9

CONSTRUCTION ACTIVITIES AND EQUIPMENT REQUIREMENTS

Four model platforms were selected for an in-depth analysis of fixture requirements. The platforms were categorized into:

Class I - Platforms that would be assembled during one orbiter flight.
- o Small Area Erectable
- o Deployable

Class II - Platforms requiring more than one orbiter flight or assembly.
- o Large Area Erectable
- o Linear Erectable

For each platform a matrix of construction activities versus equipment requirements (see Figure 10) was generated. This matrix defined the construction activity, fixture requirements (including orbiter and platform interfaces), visual aids and other equipment required (i.e., RMS, Cherry Picker, etc.). Commonality of requirements for construction fixtures for all platforms included: (a) platform secure/release capability, (b) platform translation, (c) provision for electrical interface - orbiter to platform, (d) indicating sensors for operations (deploy, capture, etc.), and (e) lighting and TV installations. The fixture requirements analysis also pointed out the impact that size and shape of the platforms have on the construction fixture. For example, the large area platform requires additional construction equipment to assemble as compared to the small area platform or the linear platform where the RMS reach is more effective. Additionally, installation of systems (utility distribution) and payloads can be drivers in the design of the fixture insofar as reaching to distant points of a platform to install or service a system may require rotation or tilting of the platform for accessibility.

CONSTRUCTION ACTIVITIES AND EQUIPMENT REQUIREMENTS
CLASS I AREA ERECTABLE STRUCTURE

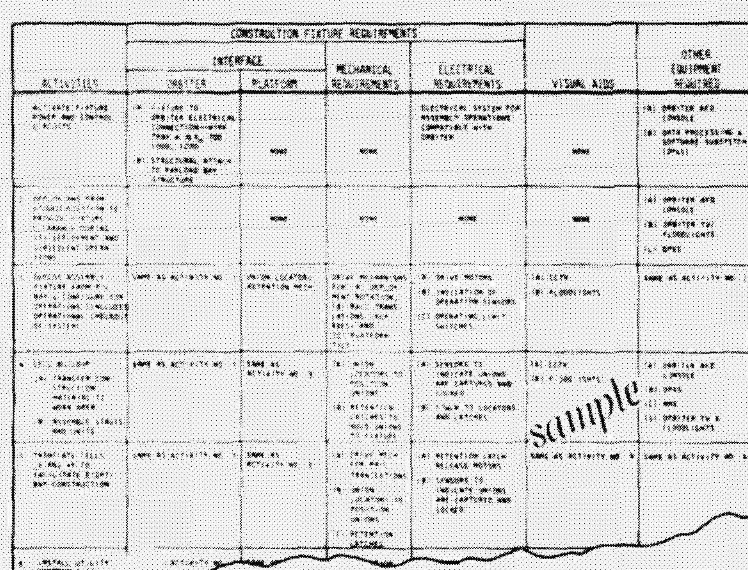


Figure 10

CONSTRUCTION FIXTURE DESIGN FUNDAMENTALS

From the studies performed to date certain fundamental design criteria have been generated (see Figure 11). During construction operations the fixture must not only include platform retention and mobility (translation, rotation, tilting) but should incorporate provisions to support EVA activity in the form of foot restraints, hand holds, equipment stowage, etc.. Large platform construction requiring more than one orbiter flight to assemble would impose the requirement in the fixture to provide an attaching module containing libration damping capability as well as orbiter return capability (i.e., docking port, rendezvous lights/transponders, etc.). The fixture design must also include consideration for packaging in the orbiter payload bay. In most cases volume in the bay is the critical factor; therefore, the least volume required for the fixture should be a design goal. Lastly, the fixture to platform interface must be compatible structurally and mechanically as well as providing utilities transfer if required.

CONSTRUCTION FIXTURE DESIGN FUNDAMENTALS

- OPERATIONAL REQUIREMENTS
  - SUPPORT/TRANSLATE ASSEMBLY
  - ENHANCE EVA
  - STOW EQUIPMENT
  - MANAGE UNTENDED OPERATIONS (LARGE PLATFORM)
  - UTILIZE RMS CAPABILITY TO MAXIMUM EXTENT
- DESIGN FOR PACKAGING WITHIN PAYLOAD BAY
- PROVIDE INTERFACE COMPATIBILITY WITH PLATFORM

Figure 11

DUAL-USAGE FIXTURE, DEPLOYABLE/ERECTABLE

A design concept is presently being formulated which will provide an interchangeability in components to accommodate the construction of the following platforms: (a) a small area erectable, (b) a deployable, and (c) a linear erectable. This concept will be developed in sufficient detail to provide a rough order of magnitude (ROM) estimate for fabricating a test article for subsequent systems tests. A preliminary concept of this fixture is shown in Figure 12. The concept incorporates a deployable arm, which can be mounted either on the orbiter payload bay longeron or on a special structural member, and a translating rail fixture. One or both portions of the fixture can be used dependent on the platform to be constructed. The addition of the translating rail fixture would allow larger platforms to be assembled with the RMS.

DUAL-USAGE FIXTURE, DEPLOYABLE/ERECTABLE

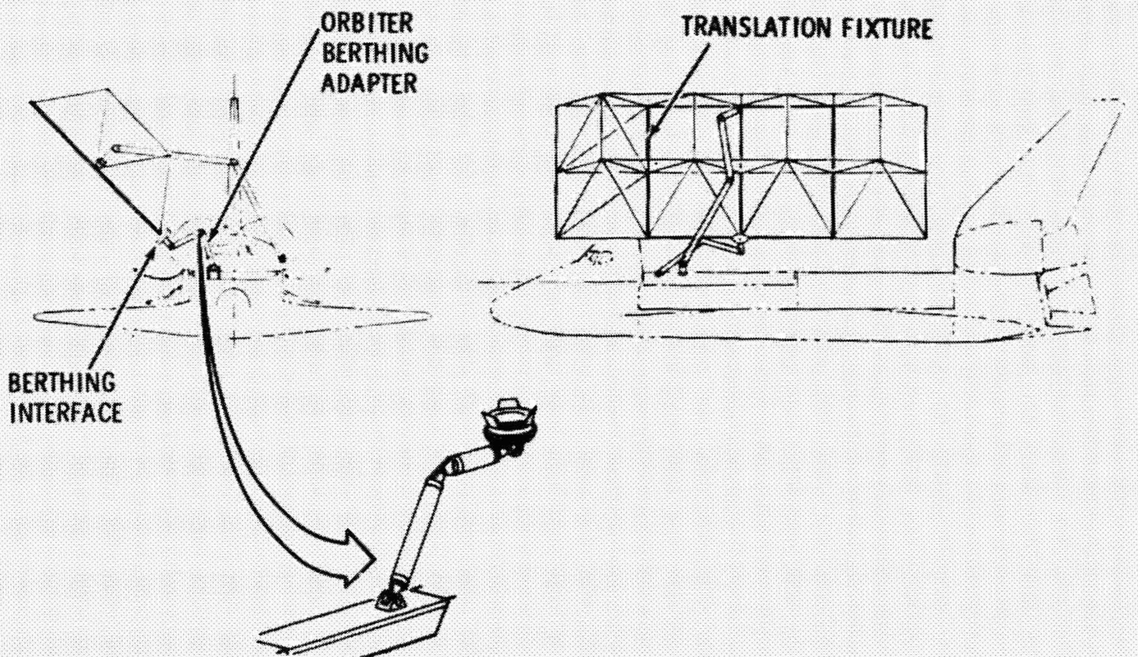


Figure 12