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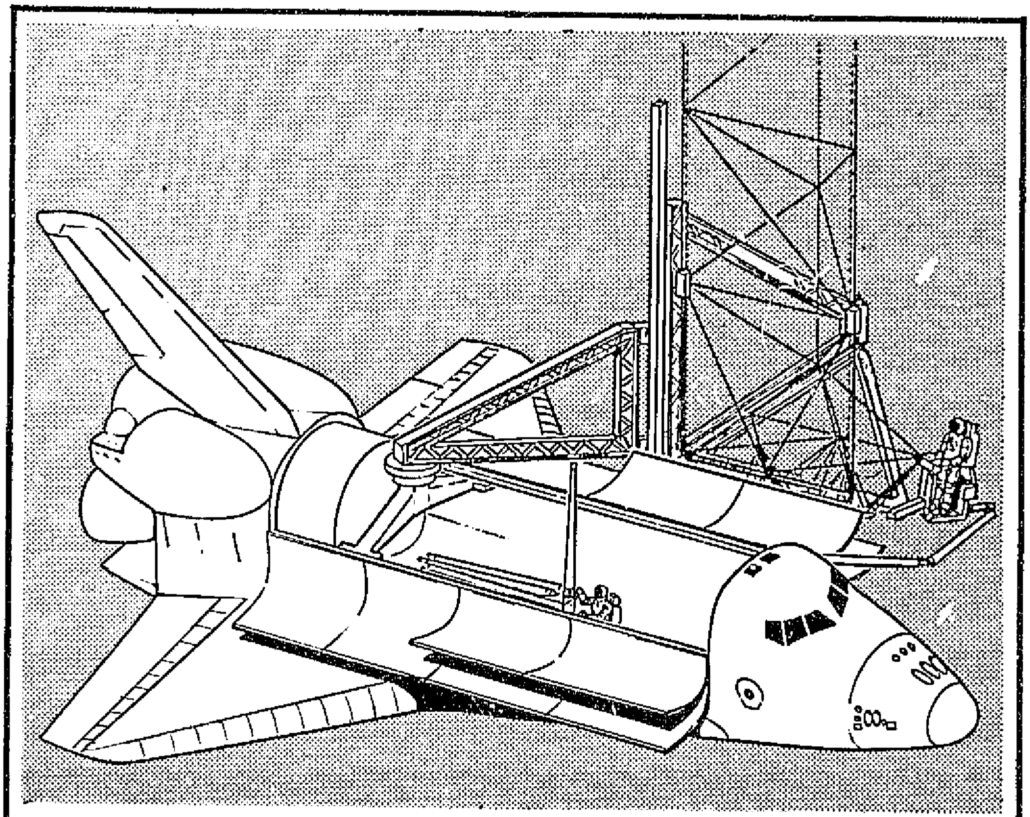
LINE ITEM 3

NAS9-15718
SSD 79-0125

CR-160297

SPACE CONSTRUCTION DATA BASE



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Rockwell International

Satellite Systems Division
Space Systems Group

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Contract No. NAS9-15718
DRL T-1511
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June 1979

Approved by
Ellis Katz

Satellite Systems Division
Space Systems Group

Rockwell International

FOREWORD

This Data Base document reflects the results of an analysis of construction methods for Task 2, *System Analysis of Space Construction*, of the Construction System Analysis Study, Contract NAS9-15718. The effort was conducted by the Satellite Systems Division, Space Systems Group of Rockwell International Corporation for the National Aeronautics and Space Administration (NASA), Johnson Space Center (JSC).

The study was conducted under the direction of Ellis Katz, Study Manager. The development of this Data Base was directed and coordinated by R. E. Cook. Other persons making significant contributions to the data presented are:

- P. Buck
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INTRODUCTION

GENERAL

Construction of large systems in space is a new technology requiring the development of construction methods to deploy, assemble, and fabricate the elements comprising such systems. As herein defined, a construction method is comprised of all essential functions and operations and related support equipment necessary to accomplish a specific construction task in a particular way. It does not reflect an integrated approach to the overall construction of a complete project system. It deals with the individual construction tasks, thereby providing a more fundamental set of data which can be applied to other space construction projects.

In September 1978, NASA/JSC commissioned Rockwell International to perform a Space Construction Systems Analysis Study (Contract NAS9-15718) for the purpose of defining construction methods which would be appropriate to potential large systems in the 1985-1995 time period. The present document, *Space Construction Data Base*, was identified as one of the major products of Part I of the study.

The objective of the Data Base is to provide to the designers of large space systems a compendium of the various space construction methods which could have application to their projects. In this context, it is intended that the Data Base will be a "living" document which, as additional methods are defined and others are changed or replaced, will reflect an updated state-of-the-art of space construction.

METHODOLOGY

The first step in the process of generating this data base was to develop preliminary definitions of several potential space projects and construction fixtures compatible with building in space, using the Shuttle orbiter as the payload carrier and as the construction facility. Initial construction scenarios (strategies), consistent with these baseline designs, were developed. A thorough review of these data revealed a series of operations which were required to construct the project as originally designed using the baseline construction fixture, the orbiter, and the appropriate construction support equipment. This equipment included the manned maneuvering unit (MMU), the manned remote work station (cherry picker), and the remote manipulator system (RMS). The original list of 36 operations identified for the three projects was reduced to 22 by eliminating those which were basically redundant from project to project. Each of the 22 was given careful study, and three to six alternate methods of performing the operation were identified. A total of 76 methods was identified. Two or three of the most viable and/or different approaches for each critical function were selected for detailed definition (47 total) and inclusion in the data base. No evaluation or comparison of the individual methods for a particular operation has been made.

FORMAT

This document has been organized to permit the addition of data from future studies. The contents are coded by generic project (space-fabricated, erectable, or deployable) to permit unlimited additions and convenient access to the information.

The document is divided into four major sections, as described below.

Section I

This section contains a brief description of each of the three project systems which were the basis for the information contained within. Sketches of the important subsystems/major components and construction scenarios (strategies) are also included so that the user can understand the context in which various constructions methods are applied.

Section II

This section is the core of the data base as it contains the basic information concerning construction methods and is indexed by the general construction process, function, and item as described in Figure 1.

Since the understanding of what constitutes an "Assembly" and other items can vary, Table 1 lists the definitions as used in the data base for each of the "Items."

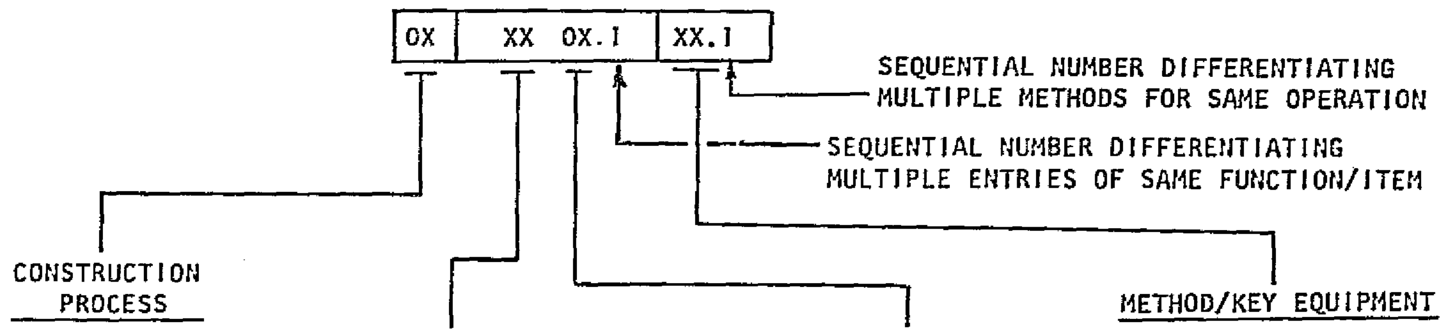
A review of the design, construction scenario, and initial construction fixture concept for each of the three projects resulted in the identification of 22 critical functions or operations (e.g., How do we install the system control module?). While these operations were identified considering a specific design and construction strategy, they are expected to be representative of the major operations to be performed in all construction processes.

Each of the 22 operations, in addition to the individual method descriptions (two or three), contains several pages of general information pertinent to each of the methods. These data include the project the data were based upon, a simple statement of the operation, the physical situation and a list of all the methods identified. The physical situation delineates the condition of the project at the start of the operation being covered, and the ground rules and assumptions as applicable. The physical situation is meant to clearly identify a common starting point for each of the methods so that a true comparison of the methods can be made by the user. The basic format for each of the methods is to include pages, as applicable, for the following subjects:

1. Method Description

2. Project Modifications—Changes to the project configuration which are peculiar to the method being discussed.

3. Operations—In addition to the manpower requirements and estimated time to perform the actual operations, the "Supporting



CONSTRUCTION PROCESS

01 SPACE FAB.
02 ERECTABLE
03 DEPLOYABLE

FUNCTION

01 DEPLOY
02 FABRICATE
03 TRANSPORT
04 POSITION
05 JOIN
06 INSTALL
07 CONNECT
08 SERVICE
09 QUALITY ASSURANCE
10 —

ITEM

01 STRUCTURAL ELEMENTS
02 ASSEMBLIES
03 WIRING/LINES
04 MODULES
05 BLANKETS/ MEMBRANES
06 SYSTEM
07 COMPONENTS
08 --

METHOD/KEY EQUIPMENT

01 EVA
02 MMU
03 CHERRY PICKER
04 RMS
05 CRANE/BOOM
06 SPECIAL TOOL
07 SELF-ACTUATING
08 ELEC. C/O TESTER
09 MISCELLANEOUS
10 CONSTRUCTION FIXTURE
11 —

EXAMPLE:

01 03 06.I 04

CONSTRUCTION PROCESS: SPACE FABRICATED
FUNCTION: TRANSPORT
ITEM: SYSTEM (FIRST ENTRY IN DATA BASE FOR "TRANSPORT SYSTEM")
METHOD: RMS (FIRST METHOD FOR THIS OPERATION USING RMS)

Figure 1. Code Explanation

Table 1. Item Definitions

01	Structural Elements—Individual pieces used to fabricate the basic structure of the spacecraft.
02	Assemblies—An item which is comprised of several structural elements which have been assembled on the ground or on orbit, but prior to being joined to the basic structure.
03	Wiring/Lines—Electrical or fluid lines.
04	Module—End item representing a major subsystem or payload element of the platform.
05	Blankets/Membranes—Long, narrow, and/or thin surfaces.
06	System—A package similar to a module during transport to orbit and installation on the basic structure, but one which is unfolded or deployed after installation.
07	Component—A part (instrument or bracket) which may be used interchangeably in multiple applications on the platform.

Activity" is also identified. This is used in most cases to identify the time to perform tasks which are pertinent to the operation being described, but are of a one-time nature and thus are not included in the activity time for a repetitious type of operation.

4. Construction Support Equipment Requirements—The basic construction fixture has not been included as it is common to all methods for a particular construction project.

5. Support Services—The support services are those to be provided by the construction base, in this case the orbiter. The electrical requirements for the basic operation of the fixture (welding, translation, etc.) and the beam machine have not been included, as these requirements can only be determined from an integrated construction analysis. Two numbers are shown for the crew requirements; the one on the left (top) is the number of different individuals, and the one on the right (bottom) the average usage of the individuals to perform the operation. The operations time is that required to perform the generic operation. For example, even though there are 16 antennas to be installed on the communications platform, the time shown is only to install one. Thus, the data are more representative for other similar antenna installations.

6. Summary—The data presented on this page identify projected mass, volume, electrical, and operational parameters, including relative order of magnitude costs associated with construction support equipment, support services, and project modifications as represented by the level of technical definition. These parameters will provide approximations for the comparative assessment or selection of specific functional methods and construction scenario. The treatment of cost estimates for several items of construction support equipment follows.

   - *Remote Manipulator System (RMS)*—Available as item of standard equipment for use during Shuttle orbiter missions. Charges for the use of one or two RMS's are considered as part of the basic charge for the Shuttle orbiter flight and were not separated as a unique charge in this analysis.

   - *Manned Maneuvering Unit (MMU)*—A charge of $100,000 per mission use is identified in concert with the MMU Users' Guide (Martin-Marietta document MCR-78-517, Contract NAS9-14593).

   - *Open Cherry Picker (OCP)*—It is expected that a flat fee will be charged for the use of this equipment per mission. The charge will be established at a later date.

Costs for operations are designated NA (not appropriate) since the STS user charges for many items are on a per mission basis. The prorated costs per individual usage, thus, are dependent upon the total number of usages which cannot be determined until the integrated construction process is established.

In some cases, additional pages have been included to provide a more complete package on a particular method.

Section III

This section includes general information regarding the major pieces of common construction support equipment that were used to support the various construction methods.

Section IV

This section presents three indexes: *Function*, *Item*, and *Methods/Key Equipment*. These titles refer to the major headings associated with the method code. The indexes are included to provide additional means of entering the data base. Thus, should a user of the data base be interested in methods associated with installation he can look in the Function Index under "06 Install" and find nine operations, each of which includes two or three methods.

SECTION I.

PROJECT SYSTEMS DESCRIPTION

Three space construction projects were used as the basis for the data presented herein:

A. Erectable Advanced Communications Platform

B. Space-Fabricated Advanced Communications Platform

C. SPS Test Article

Each of the three projects will be described in the following subsections. Sketches of the major systems/parts of the platform, as well as a simple construction scenario, have been included so that the user of the data can put the construction methods in the proper context.

A. ERECTABLE ADVANCED COMMUNICATIONS PLATFORM

This antenna platform concept consists of an erectable-type structure and a solar array which produces 133 kW of electrical power. The GN&C system utilizes CMG's and RCS for attitude control and stationkeeping. The platform is boosted to its operating orbit, utilizing low-thrust chemical-fueled engines. The 16 antennas are arranged into two groups: (1) eight 4-6 GHz C-band receivers and transmitters, and (2) eight 12-14 GHz K-band receivers and transmitters. Growth capability for additional antennas is also provided. A sketch of the configuration and the pertinent characteristics are shown in Figure 1-1.

During orbit transfer the solar arrays are folded parallel to the longitudinal axis of the platform, which is also the direction of acceleration. Each antenna horn and boom support is also retracted during the orbit transfer mode. The reflector portion of each antenna, however, is in the deployed position (Figure 1-2).

The platform structure consists of double tapered tubes with ball-type end fittings. The tubes are formed from two conical tubes joined at their large ends. This concept permits "dixie cup" type packaging of the structural members for transport. Most of the tube assemblies are joined to each other through a receptacle type of union member, creating a pinned joint (Figure 1-3). However, the antenna mounting concept requires fixed-type joints (Figure 1-3) in order to react the orbit transfer thrust loads. For this condition, the strut ends and the receptacles are designed to transmit moments. The support arrangement for the RCS pods, the systems module, and the orbit transfer propulsion modules utilize struts arranged to form A-frame reaction members. This arrangement results in only axial loads being introduced into these members. Most of the struts are a common length and size. However, the two load conditions described above use unique struts to fulfill their individual requirements.

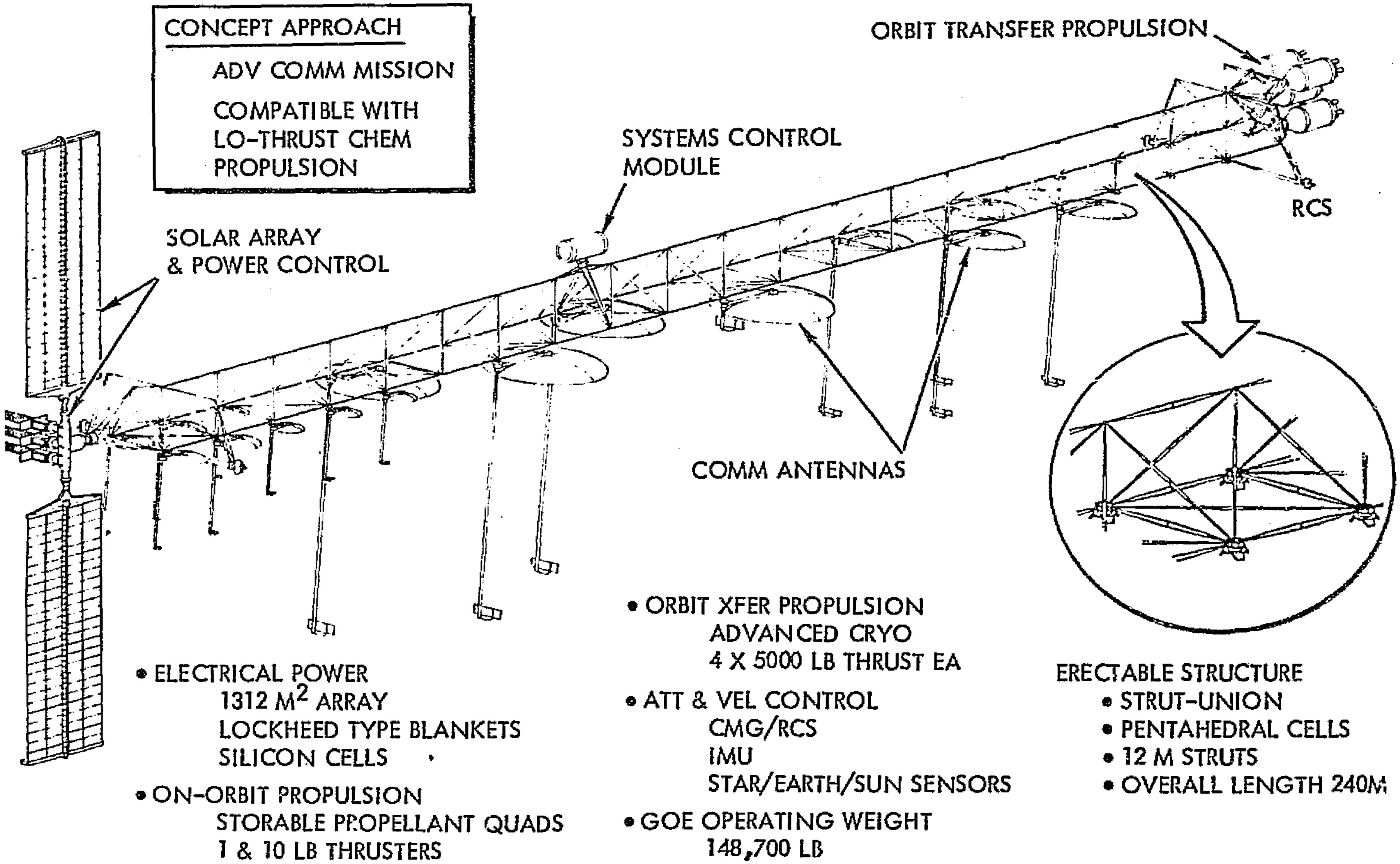


Figure 1-1. General Configuration—Erectable Communications Platform

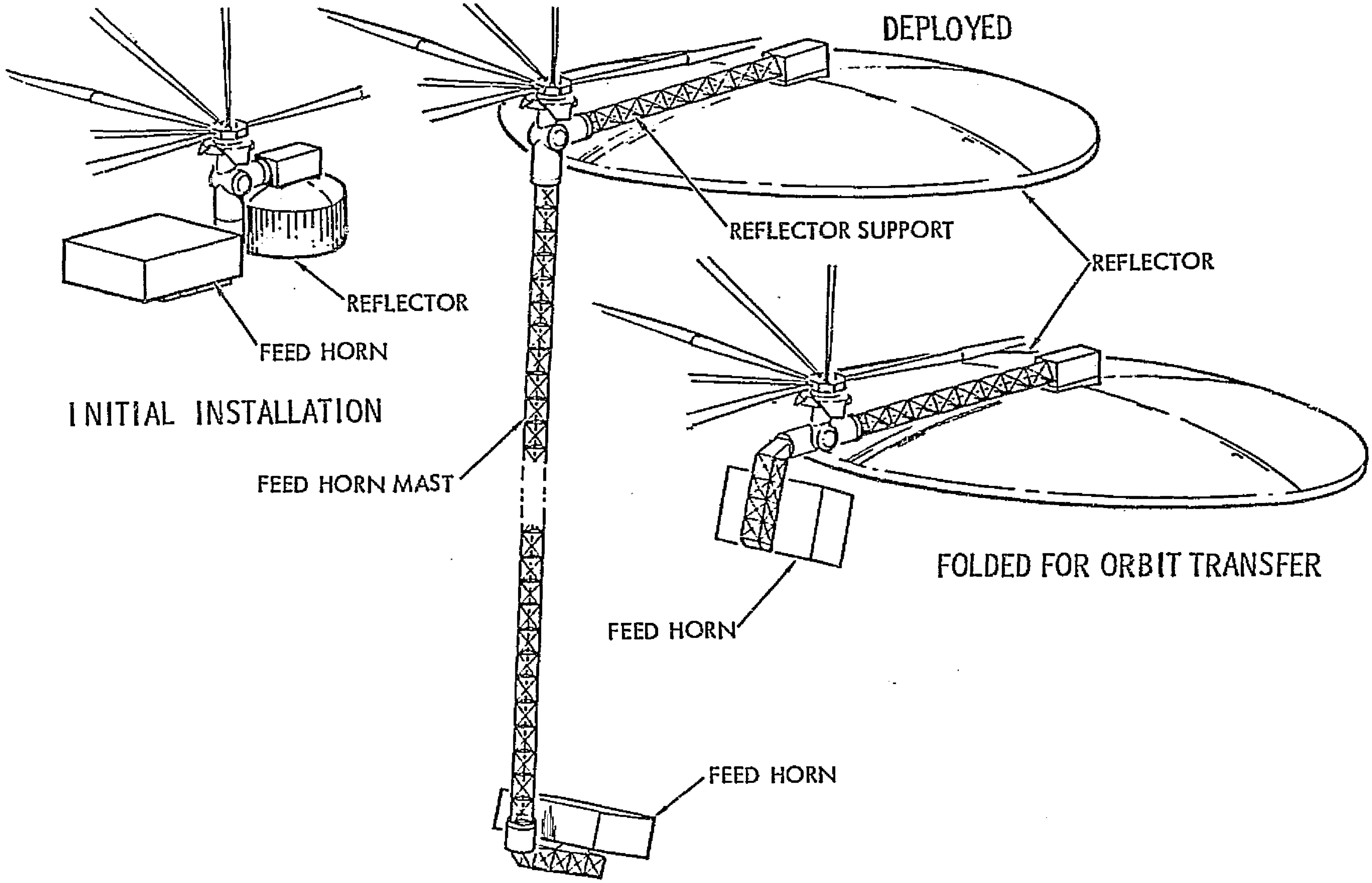


Figure 1-2. Antenna Installation—Erectable Communications Platform

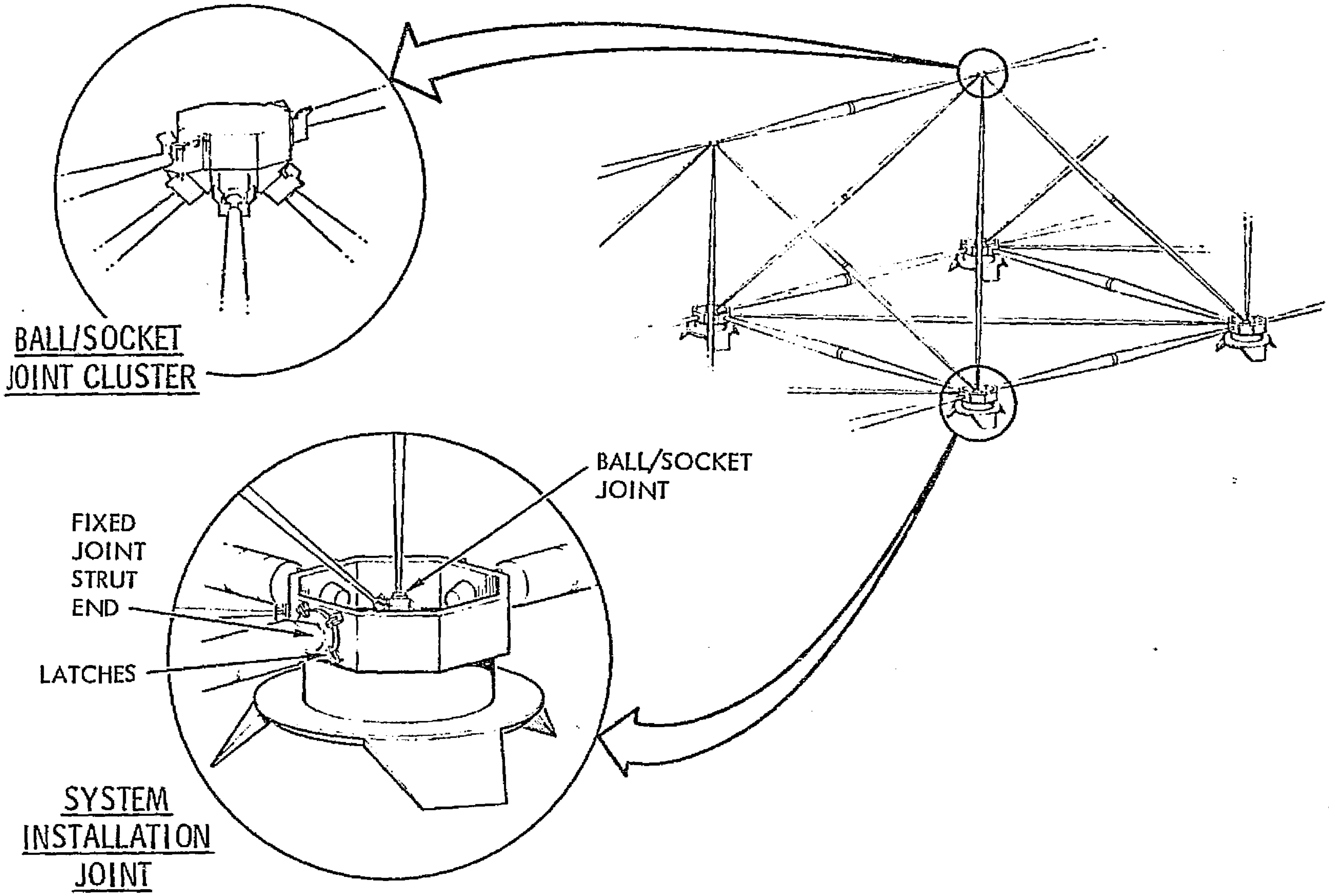


Figure 1-3. Structure Assembly—Erectable Communications Platform

The struts are assembled into a linear, pentahedral, structural arrangement. The size of the pentahedrons are dictated by the reach envelope of the orbiter RMS required for assembly of the struts. The size of the individual struts is dictated by the orbit transfer loads and by the control stiffness required.

All of the larger modular items such as the antennas, the GN&C/ATT&C module, and the orbit transfer engines are attached to the structure via berthing ports. The berthing port concept is the three-petal, neuter concept, baselined for the Shuttle orbiter. Because all of the berthing activities are accomplished by using the orbiter RMS, no velocity attenuation is required. Consequently, the berthing ports—both on the structure and on the modules—contain no attenuation systems. Structural latches are provided only on the mating module. This permits a final checkout of the active latching system on the ground immediately before transport and assembly in orbit. A utilities interface is provided at each berthing port and each interface will be unique to its particular utilities requirements.

Smaller units, such as the electrical junction boxes, may be secured to the struts with clamping-type devices that are compatible with the structural capability of the struts. The electrical lines may also be secured to the struts with clamping-type, wire-supporting clips.

The solar arrays are mounted to a rotary joint which provides 360° rotation capability perpencicular to the orbit plane. A 24° nodding capability is also provided to permit full sun illumination during all sun beta angles. A folding capability for orbit transfer is provided. The orientation of the solar array wings minimizes platform disturbance torque caused by solar pressures. Each solar array wing consists of four SEPS concept panels.

The battery power storage system, which is sized to provide continuous operation during the orbit eclipse periods, is packaged into three independent units. Each package of batteries includes battery chargers and controls, thermal control insulation and meteoroid protections, and its own heat-rejection radiator system. Each unit is a replaceable item.

The rotary joint provides for the power transfer from the power generation system to the platform through a slip ring assembly. Data and control signals between the central control processor and the power generation system is also transferred through the rotary joint via a dedicated slip ring assembly. The rotary joint, as a unit or subassembly, is attached to the platform structure via a berthing port. A power and data/control signal interface is also established at this joint.

A system module (Figure 1-4) containing the GN&C CMG's and sensor, the TT&C receivers, transmitters, antennas, etc., and a central data/signal processor is provided in a centrally located position on the platform. Thermal control, meteoroid protection, and heat-rejection radiator systems are provided as part of the module to support these systems

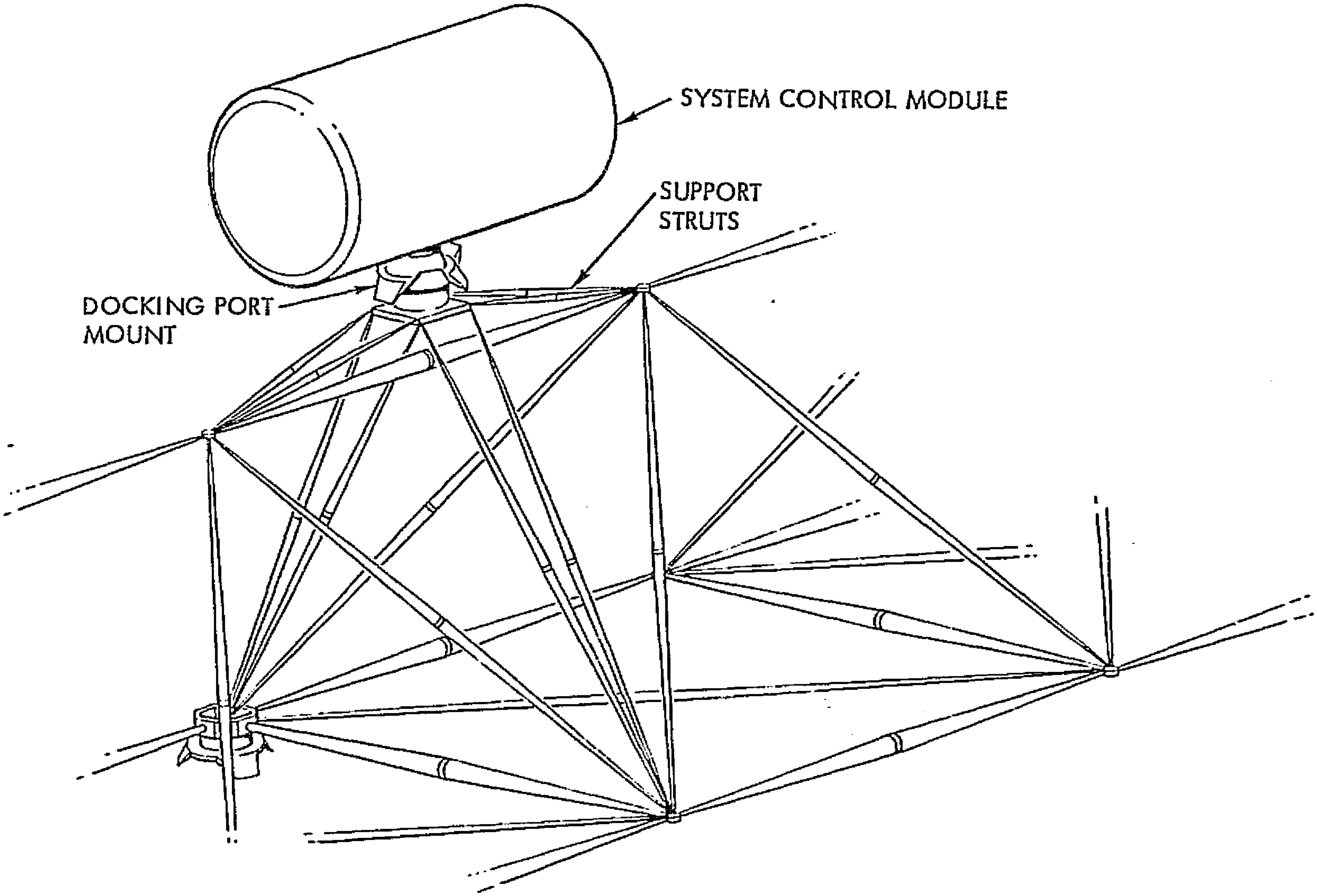


Figure 1-4. System Control Module Installation—Erectable Communications Platform

A communications message switching control unit is centrally located within the C-band antenna complex, and a similar unit is also centrally located within the K-band antenna complex.

The last items to be installed will be the orbit transfer propulsion modules (Figure 1-5). The propulsion modules attach to the supporting structure, utilizing berthing ports to effect the joint and to establish the lines interfaces. The five modules are arranged to permit an initial firing of three modules and staging to two modules. The three initial modules will be jettisoned during the staging operation. Both the initial and final stages will be aligned to thrust through the c.g. of the platform.

The complete platform less the propulsion modules has an estimated weight of 60,500 kg (133,400 lb).

A simplified representation of the construction strategy is shown in Figure 1-6.

A review of the design, construction scenario, and initial construction fixture concept resulted in the identification of 12 critical functions or operations as listed in Table 1-1. Since some of the operations (critical functions) were similar among the three projects, only one in each similar group was selected for further investigation. Table 1-2 is the result of this screening process for the Erectable Communication Platform project. These six operations are treated in Section II.

B. SPACE-FABRICATED ADVANCED COMMUNICATIONS PLATFORM

Many features of this configuration are similar if not identical to those of the erectable concept of the communications antenna platform. Consequently, this description will concentrate on those features that are unique to this concept. The general arrangement and major characteristics are presented in Figure 1-7.

This concept represents an antenna platform consisting of a space-fabricated structure, 133 kW of power, and a low-thrust, chemical-fueled orbit transfer system with a G&N CMG/RCS control system. The 16 antennas are arranged into two groups: (1) eight 4-6 GHz C-band receivers and transmitters, and (2) eight 12-14 GHz K-band receivers and transmitters. Growth capability for additional antennas is also provided.

During orbit transfer, the solar arrays are folded parallel to the longitudinal axis of the platform, which is also the direction of acceleration. The antenna horn and boom support are retracted during the orbit transfer mode. The reflector portion of the antenna remains in the deployed position, as shown in Figure 1-8.

The platform structure consists of members fabricated in orbit by a single beam builder and assembled by use of appropriate fixtures. The configuration is dictated by the reach envelope of the orbiter RMS, by the loads induced during orbit transfer, and by the required control stiffness. The individual beam configuration and the beam builder device are from the General Dynamics SCAFE study concepts.

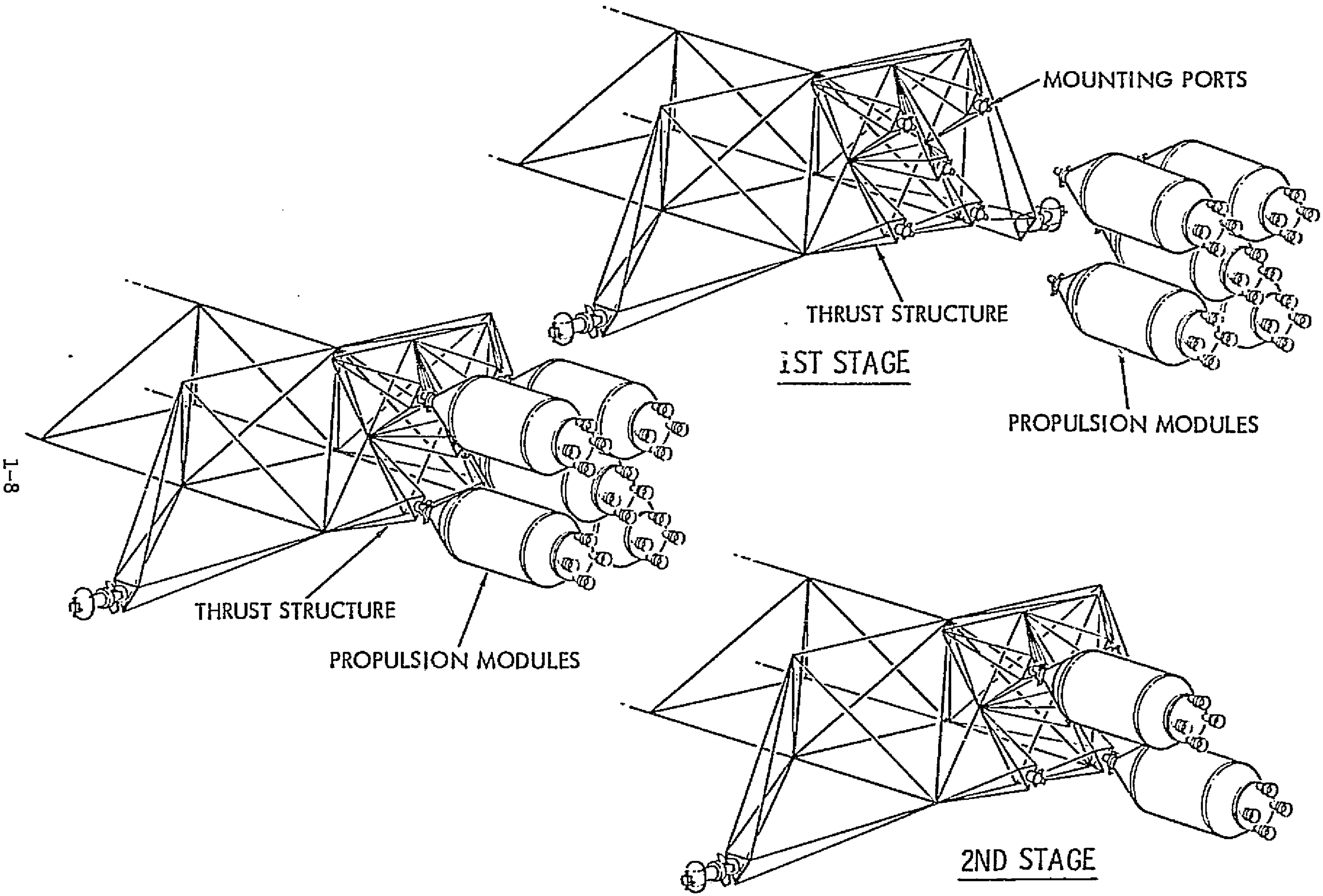


Figure 1-5. Thrust Structure—Erectable Communications Platform

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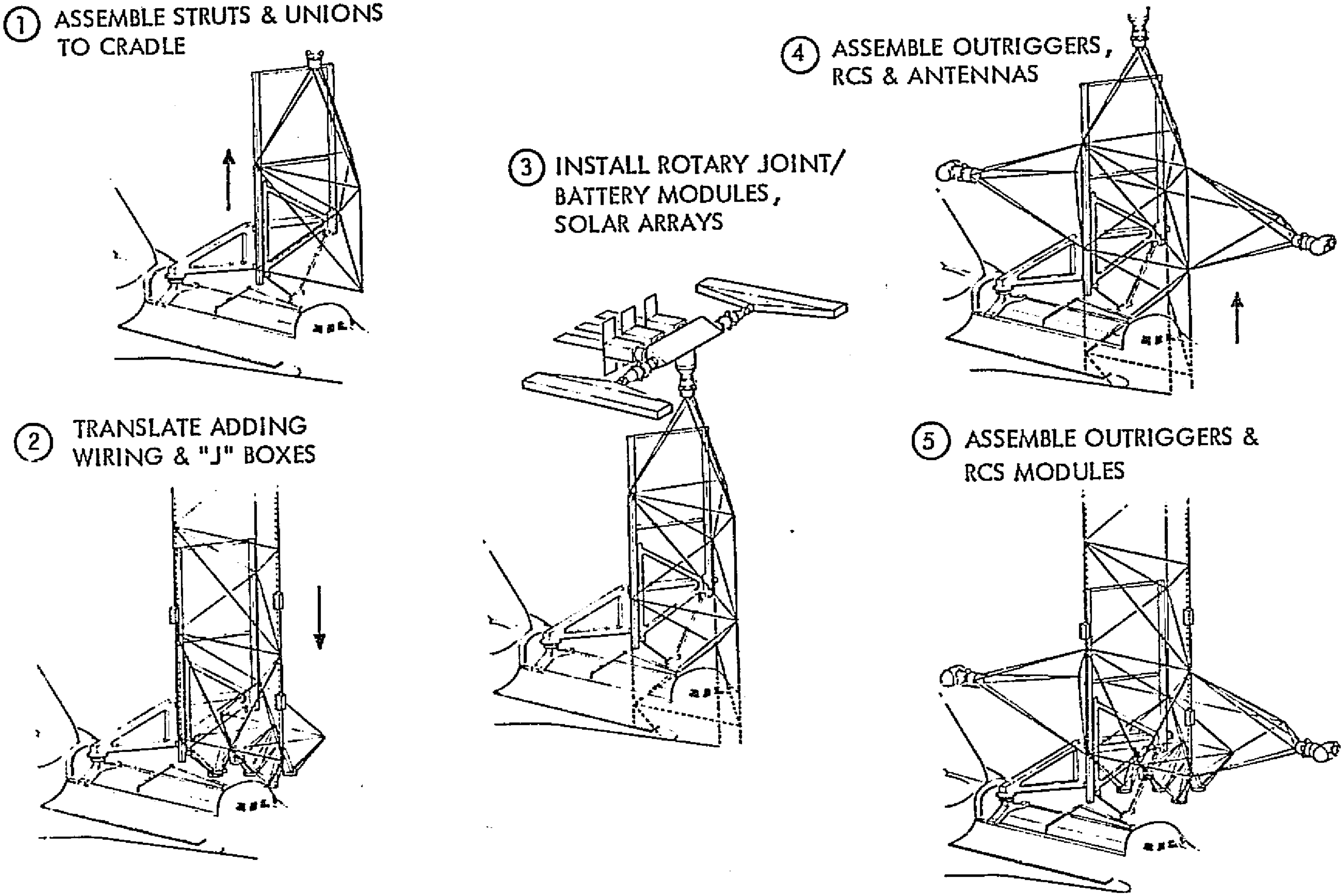

Figure 1-6. Construction Strategy—Erectable Communications Platform

Table 1-1. Erectable Communications Platform
Critical Construction Functions
(Original List)

1. How do we assemble struts and unions into structural assembly?
2. How do we install antenna docking adapter and supporting structure?
3. How do we assemble/install thrust structure?
4. How do we install wiring and J-boxes?
5. How do we install outrigger structure and RCS modules, including wiring and connections?
6. How do we make electrical connections between the solar panel assembly and the power distribution system?
7. How do we install the antennas?
8. How do we make electrical connections to antennas?
9. How (and when) do we install the system control module?
10. How do we measure and align antennas to structure?
11. How would be change-out (service) CMG's in GEO?
12. How do we align structure?

Table 1-2. Erectable Communications Platform
Operations (Critical Functions)

	Data Base Code Reference	
Join struts/unions into structural assembly Join antenna berthing port (moment joints)	02	0501.1
Join thrust structure to structure assembly	02	0501.2
Install outrigger struts, RCS modules, wiring, and connections	02	0601.1
Install wiring and junction boxes	02	0603.1
Change-out (service) CMG's in GEO	02	0804.1

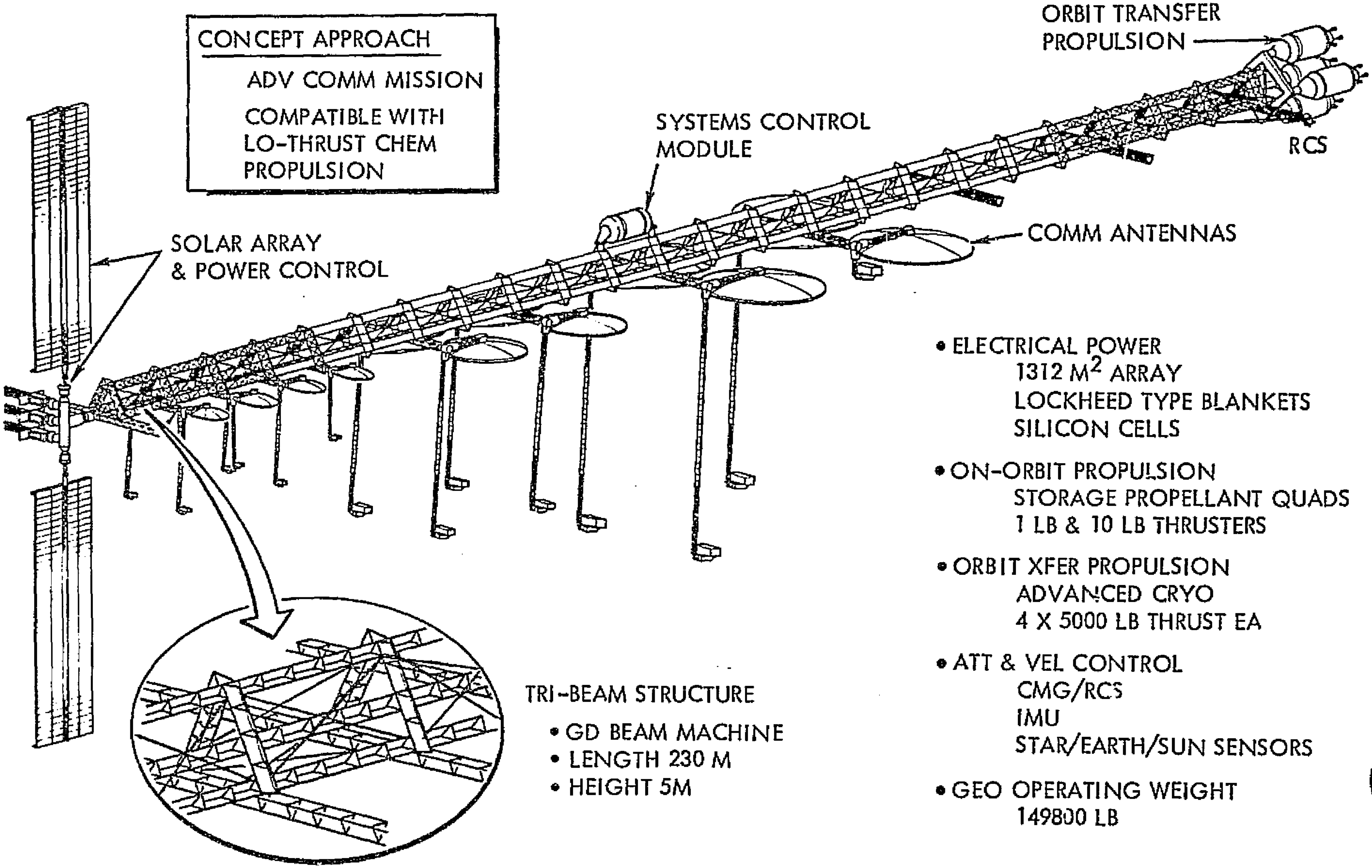

Figure 1-7. General Configuration—Space Fabricated Communications Platform

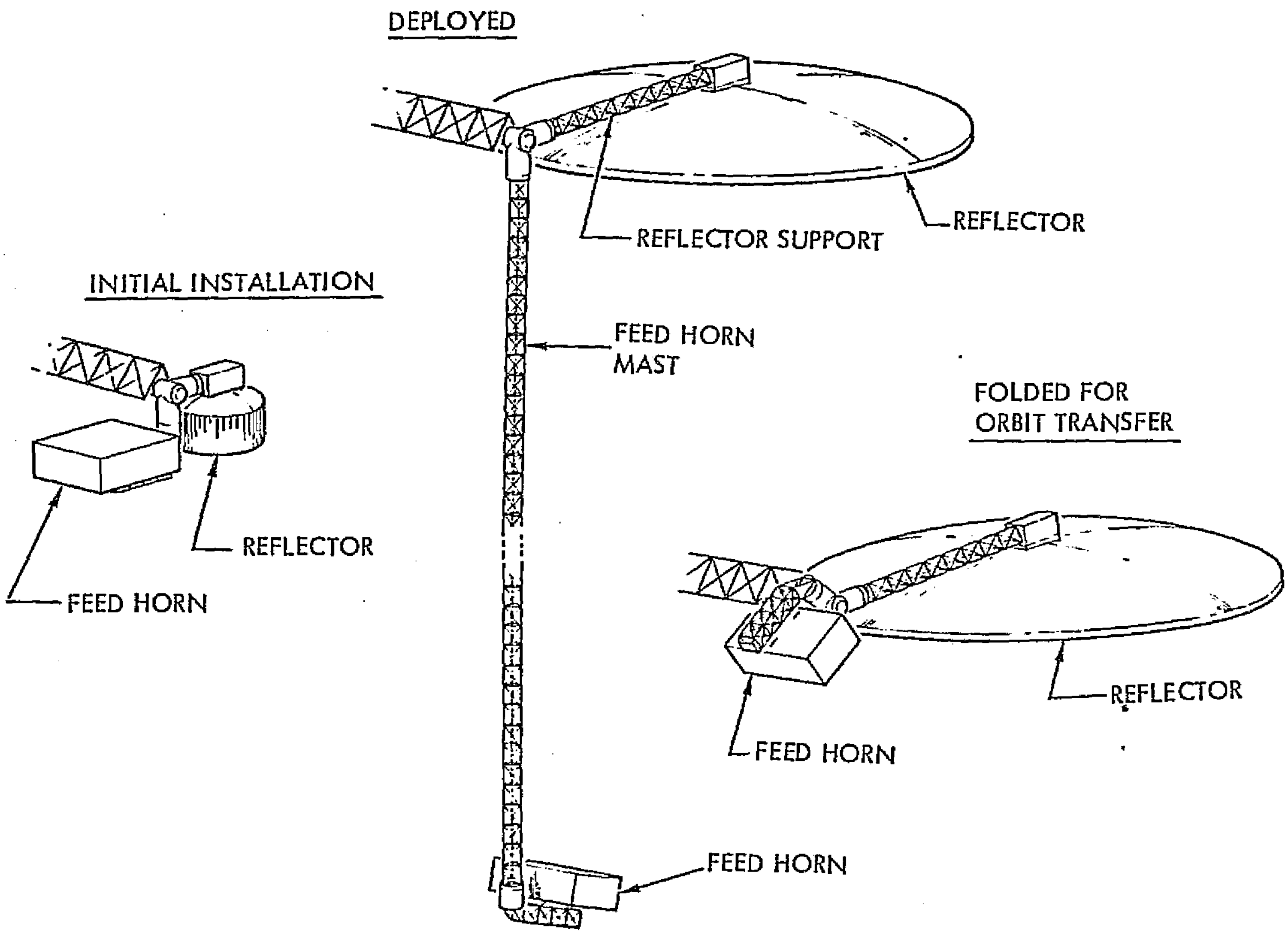

Figure 1-8. Antenna Installation—Space-Fabricated Communications Platform

The installation of the larger modular units utilizes the berthing port concept. The description of this installation concept is identical to that discussed for the erectable antenna platform concept.

Smaller units, such as the electrical junction boxes, will be secured to the structure with clamp-type devices that are compatible with the structural beam configuration and load capability.

The electrical lines are secured to the structure with special clips. The clips may require pre-punched holes in the post members of the beams.

The electrical power generation system (Figure 1-9) including the solar arrays and the power storage battery arrangement, and the rotary joint through which the electrical power is transmitted to the antennas and subsystems, are identical to the concept description for the erectable platform.

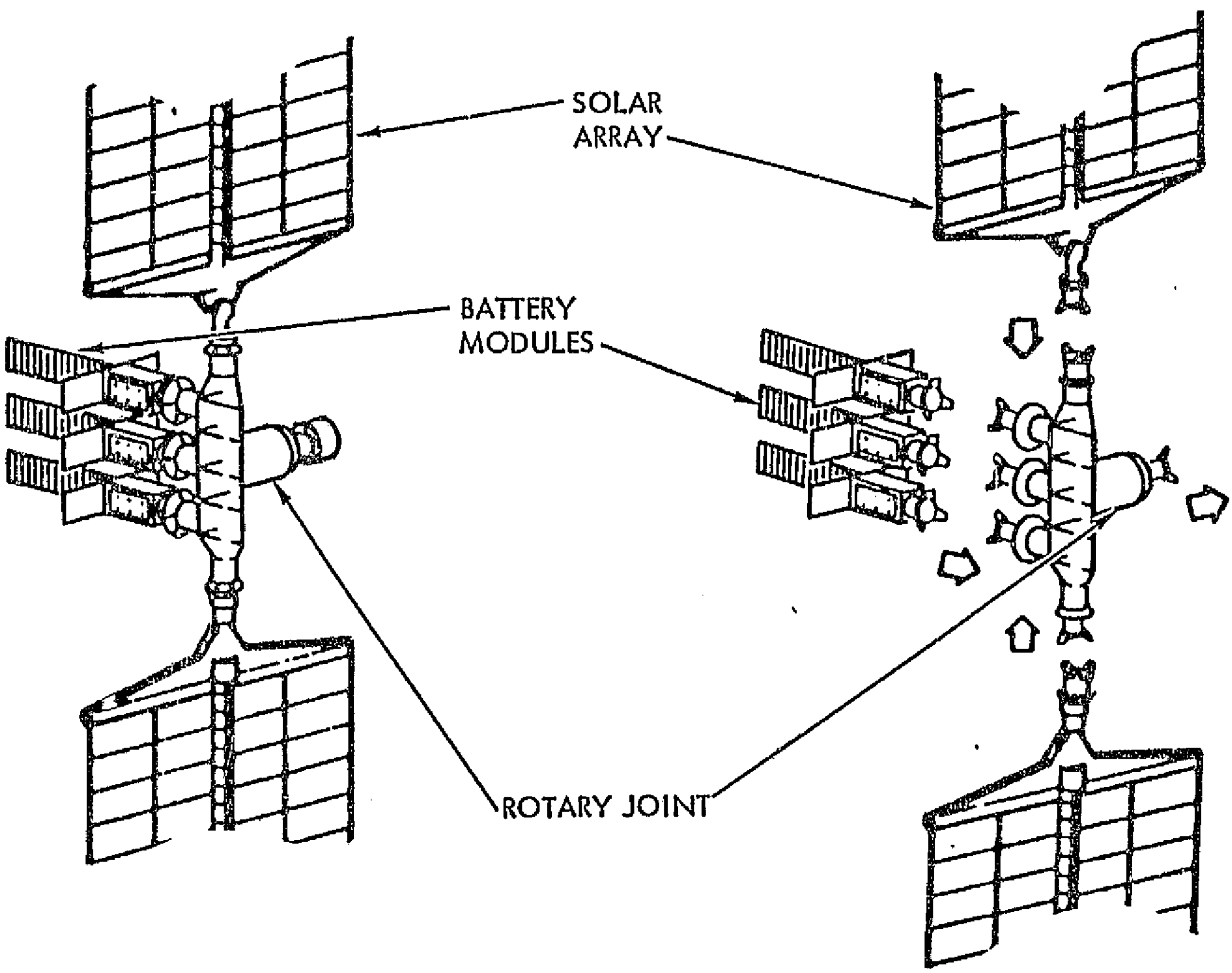

Figure 1-9. Solar Array/Battery/Rotary Joint Installation, Space-Fabricated Communications Platform

The systems module (Figure 1-10) contents and installation concept are identical to that of the erectable platform, as also is the communications message switching control units.

The last items to be installed will be the orbit transfer support structure and the orbit transfer propulsion modules. The support structure interfaces with the three longitudinal members of the platform structure by means of berthing ports. The propulsion modules attach to the supporting structure in the same manner (Figure 1-11).

The five modules are arranged to permit an initial firing of three modules and staging to two modules. The three initial modules will be jettisoned during the staging operation. Both the initial and final stages will be aligned to thrust through the c.g. of the platform.

The complete platform, less the propulsion modules, has an estimated weight of 61,000 kg (134,200 lb).

A simplified version of the construction strategy is shown in Figure 1-12.

A review of the design construction scenario and initial construction fixture concept resulted in the identification of 14 critical functions or operations as listed in Table 1-3. Since some of the operations (critical functions) were similar among the three projects, only one in each similar group was selected for further investigation. Table 1-4 is the result of this screening process for the Space-Fabricated Communications project. These 11 operations are treated in Section II.

C. SPS TEST ARTICLE

The general arrangement of the SPS test article is illustrated in Figure 1-13. This figure also lists the subsystems and the major component/descriptions of each of the subsystems that make up the project system. The configuration shown represents the LEO operational configuration. Figure 1-14 illustrates the orbit transfer and GEO operating configuration, showing the installed SEP modules used for orbit transfer.

The SPS microwave test article project is a "ladder" type structural arrangement utilizing space-fabricated beam members to which 25 solar blankets are attached. The ladder structure is an assembly of beams fabricated by a single beam builder in orbit. The beam configuration is that developed by the General Dynamics SCAFE study, with modifications as required, such as increased cap gauges and diagonal cord diameters. The structure configuration is dictated by the requirement for approximately 400 m^2 of solar array, and by the stiffness required for attitude control during operations in LEO and during orbit transfer. Consideration of the assembly fixture size and packaging concept also influenced the width of the configuration. The 20-m width selected is compatible with the solar blanket width of 4 m, thus permitting a five-blanket-wide arrangement. A control moment gyro/reaction control system (CMG/RCS) attitude control stationkeeping concept is incorporated. A system housing contains the CMG's, tracking, telemetry and control (TT&C), and power storage batteries with thermal control provided by a radiator and external

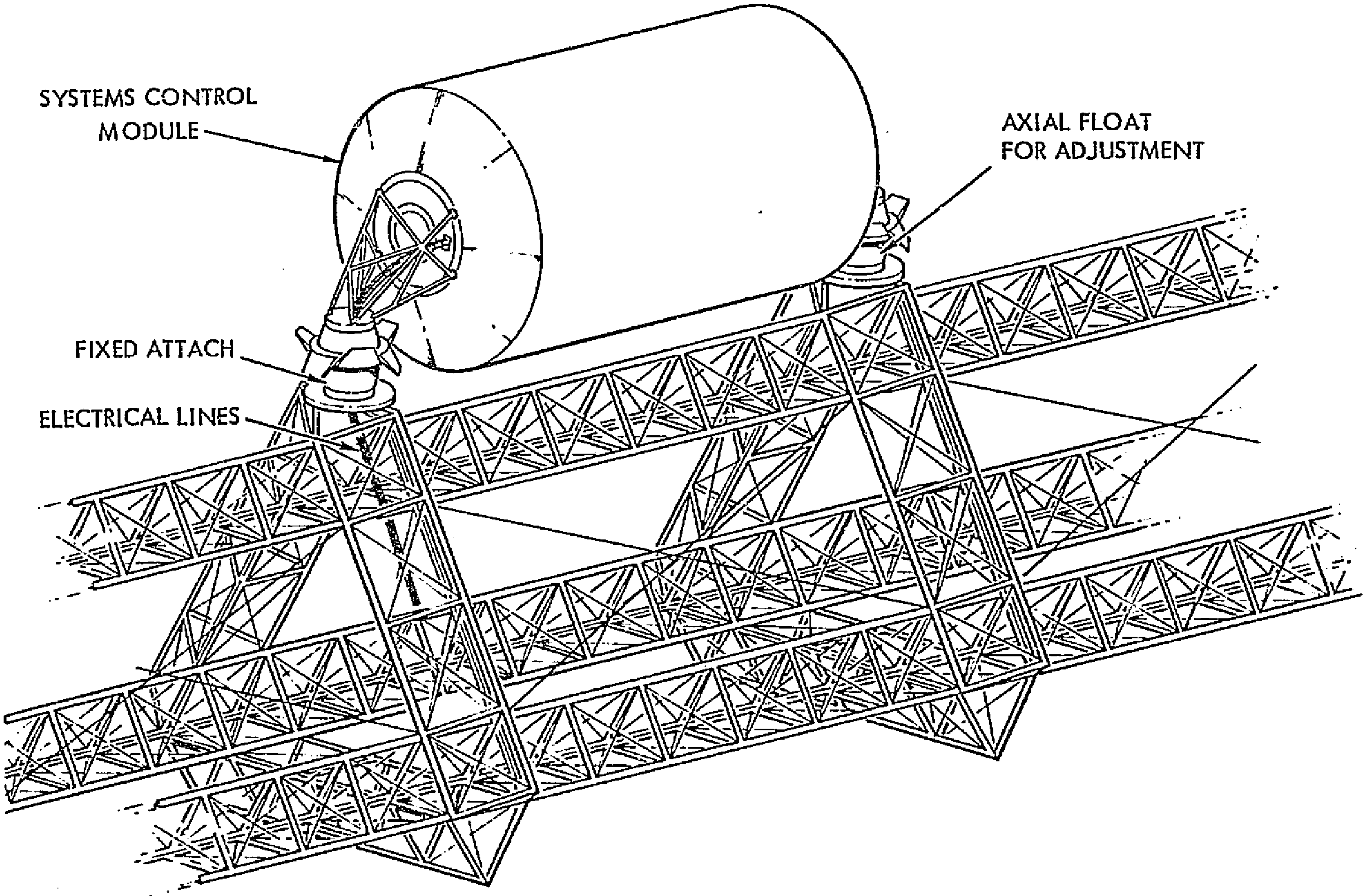

Figure 1-10. System Control Module Installation, Space-Fabricated Communications Platform

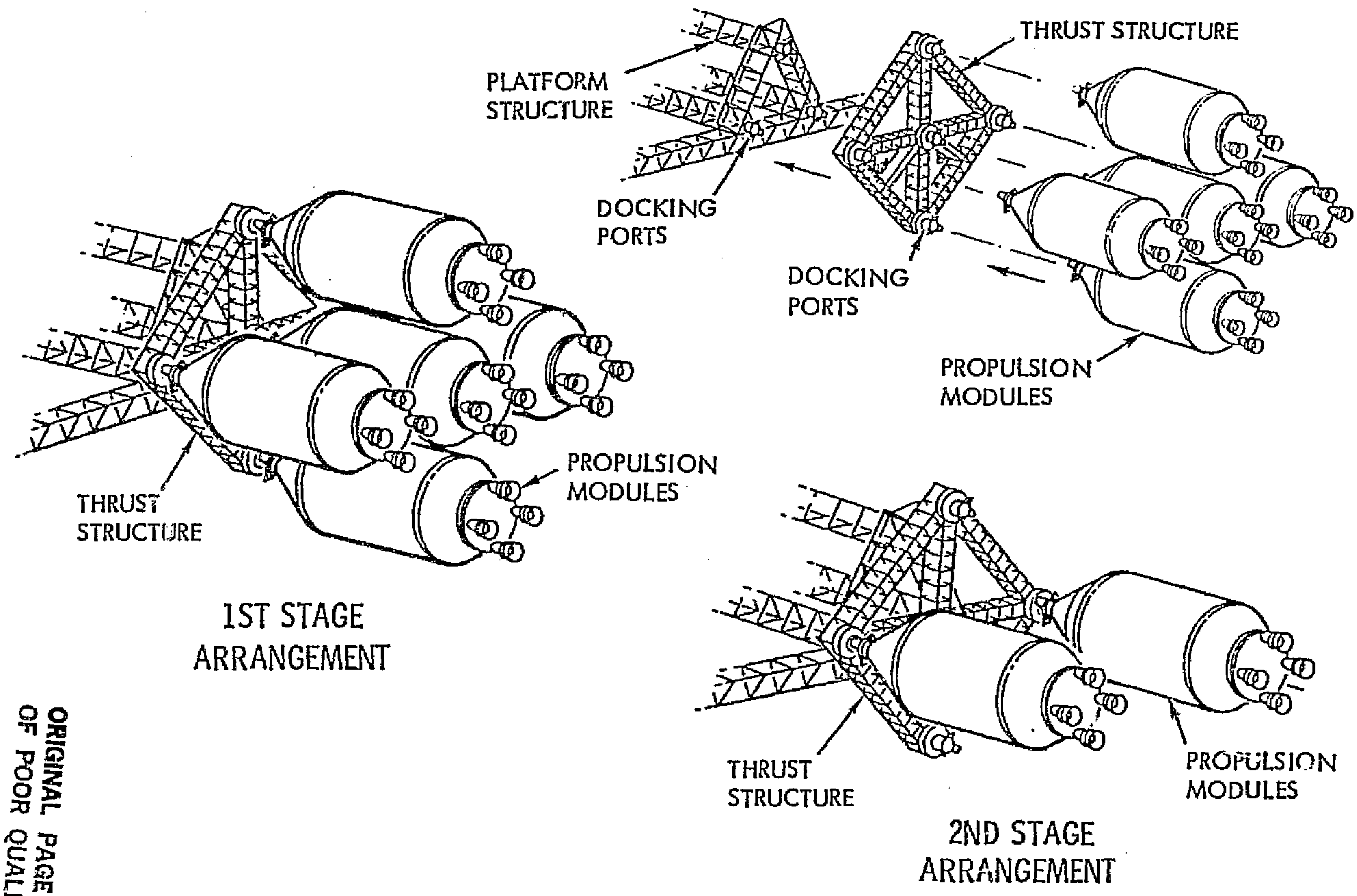

Figure 1-11. Thrust Structure, Space-Fabricated Communications Platform

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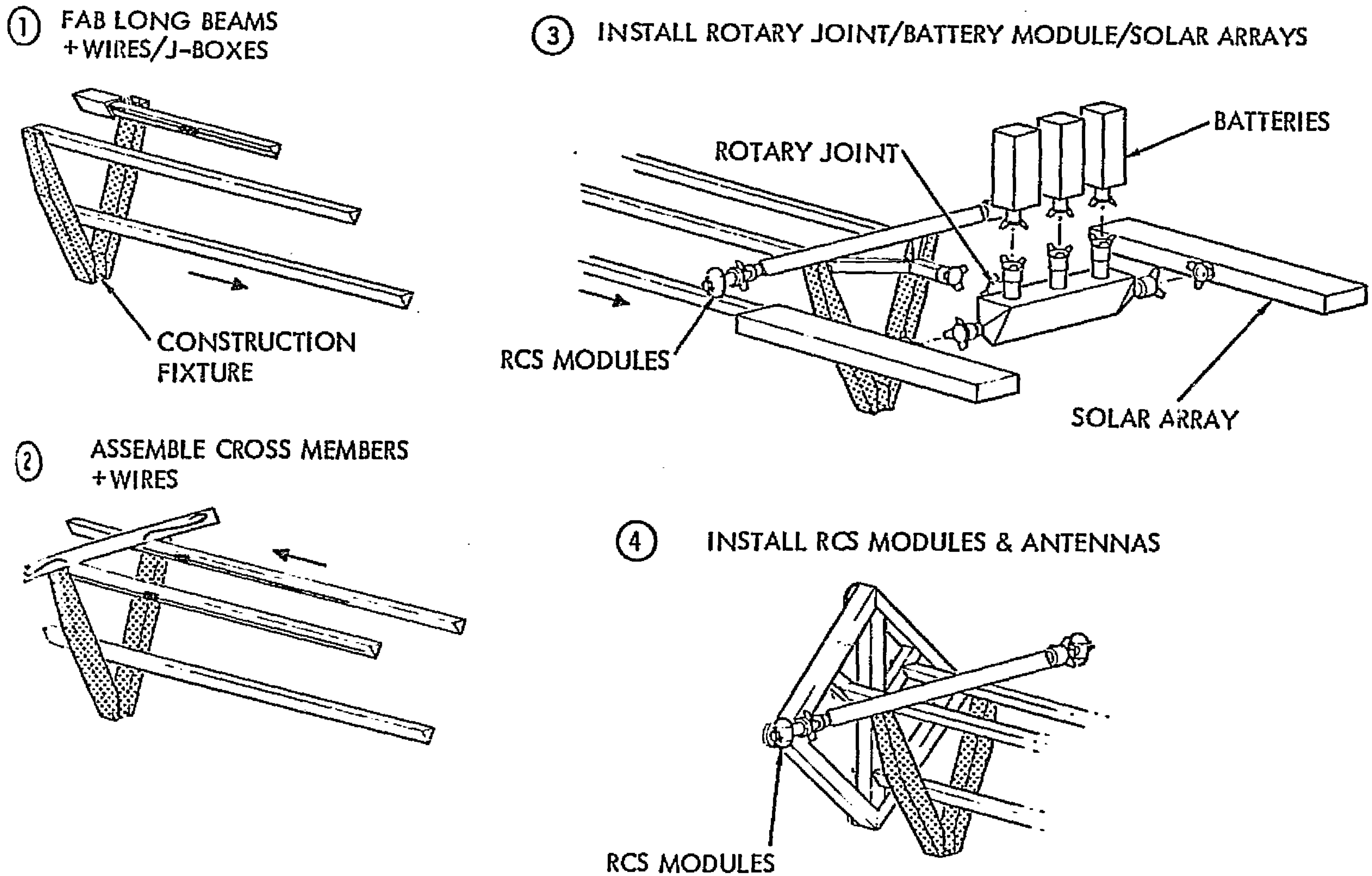


Figure 1-12. Construction Strategy, Space-Fabricated Communications Platform

Table 1-3. Space-Fabricated Communications Platform Critical Construction Functions (Original List)

1. How do we retain longitudinal beams as they are fabricated?
2. How do we transport long X-beams into position for welding?
3. How do we make electrical connection from X-beams to J-boxes?
4. How do we remove beam machine assembly from assembly fixture and install in cargo bay?
5. How do we install solar panel assembly?
6. How do we install the antennas?
7. How do we make electrical connections to antennas?
8. How do we assure satisfactory alignment of antennas?
9. How do we install the system control module?
10. How do we install the thrust structure?
11. How do we assure structural accuracy?
12. How do we service antenna in GEO?
13. How do we install electrical lines on X-beams?
14. How do we install structural cross-bracing wires?

Table 1-4. Space-Fabricated Communications Platform Operations (Critical Functions)

	Data Base Code Ref.	
Transport beams into position for welding	01	0301.1
Join thrust structure assembly to platform	01	0501.2
Install structural cross-bracing wires to primary structure	01	0601.1
Install electrical lines on longitudinal and cross-beams	01	0603.1
Install system control module	01	0604.1
Install antennas	01	0604.3
Electrical connection of cross-beams wiring to J-box	01	0703.1
Electrical connection of antennas	01	0704.1
Structural alignment	01	0901.1
Checkout of electrical power generation, storage and distribution system	01	0903.1
Antenna alignment	01	0904.1

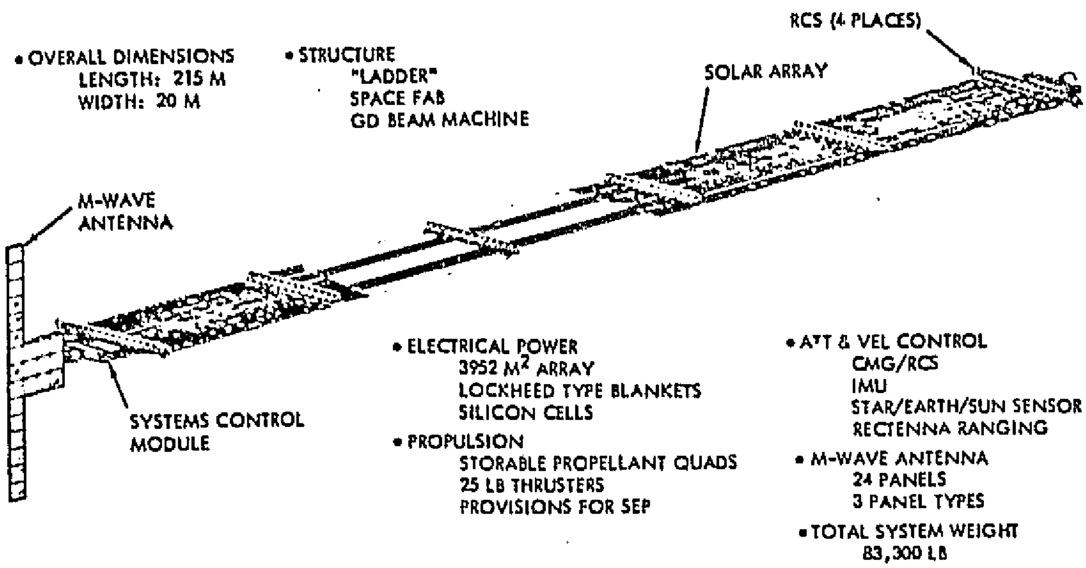


Figure 1-13. SPS Test Article General Arrangement, LEO Configuration

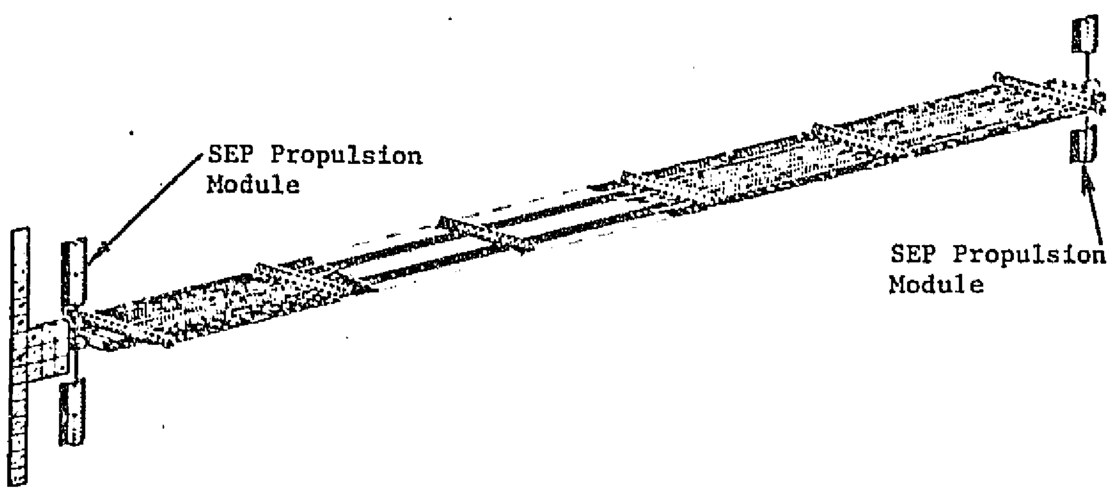


Figure 1-14. SPS Test Article GEO Configuration

insulation. Micrometeoroid protection is also incorporated. A rotary joint provides the connection between the solar array power generation system and the microwave test antenna (Figure 1-15). The microwave test antenna can be replaced with other test articles if so desired.

For orbit transfer, solar electric modules (Figure 1-16) are installed on both ends of the solar array structure. The SEP modules are installed on rotary joints. Consequently, another rotary joint is required at the end of the solar array structure opposite from the microwave antenna in order to accept the SEP modules at this location. This represents the system configuration in GEO.

All of the larger modular items such as the RCS modules and the systems housing are attached to the structure via berthing ports. The berthing port concept is the three-petal, neuter concept baselined for the Shuttle orbiter. Because all of the berthing activities are accomplished by using the orbiter remote manipulator system (RMS), no velocity attenuation system is required. Structural latches are provided only on the mating model. This permits a final checkout of the active latching system on the ground and immediately before assembly in orbit. A utilities interface is provided at each berthing port and each interface will be unique to its particular utilities requirements.

Smaller units, such as the electrical junction boxes and the solar blanket switching boxes (Figure 1-17), will be secured to the structure with clamp-type devices that are compatible with the structural beam configuration and load capability. The clamping devices that secure the solar array switching boxes also provide the attachments for the individual solar array blankets.

Electrical lines are secured to the structure with special clips. The clips may require pre-punched holes in the post members of the fabricated beams.

The systems housing which contains the electrical power storage batteries and controls, the CMG's, the TT&C equipment, and the heat-rejection radiator is also the structural bridge that provides the structural interface between the solar array structure and the rotary joint to which the microwave antenna is attached. The housing will also be provided with thermal control insulation and meteoroid protection. A similar structural bridge at the opposite end of the solar array structure provides the support for the rotary joint and solar electric propulsion modules used for orbit transfer. No other system components are included in this bridge structure.

The solar array consists of 25 solar blankets. Each blanket is attached to the transverse beams of the structure. The attachment is provided with clamp-type fittings to which the solar blankets are attached at three places along the 4-m width of the blanket. Power leads will plug into individual switching boxes. From each of the switch gear boxes, power lines will run along the longitudinal beams to interface with the systems housing and continue on to the power slip ring of the rotary joing. This arrangement provides voltage control to each of the 25 blankets.

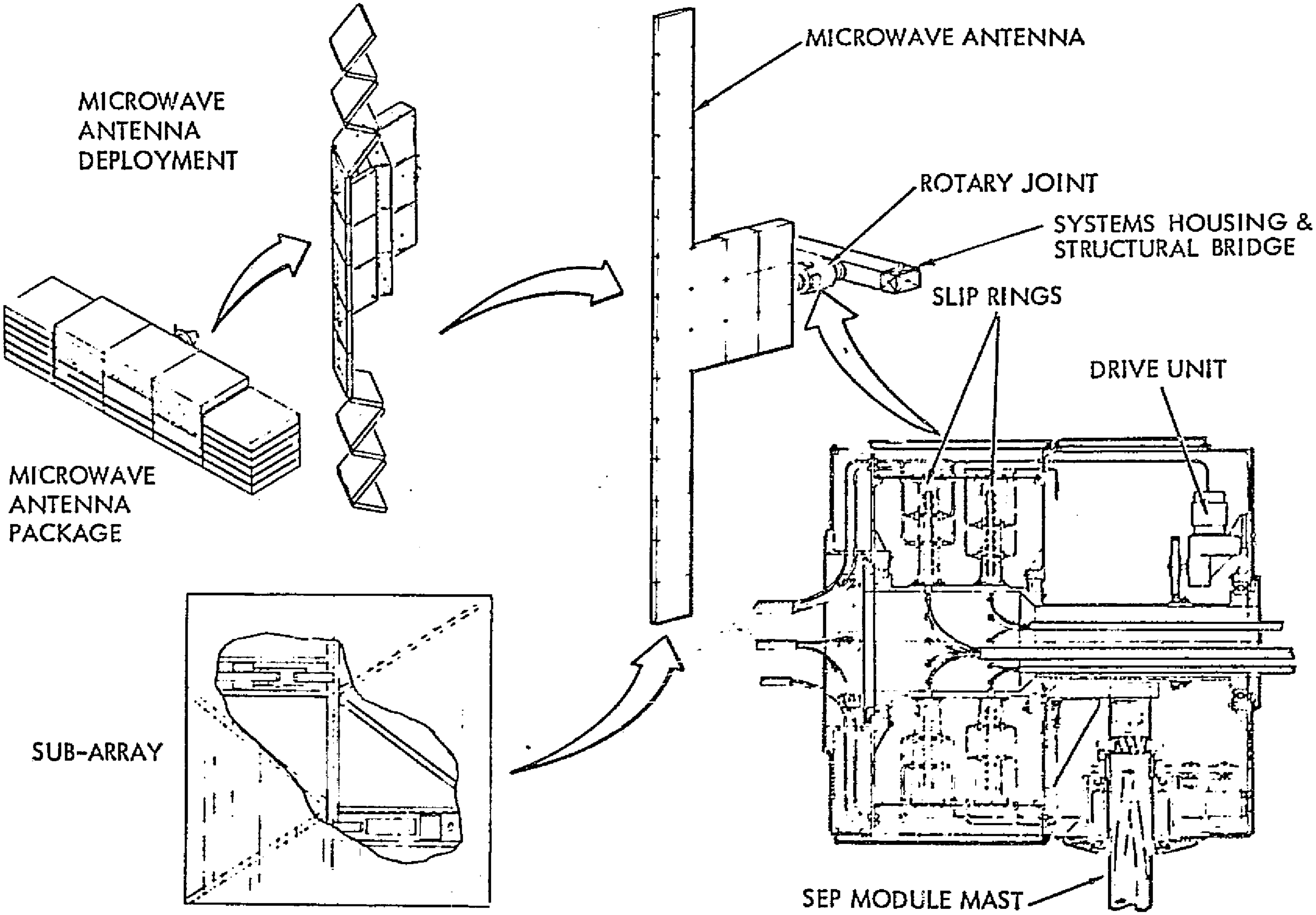


Figure 1-15. Microwave Antenna Configuration

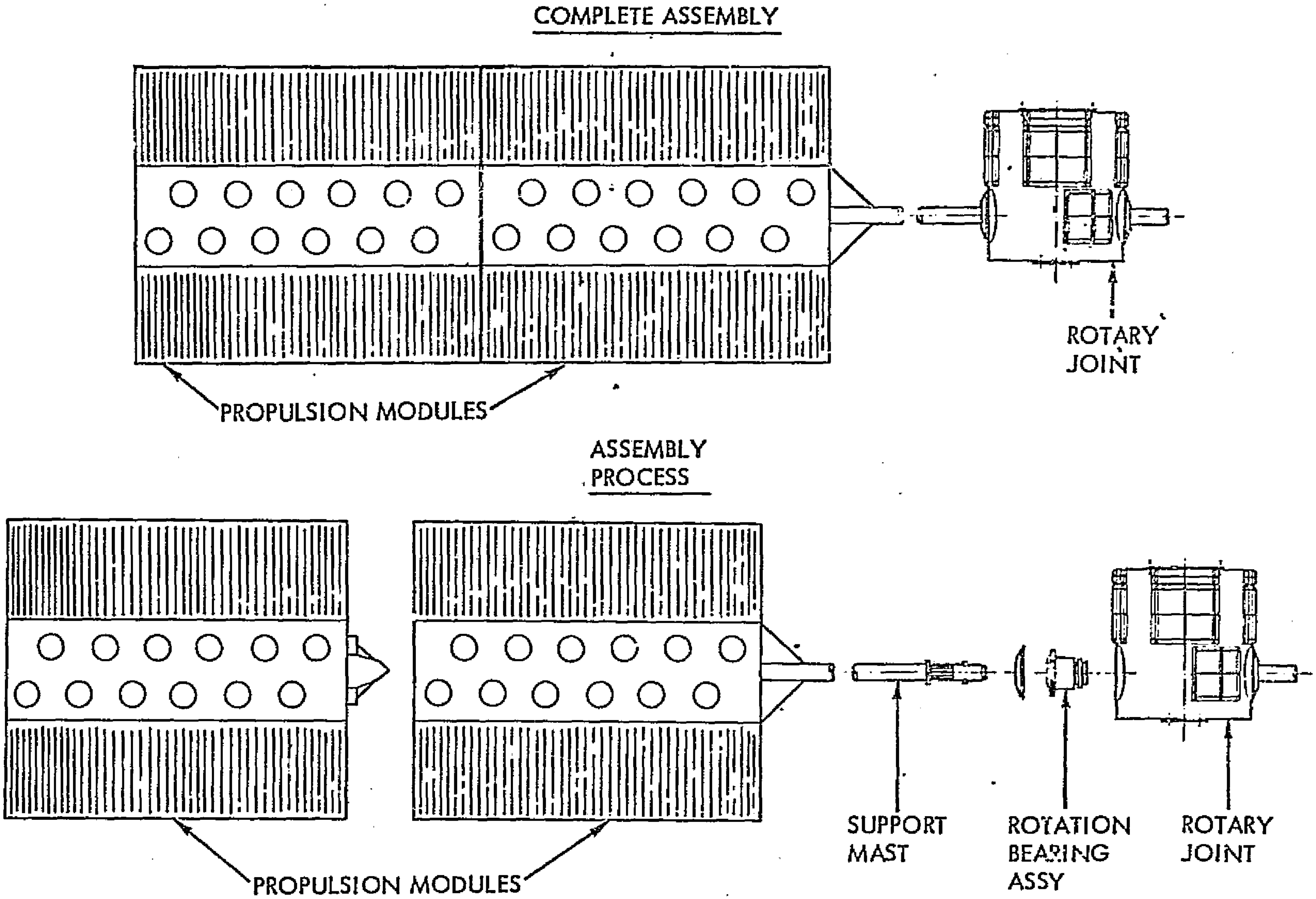


Figure 1-16. SEP Installation, SPS Test Article

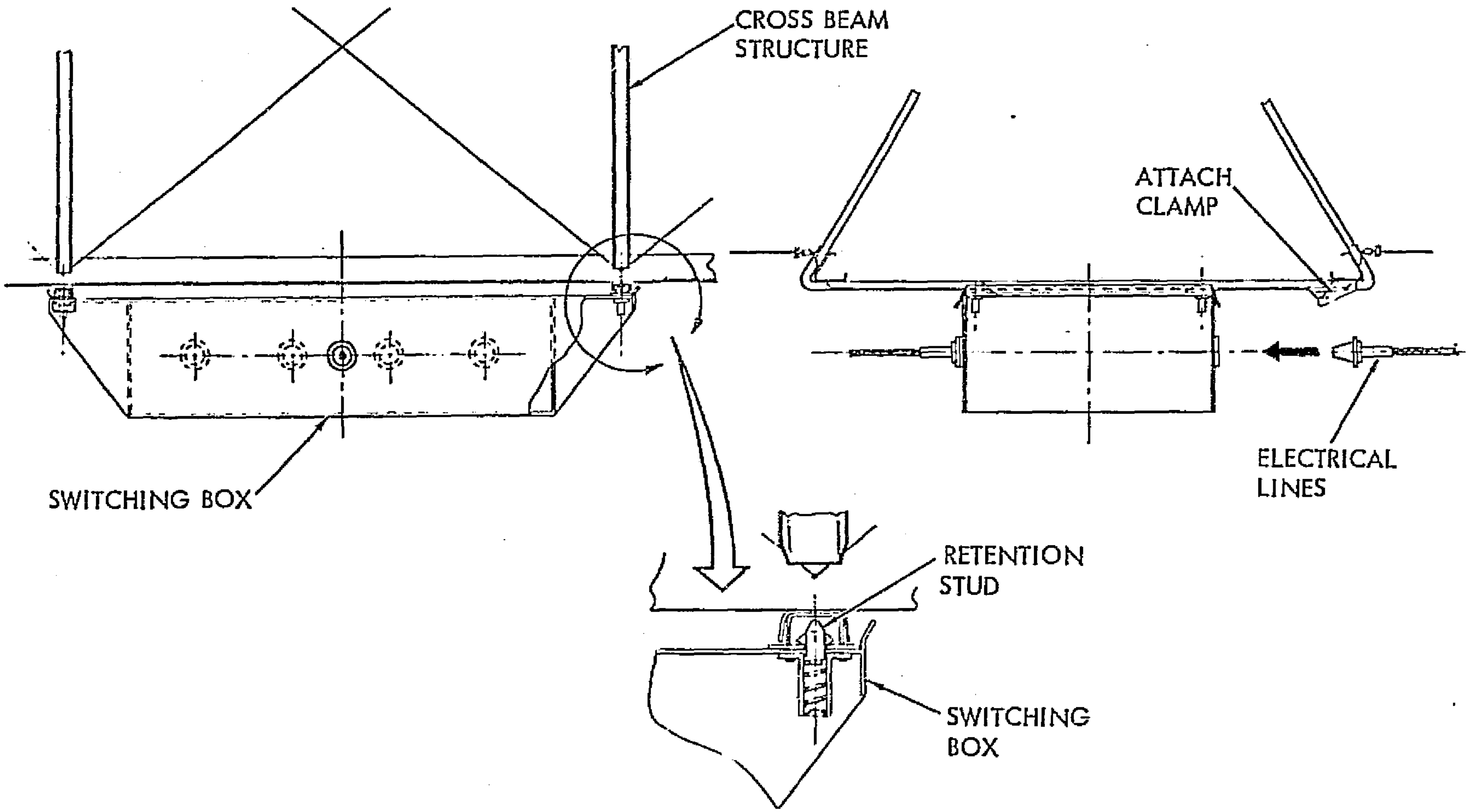


Figure 1-17. Solar Array Switching Boxes Installation, SPS Test Article

The rotary joint provides one degree of freedom rotation between the solar array and the microwave antenna. It also provides the support for the Solar Electric Propulsion (SEP) modules. A slip ring assembly within the rotary joint provides the electrical power transfer across the rotary joint, and a second slip ring assembly provides for the transfer of data and control signals. The rotary joint as a unit is attached to the systems housing via a berthing port. An electrical power and data/control signal interface is established at this port. A berthing port also is provided on the other end of the rotary joint unit to accept the microwave test antenna or other test articles if desired.

When GEO operations are desired, then—and only then—will the SEP modules be installed. Each module consists of 12 engines and their controls and propellant. Each of four modules contains a mounting post which is designed to plug into the rotary joints making the structural attachment as well as the electrical power and data/control connections. Two additional modules are mounted to two of the module/post configurations to make two 24-engine clusters which are required at the microwave antenna end of the SPS microwave test article. The rotary joint required at the other end of the solar array structure will also only be installed when the orbit transfer mode is desired.

The estimated weight of the SPS microwave test article in the LEO operational configuration is 37,800 kg (83,160 lb). The orbit transfer configuration estimated weight is 49,200 kg (108,250 lb).

The microwave antenna is considered as the initial payload item for the SPS flight test article. It would probably be replaced by another payload for subsequent operations at GEO after the initial microwave testing effort.

The microwave test antenna is composed of 24 subarray panels. Each panel is approximately 3 m^2, but their internal arrangement differs depending on their test function.

The 15 A-panels constitute the phase control function of the test. The panel is approximately 3 m^2 by 0.4 m deep. It contains two 1-kW klystrons which excite 16 waveguides on one half, and 17 on the other half, of the subarray. The waveguides are soft-mounted to the panel frame to minimize thermal expansion effects. Two receiving elements which receive signals from the trailing antenna are located along one edge of the subarray panel. The heat-rejection radiator is located on the surface opposite the microwave radiating waveguides.

Eight B-panels are configured for the thermal phase of the test. Sixteen klystrons are utilized in this panel for the purpose of thermal testing. Five of the panels require additional structure for packaging purposes.

One center panel, (C), of the thermal test portion of the antenna is configured to obtain a heat flux comparable to that anticipated for the SPS transmitting antenna. This panel contains 121 1-kW klystrons within the same 3-m^2 panel. The depth of the panel is 1.1 m, which is sized to accommodate the klystrons. Additional heat-rejection radiator surface may be required for this unique panel.

The total antenna assembly is folded for transport to the LEO operating altitude. The total package is installed on a berthing port located on the end of the rotary joint of the solar array assembly. The antenna is deployed into the using configuration only after the antenna has been secured to the rotary joint.

The estimated weight of the antenna assembly is 9140 kg (20,110 lb).

A simplified construction strategy for the entire test article is shown in Figure 1-18.

A review of the design construction scenario and initial construction fixture concept resulted in the identification of 10 critical functions or operations as listed in Table 1-5. Since some of the operations (critical functions) were similar among the three projects, only one in each similar group was selected for further investigation. Table 1-6 is the result of this screening process for the SPS Test Article project. These five operations are treated in Section II.

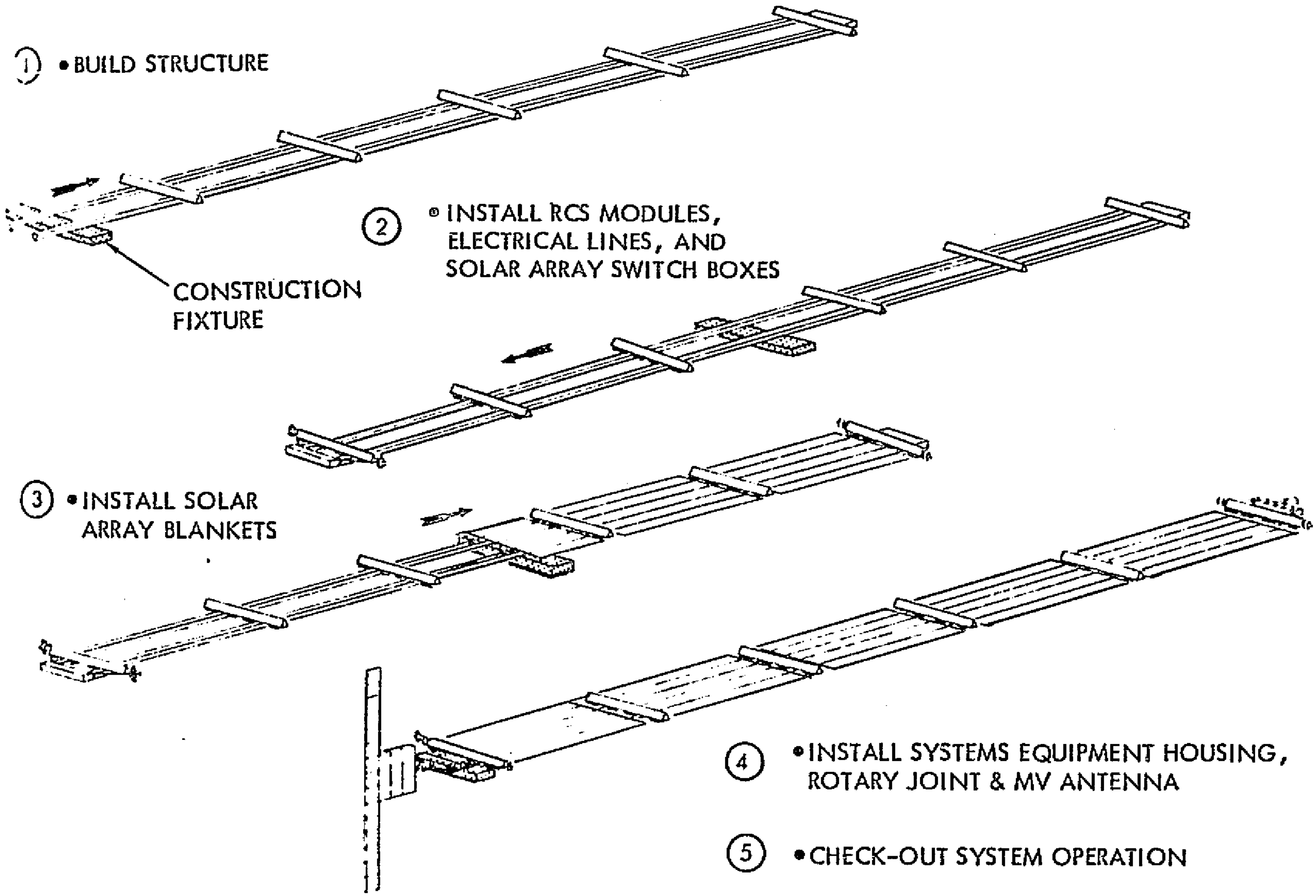


Figure 1-18. Construction Strategy, SPS Test Article

Table 1-5. SPS Test Article Critical Construction Function (Original List)

1. How do we install RCS Modules?
2. How do we install RCS docking adapters on X-beams?
3. How do we install beam attachment devices ("straps") and EPD switching boxes to beams?
4. How do we install system support housing?
5. How do we install power lines on longitudinal beams?
6. How do we install solar blankets?
7. How do we install microwave antenna?
8. How do we install SEP assembly at conclusion of microwave antenna test?
9. How do we install rotary joint?
10. How do we make electrical connection to RCS?

Table 1-6. SPS Test Article Operations (Critical Functions)

	Data Base Code Ref.
Join berthing ports to end of longitudinal and cross-beams	01 0501.1
Join attach fittings to beams for switch boxes and solar array support	01 0501.3
Install RCS modules	01 0604.2
Install SEP modules	01 0604.4
Install solar array blankets	01 0605.1

SECTION II

CONSTRUCTION METHODS

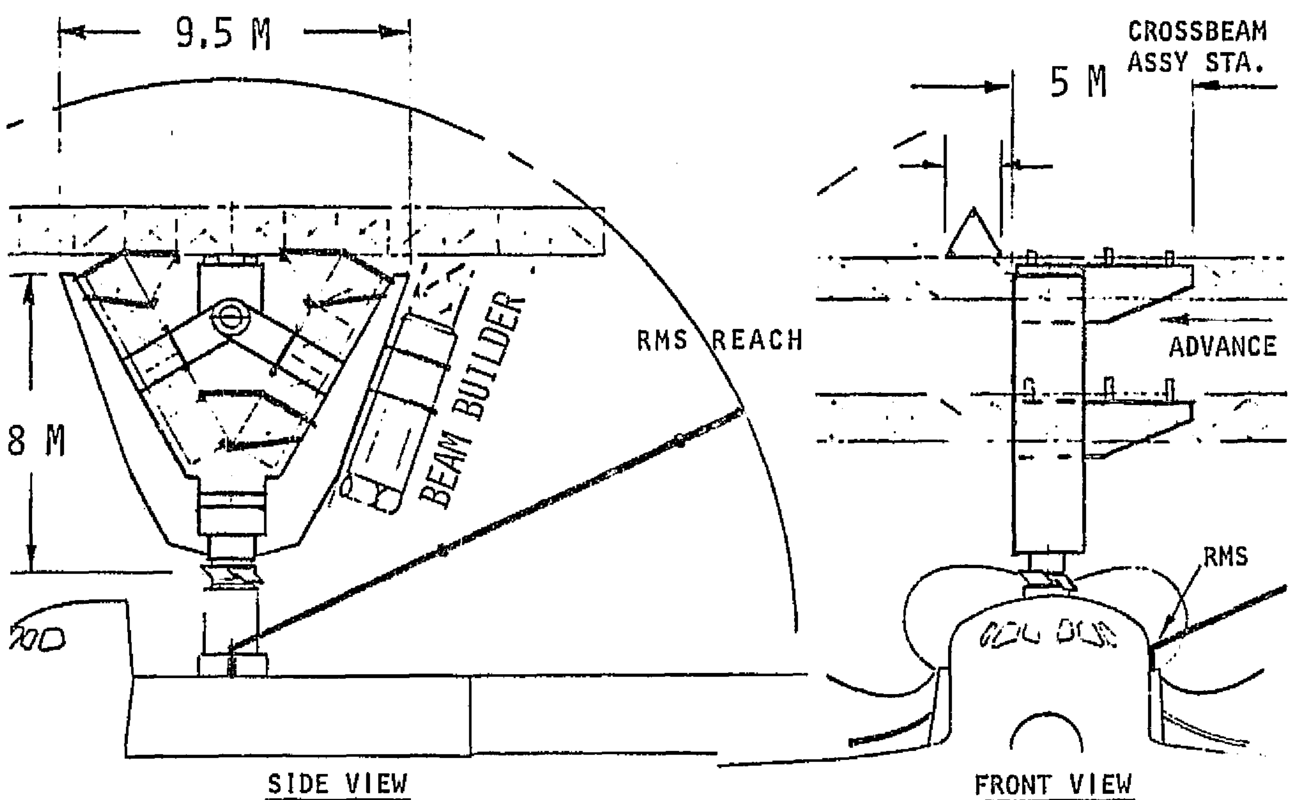
This section is comprised of 22 operation methods packages. The lists of these operations can be found in Tables 1-2, 1-4, and 1-6 of Section I. For most of the operations, several alternate methods to accomplish each have been described. The more viable or representative have been detailed. Each of the methods has been assigned a unique code number. This code is explained in Figure 1 of the Introduction to this document. In the event that further information on any of the data is desired, the following list identifies the responsible project engineer for each of the operations. The Rockwell Seal Beach telephone number is 213/594 and the four-digit extension. If any of the engineers listed below cannot be reached, please contact R. E. Cook, extension 3127, or A. Stefan; extension 3582.

Operations Project Engineers

Code		Subject	Engineer	Extension
01	0301.1	Transport Beams	A. Le Fever	3634
01	0501.1	Joint Berthing Ports	P. Buck	3658
01	0501.2	Joint Thrust Structure	R. Hart	3237
01	0501.3	Install Solar Array Fittings	P. Buck	
01	0601.1	Install Cross-Bracing Wires	R. Hart	
01	0603.1	Install Electrical Lines	A. Le Fever	
01	0604.1	Install System Control Module	R. Hart	
01	0604.2	Install RCS Module	P. Buck	
01	0604.3	Install Antenna Module	R. Hart	
01	0604.4	Install SEPS Panels	R. Thompson	3237
01	0605.1	Install Solar Blankets	P. Buck	
01	0703.1	Connect Cross/Long Beam Wiring	A. Le Fever	
01	0704.1	Elect. Connect. Antenna Module	A. Le Fever	
01	0901.1	Align Tri-Beam Structure	R. Hart	
01	0903.1	Elect. Wire Checkout	W. Fredrickson	
01	0904.1	Align Antenna Module	R. Hart	
02	0501.1	Join Struts, Unions, and Berthing Ports	R. Thompson	
02	0501.2	Join Thrust Structure to Platform	R. Thompson	
02	0601.1	Install RCS	R. Thompson	
02	0603.1	Install Wiring and J-Boxes	R. Thompson	
02	0804.1	Service CMG's	R. Cook	

No formal page numbers have been assigned to the remainder of Section II. Page numbers have been omitted on the data package sheets presented in this section to facilitate the addition of new data. The code numbers and individual page numbers for each method have been used for this version of the book and can be used for all future versions to order the data.

FUNCTION ·	TRANSPORT	CODE	01	03 01.1	00
ITEM ·	CROSS AND TRANSVERSE BEAMS	PAGE	1 of 3		
METHOD					
SUBJECT	OPERATION IDENTIFICATION				



Project System

Space-fabricated advanced communications platform

Operation

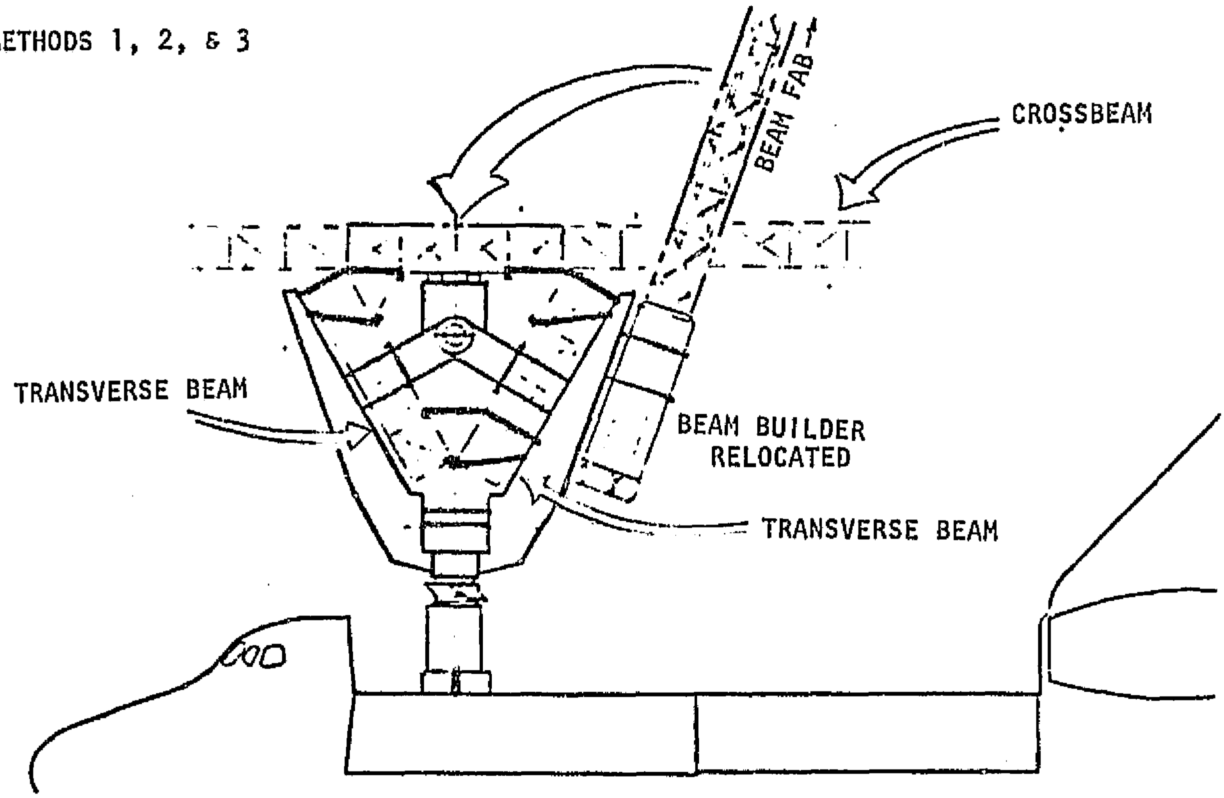
Transport the cross and transverse beams from the beam builder to the assembly station for joining to the longitudinal beams.

Physical Situation

The three longitudinal beams have been fabricated. The RMS has free reach capability inside the triangular structure, but limited reach over the upper area. The beam machine has been relocated to the side of the construction fixture.

FUNCTION ·	TRANSPORT	CODE	01	03 01.1	00
ITEM ·	CROSS AND TRANSVERSE BEAMS				
METHOD		PAGE	2 of 3		
SUBJECT	ALTERNATE METHODS				

METHODS 1, 2, & 3



The following methods have been identified:

Beam builder is relocated to the side of the construction fixture for beam fabrication for Methods 1, 2 and 3.

Manual

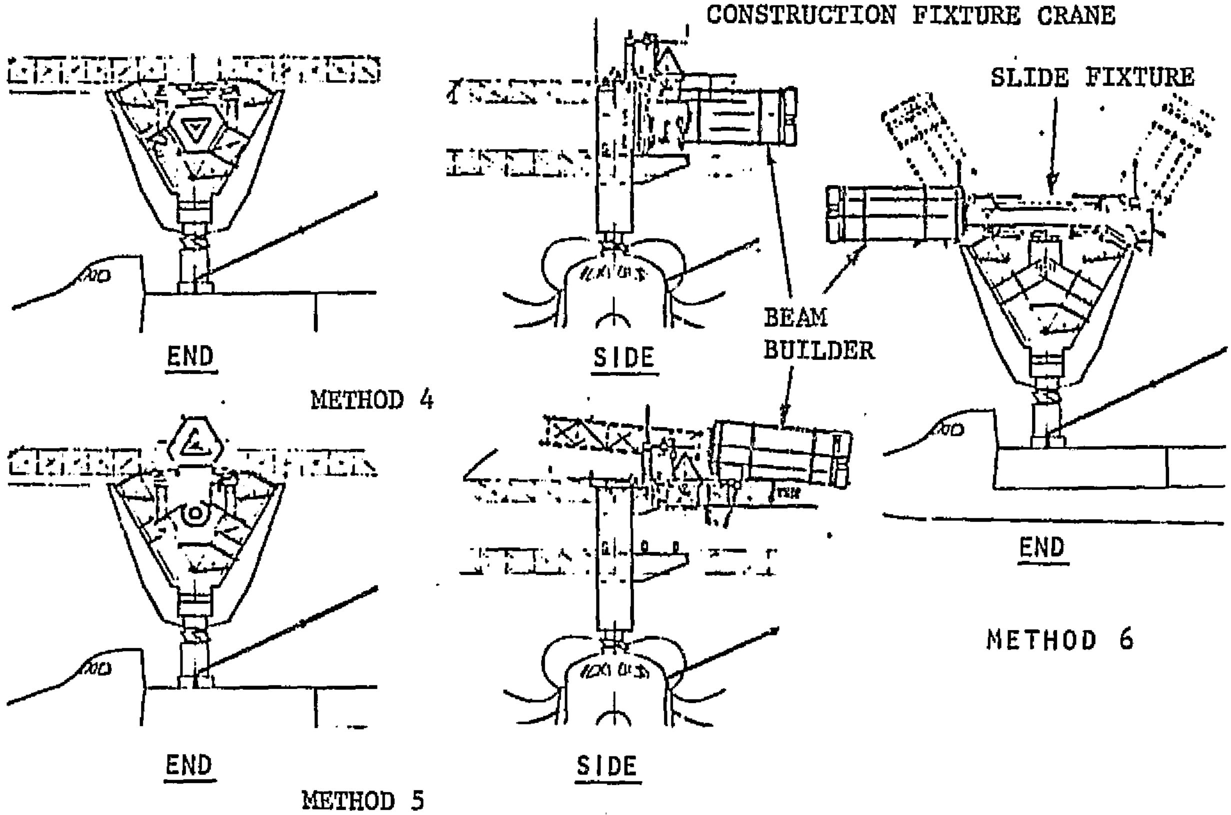
1. An EVA operator transports the three beams from the fabrication station to the assembly station with an MMU.

2. An EVA operator transports the three beams with a cherry picker on the RMS.

Automatic

3. Beams are transported by the RMS.

FUNCTION · TRANSPORT	CODE	01	03 01.1	00
ITEM · CROSS AND TRANSVERSE BEAMS				
METHOD	PAGE	3 of 3		
SUBJECT ALTERNATE METHODS (CONT.)				



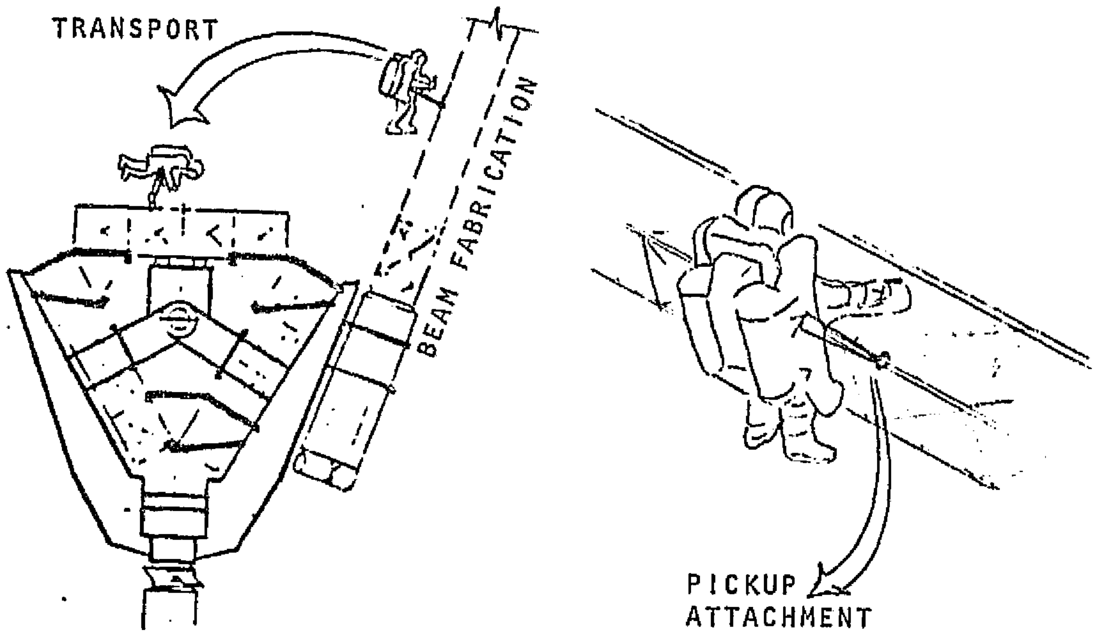
4. Beam builder is fixed at center and transportation is made by a construction fixture crane.

5. Beam builder is positioned at the vertical position and slightly tilted upward to avoid previously installed cross beam. Transport is made by the RMS.

6. Beam builder is relocated onto a slide fixture across the top of the construction fixture. Beams are fabricated in position so that no extra transport is required.

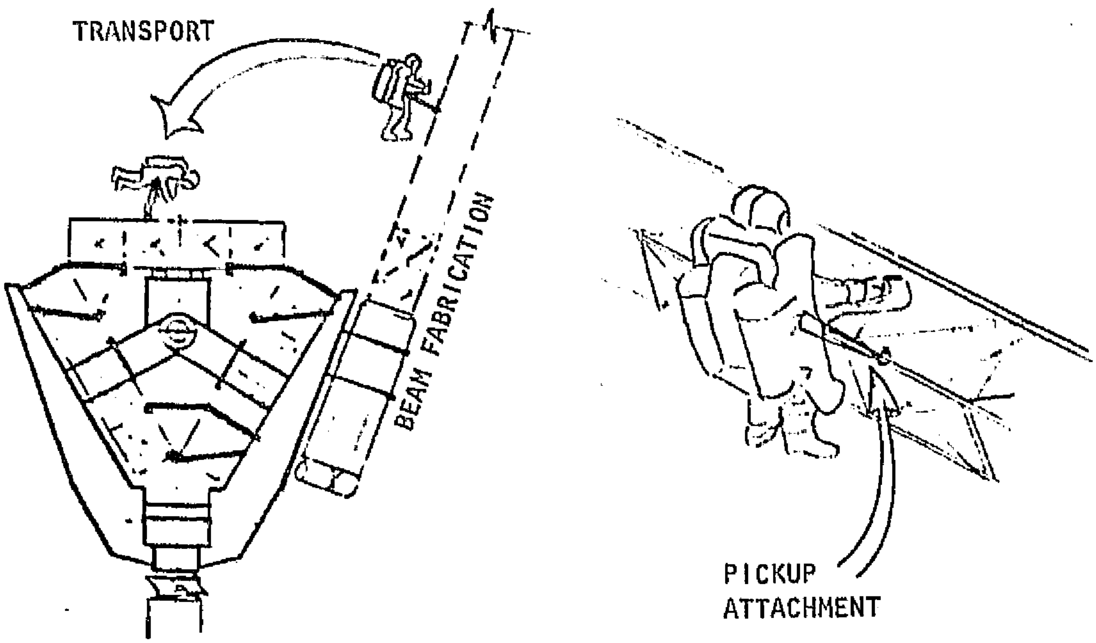
Methods 1, 2, 3, and 4 are detailed.

FUNCTION	TRANSPORT	CODE	01	03 01.1	02.1
ITEM	CROSS AND TRANSVERSE BEAMS	PAGE	1 of 5		
METHOD	EVA/MMU				
SUBJECT	METHOD DESCRIPTION				



The MMU operator attaches to the fabricated beam and transports each one in turn to the two sides and the top. The operator locates the beams into the beam positioners and, when captured, releases his attachment. The beam is then welded into place.

FUNCTION· ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	02.1
METHOD	EVA/MMU	PAGE	2 of 5		
SUBJECT	OPERATIONS				



Manpower

One EVA/MMU operator

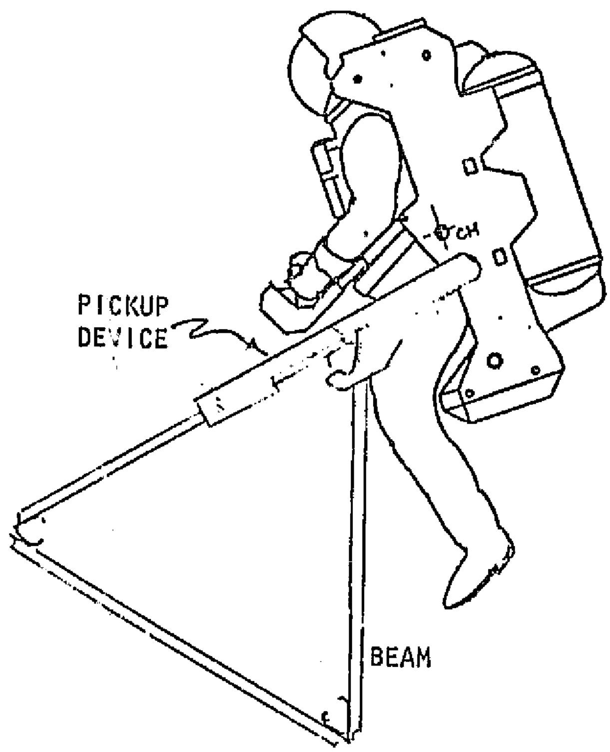
Activity Time

	(Minutes)	
Attachment	4	
Transportation	7	
Positioning	4	
Relocation to BB	2	
Total	17	(each beam)

Support Activity

Recharge MMU after workshift.

FUNCTION	TRANSPORT	CODE	01	03 01.1	02.1
ITEM	CROSS AND TRANSVERSE BEAMS				
METHOD	EVA/MMU	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- MMU
- Beam pickup device

Crew

One EVA/MMU operator

Power

MMU recharge—TBD

Lighting and TV

Standard MMU

Computer Software

None

Stowage

Beam pickup device—1×0.2×0.3 m

Other

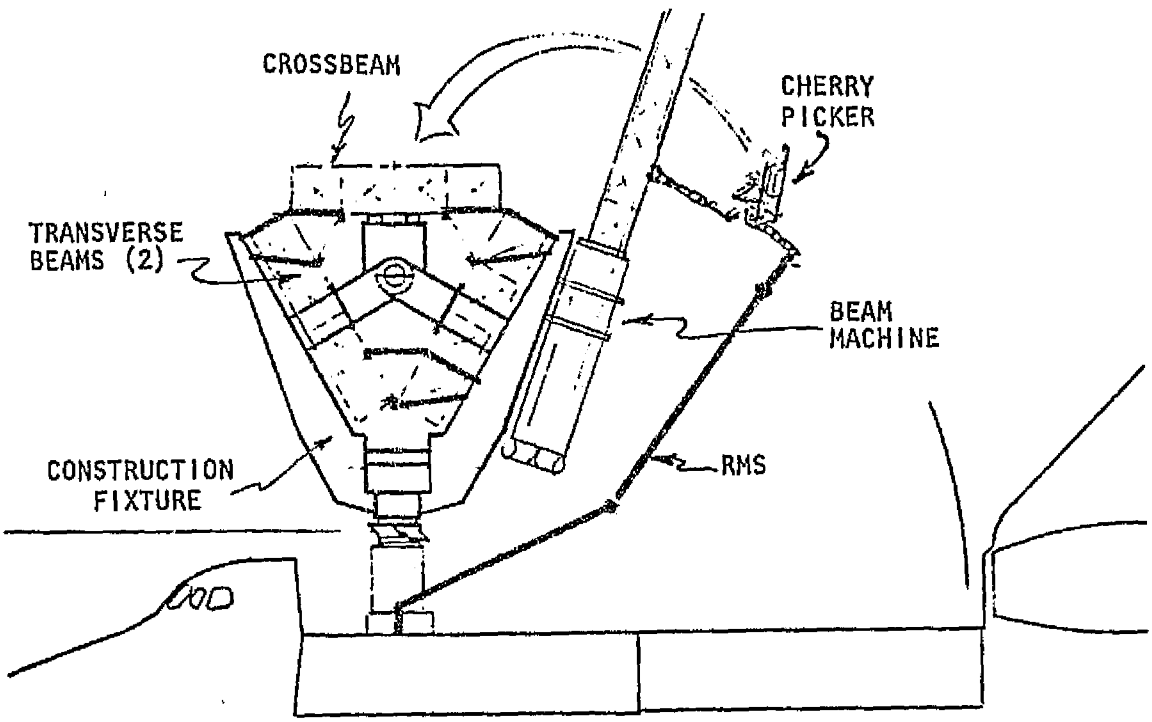
MMU propulsion recharge

FUNCTION	TRANSPORT	CODE	01	03 01.1	02.1
ITEM	CROSS AND TRANSVERSE BEAMS				
METHOD	EVA/MMU	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
MMU	110	1.1	–	TBD	TBD	–	100
Beam pickup device	15	0.1	–	TBD	TBD	–	523
Support Services							
Crew	–	–	1/1	–	–	–	–
Power	–	–	–	TBD	TBD	–	–
GN_2 propellant	TBD	TBD	–	–	–	–	TBD
Project Modification							
None	0	0	–	–	–	–	0
Operations	–	–	1/1	–	–	17	NA*

*Not appropriate, see page 6.

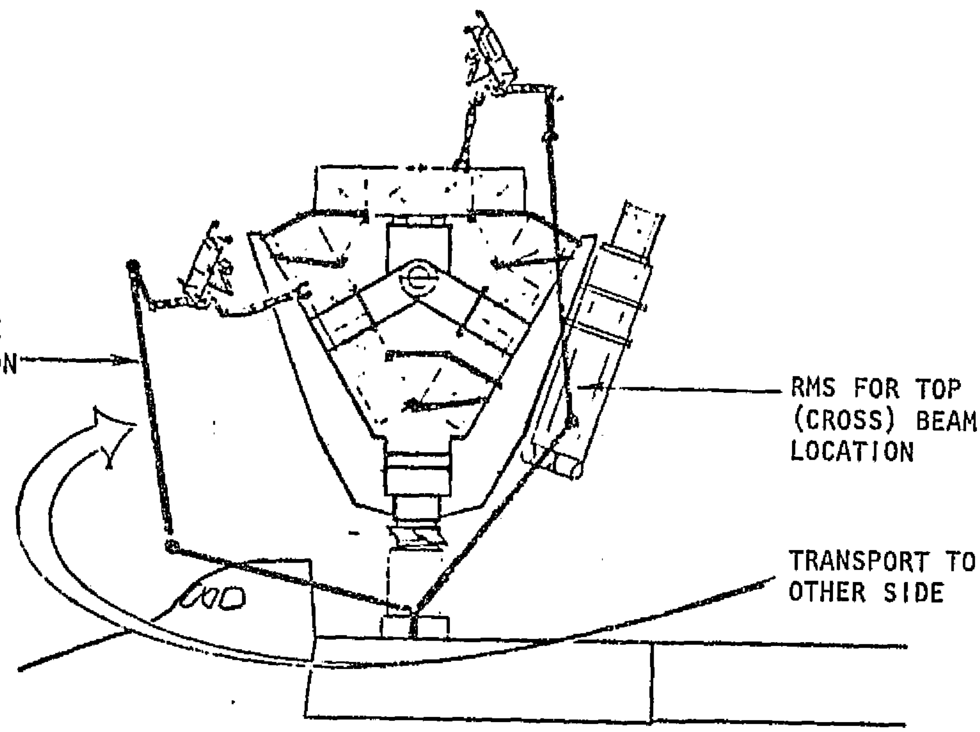
FUNCTION· ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	03.1
METHOD	CHERRY PICKER	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



Cherry picker operator attaches to the fabricated cross or transverse beam and transports each one in turn to the two sides and the top. The operator locates the beams into the beam positioners and, when captured, releases his attachment.

Transportation to the far side beam station requires maneuvering underneath the extended tri-beam, below the 3.7 m clearance line.

FUNCTION · ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	03.1
METHOD	CHERRY PICKER	PAGE	2 of 5		
SUBJECT	OPERATIONS				



Manpower

Cherry picker operator

Activity Time

	(Minutes)
Pickup cherry picker	(15)
Attachment	5
Transportation	3
Positioning	4
Relocation to BB	2
Transport to opposite side	5
Total average each beam	19

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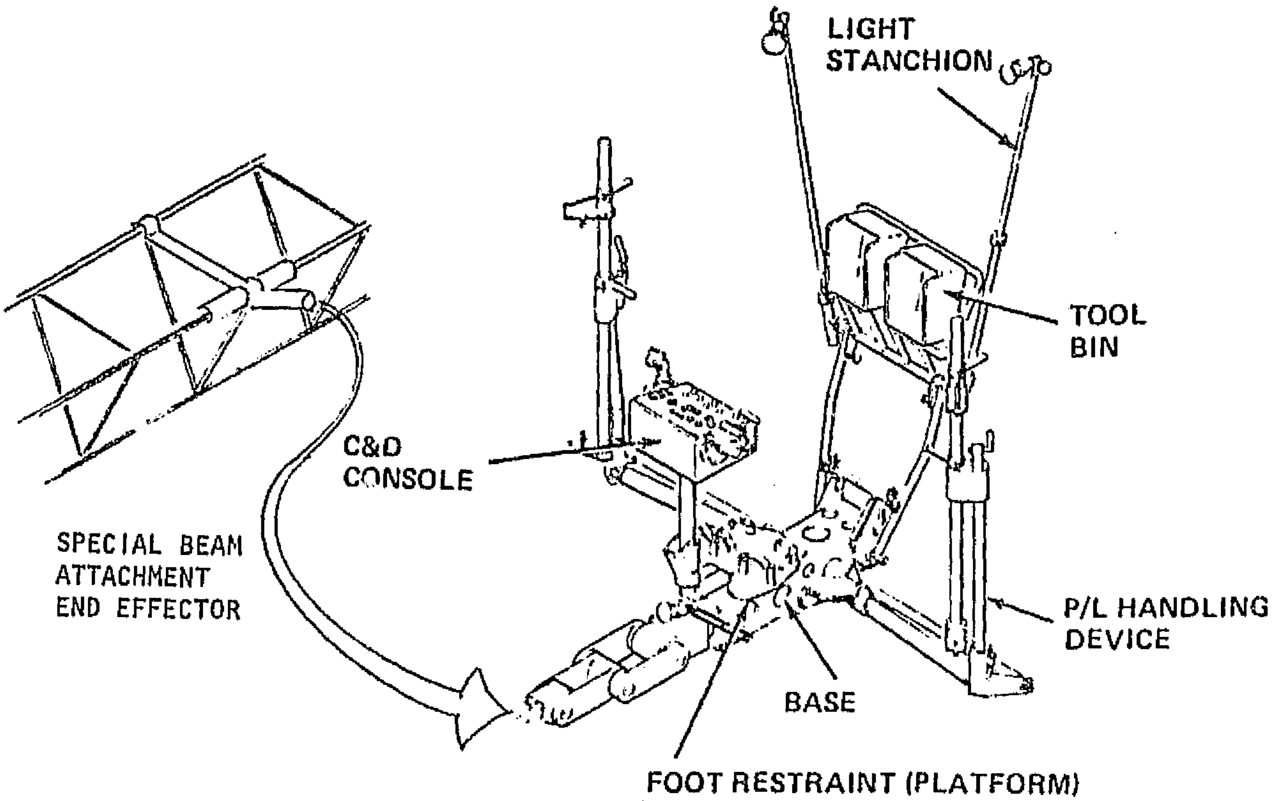
( ) One-time operation

FUNCTION · TRANSPORT ITEM · CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	03.1
METHOD CHERRY PICKER	PAGE	3 of 5		
SUBJECT CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- Cherry picker
- Special end effector to grasp and handle beams
- Modifications to RMS

    Shoulder roll axis in the upper arm to permit elbow motion upward

Crew

1 cherry picker operator

Power

RMS operation	1000 - 1800 watts
Cherry picker operation	500 watts

Lighting and TV

Standard cherry picker illumination

Computer/Software

RMS coordinate transform system

Stowage

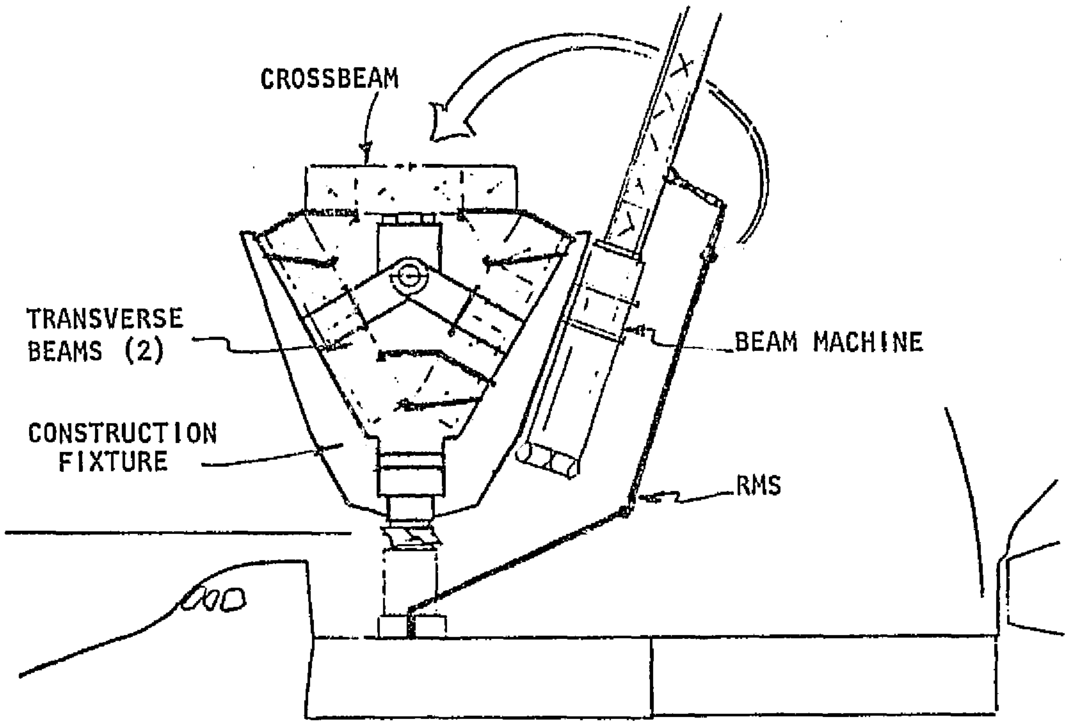
Special end effector	2×0.5×0.3 m
Cherry picker	0.9×1.6×1.1 m

FUNCTION ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	03.1
METHOD	CHERRY PICKER	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
Special End Effector	2	0.3	-	0	0	-	473
Cherry picker	273	1.6	-	0.5	TBD	-	TBD
RMS	0	0	-	1.8	TBD	-	NC
RMS Upper Arm Modifications	79	0	-	TBD	TBD	-	1764
<u>Support Services</u>							
Crew	-	-	1/1	-	-	-	-
Power	-	-	-	TBD	TBD	-	-
<u>Project Modification</u>							
None							
<u>Operations</u>	-	-	1/1	-	-	19	NA*

*Not appropriate, see page 6.

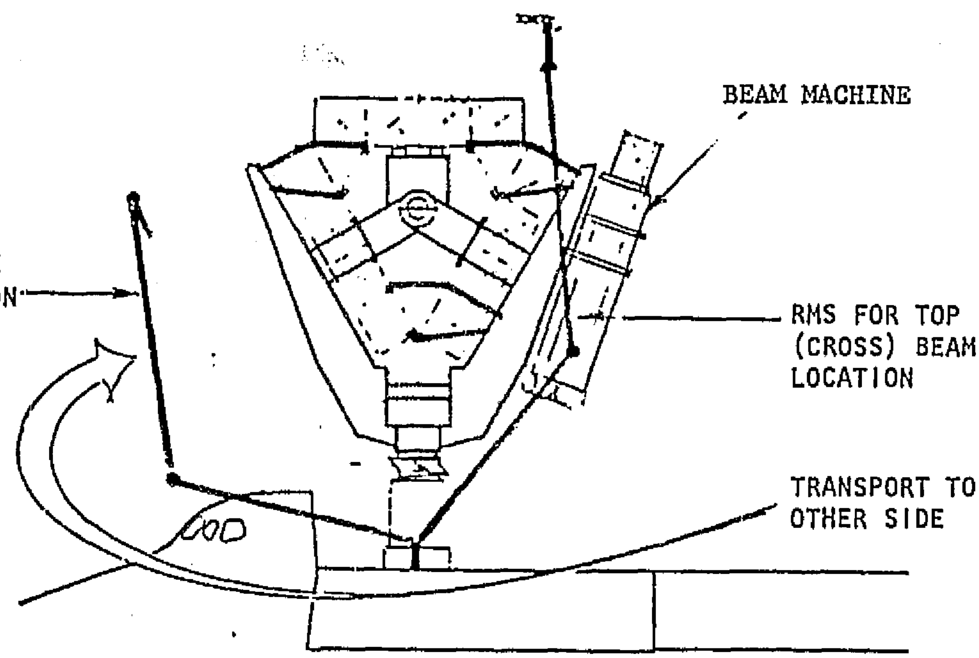
FUNCTION · ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	04.1
METHOD	RMS	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



The RMS, with a special end effector, attaches to the fabricated cross beam and transports each one in turn to the two sides and the top. The RMS operator locates the beams into the beam positioners and, when captured, releases his attachment.

Transportation to the far-side beam station requires maneuvering underneath the extended tri-beam, below the 3.7-m clearance line.

FUNCTION	TRANSPORT	CODE	01	03 01.1	04.1
ITEM	CROSS AND TRANSVERSE BEAMS				
METHOD	RMS	PAGE	2 of 5		
SUBJECT	OPERATIONS				



<u>Manpower</u>

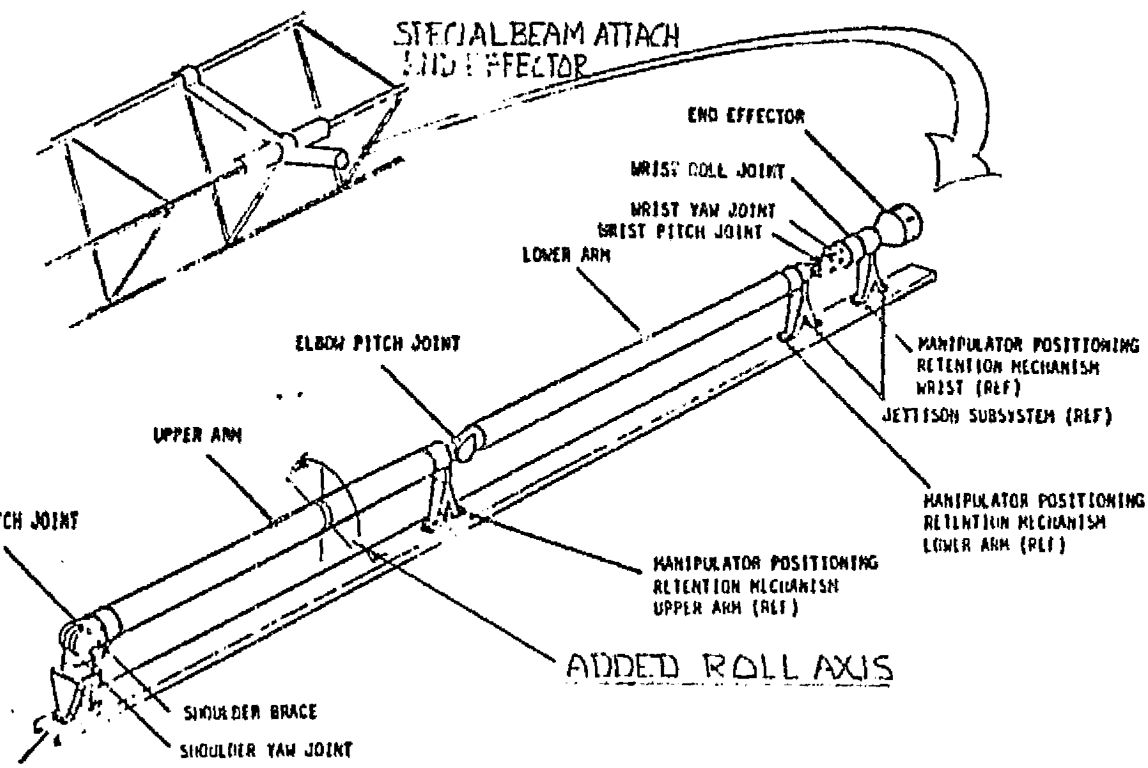
RMS operator

<u>Activity Time</u>

Pickup special end effector (15 min.)	
Beam attachment	6 min.
Transportation	4
Positioning	5
Relocation to BB	3
Beam transport to opposite side	6
Total average, each beam	24 min.

( ) One-time operation

FUNCTION · ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	04.1
METHOD	RMS	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- Special end effector to grasp and handle beams
- Modifications to RMS

  Shoulder roll axis in the upper arm to permit upward elbow motion

Crew

RMS operator

Power

RMS operation 1000 - 1800 watts

Lighting and TV

Standard RMS floodlight and CCTV camera

Computer/Software

None

Stowage

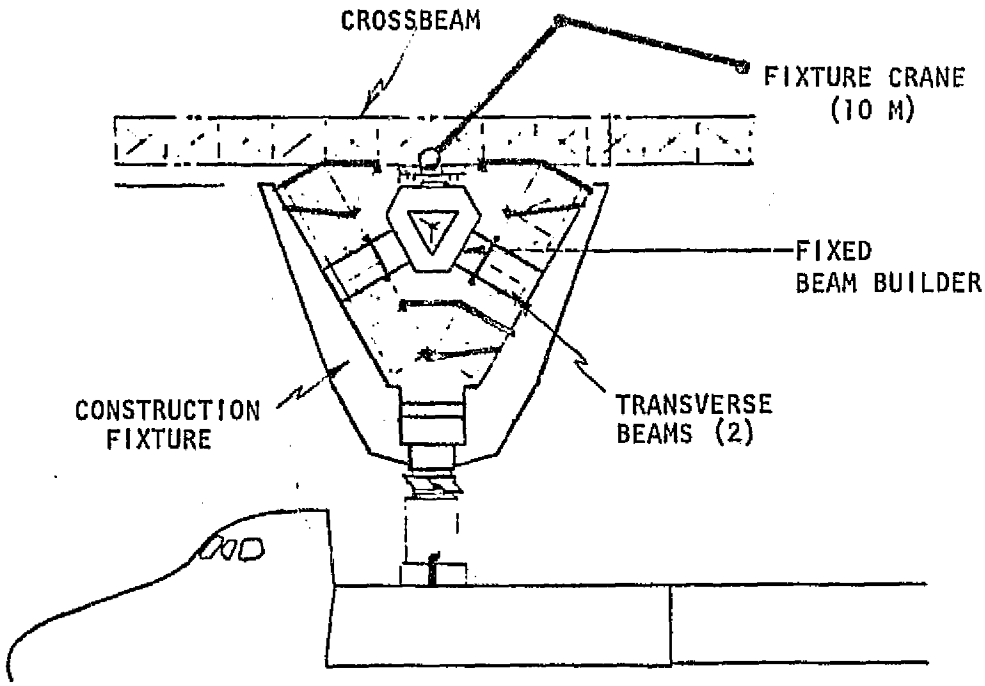
End effector, 2×0.5×0.3 m

FUNCTION	TRANSPORT	CODE	01 | 03 01.1 | 04.1
ITEM	CROSS AND TRANSVERSE BEAMS		
METHOD	RMS	PAGE	5 of 5
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
End effector	15	0.3	-	TBD	TBD	-	473
RMS	0	0	-	1.8	TBD	-	NC
RMS Upper Arm Modifications	79	0	-	TBD	TBD	-	1764
<u>Support Services</u>							
Crew	-	-	1/1	-	-	-	-
Power	-	-	-	TBD	TBD	-	-
<u>Project Modification</u>							
None							
<u>Operations</u>	-	-	1/1	-	-	24	NA*

*Not appropriate, see page 6.

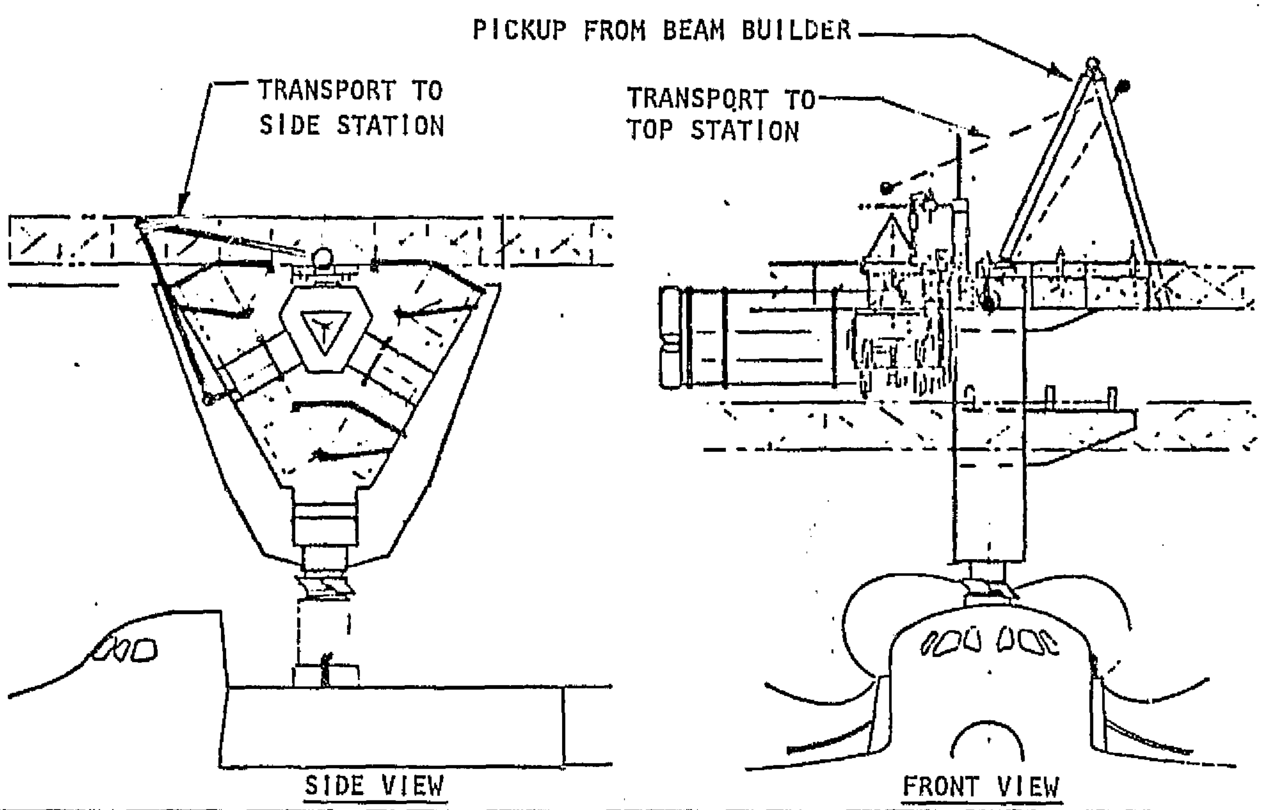
FUNCTION · ITEM ·	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	05.1
METHOD	FIXTURE CRANE	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



Beam builder is fixed at center of tri-beam structure. After fabrication of each longitudinal beam, the fixture crane will relocate them in the construction fixture to their appropriate positions. After longitudinal beams are in place, the beam builder fabricates cross and transverse beams in the open center of the longitudinal beams in the opposite direction of the assembly advancement.

fixture crane picks up cross and transverse beams from the open center area and transports them to the beam positioner stations.

FUNCTION ·	TRANSPORT	CODE	01	03 01.1	05.1
ITEM ·	CROSS AND TRANSVERSE BEAMS				
METHOD	FIXTURE CRANE	PAGE	2 of 5		
SUBJECT					



Manpower

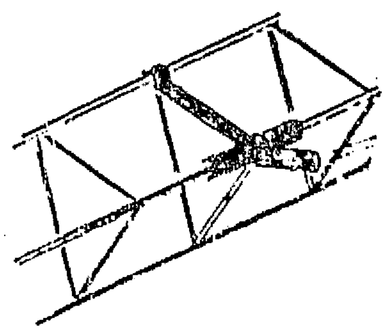
Fixture crane operator at AFD

Activity Time

Install end effector		(10 min.)
Attachment	3 min.	
Transportation	2 min.	
Positioning	3 min.	
Relocation	1 min.	

Total time per beam, 9 min.

(   ) One time operation



SPECIAL BEAM ATTACH END EFFECTOR

Items

- Fixture crane with light and TV
- Special end effector

Crew

Crane operator at AFD

Power

TBD

Lighting and TV

Lights and TV on fixture crane

Computer/Software

Automation software as a part of entire fixture software

Stowage

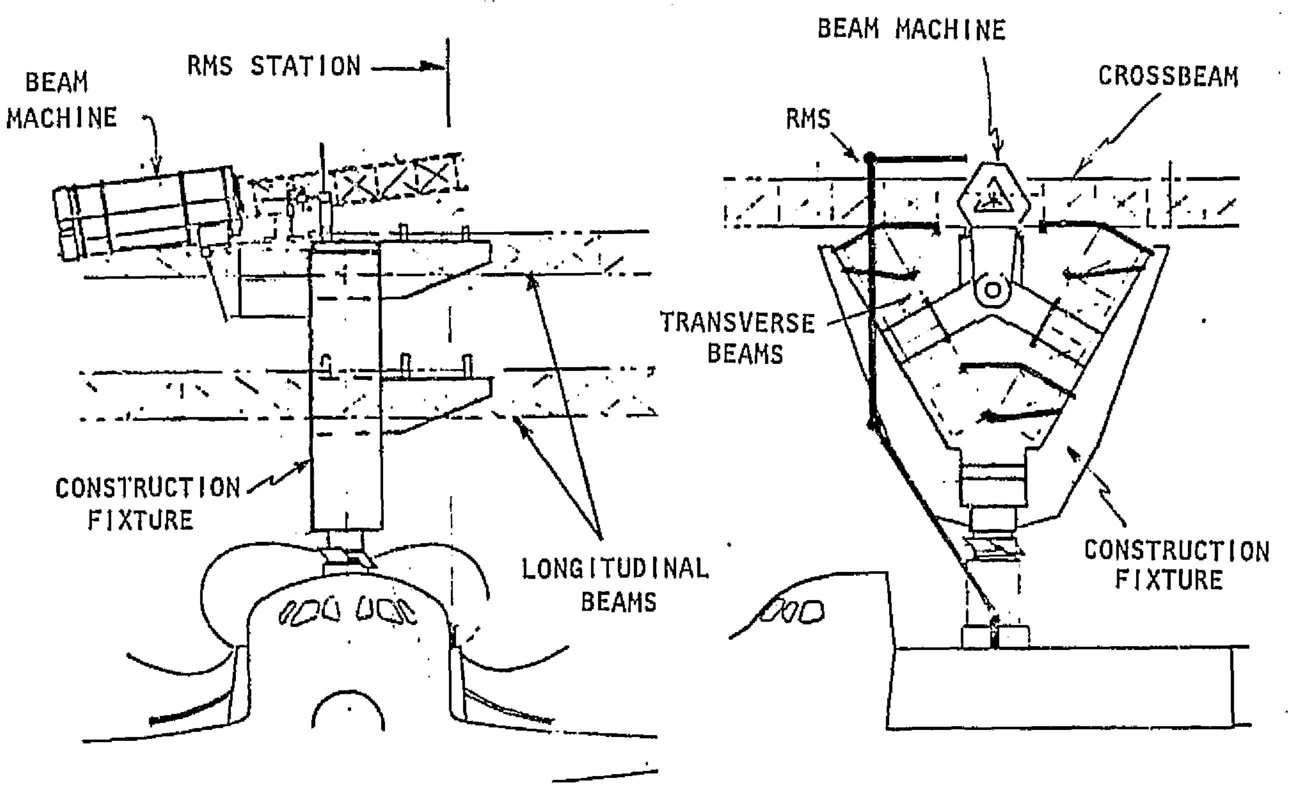
End effector—2×0.5×0.3 m

FUNCTION	TRANSPORT	CODE	01	03 01.1	05.1
ITEM	CROSS AND TRANSVERSE BEAMS				
METHOD	FIXTURE CRANE	PAGE	5 of 5		
SUBJECT					

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
- Fixture crane	TBD	TBD	-	TBD	TBD	-	TBD
- Special end effector	15	0.3	-	TBD	TBD	-	473
Support Services							
- Crew	-	-	1/1	-	-	-	-
- Power	-	-	-	TBD	TBD		-
Project Modification							
None							
Operations	-	-	1/1	-	-	9	NA*

*Not appropriate, see page 6.

FUNCTION · ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	04.2
METHOD	RMS	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

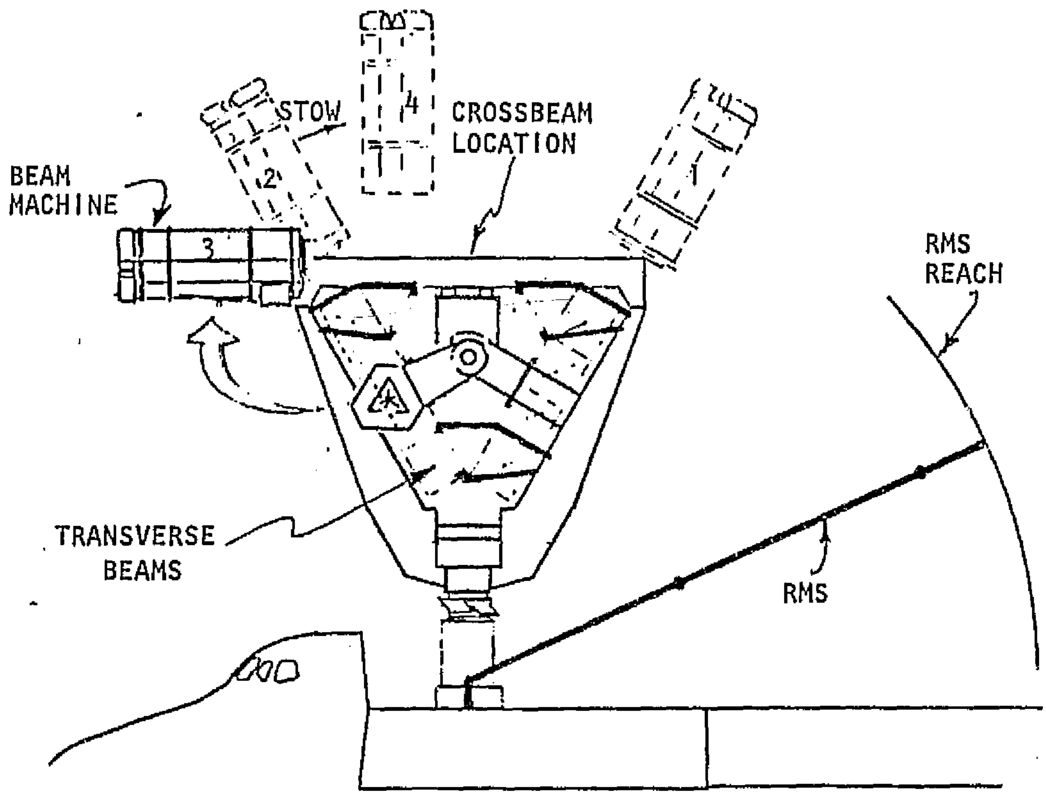


Following fabrication of the longitudinal beams, the beam builder is rotated to the vertical and fabricates the cross and transverse beams at a slight upward angle to avoid the last installed cross beam.

The RMS then picks up the beam and transports it to the beam positioner on the construction fixture.

NO ADDITIONAL DETAILS ARE PROVIDED

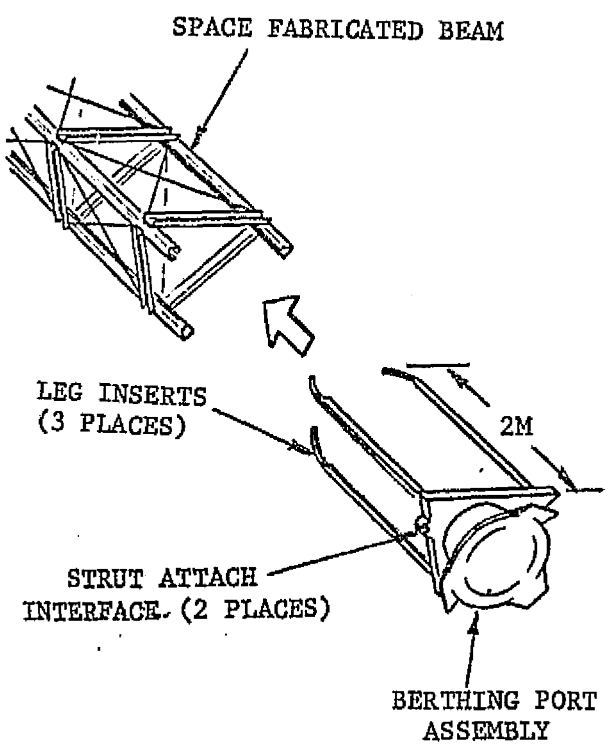
FUNCTION · ITEM	TRANSPORT CROSS AND TRANSVERSE BEAMS	CODE	01	03 01.1	10.1
METHOD	CONSTRUCTION FIXTURE	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

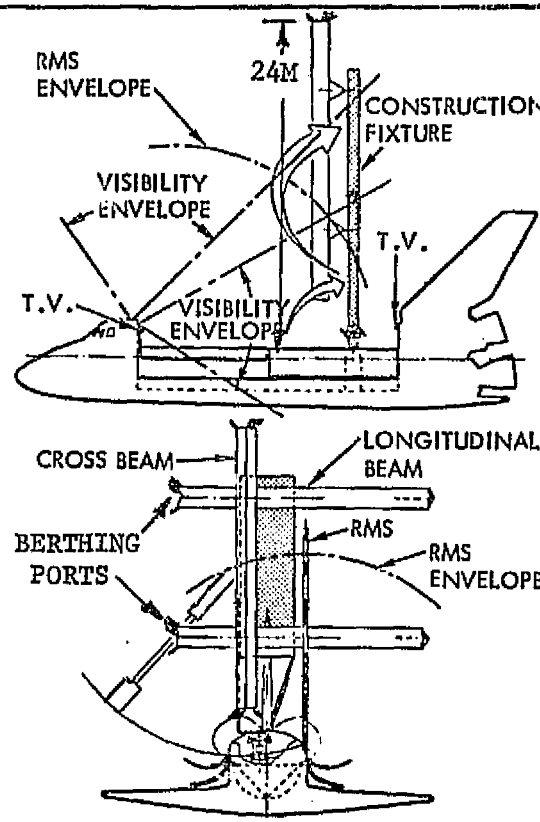


The beam builder is relocated from the swing-arm to a track-assembly across the top of the construction fixture. Track-assembly translates and rotates beam builder to Positions 1, 2, 3, and 4 in sequence, from where the cross and transverse beams are fabricated and loaded directly onto the beam-positioner fixtures. Stow position, No. 4, is out of the way of the 20-m cross beams.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM ·	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	00
METHOD		PAGE	1	of	2
SUBJECT	OPERATION IDENTIFICATION				





Project System

- SPS Test Article

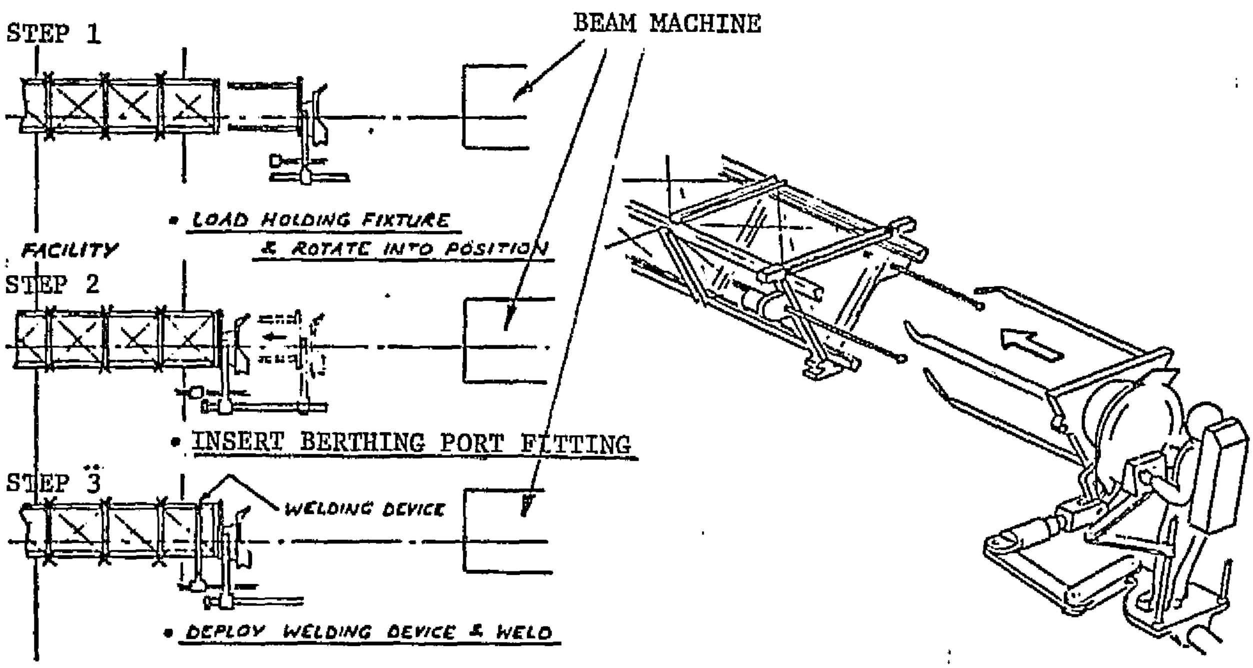
Operation

- Join Berthing Port Fitting to end of beam

Physical Situation

- The construction fixture and required hardware are ready to begin construction. (No beams have been fabricated)
- Berthing ports assemblies must be installed at ends of longitudinal and cross beams

FUNCTION· ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



AUTOMATED

MANUAL

The following methods have been identified:

Automated

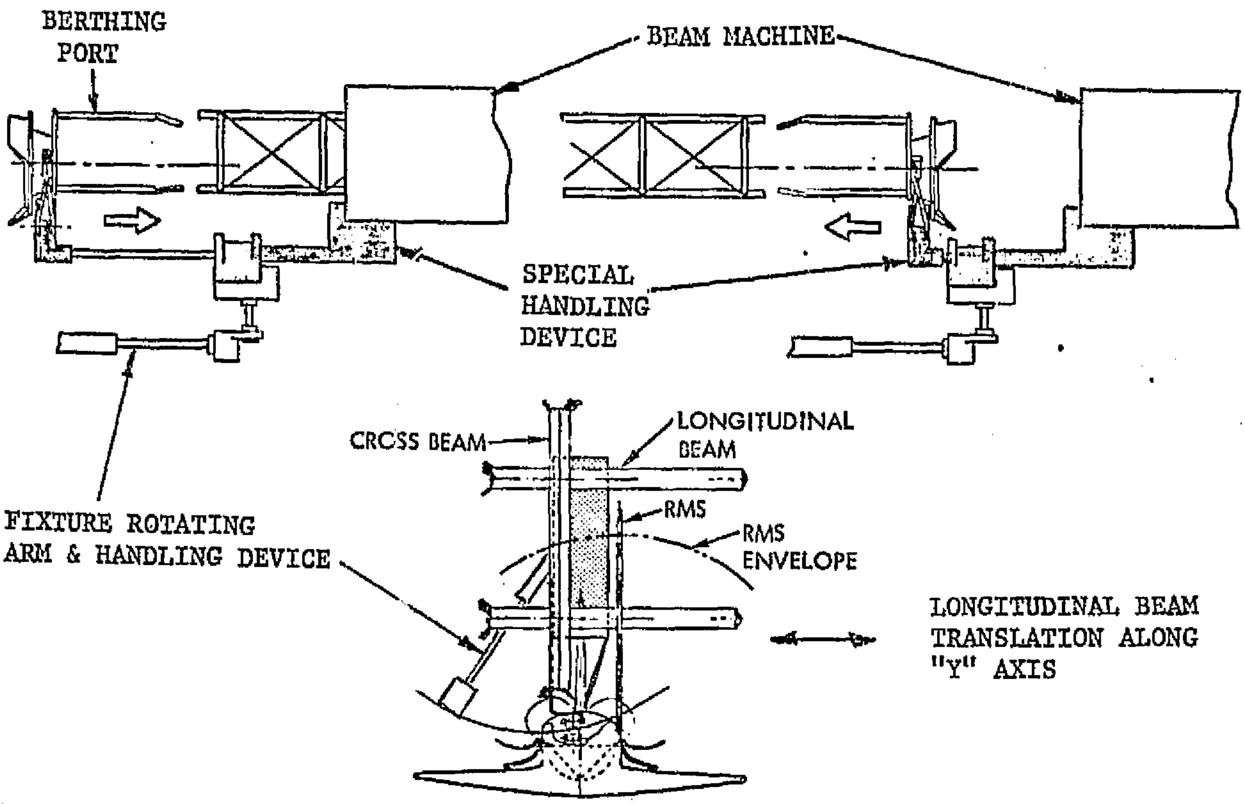
1. Install during beam fabrication - both ends of beams
   - Longitudinal beams
   - Cross Beams (fabricated perpendicular to longitudinal beams)
2. Install after structure is complete (cross beams installed)
3. Same as Item 1 except cross beam fab position is parallel to long. beams

Manual

4. Cherry picker
5. EVA/MMU

Methods 1, 2 and 4 are detailed

FUNCTION · ITEM ·	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.1
METHOD	SPECIAL HANDLING DEVICE (DURING BEAM FAB)	PAGE	1	of	5
SUBJECT	METHOD DESCRIPTION				



With the special handling device loaded with the beam machine and a berthing port (by the RMS), the beam machine manufactures a short length of beam and stops.

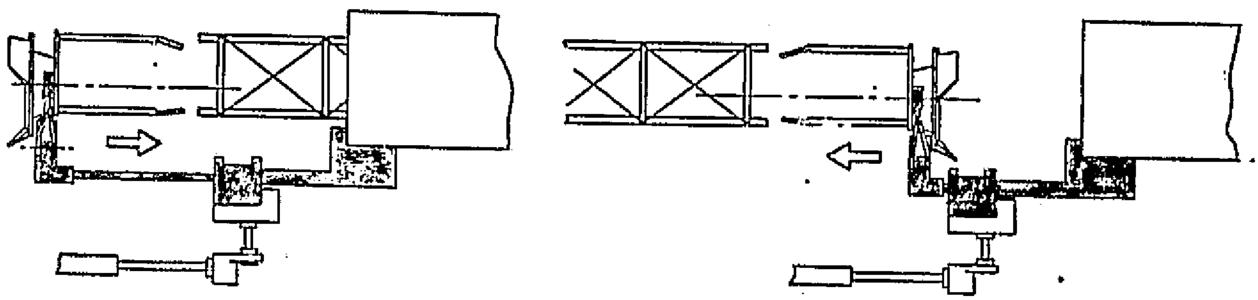
The handling device is activated inserting the berthing port fitting into the end of the beam and the fitting welded in place. The holding fixture then releases the fitting and rotates clear. The beam machine is then reactivated.

After the desired length of beam has been manufactured the beam is translated to its assembly position on the fixture. The rotating arm returns to within reach of the RMS where another port is procured. The arm returns to the installation position.

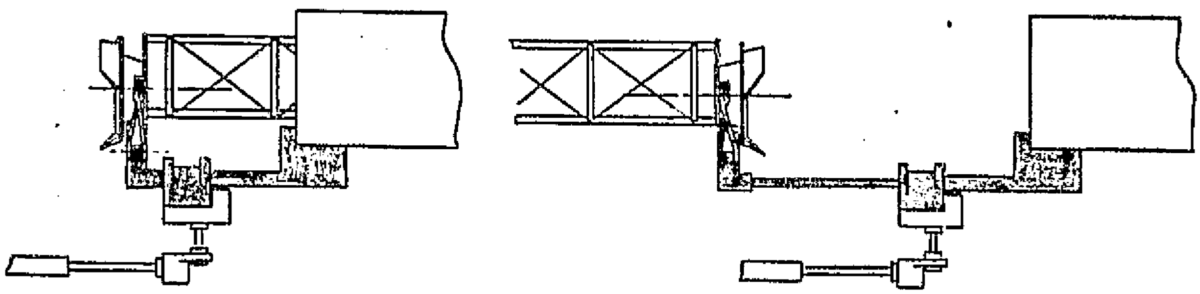
The handling device is activated inserting the port into the end of the beam where it is welded. The holding fixture is reloaded and the rotating arm moved to the next location where the above procedures are repeated.

The same procedure is followed for each of the two cross beams as the longitudinal beams are translated back through the construction fixture. (The cross beams are fabricated in place - perpendicular to the longitudinal beams).

FUNCTION · ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.1
METHOD	SPECIAL HANDLING DEVICE (DURING BEAM FAB)	PAGE	2 of 5		
SUBJECT	OPERATIONS				



STEP 1   STEP 1



STEP 2   STEP 2

Manpower

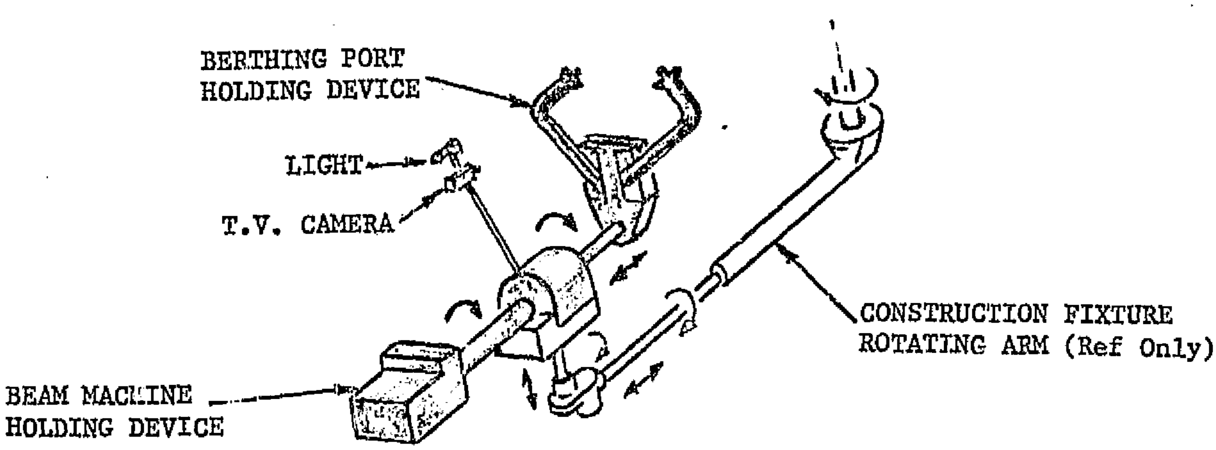
- RMS/Fixture Operator at AFD

Activity Time

• Install Handling Device on Fixture Rotating Arm with RMS	(10 Min.)
• Install Beam Machine on Device	(10 Min.)
• Load Berthing Port	3 Min.
• Rotate Arm, Align and Insert Port	3 Min.
• Weld	10 Min.
Time per port	16 Min.

(   ) One time activity

SPECIAL HANDLING DEVICE



Items

- RMS
- Special Handling Device (shown above)

  This device provides mounting provisions for the beam builder, a berthing port holding/location position, and provisions for mounting TV camera and lights. The berthing port holding/location section has the capability to translate in order to insert the berthing ports into the beam caps. A rotation capability is also provided in order to orient this handling device in relationship to the construction fixture.

FUNCTION ITEM.	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.1
METHOD	SPECIAL HANDLING DEVICE (DURING BEAM FAB)	PAGE	4 of 5		
SUBJECT	SUPPORT SERVICES				

Crew

- One RMS/Fixture Operator at AFD

Power

- RMS Operation 1000 - 1800 Watts
- Fixture Operation TBD

Lighting and TV

- Standard RMS and Fixture Rotating Arm Lights and TV are Adequate

Computer/Software

- RMS Coordinate Transform System
- Fixture Rotating Arm Transform System

Stowage

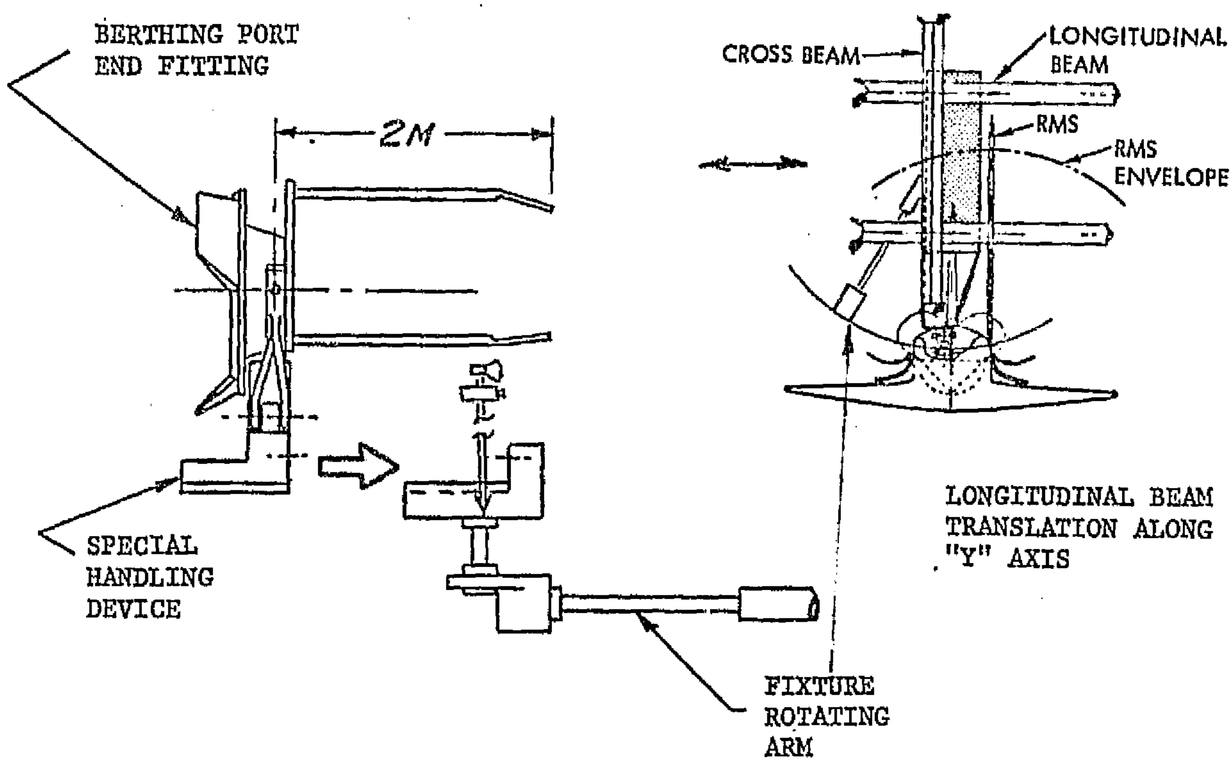
- Special Handling Device-3 x 2 x 0.5 M

FUNCTION ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.1
METHOD	SPECIAL HANDLING DEVICE (DURING BEAM FAB)	PAGE	5	of	5
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Special Handling Device	60	3	–	TBD	TBD	–	1014
RMS	0	0	–	1.8	TBD	–	–
Support Services							
Crew	–	–	1/1	–	–	–	–
Power	–	–	–	TBD	TBD	–	–
Project Modifications	0	0	–	–	–	–	0
Operations	–	–	–	–	–	16	NA*

*Not appropriate, see page 6.

FUNCTION ·	JOIN	CODE	01	0501.1	06.2
ITEM ·	BERTHING PORT/BEAM				
METHOD	SPECIAL HANDLING DEVICE (AFTER STRUCTURE FAB)	PAGE	1	of	5
SUBJECT	METHOD DESCRIPTION				

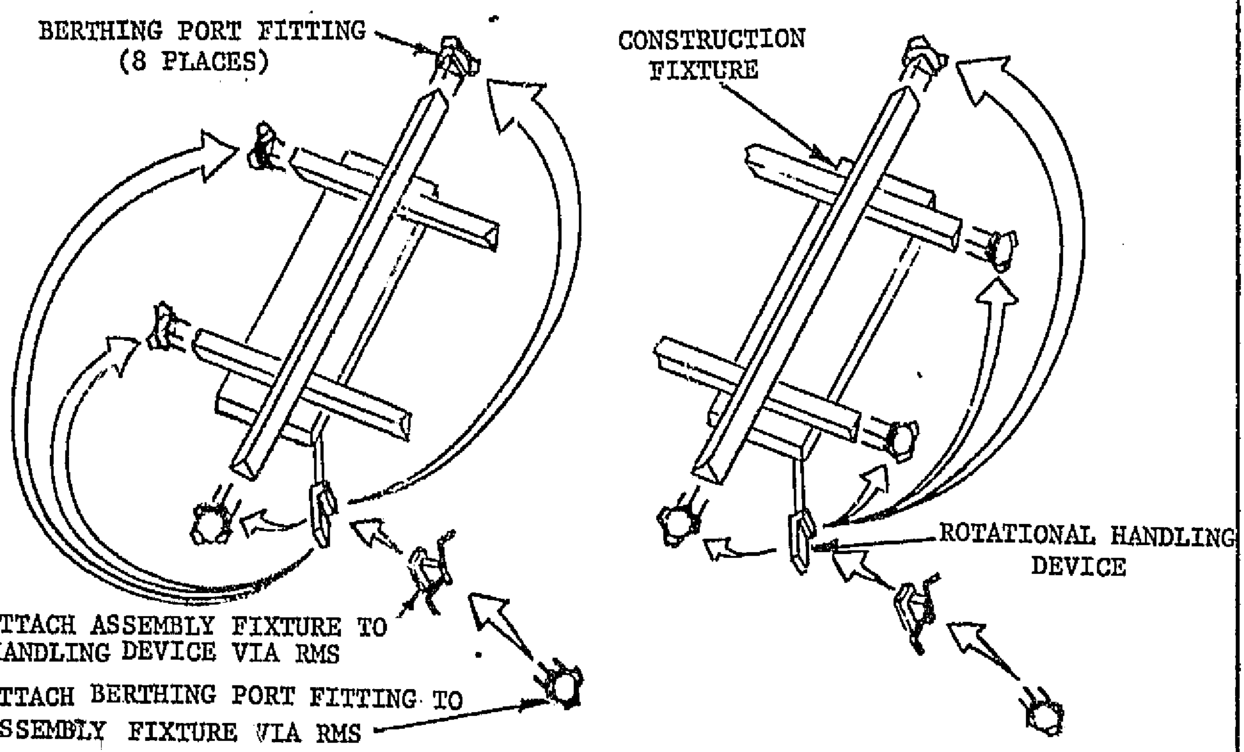


The construction fixture rotating arm is rotated to the payload bay where the RMS removes and attaches the special handling device and the first berthing port fitting.

The arm is rotated to the first position and aligned with the end of the beam. The arm is then retracted with the handling device inserting the fitting into the open end of the beam and the fitting is welded in place.

After welding, the handling device releases the end fitting and the arm is rotated to within reach of the RMS, where the next port is attached. This sequence is repeated for each end fitting location.

FUNCTION · ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.2
METHOD	SPECIAL HANDLING DEVICE (AFTER STRUCTURE FAB)	PAGE	2 of 5		
SUBJECT	OPERATIONS				



- o ATTACH ASSEMBLY FIXTURE TO HANDLING DEVICE VIA RMS
- o ATTACH BERTHING PORT FITTING TO ASSEMBLY FIXTURE VIA RMS
- o ROTATE ARM, PERFORM FUNCTION AND REPEAT

Manpower

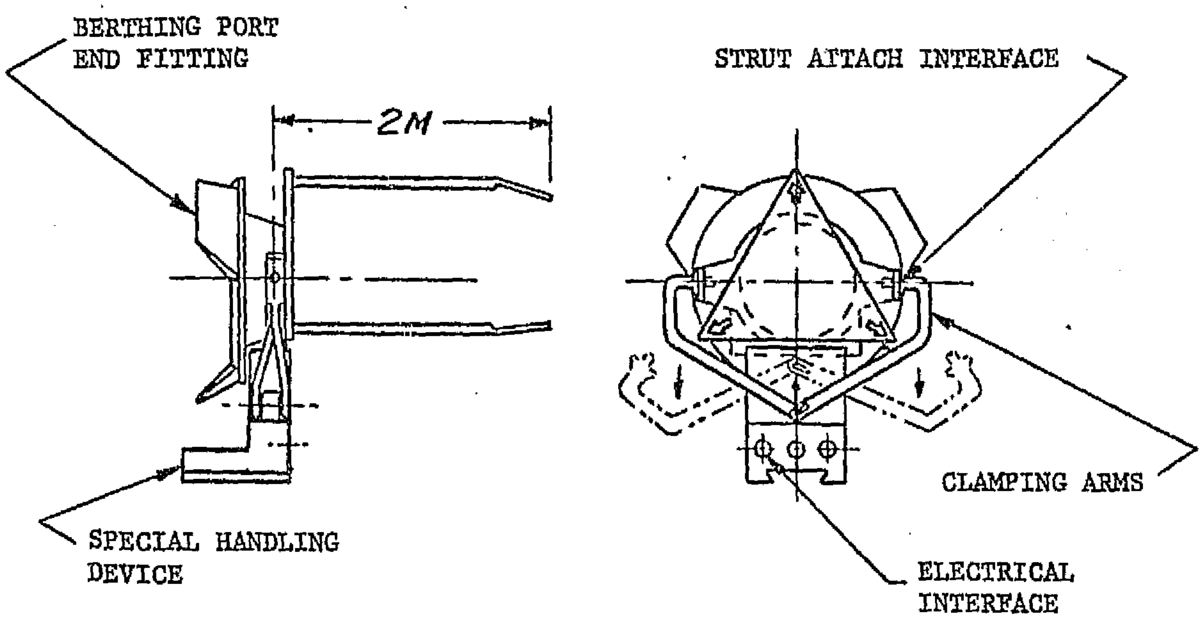
RMS/Fixture Operator at AFD

Activity Time

• Install Handling Device on Fixture Rotating Arm with RMS	(10 Min.)
• Load Berthing Port	3 Min.
• Rotate Arm, Align and Insert Port	3 Min.
• Weld	10 Min.
TOTAL PER PORT	16 Min.
This method requires an additional translation of the Entire Structure (1M/Min. Rate)	214 Min.

( ) One time operation

FUNCTION · ITEM ·	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.2
METHOD	SPECIAL HANDLING DEVICE (AFTER STRUCTURE FAB)	PAGE	3	of	5
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS

- Special Handling Device (shown above)

  This device provides mounting provisions for the beam builder, a berthing port holding/location position, and provision for mounting TV camera and lights. The berthing port holding/location section has the capability to translate in order to insert the berthing ports into the beam caps. A rotation capability is also provided in order to orient this handling device in relationship to the construction fixture.

Crew

- One RMS/Fixture Operator at AFD

Power

- RMS Operation 1000 - 1800 Watts
- Fixture Operation TBD

Lighting and TV

- Standard RMS and fixture rotating arm lights and TV adequate

Computer/Software

- RMS Coordinate Transform System
- Fixture Rotating Arm Transform System

Stowage

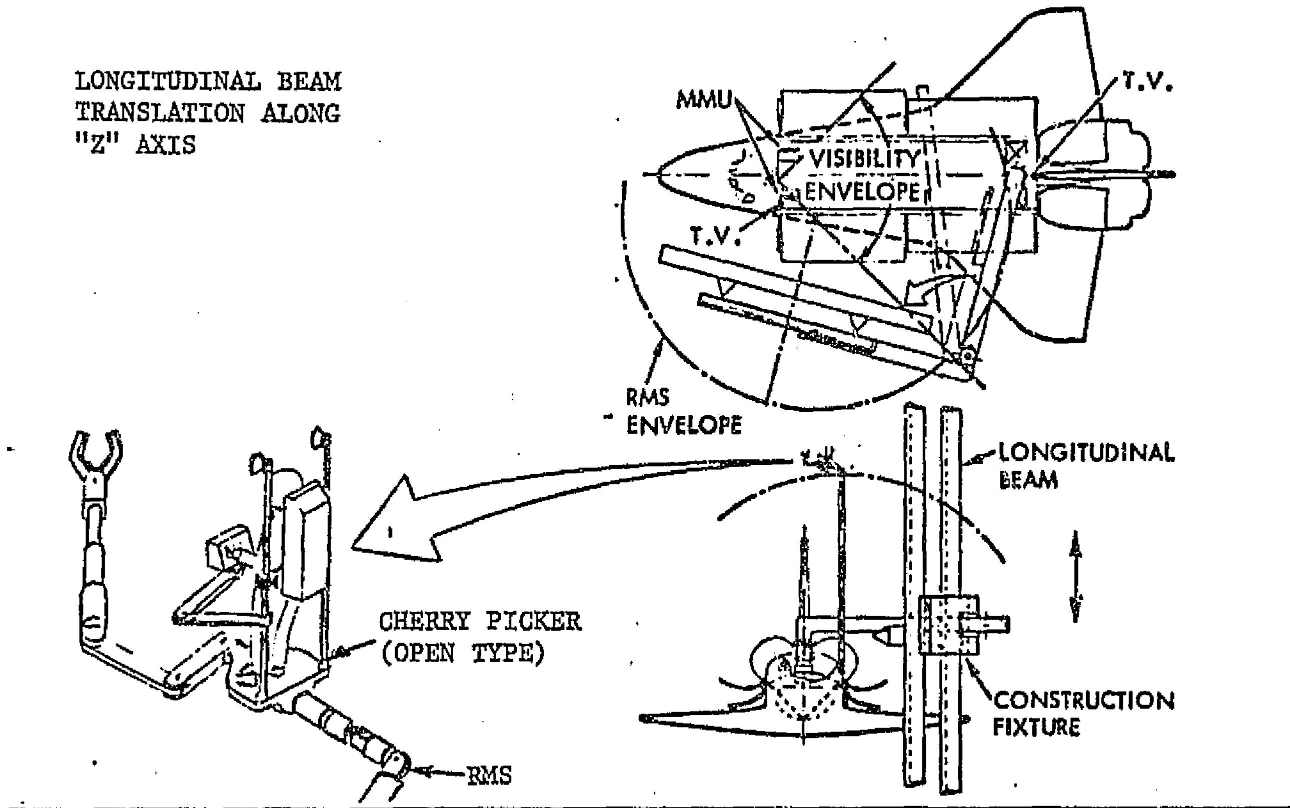
- Special Handling Device-2 x 0.5 x 0.5M

FUNCTION ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.2
METHOD	SPECIAL HANDLING DEVICE (AFTER STRUCTURE FAB)	PAGE	5	of	5
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M³)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Special Handling Device	23	0.5	–	TBD	TBD	–	638
RMS	0	0	–	1.8	TBD	–	NC
Support Services							
Crew	–	–	1/1	–	–	–	–
Power	–	–	–	TBD	TBD	–	–
Project Modifications	0	0	–	–	–	–	0
Operations	–	–	–	–	–	16	NA*

*Not appropriate, see page 6.

FUNCTION· ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	03.1
METHOD	CHERRY PICKER	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



The Cherry Picker installs the special berthing port/beam end insertion device on the beam, then removes the fitting (berthing port) from the payload bay and aligns same with end of beam.

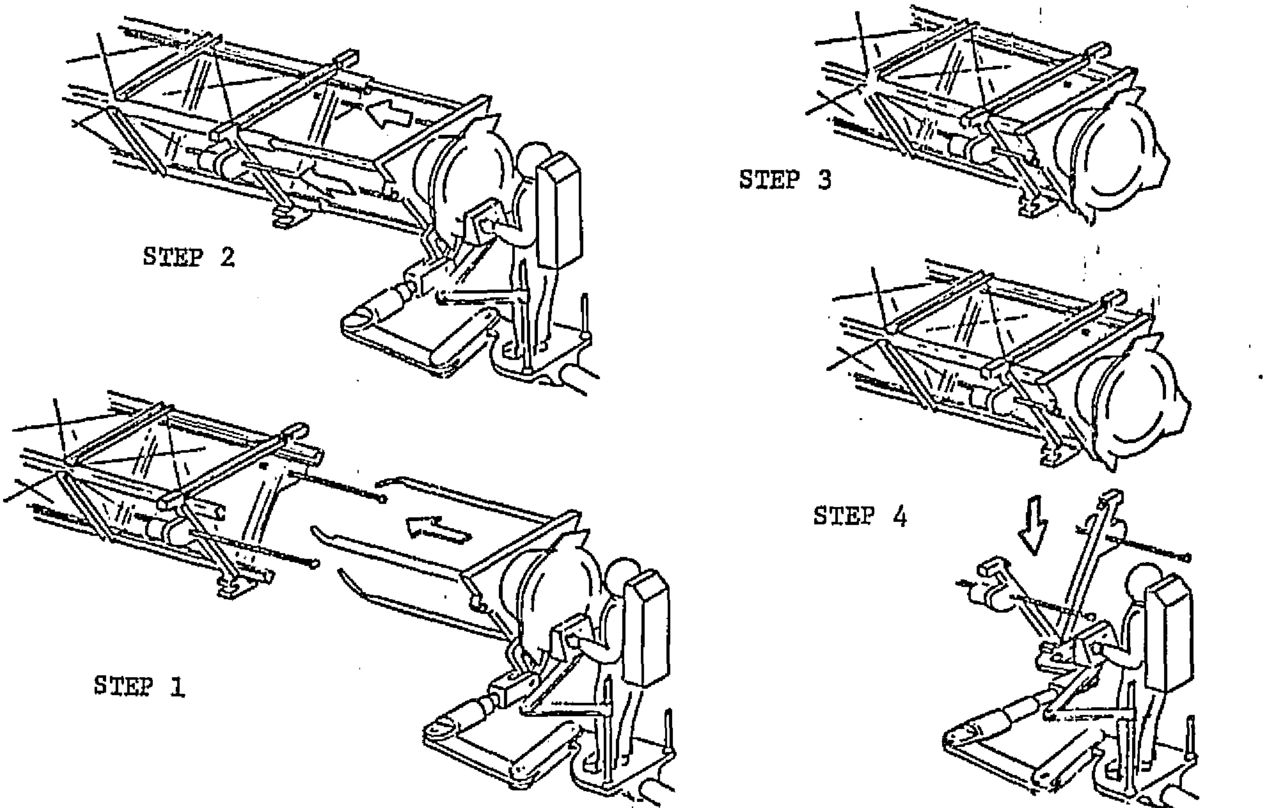
The Cherry Picker inserts the tapered legs of the end fitting into the beam until the legs just engage the inner cap surfaces.

The drive units on the insertion device are activated extending the drive screws until engagement can be made with the side (strut) fittings

The drive units are reactivated reversing the drive screws thus pulling the legs of the end fitting inside the beam cap members. The berthing port fitting is then welded in place.

The Cherry Picker releases the end fitting and removes the insertion device from the beam.

FUNCTION · ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	03.1
METHOD	CHERRY PICKER	PAGE	2	of	5
SUBJECT	OPERATIONS				



Manpower

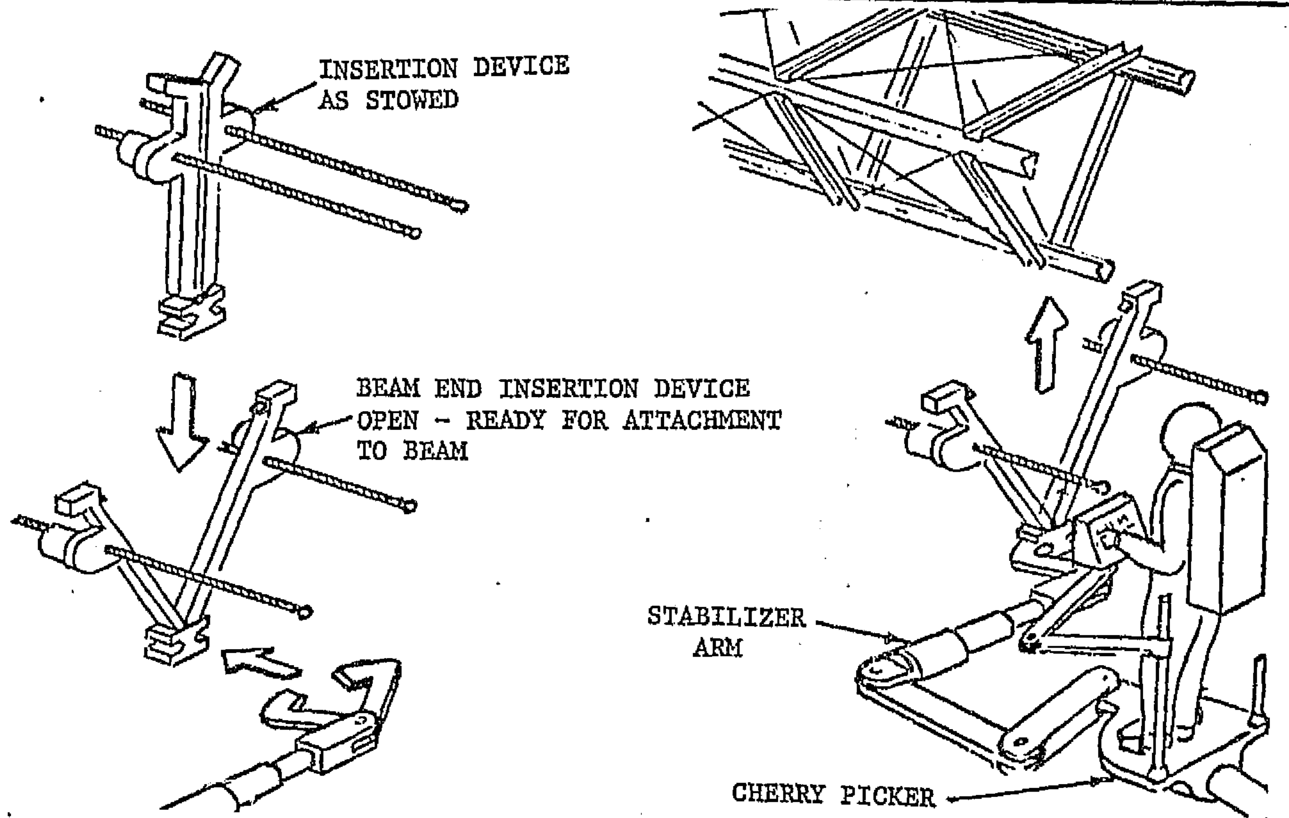
- Cherry Picker Operator

Activity Time

• RMS Pickup Cherry Picker	(15 Min)
• Pickup Beam End Insertion Device	2 Min
• Transport, Install Insertion Device	4 Min
• Pickup Berthing Port Fitting	3 Min
• Transport and Insert Port	10 Min
• Weld	10 Min
• Remove Insertion Device	2 Min
TOTAL PER PORT	31 Min

(   ) One time operation

FUNCTION · ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	03.1
METHOD	CHERRY PICKER	PAGE	3	of	5
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT				



- Berthing Port Insertion Device

  This device (shown above) consists of two sides of a triangle complete with two ball screws and drive unit. The device folds for payload storage.

  The legs of this device have the same profile as the inner surface of the beams cross members, at the end of which is a spring latch with solenoid return capability.

  The Cherry Picker picks up the device (via the stabilizer arm) and fastens it to the cross members adjacent to the beam end. The upper latches snap across the third cross member to hold the device in place.

- Cherry Picker

- RMS

FUNCTION ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	03.1
METHOD	CHERRY PICKER	PAGE	4 of 5		
SUBJECT	SUPPORT SERVICES				

Crew

- Cherry Picker Operator

Power

• RMS Operations	1000 - 1800 Watts
• Cherry Picker Operation	500 Watts
• Insertion Device	TBD

Lighting and TV

- Standard Cherry Picker Illumination Adequate

Computer/Software

- RMS Coordinate Transform System

Stowage

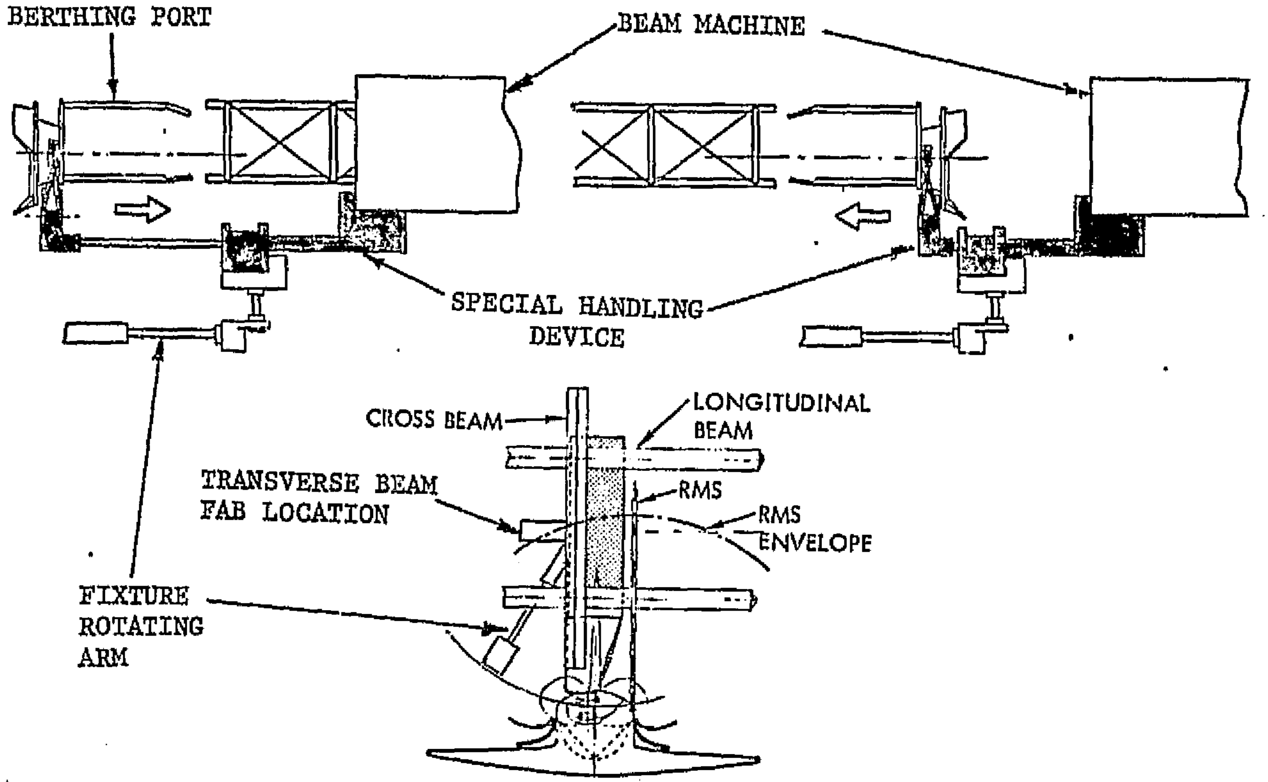
- Assembly Device - 2 x 1 x 0.5 M
- Cherry Picker - 0.9 x 1.6 x 1.1 M

FUNCTION ITEM	JOIN BERTHING PORT /BEAM	CODE	01	0501.1	03.1
METHOD	CHERRY PICKER	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Insertion Device	30	1	–	TBD	TBD	–	1.098
Cherry Picker			–	0.5	TBD	–	TBD
RMS	0	0	–	1.8	TBD	–	–
Support Services							
Crew	–	–	1/1	–	–	–	–
Power	–	–	–	TBD	TBD	–	–
Project Modifications	0	0	–	–	–	–	–
Operations	–	–	–	–	–	31	NA*

*Not appropriate, see page 6.

FUNCTION· ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	06.3
METHOD	SPECIAL HANDLING DEVICE (CROSS BEAM FAB PARALLEL TO LONG BEAM)	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



With the special handling device loaded with the beam machine and a berthing port (by the RMS), the beam machine manufactures a short length of beam and stops.

The handling device is activated inserting the berthing port fitting into the end of the beam and the fitting welded in place. The holding fixture then releases the fitting and rotates clear. The beam machine is then reactivated.

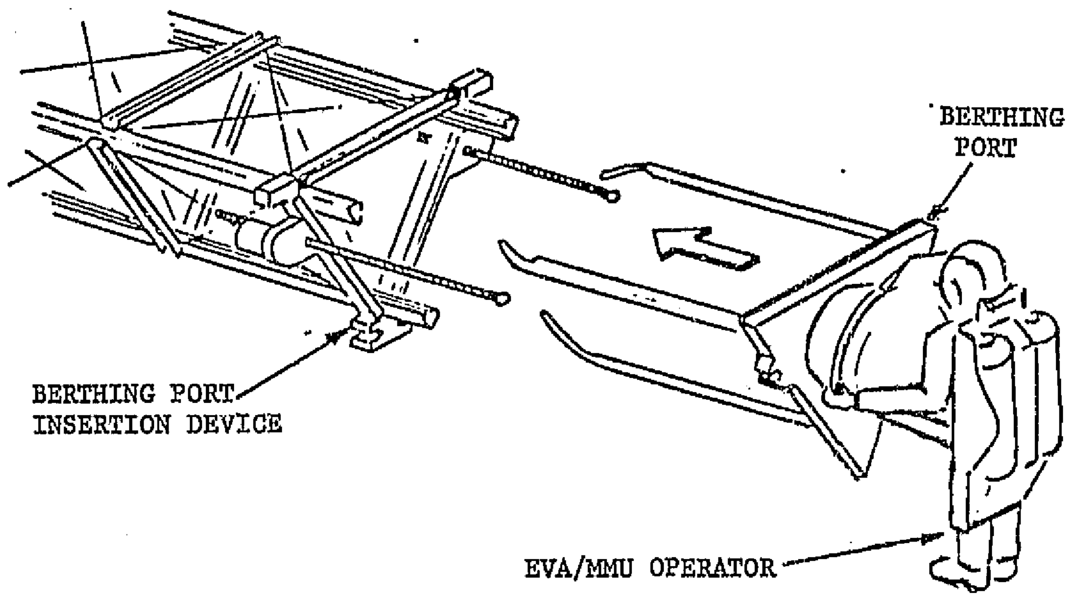
After the desired length of beam has been manufactured the beam is translated to its assembly position on the fixture. The rotating arm returns to within reach of the RMS where another port is procured. The arm returns to the installation position.

The handling device is activated inserting the port into the end of the beam where it is welded. The holding fixture is reloaded and the rotating arm moved to the next location where the above procedures are repeated.

The same procedure is followed for each of the two cross beams as the longitudinal beams are translated back through the construction fixture. The cross beams for this method are fabricated - parallel to the longitudinal beam. The completed beams, including the berthing port fittings, are then transported to their proper position for joining.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	JOIN BERTHING PORT/BEAM	CODE	01	0501.1	02.1
METHOD	EVA/MMU	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



The EVA/MMU operator installs the special berthing port/beam end insertion device. Then moves to the payload bay, removes the berthing device fitting, transports it to the beam, and aligns same with end of beam.

The operator then inserts the tapered legs of the end fitting into the beam until the legs just engage the inner cap surfaces.

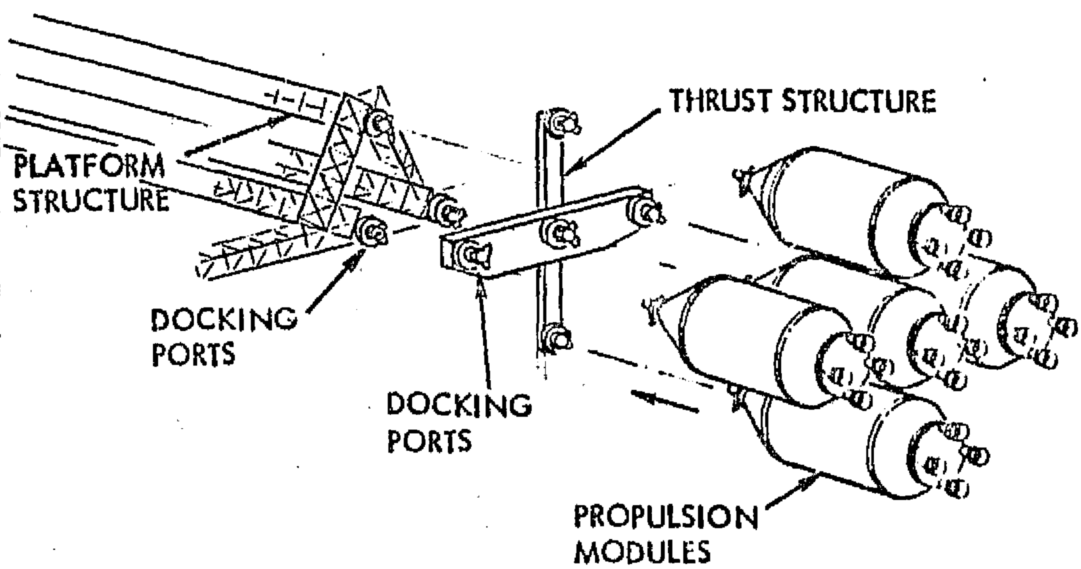
The drive units on the insertion device are activated extending the drive screws until engagement can be made with the side (strut) fittings.

The drive units are reactivated reversing the drive screws thus pulling the legs of the end fitting inside the beam cap members. The berthing port fitting is then welded in place.

The operator then removes the insertion device from the beam and proceeds to the next position.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	00
METHOD		PAGE	1 of 2		
SUBJECT	OPERATION IDENTIFICATION				



Project System

- Advanced communications space fabricated platform

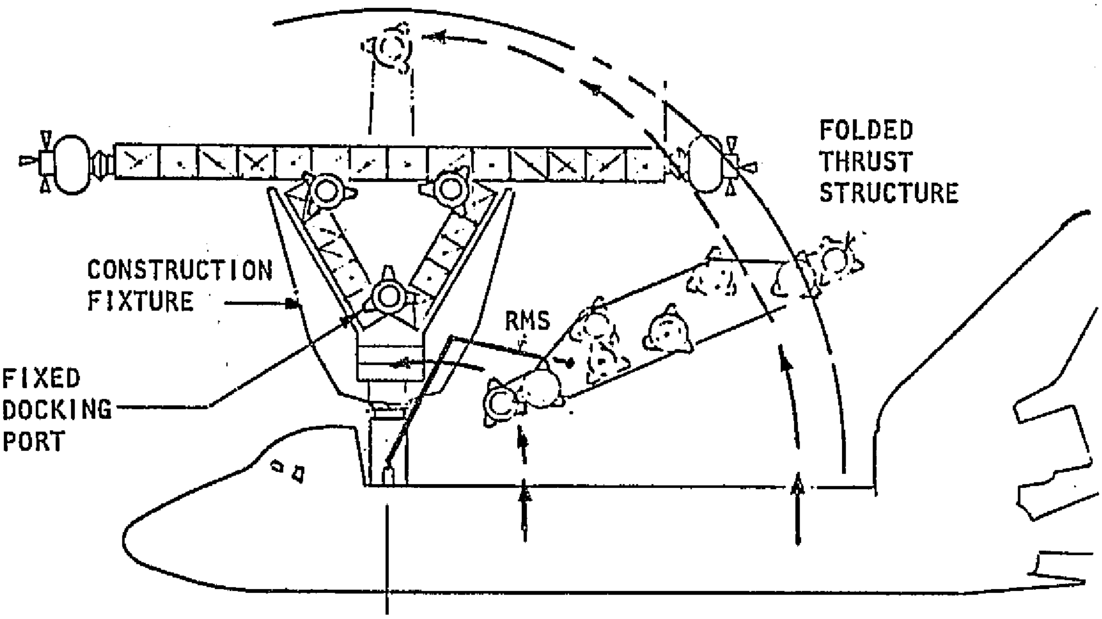
Operation

- Join the thrust structure to the platform structure

Physical Situation

- The platform structure is complete, antennas, RCS and SCCM installed
- The thrust structure installation is made on a dedicated flight
- Connection is made by means of three berthing ports previously installed at the aft end of the platform
- The platform is in position on the construction fixture

FUNCTION · ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

None

Automatic

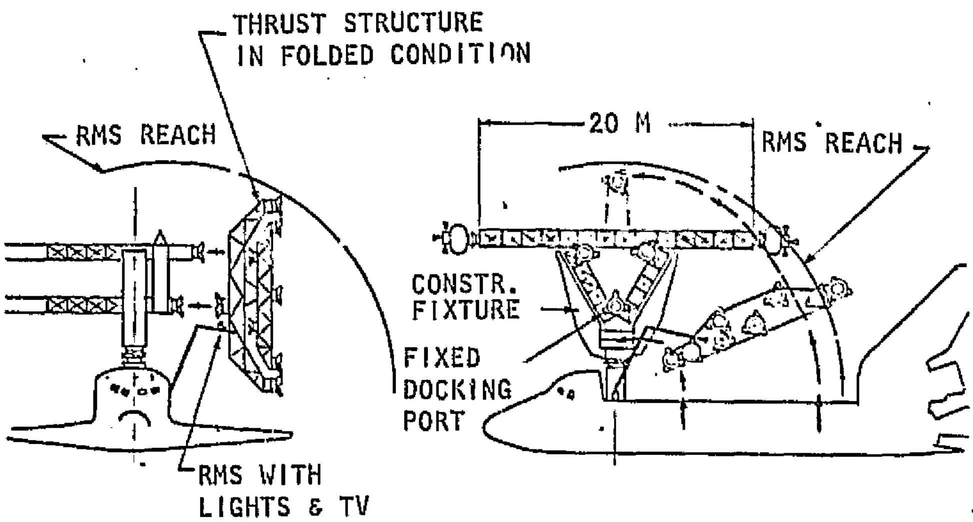
1. The orbiter docks to the construction fixture and uses the RMS to install the thrust structure

2. The RMS is used to place the thrust structure onto the orbiter docking system and the orbiter mates the thrust structure to the platform

3. The orbiter docks to the platform (using an RCS location) and then uses the RMS to install the thrust structure to the platform

Method #1 is detailed.

FUNCTION· ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	04.1
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



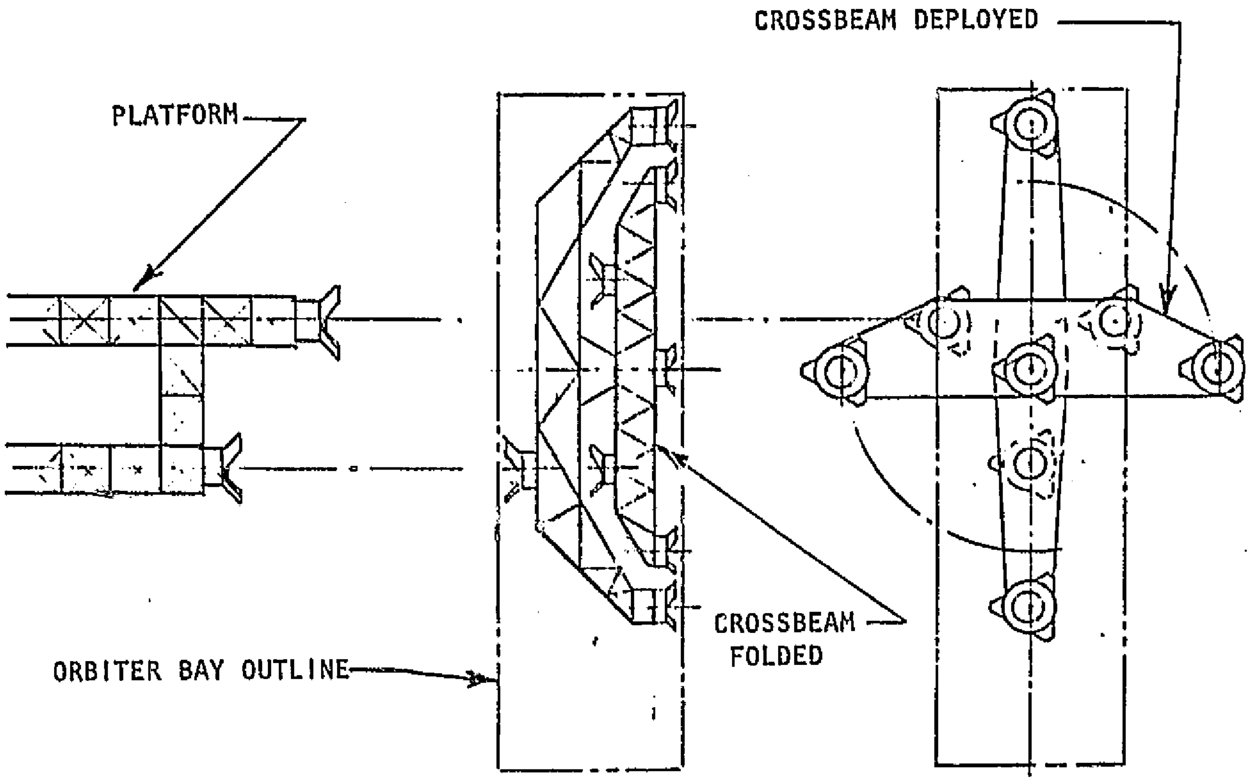
- The orbiter docks to the construction fixture in the attitude and location shown.

- The RMS removes the folded thrust structure from the orbiter bay, moves it into the correct orientation and mates the first of the three berthing ports (the fixed one) on the thrust structure with the corresponding port on the platform.

- The next step is to rotate the cross beam of the thrust structure through 90° with the RMS.

- The second and third berthing ports of the thrust structure are now opposite their corresponding ports on the platform. The platform ports are then extended and mated. These two berthing ports must be self aligning or floating.

FUNCTION · ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	04.1
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



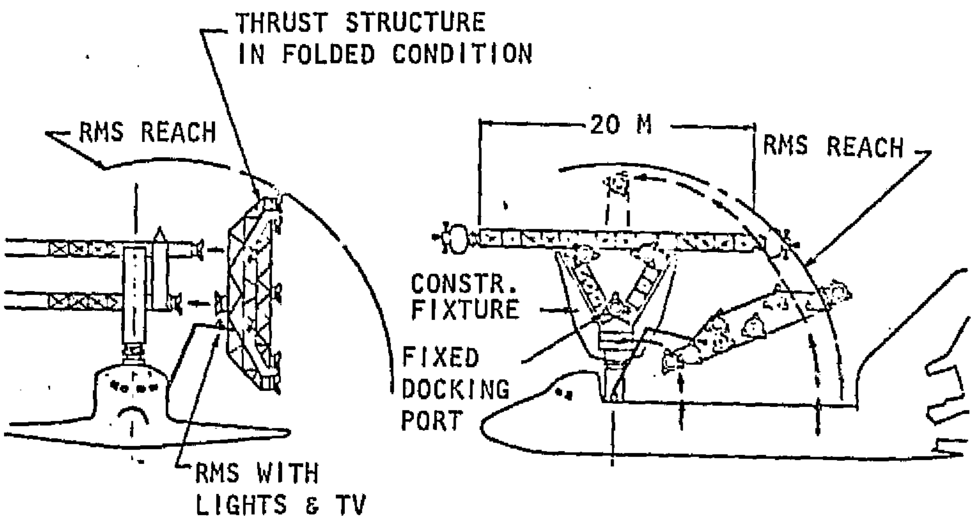
Platform Structure

- The three berthing ports at the aft end of the platform must be staggered as shown. Two are mounted further aft than the third.
- Two berthing ports require the capability to "extend and mate" on command from the orbiter.

Thrust Structure

- It must be designed so that it can be folded and stowed in the orbiter bay in one unit.
- An RMS attach point is required.
- The cross beam must be capable of rotating 90°.

FUNCTION · ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	04.1
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

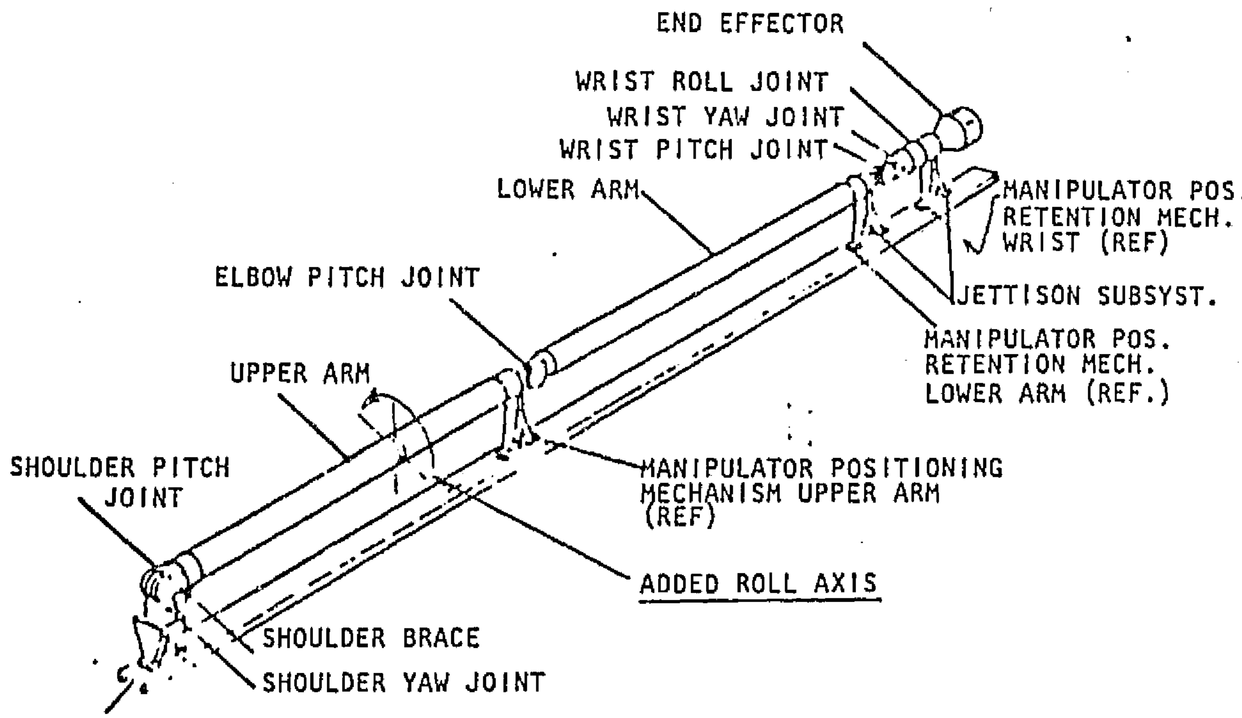
Possibly 1 EVA/MMU astronaut as observer/guide

1 RMS operator

Activity Time

Attach RMS to thrust structure	5 Min
Move thrust structure to platform	15
Align berthing port	10
Mate first berthing port	5
Rotate cross beam	10
Mate second berthing port	5
Mate third berthing port	5
	55 Min

FUNCTION · ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	04.1
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



MODIFIED RMS

Items

- RMS with rotational capability of upper arm and special light TV package with 360° rotational capability.

FUNCTION	JOIN	CODE	01	0501.2	04.1
ITEM	THRUST STRUCTURE/PLATFORM				
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	5	of	6
SUBJECT	SUPPORT SERVICES				

Crew

- 1 RMS operator

Power

- RMS Operation 1-1.8 KW

Lighting and TV

- Standard payload bay and special RMS lighting and TV (rotational capability) (daylight side of orbit preferred)

Computer/Software

- RMS orientation transform system

Stowage

- None

Other

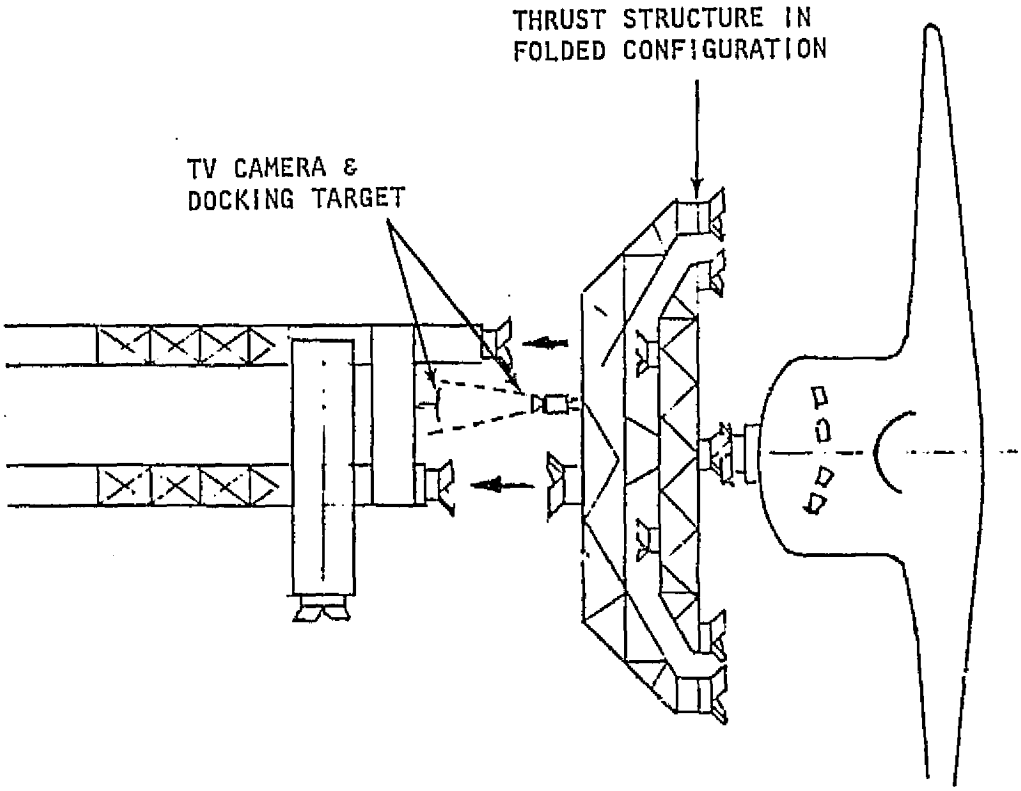
- Orbiter requires capability for remote command to extend the platform mounted berthing ports

FUNCTION	JOIN	CODE	01	0501.2	04.1
ITEM	THRUST STRUCTURE/PLATFORM				
METHOD	RMS (ORBITER TO FIXTURE)	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	–	1.8	TBD	–	NC
RMS Upper Arm Modifications	79	0	–	TBD	TBD	–	1764
Support Services							
Crew	–	–	1/1	–	–	–	–
Power (Total)	–	–	–	1.8	TBD	–	TBD
Project Modification – None							
Operations	–	–	1/1	–	–	55	NA*

*Not appropriate, see page 6.

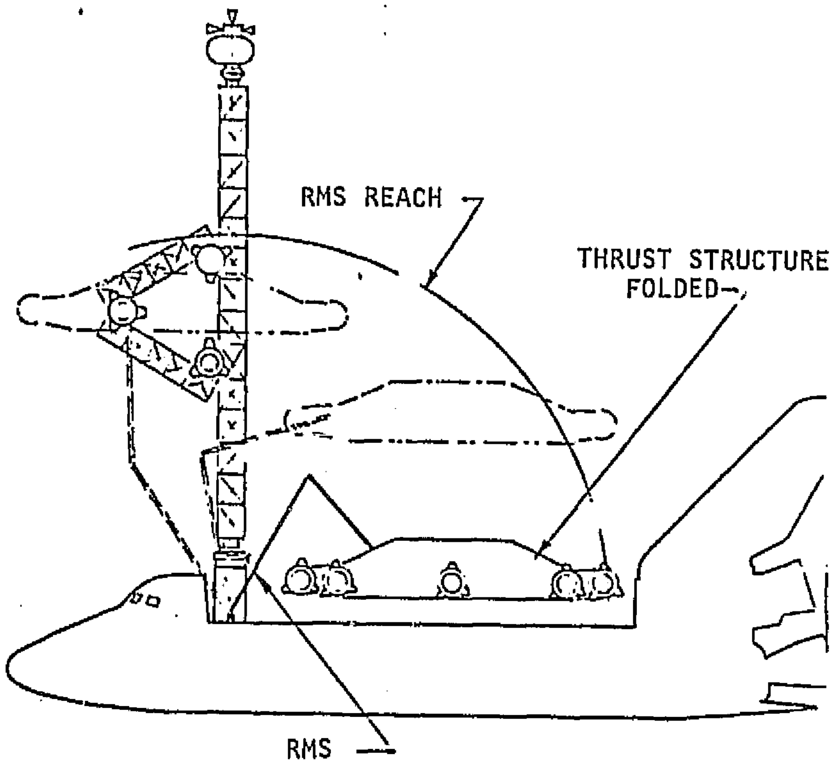
FUNCTION· ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	09.1
METHOD	ORBITER MATE	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



- The thrust structure is designed to fold and fit in the orbiter bay.
- The RMS removes the folded thrust structure from the orbiter bay and mates it with the orbiter docking port.
- The thrust structure is then mated with one of the berthing ports on the platform.
- The cross beam on the thrust structure rotates 90°. The second and third berthing ports are mated.
- Docking targets and TV cameras are required.

NO ADDITIONAL DETAILS ARE PROVIDED

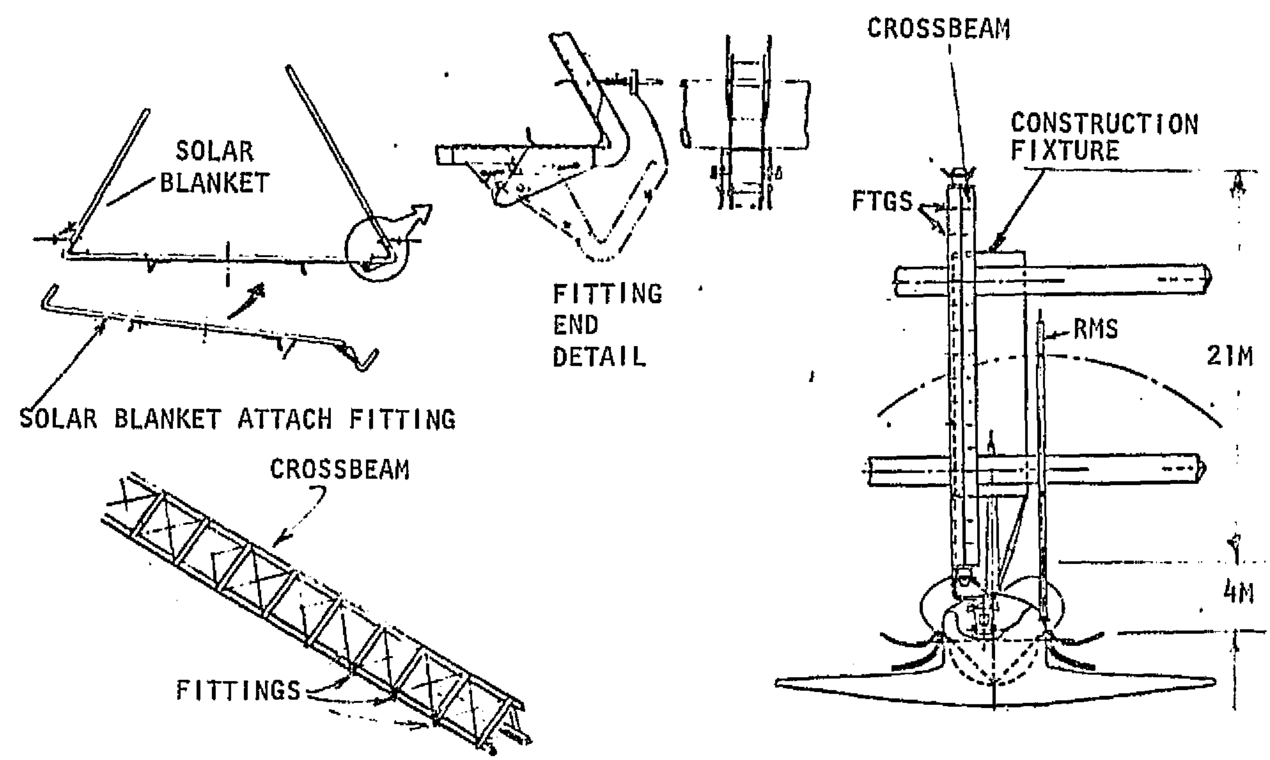
FUNCTION· ITEM	JOIN THRUST STRUCTURE/PLATFORM	CODE	01	0501.2	04.2
METHOD	RMS - ORBITER DOCKS TO RCS PORT	PAGE	1	of	1
SUBJECT	METHOD DESCRIPTION				



- The thrust structure is designed to fold and fit in the orbiter bay.
- The orbiter docks with the platform at an RCS location, before the RCS is installed.
- The RMS removes the thrust structure from the orbiter bay and mates the first of 3 berthing ports.
- The next step is to rotate the cross beam of the thrust structure through 90° with the RMS.
- The second and third berthing ports of the thrust structure are now opposite their corresponding ports on the platform. They are then extended and mated. These two berthing ports must be self aligning or floating.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION ·	INSTALL	CODE	01	05 01.3	00
ITEM ·	SOLAR BLANKET SWITCH BOX ATTACH FITTING	PAGE	1 of 2		
METHOD					
SUBJECT	OPERATION IDENTIFICATION				



Project System

SPS Test Article

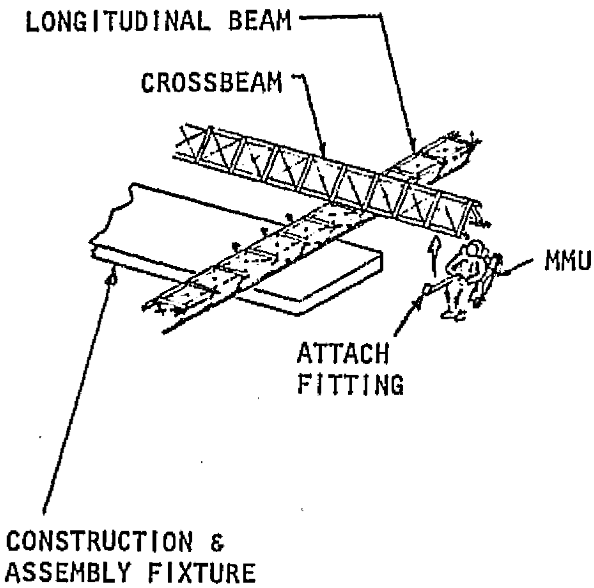
Operation

Install attach fitting at every cross member on base of fabricated cross beam (15 places on each of 6 cross beams).

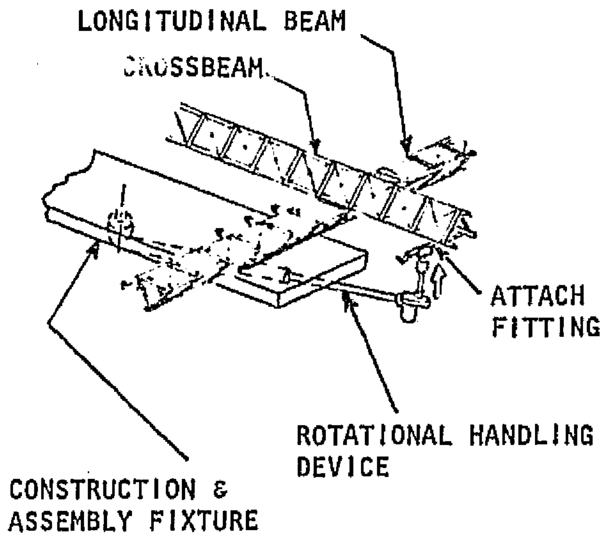
Physical Situation

The structure completed, berthing ports attached and RCS modules installed.

FUNCTION	INSTALL	CODE	01	05 01.3	00
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING	PAGE	2 of 2		
METHOD					
SUBJECT	ALTERNATE METHODS				



MANUAL



AUTOMATED

The following methods have been identified:

Manual

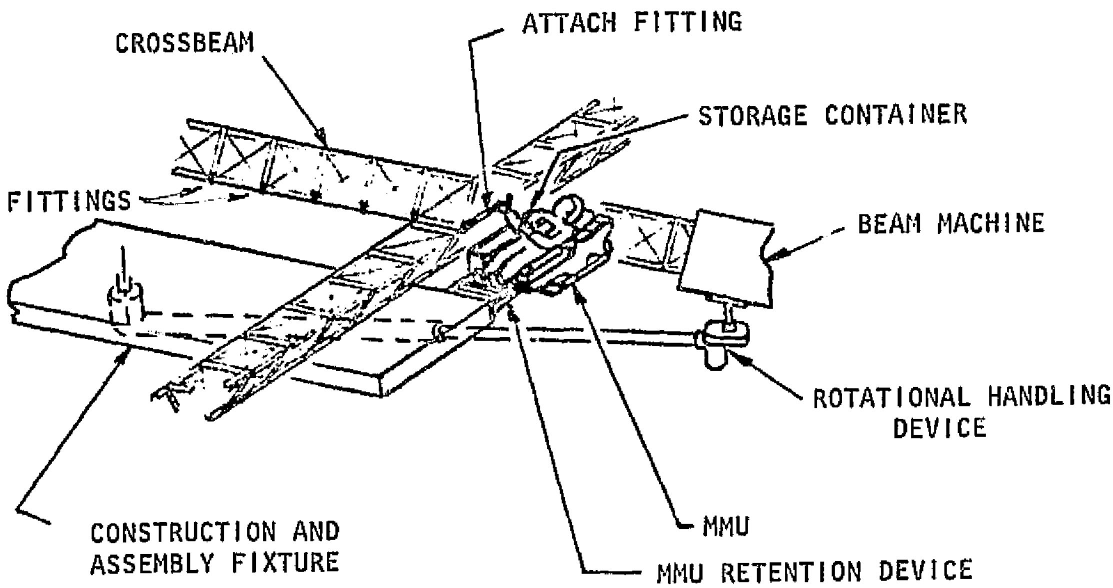
1. EVA/MMU fixed station (fittings installed during beam fabrication)
2. Cherry Picker/Fixture Rotational Handling Device.
3. MMU Free Flyer
4. Cherry Picker with fixture in Z axis orientation.

Automated

5. Fixture Rotational Handling Device

Methods 1 and 2 are detailed.

FUNCTION · ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	02.1
METHOD	MMU/FIXED STATION	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



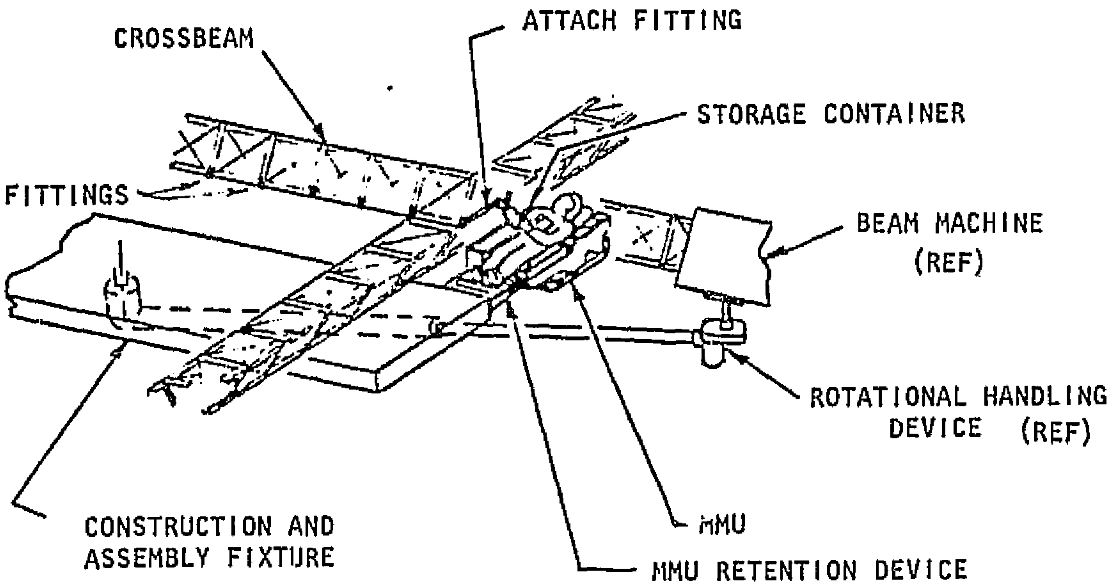
- The EVA/MMU astronaut proceeds to an MMU retention device (work station) attached to the construction and assembly fixture.

- After securing, the crewman is ready for installation of the attach fittings, the fittings are contained in the cannister which he transported to the work station.

- Installation of the attach fittings is executed during cross beam fabrication and is sequenced with the beam machine operations.

- The beam machine stops intermittantly to attach the cross members. During this period, each attach fitting will be manually installed.

FUNCTION· ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	02.1
METHOD	MMU/FIXED STATION	PAGE	2 of 5		
SUBJECT	OPERATIONS				



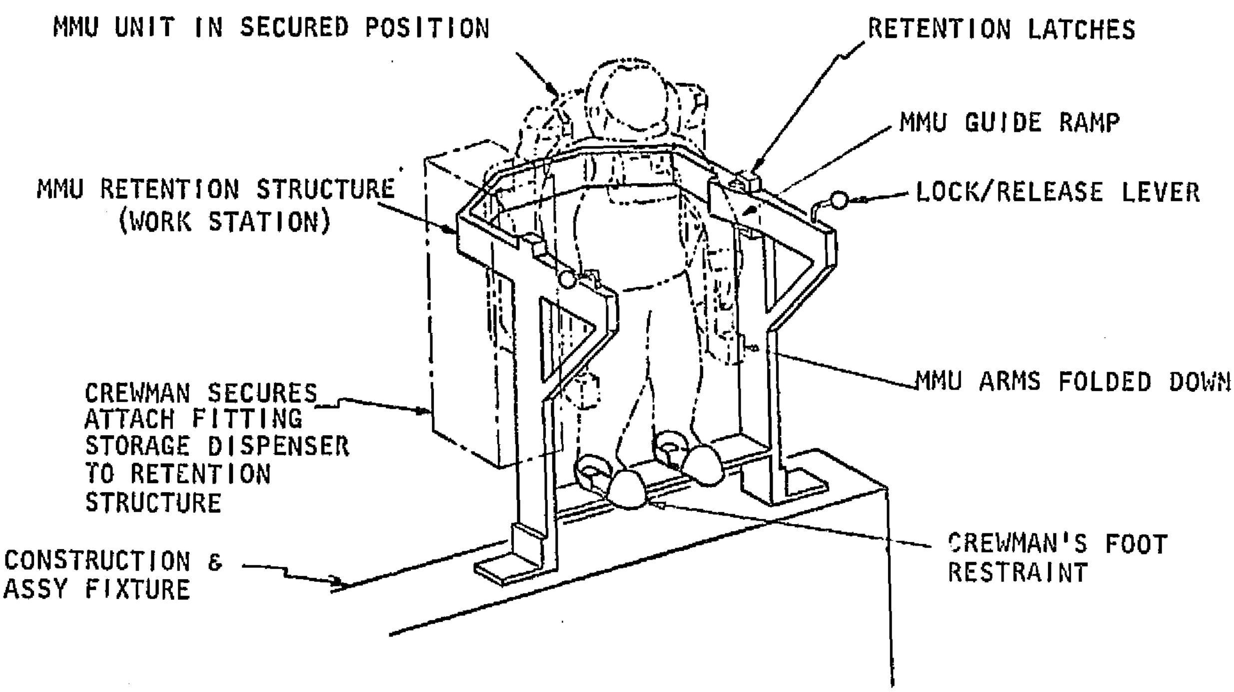
<u>Manpower</u>

- One EVA/MMU crewman

<u>Activity Time</u>

- EVA/MMU crewman picks up attach fitting container from payload bay.	3 min.
- MMU proceeds to work station, attaches container and locks MMU unit into retention structure.	7 min.
- Crewman removes fitting and joins to base of cross beam at each cross member (15)	<u>15 min</u>.
TOTAL PER CROSS BEAM	25 min.

FUNCTION· ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	02.1
METHOD	MMU/FIXED STATION	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- MMU
- Work Station
    - o The station is a structural framework attached to the upper end of the construction and assembly fixture.
    - o The "U" shaped frame simulates the orbiter provision for securing the MMU in the payload bay. This concept permits the EVA/MMU crewman to back in and secure the MMU to the frame.
    - o The crewman is also provided with foot restraints (as shown).
    - o Release levers retract the latches when the MMU unit is ready to leave.
    - o Attach provisions are also provided for the base attach fitting container.
- Attach Fitting Storage Container

FUNCTION	INSTALL	CODE	01	05 01.3	02.1
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING				
METHOD	MMU/FIXED STATION	PAGE	4 of 5		
SUBJECT	SUPPORT SERVICES				

<u>Crew</u> - One EVA/MMU Crewman

<u>Power</u> - MMU Recharge TBD

<u>Lighting & TV</u>

- Standard MMU and orbiter

<u>Computer/Software</u>

- None

<u>Stowage</u> - Work Station - 1.3 x 1.8 x 1.2m
Attach fitting storage container - 0.3 x 0.5 x 1.8m

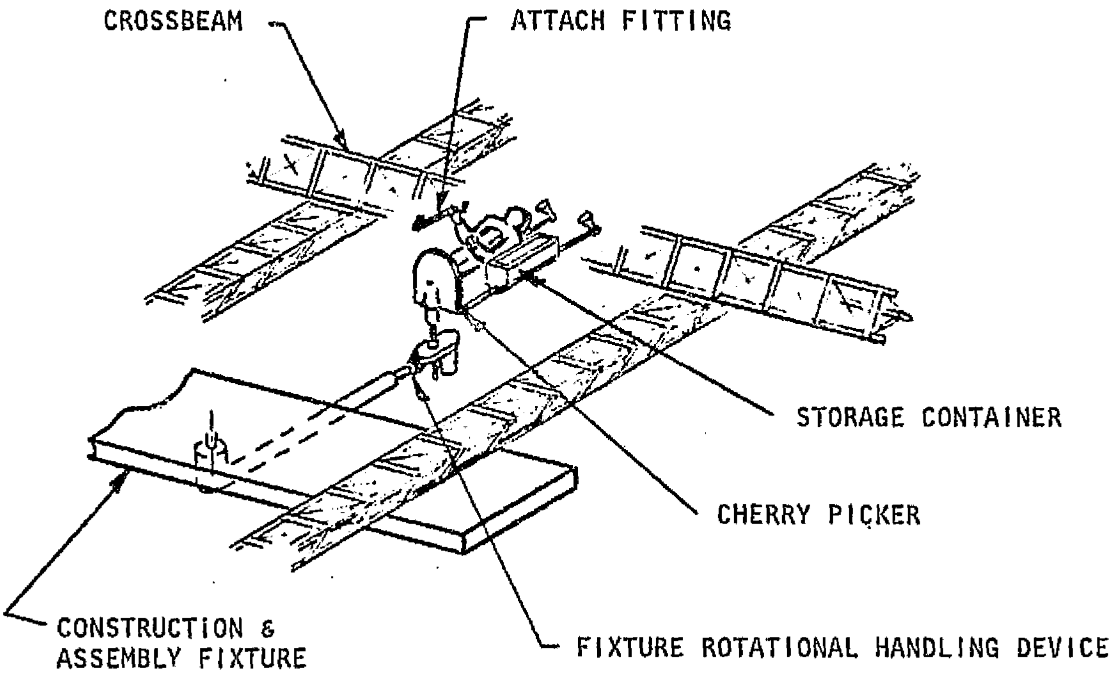
<u>Other</u> - MMU Propulsion Charge

FUNCTION	INSTALL	CODE	01	05 01.3	021
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING				
METHOD	MMU/FIXED STATION	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
MMU	110	1.1	--	TBD	TBD	--	100
Work Station (MMU Retention Structure)	25	2.8	--	0	0	--	748
Attach Fitting Container	20	2.7	--	0	0	--	613
<u>Support Services</u>							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
<u>Project Modification</u>							
None							
<u>Operations</u>	--	--	1/1	--	--	25	NA*

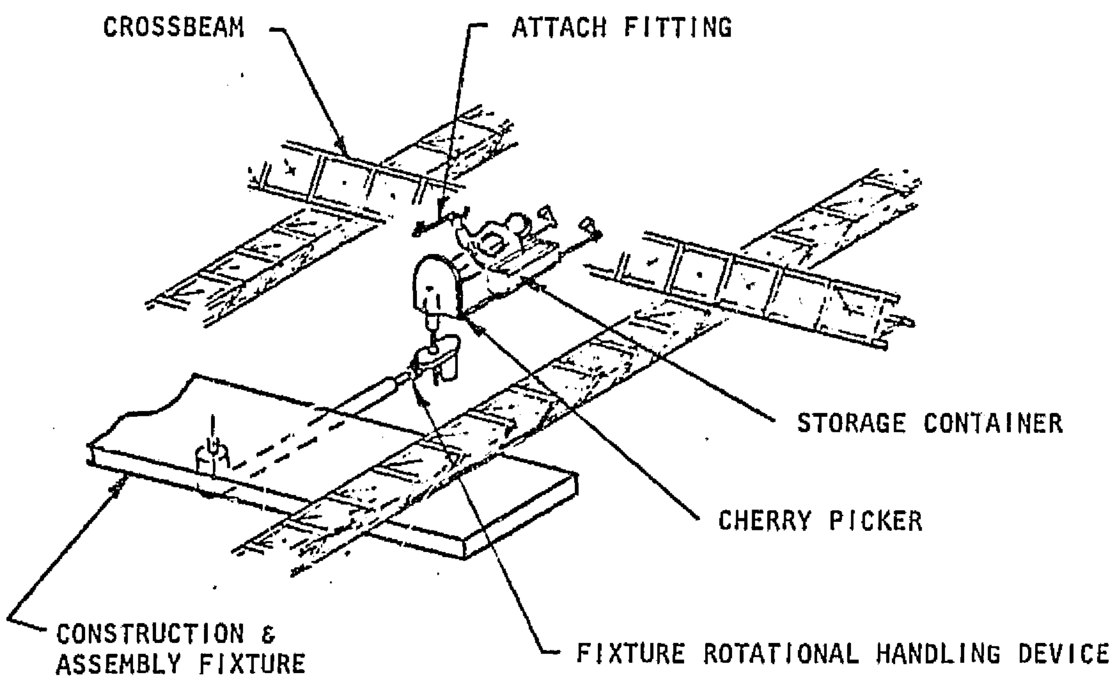
*Not appropriate, see page 6.

FUNCTION· ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	03.1
METHOD	CHERRY PICKER/HANDLING DEVICE	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- The cherry picker located at the end of the fixture rotational handling device moves towards the payload bay where a cannister of attach fittings is removed from the bay by the RMS and secured to the cherry picker.
- The handling device (controlled from the cherry picker) is rotated and aligned in position and the crewman joins the first attach fitting to the cross beam.
- The crewman activating the handling device aligns himself at each subsequent cross member location along the cross beam and attaches a fitting until all have been installed.
- The operation is repeated for each of the six cross beams.

FUNCTION	INSTALL	CODE	01	05 01.3	03.1
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING				
METHOD	CHERRY PICKER/HANDLING DEVICE	PAGE	2 of 5		
SUBJECT	OPERATIONS				



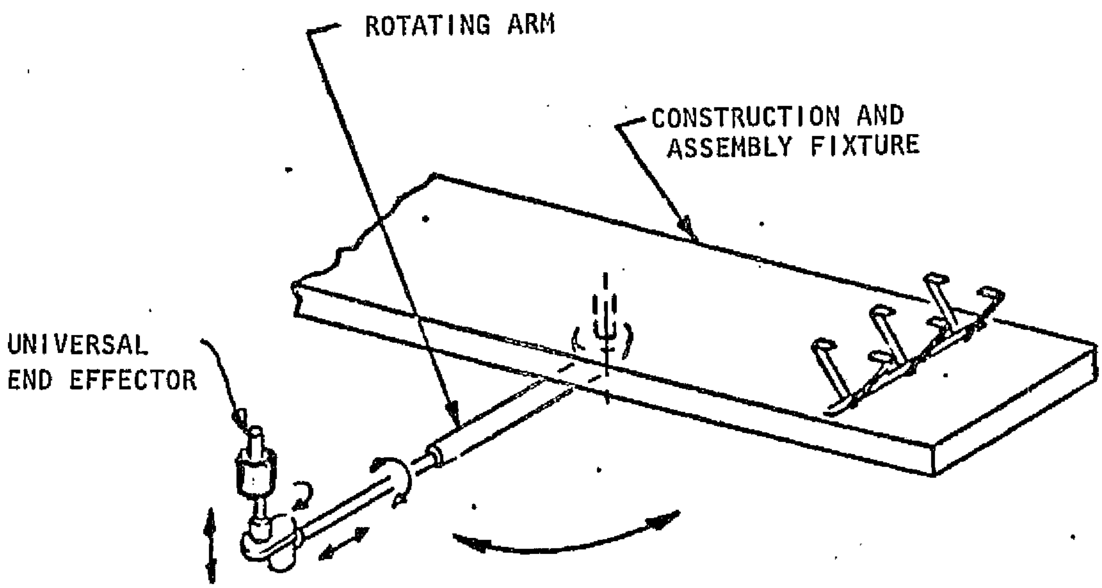
Manpower

- One cherry picker/rotational handling device operator
- One RMS operator at AFD

Activity Time

- RMS retrieves storage container and attaches to cherry picker.	4 min.
- Handling device rotates to first position.	2 min.
- Crewman removes fitting from container and attaches to base of cross beam.	2 min.
- Handling device is activated, positioned for next assembly and fitting installed.	3 min.
- Procedure repeated 13 times.	39 min.
TOTAL PER CROSS BEAM	50 min.

FUNCTION	INSTALL	CODE	01	05 01.3	03.1
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING				
METHOD	CHERRY PICKER/HANDLING DEVICE	PAGE	3	of	5
SUBJECT	CONFIGURATION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS
- Cherry Picker
- Attach Fittings Storage Container
    - Spring loaded magazine

Crew - One Cherry Picker/Rotational Handling Device Operator

- One RMS Operator at AFD

Power - Cherry Picker Operation 0.5 kW

- RMS Operation 1-1.8 kW

Lighting & TV

- Standard Cherry Picker Orbiter and RMS

Computer/Software

- RMS Coordinate Transform System

Stowage

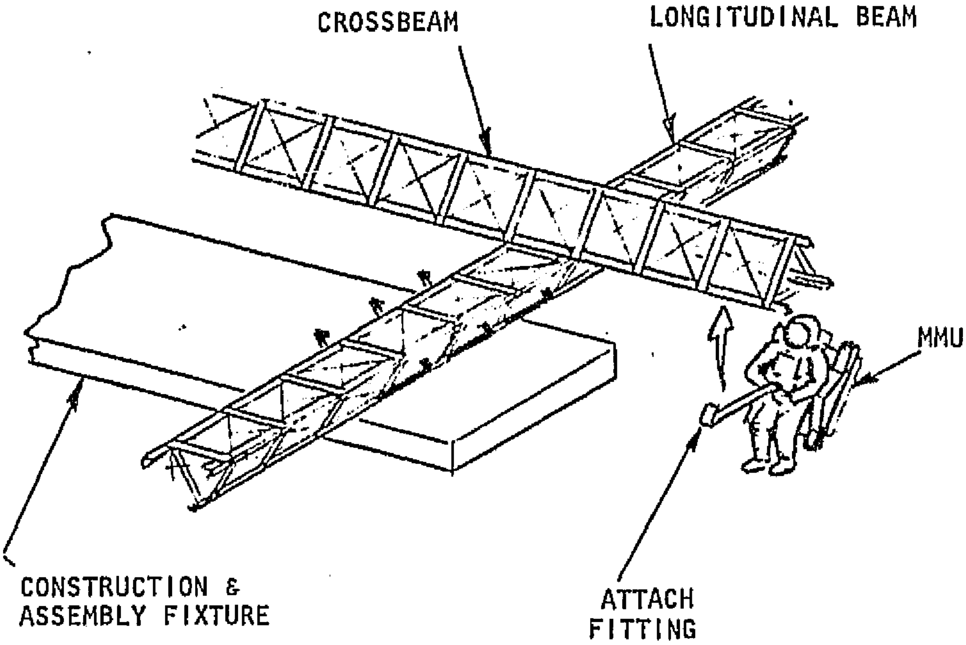
- Attach Fitting Storage Container - 0.3 x 0.5 x 1.8m

FUNCTION ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	03.1
METHOD	CHERRY PICKER/HANDLING DEVICE	PAGE	5 of 5		
SUBJECT					

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	--	1.8	TBD	--	NC
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
Attach Fitting Container	20	2.7	--	0	0	--	611
Support Services							
Crew	--	--	2/1.1	--	--	--	--
Power (Total)	--	--	--	2.3	TBD	--	TBD
Project Modification							
None							
Operations	--	--	2/1.1	--	--	50	NA*

*Not appropriate, see Page 6.

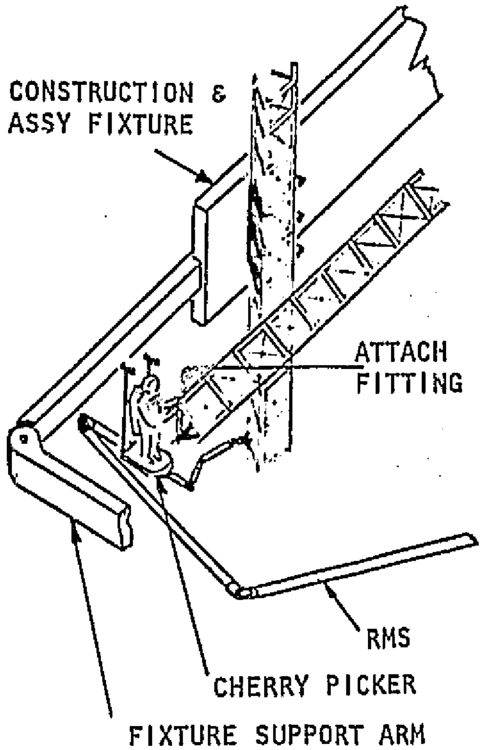
FUNCTION ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 03.1	02.2
METHOD	EVA/MMU FREE FLYER	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

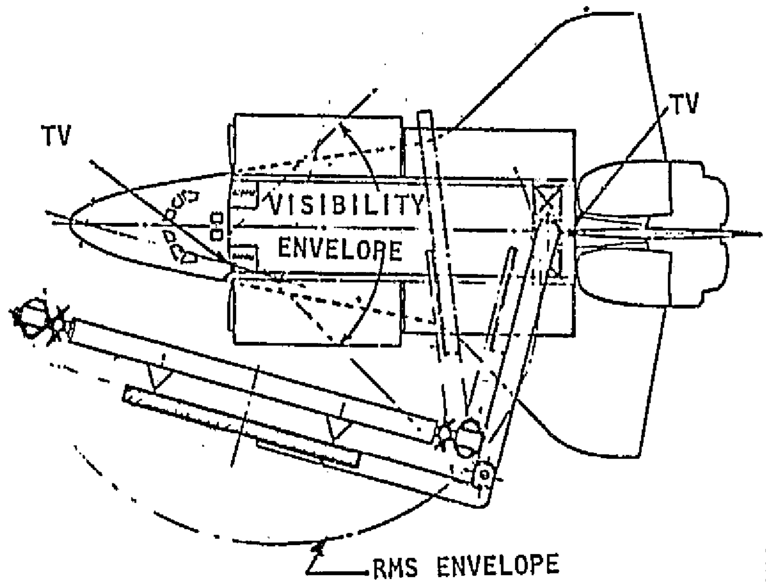


- The EVA/MMU crewman proceeds to a position where he manually installs the first attach fitting to the base of the cross beam.
- The crewman then translates "below" the length of the cross beam, manually installing all subsequent fittings, which are stored in a cannister attached to the MMU unit.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	INSTALL SOLAR BLANKET SWITCH BOX ATTACH FITTING	CODE	01	05 01.3	03.2
METHOD	CHERRY PICKER (FIXTURE IN Z-AXIS)	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



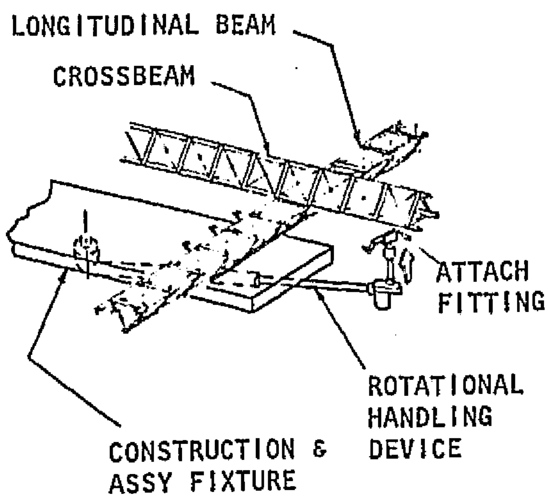


CONSTRUCTION FIXTURE IN Z-AXIS ORIENTATION

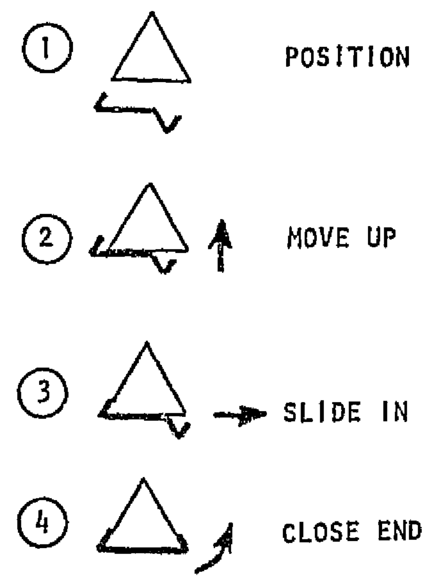
- The cherry picker crewman picks up attach fitting container from cargo bay, attaches it to the cherry picker and moves to work site.
- The crewman moves the cherry picker along the cross beam to allow for manual installation of an attach fitting at each cross member.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION	INSTALL	CODE	01	05 01.3	10.1
ITEM	SOLAR BLANKET SWITCH BOX ATTACH FITTING				
METHOD	ROTATIONAL HANDLING DEVICE	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



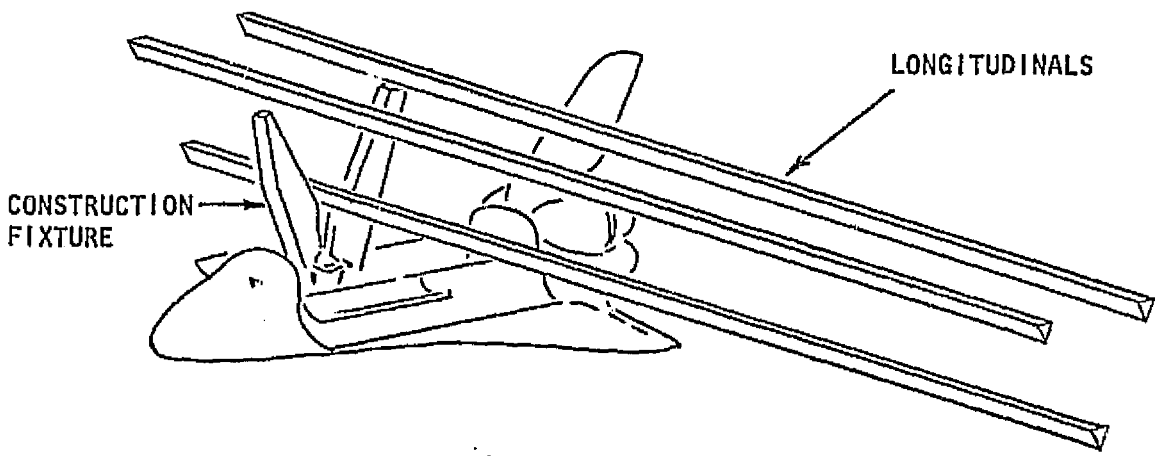
ATTACH FITTING



- o The RMS deploys an automated attach fitting dispensing cannister and secures it to a surface within reach of the fixture rotational handling device.
- o The handling device picks up an attach fitting from the dispenser and rotates into position below the first cross member at the base of the cross beam.
- o Assembly sequence 1 through 4 is then followed.
- o The handling device releases fitting, returns to dispenser and the procedure is repeated.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION· ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	00
METHOD		PAGE	1 of 2		
SUBJECT	OPERATION IDENTIFICATION				



<u>Project System</u>

Space Fabricated Advanced Communications Platform.

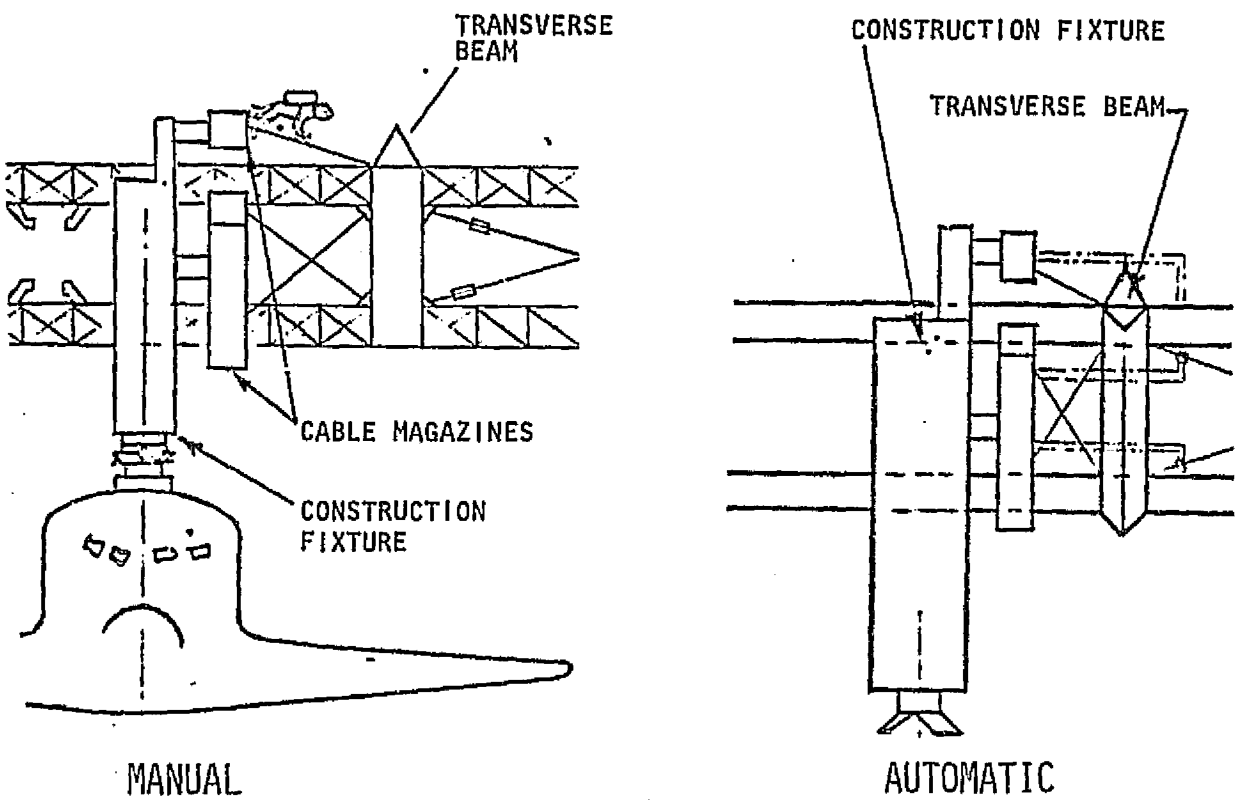
<u>Operation</u>

Install cross bracing cables between the three longitudinal beams which form the basic structure of the platform.

<u>Physical Situation</u>

- The orbiter is docked to the construction fixture
- The three longitudinal beams have been fabricated

FUNCTION · ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	00
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

1. Two EVA astronauts with cross bracing cables in magazines.

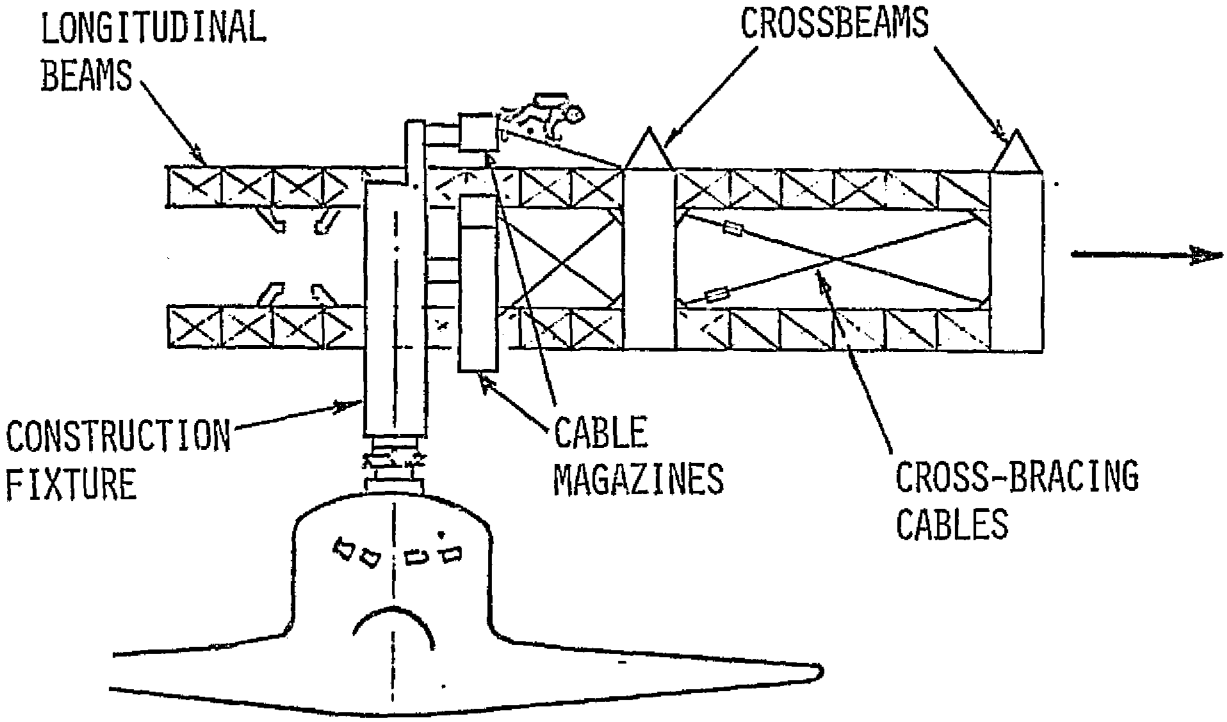
2. EVA/MMU astronaut with cross bracing struts in magazines.

Automated

3. Fully automatic station on the construction fixture.

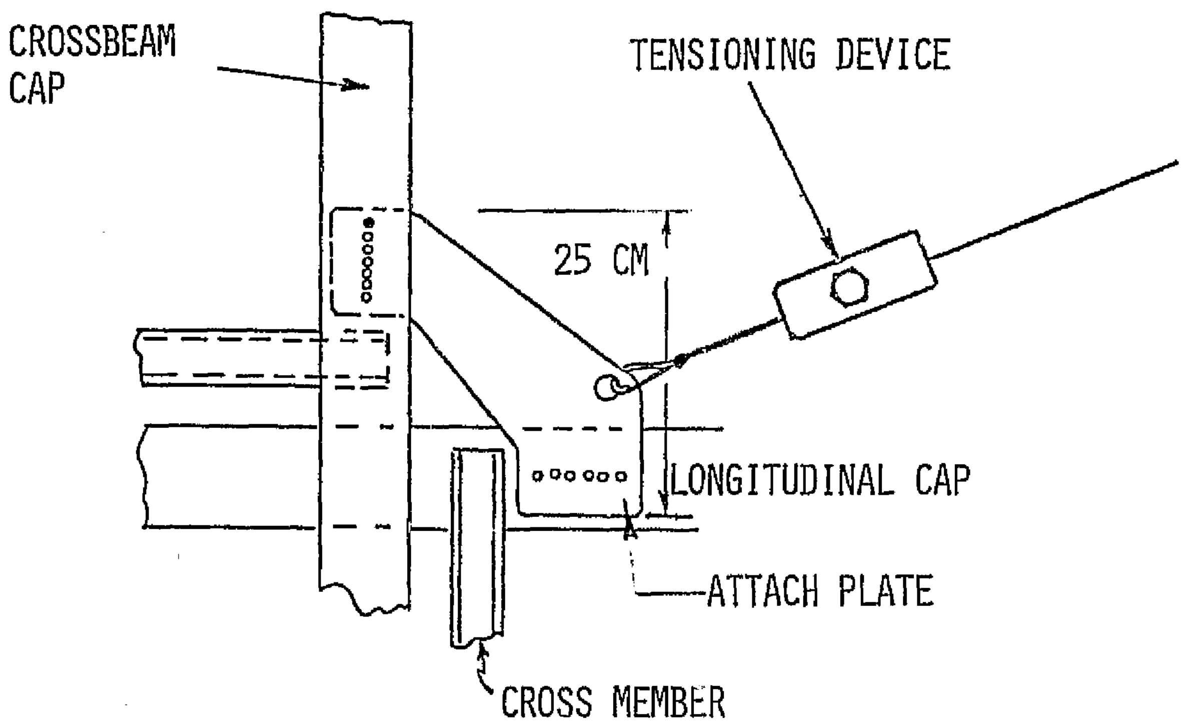
Methods 1, 2 and 3 are detailed.

FUNCTION · ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	01.1
METHOD	EVA	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- o Weld the attach plates (Page 2) to the longitudinal beams as they are fabricated by the beam builder.
- o The pre-fabricated cables are in three magazines.
- o Retract the three longitudinal beams.
- o Fabricate and install the first set of cross and transverse beams. Weld attach bracket to beams.
- o EVA astronauts install the forward ends of six cables to the attach plates while the first set of cross and transverse beams are being fabricated and installed.
- o The longitudinal beams are advanced, pulling out the six cables, two from each magazine.
- o EVA astronauts install the aft ends of the six cables.
- o Fabricate and install the second set of cross and transverse beams. Weld attach bracket to beams.
- o EVA astronauts tension the six cables using the tool shown on Page 4, and install the forward ends of the second set of cables while the second set of cross and transverse beams are being fabricated and installed. The two cables in each plane must be tensioned simultaneously.

FUNCTION·	INSTALL	CODE	01	06 01.1	01.1
ITEM	CROSS BRACING CABLES				
METHOD	EVA	PAGE	2	of	6
SUBJECT	PROJECT MODIFICATIONS				

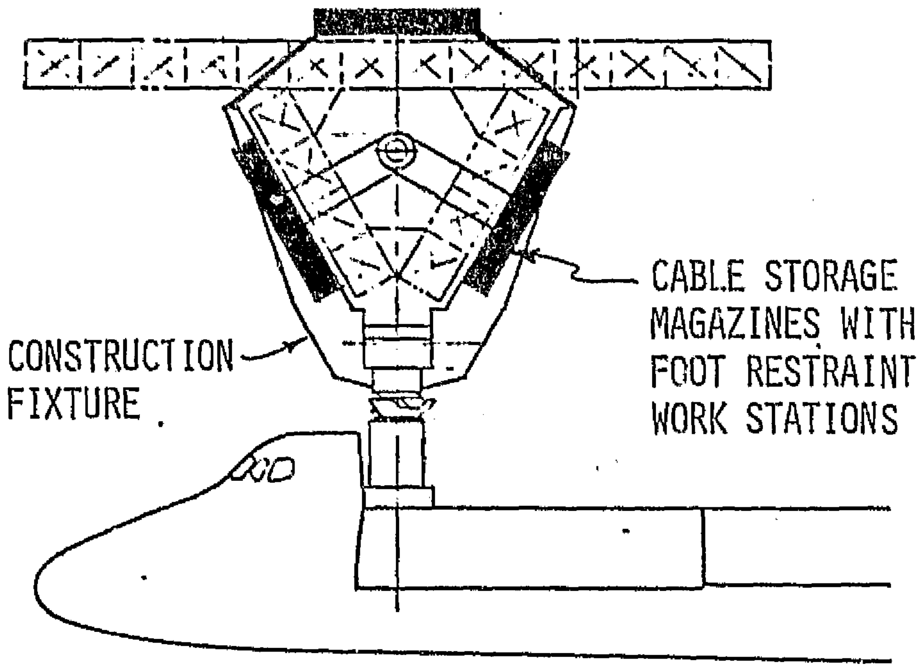


Cable attach plates welded to the four corners of each of three sides of each bay (23).

Cross bracing cables have attaching hooks and safety bars at each end, and a tensioning device which can be operated by the tool shown on Page 4.

The cables are graphite epoxy and are fabricated as a strap .38mm (.015") x 83mm (3.27") to facilitate coiling for most of its length.

FUNCTION · ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	01.1
METHOD	EVA	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

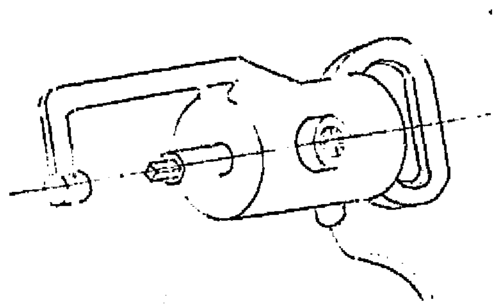
- Two EVA operators

Activity Time

- Install front ends of set of six cables (one bay)	9 min.
- Advance structure	2 min.
- Install aft ends of set of six cables	9 min.
- Tension cables	9 min.
Total per bay	29 min.

Support Activity

- Remove cable storage magazines (three) from payload bay and install on fixture	180 min.
- Remove magazines (three) from fixture and place in payload bay.	180 min.



POWERED MANUAL TOOL FOR
TENSIONING CABLES

Items

- RMS
- Powered manual tool for applying tension load of approximately 1200 lbs. to the cross bracing cables.
- Three magazines or containers for pre-fabricated cross bracing cables. Each magazine to contain 46 cables.
- Work stations to be attached to the construction fixture.

Crew - Two EVA operators

Power - Hand held tensioning tools 300 Watts

Lighting & TV -

Standard illumination

Computer/Software -

Not required

Stowage -

Three cable magazines - 3 x 1 x 0.2m each

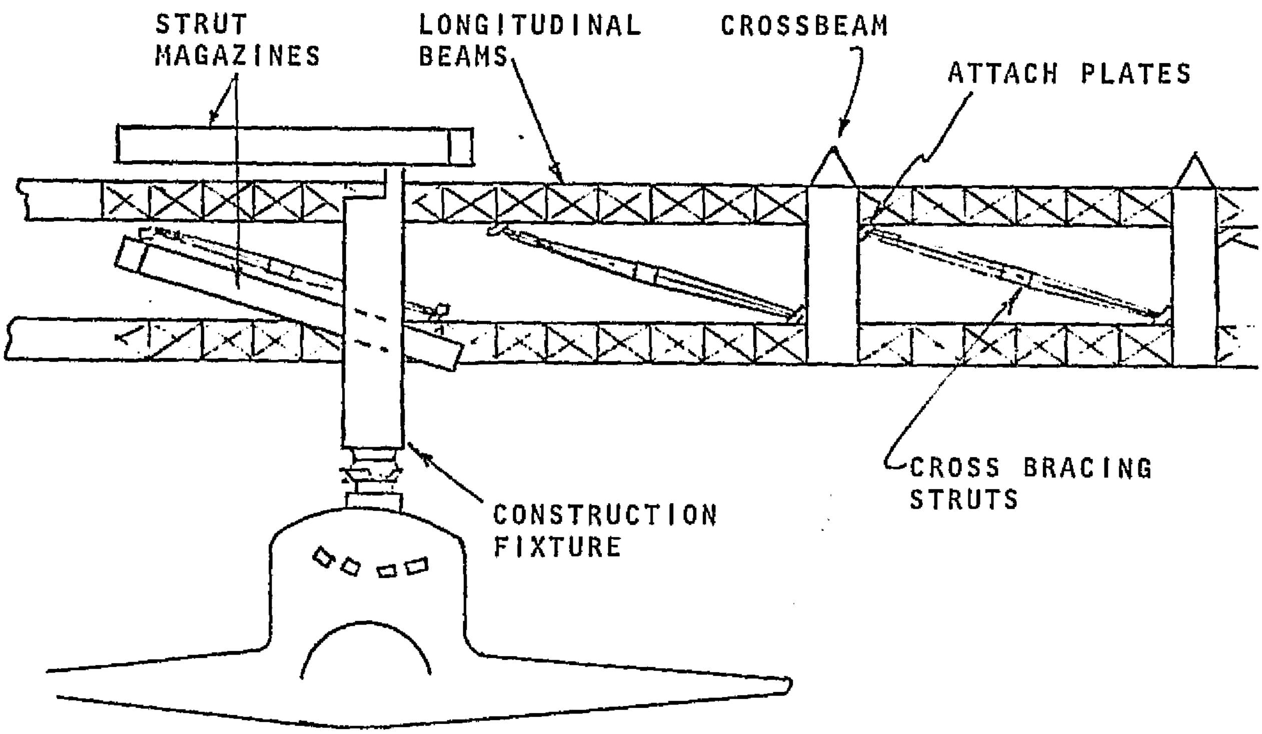
Six work stations - 0.5 x 0.5 x 0.2m each

FUNCTION	INSTALL	CODE	01	06 01.1	01.1
ITEM	CROSS BRACING CABLES				
METHOD	EVA	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Magazines (3)	30	1.8	--	0	0	--	563
Work stations (6)	12	0.4	--	0	0	--	197
Power tools (2)	10	NEG	--	0.6	TBD	--	515
RMS	0	0	--	1.8	TBD		NC
Support Services							
Crew	--	--	2/2	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Project Modification							
Attach plates (276)	15	0.2	--	--	--	--	155
Tension Devices (138)	138	0.1	--	--	--	--	1436
Operations	--	--	2/2	--	--	29	NA*

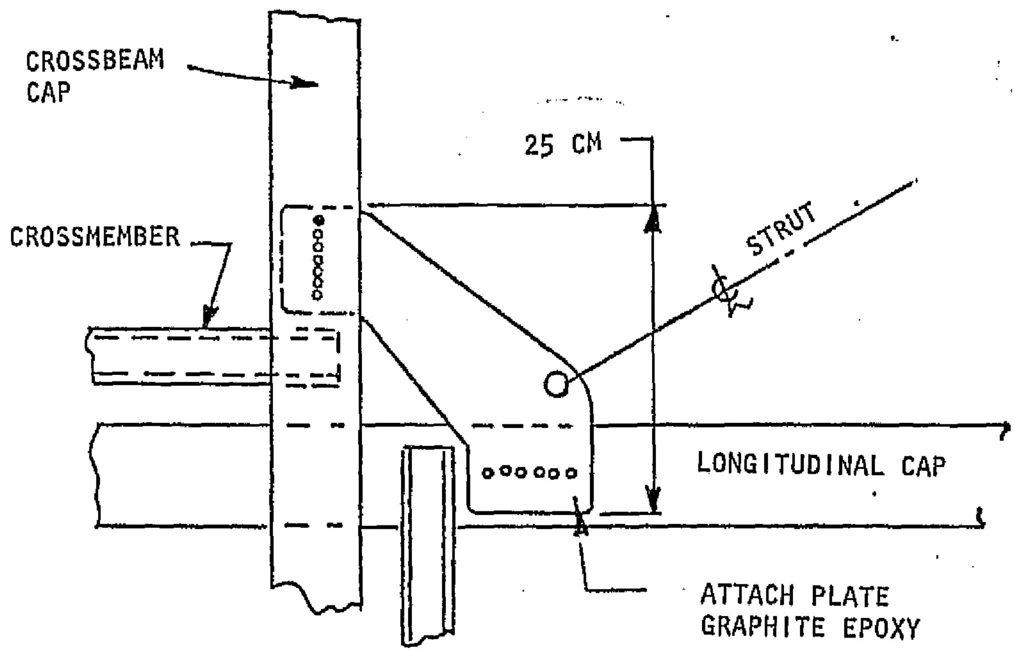
*Not appropriate, see page 6.

FUNCTION	INSTALL	CODE	01	06 01.1	02.1
ITEM	CROSS BRACING STRUTS				
METHOD	MMU/STRUTS	PAGE	1 of 7		
SUBJECT	METHOD DESCRIPTION				



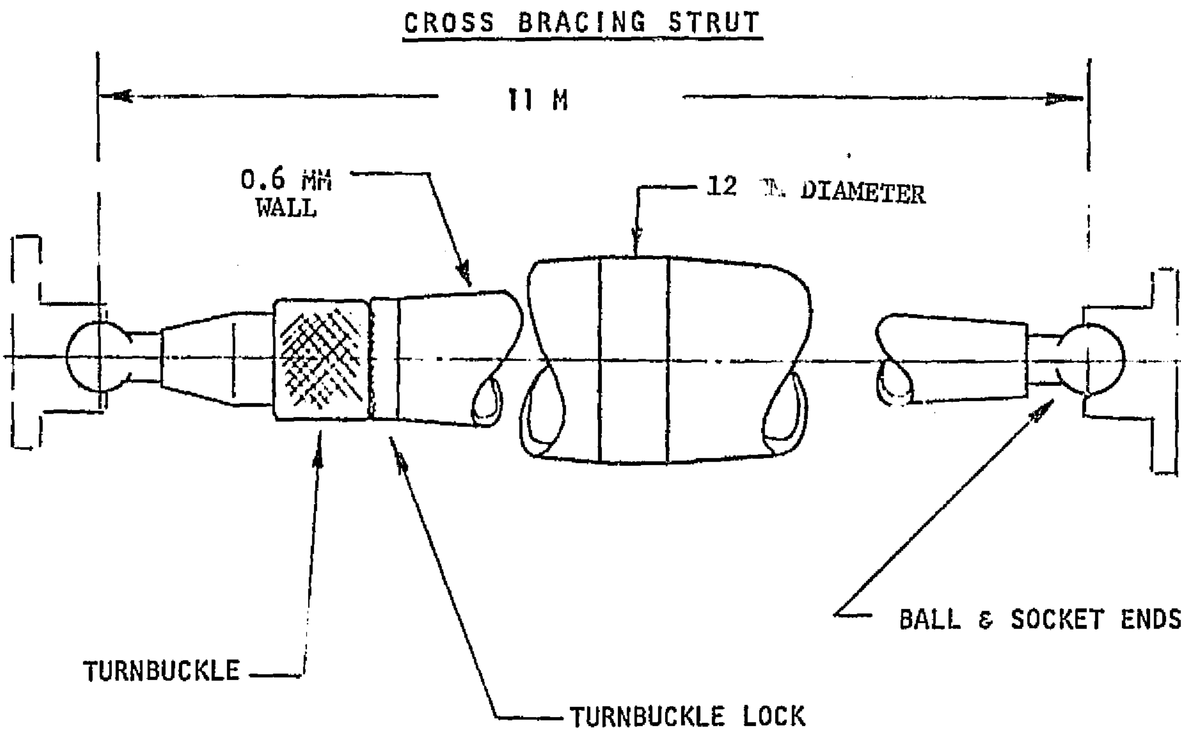
- Weld the attach plates to the longitudinal beams as they are fabricated by the beam builder.
- The struts are in three magazines.
- Retract the three longitudinal beams.
- Fabricate and install the first set of cross and transverse beams. Weld attach brackets to beams.
- While the first set of cross and transverse beams is in work, an EVA/MMU astronaut removes the first set of three struts from their magazines and installs them to the platform.

FUNCTION · ITEM	INSTALL CROSS BRACING STRUTS	CODE	01	06 01.1	02.1
METHOD	MMU/STRUTS	PAGE	2 of 7		
SUBJECT	PROJECT MODIFICATIONS				



Attach plates at two corners of each of three sides of 23 bays of the platform - 138 plates total.

FUNCTION	INSTALL	CODE	01	06 01.1	02.1
ITEM	CROSS BRACING STRUTS				
METHOD	MMU/STRUT	PAGE	3 of 7		
SUBJECT	PROJECT MODIFICATIONS (Continued)				



Material

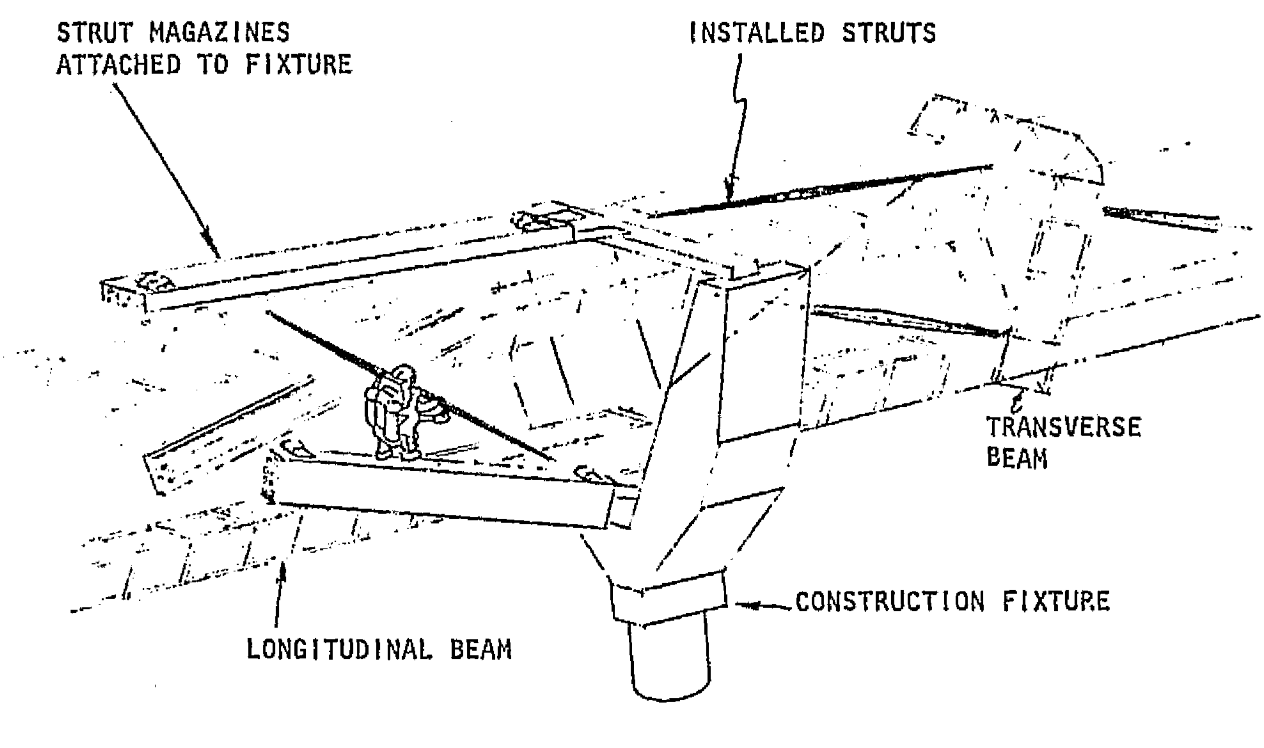
Graphite epoxy with aluminum fittings.

Number Required

Three per bay - 3 x 23 = 69.

Knurled turnbuckle for adjusting length of strut, with a spring loaded turnbuckle lock.

FUNCTION·	INSTALL	CODE	01	06 01.1	02.1
ITEM	CROSS BRACING STRUTS				
METHOD	MMU-STRUTS	PAGE	4	of	7
SUBJECT	OPERATIONS				



Manpower - One EVA/MMU Operator

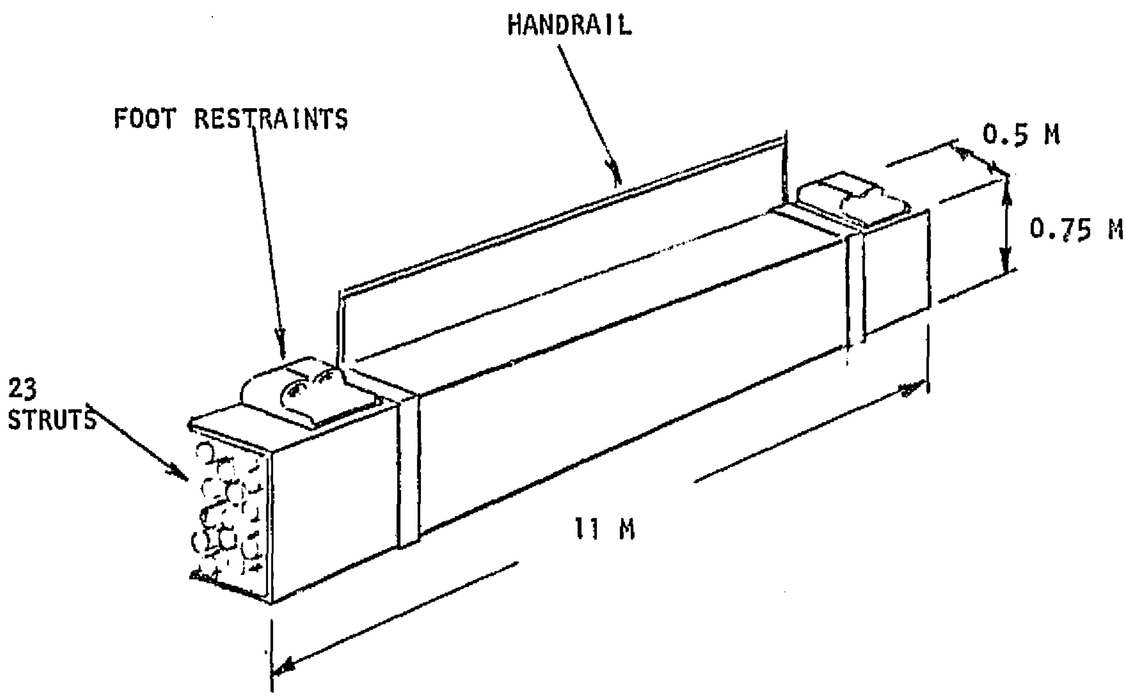
Activity Time

Obtain strut and move into position	7 min.
Install one strut end	1 min.
Move to other end of strut	2 min.
Install second end of strut	3 min.
Move to magazine for next strut	2 min.
Total Time Per Strut	15 min.

Support Activity

Remove magazines from orbiter bay and install in working position	180 min.
Remove and replace in orbiter bay	180 min.

FUNCTION· ITEM	INSTALL CROSS BRACING STRUTS	CODE	01	06 01.1	02.1
METHOD	MMU/STRUTS	PAGE	5	of	7
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS
- MMU
- Strut storage magazines capacity (each) - 23 struts 11m long x 12 cm in diameter. Fitted with foot restraints at each end and a handrail along the length. Capable of being removed from the orbiter bay by the RMS and attached to the construction fixture.

Crew - One EVA/MMU operator

Power - MMU recharge - TBD

Lighting & TV -

Standard MMU illumination

Computer/Software -

Not required

Stowage -

Three magazines - 11.5 x 0.8 x 1m each

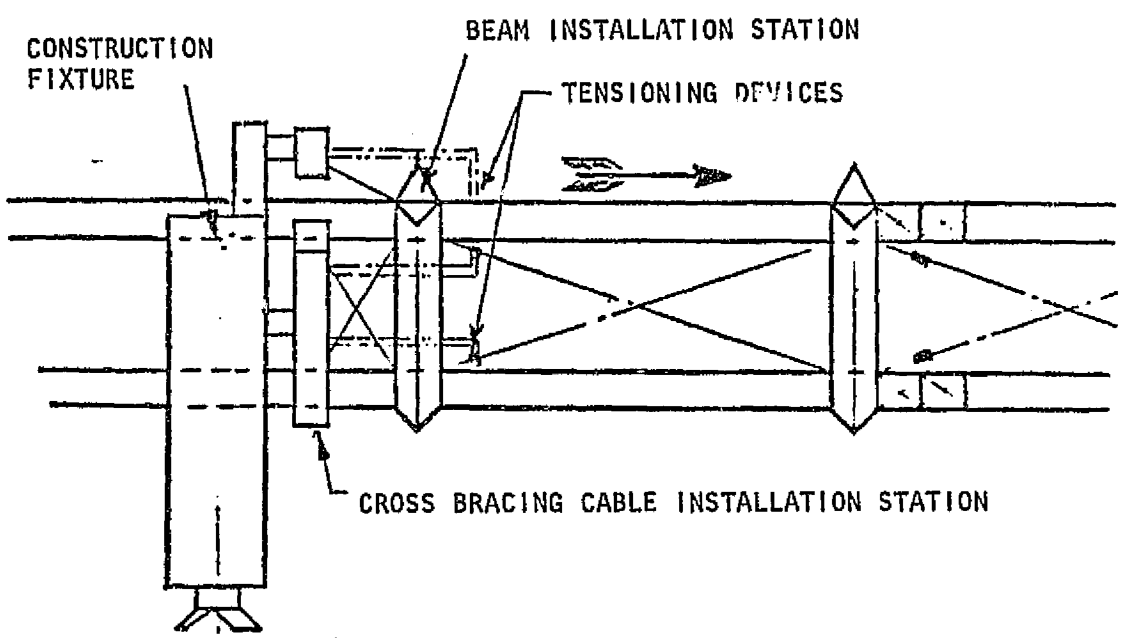
Other - MMU propulsion recharge

FUNCTION	INSTALL	CODE	01	06 01.1	02.1
ITEM	CROSS BRACING STRUTS				
METHOD	MMU/STRUTS	PAGE	7 of 7		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
Magazines (3)	150	25.9	--	0	0	--	1787
MMU	110	1.1	--	TBD	TBD	--	100
RMS	0	0	--	1.8	TBD	--	NC
<u>Support Services</u>							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
<u>Project Modification</u>							
Attach plates (138)	7.5	.05	--	--	--	--	86
Struts at 7 kg (69)	483**	*	--	--	--	--	3350
<u>Operations</u>	--	--	1/1	--	--	15	TBD

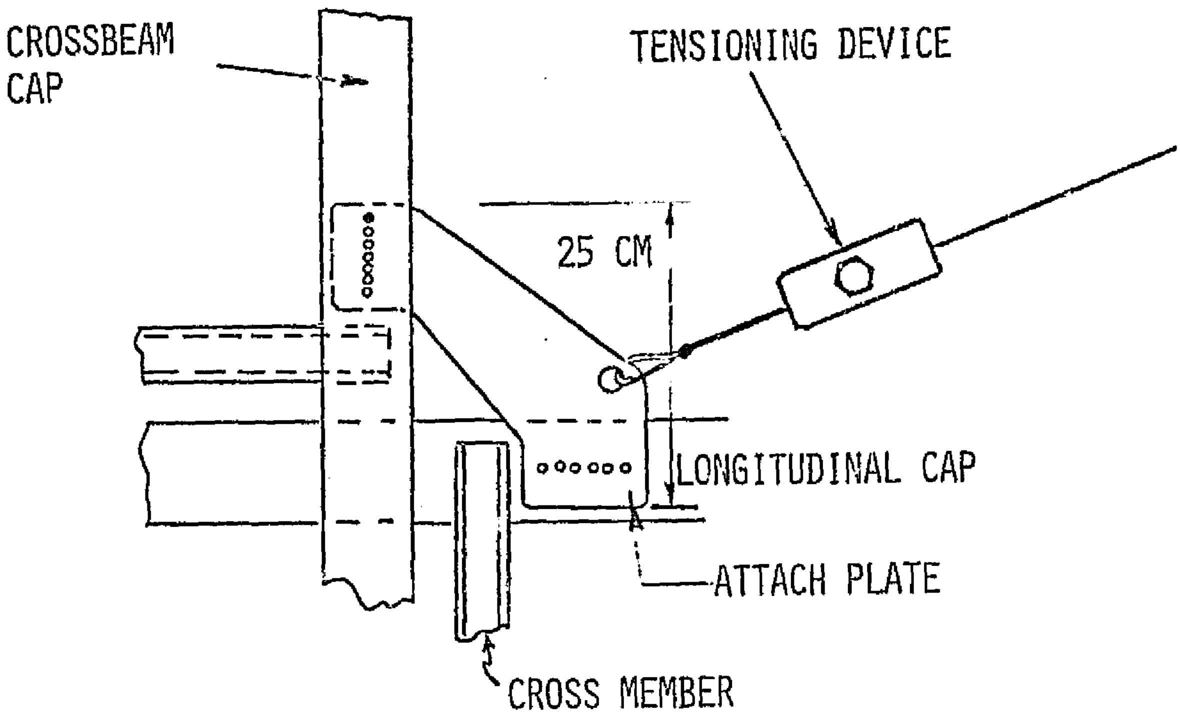
*Stowed inside magazines
**Baseline cables (138 @ 0.8 kg = 110 kg)

FUNCTION · ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	10.1
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- o Weld attach plates (Page 2) to the three longitudinal beams as they are fabricated by the beam builder.
- o Retract the three longitudinal beams.
- o Fabricate and install the first set of cross and transverse beams.
- o The pre-fabricated cables are stowed in six magazines which are located on the construction fixture aft of the beam installation station. Each magazine has a mechanism for hooking the cables to the attach plates and a mechanism for applying tension to the cables.
- o The forward ends of the first set of six cables are hooked to their attach plates.
- o The longitudinal beams move forward pulling out the cables from the magazines.
- o The aft ends of the six cables are hooked to their attach plates.
- o The tensioning mechanism is retracted to the cross bracing installation station while the cross and transverse beams are being installed. The second set of cross and transverse beams are fabricated and installed.
- o After the beams are installed and before the platform structure is moved forward, the tensioning mechanism extends and tensions the cross bracing cables to 1,200 lbs.

FUNCTION	INSTALL	CODE	01	06 01.1	10.1
ITEM	CROSS BRACING CABLES				
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



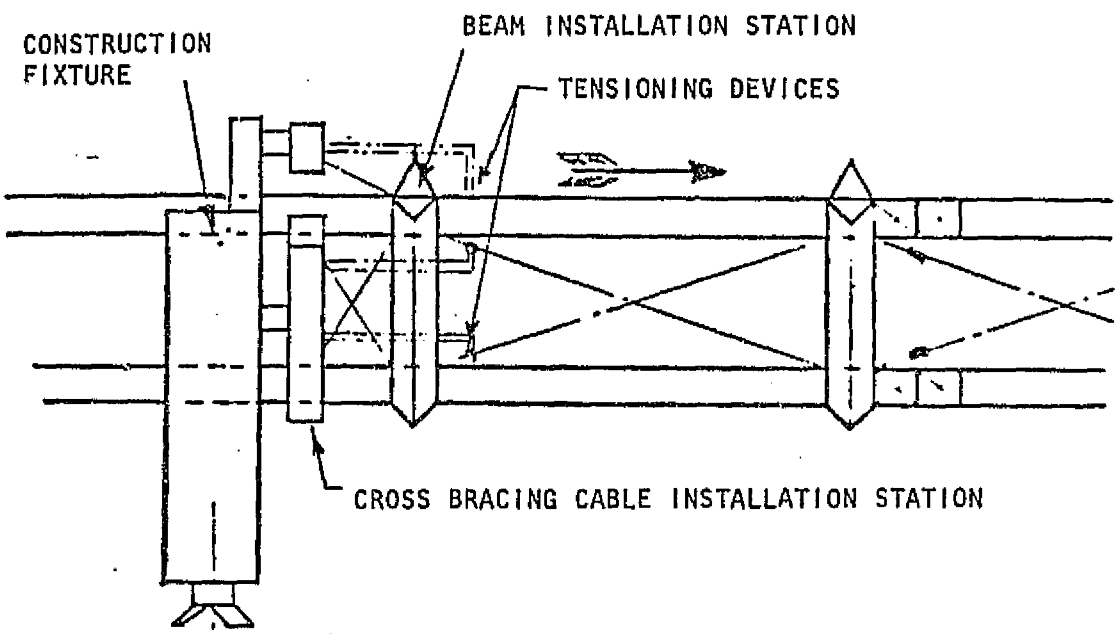
<u>Structure</u>

- Cable attach plates welded to the four corners of each of three sides of 23 bays. Total 276 plates.

- Cross bracing cables have attaching hooks and safety bars at each end and a tensioning device which can be operated by the tool shown on Page 4.

- The cables are fabricated from graphite epoxy - to facilitate coiling they are fabricated as a strap 0.38mm (.015") x 83mm (3.27") for most of its length.

FUNCTION · ITEM	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	10.1
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	3	of	6
SUBJECT	OPERATIONS				



Manpower

- None, fully automatic

Activity Time

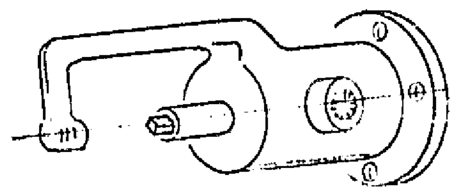
- Hook forward ends
- Hook aft ends — 4 min/bay
- Apply tension

NOTE: The four minutes is not additional time because it occurs in parallel with the fabrication and installation of the cross and transverse beams.

Support Activity

- Remove cable storage magazines (6) from payload bay and install on fixture. — 180 min.
- Remove magazines (6) from fixture and place in payload bay. — 180 min.

FUNCTION · ITEM ·	INSTALL CROSS BRACING CABLES	CODE	01	06 01.1	10.1
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



TOOL FOR TENSIONING CABLES

Items

- Power tool for applying tension load of approximately 1,200 lbs to the cross bracing cables (Part of cable installation unit).
- Six magazines or containers for pre-fabricated cross bracing cables. Each magazine to contain 23 cables.
- RMS

FUNCTION	INSTALL	CODE	01	06 01.1	10.1
ITEM	CROSS BRACING CABLES				
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	5	of	6
SUBJECT	SUPPORT SERVICES				

Crew - None Required

Power - Power to operate the cable installation station, 6 units @ 300 watts — 1800 Watts

Lighting & TV

- Three (3) TV cameras located one at each side of tri-beam at cable installation station. — 1500 Watts

- Lighting as required by TV.

Computer/Software

- None

Stowage - Six (6) cable installation units 3 x 1 x 0.5m each

FUNCTION	INSTALL	CODE	01	06 01.1	10.1
ITEM	CROSS BRACING CABLES				
METHOD	AUTOMATIC FIXTURE MECHANISM	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
Cable Installation Units (6)	300	9	--	1.8	TBD	--	6148
Fixture TV & Lighting (3)	48	1.5	--	1.5	TBD	--	1220
RMS	0	0	--	1.8	TBD	--	NC
<u>Support Services</u>							
Crew	--	--	0	--	--	--	--
Power (Total)	--	--	--	3.3	TBD	--	TBD
<u>Project Modification</u>							
Attach Plates (276)	15	0.2	--	--	--	--	162
Tension Devices (138)	138	0.1	--	--	--	--	956
<u>Operations</u>	--	--	0	--	--	4	NA*

*Not appropriate, see page 6.

FUNCTION · ITEM ·	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	00
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				

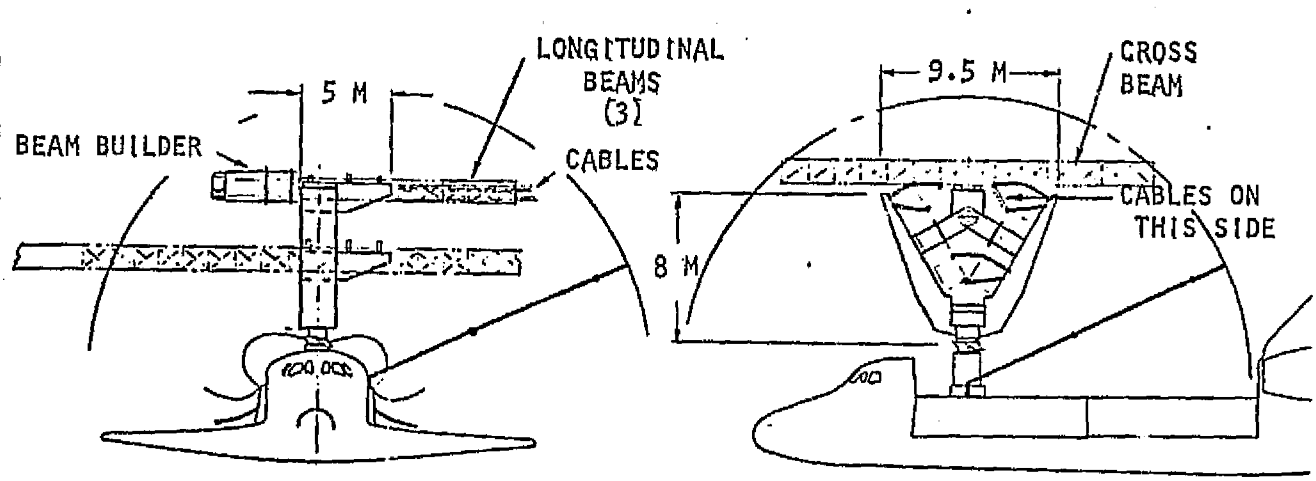


FIGURE 1

Project System

- Space fab advanced communications platform

Operation

- Installing the electrical and communication lines onto the fabricated beams (longitudinal and cross)

Physical Situation

- Cables are to be installed the entire length of one longitudinal beam (230M) and on selected cross beams which support equipment modules. Cabling may be as great as five 13MM and six 25MM bundles for propulsion, power and signal lines and three 25MM bundles of coax for R.F. data.
- Cables are to be installed on the longitudinal beam in 10M segments with junction box connections at each cross beam.
- Cables are to be installed on the cross beams in lengths from the longitudinal J-boxes to each end (equipment module points). These cables range from approximately 9M to 13M.
- Cabling will be installed during the beam fabrication cycle for both types of beams.
- Cabling on the longitudinal beam will be installed on the inner side of the beam.

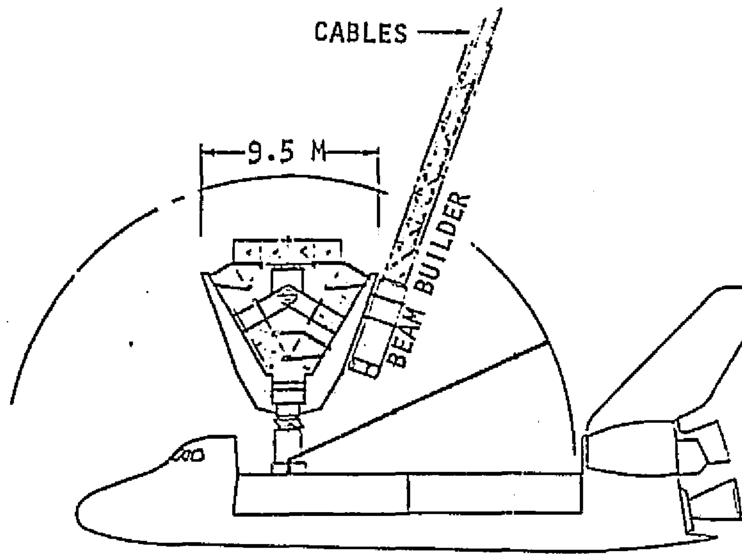
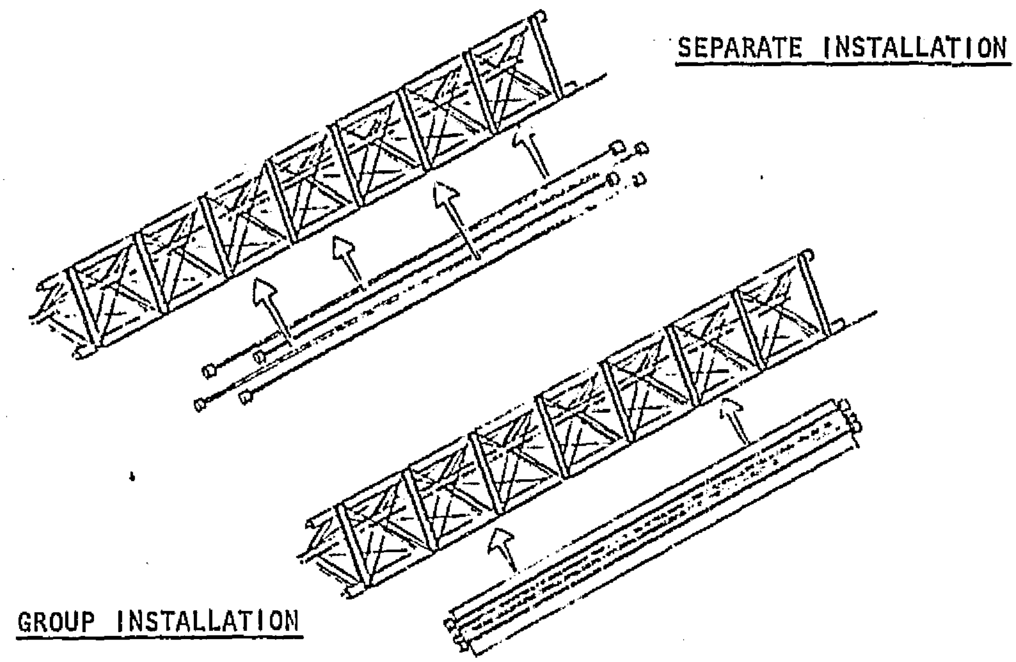


FIGURE 2

- For installation, both in the construction fixture, Figure 1, and with the relocated beam builder for cross beams, Figure 2, a cradle, or tray, will be used to contain and disburse the cable sections.

FUNCTION· ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	00
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

1. Separate Installation

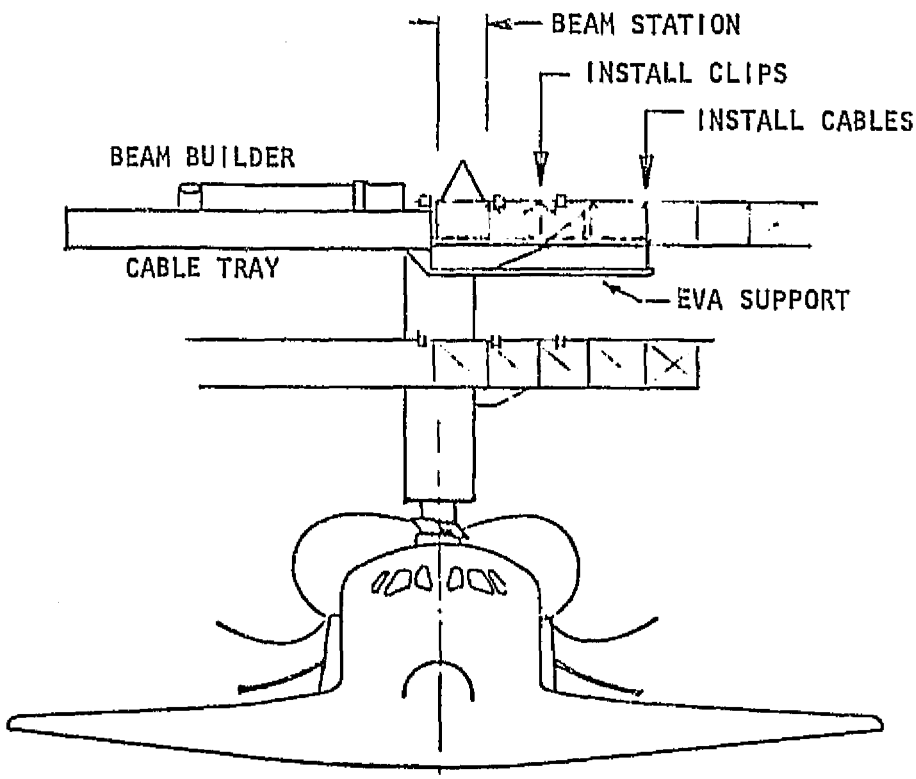
   Individual cable bundles are attached to the beam as separate items.

2. Group Installation

   The entire group of cable bundles is integrated and attached to the beam as a unit for each segment length.

Methods 1 and 2 are detailed

FUNCTION· ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.1
METHOD	EVA-SEPARATE LINES	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



During the fabrication of the beam, clips are installed on the cross members and cables are installed in the clips during the stop-cycle of the beam builder. (welding operation of the cross members assembly)

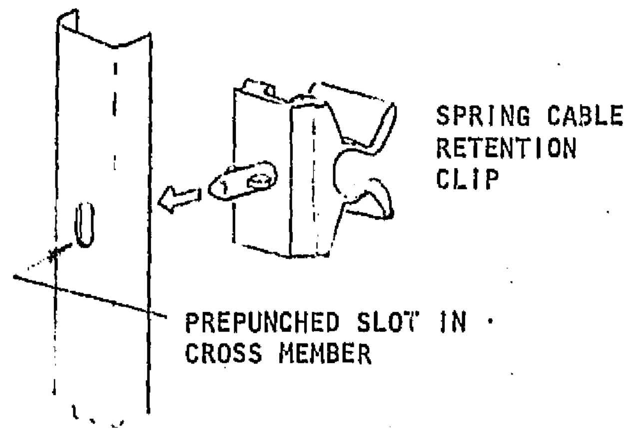
One EVA astronaut installs clips into the cross-members of the beam, retrieves the cables, singley, from a cable tray and passes the cables to a second EVA astronaut.

The second man installs each cable into a clip as it passes his work station.

Extrusion of the beam withdraws the cable.

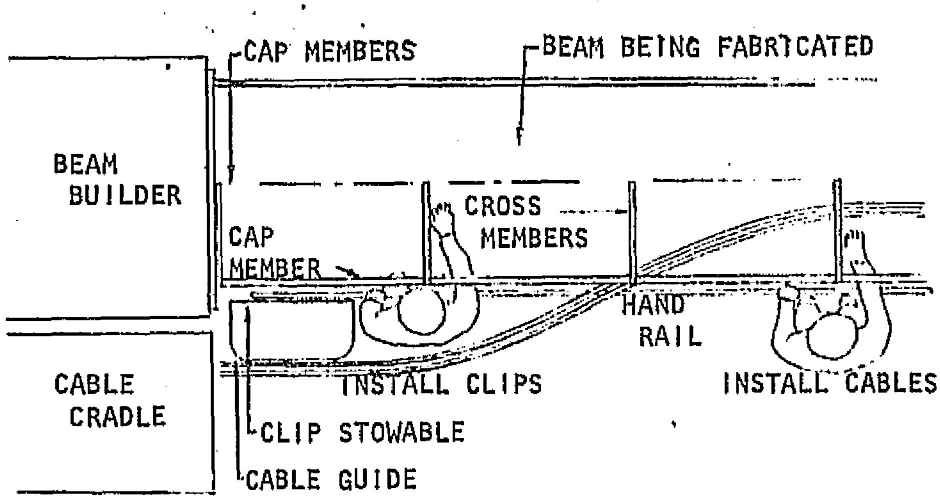
Astronauts are generally restricted to a fixed work station.

FUNCTION· ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.1
METHOD	EVA-SEPARATE LINES	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



- Cables are precut and terminated (connectors)
- Cross members (on the side where wiring is to be installed) are prepunched for the maximum clip requirement
- Spring retention clips are provided for installation in each cross member

FUNCTION · ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.1
METHOD	EVA-SEPARATE LINES	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

- 2 EVA astronauts

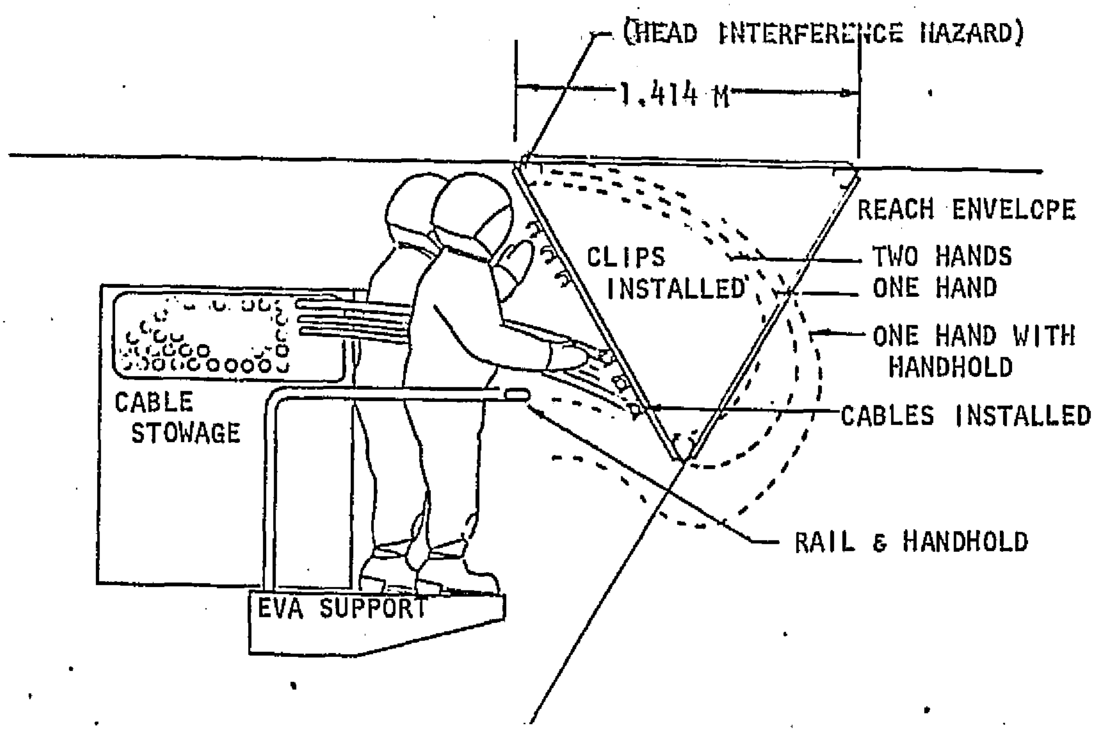
Activity Time

- Cable withdrawal - 8 bundles	8 min.
- Clip retrieval and installation - each cross member	4 min.
- Cable installation - each cross member	8 min.
Total Per Section	20 min.

Support Activity

- Cable tray and EVA support station installation onto construction fixture by RMS	30 min.
- Cable tray and EVA support station relocated to cross beam fab location	45 min.

FUNCTION · ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.1
METHOD	EVA-SEPARATE LINES	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



- Cable stowage tray to contain up to 344 cable segments with terminations
- EVA support fixture with handholds and foot restraints for two work stations
- Stowage tray for cable clips
- The cable stowage tray must contain the cables in a prescheduled sequence with easy access and dispersal. The fixture must position the EVA work station, as shown, for manual access to the cross member installation points.

FUNCTION	INSTALL	CODE	01	06 03.1	01.1
ITEM	ELECTRICAL LINES	PAGE	5 of 6		
METHOD	EVA-SEPARATE LINES				
SUBJECT	SUPPORT SERVICES				

Crew

- 2 EVA astronauts

Power

- Lights - 0.1 KW

Lighting and TV

- Lights at two work stations

Computer/Software

- None

Stowage

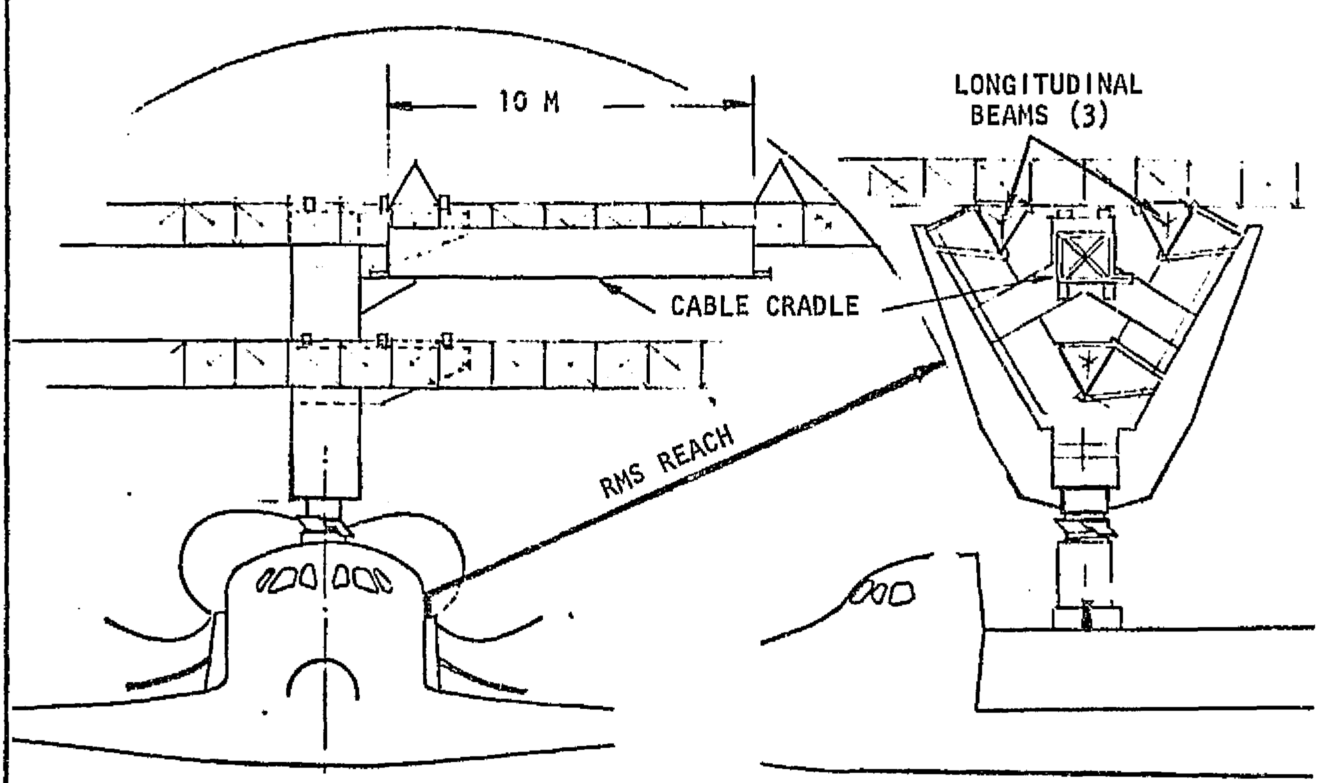
- Cable Tray - 11x1x1 M
- EVA Support Fixture - 5x1x0.5 M

FUNCTION ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.1
METHOD	EVA-SEPARATE LINES	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Cable Tray	20	11	-	0	0	-	781
EVA Support Fixture	20	2.5	-	0.1	TBD	-	1172
Clip Storage Container	10	1.5	-	0	0	-	443
RMS							NC
Support Services							
Crew	-	-	2/2	-	-	-	-
Power (Lighting)	-	-	-	0.1	TBD	-	TBD
Project Modifications							
Cable Clips (Per Section) (56)	2.5	Neg.	-	-	-	-	19
Mounting Hole Modification							2
Operations	-	-	2/2	-	-	20	NA*

*Not appropriate, see page 6.

FUNCTION·ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.2
METHOD	EVA-GROUPED LINES	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



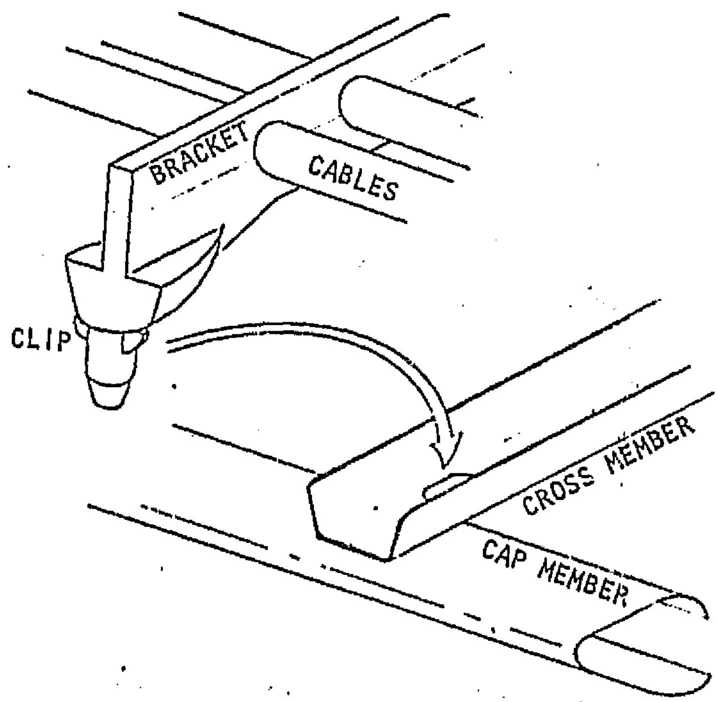
During the fabrication of the beam, an integrated group of cables is installed on the cross-members as a single unit.

Two EVA astronauts, one at each end, retrieve the cable group from the cable cradle, orient the group against the side of the beam and snap it into place at two points on each cross-member.

Each of the two astronauts operates at three or four cross beam stations.

The cable group is integrated by brackets that correspond to the beam cross members (1.434 M apart).

FUNCTION · ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.2
METHOD	EVA-GROUPED LINES	PAGE		2 of 6	
SUBJECT	PROJECT MODIFICATIONS				



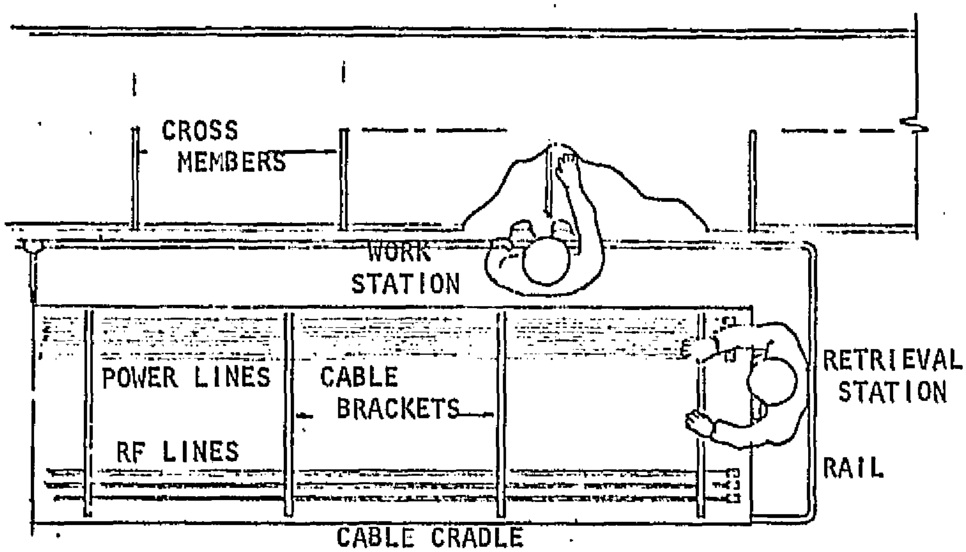
- Cable group brackets with a clip at each end. Brackets may be universal with some empty cable holes, or may be specific for each cable segment.

- Cross members are prepunched at each end

<u>Other</u>

This method has the possibility of combining junction box installation, at one end, with the cable group installation.

FUNCTION · ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.2
METHOD	EVA-GROUPED LINES	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

- 2 EVA astronauts

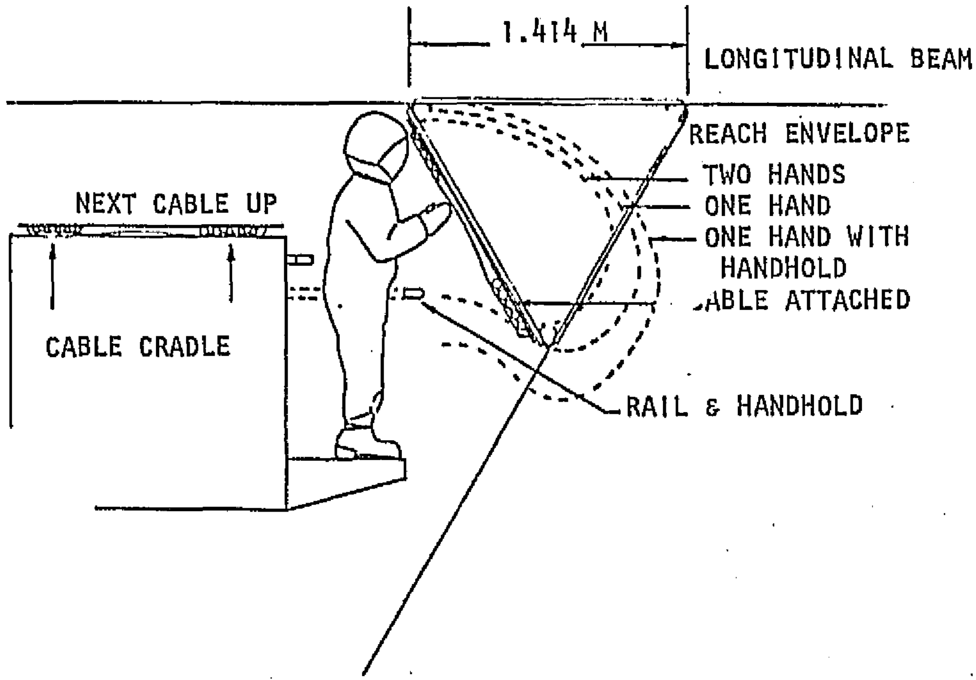
Activity Time

- Obtain (or grasp) cable group from cradle and reposition at the side of the beam	3 min.
- Astronaut reposition to new work station (4 stations)	8 min.
- Install each bracket (4)	4 min.
Total Per Section	15 min.

Support Activity

- Cable cradle and EVA work station installation onto construction fixture by RMS	30 min.
- Cable cradle and EVA support station installed at cross beam fab location	30 min.

SUBJECT CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS



- Cable cradle and EVA support fixture with handholds and foot restraints for eight work stations. Fixture must position the EVA work stations as shown for manual access to cross member installation points.

  Bulk size of cable groups requires two cradles

  1 - 23 cable groups for longitudinals
  1 - 20 cable groups for cross beams

- RMS

FUNCTION	INSTALL	CODE	01	06 03.1	01.2
ITEM	ELECTRICAL LINES				
METHOD	EVA-GROUPED LINES	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

Crew

- 2 EVA astronauts

Power

- Lights 0.1 KW

Lighting

- Lights at 8 work stations (3 simultaneously)

Computer/Software - RMS Coordinate Transform System

Stowage

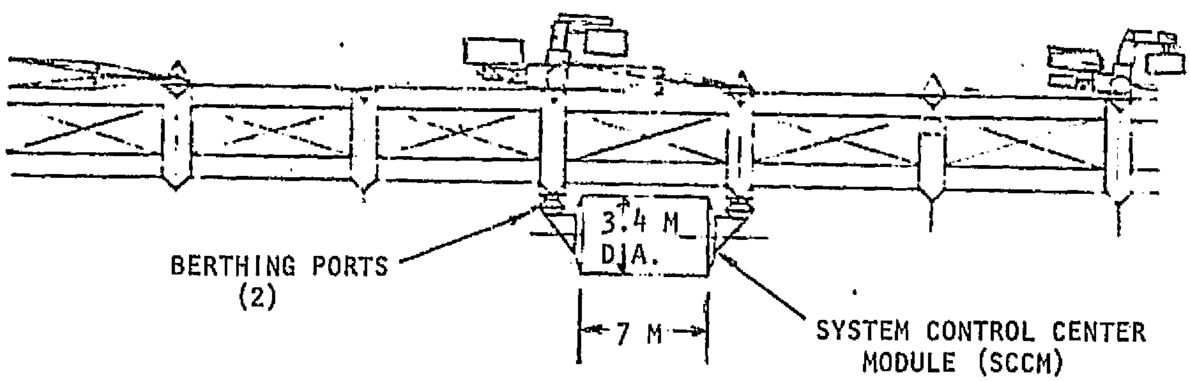
- Longitudinal cable cradle - 11 x 1.5 x 2.5 M
- Cross Beam cable cradle - 13 x 1.5 x 2 M

FUNCTION ITEM	INSTALL ELECTRICAL LINES	CODE	01	06 03.1	01.2
METHOD	EVA-GROUPED LINES	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Longitudinal Cable Cradle and EVA Support	30	41	–	0	0	–	1468
Cross Beam Cable Cradle and EVA Support	30	39	–	0	0	–	1468
RMS	0	0	–	1.8	TBD	–	NC
Support Services							
Crew	–	–	2/2	–	–	–	–
Power	–	–	–	0.1	TBD	–	TBD
Project Modifications							
Cable Brackets (Per Section)	0.4	Neg.	–	–	–	–	63
Crossmember Prepunching							36
Operations	–	–	2/2	–	–	15	NA*

*Not appropriate, see page 6.

FUNCTION· ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	00
METHOD		PAGE	1 of 2		
SUBJECT	OPERATION IDENTIFICATION				



Project System

Space fabricated advanced communications platform

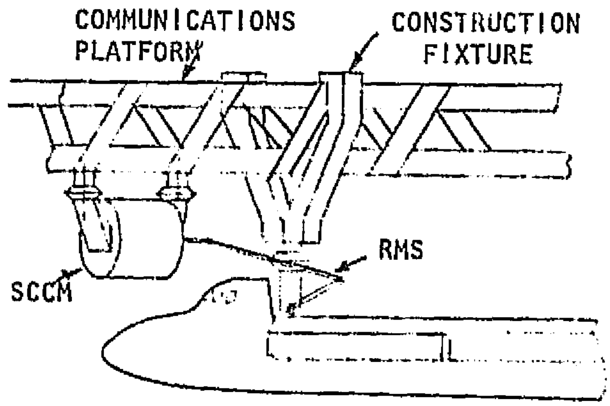
Operation

Install the SCCM to the platform using the two berthing ports as interfaces

Physical Situation

The platform structure is completed and the two halves of the SCCM berthing ports are installed on it.

FUNCTION · ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

None

Automated

1. Orbiter docks to platform, uses RMS to rotate SCCM into position

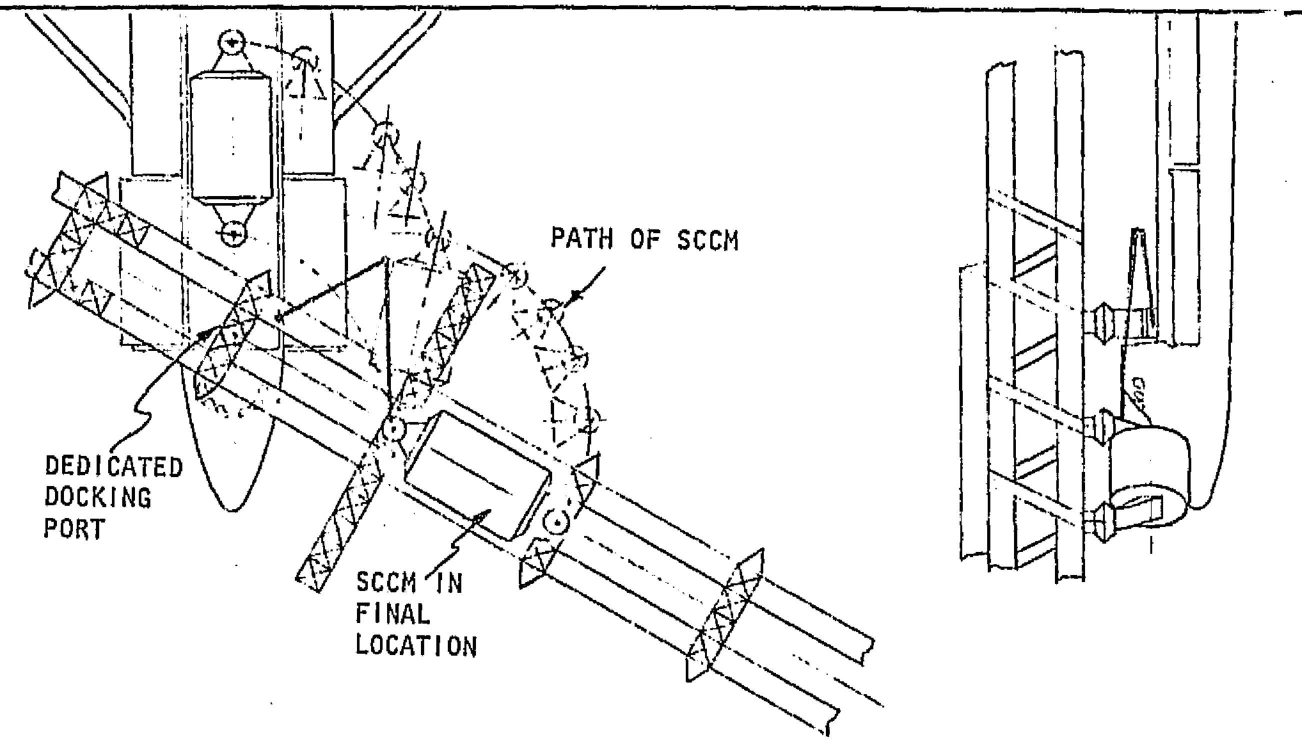
2. Orbiter docks to construction fixture, uses RMS to rotate SCCM into position

3. SCCM is docked to orbiter and flown into the platform

4. Orbiter docks to construction fixture uses RMS to install SCCM directly to platform

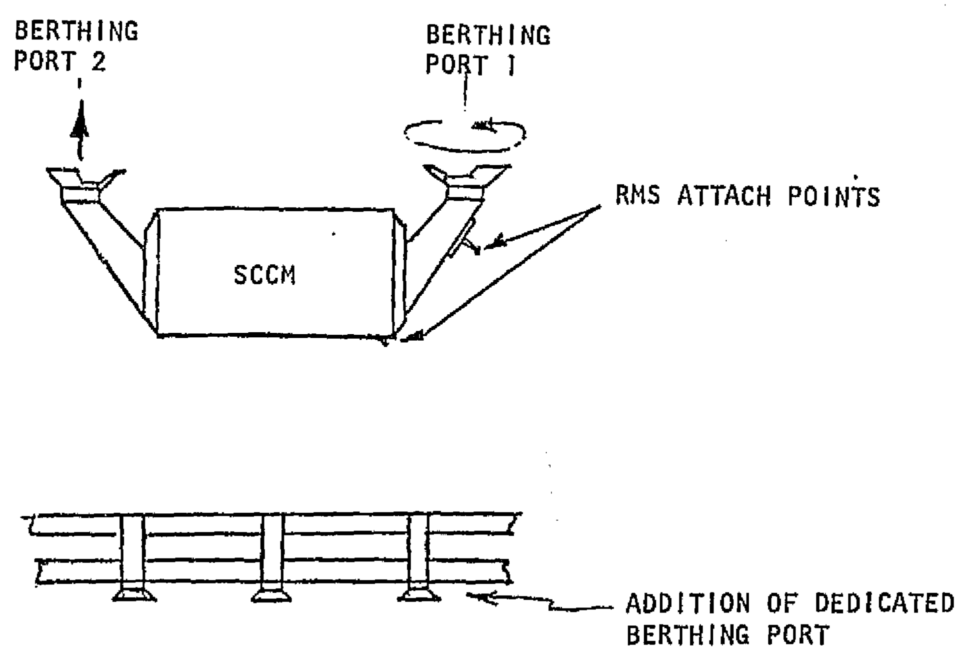
Methods 1 and 2 are detailed.

FUNCTION· ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.1
METHOD	RMS - ORBITER DOCKS TO PLATFORM	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- The orbiter docks to the platform in the location shown.
- The SCCM is removed from the orbiter by means of the RMS, and is mated with one of the berthing ports on the platform.
- The SCCM is rotated by the RMS using the mated berthing port as a pivot, until the second port is correctly aligned with the platform.
- The second berthing port is then actuated and the connection is completed.

FUNCTION· ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.1
METHOD	RMS → ORBITER DOCKS TO PLATFORM	PAGE	2	of	6
SUBJECT	PROJECT MODIFICATIONS				



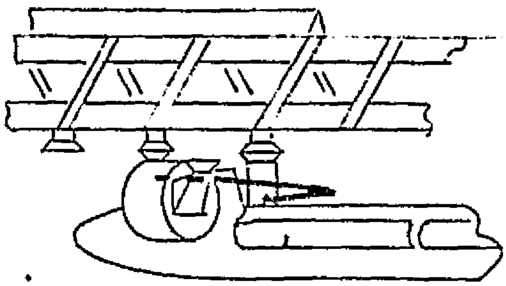
Basic Structure

- Dedicated berthing port for orbiter attachment

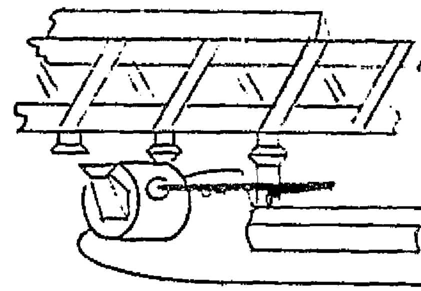
System Control Center Module

- Free rotational capability for berthing port #1
- "Extend and mate" capability for berthing port #2
- Two RMS attach points
- Battery power for port #2 extension

FUNCTION· ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.1
METHOD	RMS - ORBITER DOCKS TO PLATFORM	PAGE	3 of 6		
SUBJECT	OPERATIONS				

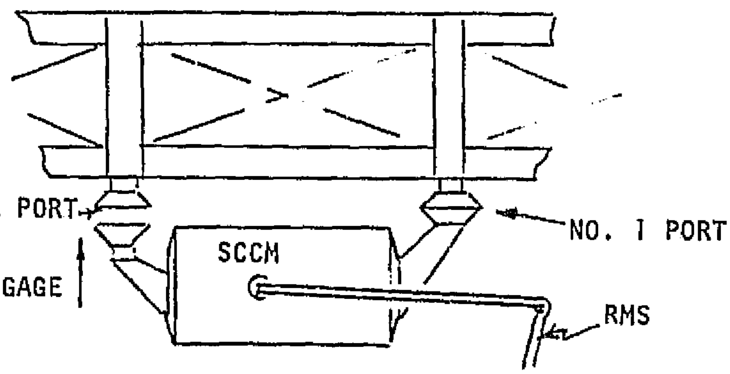


STEP 1. SCCM TO NO. 1 PORT & ENGAGEMENT



STEP 2. RELOCATE RMS AND ROTATE SCCM

STEP 3. ENGAGE NO. 2 PORT



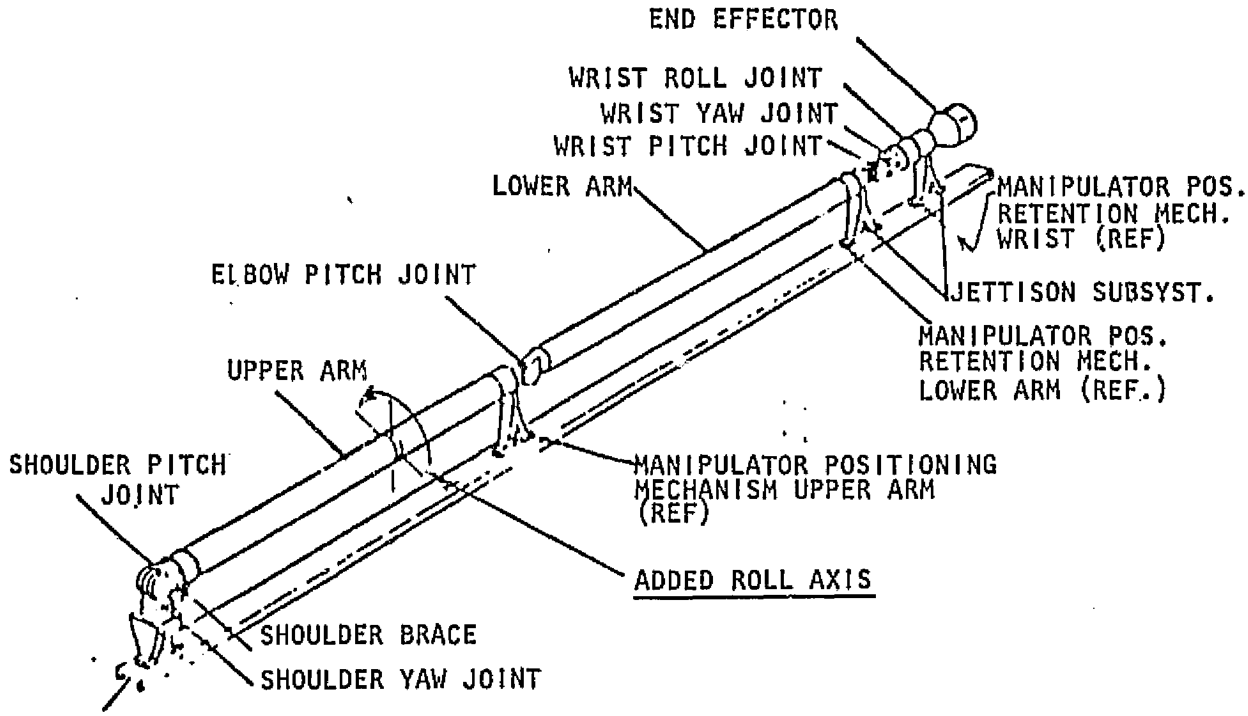
Manpower

- RMS operator at AFD

Activity Time

• Attach RMS to SCCM	5 Min
• Move SCCM to platform and align with #1 berthing port	15
• Mate #1 berthing port	5
• Relocate RMS on SCCM	2
• Rotate SCCM to #2 berthing port and align	10
• Mate #2 berthing port	1
	38 Min

FUNCTION	INSTALL	CODE	01	0604.1	04.1
ITEM	SYSTEM CONTROL CENTER MODULE (SCCM)				
METHOD	RMS - ORBITER DOCKS TO PLATFORM	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



MODIFIED RMS

Items

- Orbiter docking system
- RMS with rotational capability of upper arm

Crew

- One RMS operator

Power

- RMS operation - 1000-1800 watts

Lighting and TV

- Standard RMS lighting
- Tilt and pan capability for RMS TV

Computer/Software

- RMS coordinate transform software

Stowage

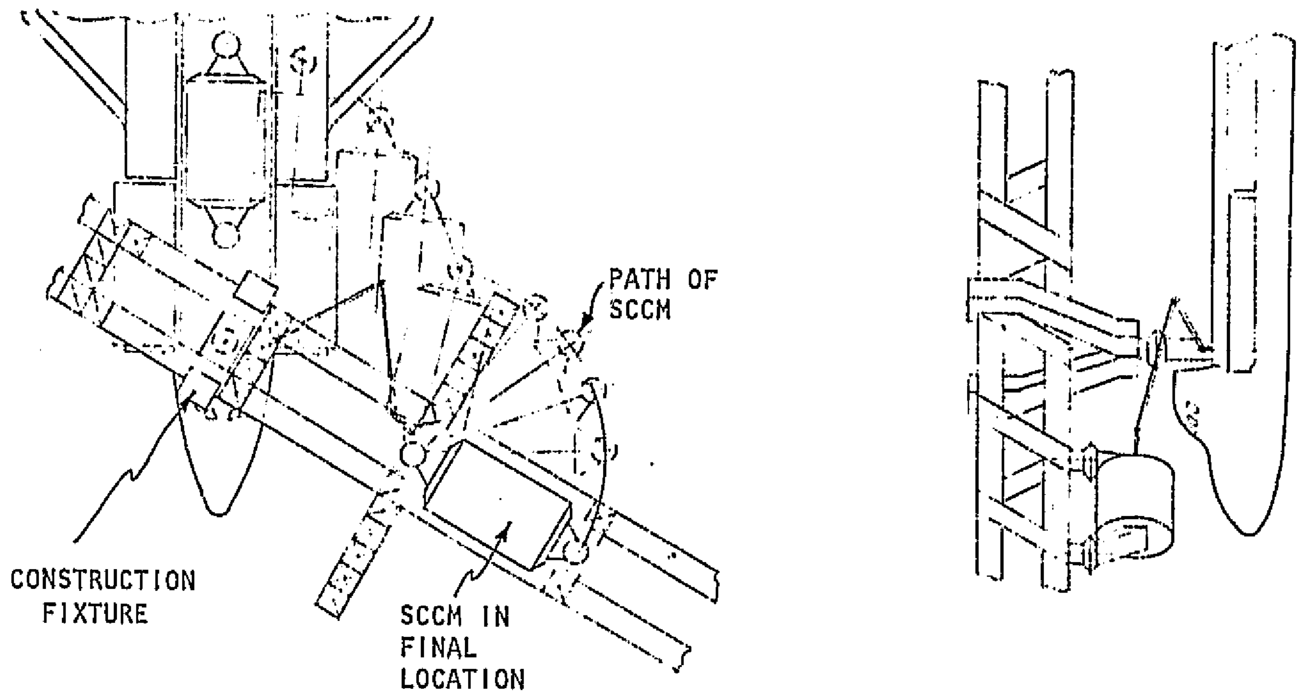
- None

FUNCTION ITEM	INSTALL SYSTEMS CONTROL CENTER MODULE (SCCM)	CODE	01 | 0604.1 | 04.1
METHOD	RMS - ORBITER DOCK TO PLATFORM	PAGE	6 of 6
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	-	1.8	TBD	-	NC
RMS Upper Arm Modifications	79	0	-	TBD	TBD	-	1764
Support Services							
Crew	-	-	1/1	-	-	-	-
Power (Total)	-	-	-	1.8	TBD	-	TBD
Project Modification							
SCCM							
Berthing Port Mods	70	0	-	-	-	-	1594
RMS Attach Points (2)	20	0.2	-	-	-	-	113
Structure							
Docking Port	110	1.0	-	-	-	-	473
Operations	-	-	1/1	-	-	38	NA*

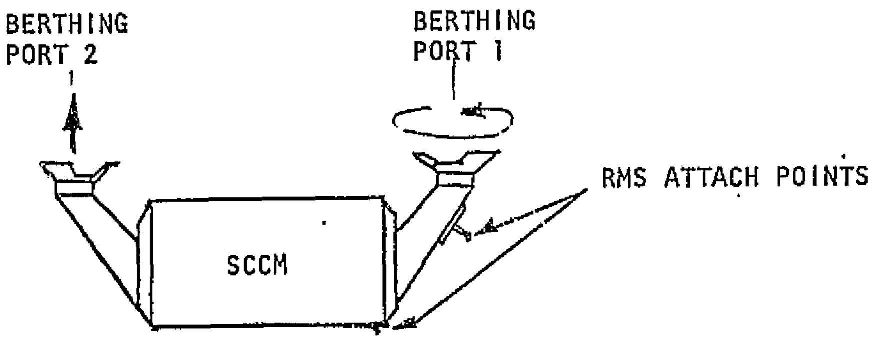
*Not appropriate, see page 6.

FUNCTION · ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.2
METHOD	RMS - ORBITER DOCK TO FIXTURE	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



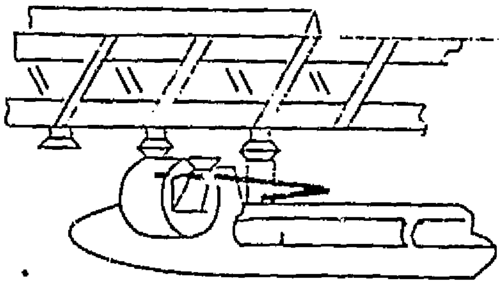
- The construction fixture moves the platform structure to the location shown.
- The orbiter docks to the construction fixture.
- The SCCM is removed from the orbiter by means of the RMS, and is mated with one of the docking ports on the platform.
- The SCCM is rotated by the RMS using the mated berthing port as a pivot until the second port is correctly aligned with the platform.
- The second berthing port is then actuated and the connection is completed.

FUNCTION· ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.2
METHOD	RMS - ORBITER DOCKS TO FIXTURE	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				

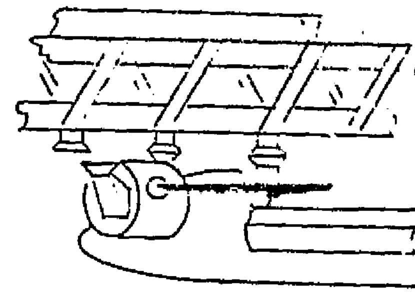


System Control Center Module

- Free rotational capability for berthing port #1
- "Extend and mate" capability for berthing port #2
- Two RMS attach points
- Battery power for port #2 extension

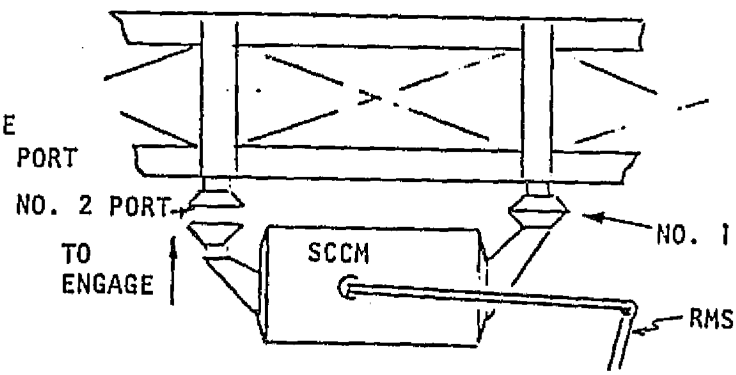


STEP 1. SCCM TO NO. 1 PORT & ENGAGEMENT



STEP 2. RELOCATE RMS AND ROTATE SCCM

STEP 3. ENGAGE NO. 2 PORT



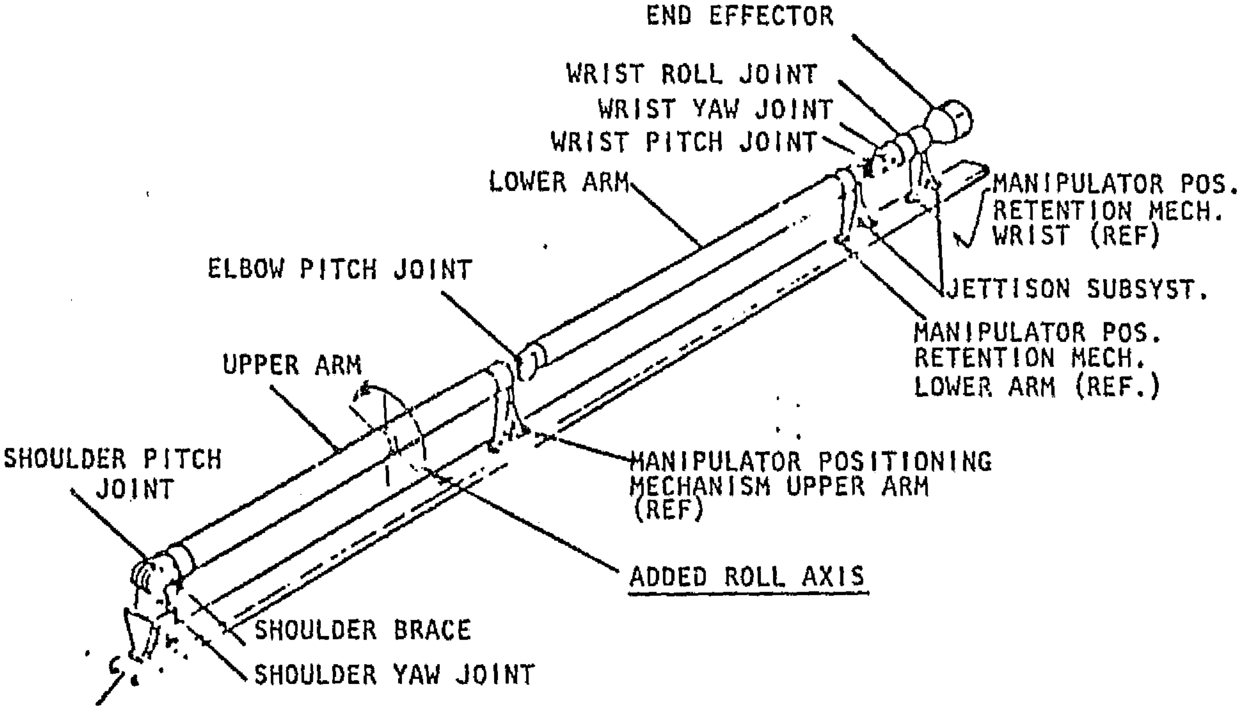
Manpower

- RMS operator at AFD

Activity Time

• Attach RMS to SCCM	5 Min
• Move SCCM to platform and align with #1 berthing port	15
• Mate #1 berthing port	5
• Relocate RMS on SCCM	2
• Rotate SCCM to #2 berthing port and align	10
• Mate #2 berthing port	1
	38 Min

FUNCTION · ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.2
METHOD	RMS - ORBITER DOCKS TO FIXTURE	PAGE	4	of	6
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



MODIFIED RMS

Item

- RMS with rotational capability of upper arm

Crew

- RMS operator

Power

- RMS operation - 1000-1800 watts

Lighting and TV

- Standard RMS lighting
- Tilt and pan capability for RMS TV

Computer/Software

- RMS coordinate transforms software

Stowage

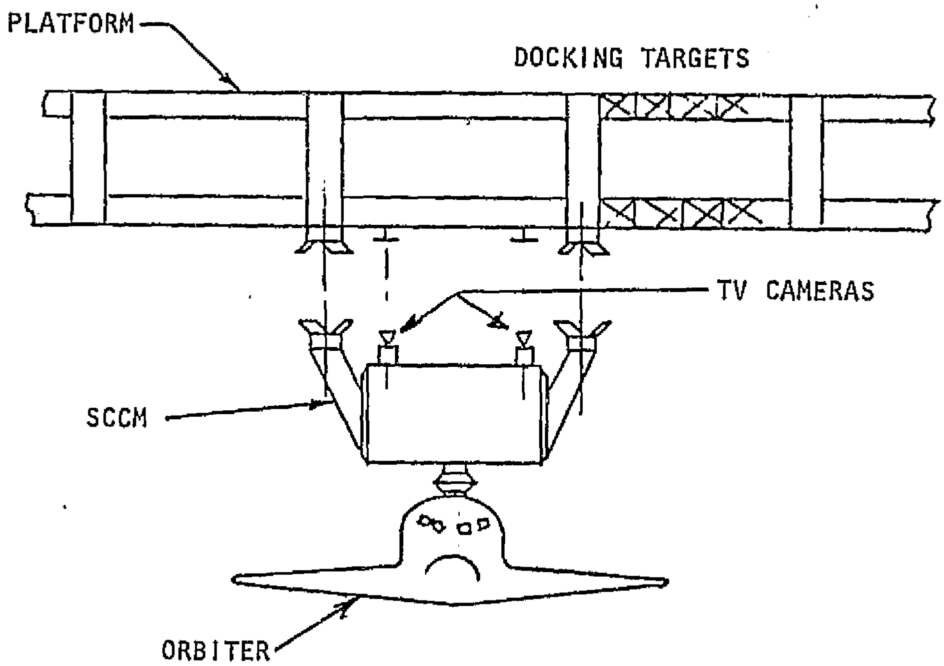
- None

FUNCTION ITEM	INSTALL SYSTEM CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.2
METHOD	RMS - ORBITER DOCKS TO FIXTURE	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	-	1.8	TBD	-	NC
RMS Upper Arm Modifications	79	0	-	TBD	TBD	-	1764
Support Services							
Crew	-	-	1/1	-	-	-	-
Power (Total)	-	-	-	1/8	TBD		TBD
Project Modification							
SCCM							
Berthing Ports Mod	70	0	-	-	-	-	1594
RMS Attach Points (2)	20	0.2	-	-	-	-	113
Operations	-	-	1/1	-	-	38	NA*

*Not appropriate, see page 6.

FUNCTION · ITEM	INSTALL SYSTEMS CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	07.1
METHOD	ORBITER DOCKS TO SCCM	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

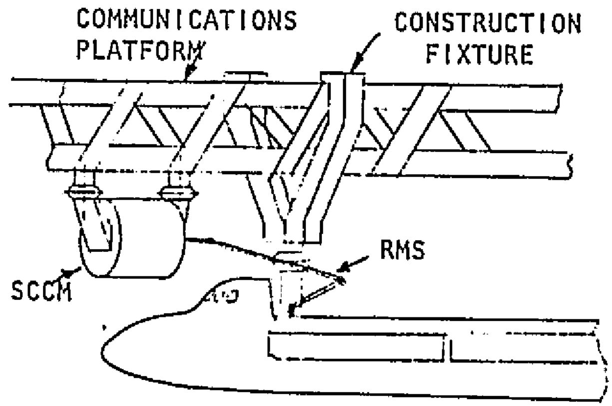


The SCCM is removed from the orbiter bay by means of the RMS and placed onto the orbiter docking system.

TV cameras mounted to the SCCM and docking targets mounted on the platform are used as aids to fly the SCCM in to mate with the platform.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION ITEM	INSTALL SYSTEMS CONTROL CENTER MODULE (SCCM)	CODE	01	0604.1	04.3
METHOD	RMS	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

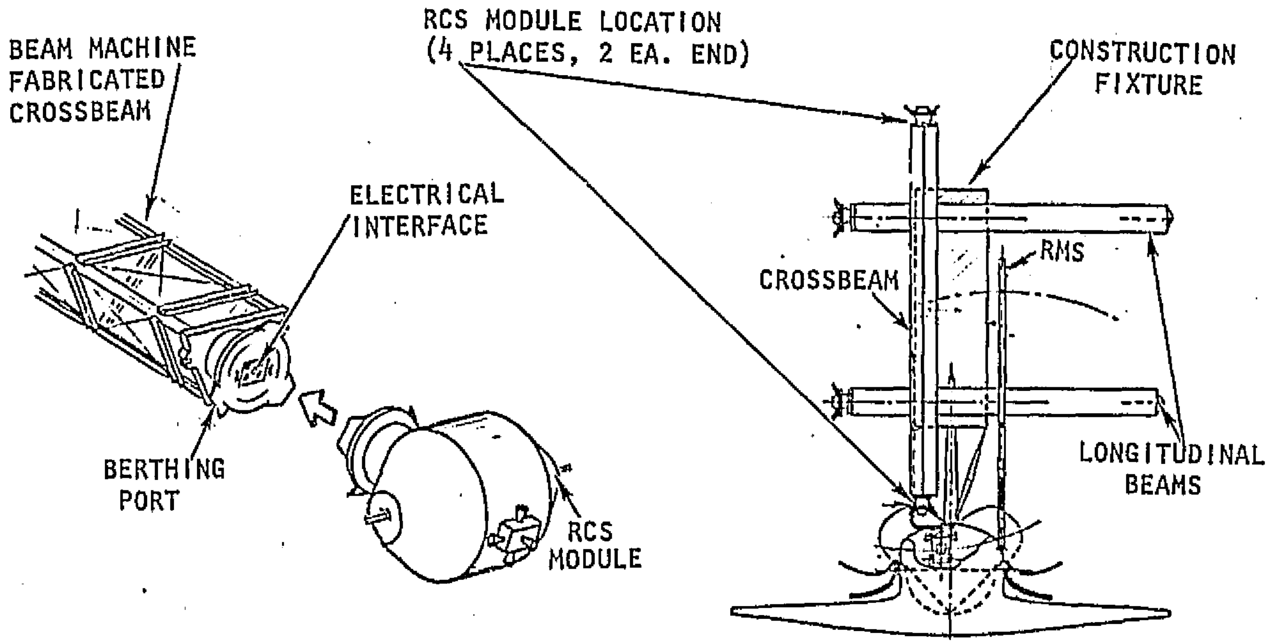


The orbiter docks to the construction fixture.

The RMS is used to remove the SCCM from the orbiter bay and install on the platform. There is no rotating berthing port. The SCCM is aligned with the platform and the two berthing ports mated simultaneously.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	00
METHOD		PAGE	1	of	2
SUBJECT	OPERATION IDENTIFICATION				



Project System

SPS Test Article

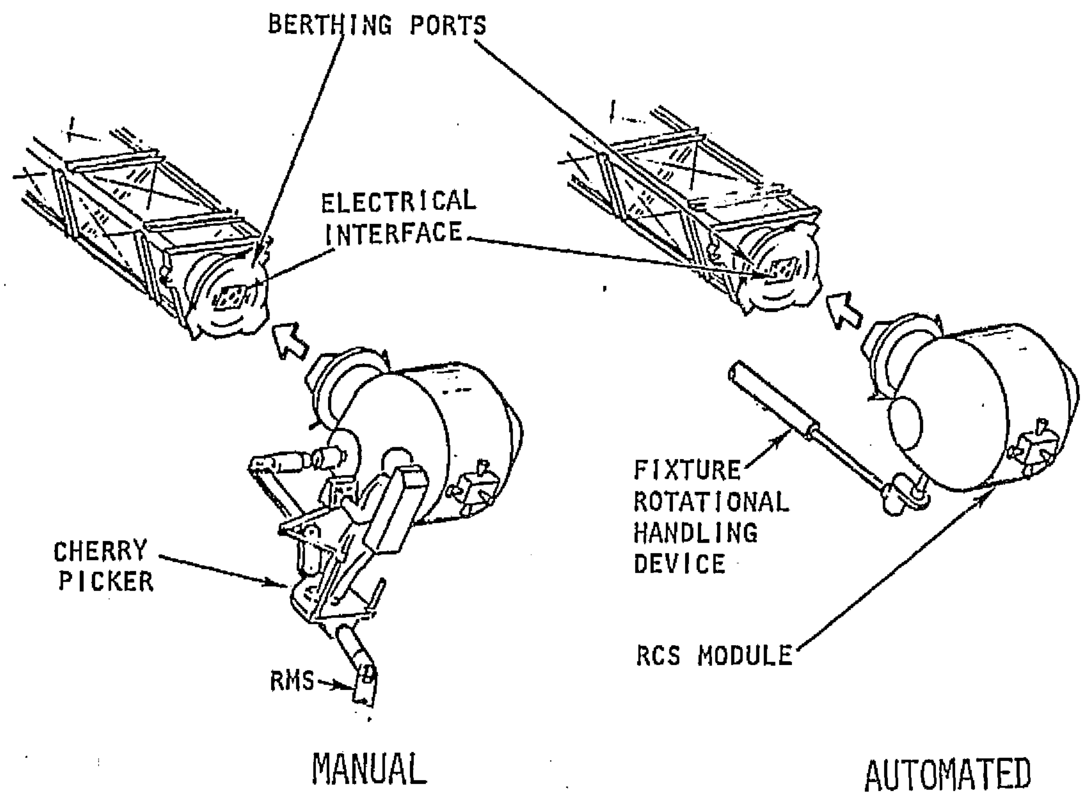
Operation

Install RCS module at outboard ends of cross beams. (Four locations)

Physical Situation

The structure is complete and berthing ports/berthing targets and electrical interface installed.

FUNCTION · ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	00
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

1. Cherry Picker (RMS supported) in Z orientation.

2. Cherry Picker (supported from construction fixture rotational handling device) in Y orientation.

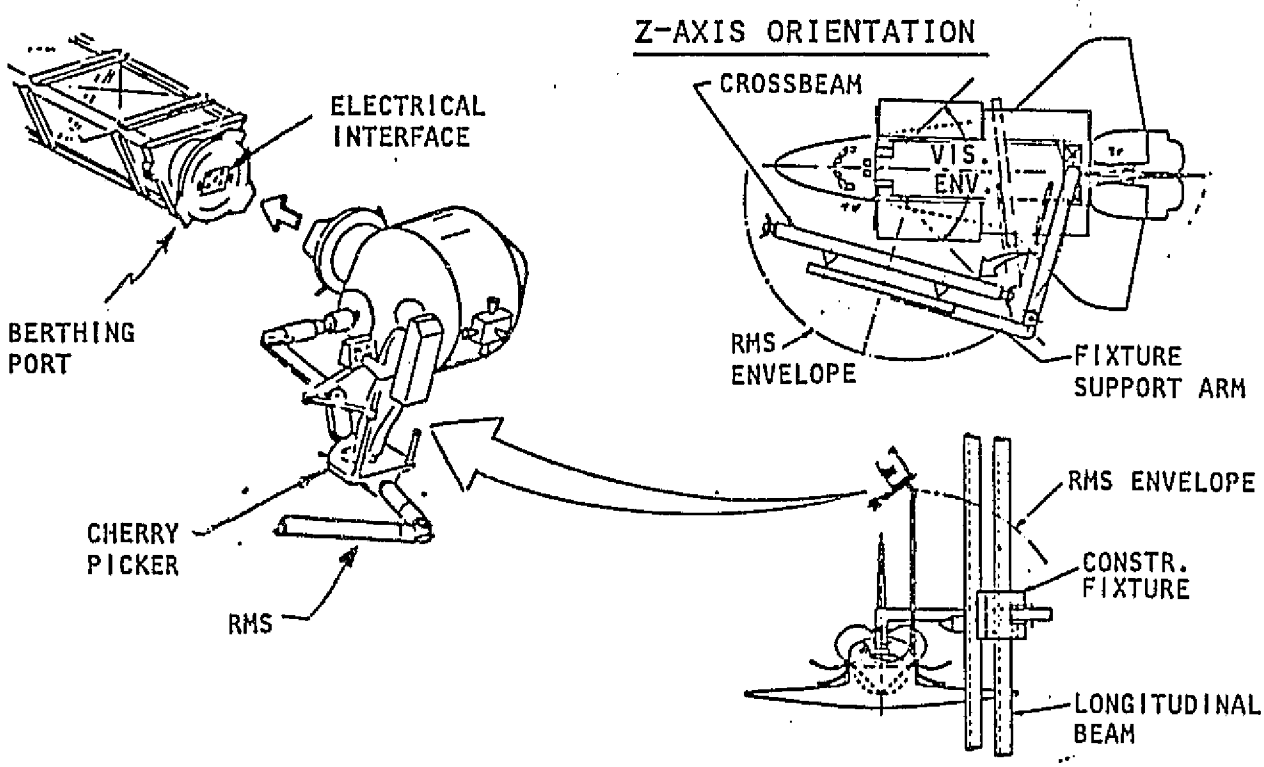
Automated

3. Construction fixture rotational handling device in Y direction.

4. RMS only in Z direction.

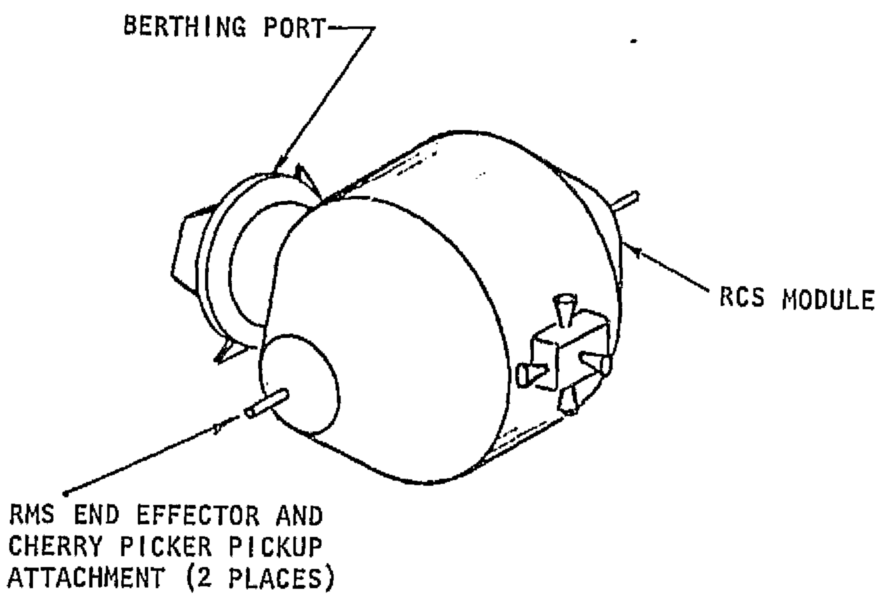
Methods 1, 2, and 3 are detailed.

FUNCTION ·	INSTALL	CODE	01	06 04.2	03.1
ITEM ·	RCS MODULE				
METHOD	CHERRY PICKER	PAGE	1	of	6
SUBJECT ·	METHOD DESCRIPTION				



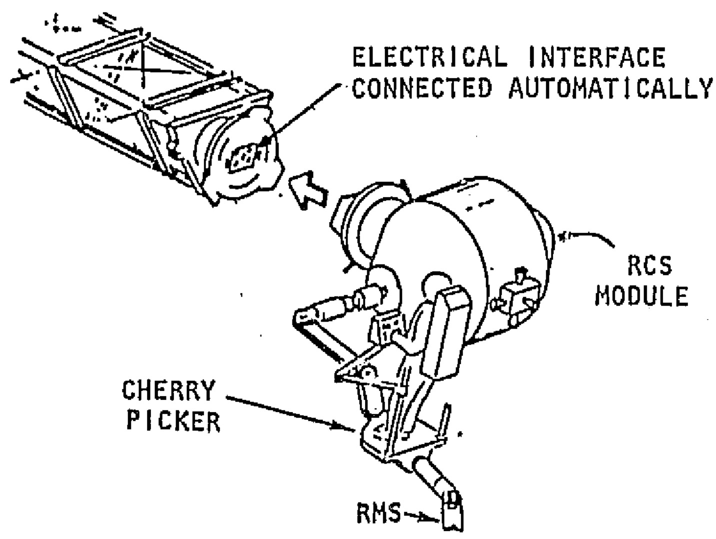
- o The Cherry Picker (complete with EVA crewman) located at the end of the RMS by prior operation, moves towards the payload bay and engages RCS module.
- o The Cherry Picker with RCS module moves to the first assembly position.
- o The Cherry Picker aligns and advances module, engagement is made with latches and electrical connection is made.
- o The Cherry Picker releases the module and moves clear.
- o The above procedure is repeated at each RCS module location (4).
- o This method is a deviation from baseline in that the satellite is constructed in the Z axis orientation. This allows all extremities of the satellite structure to be reached by the RMS attached cherry picker.

FUNCTION	INSTALL	CODE	01	06 04.2	03.1
ITEM	RCS MODULE				
METHOD	CHERRY PICKER	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



Trunnions are required at the module tank extremities to enable pick-up by the cherry picker.

FUNCTION · ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	03.1
METHOD	CHERRY PICKER	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

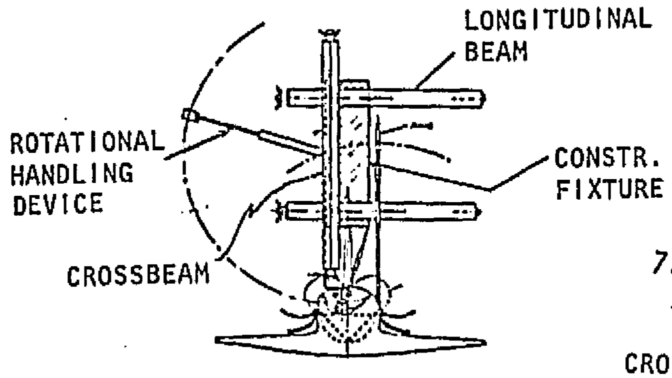
- One Cherry Picker Operator

Activity

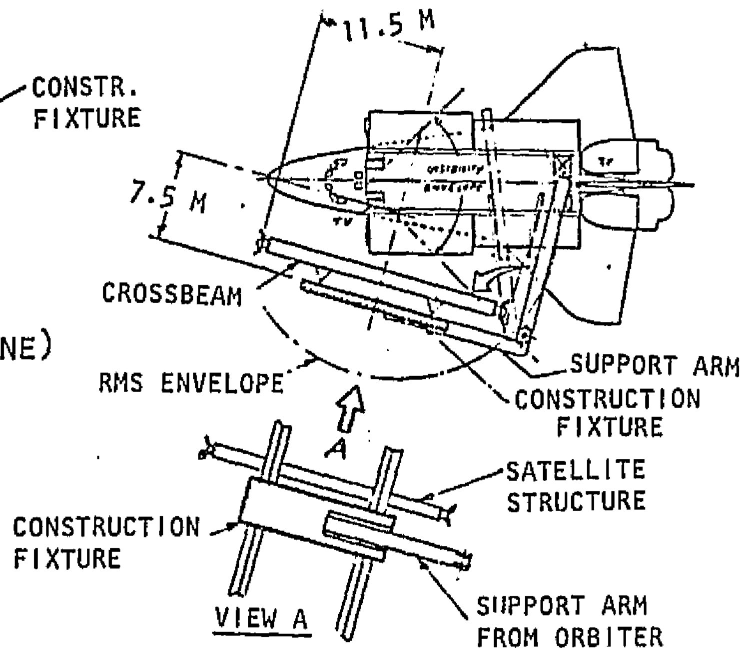
- Pickup Cherry Picker	(15 min.)
- RMS moves cherry picker to RCS pickup position	2 min.
- Cherry Picker attaches to RCS module.	4 min.
- Mocule is moved to first position and aligned	4 min.
- Cherry Picker installs and releases module	4 min.
	14 min.

( ) One Time Operation

FUNCTION·	INSTALL	CODE	01	06 04.2	03.1
ITEM ·	RCS MODULE				
METHOD	CHERRY PICKER	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Y-AXIS ORIENTATION (BASELINE)



Z-AXIS ORIENTATION

Items

- RMS
- Cherry Picker
- Modified Construction Fixture

The "Z" axis orientation is accomplished by securing the construction fixture to a supporting arm that locates the fixture on the left outboard side of the orbiter. The construction project is assembled facing the orbiter.

(BASELINE)

Crew - One Cherry Picker Operator

Power - RMS Operation 1,000-1,800 Watts
Cherry Picker Operation 500 Watts

Lighting & T.V.

- Lights and TV as provided on Cherry Picker and orbiter.

Computer/Software

- RMS orientation transform system

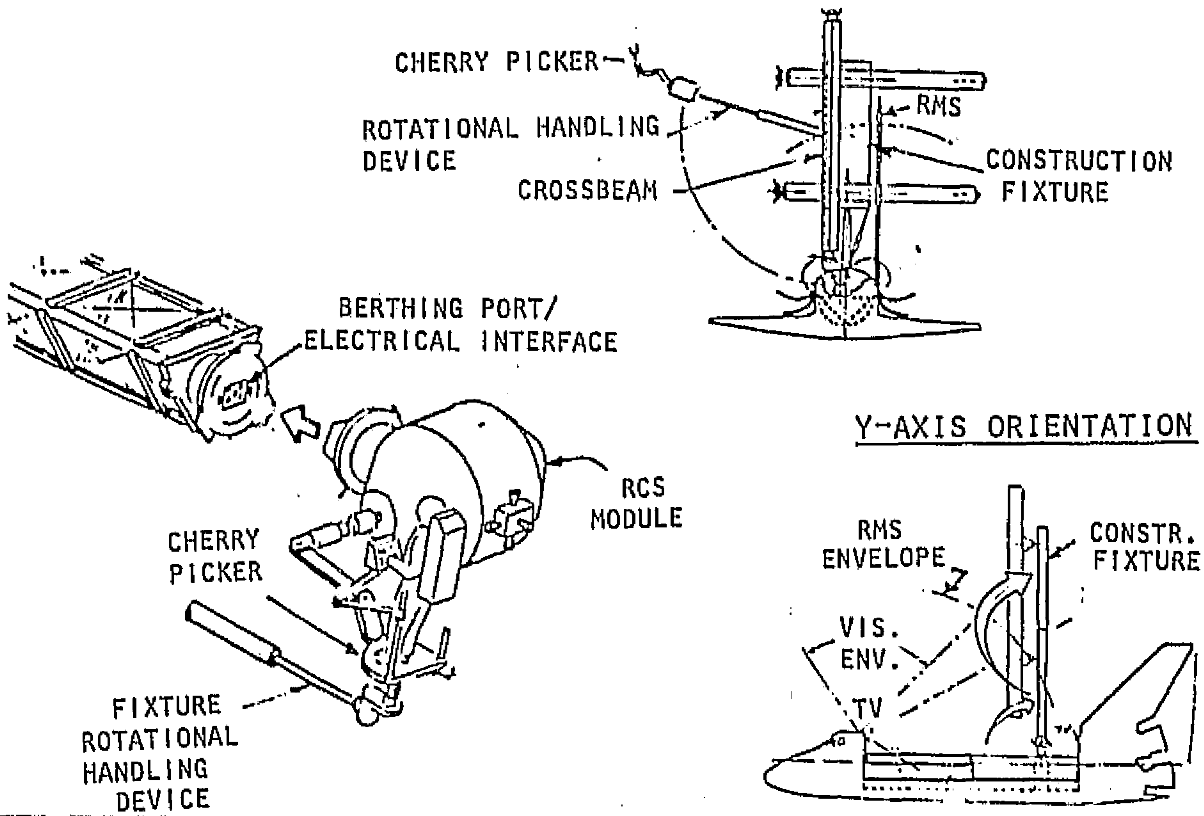
Stowage - Cherry Picker - 0.9 x 1.6 x 1.1m

FUNCTION	INSTALL	CODE	01	06 04.2	03.1
ITEM	RCS MODULE				
METHOD	CHERRY PICKER	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
RMS	0	0	--	1.8	TBD	--	NC
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
<u>Support Services</u>							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	2.3	TBD	--	TBD
<u>Project Modification</u>							
RCS Module	1	Neg	--	--	--	--	80
<u>Operations</u>	--	--	1/1	--	--	14	NA*

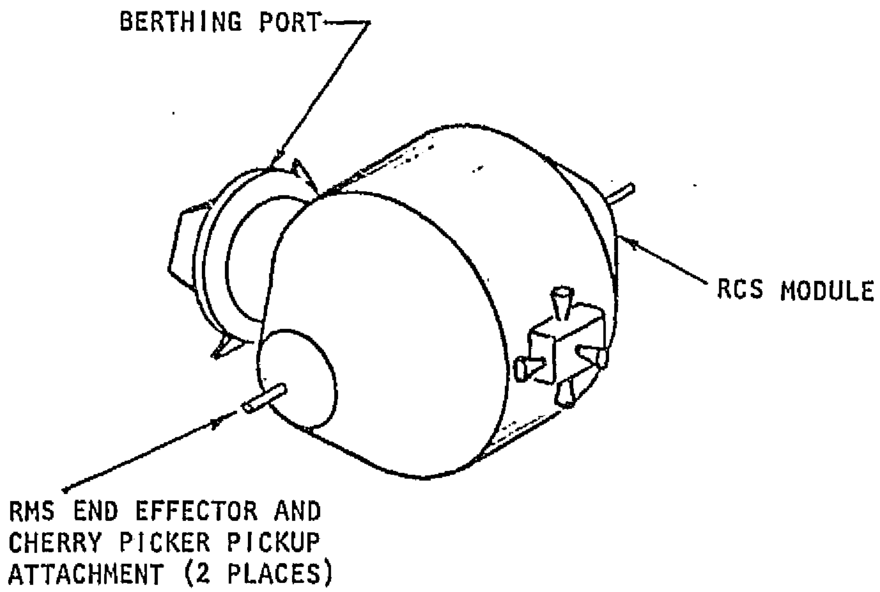
*Not appropriate, see page 6.

FUNCTION:	INSTALL	CODE	01	06 04.2	03.2
ITEM:	RCS MODULE	PAGE	1 of 6		
METHOD	CHERRY PICKER/FIXTURE HANDLING DEVICE				
SUBJECT	METHOD DESCRIPTION				



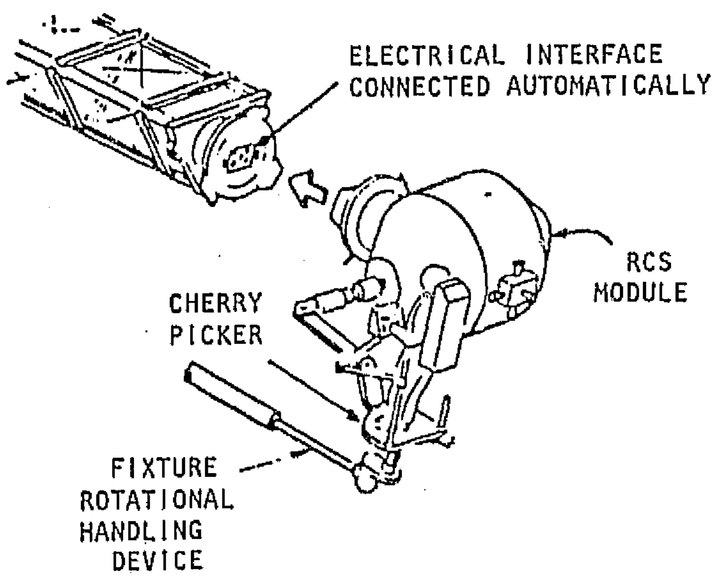
- o The cherry picker (complete with EVA crewman) located at the end of the fixture rotational handling device by a prior operation moves to the payload bay where the RMS engages the first RCS module and transfers it to the cherry picker.
- o The handling device moves cherry picker and RCS module to the first assembly position.
- o The cherry picker aligns and advances module, engagement is made with latches and electrical connection is made.
- o The cherry picker releases the module and moves clear.
- o The above procedure is repeated for each RCS module location.

FUNCTION	INSTALL	CODE	01	06 04.2	03.2
ITEM	RCS MODULE				
METHOD	CHERRY PICKER/FIXTURE HANDLING DEVICE	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



- Trunnions are required at the module tank extremities to enable pickup by the cherry picker and RMS.
- Transfer is attained by the RMS holding on the one trunnion while the cherry picker grabs the other.

FUNCTION · ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	03.2
METHOD	CHERRY PICKER/FIXTURE HANDLING DEVICE	PAGE	3 of 6		
SUBJECT	OPERATIONS				



<u>Manpower</u>

- One RMS and one cherry picker operator.

<u>Activity Time</u>

- RMS attaches to RCS module	3 min.
- Module is transferred to cherry picker	5 min.
- Handling device rotates to position	1 min.
- Cherry picker aligns and installs module	3 min.
- Module Released and cherry picker returns for pickup	2 min.
	14 min.

FUNCTION ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	03.2
METHOD	CHERRY PICKER/FIXTURE HANDLING DEVICE	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				

NOTHING SPECIAL

Items

- RMS
- Cherry Picker
- Fixture Rotational Handling Device

Crew - One RMS and one cherry picker operator

Power - RMS Operation 1-1.8 kW
Cherry Picker Operation 0.5 kW

Lighting & TV

- Lights and TV as provided on cherry picker and orbiter.

Computer/Software

- RMS and fixture handling device coordinate transform system.

Stowage

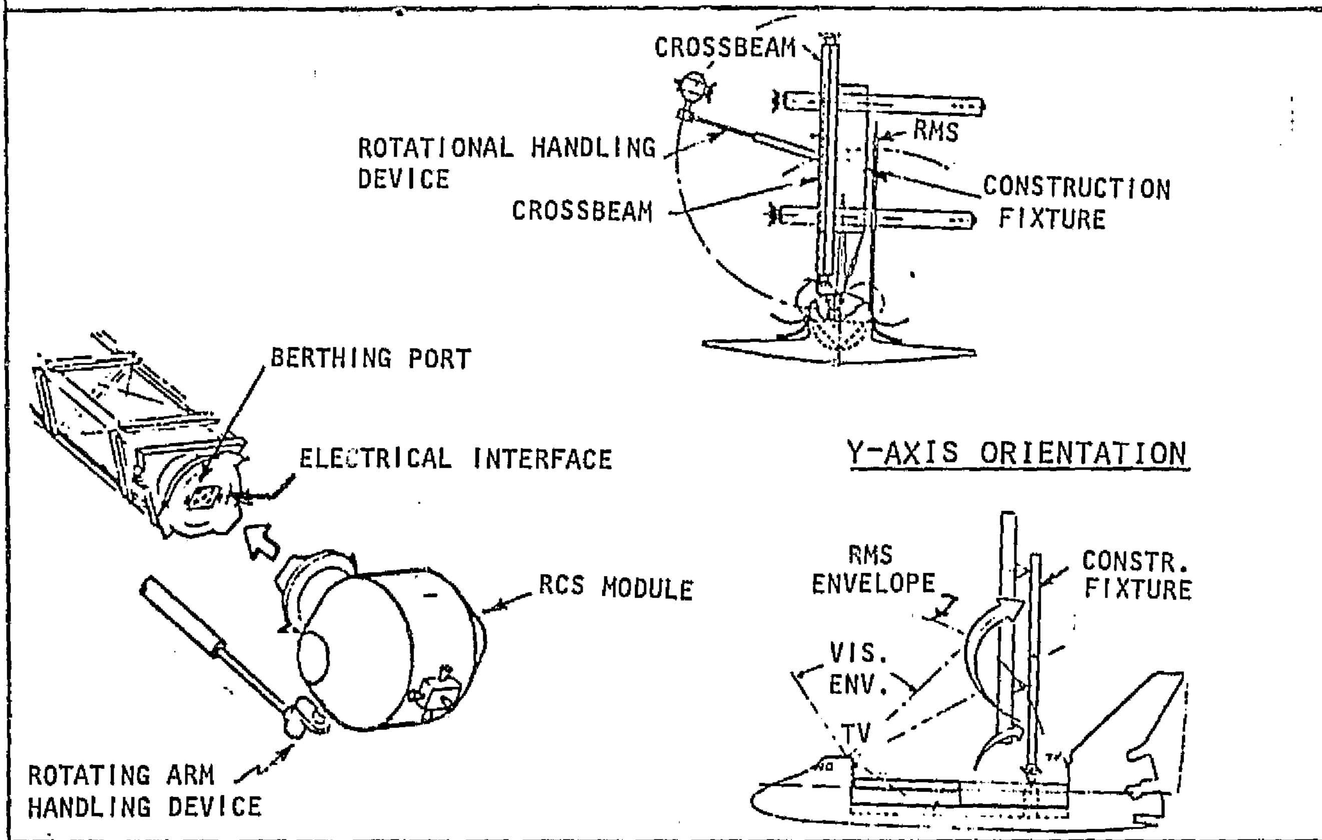
- Cherry picker - 0.9 x 1.6 x 1.1m

FUNCTION	INSTALL	CODE	01	06 04.2	03.2
ITEM	RCS MODULE				
METHOD	CHERRY PICKER/FIXTURE HANDLING DEVICE	PAGE	6	of	6
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	--	1.8	TBD	--	NC
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
Support Services							
Crew	--	--	2/1.2	--	--	--	--
Power (Total)	--	--	--	2.3	TBD	--	TBD
Project Modification							
RCS Module	1	NEG	--	--	--	--	80
Operations	--	--	2/1.2	--	--	14	NA*

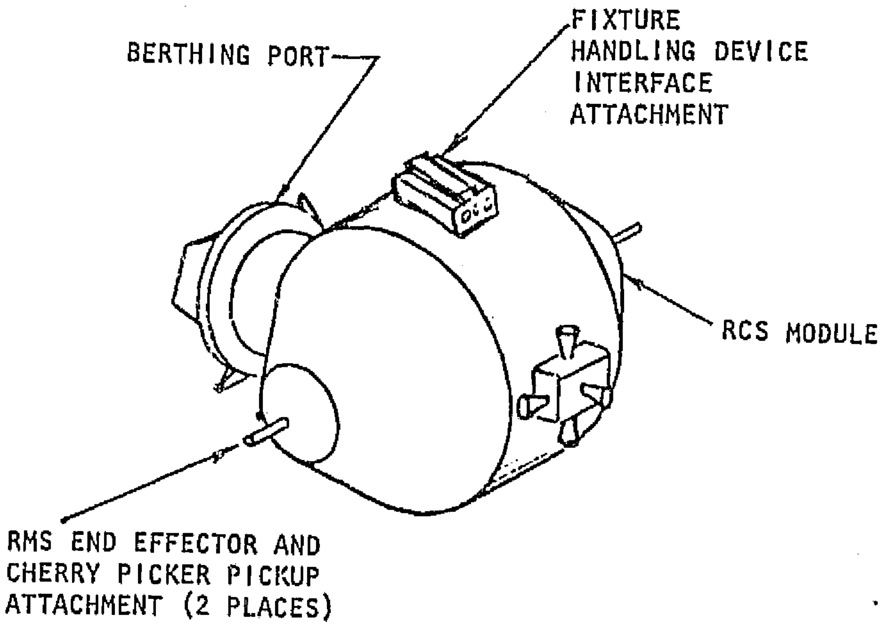
*Not appropriate, see page 6.

FUNCTION · ITEM	INSTALL RCS MODULE	CODE	01	06 04.2	10.1
METHOD	FIXTURE HANDLING DEVICE	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- The construction fixture handling device is rotated toward the payload bay and within reach of the RMS.
- The RCS module is picked up by the RMS and attached to the handling device.
- The handling device is rotated to the first RCS location. The berthing ports aligned and latched. The electrical interfaces are mated.
- The handling device releases the module and rotates to vicinity of payload bay where the RMS attaches the second RCS module.
- The above procedure is then repeated for the second, third, and fourth RCS modules.

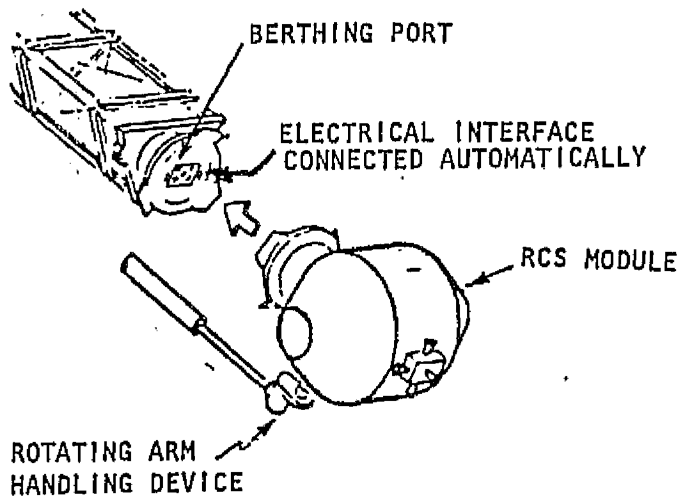
FUNCTION · ITEM ·	INSTALL RCS MODULE	CODE	01	06 04.2	10.1
METHOD	FIXTURE HANDLING DEVICE	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



RCS Module

- Trunnions are required at the module tank extremities to enable pickup by the RMS.
- An attachment fixture located on the tank, below and parallel to the berthing port center line, is provided for interfacing with the fixture handling device.

FUNCTION ·	INSTALL	CODE	01	06 04.2	10.1
ITEM	RCS MODULE				
METHOD	FIXTURE HANDLING DEVICE	PAGE	3 of 6		
SUBJECT	OPERATIONS				



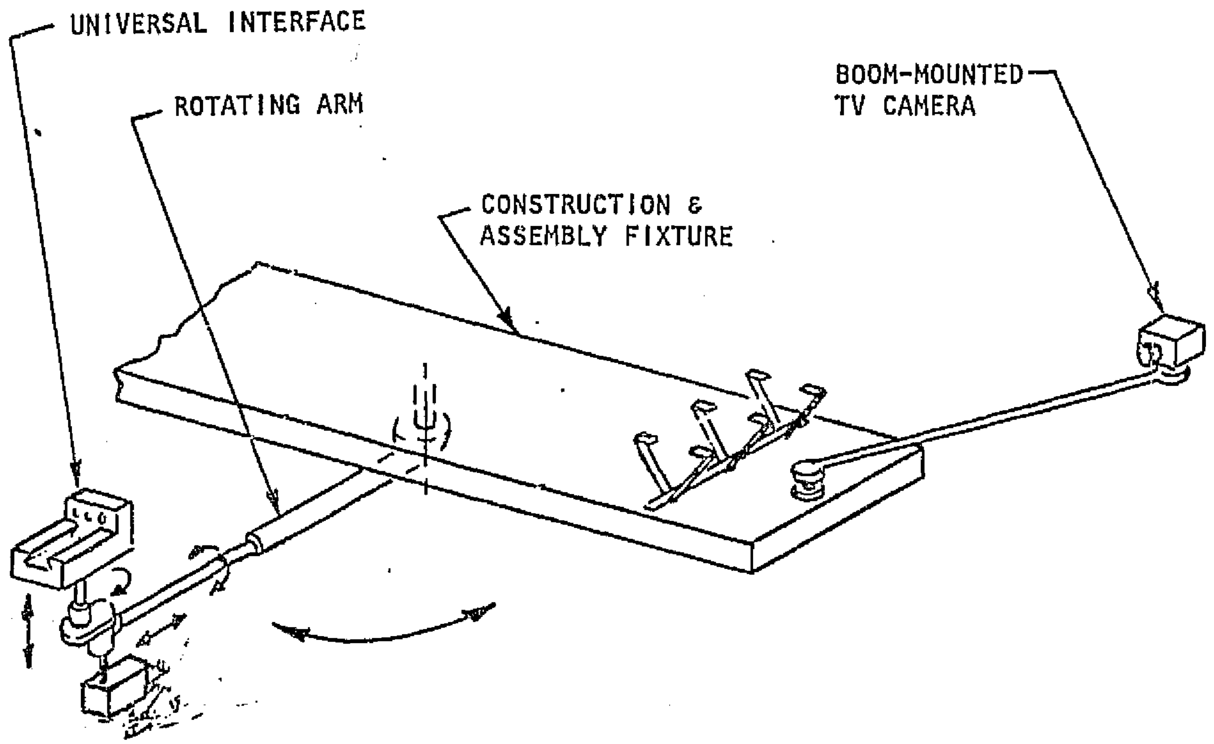
Manpower

- RMS/handling device operator at AFD.

Activity Time

- Position RMS ready for pickup	2 min.
- RMS picks up module and attaches to device	8 min.
- Handling device positions and aligns module	4 min.
- Handling device installs module	4 min.
- Device returned to vicinity of bay	2 min.
	20 min.

FUNCTION·	INSTALL	CODE	01	06 04.2	10.1
ITEM	RCS MODULE				
METHOD	FIXTURE HANDLING DEVICE	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Item

- RMS
- Construction Fixture Rotational Handling Device
    - o The handling device consists of a rotating arm and universal end effector complete with light and TV camera.
    - o The arm is secured and driven from beneath the construction and assembly fixture.
    - o The arm itself is capable of extension, retraction and rotation.
    - o The universal end effector attached to a shaft at 90^{o} to the arm is capable of rotation, extension and retraction.
    - o The universal end effector consists of an alignment track (with locking catches) and electrical interface.
    - o A rotational boom mounted TV camera is attached to the upper end of the construction facility.

Crew - One RMS Handling Device Operator at AFD

Power - RMS - 1-1.8 kW

Lighting & TV

- Requirements satisfied by construction fixture and orbiter mounted lights and TV.

Computer/Software

- RMS coordinate transform system

Stowage - None

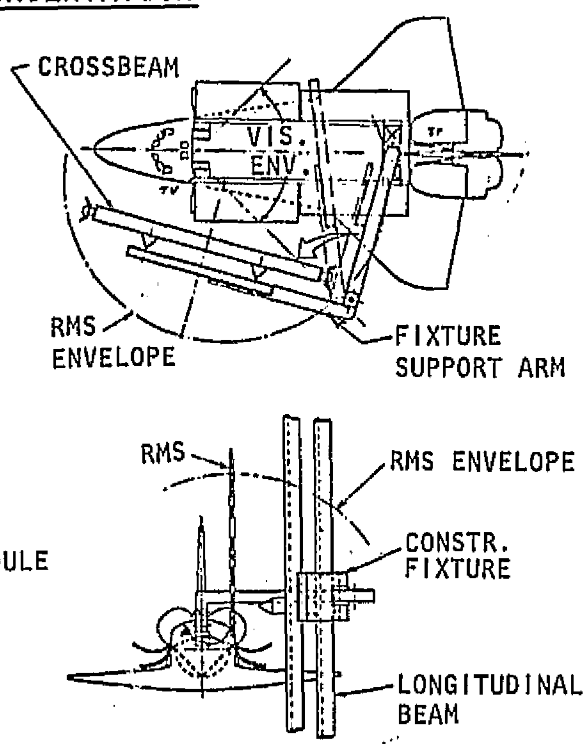
FUNCTION	INSTALL	CODE	01	06 04.2	10.1
ITEM	RCS MODULE				
METHOD	FIXTURE HANDLING DEVICE	PAGE	6 of 6		
SUBJECT	SUMMARY				

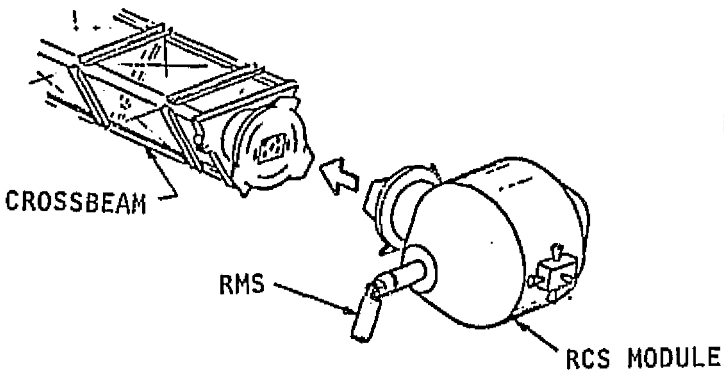
	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Construction Fixture	--	--	--	--	--	--	--
RMS	0	0	--	1.8	TBD	--	NC
Support Services							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	1.8	TBD	--	TBD
Project Modification							
RCS Module (Fixture Handling Device Interface Attachment)	1	NEG	--	--	--	--	25
Operations	--	--	1/1	--	--	20	NA*

*Not appropriate, see page 6.

FUNCTION	INSTALL	CODE	01	06 04.2	04.1
ITEM	RCS MODULE				
METHOD	RMS	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

Z-AXIS ORIENTATION



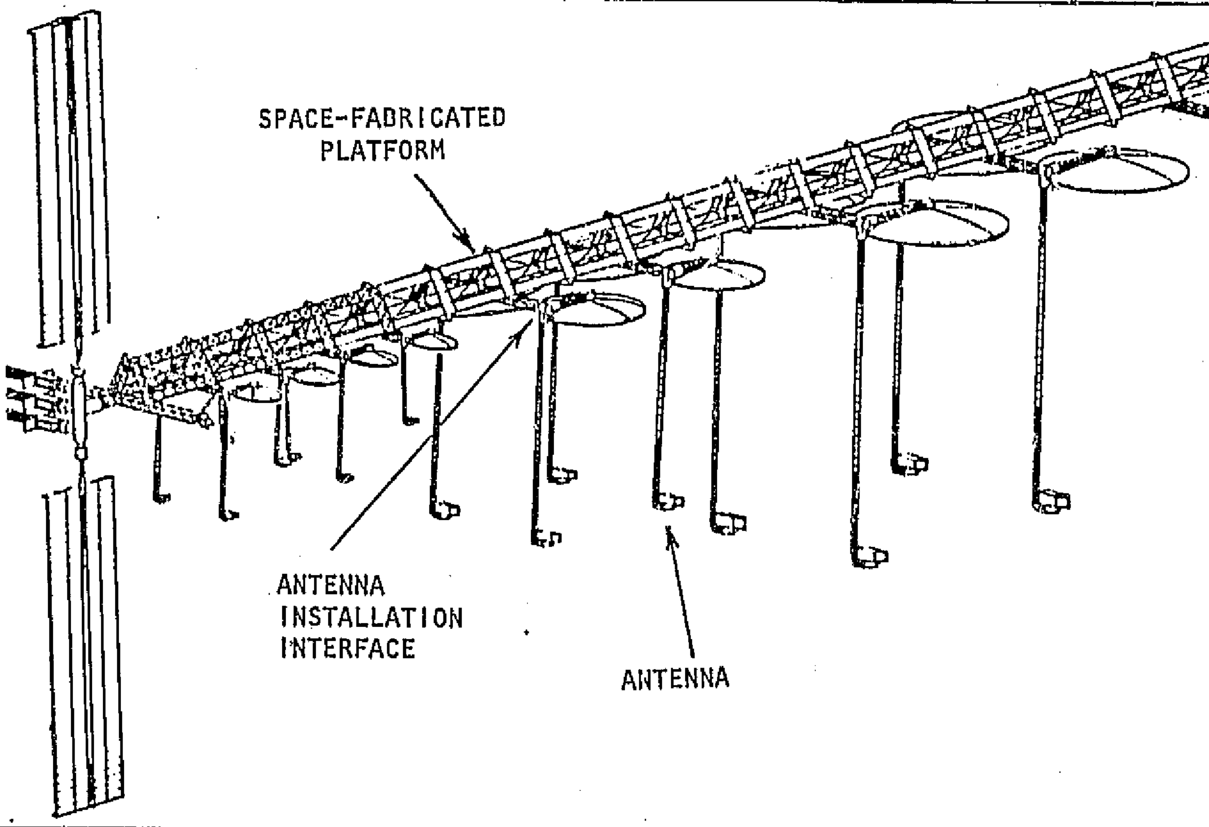


DIRECT RMS ASSEMBLY

- The RMS removes the first RCS module from the payload bay and delivers it to the first assembly position.
- The module is aligned and berthed, latches locked and electrical connected.
- The module is released and RMS returns to the payload bay for next pick-up.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION ·	INSTALL	CODE	01	06 04.3	00
ITEM ·	ANTENNA MODULE	PAGE	1 of 2		
METHOD					
SUBJECT	OPERATION IDENTIFICATION				



Project System

. Space Fabricated Communications Platform

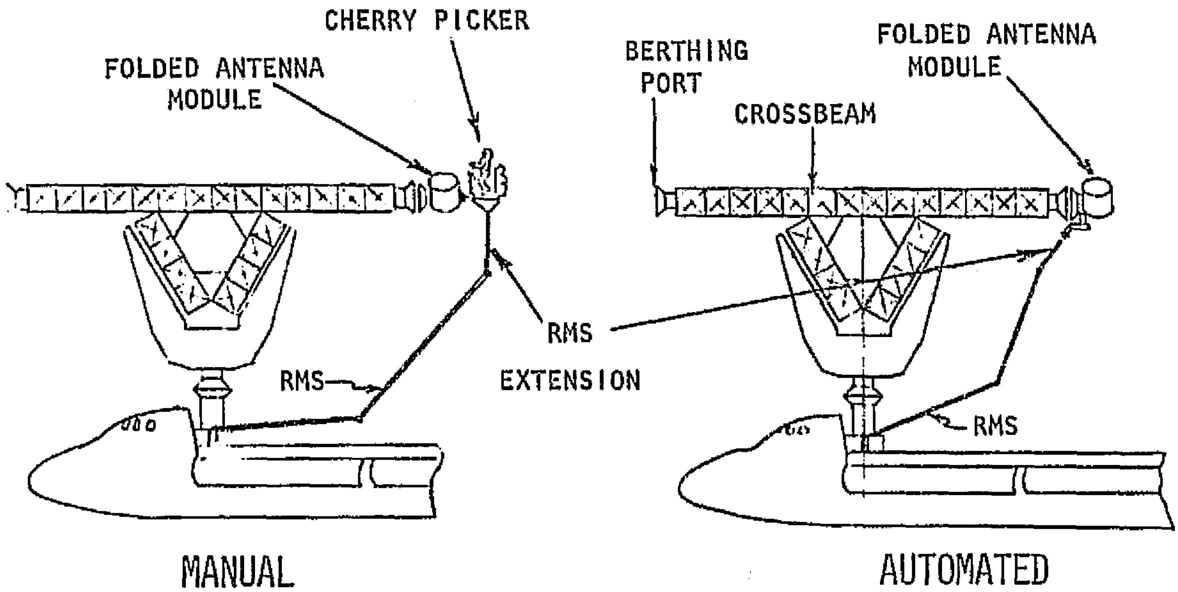
Operation

Install Antenna Modules (16)

Physical Situation

Platform structure is complete except for control module and thrust structure. Platform is in the construction fixture and is able to be translated along the entire length of the platform. Antennas are in the orbiter in their stowed configuration.

FUNCTION · ITEM	INSTALL ANTENNA MODULE	CODE	01	06 04.3	00
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

1. Operator in cherry picker mates the antenna modules to the platform.

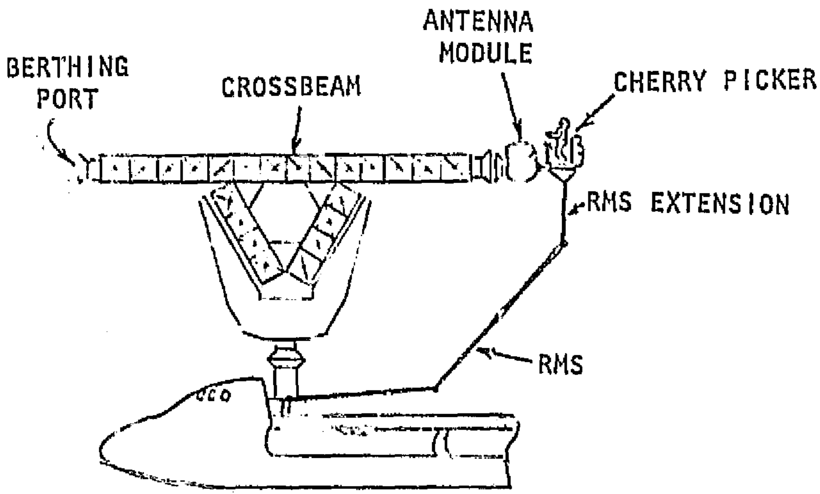
Automated

2. RMS used to install the antenna modules.

3. Orbiter is docked to the platform and the RMS is used to install the antenna modules.

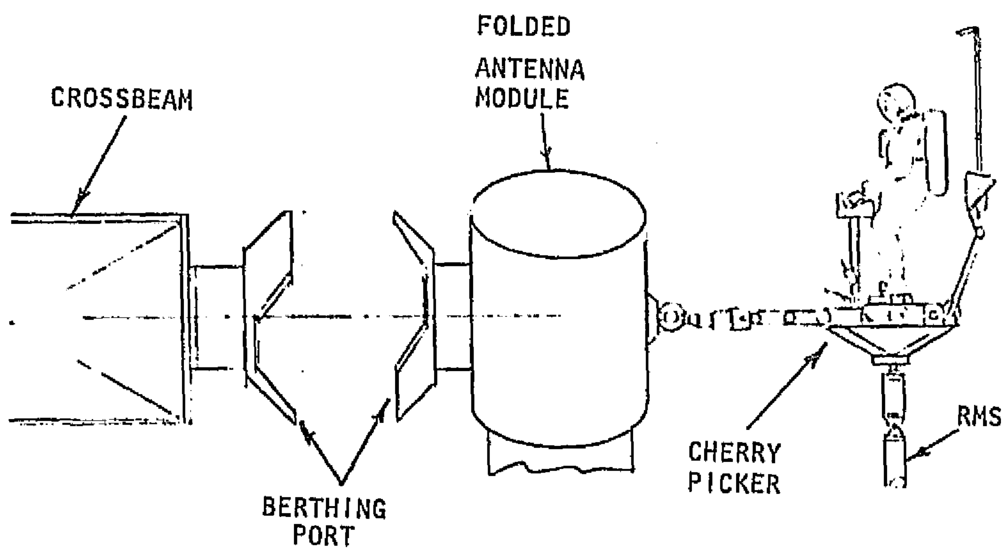
Methods 1 and 2 are detailed.

FUNCTION	INSTALL	CODE	01	06 04.3	03.1
ITEM	ANTENNA MODULE	PAGE	1 of 5		
METHOD	CHERRY PICKER				
SUBJECT	METHOD DESCRIPTION				



- o The orbiter docks to the construction fixture.
- o The operator using the cherry picker removes the antenna module from the orbiter bay and installs it on the platform

FUNCTION	INSTALL	CODE	01	06 04.3	03.1
ITEM	ANTENNA MODULE	PAGE	2 of 5		
METHOD	CHERRY PICKER				
SUBJECT	OPERATIONS				



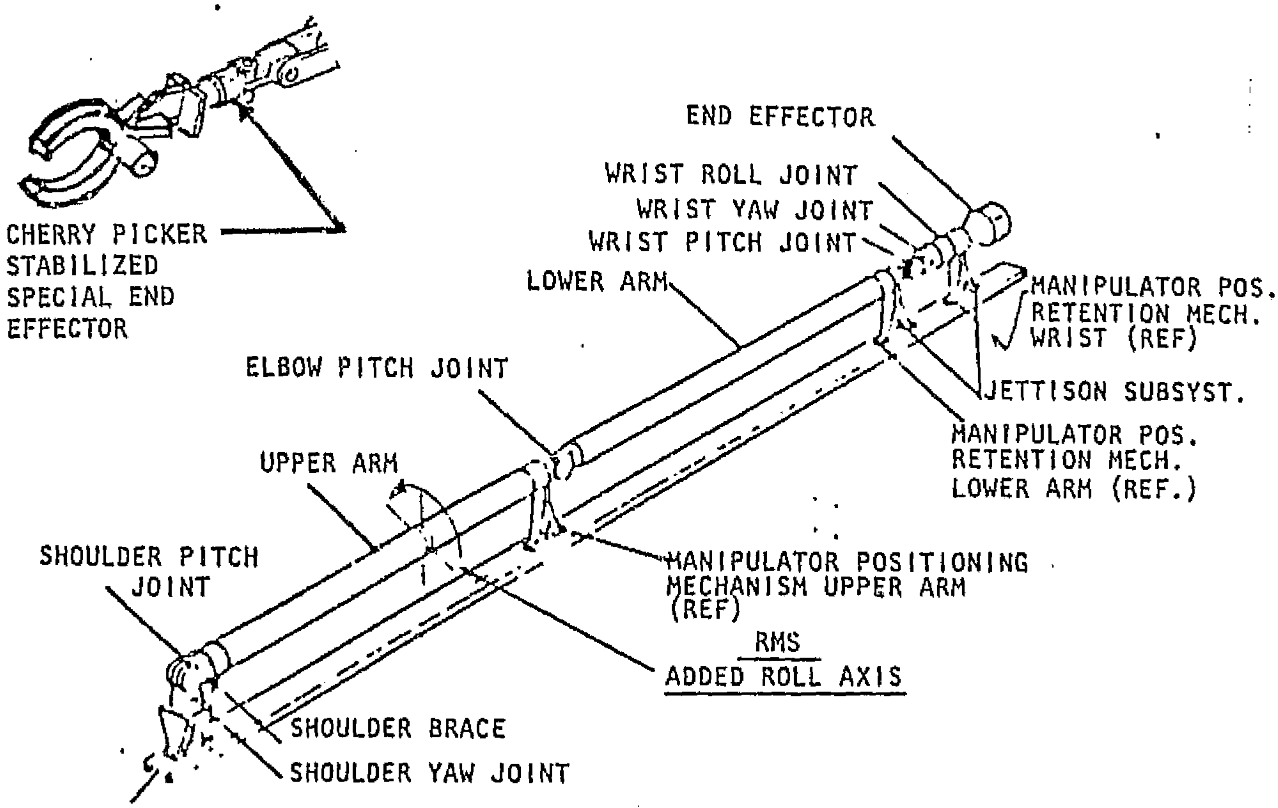
Manpower

- One Cherry Picker Operator

Activity Time

- Cherry picker operator pick-up of antenna module	6 min.
- Remove antenna module from orbiter bay and transport to the vicinity of the platform interface.	15 min.
- Berth the antenna module to the platform	4 min.
TOTAL PER ANTENNA	25 min.

FUNCTION	INSTALL	CODE	01	06 04.3	03.1
ITEM	ANTENNA MODULE	PAGE	3 of 5		
METHOD	CHERRY PICKER				
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- Cherry Picker with special RMS attachment
- RMS with extra upper arm joint
- Special end effector for cherry picker stabilizer arm to grasp antenna modules.
- RMS extension (1-1.5 M)

Crew - One Cherry Picker Operator

Power - RMS 1 - 1.8 kW

Cherry Picker 0 - 5 kW

Lighting & TV

- Standard Cherry Picker

Computer/Software

- RMS Coordinate Transform System

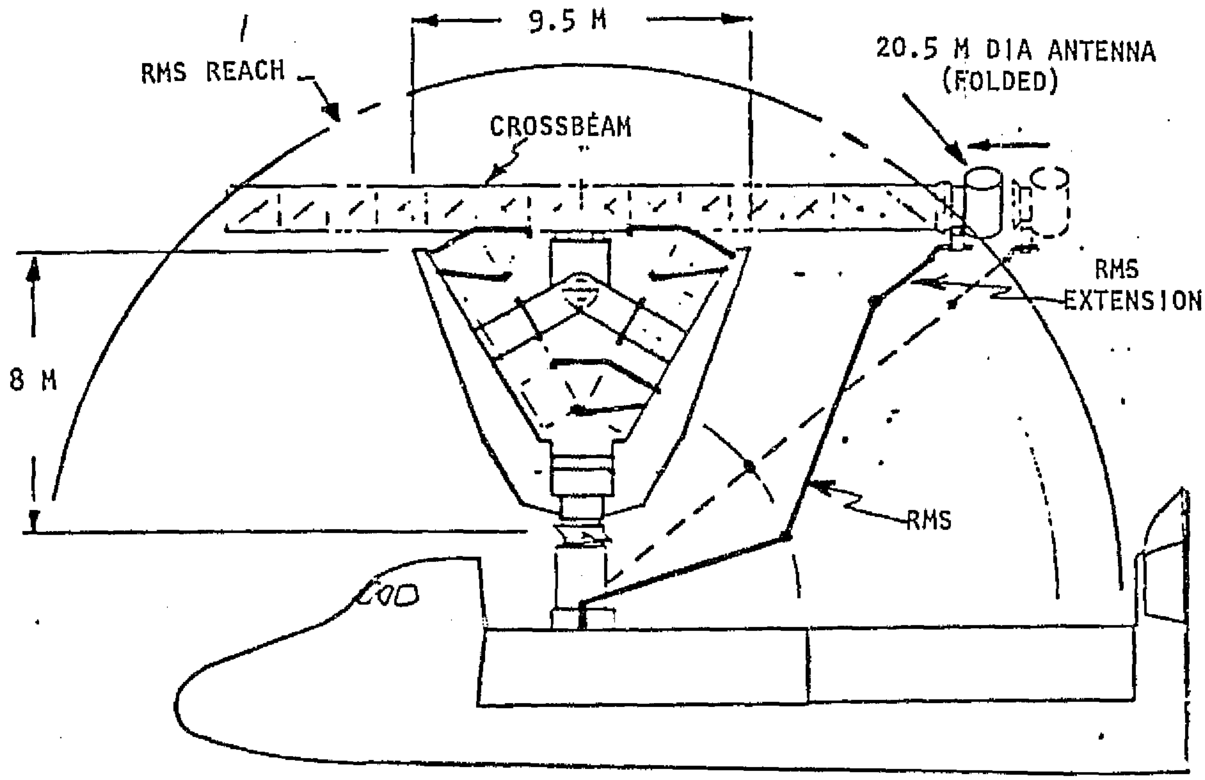
Stowage - Cherry Picker - 0.9 x 1.6 x 1.1m

FUNCTION	INSTALL	CODE	01	06 04.3	03.1
ITEM	ANTENNA MODULE				
METHOD	CHERRY PICKER	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
Cherry Picker End Effector	3	NEG	--	TBD	TBD	--	212
RMS	0	0	--	1.8	TBD	--	NC
RMS Upper Arm Modifications	79	0	--	TBD	TBD	--	1764
RMS Extension	10	NEG	--	0	0	--	353
Support Services							
Crew	--	--	1/1	--	--	--	--
Power	--	--	--	2.3	TBD	--	TBD
Project Modification							
None							
Operations	--	--	1/1	--	--	25	NA*

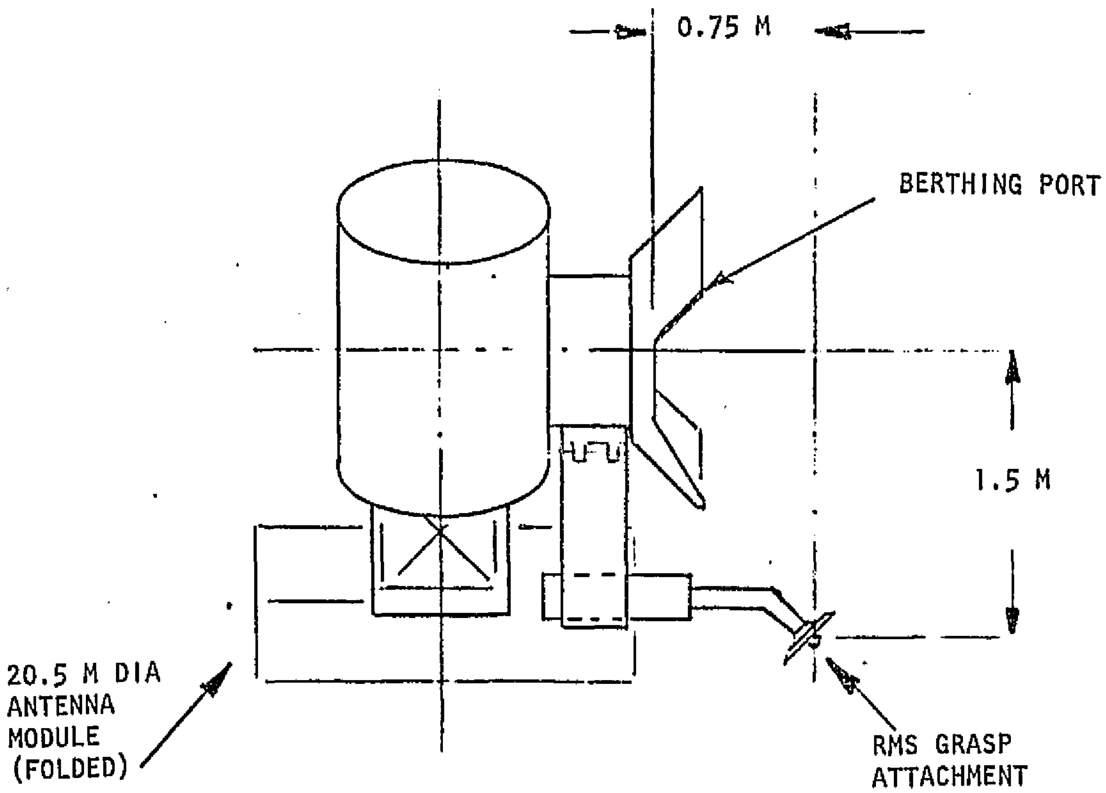
*Not appropriate, see page 6.

FUNCTION	INSTALL	CODE	01	06 04.3	04.1
ITEM	ANTENNA MODULE				
METHOD	RMS	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



The RMS operator uses the RMS to remove the folded antenna from the orbiter bay and installs the antenna to the platform. By means of an appropriate attachment on the antenna, the RMS is able to achieve a linear movement of 2m in the direction required to install the antenna.

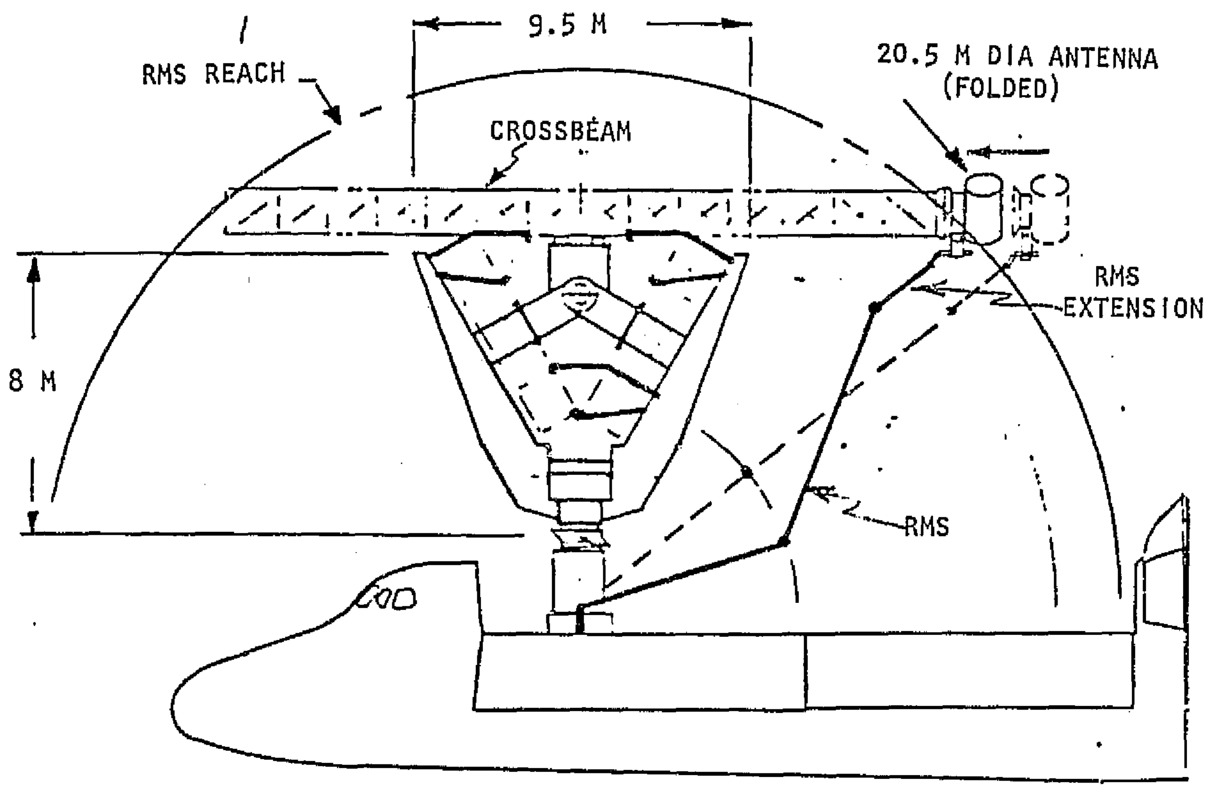
FUNCTION	INSTALL	CODE	01	06 04.3	04.1
ITEM	ANTENNA MODULE				
METHOD	RMS	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



Antenna Module

Add RMS grasp attachments to the antenna modules. RMS grasp attachment requires a spring loaded hinge and a spring bungee to give rotational and linear compliance.

FUNCTION	INSTALL	CODE	01	06 04.3	04.1
ITEM	ANTENNA MODULE	PAGE	3	of	6
METHOD	RMS				
SUBJECT	OPERATIONS				



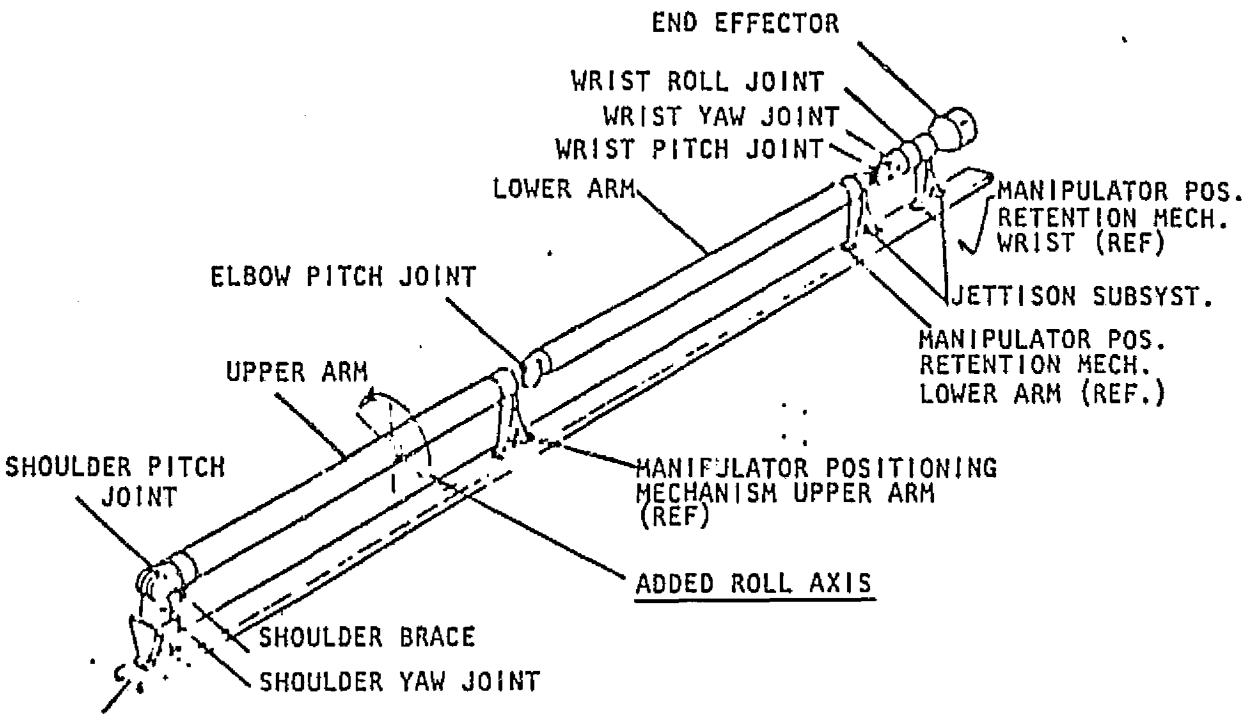
Manpower

- One RMS Operator at AFD

Activity Time

- Attach RMS to antenna module	10 min.
- Remove antenna module from orbiter bay and move to vicinity of platform interface	15 min.
- Berth the antenna module to the platform.	4 min.
TOTAL PER ANTENNA	29 min.

FUNCTION ·	INSTALL	CODE	01	06 04.3	04.1
ITEM ·	ANTENNA MODULE	PAGE	4 of 6		
METHOD	RMS				
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS with an extra joint in the upper arm.
- RMS extension (1-1.5 M)

FUNCTION	INSTALL	CODE	01	06 04.3	04.1
ITEM	ANTENNA MODULE				
METHOD	RMS	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

Crew - One RMS Operator at AFD

Power - RMS Operation - 1 - 1.8 kW

Lighting & TV

- Standard RMS

Computer/Software

- RMS Coordinate Transform System

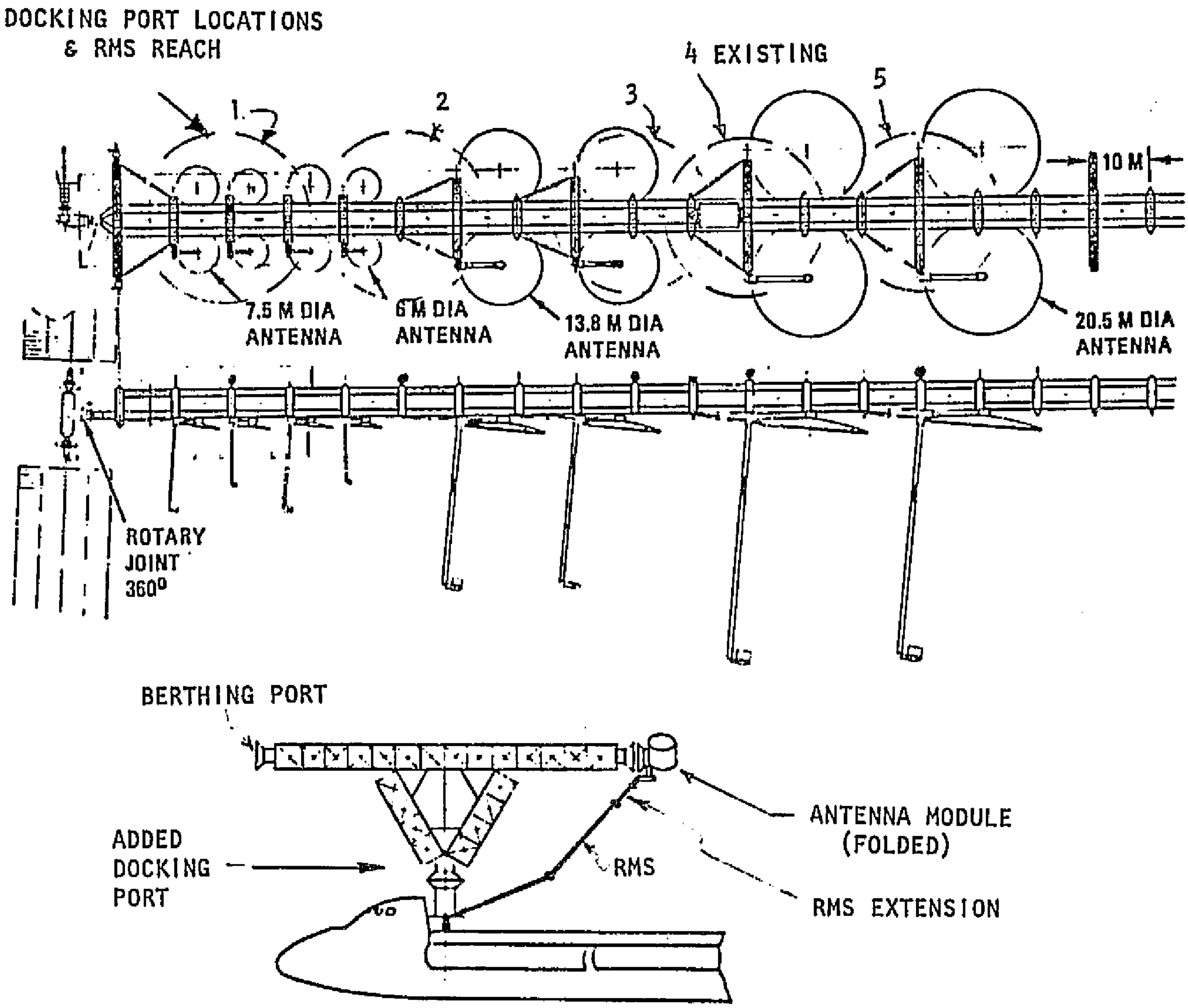
Stowage - None

FUNCTION	INSTALL	CODE	01	06 04.3	04.1
ITEM	ANTENNA MODULE				
METHOD	RMS	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
RMS	0	0	--	1.8	TBD	--	NC
RMS Upper Arm Modification	79	0	--	TBD	TBD	--	1764
RMS Extension	10	NEG	--	0	0	--	353
<u>Support Services</u>							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	1.8	TBD	--	TBD
<u>Project Modification</u>							
Antenna Mod (Grasp Attachment)	12	0.1	--	--	--	--	116
<u>Operations</u>	--	--	1/1	--	--	29	NA*

*Not appropriate, see page 6.

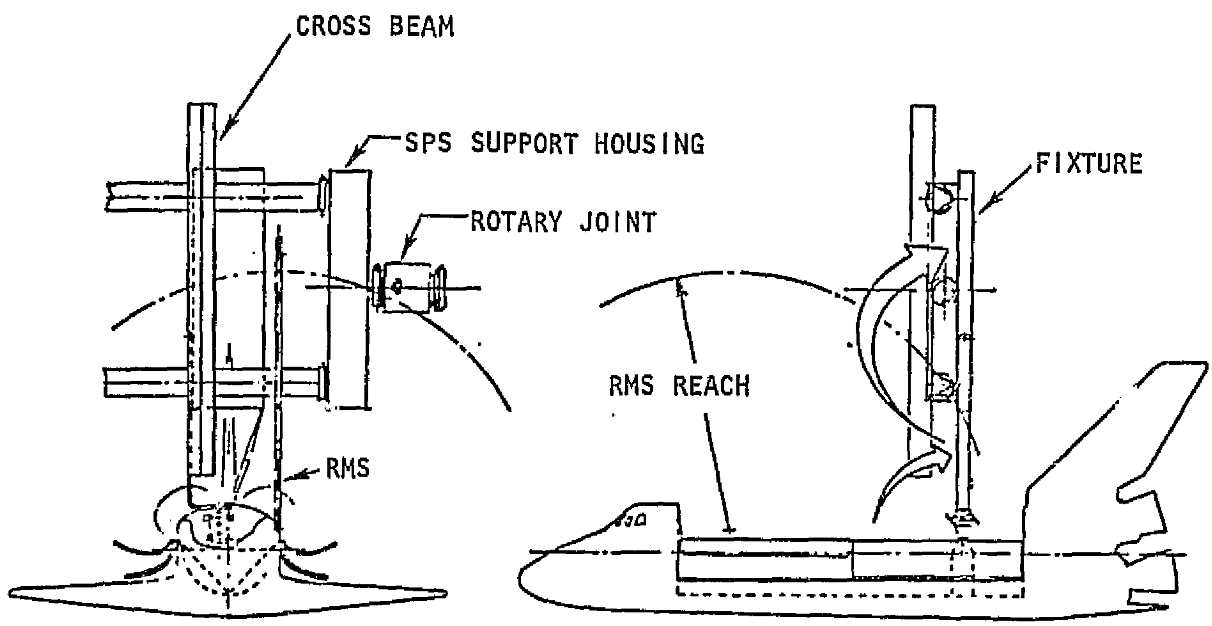
FUNCTION ITEM	INSTALL ANTENNA MODULE	CODE	01	06 04.3	04.2
METHOD	RMS - ORBITER DOCK TO PLATFORM	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



The orbiter docks to the platform and the RMS is used to install the antenna modules. The platform must be modified to add four (4) docking ports. The fifth docking port is existing (System Control Module Berthing Port).

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION· ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	00
METHOD		PAGE		1 of 2	
SUBJECT	OPERATION IDENTIFICATION				



Project System

- SPS Test Article

Operation

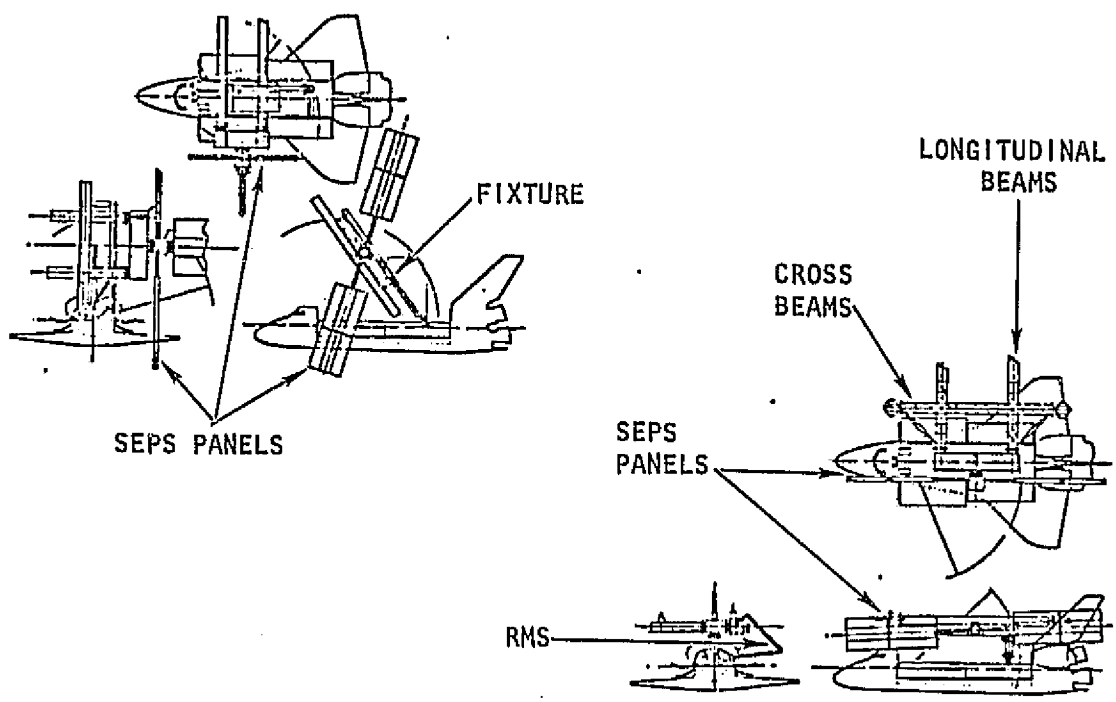
- Install solar electric propulsion system (SEP) on platform

Physical Situation

- Structure is complete
- LEO mission is complete, platform is being prepared for move to GEO

0-3

FUNCTION · ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	00
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

1. Platform in basic Y orientation. RMS removes SEP's panels from cargo bay, fixture is tilted forward 30° and SEP's panels installed.

2. Platform is berthed directly to orbiter at port on support housing - platform is in horizontal plane along "Y" axis. SEP's panels removed from cargo bay and installed by RMS.

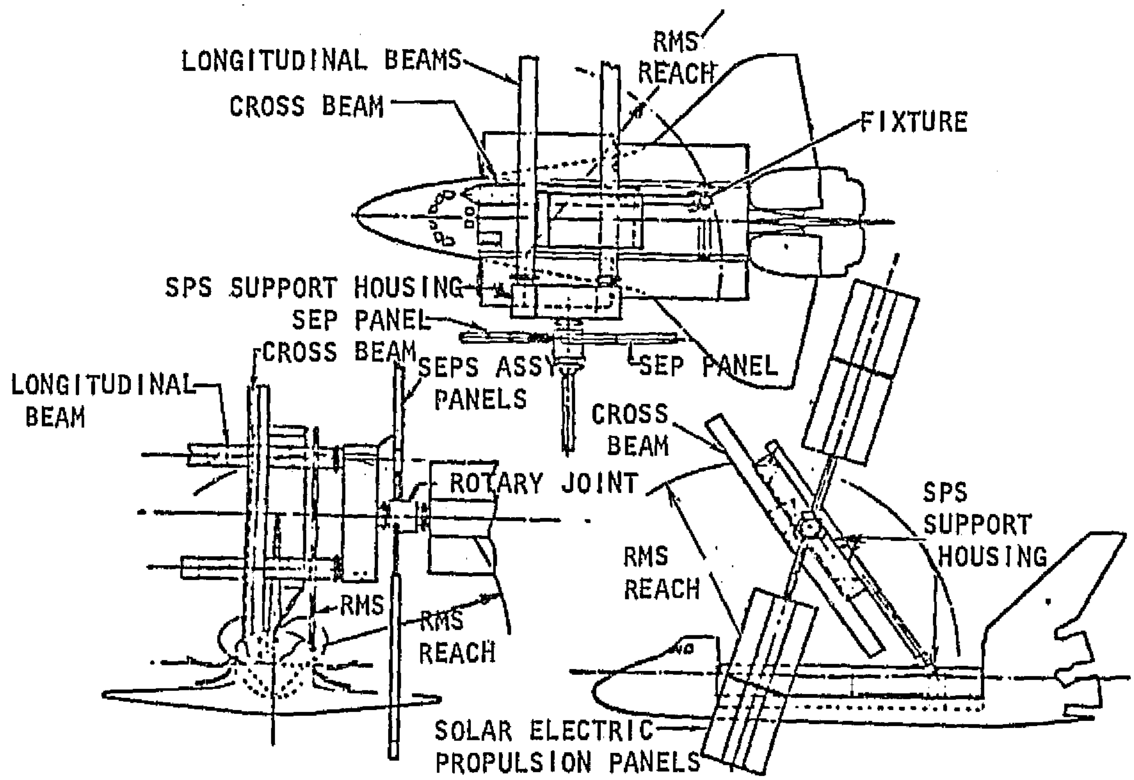
3. Same as #2 except test article is oriented vertically along Z axis.

4. Same as #2 except test article is oriented horizontally along X axis and attached to orbiter at forward end of payload bay.

5. Platform oriented along Z axis. RMS removes SEP's panels from the bay and installs them on rotary joint.

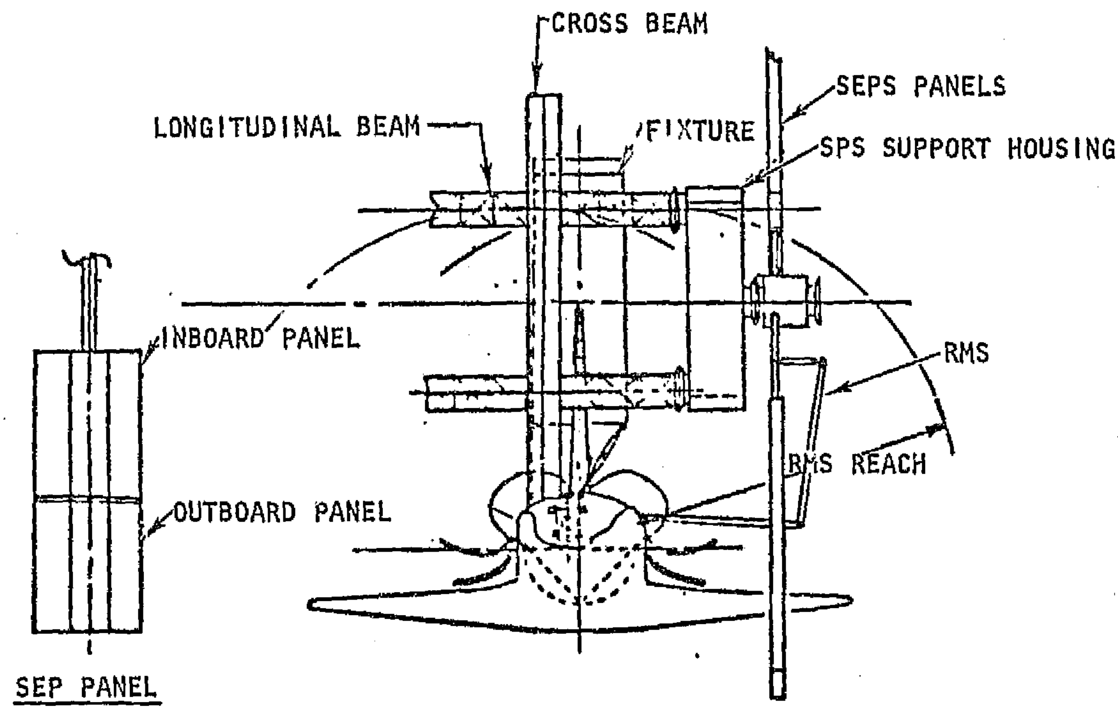
Methods 1 and 2 are detailed.

FUNCTION· ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	041
METHOD	RMS/TILTING FIXTURE	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- Construction fixture supports test article along "Y" axis from a point near the structure support housing (fixture remained attached to platform during LEO operations).
- Panel connection device is attached to stem by EVA astronaut
- Port side RMS removes folded SEP panel from cargo bay
- Fixture with test article is rotated forward 30° from the vertical position to improve the RMS reach capability
- SEP panel (as shown nearest orbiter) is attached to the rotary joint by inserting the mast into the receptacle provided.
- Fixture with test article is rotated back to vertical position
- Second panel is removed from the bay by RMS, fixture is tilted and panel attached to first panel, radiators are unfolded by RMS
- Rotary joint is rotated, moving installed panel 180° and second panel set is installed
- Radiators are unfolded by RMS

FUNCTION	INSTALL	CODE	01	06 04.4	04.1
ITEM	SOLAR ELECTRIC PROPULSION PANELS (SEP)	PAGE	2 of 5		
METHOD	RMS/TILTING FIXTURE				
SUBJECT	OPERATIONS				



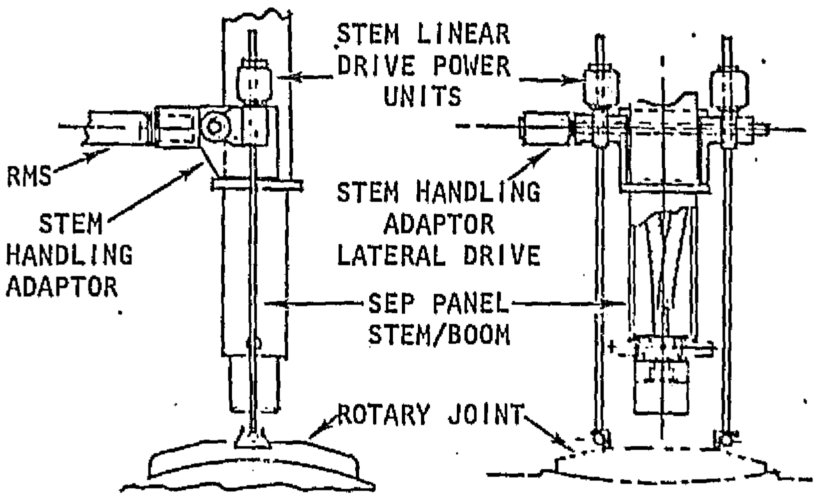
Manpower

- One RMS operator
- One EVA astronaut
    - Attach panel connection device to stem
    - Attach device to rotary joint

Activity Time

- Attach panel connection device	10 min.
- Obtain SEP panel from bay	10 min.
- Tilt fixture and install panel	30 min.
- Obtain outboard panel - attach to inboard panel	35 min.
- Unfold radiators	20 min.
- Repeat operations for second side	105 min.
Total (Microwave End)	210 min.

FUNCTION · ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	04.1
METHOD	RMS/TILTING FIXTURE	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



CONNECTION DEVICE

- RMS
- Fixture
    - Provision to tilt fixture 30° forward of vertical position
- Connection Device
    - Linear drive screws attach to rotary joint
    - Lateral drive positions stem handling adaptor on stem
    - Stem linear drive move stem into rotary joint making final physical and electrical connection

Crew

- 1 RMS operator
- 1 EVA astronaut

Power

- RMS   1 - 1.8 KW
- Connection Device - TBD

Lighting and TV

- Standard orbiter and RMS

Computer/Software

- RMS coordinate transform system

Stowage

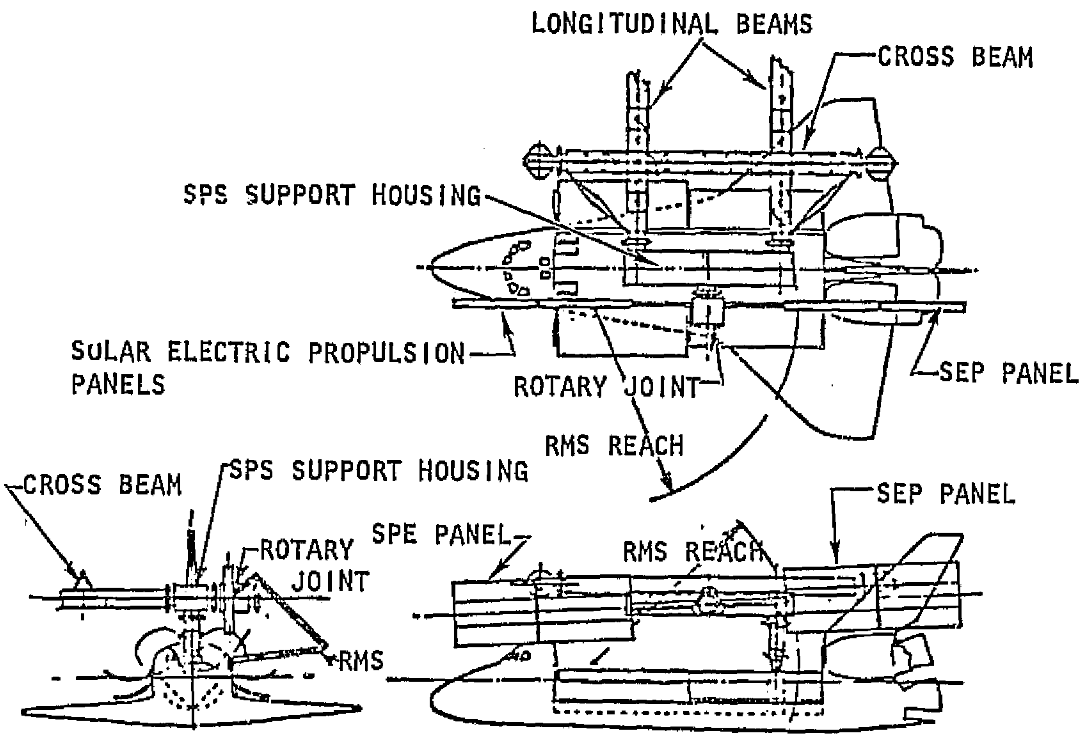
- Connection device 0.2 x 0.1 x 1M

FUNCTION ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)
METHOD	RMS/TILTING FIXTURE
SUBJECT	SUMMARY
CODE	01 06 04.4 04.1
PAGE	5 of 5

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	-	1.8	TBD	-	NC
Fixture Tilting Mod	0	0	-	0	0	-	NC
Connection Device	20	Neg	-	TBD	TBD	-	798
Support Services							
Crew	-	-	2/1.5	-	-	-	-
Power (Total)	-	-	-	TBD	TBD	-	TBD
Operations	-	-	2/1.5	-	-	210	NA*

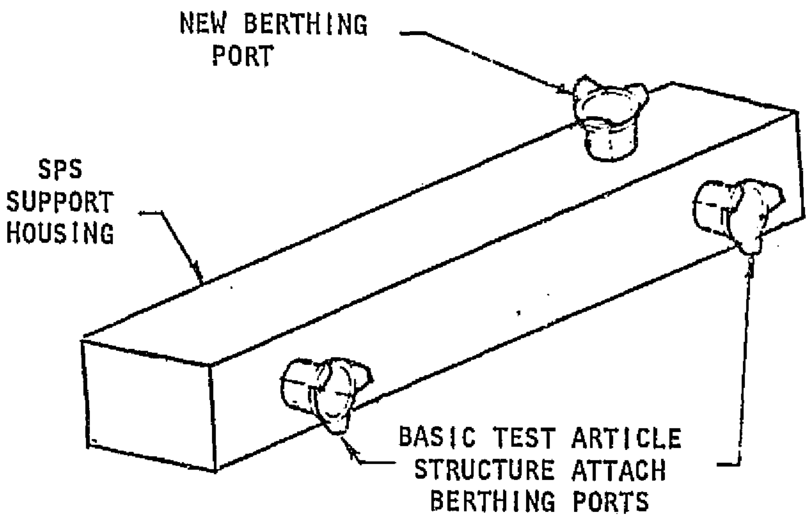
*Not appropriate, see page 6.

FUNCTION·	INSTALL	CODE	01 06 04.4 04.2
ITEM	SOLAR ELECTRICAL PROPULSION PANELS (SEP)		
METHOD	RMS/HORIZONTAL Y AXIS	PAGE	1 of 6
SUBJECT	METHOD DESCRIPTION		



- Test article is attached directly to orbiter by extension of construction fixture berthing port
- Platform berthing interface is located on the SPS support housing (platform is horizontal)
- Panel connection device is attached to stem by EVA astronaut
- Port side RMS removes folded SEP panel from cargo bay
- SEP panel (shown in forward position above) is attached to the rotary joint receptacle
- Second panel is removed from the bay and attached to the first
- Radiators are unfolded by RMS
- Rotary joint is activated and installed SEP panel set is rotated 180° to rear position shown
- Operation is repeated for second set of panels

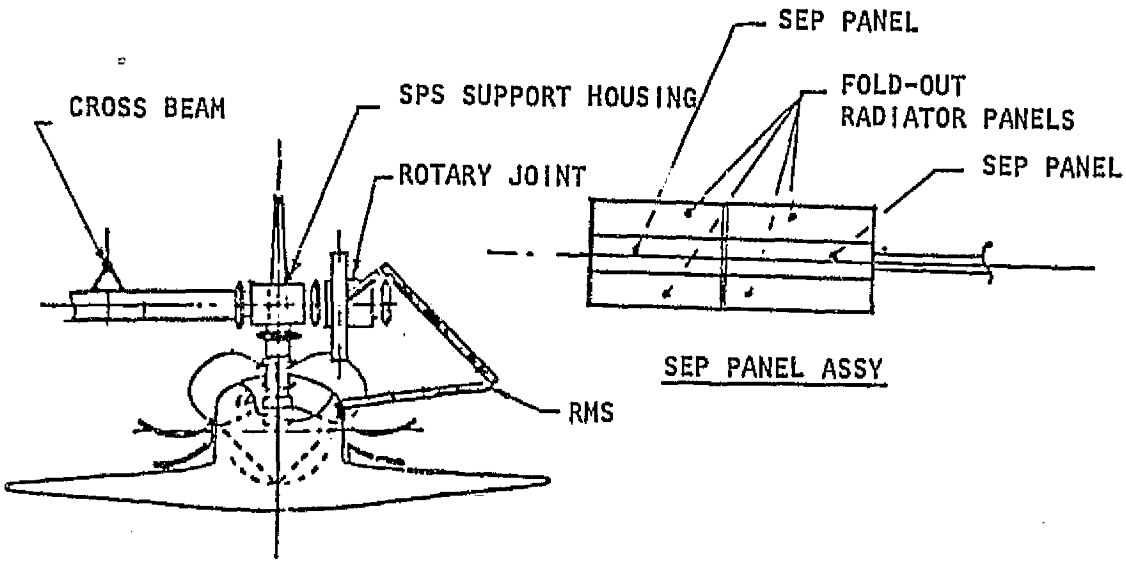
FUNCTION ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	04.2
METHOD	RMS/HORIZONTAL Y AXIS	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



Support Housing

- Berthing port added to provide attachment interface for orbiter

FUNCTION ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	04.2
METHOD	RMS/HORIZONTAL Y AXIS	PAGE	3 of 6		
SUBJECT	OPERATIONS				

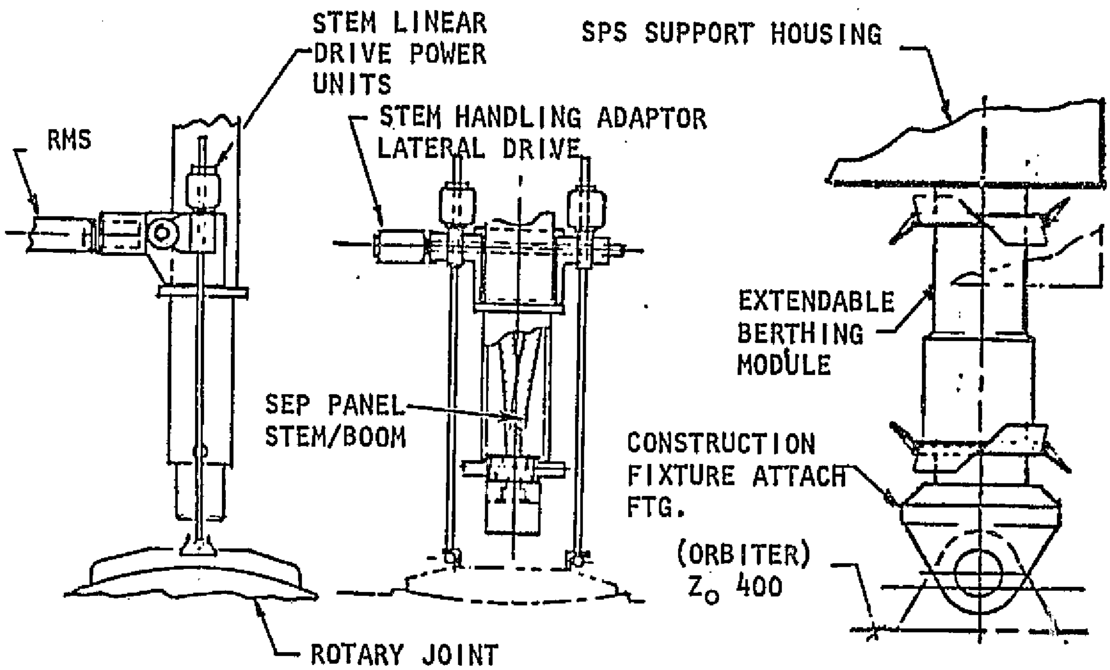


Manpower

- One RMS operator
- One EVA astronaut
    - Attach panel connection device to stem
    - Attach device to rotary joint

Activity Time

- Attach panel connection device	10 min.
- Obtain panel from payload bay	10 min.
- Install panel	30 min.
- Obtain outboard panel and attach to inboard panel	35 min.
- Unfold radiators	20 min.
- Repeat operations for second side	105 min.
Total (Microwave End)	210 min.



- RMS
- Berthing Adaptor
  - Extendable berthing adaptor to provide clearance between test article and orbiter during SEP installation operations
- Connection Device
  - Linear drive screws attach to rotary joint
  - Lateral drive positions stem handling adaptor on stem
  - Stem linear drive move stem into rotary joint making final physical and electrical connection

Crew

- 1 RMS Operator
- 1 EVA Astronaut

Power

- RMS 1 - 1.8 KW
- Connection Device - TBD

Lighting and TV

- Standard orbiter and RMS

Computer and Software

- RMS coordinate transform system

Stowage

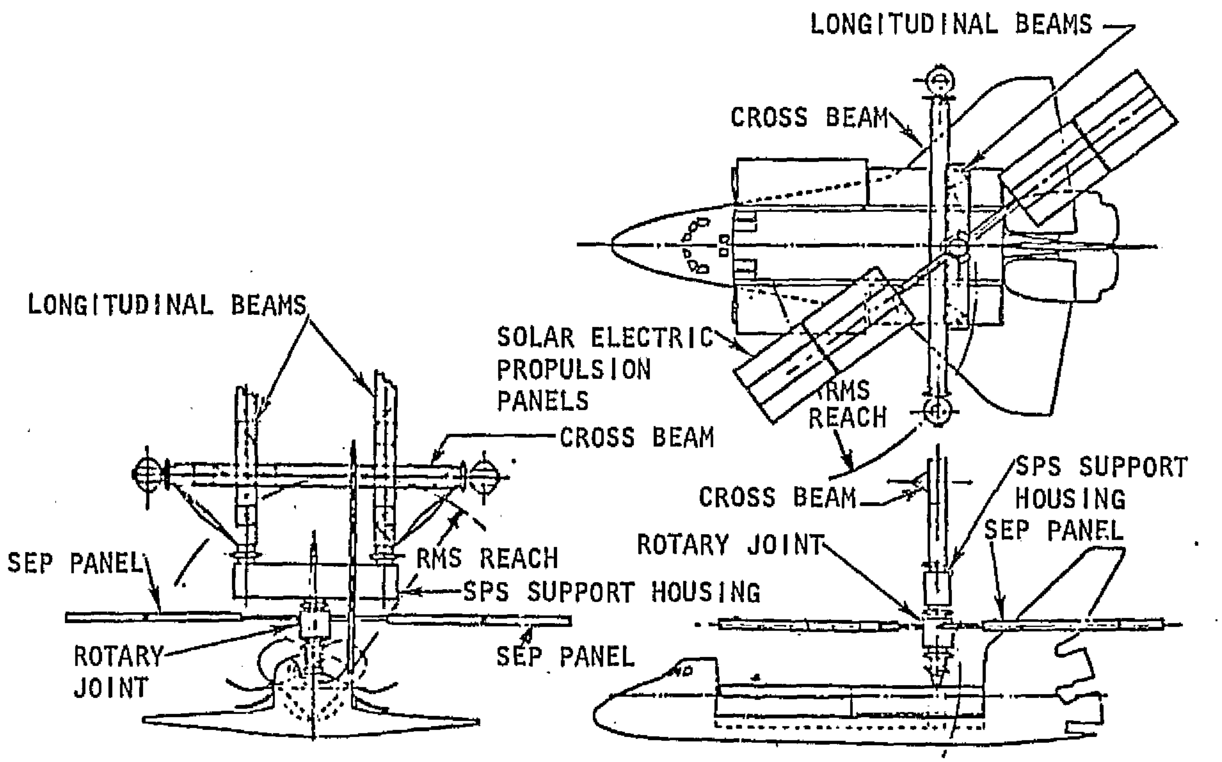
- Connection device 0.2 x 0.1 x 1M
- Extendable berthing module 2M dia x 2M long

FUNCTION	INSTALL	CODE	01	06 04.4	04.2
ITEM	SOLAR ELECTRIC PROPULSION PANELS (SEP)				
METHOD	RMS/HORIZONTAL Y AXIS	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	-	1.8	TBD	-	NC
Berthing Adaptor	200	6.3	-	TBD	TBD	-	935
Connection Device	20	Neg	-	TBD	TBD	-	798
Support Services							
Crew	-	-	2/1.5	-	-	-	-
Power (Total)	-	-	-	TBD	TBD	-	TBD
Project Modification							
Berthing Port	110	1.0	-	-	-	-	473
Operations	-	-	2/1.5	-	-	210	NA*

*Not appropriate, see page 6.

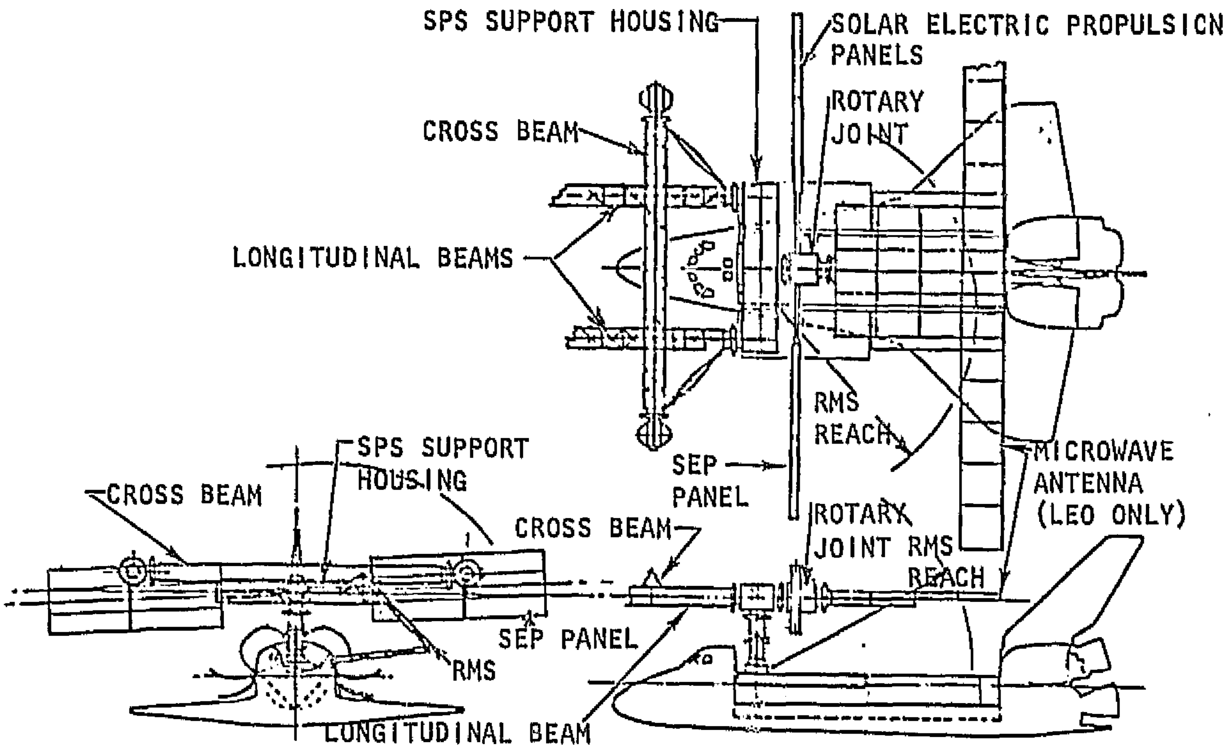
FUNCTION · ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	04.3
METHOD	RMS/Z-AXIS ORIENTATION	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



- Test article structure is orientated along the "Z" axis
- The test platform is attached directly to the orbiter construction fixture berthing port by a berthing port on the outboard end of the rotary joint.
- Panel connection device is attached to stem by EVA astronaut
- Port side RMS removes folded SEP panel from cargo bay
- SEP panel (shown in forward position above) is attached to the rotary joint receptacle
- Second panel is removed from the bay and attached to the first
- Radiators are unfolded by RMS
- Rotary joint is activated and installed SEP panel set is rotated 180° to rear position shown
- Operation is repeated for second set of panels

NO ADDITIONAL DETAILS ARE PROVIDED

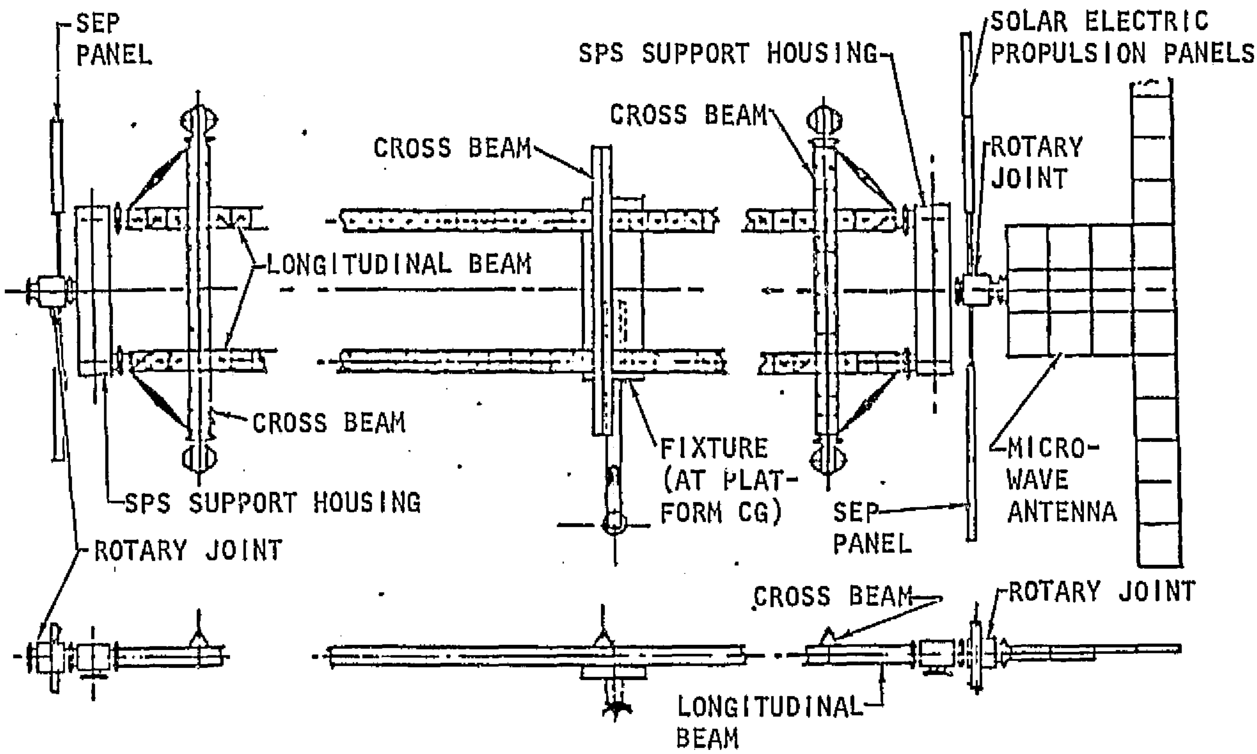
FUNCTION ·	INSTALL	CODE	01	06 04.4	04.4
ITEM ·	SOLAR ELECTRIC PROPULSION PANELS (SEP)				
METHOD	RMS/X AXIS ORIENTATION	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



- Test article structure is attached directly to orbiter by extendable berthing port adaptor at forward end of cargo bay
- SPS berthing port on side of support housing
- Structure is oriented along "X" axis of orbiter
- Panel connection device is attached to stem by EVA astronaut
- Port side RMS removes folded SEP panel from cargo bay
- SEP panel (shown in forward position above) is attached to the rotary joint receptacle
- Second panel is removed from the bay and attached to the first
- Radiators are unfolded by RMS
- Rotary joint is activated and installed SEP panel set is rotated 180° to rear position shown
- Operation is repeated for second set of panels

NO ADDITIONAL DETAILS ARE PROVIDED

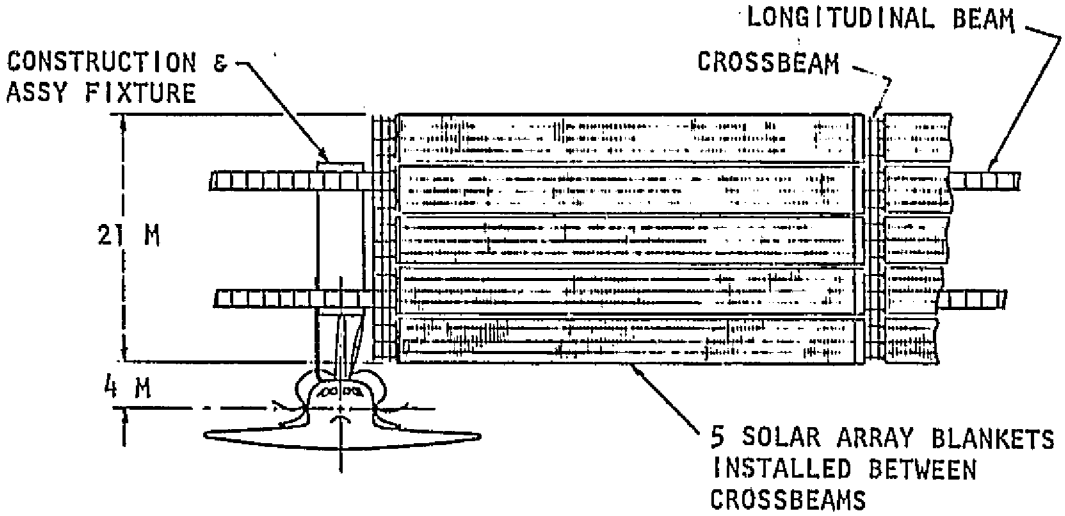
FUNCTION · ITEM	INSTALL SOLAR ELECTRIC PROPULSION PANELS (SEP)	CODE	01	06 04.4	04.5
METHOD	RMS/Z AXIS ORIENTATION	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



- Construction fixture supports test article along Z axis (fixture remained attached to platform during LEO operation
- Panel connection device is attached to stem by EVA astronaut
- SEP panel is removed from the bay by RMS and attached to the rotary joint
- Second panel is removed from the bay and attached to the first. Radiators are unfolded.
- Rotary joint and installed panel set is rotated 180°
- Second set is installed in same manner as the first

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION· ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	06 05.1	00
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				



Project System

- SPS Test Article

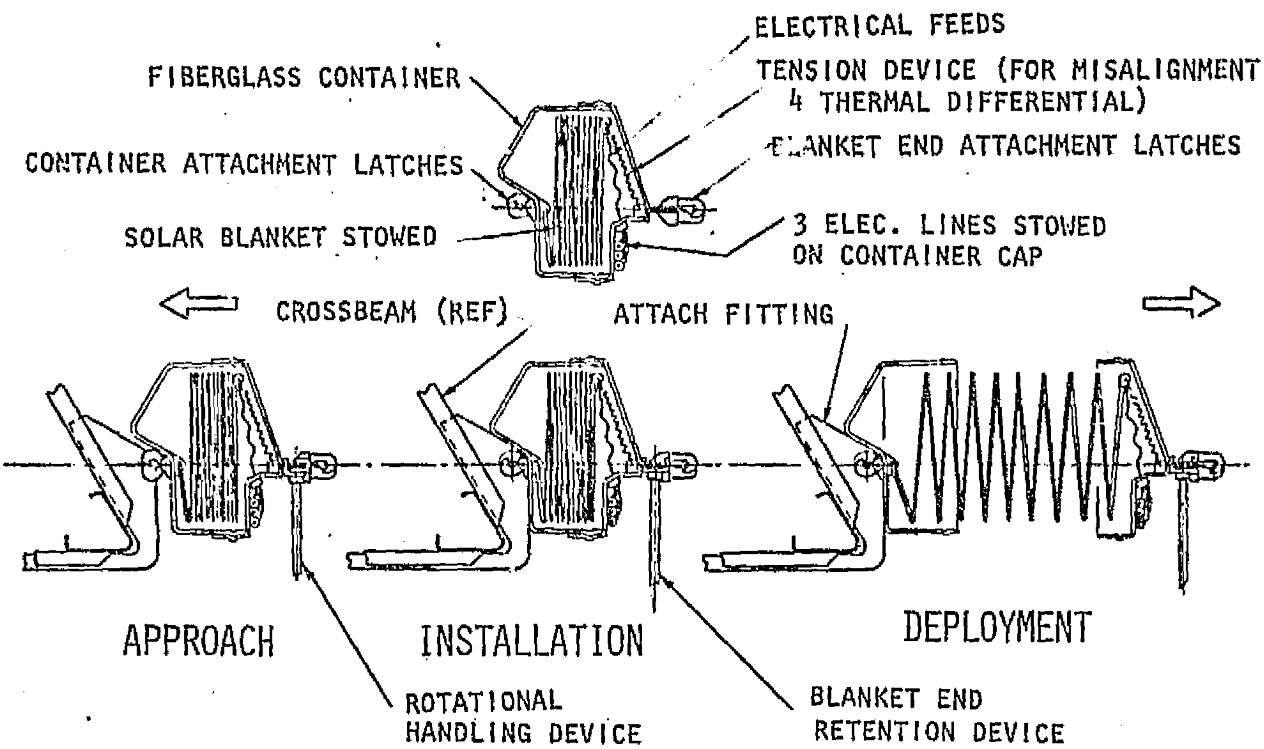
Operation

- Install solar array blankets between cross beams

Physical Situation

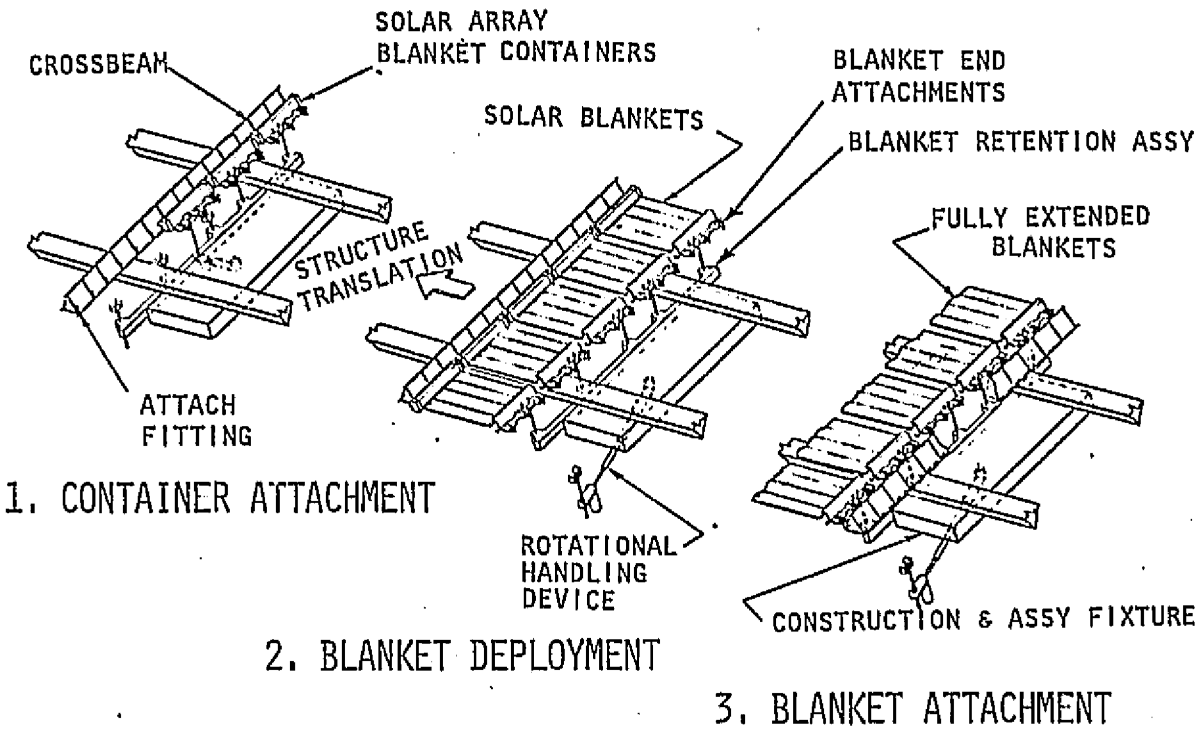
- The structure, held in the assembly fixture, has been completed. The bridge fitting and all RCS modules have been installed. All electrical boxes and wiring have been attached.

FUNCTION· ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	06 05.1	00
METHOD		PAGE	2 of 3		
SUBJECT	OPERATION IDENTIFICATION (CONTINUED)				



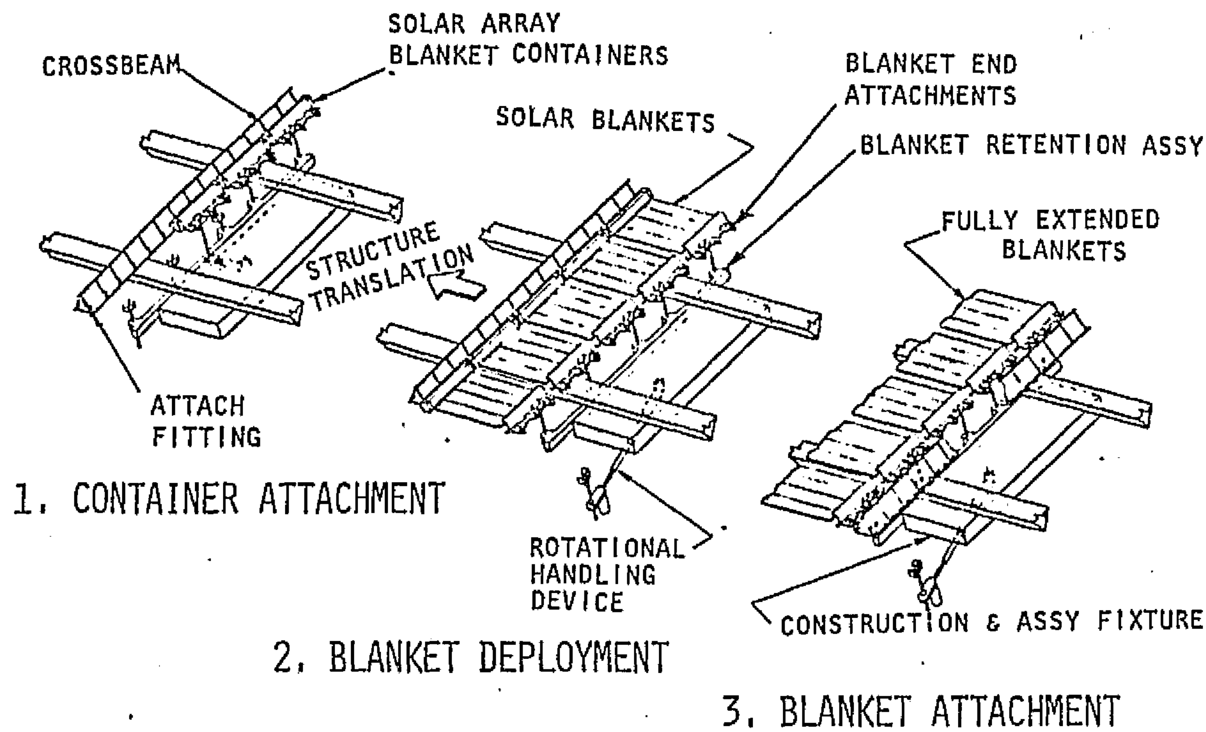
- 25 solar array blanket containers (as shown) required for total installation.

FUNCTION · ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	06 05.1	00
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				



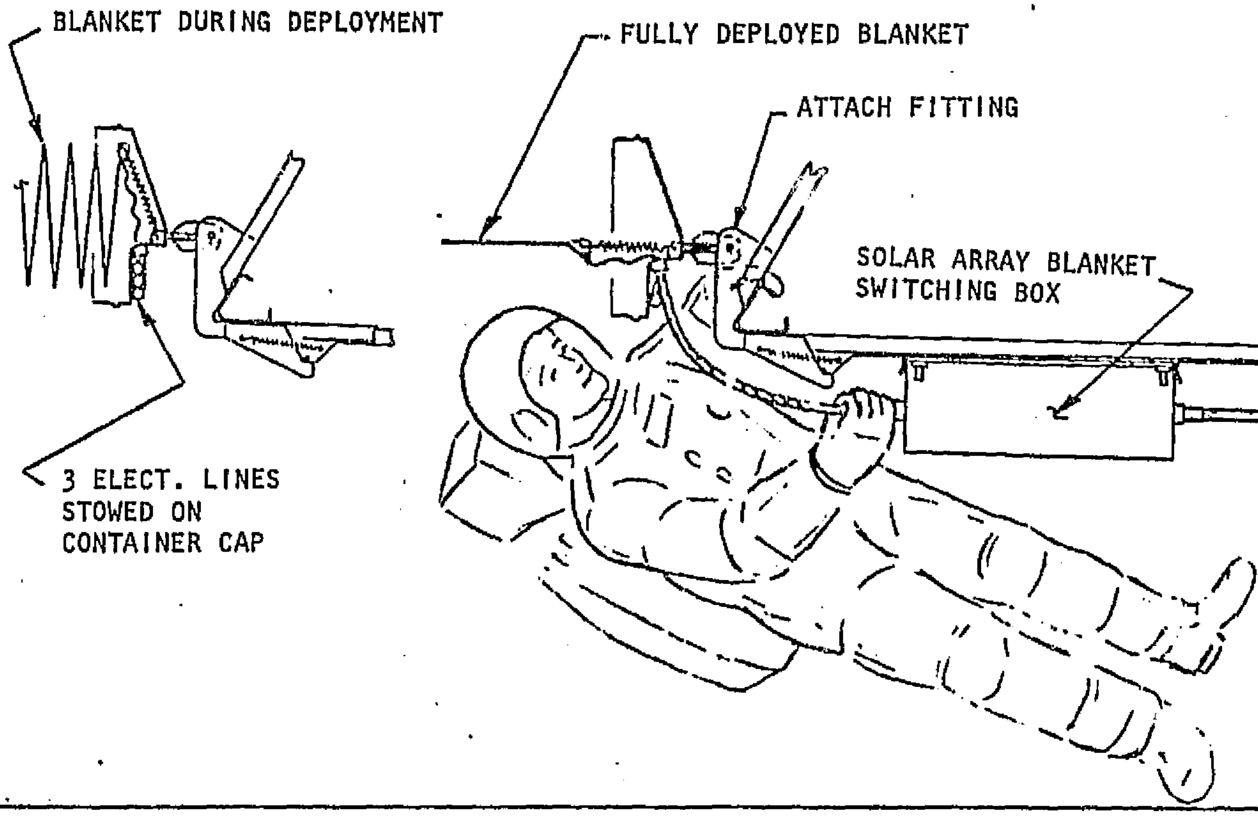
No viable alternate methods identified.

FUNCTION	INSTALL	CODE	01	0605.1	06.1
ITEM	SOLAR ARRAY BLANKETS	PAGE	1 of 7		
METHOD	BLANKET RETENTION ASSEMBLY				
SUBJECT	METHOD DESCRIPTION				



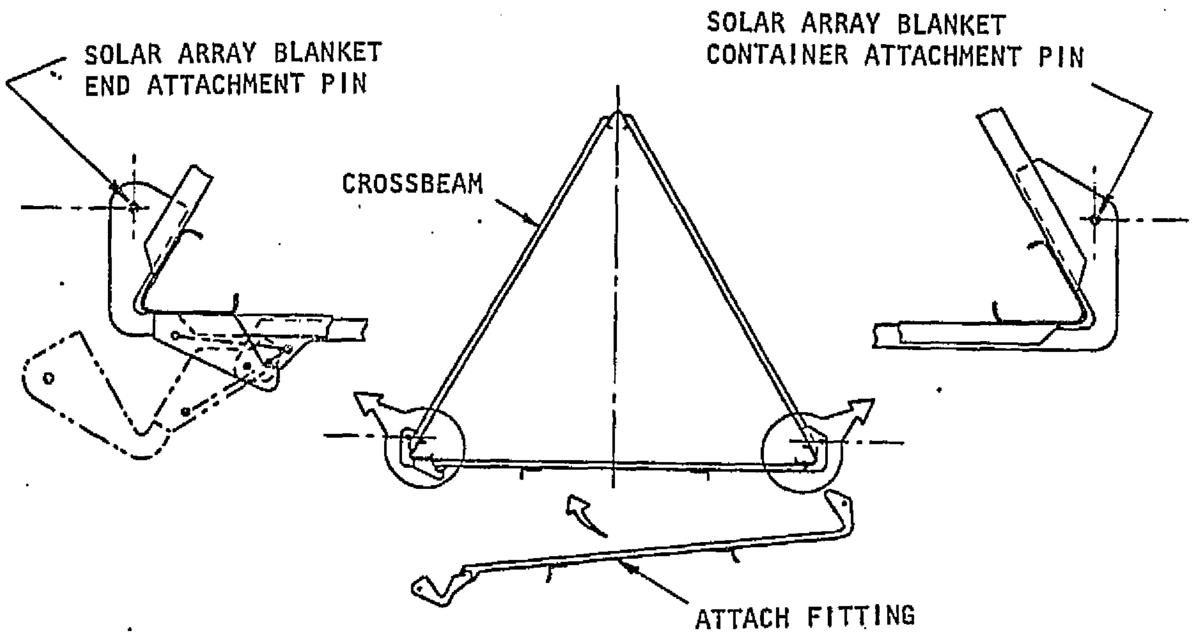
- The RMS removes the first solar array blanket container from the payload bay and attaches it to the rotational handling device.
- The handling device rotates into position where it attaches the first container to the cross beam.
- While still being held by the handling device, the first member of the retention assembly is activated to hold the solar array blanket end (alignment assistance is provided by the handling device).
- This procedure is repeated for the remaining four blanket containers.
- The assembly fixture is activated, translating the longitudinal beams, thus deploying the solar array blankets (the blanket ends being held in the retention assembly).
- As the blanket ends (held in the retention assembly) close on the approaching cross beam, the blanket end attachment latches snap closed securing the deployed blankets between the two cross beams.
- The retention assembly ends are retracted.

FUNCTION · ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	0605.1	06.1
METHOD	BLANKET RETENTION ASSEMBLY	PAGE	2 of 7		
SUBJECT	METHOD DESCRIPTION (CONTINUED)				



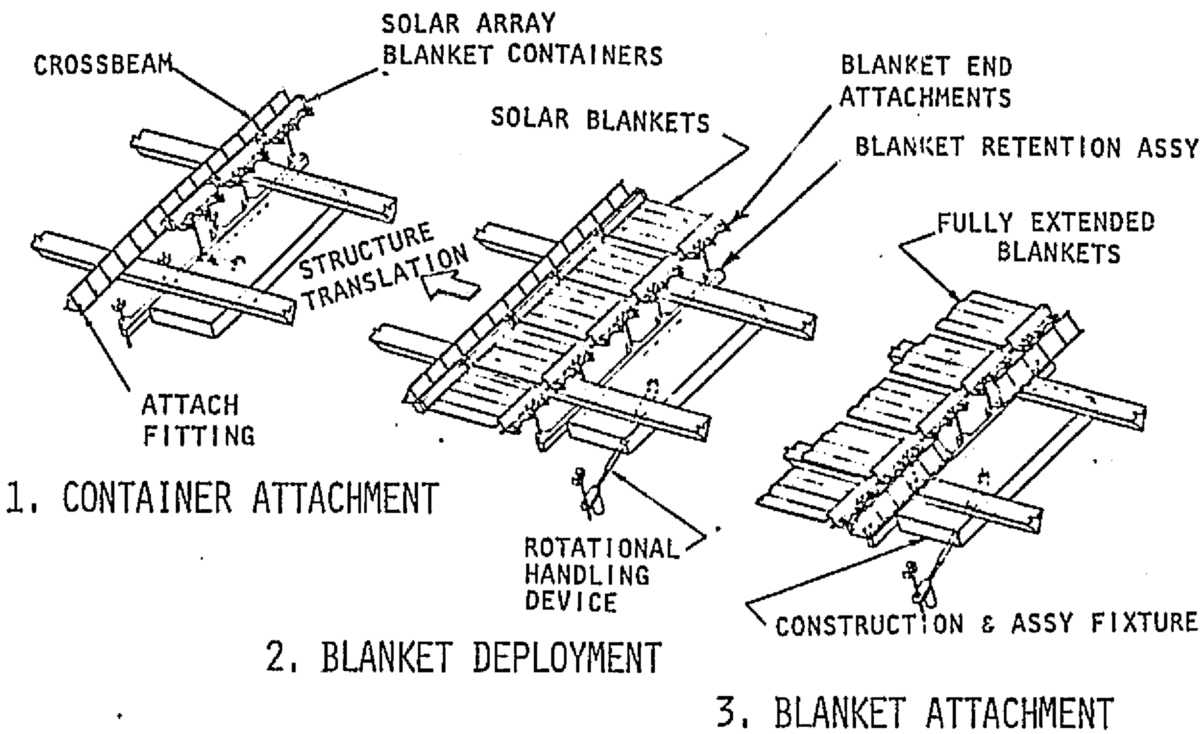
- An EVA astronaut unstows the three electrical lines from each blanket container cap and connects them to the switch box.
- The structure is translated and the total procedure repeated for the other bays.

FUNCTION · ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	0605.1	06.1
METHOD	BLANKET RETENTION ASSEMBLY	PAGE	3 of 7		
SUBJECT	PROJECT MODIFICATIONS				



The attach fitting fits into each cross member on base of cross beam.

- Both ends of the fitting have been modified to allow greater latch clearance around the attachment pins.
- The container attachment end has been contoured to stabilize container when attached.



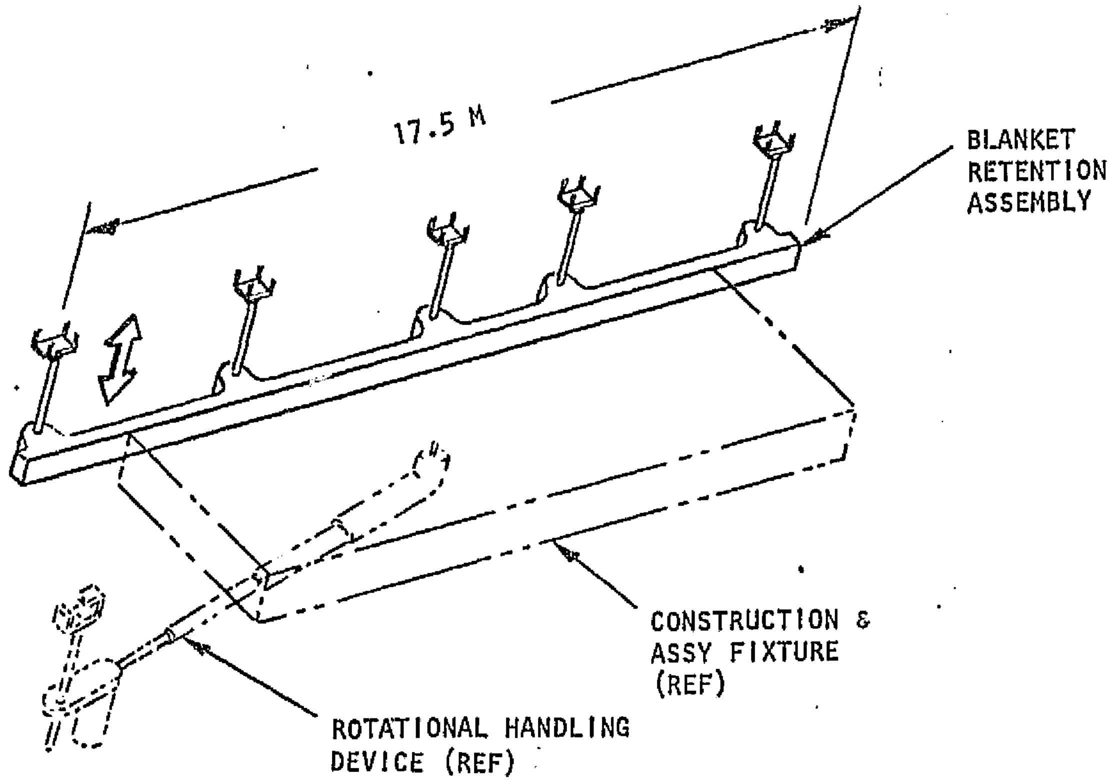
Manpower

- One RMS and rotational handling device operator
- One EVA astronaut

Activity Time

- RMS removes container and attaches to rotational handling device	6 min.
- Handling device aligns and attaches container to cross beam	2 min.
- Retention device activated, securing blanket end in relation to assembly fixture	1 min.
- Above procedure repeated four times	28 min.
- Structure translated 40 M	60 min.
- Slow down for latching operation	2 min.
- Retention Assembly retraction	1 min.
- Connect electrical	25 min.
- Translate structure for next start	2 min.
Total Per Bay	127 min.

FUNCTION· ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	0605.1	06.1
METHOD	BLANKET RETENTION ASSEMBLY	PAGE	5 of 7		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



- The blanket retention assembly is attached along the longitudinal edge of the construction and assembly fixture.

  - The assembly consists of a frame into which five independently operated shafts are supported.
  - These shafts translate at 90° to the frame and construction fixture.
  - A blanket end holding device is attached to the "upper" ends of these shafts.

- RMS

FUNCTION ITEM	INSTALL SOLAR ARRAY BLANKETS	CODE	01	0605.1	06.1
METHOD	BLANKET RETENTION ASSEMBLY	PAGE	6 of 7		
SUBJECT	SUPPORT SERVICES				

Crew

- One RMS and rotational handling device operator
- One EVA astronaut
- RMS

Power

- RMS - 1-1.8 KW
- Blanket retention assembly - TBD

Lighting and T.V.

- Lights and T.V. as provided on Orbiter, construction fixture and handling device

Computer/Software

- RMS coordinate transform system

Stowage

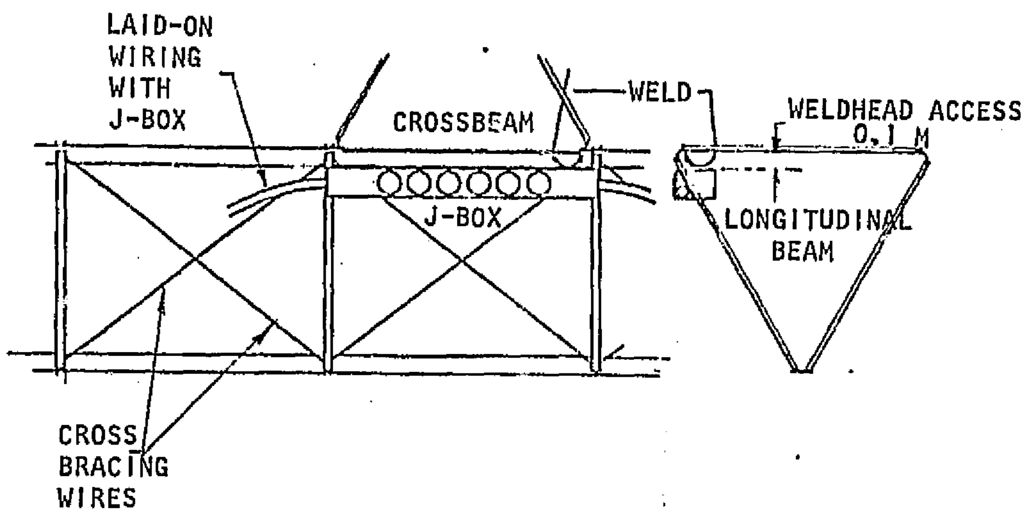
- Blanket retention assembly - 9 x 1 x 1 M

FUNCTION	INSTALL	CODE	01	0605.1	06.1
ITEM	SOLAR ARRAY BLANKETS				
METHOD	BLANKET RETENTION ASSEMBLY	PAGE	7 of 7		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (Kw.-)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
- RMS							NC
- Blanket Retention Assembly	100	9	-	TBD	TBD		1390
Support Services							
- Crew	-	-	2/1.5	-	-	-	-
- Power (Total)	-	-	-	TBD	TBD	-	TBD
Project Modification							
- Blanket Attach Fitting	Neg	Neg	-	-	-	-	13
Operations (Per Bay)	-	-	2/1.5	-	-	127	NA*

*Not appropriate, see page 6.

FUNCTION ·	CONNECT	CODE	01	07 03.1	00
ITEM ·	CROSS/LONGITUDINAL BEAM WIRING	PAGE	1	of 2	
METHOD					
SUBJECT	OPERATION IDENTIFICATION				



J-BOX INSTALLED ON INNER SIDE OF LONGITUDINAL BEAM

Project System

- Space fabricated advanced communications platform

Operation

- Make the electrical interface connection between the cross-beam wiring and the longitudinal beam wiring

Physical Situation

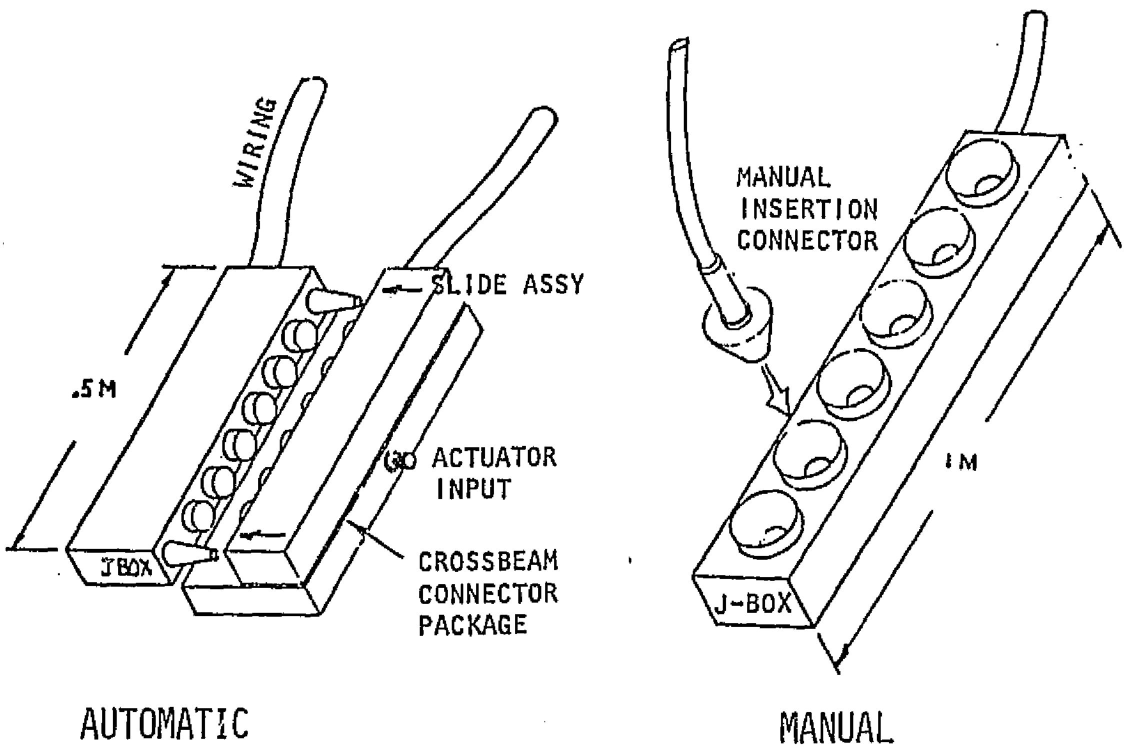
- The longitudinal beams, with wiring, are advancing through the work station

- Junction boxes are attached between cross members on the inner surface of the two longitudinal beams

- Cross-beams with wiring are being welded in place

- Electrical connections required: up to six 40 wire connectors at each cross/longitudinal beam

FUNCTION · ITEM ·	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Automatic

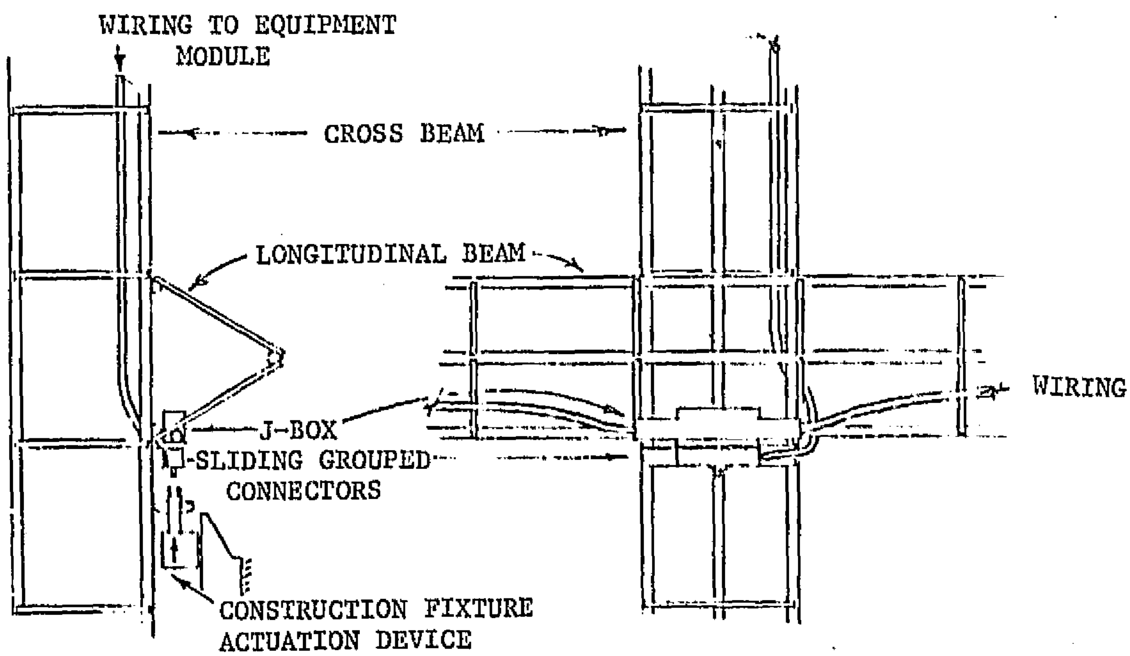
1. Multiple connector package engagement by construction fixture
2. Multiple connector package engagement by RMS

Manual

3. Individual connector engagement by EVA/MMU

Methods 1 and 3 are detailed

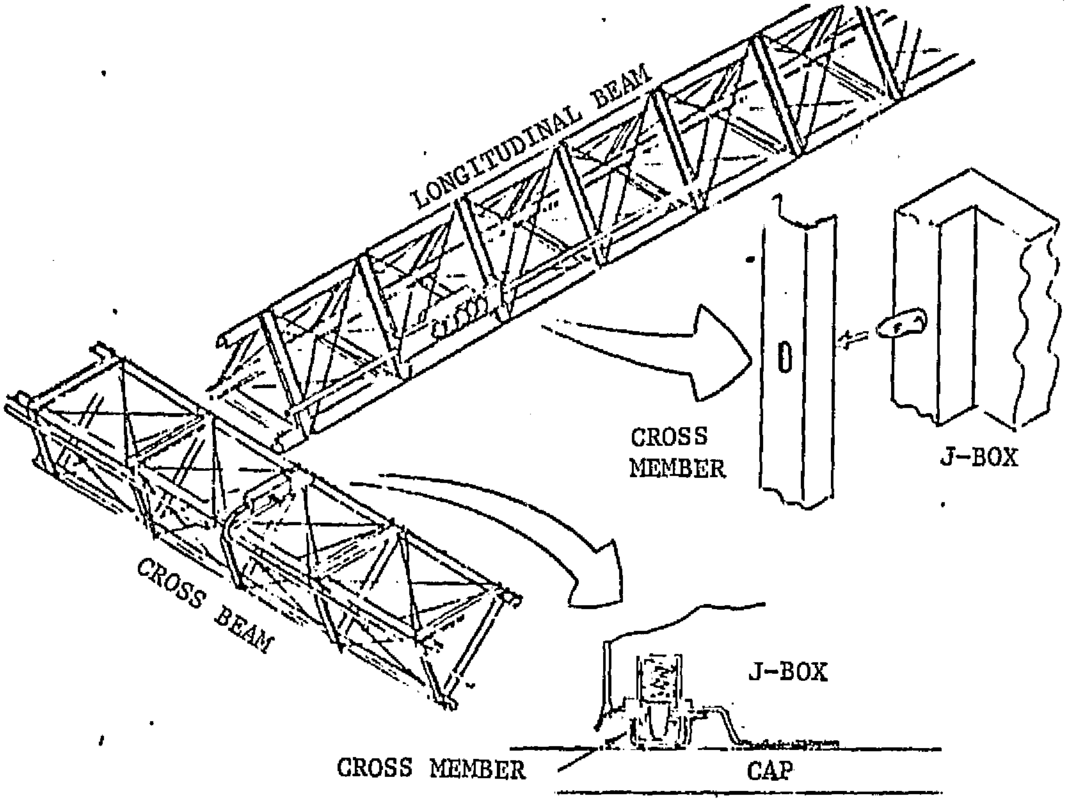
FUNCTION · ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	10.1
METHOD	CONSTRUCTION FIXTURE	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- Cross beam with all electrical connectors packaged together as a unit is positioned on longitudinal beams and welded in place

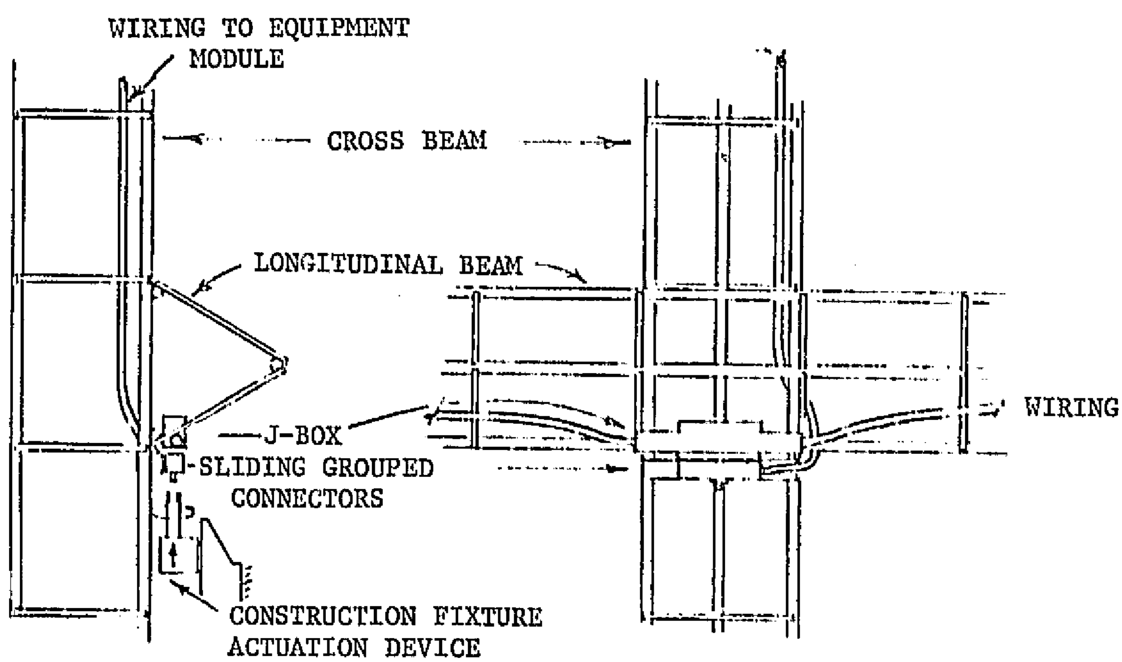
- Special actuation device on construction fixture advances cross beam connector package and makes final connection at the two (approximately 100 lb per connector) by use of a screw mechanism

FUNCTION	CONNECT	CODE	01	07 03.1	10.1
ITEM	CROSS/LONGITUDINAL BEAM WIRING				
METHOD	CONSTRUCTION FIXTURE	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



- Electrical connectors on cross beam are packaged as single unit
- Connector package is fastened to cross beam structure on sliding mount and has screw mechanism for engagement to J-box

FUNCTION· ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	10.1
METHOD	CONSTRUCTION FIXTURE	PAGE	3 of 6		
SUBJECT	OPERATIONS				



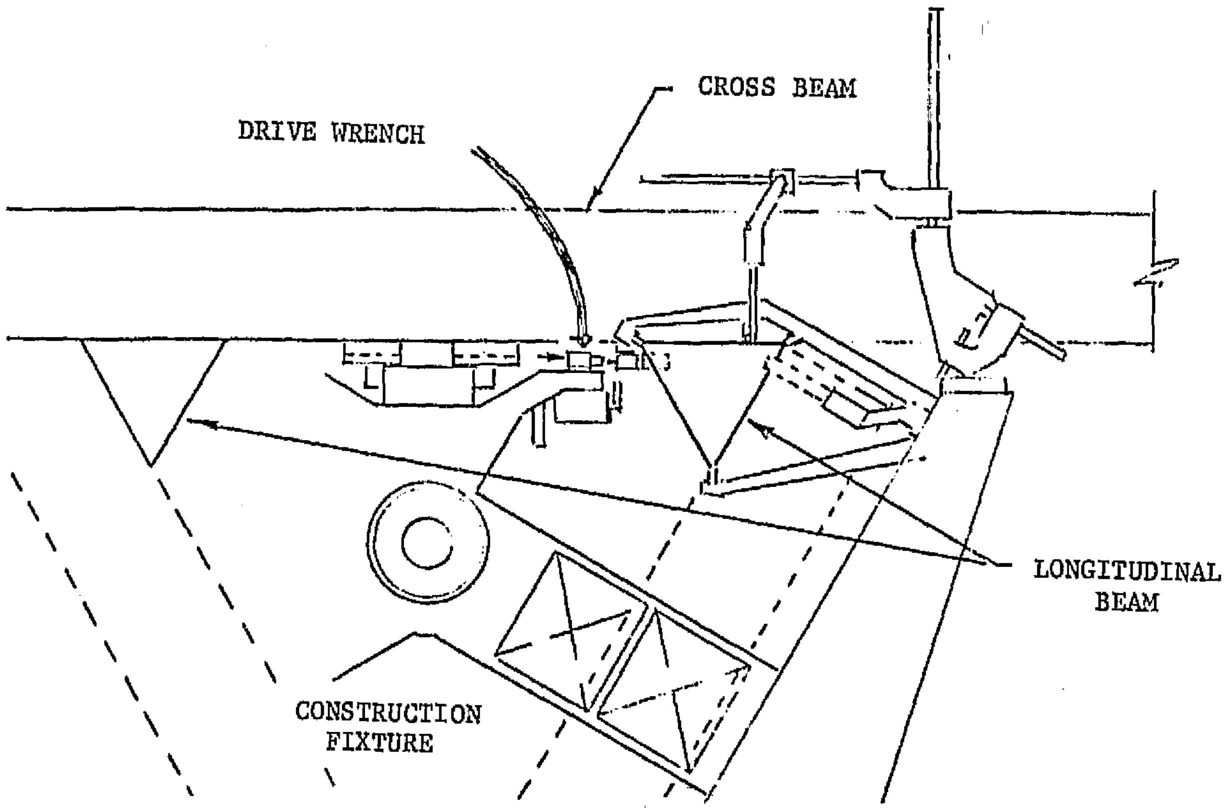
Manpower - No additional required

Activity Time

- Connection 1 Min.

Support Activity

- Installation time for connector package on cross beam 5 Min.



Actuation Mechanism

The actuation mechanism. (drive wrench) part of the construction fixture, will advance, pickup the actuation screw, and drive the screw to engage and pull the two units together.

Crew - None

Power

- Actuation device operation 40 Watts (Est.)

Lighting and T.V.

- Standard bay illumination and T.V.

Computer/Software

- None - Fixture operation controlled by self contained equipment

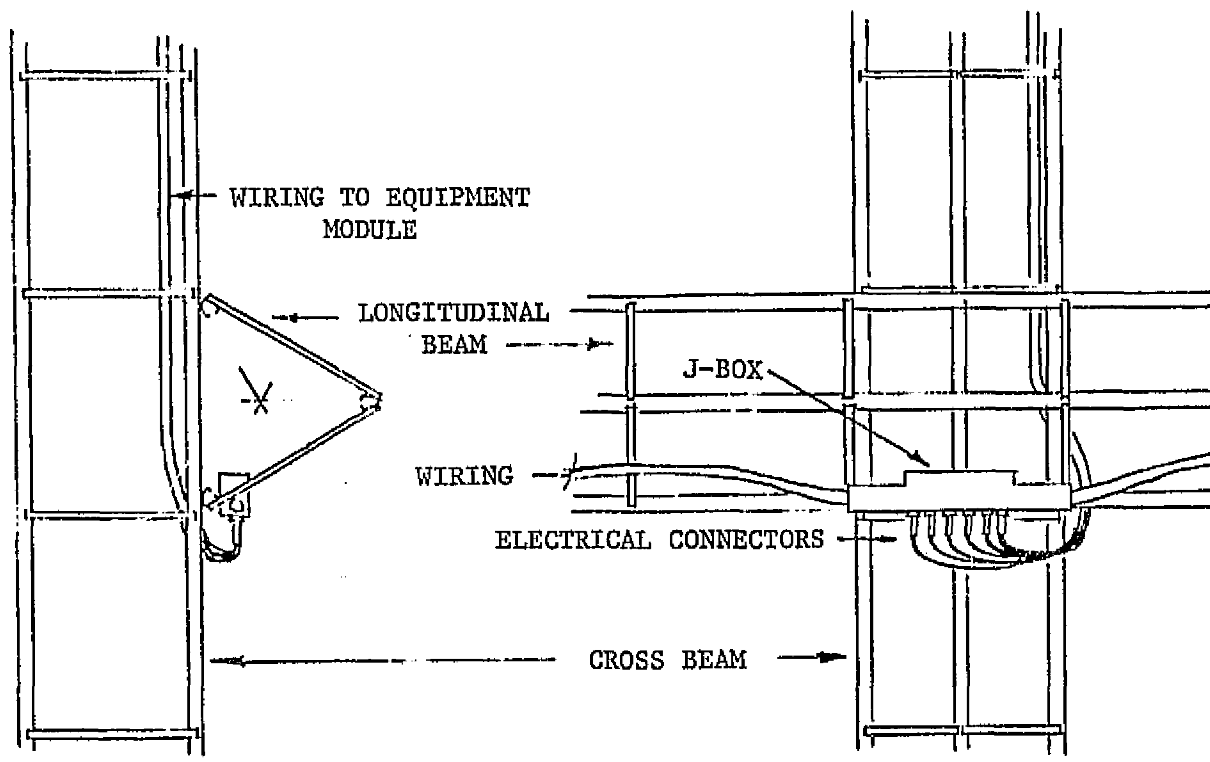
Stowage - None

FUNCTION	CONNECT	CODE	01 07 03.1 10.1
ITEM	CROSS/LONGITUDINAL/BEAM WIRING	PAGE	6 of 6
METHOD	CONSTRUCTION FIXTURE		
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
Drive Wrench	10	Neg	-	0.04	Neg	-	594
<u>Support Services</u>							
Crew	-	-	0	-	-	-	-
Power	-	-	-	0.04	Neg	-	TBD
<u>Project Modifications</u>							
Connector Packages (24)	144	0.8	-	-	-	-	1352
<u>Operations</u>	-	-	0	-	-	1	NA*

*Not appropriate, see page 6.

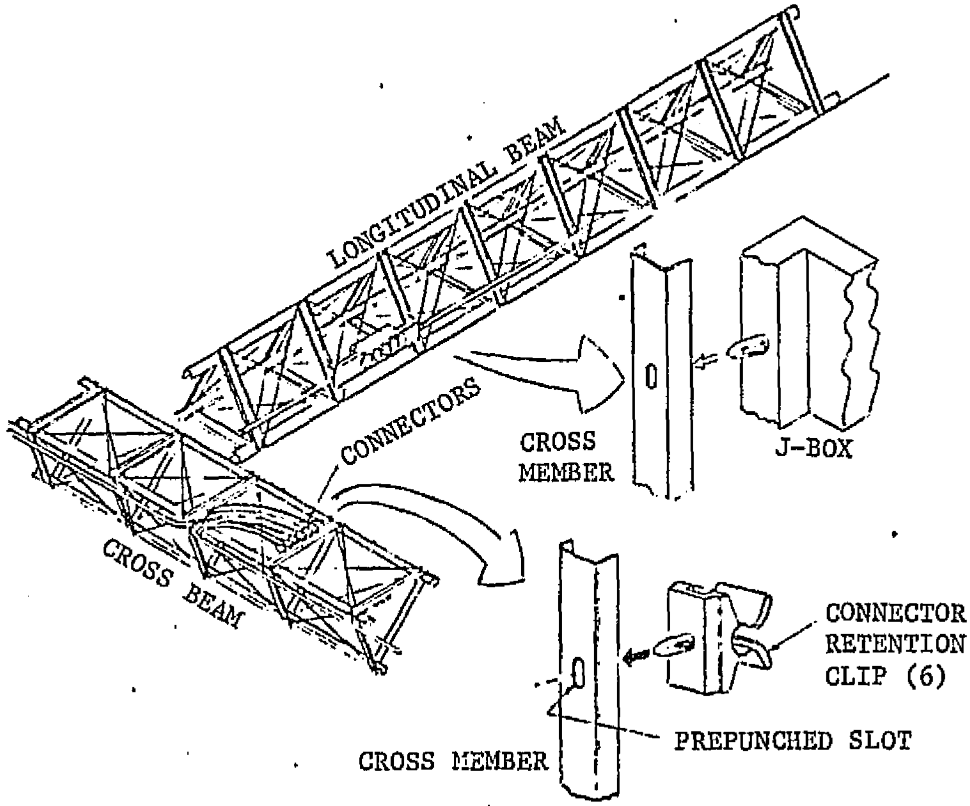
FUNCTION	CONNECT	CODE	01	07 03.1	02.1
ITEM	CROSS/LONGITUDINAL BEAM WIRING	PAGE	1 of 6		
METHOD	MMU				
SUBJECT	METHOD DESCRIPTION				



- Cross beam with individual electrical connectors stowed is positioned on longitudinal beams and welded in place

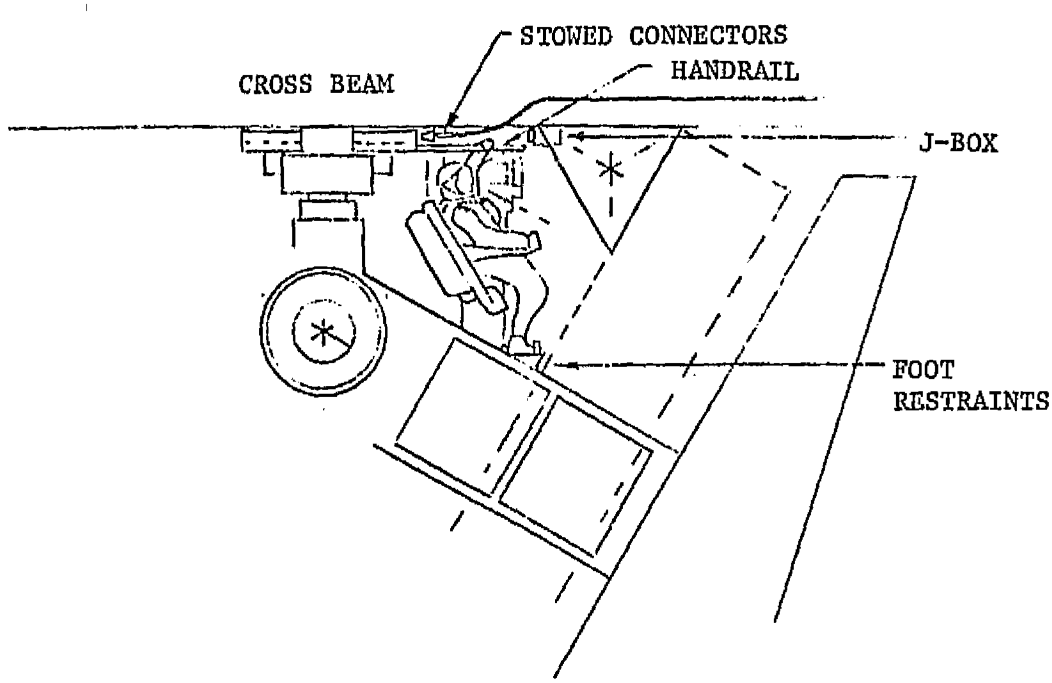
- EVA/MMU astronaut unstows connectors and connects them to J-box

FUNCTION· ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	02.1
METHOD	MMU	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



- Retention clips (6) on each end of cross beams for temporary stowage of electrical connectors

FUNCTION· ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	02.1
METHOD	MMU	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

- 1 EVA/MMU Operator

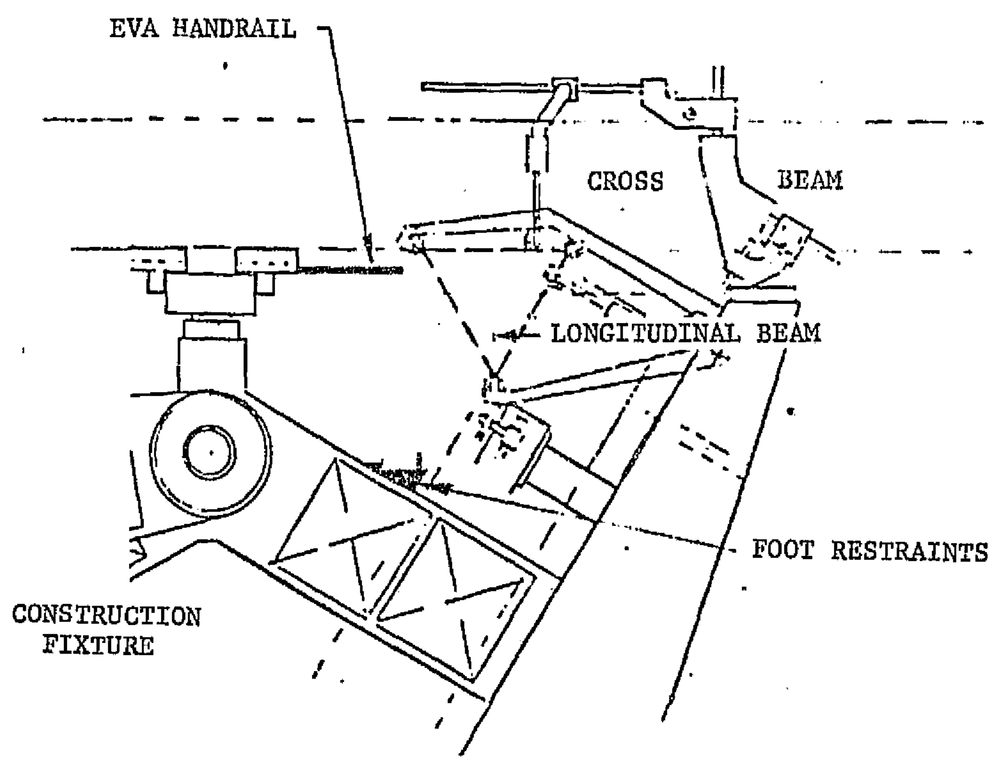
Activity Time

Position and Stabilization	5 Min.
Remove Connector	1 Min.
Relocate Body	1/2 Min.
Connector Insertion	1 1/2 Min.
Return to Connectors	1/2 Min.
Total Per Connector	3 1/2 Min.
Repeat for remaining 5 connectors	17-1/2 Min.
Relocate to other end of cross beam	2 Min.
Total Per End	28 Min.

Support Activity

- Requires connector clip installed during wiring installation	6 Min.

FUNCTION	CONNECT	CODE	01	07 03.1	02.1
ITEM	CROSS/LONGITUDINAL BEAM WIRING				
METHOD	MMU	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



- MMU
- Fixture

The construction fixture contains appropriate hand and foot restraints at both longitudinals to provide an EVA work station

Crew - EVA/MMU Operator

Power

- MMU Recharge TBD

Lighting & TV

- Standard MMU Illumination

Computer/Software - None

Stowage - MMU 0.2 x 0.2 x 0.3M

Other

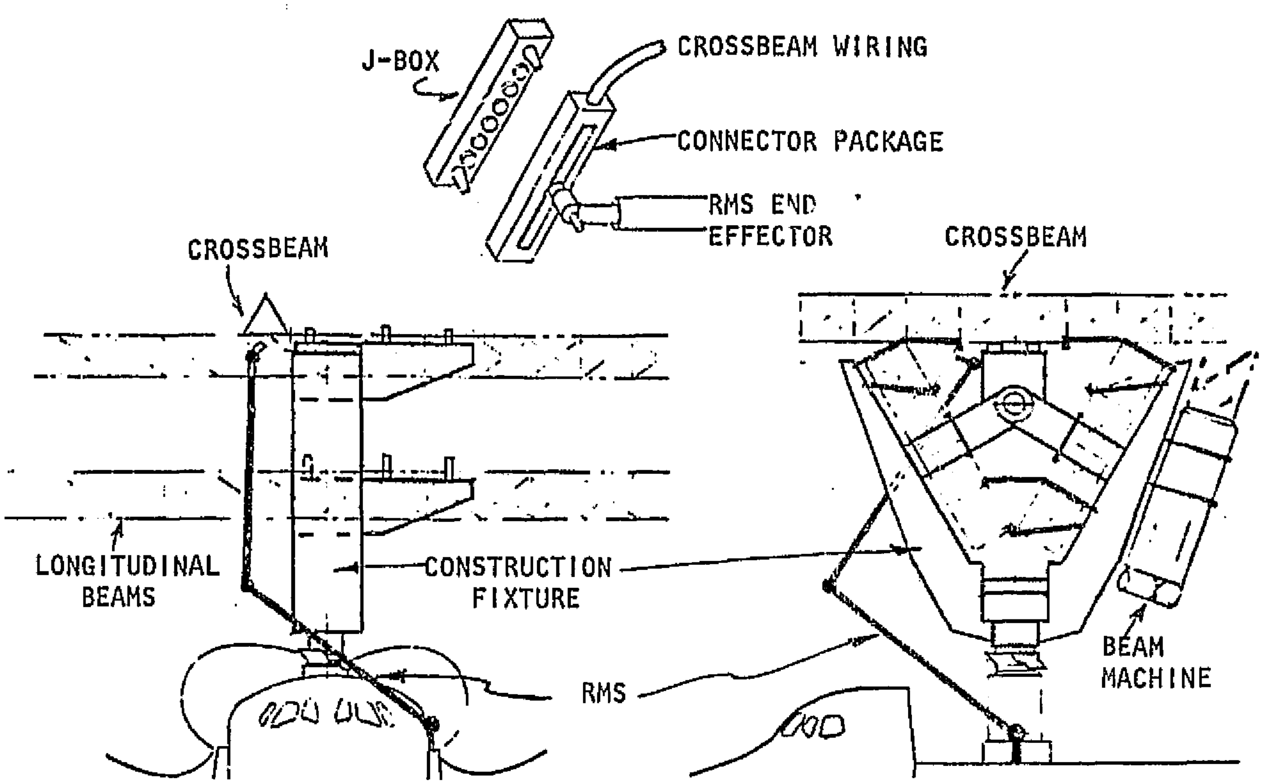
- MMU Propulsion Recharge

FUNCTION ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	02.1
METHOD	MMU	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Work Stations (2)	8	Neg	-	0	0	-	74
MMU	110	1.1	-	TBD	TBD	-	100
Support Services							
Crew	-	-	1/1	-	-	-	-
Power	-	-	-	TBD	TBD	-	TBD
Project Modifications							
Wiring Retention Clips (144)	7	Neg	-	-	-	-	40
Operations	-	-	1/1	-	-	28	NA*

*Not appropriate, see page 6.

FUNCTION · ITEM	CONNECT CROSS/LONGITUDINAL BEAM WIRING	CODE	01	07 03.1	04.1
METHOD	RMS	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				

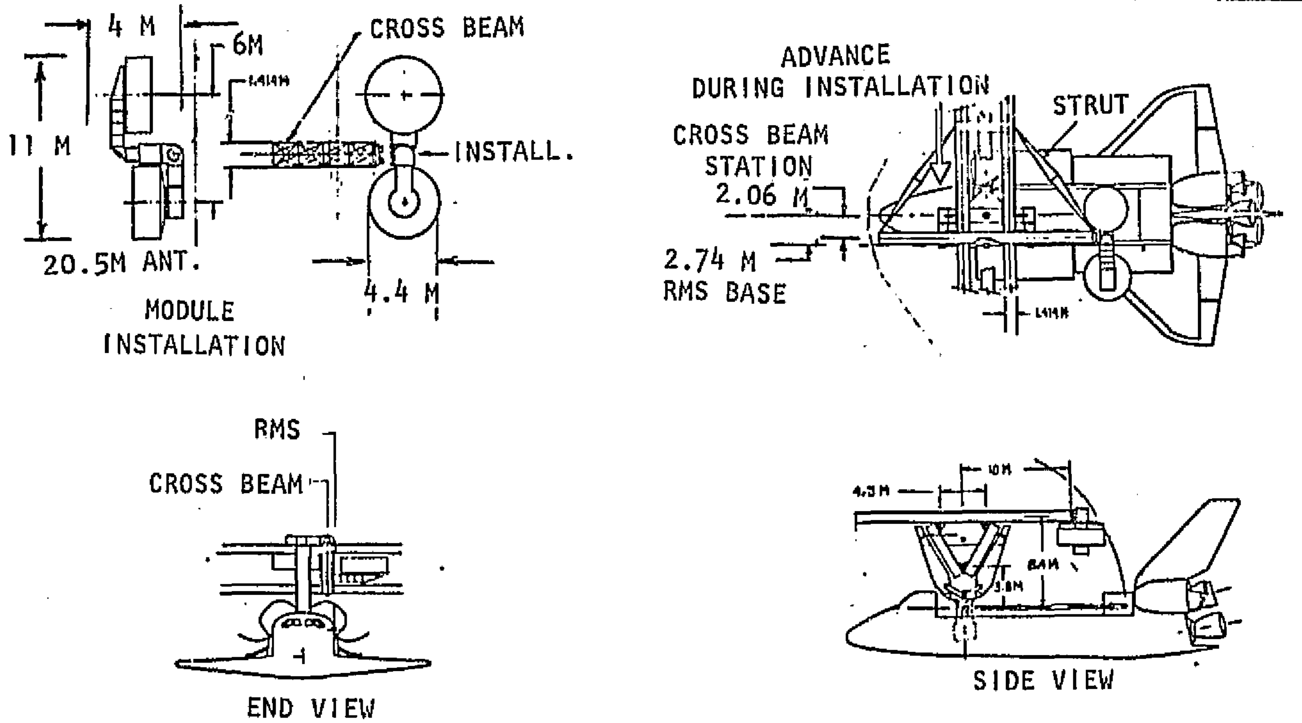


- Cross beam with all electrical connectors packaged together as a unit is positioned on longitudinal beams and welded in place

- RMS unstows connector package from temporary position on cross beam, positions it at J-box and connects the two units by actuating a screw mechanism to pull them together

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	0704.1	00
METHOD		PAGE	1	of	2
SUBJECT	OPERATION IDENTIFICATION				



PROJECT SYSTEM

Space Fabricated Communications Platform
Specific Item: 20.5 M Dia. Transmitting C-Band Antenna

OPERATION

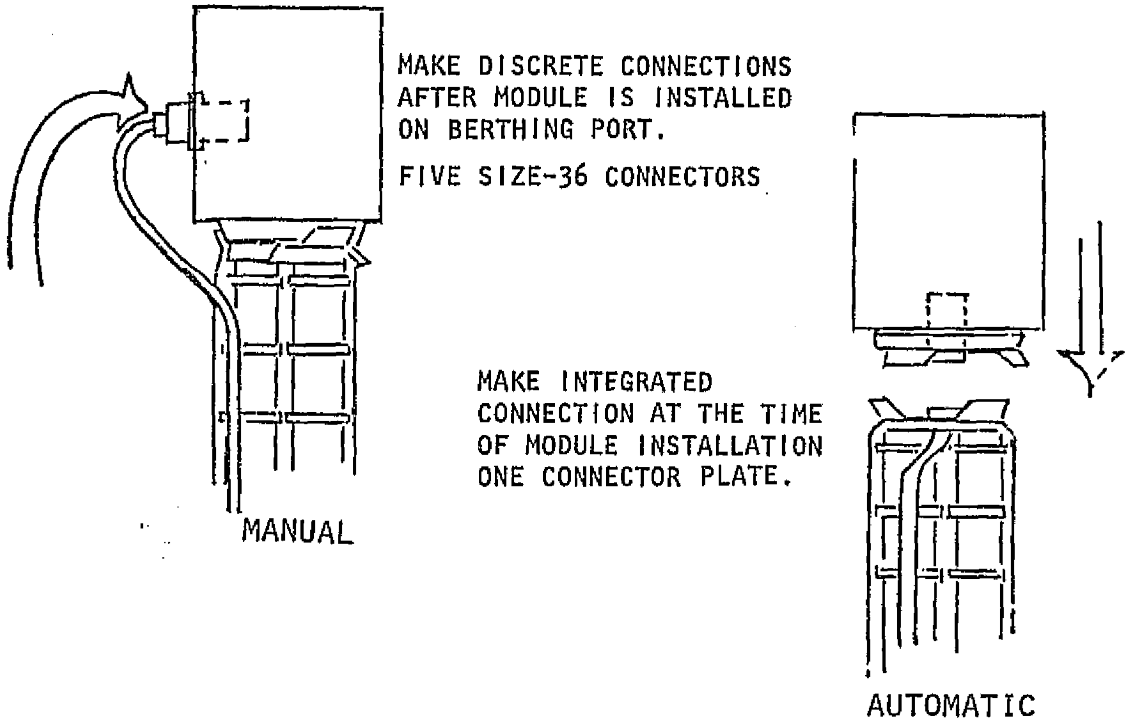
To make the electrical interface connection between the antenna module and the platform wiring system.

PHYSICAL SITUATION

The platform structure is completed.
The module is attached.
Connections are made as the structure cross beam is located in the station shown.

Connections required: Power - 1 MS 36-9 connector containing 2 #8, 6 #14 and 8 #26 copper wires.
Data - 4 MS 36-10 connectors each containing 37 coax cables (one cable equivalent to a #14 wire).

FUNCTION · ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	0704.1	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



The following methods have identified:

<u>Manual</u>

1. Making discrete connections using an MMU for transportation.

2. Making discrete connections using an open-type Cherry Picker for transportation.

3. Making discrete connections by EVA using only the construction fixture and its appurtenances as a base.

<u>Automatic</u>

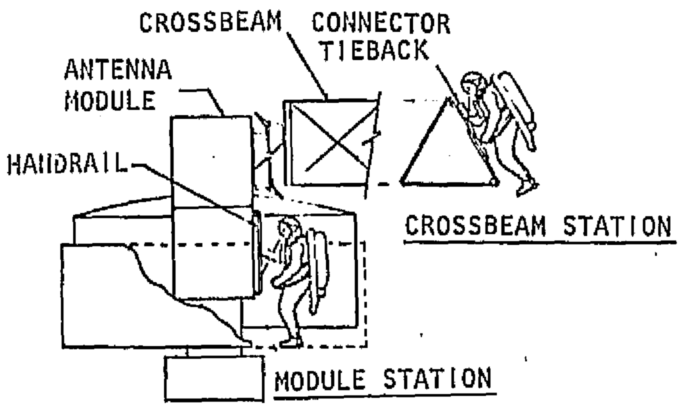
4. Making an integrated connection by means of the Orbiter RMS.

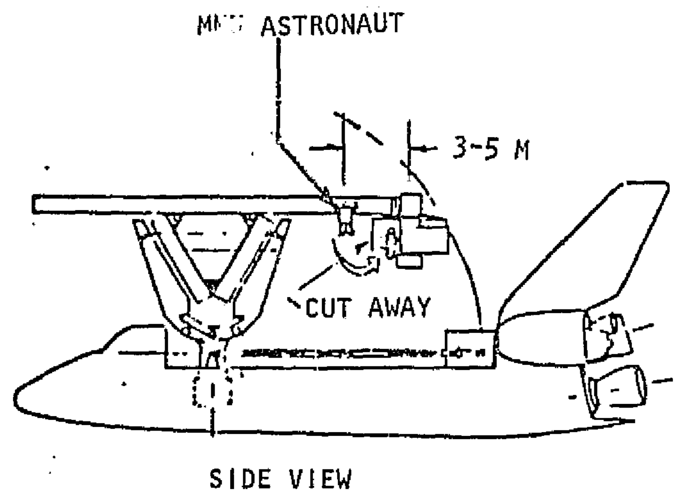
5. Making discrete connections by means of the Orbiter RMS.

6. Making an integrated connection by means of the module itself in an automatic mode.

Methods 1, 2 and 4 are detailed.

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	0704.1	02.1
METHOD	MMU	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				





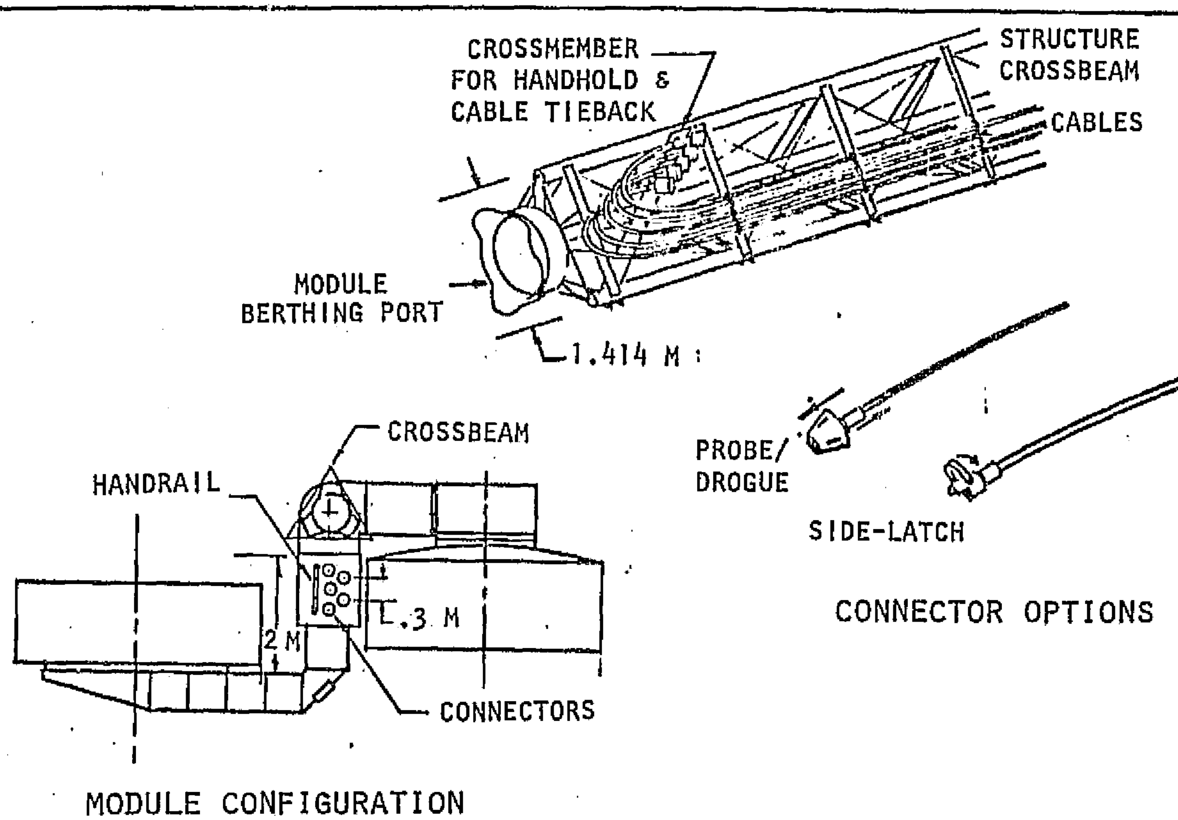
The operator, using the MMU for transportation, locates at the cable tie-back station, inboard of the module approximately 3 - 5 meters, and grasps the handhold near the cable connectors.

The operator then removes each of the five cable connectors from their stowed locations and tethers them individually to himself.

The operator then moves himself to the antenna module and grasps the handhold on the module near the receptacles.

The operator retrieves each of the five connectors in turn, and manually connects them to the receptacles on the module.

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MDOULE	CODE	01	0704.1	02.1
METHOD	MMU	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATION				



STRUCTURE

- Cable tie-back clips for cable installation pending the module installation.
- Cable tie-back and handhold cross member.

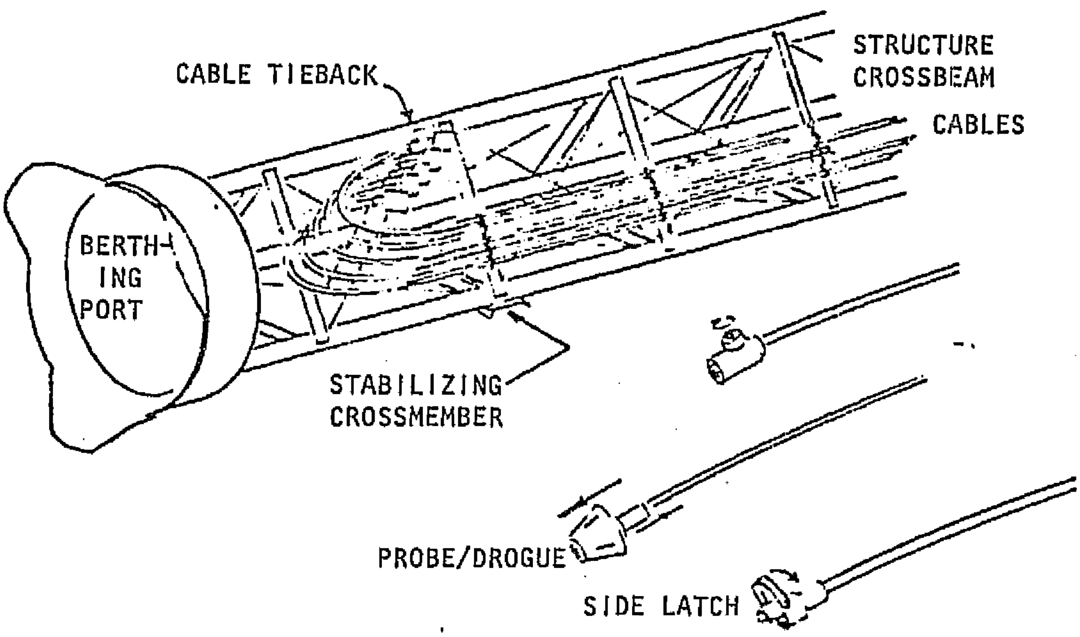
WIRING

Manual compatible connectors

MODULE

Handrail adjacent to receptacles with connector spacing approximately 0.3m minimum.

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	0704.1	02.1
METHOD	MMU	PAGE	3 of 6		
SUBJECT	OPERATIONS				



MANPOWER

One EVA MMU operator.

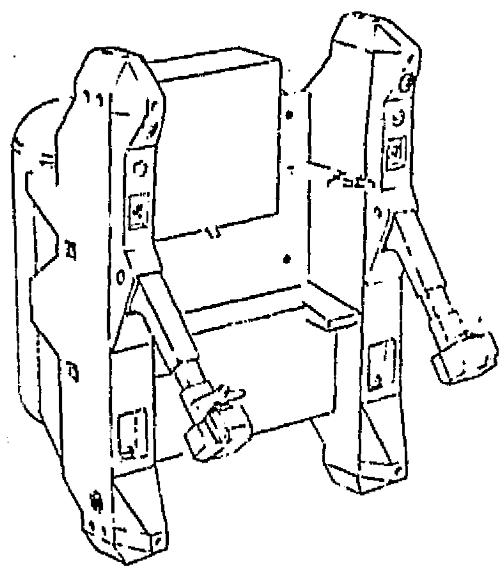
ACTIVITY TIME

Move to cross beam	2 min.
Remove five connectors	10 min.
Move to module	2 min.
Connect five connectors	15 min.
Total per module	29 min.

SUPPORT ACTIVITY

Requires structure-cabling tieback on previous construction flight.

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	0704.1	02.1
METHOD	MMU	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



MMU

Items

- MMU
- Appropriate tethers (5)

FUNCTION ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	02.1
METHOD	MMU	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

CREW - One man EVA

POWER - MMU recharge - TBD

LIGHTING & TV - MMU illumination provisions adequate.

COMPUTER/SOFTWARE - None

STOWAGE - None

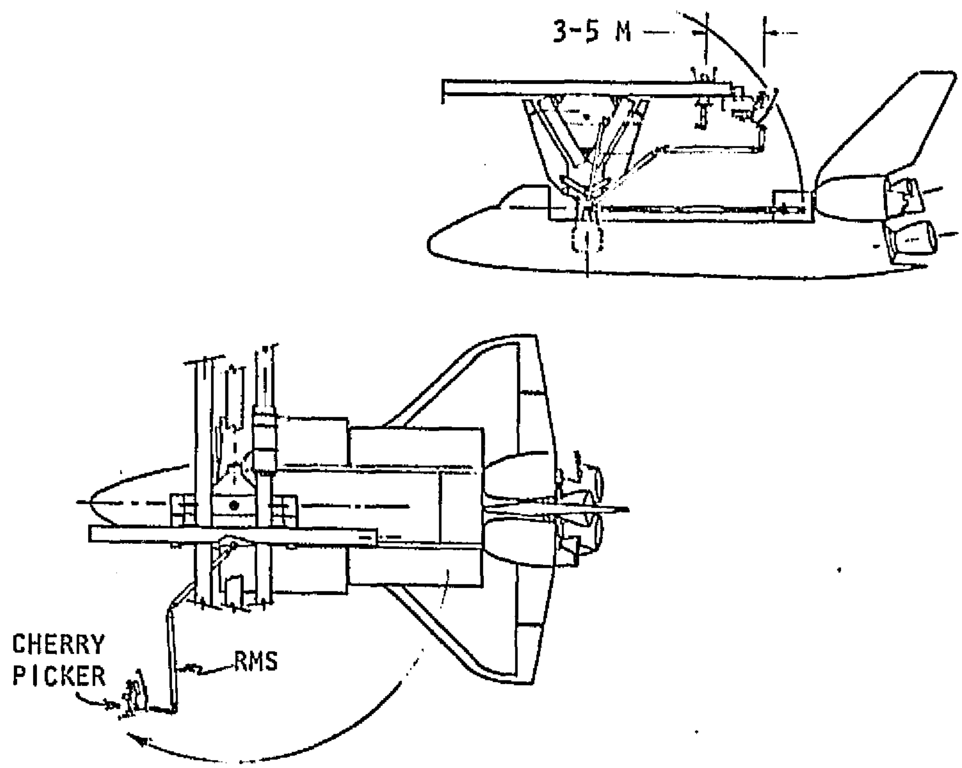
OTHER - MMU propulsion recharge

FUNCTION ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	02.1
METHOD	MMU	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Tethers	0.3	0.1	–	0	0	–	71
MMU	110	1.1	–	TBD	TBD	–	100
Support Services							
Crew	–	–	1/1	–	–	–	–
Power	–	–	–	TBD	TBD	–	TBD
GN_2 Propellant	TBD	TBD	–	–	–	–	TBD
Project Modifications							
Cable tie-backs	0.5	0.1	–	–	–	–	–
Handrail	0.2	0.1	–	–	–	–	–
Operations	–	–	1/1	–	–	29	NA*

*Not appropriate, see page 6.

FUNCTION · ITEM ·	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	03.1
METHOD	CHERRY PICKER	PAGE	1 of 7		
SUBJECT	METHOD DESCRIPTION				



The operator, using the cherry picker (CP) for transportation, locates at the cable tie-back station, inboard of the module approximately 3 to 5 meters, and stabilizes the CP to a cross-member of the cross-beam.

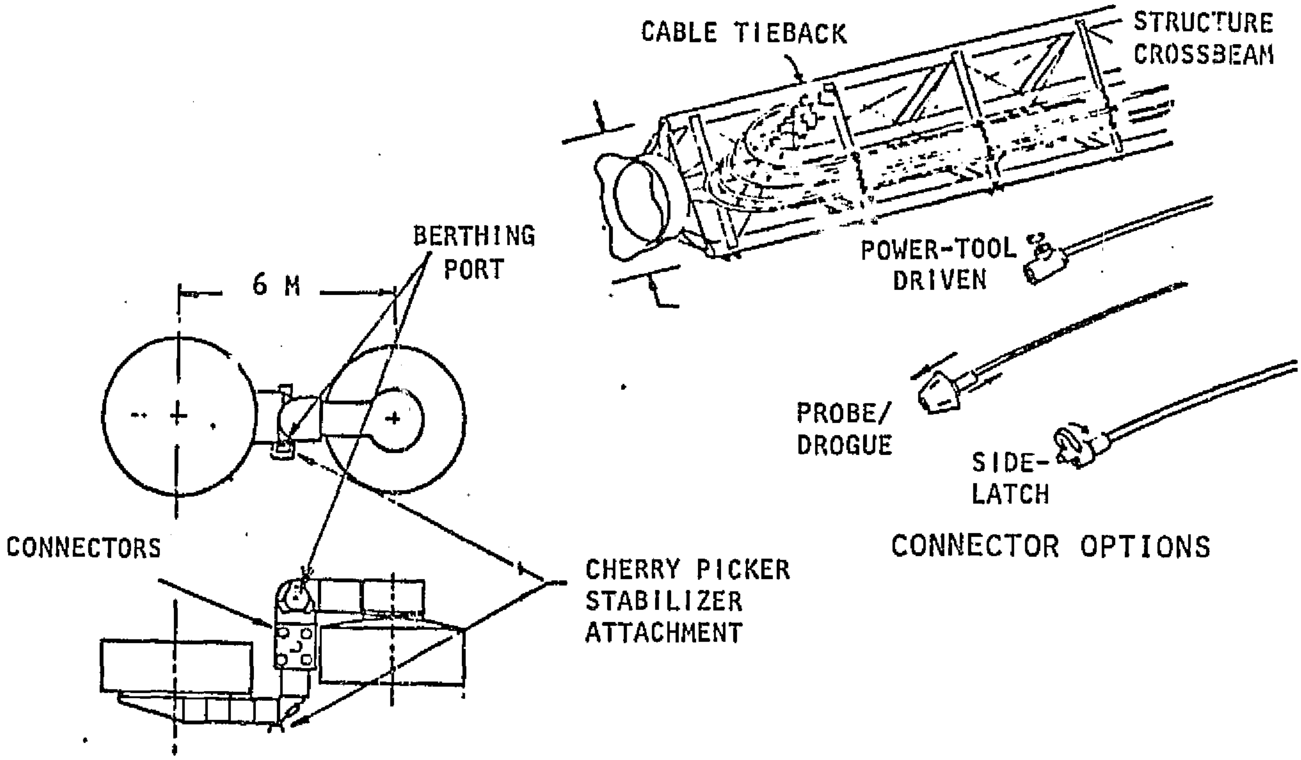
The operator then removes each of the five cable connectors from their stowed locations and tethers them individually to the CP.

The operator then detaches from the cross-beam and moves the CP to the antenna module and restabilizes to attach points on the module.

The operator retrieves each of the five connectors in turn, and manually connects them to the receptacles on the module.

The operation will be repeated at the opposite end of the cross-beam.

FUNCTION	ELECTRICAL CONNECTION	CODE	01	07 04.I	03.1
ITEM	ANTENNA MODULE	PAGE	2 of 7		
METHOD	CHERRY PICKER				
SUBJECT	PROJECT MODIFICATIONS				



ANTENNA MODULE (RETRACTED)

Structure

Cable tie-back clips for cable installations pending the module installation.

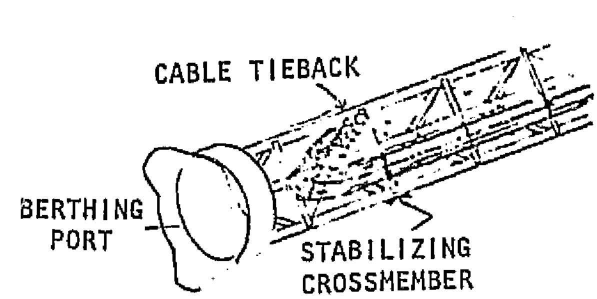
Wiring

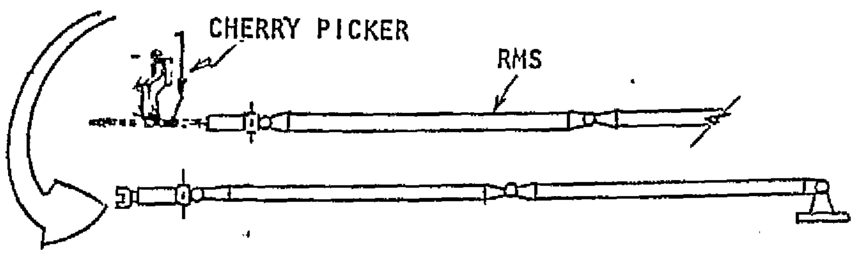
Manual compatible connectors

Module

Attach points on the module for the cherry picker stabilizer. Electrical receptacles spaced appropriately for manual insertion.

FUNCTION · ITEM · METHOD	ELECTRICAL CONNECTION ANTENNA MODULE CHERRY PICKER	CODE	01	07 04.1	03.1
		PAGE	3 of 7		
SUBJECT	OPERATIONS				





Manpower

One cherry picker (CP) operator

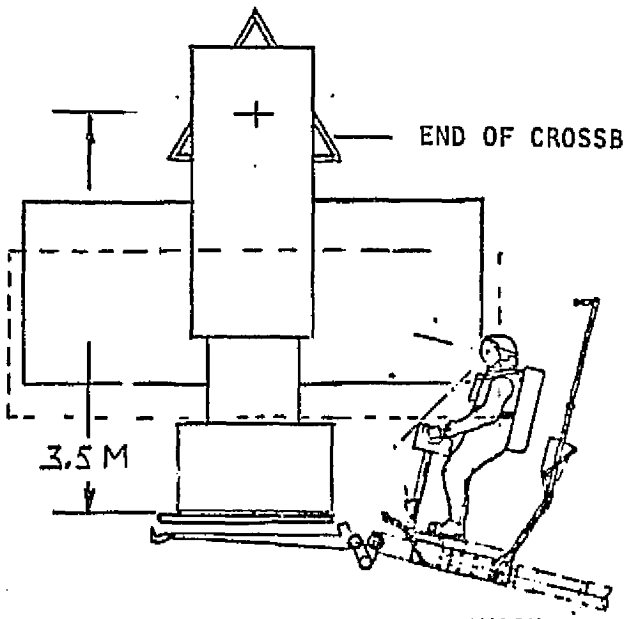
Activity Time	(minutes)
Pick up cherry picker	(15)
Move to cross-beam	2
Stabilize to cross-beam	4
Remove 5 connectors	10
Move from cross-beam to module	2
Stabilize to module	5
Make 5 connector insertions	15
Total per module	38

Support Activity

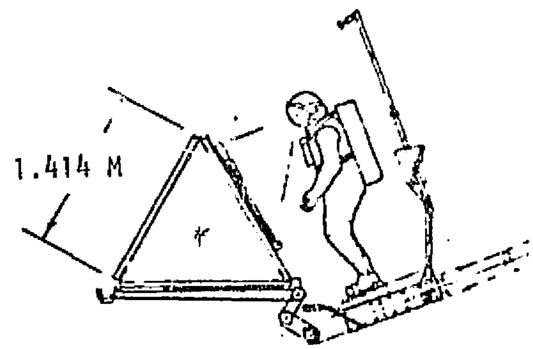
Requires structure-cabling tie-back on previous construction flight.

(   ) One time operation

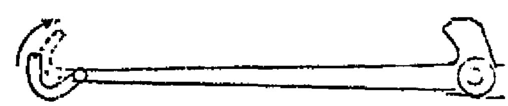
FUNCTION · ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	03.1
METHOD	CHERRY PICKER	PAGE	4 of 7		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



APPROACHING MODULE STATION



CROSSBEAM STATION

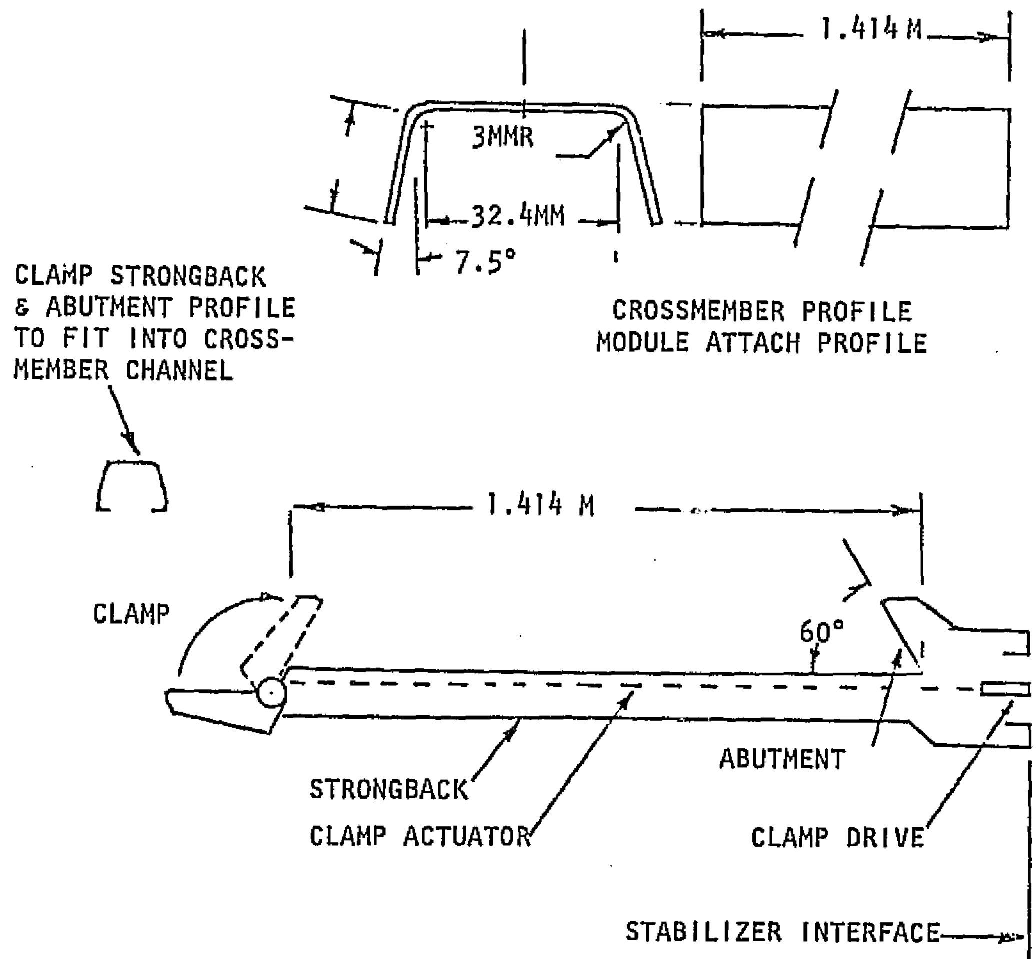


STABILIZER END EFFECTOR

Items

- Cherry picker
- Appropriate tethers (5)
- CP end-effector for stabilization, compatible with the cross-beam cross-members and the module interface. See page 5.

FUNCTION	ELECTRICAL CONNECTION	CODE	01	07 04.1	03.1
ITEM	ANTENNA MODULE	PAGE	5 of 7		
METHOD	CHERRY PICKER				
SUBJECT	SPECIAL END EFFECTOR				



ESTIMATED WEIGHT: 3 TO 4 KG

Crew

One man on cherry picker (CP)

Power

RMS operation—1000 to 1800 watts
CP operation—500 watts

Lighting and TV

CP lighting and RMS TV adequate

Computer/Software

CP and RMS coordinate transform system

Stowage

Cherry picker—0.9×1.6×1.1 m

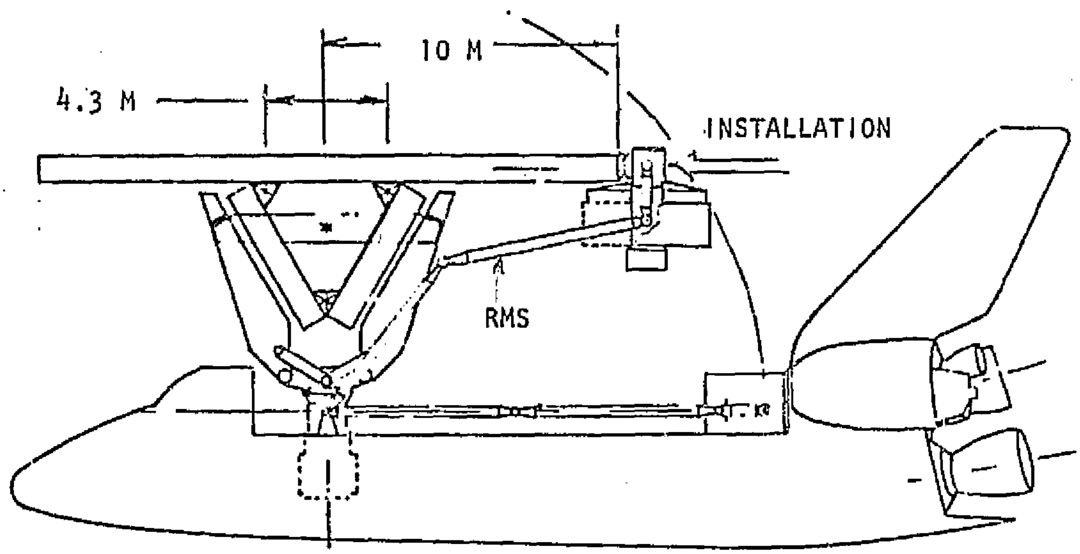
Special CP end effector—2×0.03×0.4 m

FUNCTION	ELECTRICAL CONNECTION	CODE	01	07 04.1	03.1
ITEM	ANTENNA MODULE				
METHOD	CHERRY PICKER	PAGE	7 of 7		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Cherry picker	273	1.6	-	0.5	TBD	-	TBD
RMS	0	0	-	1.8	TBD	-	NC
Special CP end effector	3.4	0.3	-	TBD	TBD	-	193
Support Services							
Crew	-	-	1/1	-	-	-	-
Power	-	-	-	2.3	TBD	-	TBD
Project Modifications							
Cable tie-backs	0.5	0.1	-	-	-	-	-
End effector provisions on module	0.1	NEG.	-	-	-	-	-
Operations	-	-	1/1	-	-	38	NA*

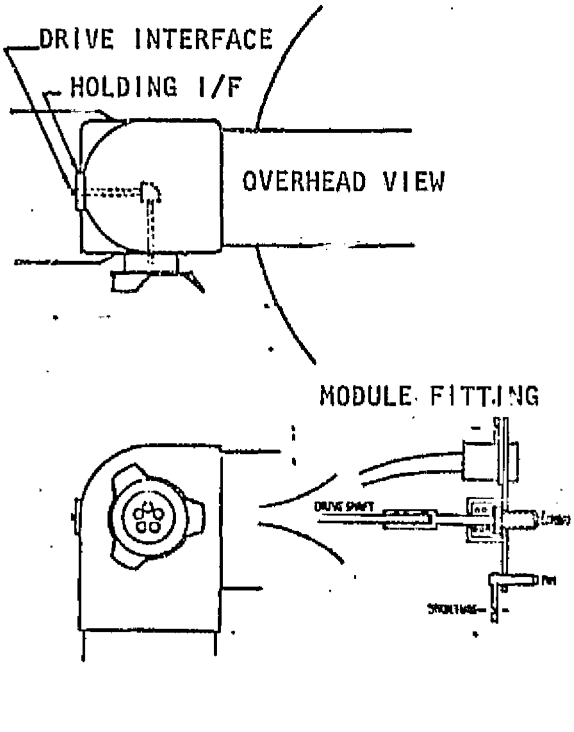
*Not appropriate, see page 6.

FUNCTION · ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	04.1
METHOD	RMS (CARRIER PLATE CONCEPT)	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				

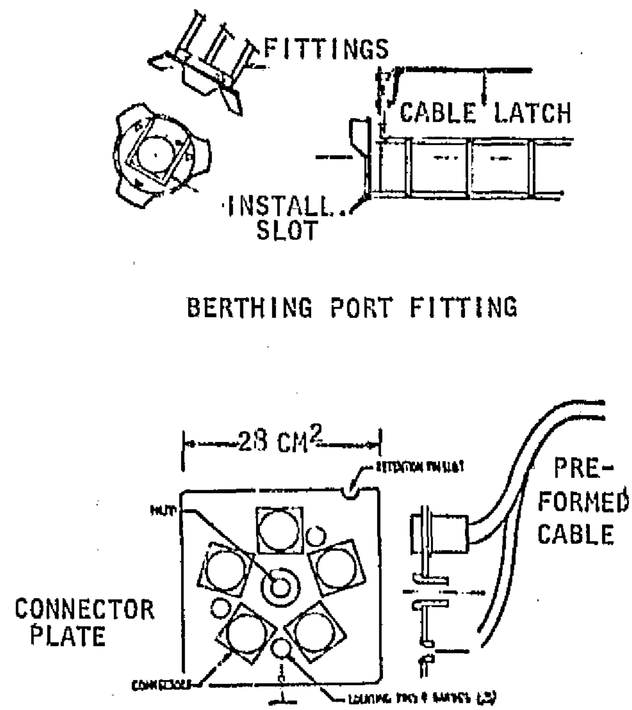


The antenna module is installed using the RMS. When installation is confirmed, the RMS actuates a drive shaft which brings the connector and receptacle halves together to effect a connection. The RMS then disengages and proceeds to next operation.

FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	04.1
METHOD	RMS (CARRIER PLATE CONCEPT)	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



MODULE CONFIGURATION



CROSSBEAM CONFIGURATION

Structure

- Docking port on end of cross-beam with module-compatible connector plate
- Target for viewing by RMS TV

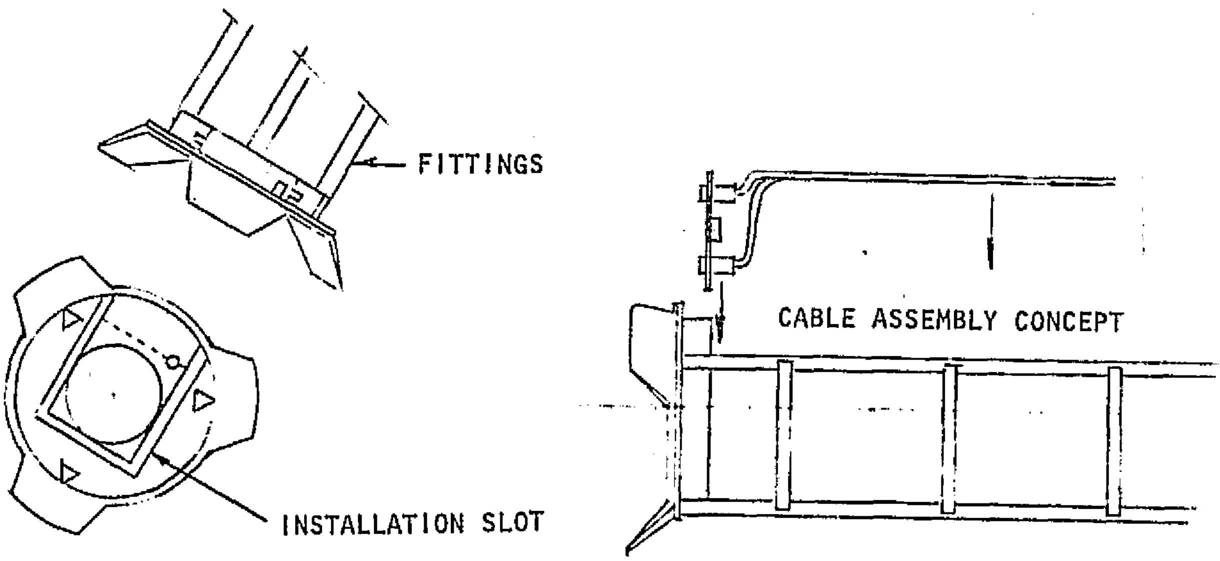
Wiring

- Individual cables connected to plate at time of installation

Module

- Module with movable connector plate/drive screw and installation holding interface

FUNCTION · ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	04.1
METHOD	RMS (CARRIER PLATE CONCEPT)	PAGE	3 of 6		
SUBJECT	OPERATIONS				



BERTHING PORT FITTING

Manpower

- RMS operator

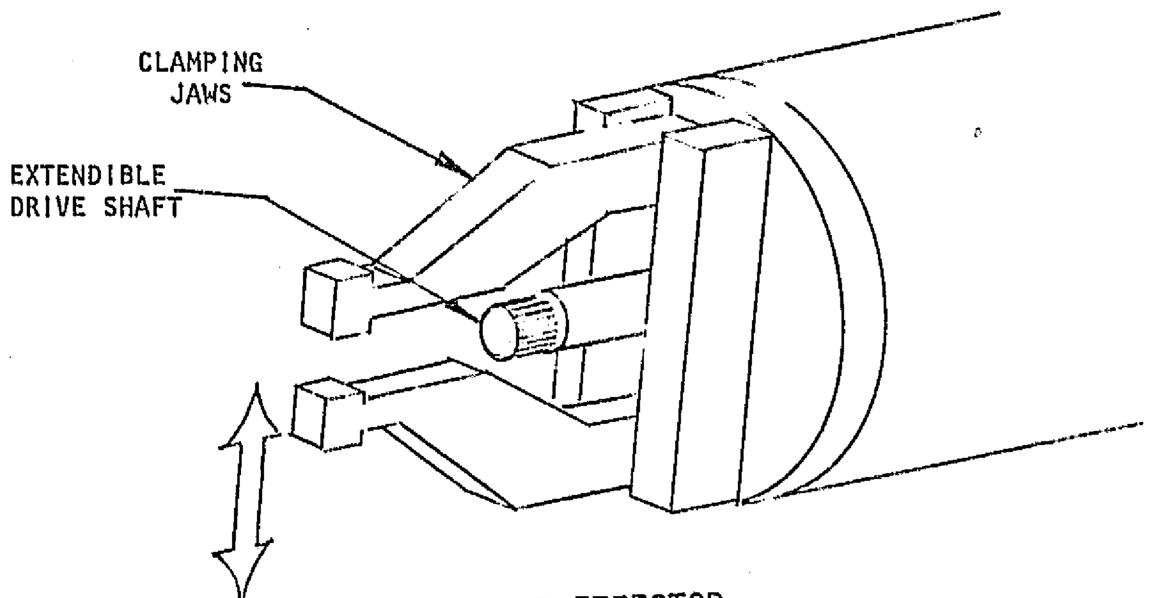
Activity Time

• Connection time	2 min.
• Disengagement	1 min.
Total time per module	3 min.

Support Activity

- Cables connected to plate and assembled to berthing port on previous operations.

FUNCTION·ITEM	ELECTRICAL CONNECTOR ANTENNA MODULE	CODE	01	07 04.1	04.1
METHOD	RMS (CARRIER PLATE CONCEPT)	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



END EFFECTOR

<u>Special RMS End Effector</u>

- RMS end effector must have a dedicated secondary action such as shown above for driving the engagement screw.
- Estimated energy required:

  Mechanical—42.38 kg m
  (500 lb x 0.75 in.)

  Power— TBD

<u>RMS End Effector TV</u>

- Tilt and pan capability required.

Crew

RMS operator

Power

RMS operation—1000 to 1800 watts
Engaging screw operation— TBD

Lighting and TV

RMS lighting is adequate. RMS TV must have tilt and pan capability.

Computer/Software

RMS coordinate transform system

Stowage

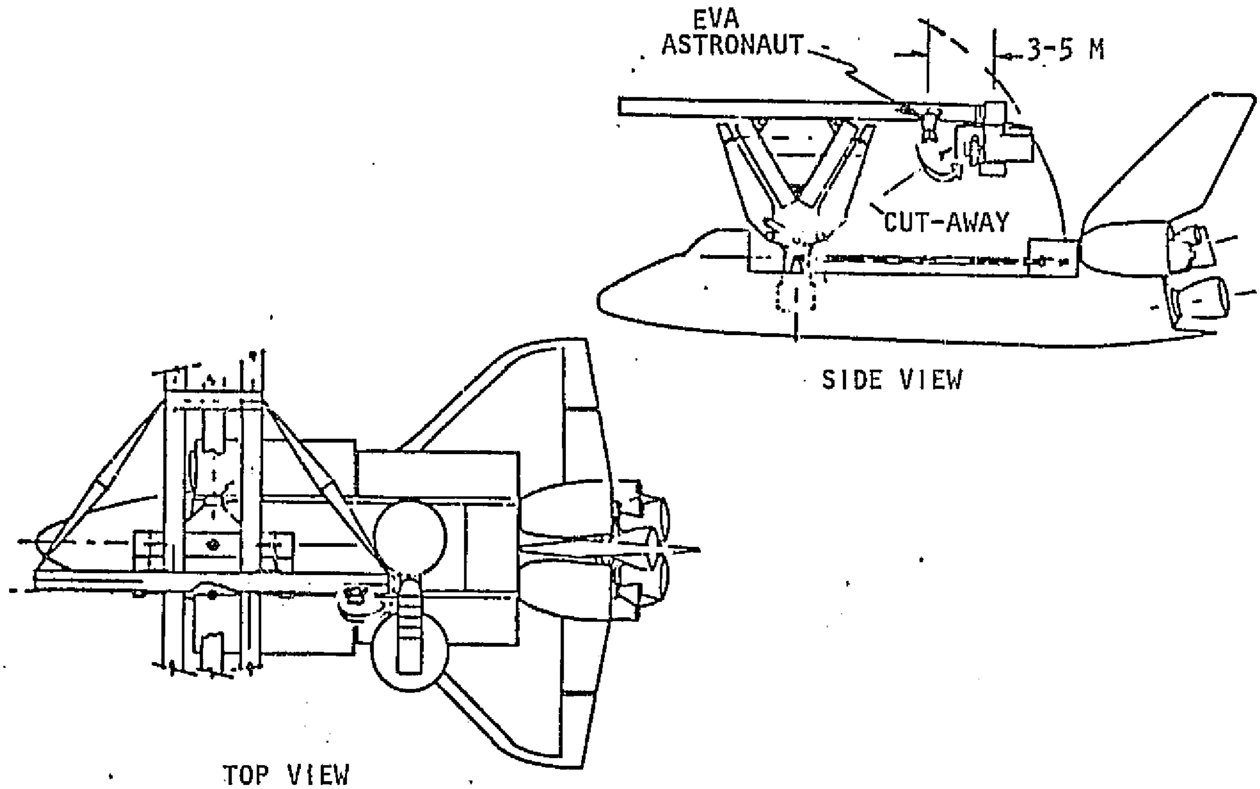
Special RMS end effector—0.4M x 0.7M diameter

FUNCTION ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	04.1
METHOD	RMS (CARRIER PLATE CONCEPT)	PAGE	6 of 6		
SUBJECT					

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	-	1.8	TBD	-	NC
Special RMS end effector	25	1	-	TBD	TBD	-	624
Support Service							
Crew	-	-	1/1	-	-	-	-
Power	-	-	-	TBD	TBD	-	TBD
Project Modifications							
Connector plate (struct.)	1	0.1	-	-	-	-	-
Module connector plate	1	0.1	-	-	-	-	-
Operations	-	-	1/1	-	-	3	NA*

*Not appropriate, see page 6.

FUNCTION	ELECTRICAL CONNECTION	CODE	01	07 04.1	01.1
ITEM	ANTENNA MODULE				
METHOD	EVA	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



The operator locates at the cable tie-back station, inboard of the module approximately 3 to 5 meters, and grasps the handhold near the cable connectors.

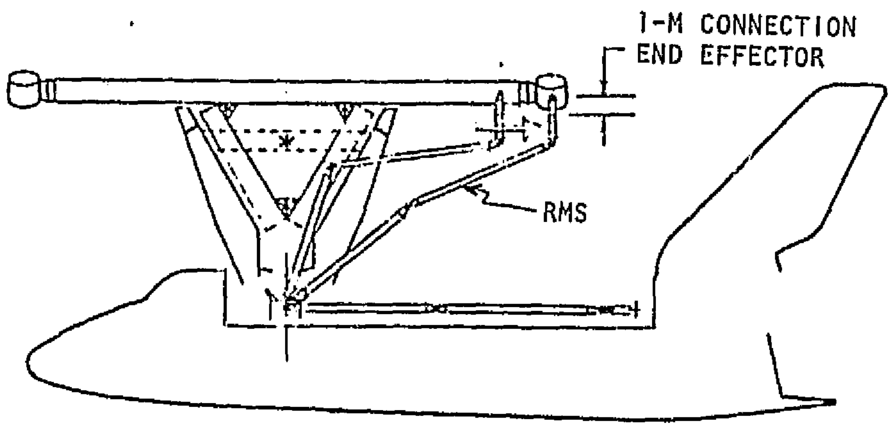
The operator then removes each of the five cable connectors from their stowed locations and tethers them individually to himself.

The operator then moves himself to the antenna module and grasps the handhold on the module near the receptacles.

The operator retrieves each of the five connectors in turn, and manually connects them to the receptacles on the module.

/NO ADDITIONAL DETAILS ARE PROVIDED/

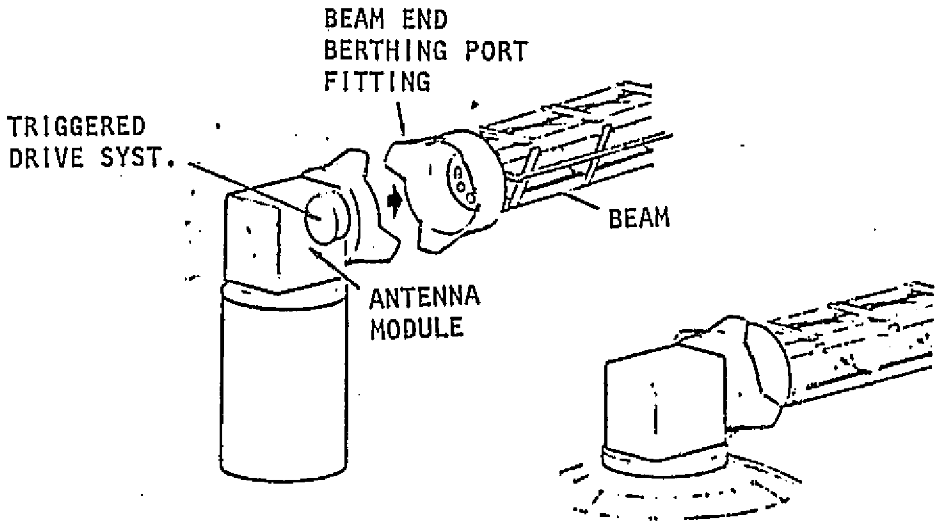
FUNCTION	ELECTRICAL CONNECTION	CODE	01	07 04.1	04.2
ITEM	ANTENNA MODULE				
METHOD	RMS (INDIVIDUAL CONNECTORS)	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



The RMS retrieves one connector from the stowed position on crossbeam, moves to the module and makes the connection. The operation is repeated for each of the five connectors.

/NO ADDITIONAL DETAILS ARE PROVIDED/

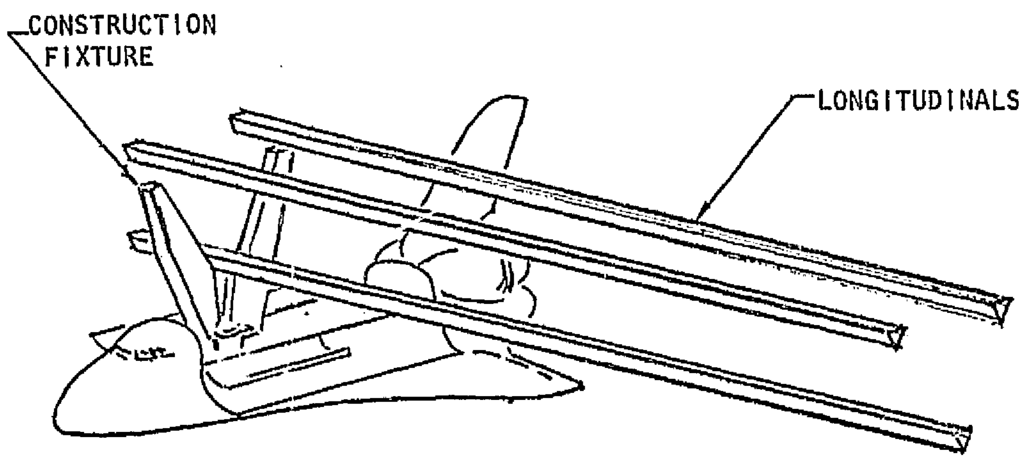
FUNCTION· ITEM	ELECTRICAL CONNECTION ANTENNA MODULE	CODE	01	07 04.1	07.1
METHOD	MODULE ACTUATED	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



As the module is installed, a drive mechanism within the module is triggered which moves the connector carrier plate into the connected position.

/NO ADDITIONAL DETAILS ARE PROVIDED/

FUNCTION · ITEM	ALIGNMENT TRI-BEAM STRUCTURE	CODE	01	09 01.1	00
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				



Project System

Space Fabricated Advanced Communication Platform

Operation

Measure and correct, as necessary, the structural alignment.

Physical Situation

The space construction fixture is in position on the orbiter, the three longitudinals are complete. The installation of the cross beams is about to begin.

Assumptions

1. The beam machine is capable of producing straight beams without twist.

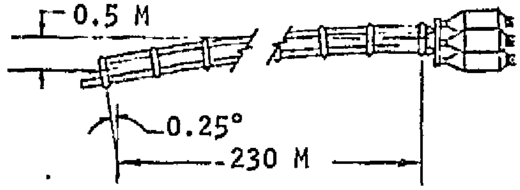
2. The construction fixture is capable of extending a longitudinal without inducing deflections in it.

FUNCTION·	ALIGNMENT	CODE	01	09 01.1	60
ITEM	TRI-BEAM STRUCTURE	PAGE	2 of 3		
METHOD					
SUBJECT	OPERATION IDENTIFICATION (Continued)				

ITEM / **REQUIREMENT**

ORBIT TRANSFER THRUST

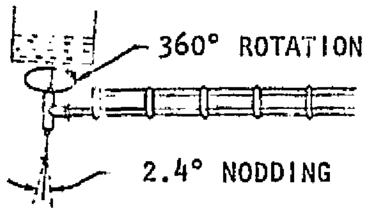
(ALIGNMENT CRITICAL CONDITION)



- MAX ALLOWABLE THRUST OFFSET, 0.5 M
- STRUCTURE CAPABILITY CRITICAL

SOLAR ARRAYS

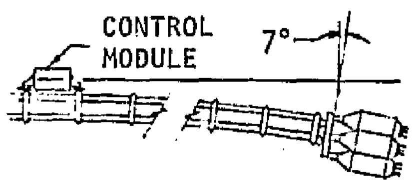
(NON-CRITICAL)



- 5° MISALIGNMENT DECREASES EFFICIENCY BY 0.5%

CONTROL MODULE

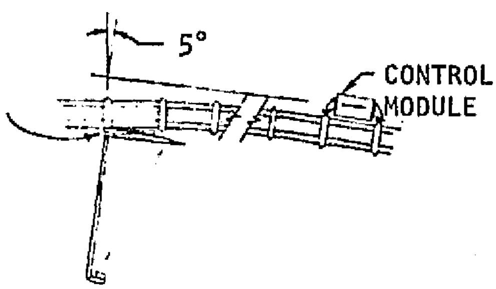
(NON-CRITICAL)



- GIMBALED ENGINES
- UTILIZE ADAPTIVE ATTITUDE CONTROL SYSTEM

ANTENNAS

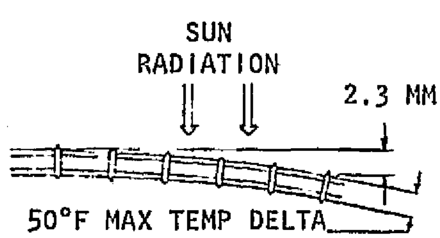
(NON-CRITICAL)



- ROUGH ALIGNMENT CAPABILITY
- FINE ALIGNMENT CAPABILITY FOR OPERATIONS CORRECTIONS

THERMAL

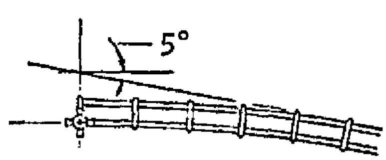
(NON-CRITICAL)



- 50° TEMP DELTA 2.3 MM

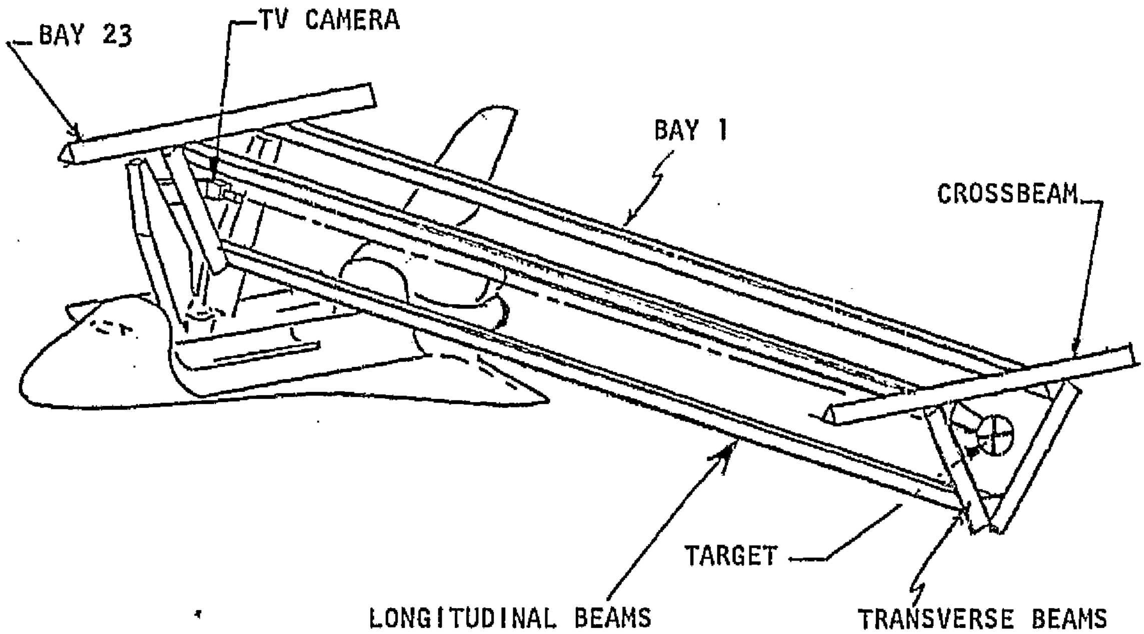
RCS

(NON-CRITICAL)



- 5° MISALIGNMENT DECREASES EFFICIENCY BY 0.38%

FUNCTION ·	ALIGNMENT	CODE	01	09 01.1	00
ITEM -	TRI-BEAM STRUCTURE				
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				

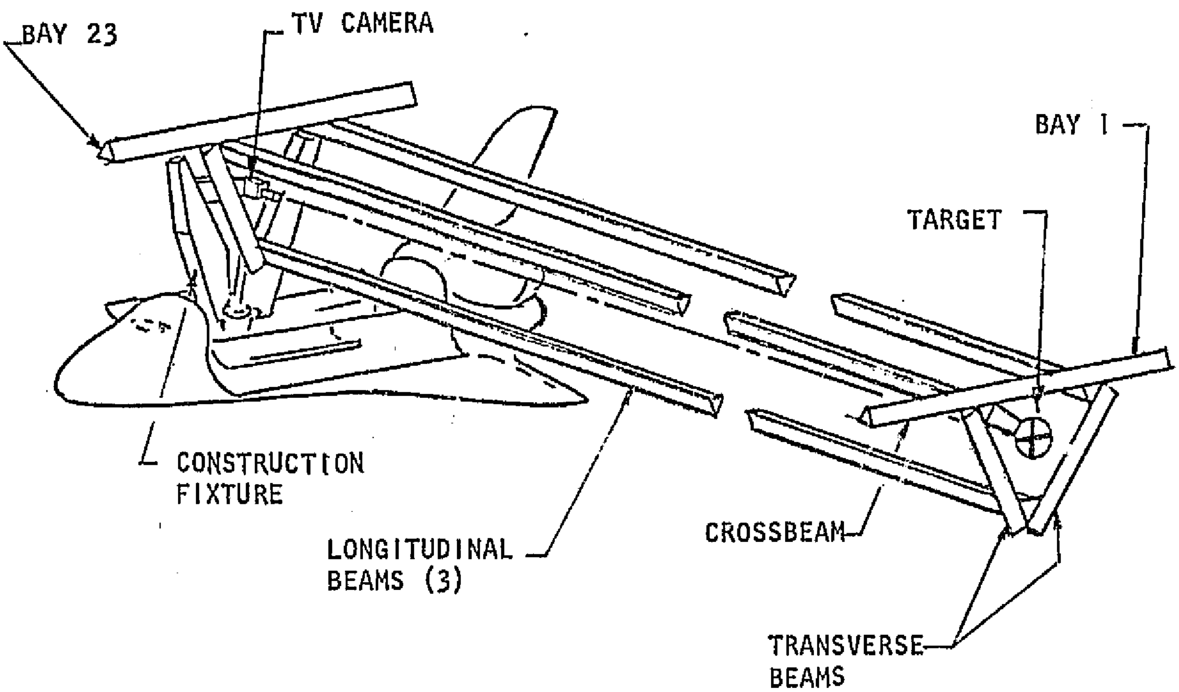


The following methods have been identified:

1. End-to-End Alignment
2. Bay-to-Bay Alignment

Methods 1 and 2 are detailed.

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.1
ITEM	TRI-BEAM STRUCTURE				
METHOD	END-TO-END	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- Install cross and transverse beams at Bay #1.
- Secure an alignment target to a longitudinal at Bay #1 by EVA/MMU.
- Extend the assembly the full length of the longitudinals to Bay #23.
- Sight through an optical device (TV camera) mounted on the construction fixture.
- Measure the alignment of the target and the structure as depicted on the CRT in the orbiter.
- Take appropriate remedial action
  - Check for equipment malfunction which could indicate misalignment: (e.g., instrumentation).
  - Extend or retract longitudinals as required to eliminate misalignment.
- The assembly is now straight within tolerance.
- Install cross beams at Bay #23.
- Retract the assembly and install the remainder of the cross and transverse beams and cross bracing cables.

Manpower

- One EVA/MMU Operator
- One Operator at AFD

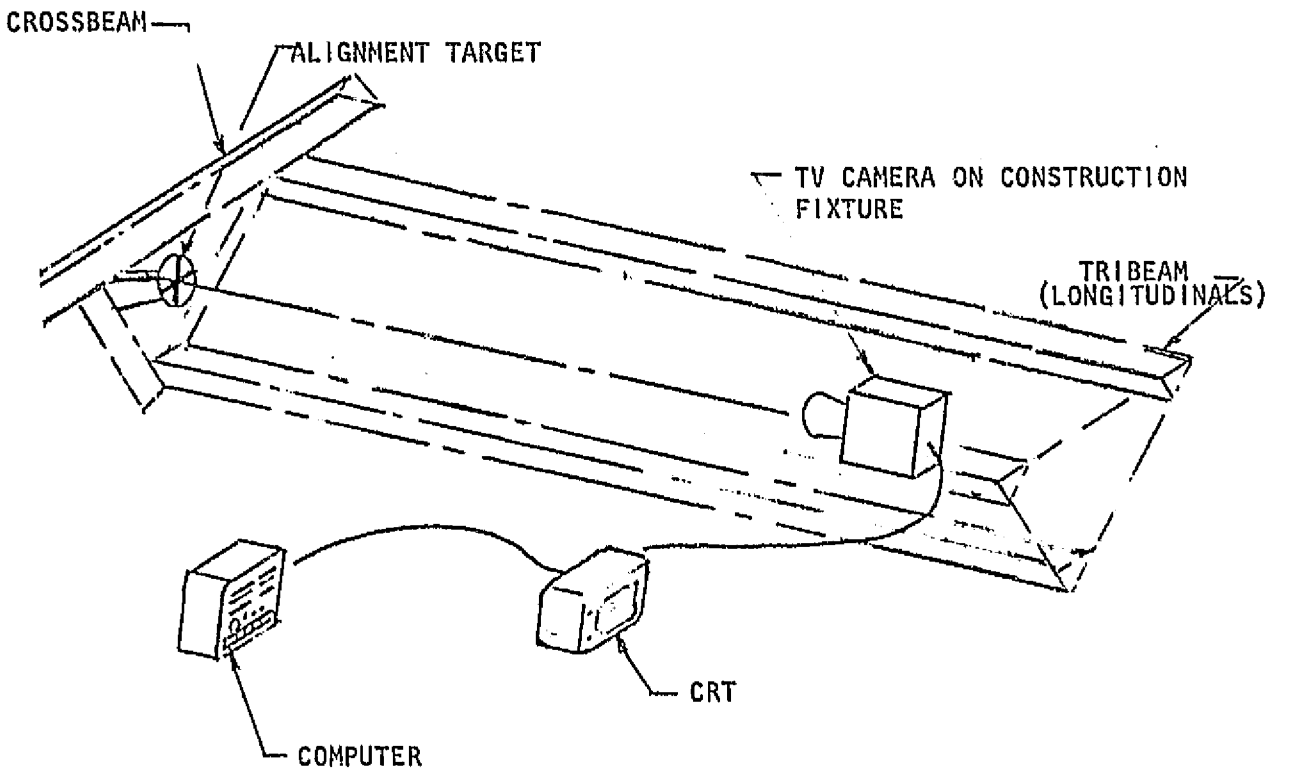
Activity Time

- Install Alignment Target	20 min.
- Alignment Check	2 min.
- Remedial Action	TBD

Support Activity

- None

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.1
ITEM	TRI-BEAM STRUCTURE				
METHOD	END-TO-END	PAGE	3	of	5
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- MMU
- Alignment target on Bay #1
- Alignment sighting TV camera on construction fixture
- CRT in orbiter AFD (adapt existing CRT)
- Computer for analyzing the data concerning structural misalignment:
  - o Orbiter Dynamics
  - o Target Movement
  - o Platform Stiffness
  - o Gravity Gradients, etc., etc.

Computer may be on board or on ground.

Crew - One EVA/MMU Operator

- One CRT Observer at AFD

Power - Instrumentation TBD

MMU Recharge TBD

Lighting & TV

- Standard orbiter and MMU lighting
- TV for alignment target sighting, CRT in orbiter

Computer/Software

- Program for analyzing structural misalignment

Stowage - Alignment Target - 1.5 x 3 x 0.2m

MMU - 0.2 x 0.2 x 0.3m

Other - May require orbiting in a pre-determined gravity gradient attitude.

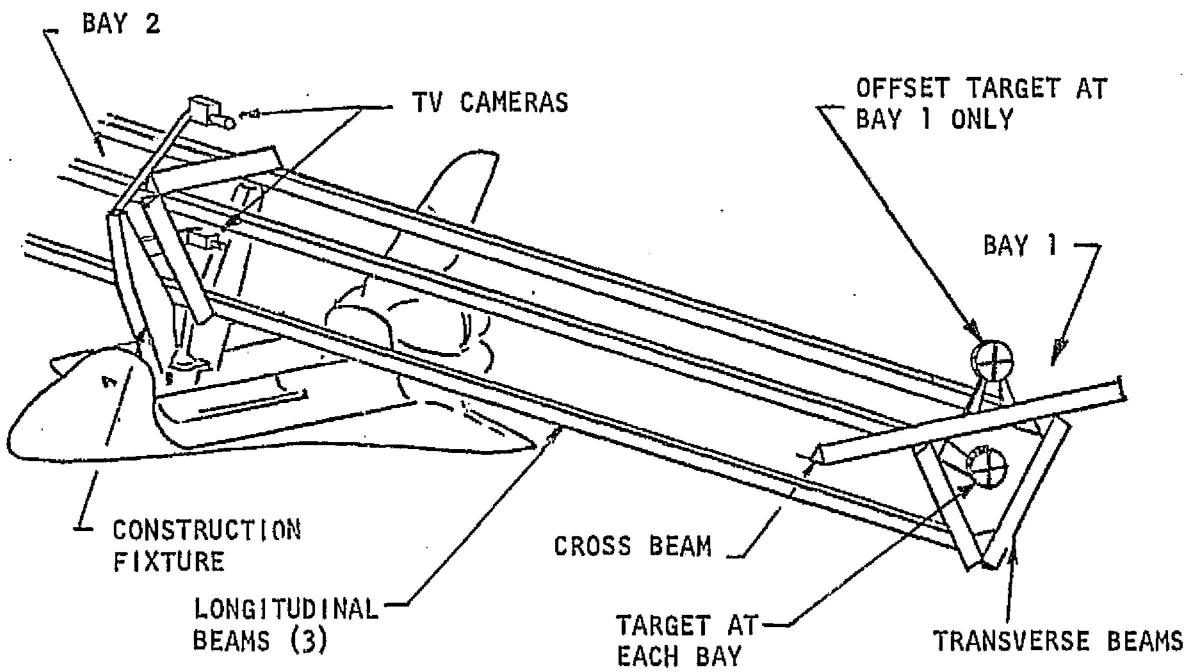
- MMU propulsion recharge TBD

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.1
ITEM	TRI-BEAM STRUCTURE				
METHOD	END-TO-END	PAGE	5 of 5		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Alignment Target	4	0.9	--	0	0	--	183
TV Camera	10	0.1	--	TBD	TBD	--	315
CRT	0	0	--	--	--	--	53
Computer	0	0	--	--	--	--	525
MMU	110	1.1	--	TBD	TBD	--	100
Support Services							
Crew	--	--	2/1.5	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Project Modification							
None							
Operations	--	--	2/1.5	--	--	22	NA*

*Not appropriate, see page 6.

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.2
ITEM	TRI-BEAM STRUCTURE				
METHOD	BAY-TO-BAY	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- o Install cross and transverse beams at Bay #1.
- o Secure alignment targets at Bay #1 by EVA/MMU.
- o Extend the assembly the length of one bay.
- o Install cross bracing cables.
- o Sight through optical devices (TV cameras) mounted on the construction fixture.
- o Measure the alignment of the targets and structure as depicted on a CRT in the orbiter.
- o Take appropriate remedial action if required:
  - o Check for equipment malfunction which could indicate misalignment (e.g., instrumentation).
  - o Extend or retract longitudinals as required to eliminate misalignment.
- o Install cross and transverse beams and a target at Bay #2 by EVA/MMU and extend the assembly.
- o Continue bay-to-bay verification and installation.
- o Periodically check the alignment from Bay #1 to the construction fixture by using the offset target at Bay #1.

Manpower

- One EVA/MMU Operator
- One Operator at AFT

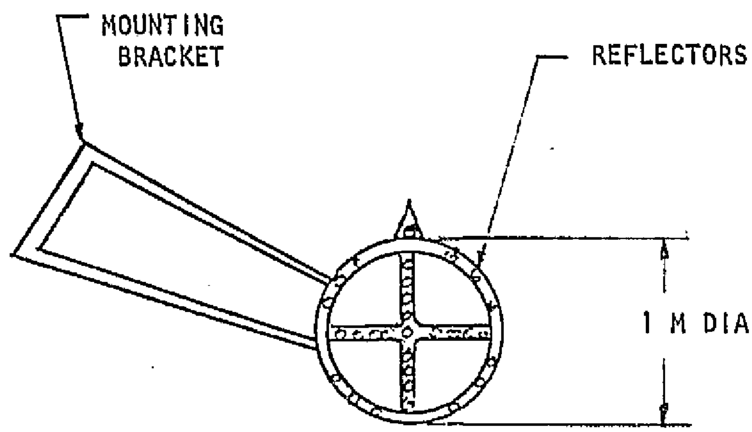
Activity Time

- Install Alignment Targets (24 @ 20 min.)	480 min.
- Alignment Check (23 @ 2 min.)	46 min.
- Remedial Action	TBD

Support Activity

- None

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.2
ITEM	TRI-BEAM STRUCTURE	PAGE	3 of 5		
METHOD	BAY-TO-BAY				
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



ALIGNMENT TARGET

Items

- MMU
- 24 Alignment Targets
- CRT in orbiter AFD (adapt existing CRT)

- Computer for analyzing the data concerning structural misalignment
    - o Orbiter Dynamics
    - o Target Movements
    - o Platform Stiffness
    - o Gravity Gradients, etc., etc.

  Computer may be on board or on the ground.
- TV Cameras

Crew - One EVA/MMU Operator

- One CRT Observer at AFD

Power - Instrumentation TBD

- MMU Recharge TBD

Lighting & TV

- Standard Orbiter and MMU Lighting
- TV for alignment target sighting, CRT in orbiter

Computer/Software

- Program for analyzing structural misalignment

Stowage

- Alignment Targets (24) - 1.5 x 3 x 0.2m each

Other

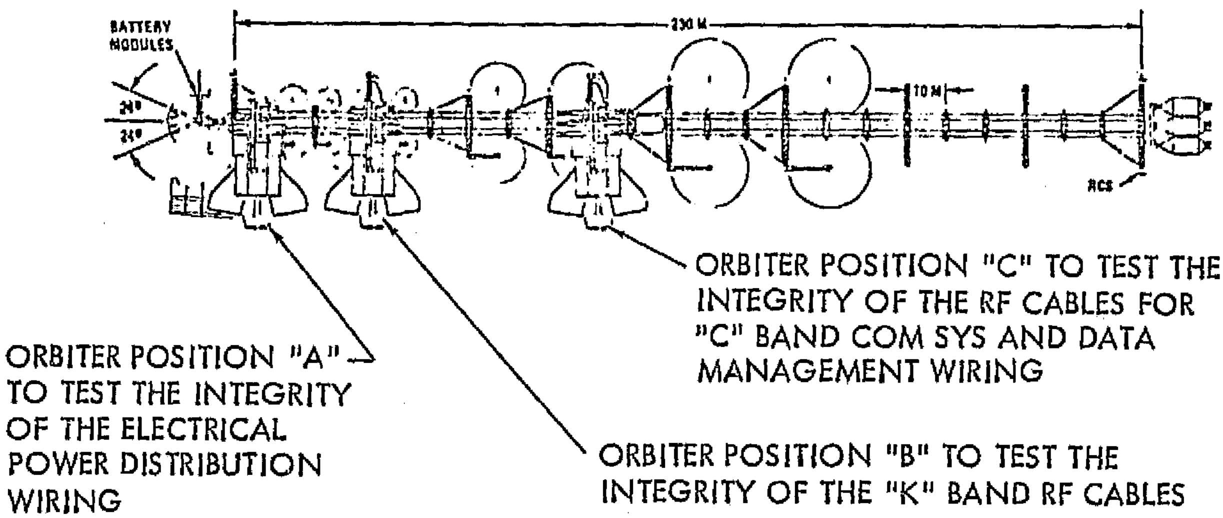
- May require orbiting in a pre-determined gravity gradient attitude.
- MMU propulsion recharge TBD

FUNCTION	ALIGNMENT	CODE	01	09 01.1	09.2
ITEM	TRI-BEAM STRUCTURE				
METHOD	BAY-TO-BAY	PAGE	5 of 5		
SUBJECT	METHOD DESCRIPTION				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Alignment Targets (24)	96	21.6	--	0	0	--	773
TV Cameras (2)	20	0.2	--	TBD	TBD	--	420
Computer	0	0	--	--	--	--	525
CRT	0	0	--	--	--	--	53
MMU	110	1.1	--	TBD	TBD	--	100
Support Services							
Crew	--	--	2/2	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Project Modification							
None							
Operations	--	--	2/2	--	--	520	NA*

*Not appropriate, see page 6.

FUNCTION	ELECTRICAL WIRE CHECKOUT	CODE	01	09 03.1	00
ITEM	ELECTRICAL DISTRIBUTION SYSTEM				
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				



Project System

Space-fabricated advanced communications platform

Operation

To test the integrity of all the electrical wiring on the communication platform.

Physical Situation

The platform structure is complete.
The electrical wiring is completely installed.
The cable end connector has not been connected to the black box, but has been connected to a permanently installed shorting receptacle adjacent to the operational interface.
Control module not installed

Connectors to be tested:

Position A: Electrical Power Distribution Panel

Power—50 connectors (15 wires/connector)	=	750 wires
Signal—15 connectors (55 wires/connector)	=	825 wires
		1575 wires

Position B: RF Signal K-Band Distribution Panel

Power—32 connectors (6 wires/connector)	=	192 wires
Signal—8 connectors (55 wires/connector)	=	440 wires
RF coaxial—30 connectors (34 wires/connector)	=	996 wires
		1628 wires

Position C: Data Management and RF Signal C-Band Distribution Panel

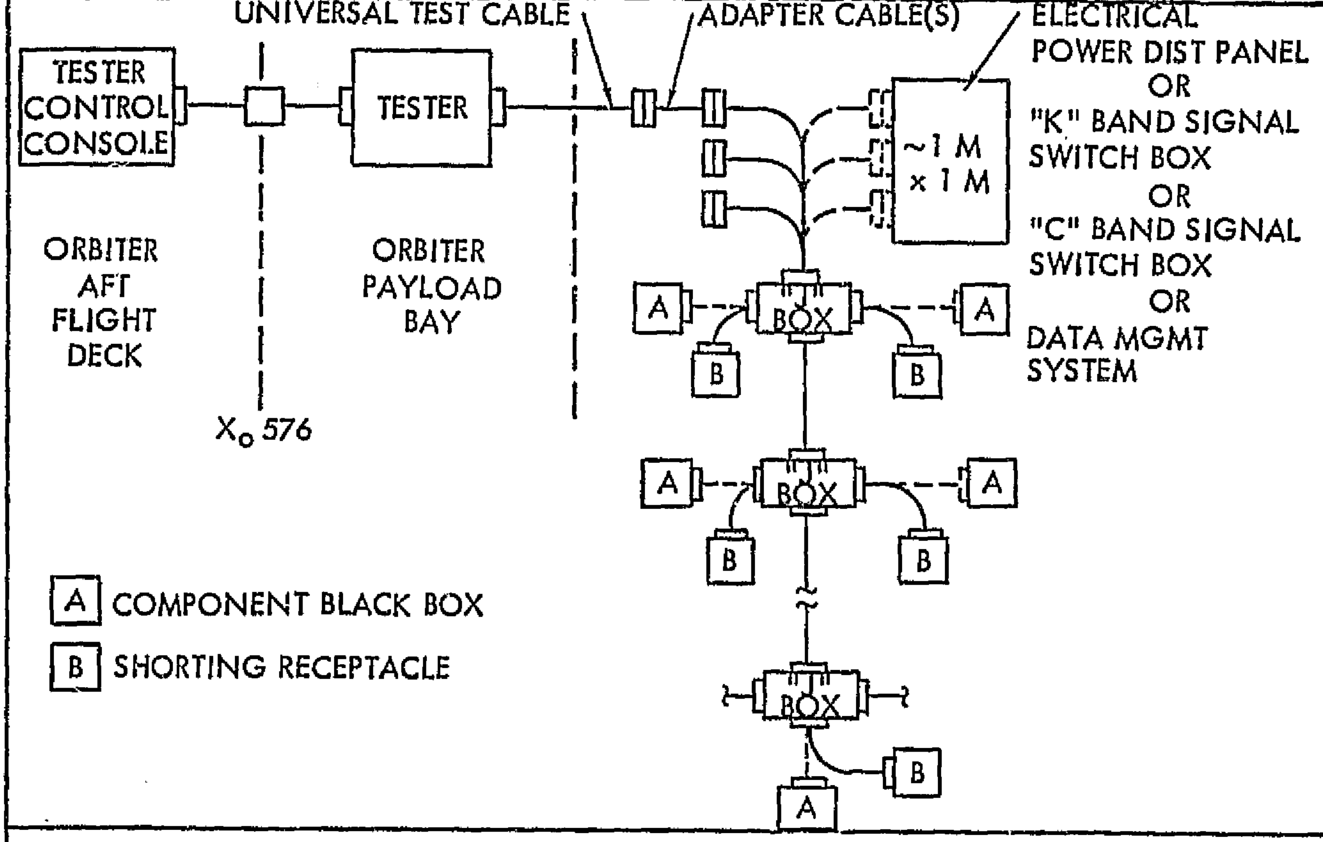
Power (ant.)—32 connectors (6 wires/connector)	=	192 wires
Signal (ant.)—8 connectors (55 wires/connector)	=	440 wires
RF coaxial—30 connectors (34 wires/connector)	=	996 wires

<u>Control Module</u>

Signal- 50 connectors—(55 wires/connectors)	=	2750 wires
Power- 50 connectors—(5 wires/connector)		250 wires
		4628 wires

An interconnect harness (multi-purpose harness in lieu of a dedicated cable for each cable) with jumper harnesses to mate with the variety of electrical connectors will interface the tester to the cable under test.

FUNCTION · ITEM ·	ELECTRICAL WIRE CHECKOUT ELECTRICAL DISTRIBUTION SYSTEM	CODE	01	09 03.1	00
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				

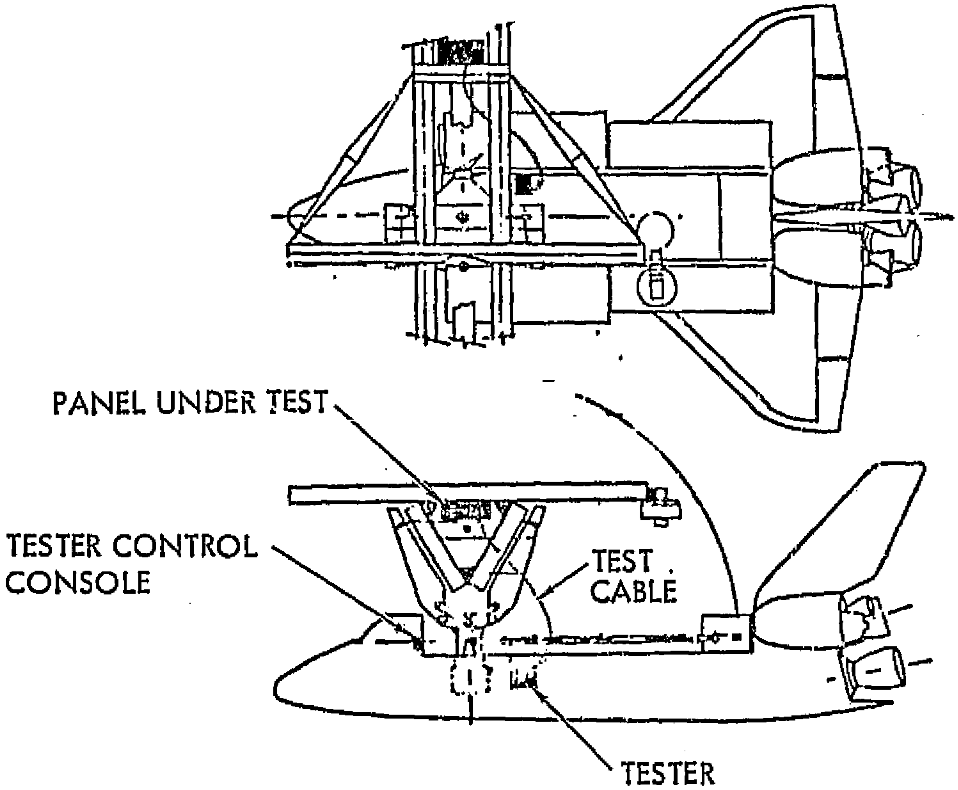


The following methods have been identified:

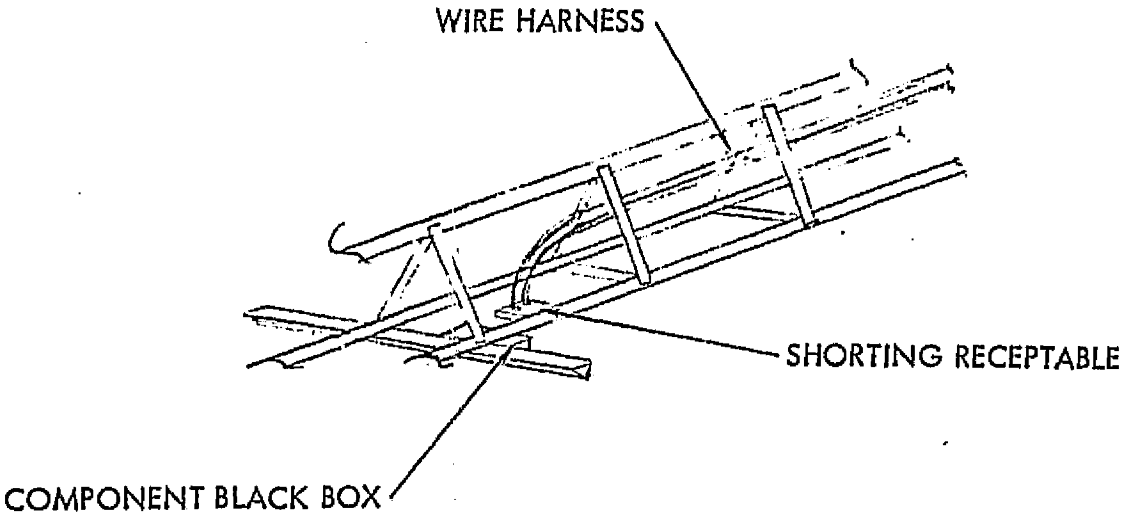
1. Special design tester
2. Commercial tester
3. Individual test instruments

Method 1 is detailed

FUNCTION · ELECTRICAL WIRE CHECKOUT	CODE	01	09 03.1	08.1
ITEM · ELECTRICAL DISTRIBUTION SYSTEM				
METHOD SPECIAL DESIGN TESTER	PAGE	1 of 6		
SUBJECT METHOD DESCRIPTION				



- The platform will be positioned for ready access to the panel under test.
- The tester will be connected to the tester control located in the aft flight deck. All pertinent test data will be recorded here.
- The tester will be coupled to the harness to be tested by the universal test cable through the adapter cable to mate with appropriate connector.
- The shorting device will allow a continuity test to be performed. After continuity of all the conductors has been verified, the device will be switched so that the remainder of the testing may be conducted, i.e., shorts, grounds, and dielectric withstand.
- Upon verifying the soundness of the wire harness, the operational testing of the systems may commence.
- The special designed tester will be a computerized system, programmed for testing for continuity; insulation resistance of wire to wire and wire to ground; shorts, wire resistance, and load test.
- The tester systematically will test one conductor of a connector at a time, and will test all conductors of a connector in seconds if no fault is detected.
- Test cable and adapter cable will be moved to the next connector upon test completion of the previous connector. The test coordinator will adjust the console control panel for the next file and will test next cable.
- To expedite procedure, several test cables may be connected at one time.



Structure

Cable shorting receptacle for stowing cable connector when cable is installed. Must be located in proximity of component black box so cables may be connected after electrical testing complete. Stowage receptacle must have pins shorted in lieu of a test harness to conduct continuity test. Pins may be shorted by means of (1) fusible links, (2) solid-state stepping switch, or (3) mechanical stepping switch.

Cable Connector

Manually compatible.

Manpower—Console control operator plus two EVA operators

Activity Time	(Minutes)
Position A	
Connect universal test cable to adapter cable	3
Attach test harness to connector to be tested (2 min./connector)	130
Perform continuity test (3 sec/cond.)	80
Perform resistance test (6 sec/cond.)	160
Activate shorting receptacle to remove short from pins (0.5 min./black box)	15
Insulation resistance wire to ground (3 sec/cond.)	80
Insulation resistance wire to ground (3 sec/cond.)	80
Remove test harness (2 min./connector)	130
Adjust tester for next connector (3 min./connector)	195
	863 min. (14.4 hr)
Position B	
Same procedure as Position A	908 min. (15.1 hr)
Position C	
Same procedure as Position A	2363 min. (39.4 hr)
If fault is detected:	
Disconnect test harness from tester	5.0
Connect time domain reflectometer	5.0
Warm-up and fault location displayed	2.0
Fault location calculation	2.0
	14.0
EVA activity to clear fault	60.0

Support Activity

While tests are being performed, select next cable for test.
Select appropriate adapter cable.
Determine next file for computer.

Items

Special design electrical tester with a computerized program to perform the necessary electrical test on the installed wire harness (tester in payload) bay and tester control console in orbiter aft flight deck).

Universal test cable—number of conductors equal to number of pins in largest connector to be interfaced with.

Test control console to control test and record data.

Adapter cables—interfaces between universal test cable and harness to be tested to provide proper connector interface.

Time domain reflectometer (TDR) to determine the location of the fault.

Repair kit necessary for clearing various faults that may be encountered.

Cherry picker.

Crew

One operator at AFD and two operators EVA.

Power

	Watts
Tester	1500
Time domain reflectometer	500
Cherry picker operation	500
RMS operation	1000-1800

Lighting and TV

Cherry picker illumination adequate.

Computer/Software

RMS and cherry picker coordinate transform system.

Stowage

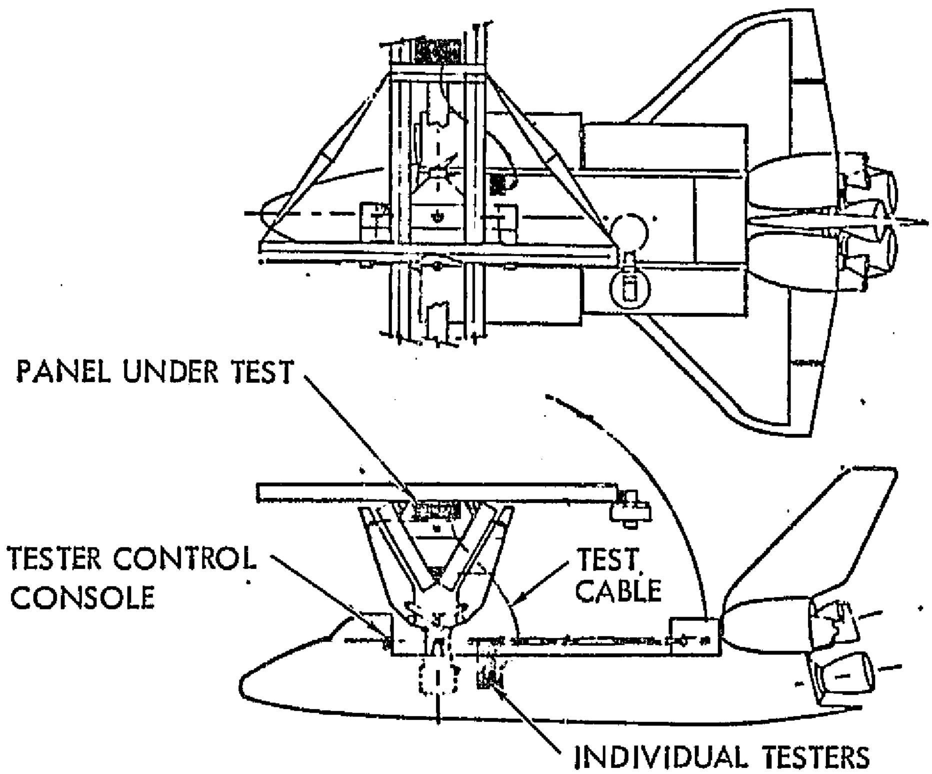
	Meters
Tester	0.5×0.6×1.5
Time domain reflectometer	0.4×0.4×0.3
Cherry picker	0.9×1.6×1.1
Test control console	0.5×0.6×0.4 (AFD)
Universal cable	2.5 cm × 35 m
Adapter cables (5)	2.5 cm × 3 m

FUNCTION	ELECTRICAL WIRE CHECKOUT	CODE	01	09 03.1	08.1
ITEM	ELECTRICAL DISTRIBUTION SYSTEM	PAGE	6 of 6		
METHOD	SPECIAL DESIGN TESTER				
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Tester	28.6	0.6	-	1.5	35	-	3532
Tester control console	20	0.1	-	TBD	TBD	-	2272
Universal cable	15.8	17.2	-	0	-	-	1006
Adapter cables (5)	20	7.4	-	0	-	-	1035
TDR	9	0.1	-	0.5	TBD	-	592
Cherry picker	273	1.6	-	0.5	TBD	-	TBD
RMS	0	0	-	1.8	TBD	-	NC
Support Services							
Crew	-	-	3/3	-	-	-	-
Power	-	-	-	TBD	TBD	-	TBD
Project Modifications							
Shorting receptacles and panel	45	0.6	-	-	-	-	2486
Operations							
*Assumes no faults	-	-	3/3	-	-	4134* (68.9 hr)	NA*

*Not appropriate, see page 6.

FUNCTION	ELECTRICAL WIRE CHECKOUT	CODE	01	09 03.1	08.2
ITEM	ELECTRICAL DISTRIBUTION SYSTEM				
METHOD	INDIVIDUAL INSTRUMENTS	PAGE	1 of 2		
SUBJECT	METHOD DESCRIPTION				



The basic procedure would be the same as for the special design tester except individual instruments would be utilized in lieu of computerized tester.

Continuity check may be performed as an independent test by using a continuity test device (light, buzzer, etc.) and individually probe each pin of the cable. Actually, two conductors can be checked at a time through the shorting device.

Continuity may be verified when the dc resistance of a conductor is measured.

Resistance measurements may be accomplished by attaching a wheatstone bridge or similar instrument across the conductor pair through the shorting device. Resistance then can be determined of each conductor knowing the size of the conductor.

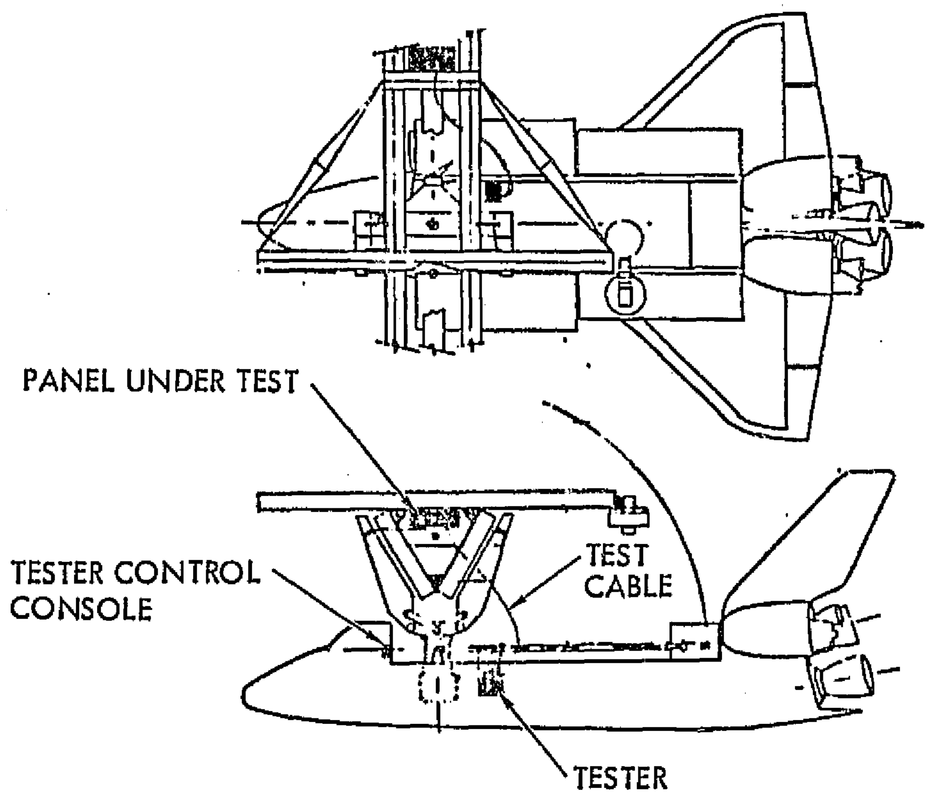
The device used in making the continuity check may be used to test for shorts and grounds.

A hi-pot tester or similar device may be used to check the insulation resistance wire to wire and wire to ground. The conductors should be stressed at a low voltage level (150% of nominal voltage of system). This test will verify that the wire insulation was not damaged during installation and fabrication of structure.

Using individual instruments to test the integrity of the electrical is time-consuming. Individual conductors of a given cable would be assessed several times during the testing procedure.

/NO ADDITIONAL DETAILS ARE PROVIDED/

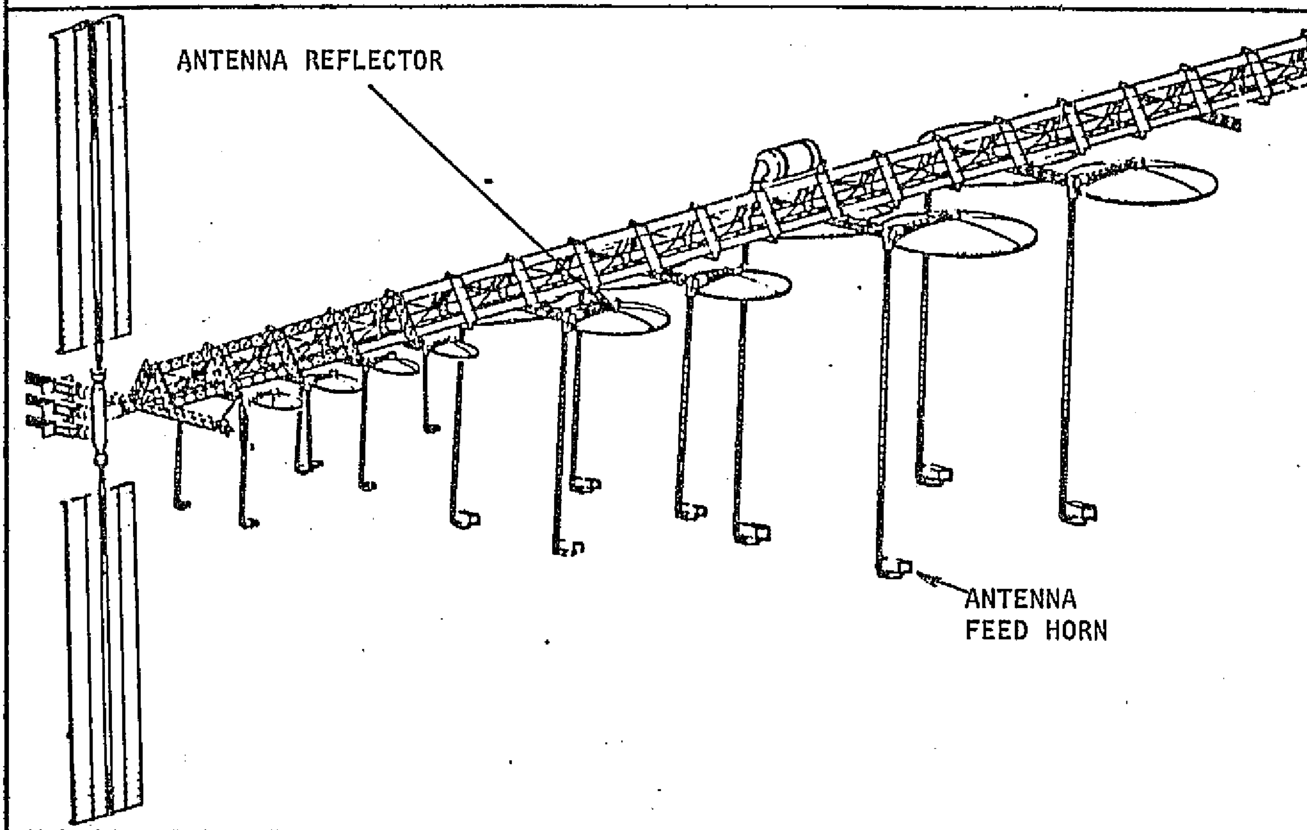
FUNCTION	ELECTRICAL WIRE CHECKOUT	CODE	01	09 03.1	08.3
ITEM	ELECTRICAL DISTRIBUTION SYSTEM				
METHOD	COMMERCIAL TESTER	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



Same description as for special design tester (01 09 03.1 08) except it will be of a standard package design and the tester console may not be compatible with aft flight deck. Also, tester may not have all built-in features which are required.

/NO ADDITIONAL DETAILS ARE PROVIDED/

FUNCTION· ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	00
METHOD		PAGE	1 of 2		
SUBJECT	OPERATION IDENTIFICATION				



Project System

- Space fabricated advanced communications platform

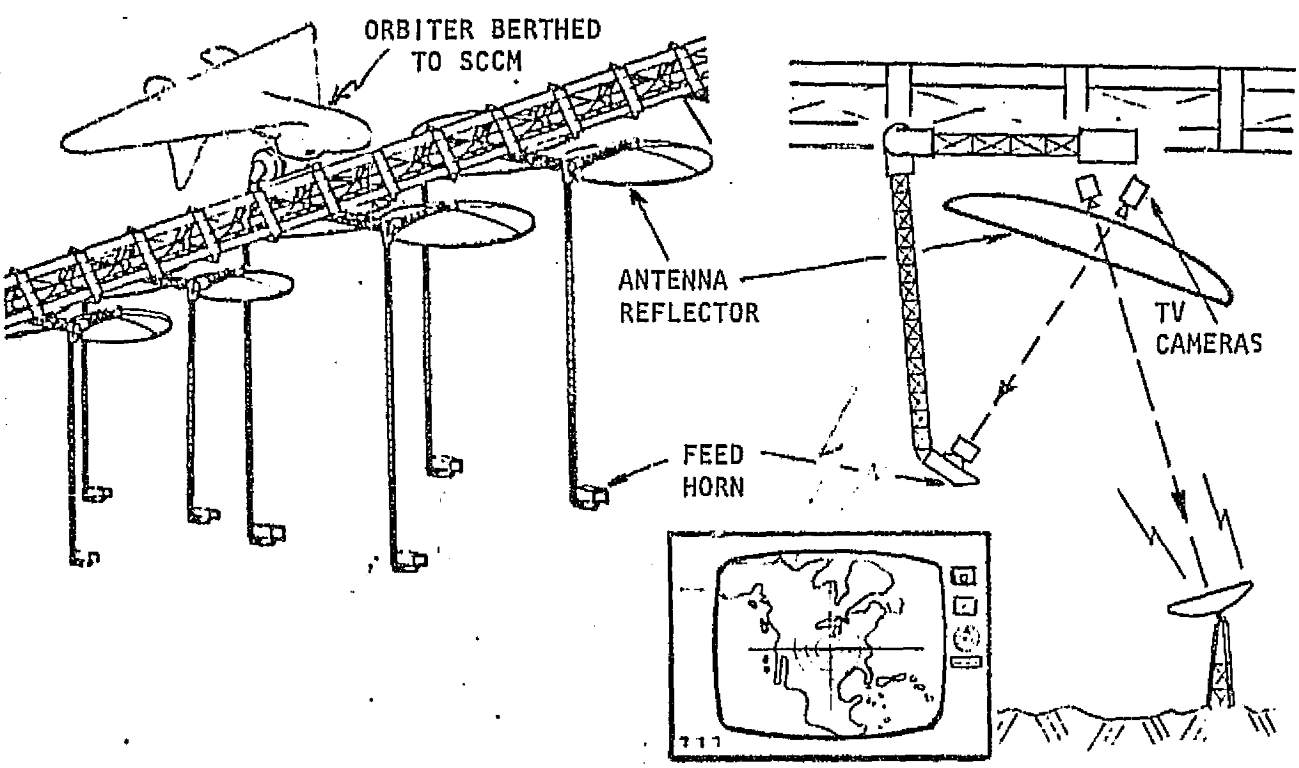
Operation

- Align the antenna system for operational use

Physical Situation

- The platform structure is completed with all systems installed.
- Antenna modules are installed but are in the stowed configuration.

FUNCTION · ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	00
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				

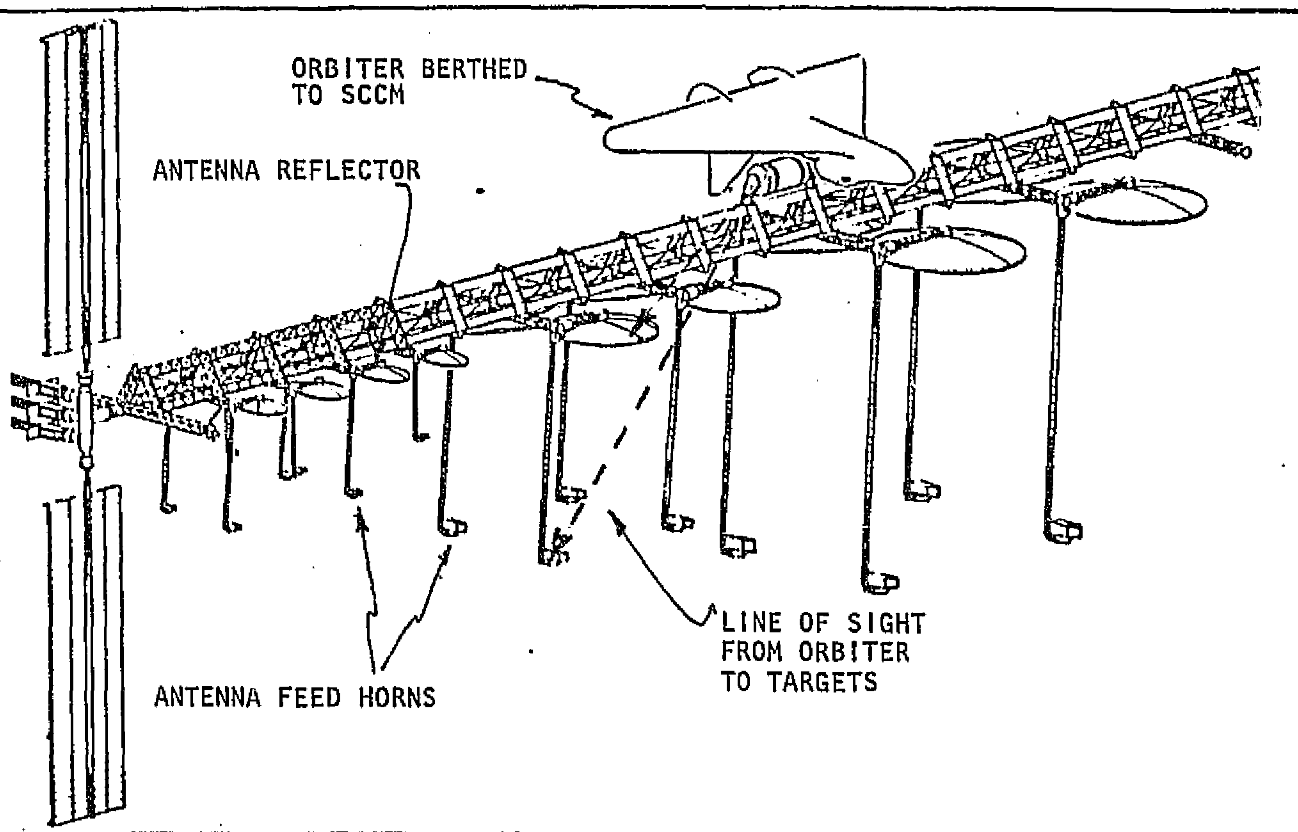


The following methods have been identified:

1. Alignment to orbiter baseline in LEO
2. Alignment to earth target in GEO

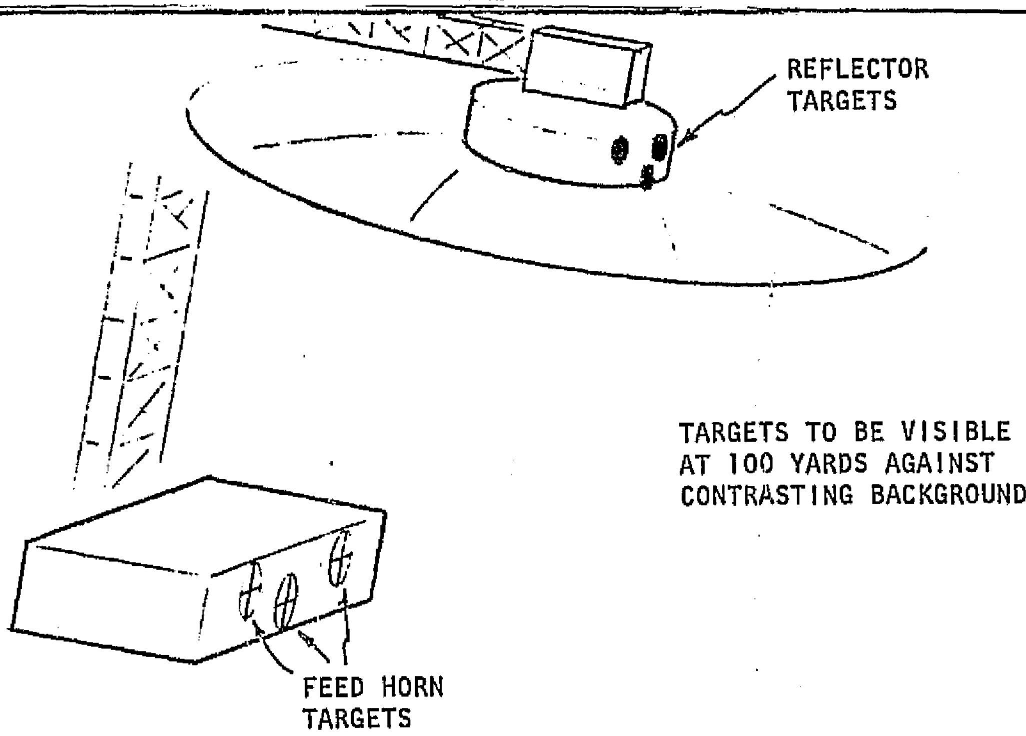
Methods 1 and 2 are detailed.

FUNCTION· ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.1
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- In LEO, orbiter berths to platform at the systems control center module (SCCM).
- Orbiter establishes positional relationship between its G&N and the platform G&N.
- The antenna farthest from SCCM is deployed.
- Laser/optical instrument in orbiter measures the attitude/location of targets accurately mounted on the antenna reflector and feed horn and calculates the correcting signals to be sent along hard wired paths between orbiter and antenna to adjust the stroke of actuators controlling the attitude/location of the feed horn and reflector.
- Antenna horn is restowed.
- Proceed with next seven antennas on that side of platform.
- Reverse the orbiter (i.e., turn through 180°) and align the 8 antennas on the other side of the platform.
- Alignment in LEO is designed to eliminate construction errors and tolerance buildups and will be accomplished to an accuracy consistent with the capability of the "auto track" mode for antenna operation at GEO. It is assumed that transfer from LEO to GEO will not cause any additional misalignment.

FUNCTION	ALIGN	CODE	01	09 04.1	09.1
ITEM	ANTENNA MODULE				
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



- Add berthing port to the system control center module (SCCM).
- Add targets to the reflector and feed horn of each antenna.
- Hard wiring between the berthing port/orbiter interface and the actuators controlling the movement of the feed horn and reflector.

FUNCTION ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.1
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	3 of 6		
SUBJECT	OPERATIONS DESCRIPTION				

Manpower

- 1 crewman to operate the orbiter measuring system

Activity Time

- Deploy, align, restow antenna and antenna horn — 60 min.

Support Activity

- Berth to SCCM — 20 min.
- Alignment between orbiter and platform G&N — 20 min.

FUNCTION	ALIGN	CODE	01	09 04.1	09.1
ITEM	ANTENNA MODULE				
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	4	of	6
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				

Laser/Optical Alignment Instrument

- Mounts in orbiter
- Aligns targets on reflector/feed horn and reads distance and angles between target and baseline
- Calculates and displays corrections (e.g., roll, pitch, yaw, X, Y, Z) to move the antenna into correct alignment

FUNCTION	ALIGN	CODE	01	09 04.1	09.1
ITEM	ANTENNA MODULE				
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

Crew

- 1 crewman in orbiter

Power

- Alignment instrument - TBD
- Antenna structure movement (supplied from platform)

Lighting and TV

- Not required

Computer/Software

- Antenna/orbiter/SCCM coordinate transform system

Stowage

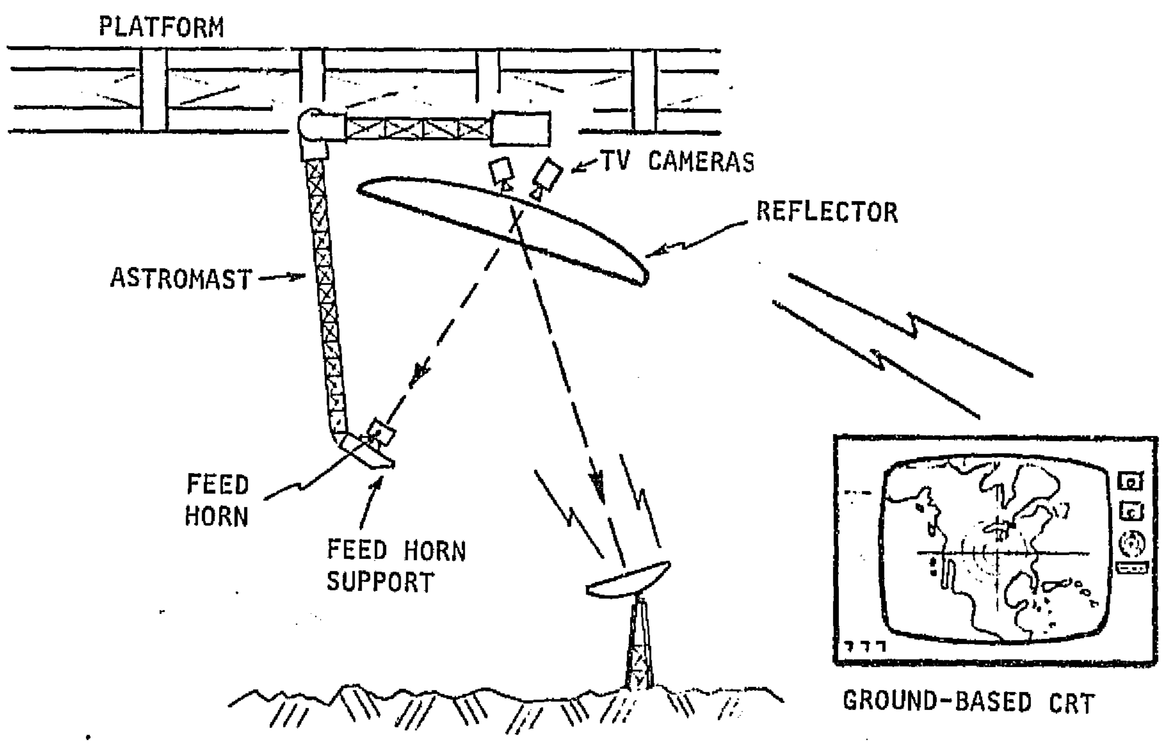
- Laser/optical alignment instrument - 0.3 x 0.3 x 0.8M

FUNCTION ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.1
METHOD	ALIGN TO ORBITER BASELINE (LEO)	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
Laser/Optical Alignment Instrument	20	0.1	-	TBD	TBD	-	2619
<u>Support Services</u>							
Crew	-	-	1/1	-	-	-	-
Power (Total)	-	-	-	TBD	TBD	-	TBD
<u>Project Modification</u>							
SCCM Berthing Port	110	1	-	-	-	-	473
Control Wiring	20	0.1	-	-	-	-	200
Targets	2	NEG	-	-	-	-	105
<u>Operations</u>	-	-	1/1	-	-	60	NA*

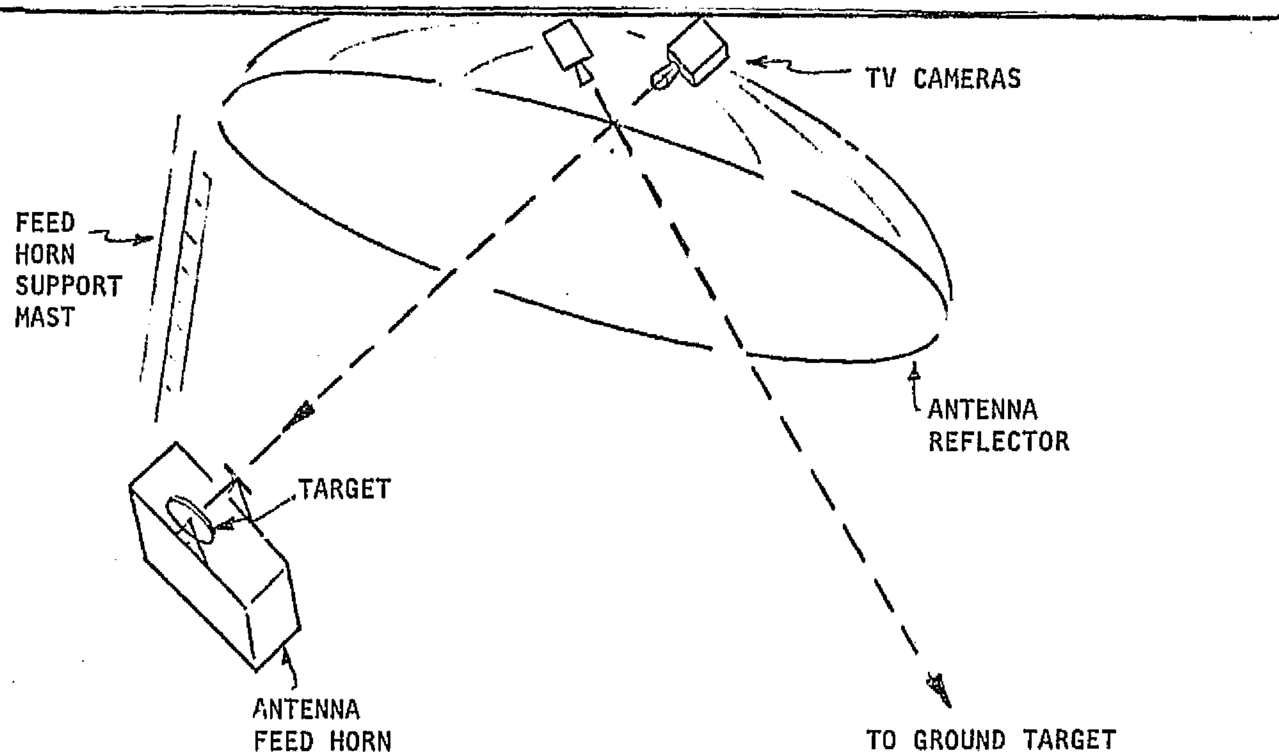
*Not appropriate, see page 6.

FUNCTION· ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.2
METHOD	ALIGN TO EARTH TARGET (GEO)	PAGE	1 of 4		
SUBJECT	METHOD DESCRIPTION				



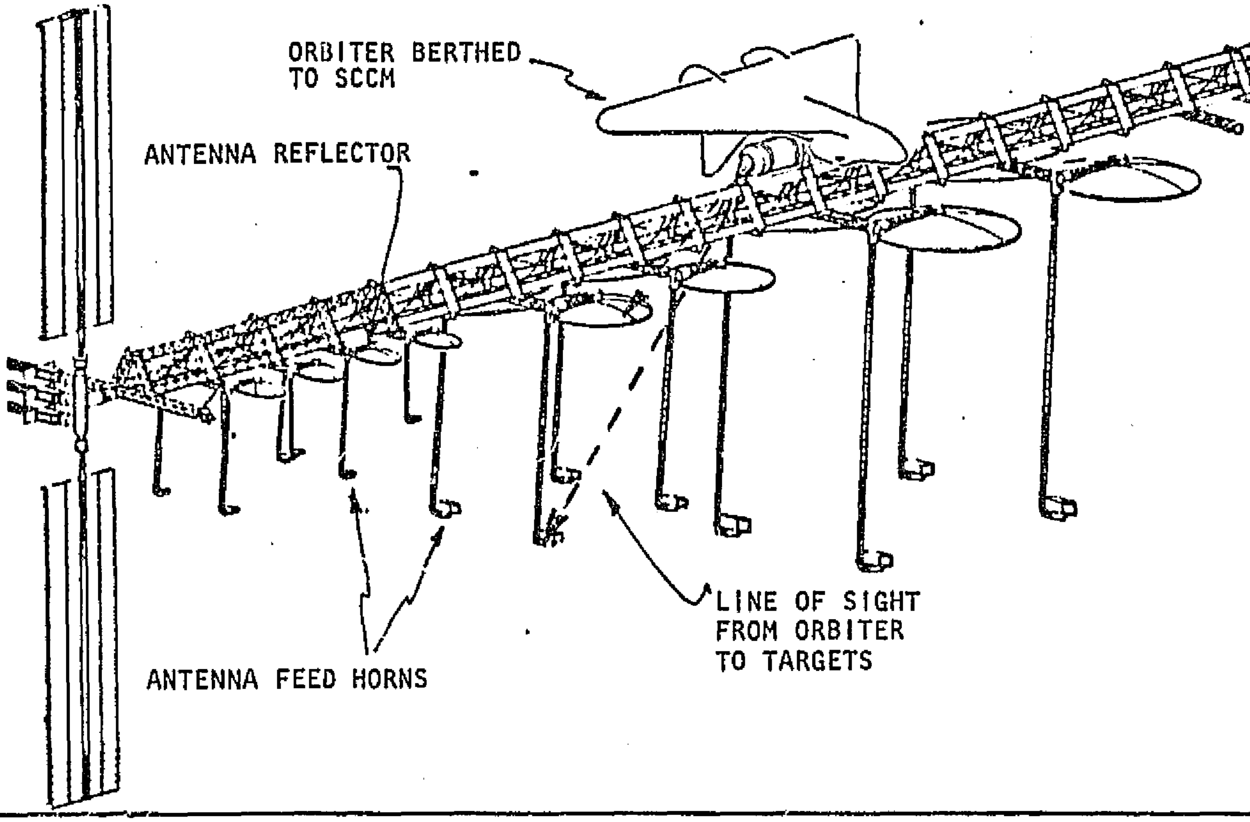
- In geosynchronous orbit the antenna module is deployed.
- A ground based operator points the reflector to the ground target by steering the boresighted TV camera using a ground based CRT. Accuracy required: ± ¼°.
- The feed horn is aligned to the reflector in similar fashion by gross movements of the astromast and feed horn support.
- Fine alignment of the feed horn and operational tracking is achieved by moving the feed horn relative to its support, through control by antenna/ground transmissions by auto track system.

FUNCTION · ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.2
METHOD	ALIGN TO EARTH TARGET (GEO)	PAGE	2 of 4		
SUBJECT	PROJECT MODIFICATIONS				



- Add two TV cameras to the antenna reflector
  - boresighted to the ground target
  - boresighted to the feed horn target
- Add a 3 dimensional target to the feed horn, boresighted to the reflector TV camera.
- Provide a ground based CRT
- Provide uplink-downlink for controlling the movement of the feed horn and reflector and for TV transmission.

FUNCTION · ITEM	ALIGN ANTENNA MODULE	CODE	01	09 04.1	09.2
METHOD	ALIGN TO EARTH TARGET (GEO)	PAGE	3 of 4		
SUBJECT	OPERATIONS				



Manpower

- 1 ground based operator

Activity Time

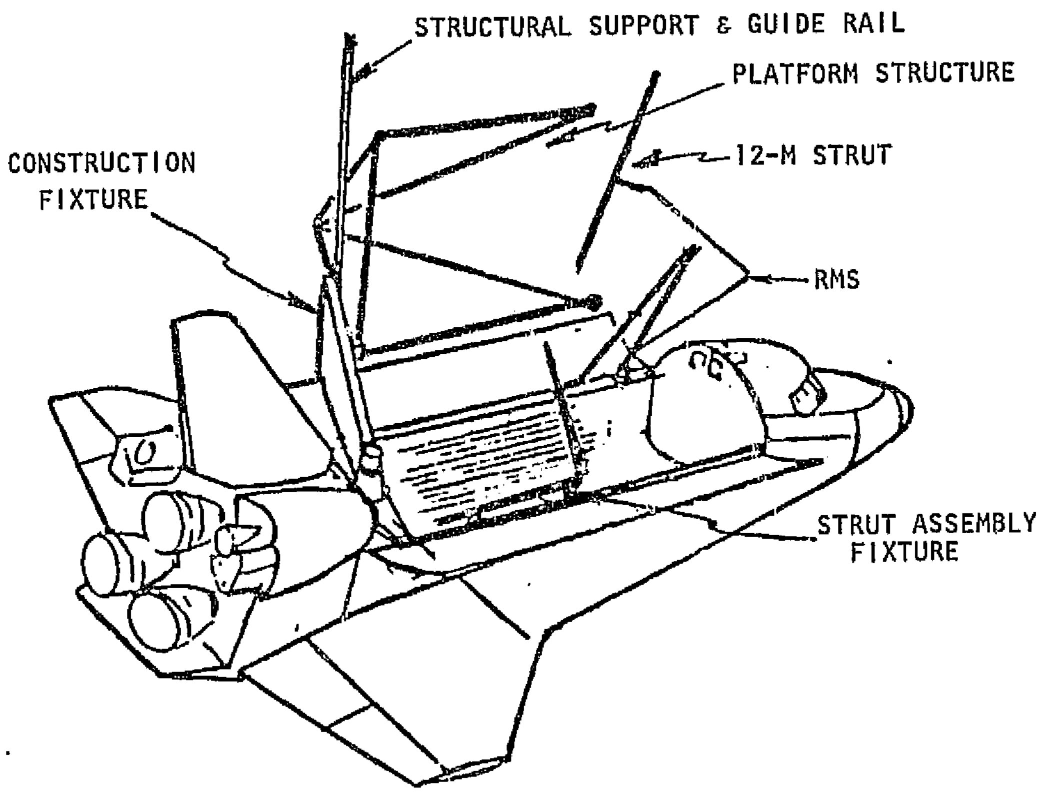
- Steer reflector to align with ground target	5 min.
- Steer feed horn to align with reflector	5 min.
Total Per Antenna	10 min.

FUNCTION	ALIGN	CODE	01	09 04.1	09.2
ITEM	ANTENNA MODULE				
METHOD	ALIGN TO EARTH TARGET (GEO)	PAGE	4 of 4		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
None	0	0	-	0	0	-	-
Support Services							
Crew	-	-	1/1	-	-	-	-
Power (Total)	-	-	-	0	0	-	TBD
Project Modification							
TV Cameras (2)	20	0.2	-	-	-	-	420
Feed Horn Target	2	0.2	-	-	-	-	294
CRT Capability (Ground Based)	0	0	-	-	-	-	53
Uplink/Downlink Electronics	0	0	-	-	-	-	437
Operations	-	-	1/1	-	-	10	NA*

*Not appropriate, see page 6.

FUNCTION	JOIN	CODE	02	05 01.1	00
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	1 of 3		
METHOD					
SUBJECT	OPERATION IDENTIFICATION				



Project System

Erectable Advanced Communications Platform

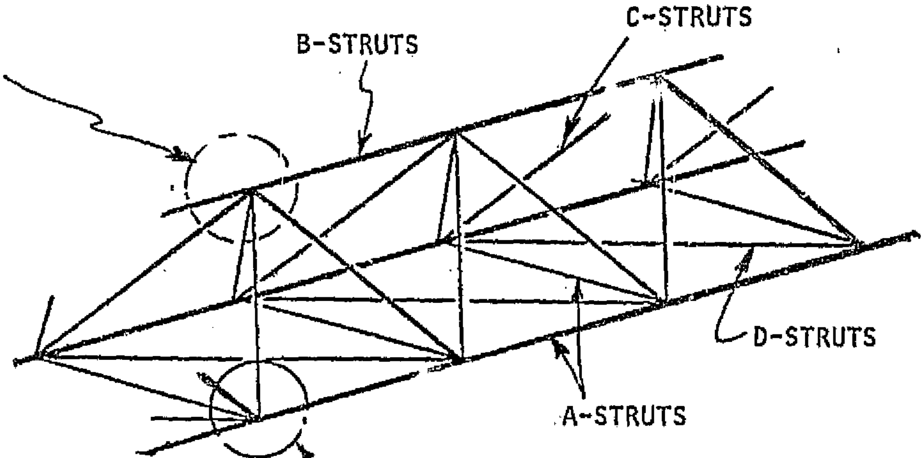
Critical Function

Join struts and unions into structural assembly and join berthing ports with moment joints.

Physical Situation

- Struts are folded and nested in payload bay.
- Joints and berthing ports are in separate containers in the bay.

FUNCTION· ITEM	JOIN STRUTS, UNIONS, BERTHING PORTS	CODE	02	05 01.1	00
METHOD		PAGE	2 of 3		
SUBJECT	OPERATION IDENTIFICATION (Continued)				



BASIC PLATFORM STRUCTURE

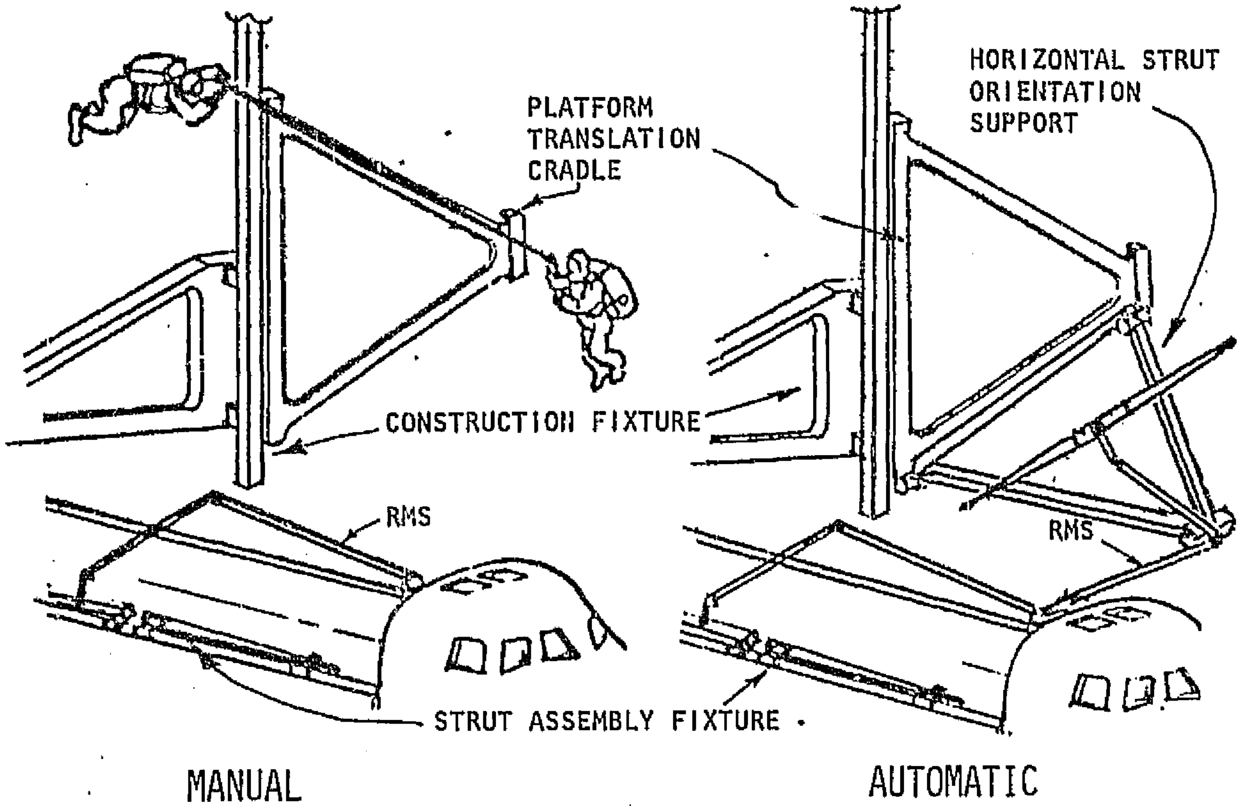
Platform consists of:

- Double-tapered struts hinged at mid point (large diameter) and each strut end configured to match either socket joint union or moment joint union.

STRUT	LENGTH G	DIA E	DIA F	WALL THICKNESS
A	12.0 M	.30 M.	.24 M	.0012 M
B	12.0 M	.44 M	.22 M	.0009 M
C	12.0 M	.19 M	.098 M	.0006 M
D	16.97 M	.19M	.098 M	.0006 M.

- o Socket Joint Unions
- o Moment Joint Unions
- o Berthing Port Adaptors

FUNCTION · ITEM	JOIN STRUTS, UNIONS, BERTHING PORTS	CODE	02	05 01.1	00
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				



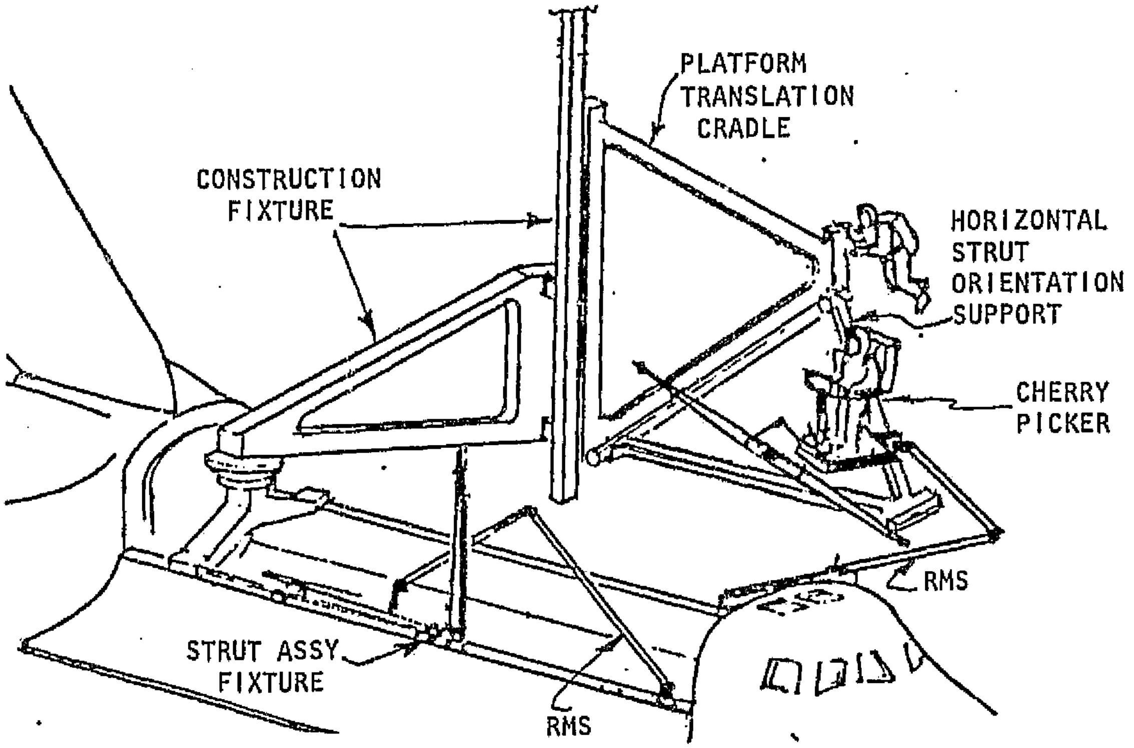
The following methods have been identified:

Manual

1. EVA/MMU and Cherry Picker
2. EVA/MMU
3. RMS
4. RMS assembly of a strut cluster then joining to the platform

Methods 1, 3 and 4 are detailed

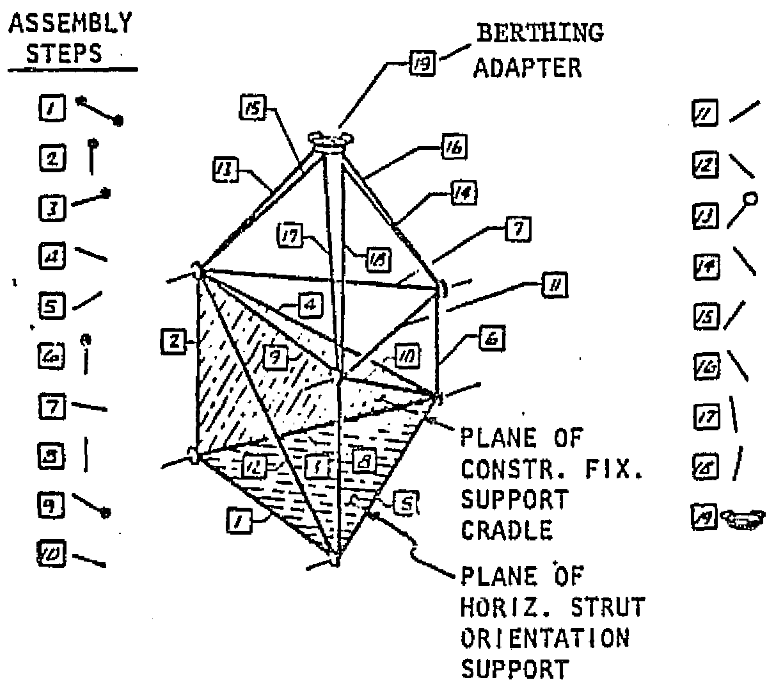
FUNCTION · ITEM	JOIN STRUTS, UNIONS, BERTHING PORTS	CODE	02	05 01.1	03.1
METHOD	EVA/MMU & CHERRY PICKER	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- o The cherry picker removes hinged strut and union from the cargo bay and joins them in the strut assembly fixture.
- o The cherry picker removes the assembled strut from the fixture and transports it to the construction fixture.
- o An EVA/MMU astronaut joins the strut to the platform strut assembly in a pre-determined sequence along the Z axis.
- o Procedure continues until the platform structure is completed.

FUNCTION ·	JOIN	CODE	02	05 01.1	03.1
ITEM ·	STRUTS, JOINTS, BERTHING PORTS				
METHOD	EVA/MMU & CHERRY PICKER	PAGE	2	of	5
SUBJECT	OPERATIONS				

STRUCTURE ASSEMBLY SEQUENCE



Manpower

- One EVA/MMU Astronaut
- One Cherry Picker Operator

Activity Time

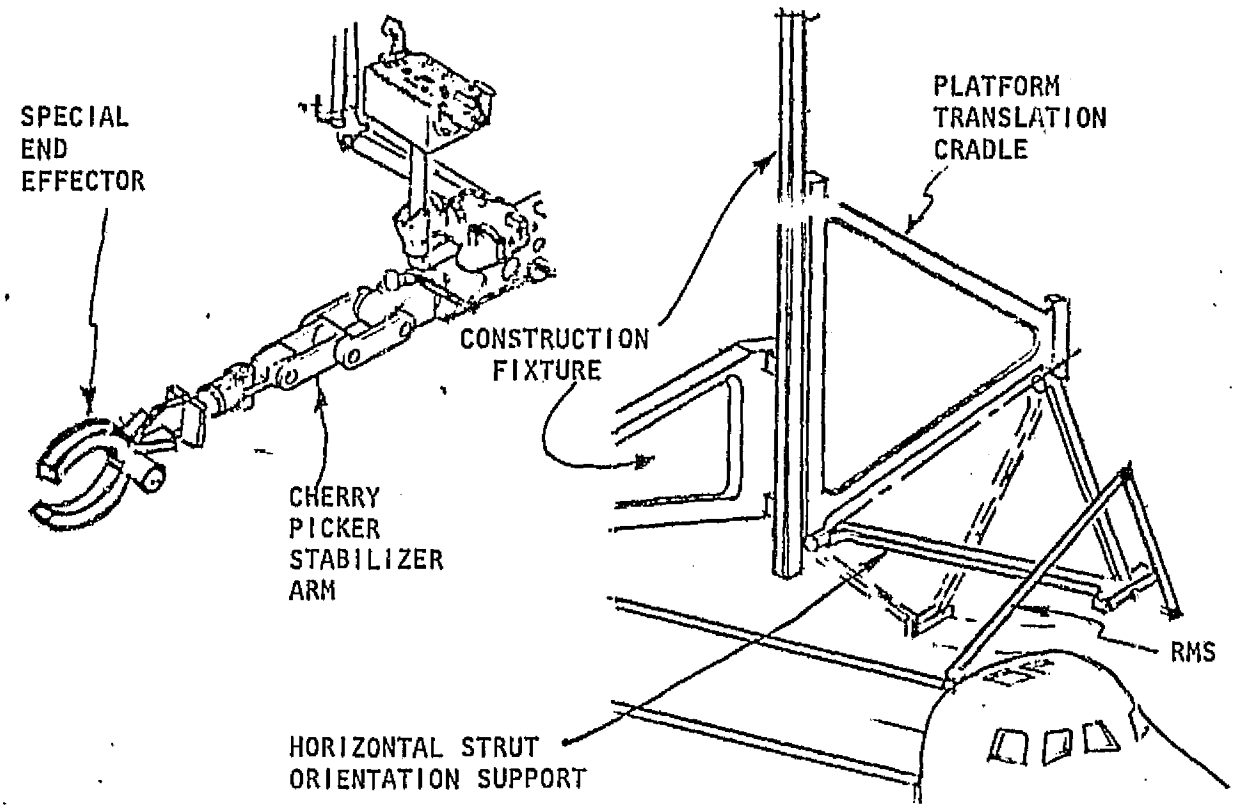
- Strut/union removal from cargo bay	(3 min.)
- Strut/union assembly at strut fixture	(3 min.)
- Transport strut to platform	(2 min.)
- EVA/MMU astronaut joins strut while cherry picker operator prepares next strut	12 min.
TOTAL PER STRUT	12 min.
- Repeat operations for next eight (8) struts to complete one bay	96 min.
TOTAL ELAPSED TIME PER BAY	108 min.

( ) These activities performed in parallel with actual joining of struts by EVA/MMU operator except for first time.

Other

- Major joining operations can be performed in light portion of orbit to permit visibility for moving the struts around (Reduce power reqmts).

FUNCTION	JOIN	CODE	02	05 01.1	03.1
ITEM	STRUTS, JOINTS, BERTHING PORTS				
METHOD	EVA/MMU & CHERRY PICKER	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- MMU
- RMS
- Cherry picker with stabilizer end effector to handle struts and unions
- Horizontal strut orientation support
    - o Triangular structure (~ 14m/side)
    - o Restraint mechanisms for struts and unions
    - o Hinged to swing down to permit structure translation

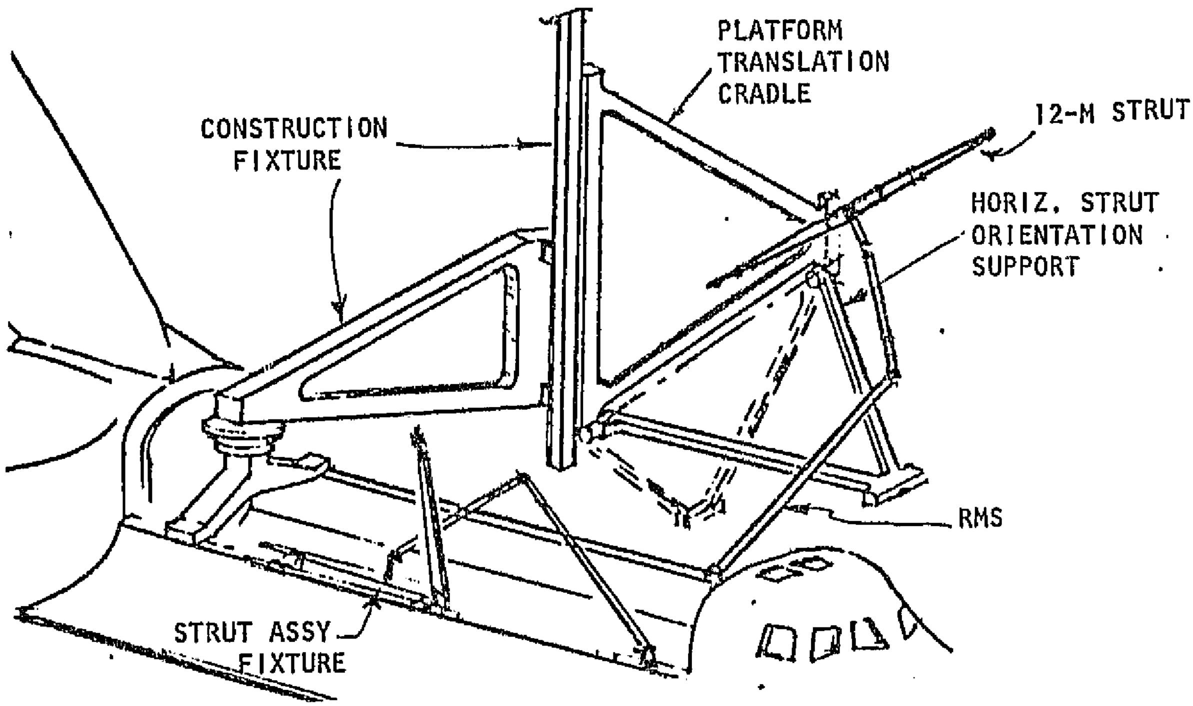
Crew	-	One EVA/MMU Operator	
	-	One Cherry Picker Operator	
Power	-	RMS	1 - 1.8 kW
	-	Cherry Picker	0.5 kW
	-	MMU	TBD
Lighting & TV			
	-	Standard Orbiter, Cherry Picker and MMU	
Computer/Software			
	-	RMS Coordinate Transform System	-
Stowage	-	Cherry Picker	0.9 x 1.6 x 1.1m
	-	Horizontal Strut Orientation Support	14 x 1 x 0.8m
Other	-	MMU Propulsion Recharge	

FUNCTION	JOIN	CODE	02	05 01.1	03.1
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	5 of 5		
METHOD	EVA/MMU & CHERRY PICKER				
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
MMU	110	1.1	--	TBD	TBD	--	100
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
Cherry Picker End Effector	3	NEG	--	TBD	TBD	--	212
RMS	0	0	--	1.8	TBD	--	NC
Horizontal Strut Orientation Support	200	11.2	--	0	0	--	1161
<u>Support Services</u>							
Crew	--	--	2/2	--	--	--	--
Power	--	--	--	TBD	TBD	--	TBD
<u>Project Modifications</u>							
None							
<u>Operations</u>	--	--	2/2	--	--	108	NA*

*Not appropriate, see page 6.

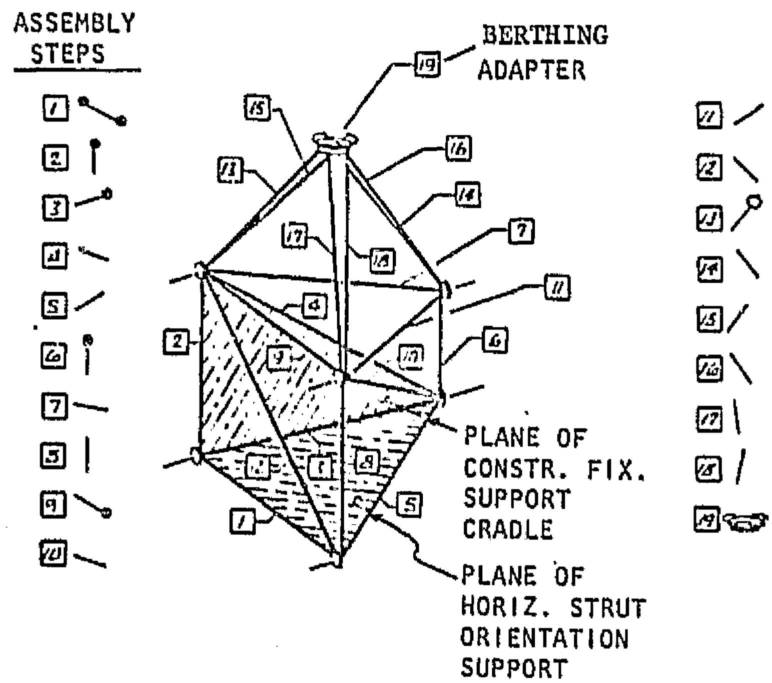
FUNCTION	JOIN	CODE	02	05 01.1	04.1
ITEM	STRUTS, UNIONS, BERTHING PORTS				
METHOD	RMS	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- The RMS removes hinged strut and union from the cargo bay and joins them in the strut assembly fixture.
- The RMS removes the assembly from the fixture and transports it to the platform.
- The strut is then joined to the platform.
- The joining of the struts/unions is continued in a pre-determined sequence along the +Z axis until the entire platform is completed.

FUNCTION · ITEM ·	JOIN STRUTS, UNIONS, BERTHING PORTS	CODE	02	05 01.1	04.1
METHOD	RMS	PAGE	2 of 5		
SUBJECT	OPERATIONS				

STRUCTURE ASSEMBLY SEQUENCE



Manpower

- One RMS Operator at AFD

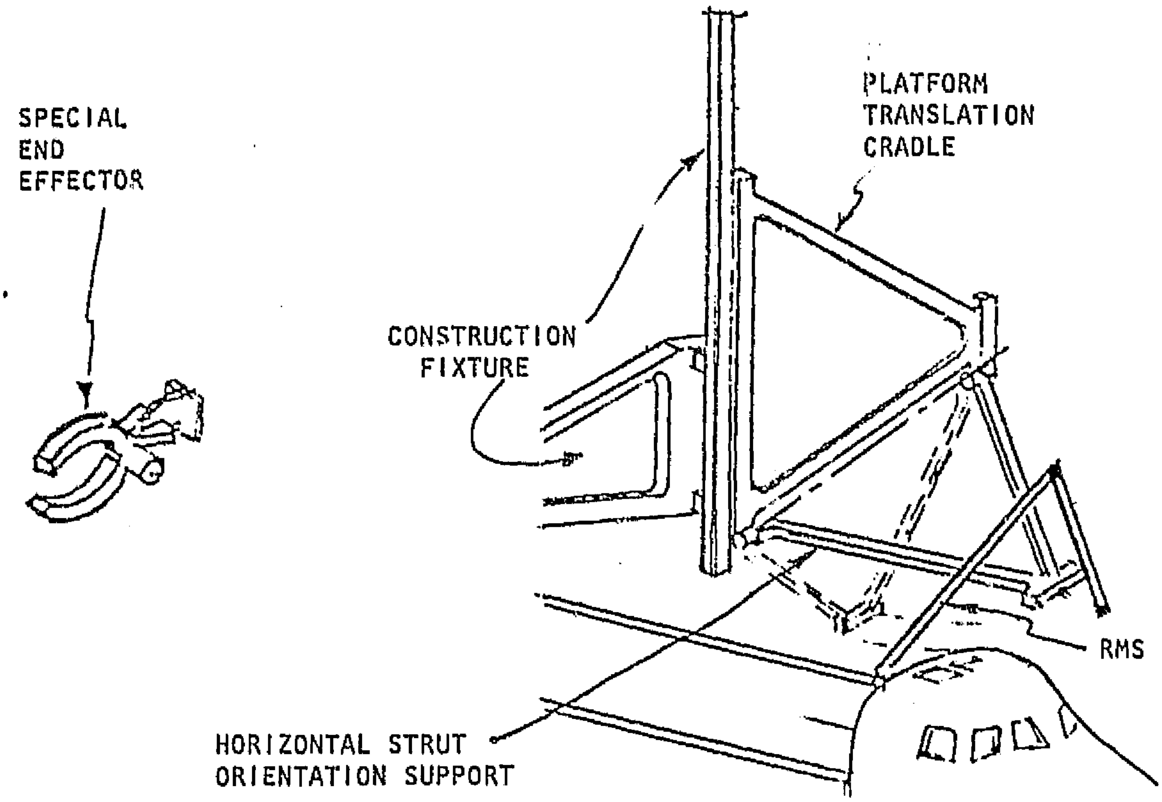
Activity Time

- Strut and union removal from cargo bay	5 min.
- Strut/union assembly at strut fixture	3 min.
- Transport strut to platform	2 min.
- Join strut to platform	10 min.
TOTAL PER STRUT (AVERAGE)	20 min.
- Repeat operations for next eight (8) struts to complete one bay	160 min.
TOTAL PER BAY (AVERAGE)	180 min.

Other

- Major joining operations can be performed in light portion of orbit to permit visibility for moving the long struts around (Reduce power requirements).

FUNCTION· ITEM	JOIN STRUTS, JOINTS, BERTHING PORTS	CODE	02	05 01.1	04.1
METHOD	RMS	PAGE	3 of 5		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS
- RMS Special End Effector
- Horizontal Strut Orientation Support
  - o Triangular structure (~ 14m/side)
  - o Restraint mechanisms for struts and unions
  - o Hinged to swing down to permit structure translation

FUNCTION	JOIN	CODE	02	05 01.1	04.1
ITEM	STRUTS, UNIONS, BERTHING PORTS				
METHOD	RMS	PAGE	4	of	5
SUBJECT	SUPPORT SERVICES				

Crew – One RMS Operator at AFD

Power – RMS 1 - 1.8 kW

Lighting & TV

– Standard RMS and Orbiter

Computer/Software

– RMS Coordinate Transform System

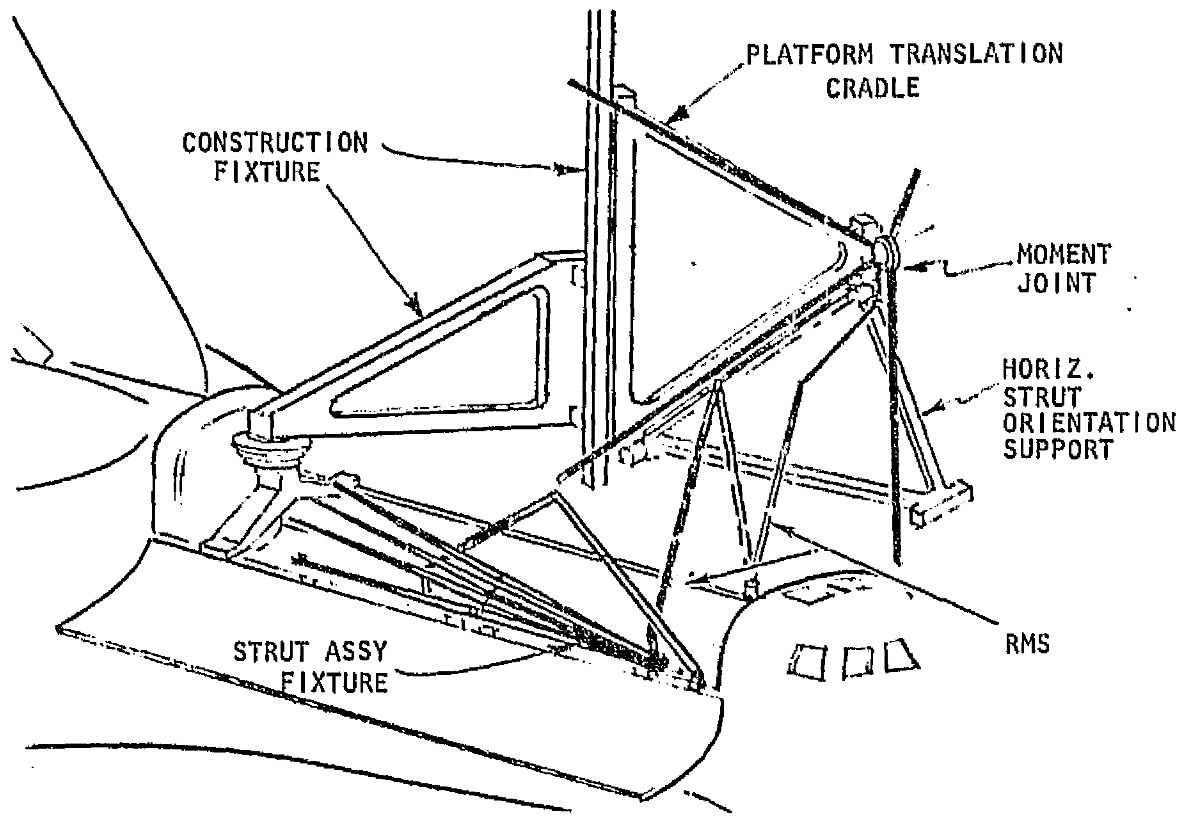
Stowage

– Horizontal Strut Orientation Support 14 x 1 x 0.8m

FUNCTION	JOIN	CODE	02 · 05 01.1 · 04.1
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	5 of 5
METHOD	RMS		
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
RMS	0	0	--	1.8	TBD	--	NC
RMS Special End Effector	3	NEG	--	TBD	TBD	--	212
Horizontal Strut Orientation Support	200	11.2	--	0	0	--	1161
<u>Support Services</u>							
Crew	--	--	1/1	--	--	--	--
Power	--	--	--	TBD	TBD	--	TBD
<u>Project Modifications</u>							
None							
<u>Operations</u>	--	--	1/1	--	--	180	NA*

*Not appropriate, see page 6.

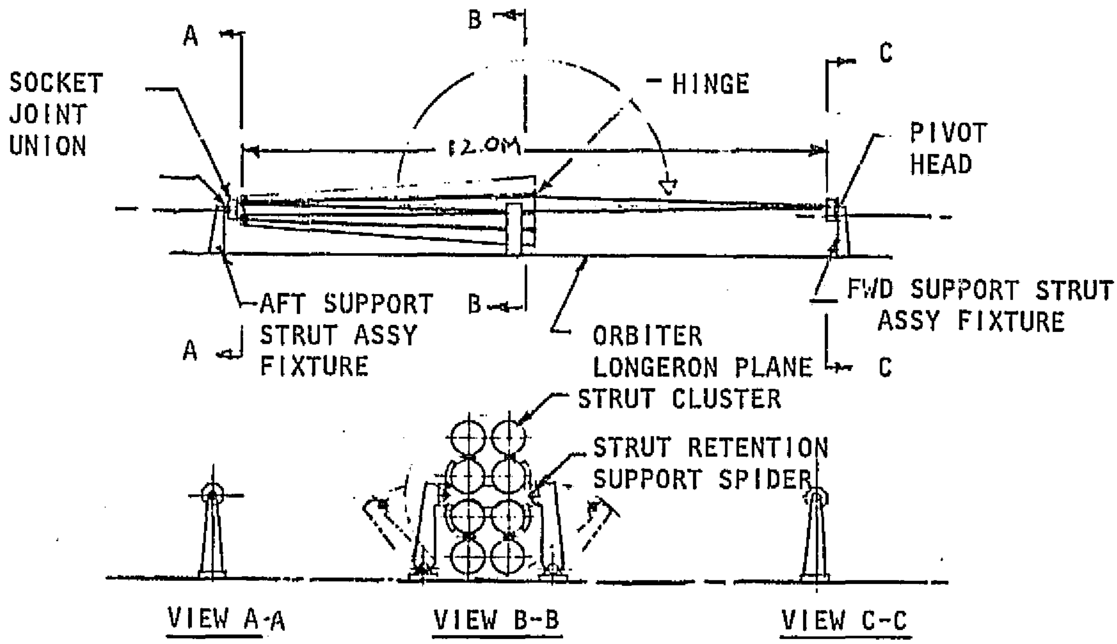


- o The RMS removes a pre-assembled strut cluster (4 apex struts) from the bay and positions it in the strut assembly fixture.
- o The strut cluster is unfolded and required unions are attached.
- o The cluster is partially deployed.
- o The deployed cluster is transported to the platform and attached to the fixture.

- o The RMS removes a single hinged strut and union from the cargo bay and joins them in the strut assembly fixture
- o The RMS removes the strut from the fixture and transports it to the platform.
- o The strut is then joined to the platform.
- o This operation is continued to complete one bay (4 struts).

- o The single strut operation is repeated for the apex to apex strut.
- o This entire sequence is repeated for each bay.

FUNCTION	JOIN	CODE	02	05 01.1	04.2
ITEM	STRUTS, UNIONS, BERTHING PORTS				
METHOD	RMS/STRUT CLUSTER	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				

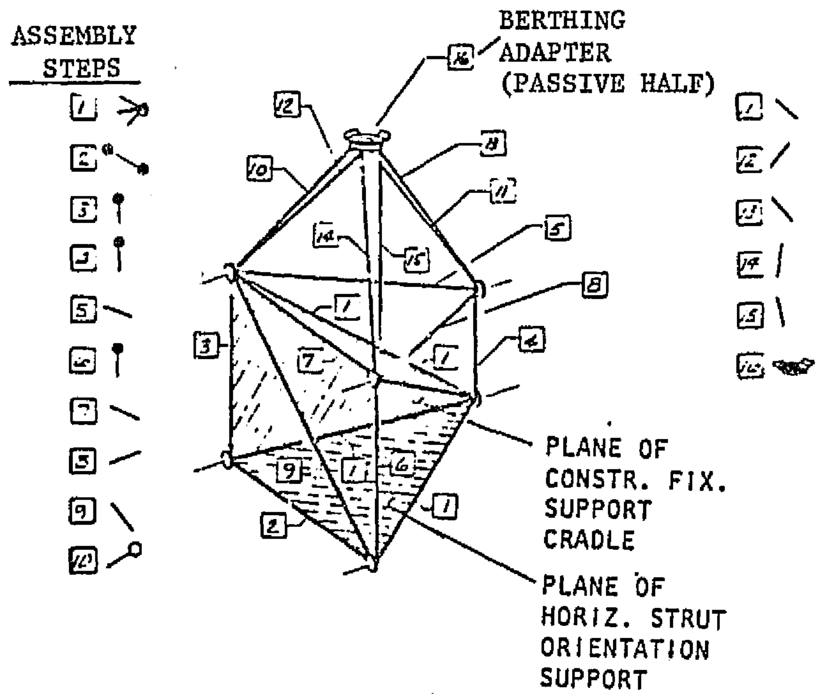


Structure (Struts)

- Four 12.0m long struts are hinged at their midpoint with four ball ends of the struts attached to a socket joint union, and the four free strut halves are folded back over and secured to their counterpart at the small strut end near the union joing. The large (hinged end) of the struts are secured with a supporting retention spider.

FUNCTION	JOIN	CODE	02	05 01.1	04.2
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	3 of 6		
METHOD	RMS/STRUT CLUSTER				
SUBJECT	OPERATIONS				

STRUCTURE ASSEMBLY SEQUENCE



Manpower

- One RMS Operator at AFD

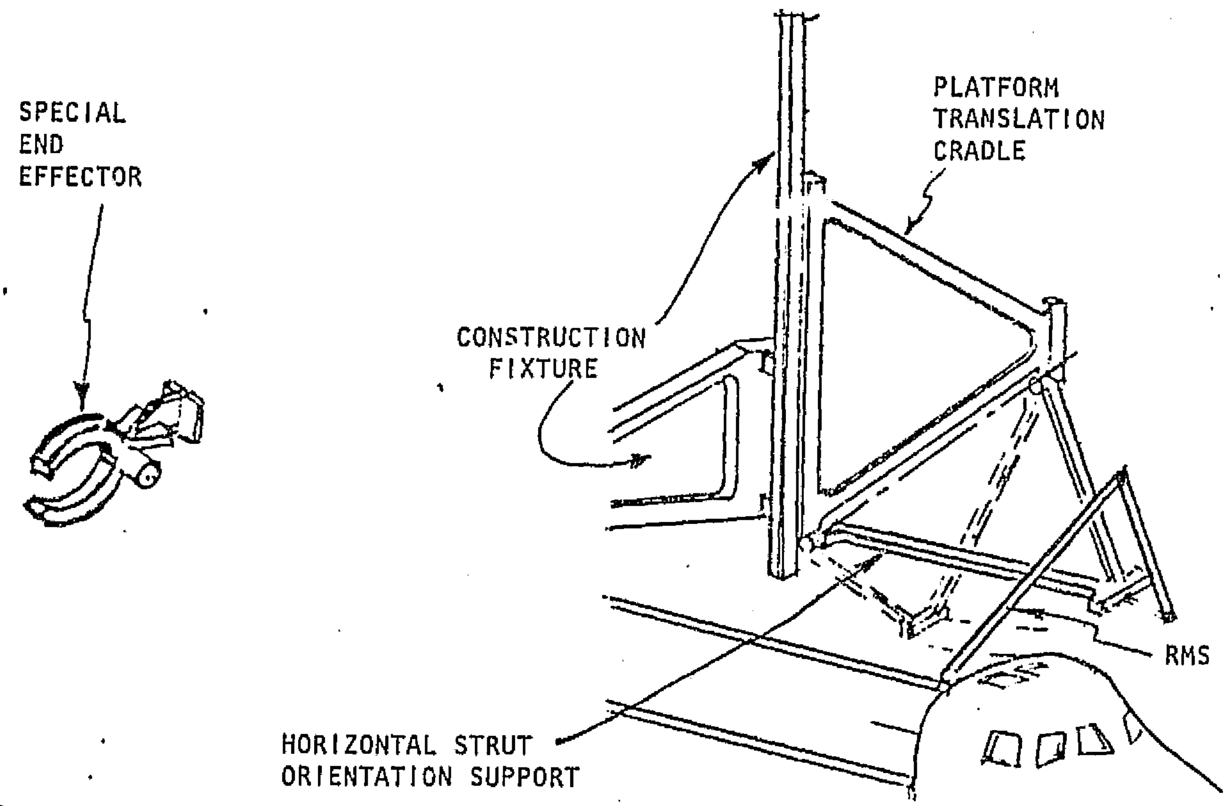
Activity Time

- Strut and union removal from cargo bay	5 min.
- Strut/union assembly at strut fixture	3 min.
- Transport strut to platform	2 min.
- Join strut to platform	10 min.
TOTAL PER STRUT (AVERAGE)	20 min.
- Repeat operations for next four struts to complete base and apex tie struts	80 min.
- Remove strut cluster from cargo bay	2 min.
- Cluster/union assembly of strut fixture	12 min.
- Cluster transport to platform	3 min.
- Strut joining	20 min.
TOTAL PER BAY	137 min.

Other

- Major joining operations will be performed in light portion of orbit to permit visibility for moving the long struts around.

FUNCTION · ITEM	JOIN STRUTS, JOINTS, BERTHING PORTS	CODE	02	05 01.1	04.2
METHOD	RMS/STRUT CLUSTER	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- Horizontal Strut Orientation Support
  - o Triangular Structure (~ 14m/side)
  - o Restraint Mechanisms for Struts and Unions
  - o Hinged to swing down to permit structure translation.
- RMS with Special End Effector

FUNCTION	JOIN	CODE	02 | 05 01.1 | 04.2
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	5 of 6
METHOD	RMS/STRUT CLUSTER		
SUBJECT	SUPPORT SERVICES		

Crew - One RMS Operator at AFD

Power - RMS 1 - 1.8 kW

Lighting & TV

- Standard RMS & Orbiter

Computer/Software

- RMS Coordinate Transform System

Stowage - Horizontal Strut Orientation Support 14 x 1 x 0.8m

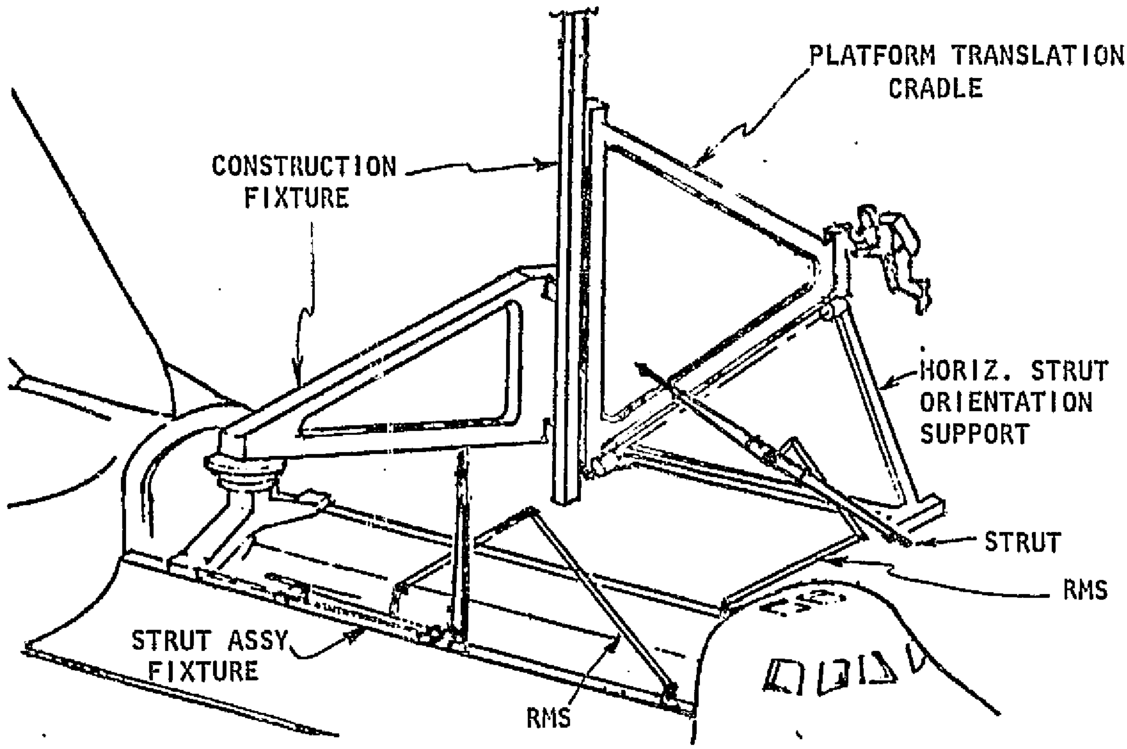
FUNCTION	JOIN	CODE	02	05 01.1	04.2
ITEM	STRUTS, UNIONS, BERTHING PORTS	PAGE	6 of 6		
METHOD	RMS/STRUT CLUSTER				
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	--	1.8	TBD	--	NC
RMS End Effector	3	NEG	--	TBD	TBD	--	212
Horizontal Strut Orientation Support	200	11.2	--	0	0	--	1161
Support Services							
Crew	--	--	1/1	--	--	--	--
Power	--	--	--	TBD	TBD	--	TBD
Project Modifications							
Strut Clusters	*0	--	--	--	--	--	NA**
Operations	--	--	1/1	--	--	137	

*No change from individual struts and unions

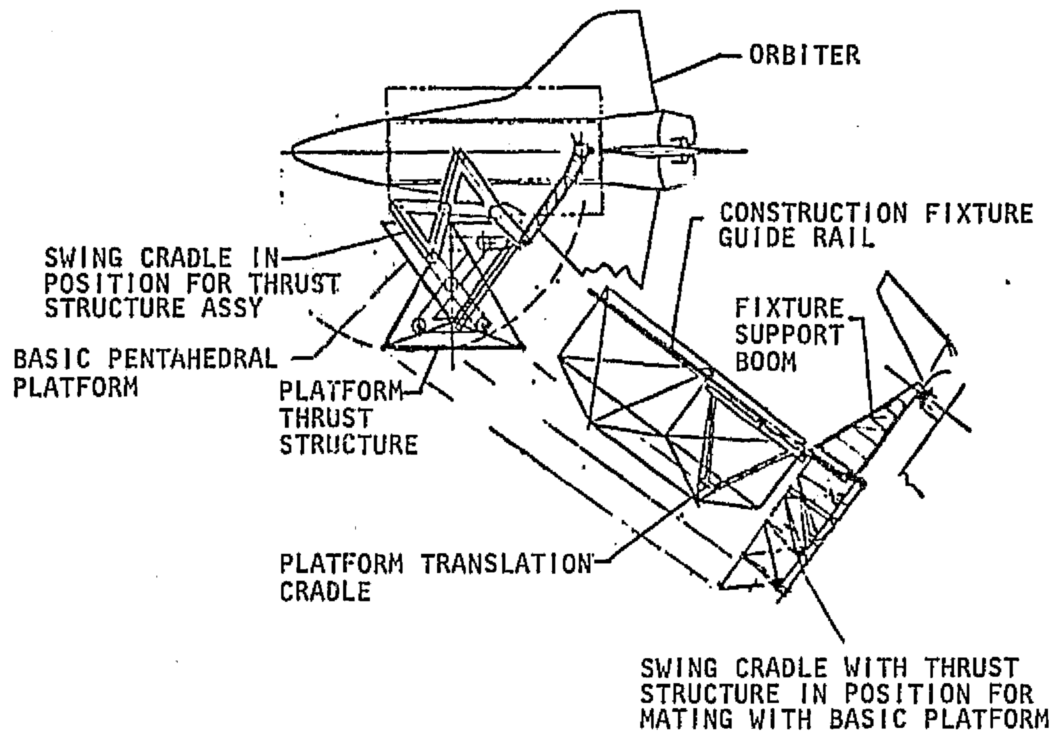
**Not appropriate, see page 6.

FUNCTION	JOIN	CODE	02	05 01.1	01.1
ITEM	STRUTS, UNIONS, BERTHING PORTS				
METHOD	EVA/MMU	PAGE	1 of 1		
SUBJECT					



- EVA/MMU astronaut remove hinged strut and union from the cargo bay and joins them in the strut assembly fixture.
- The assembly is removed from the fixture and transported to the platform by EVA/MMU.
- The struts are joined to the partially completed platform, one end at a time.
- These operations are repeated until the entire platform structure is completed.
- The operations can be performed by one or two EVA/MMU astronauts.

FUNCTION · JOIN	CODE	02	05 01.2	00
ITEM THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	PAGE	1 of 2		
METHOD				
SUBJECT OPERATION IDENTIFICATION				



Project System

Erectable Advanced Communications Platform

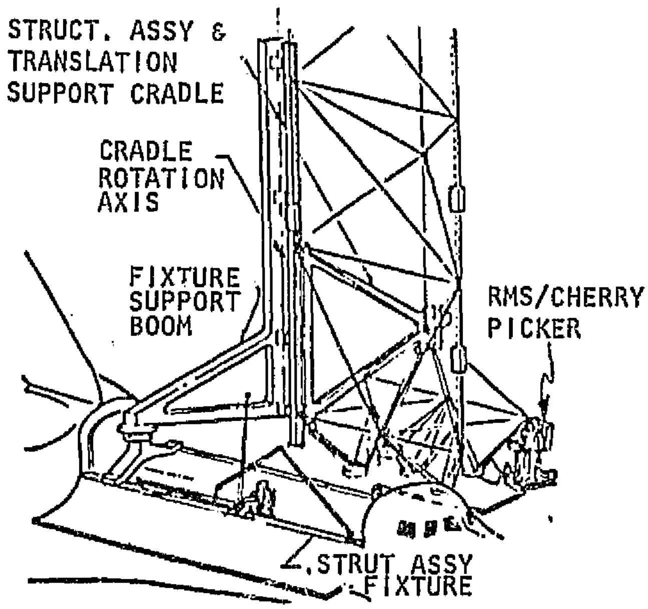
Operation

Join thrust structure struts, joints and berthing ports to platform.

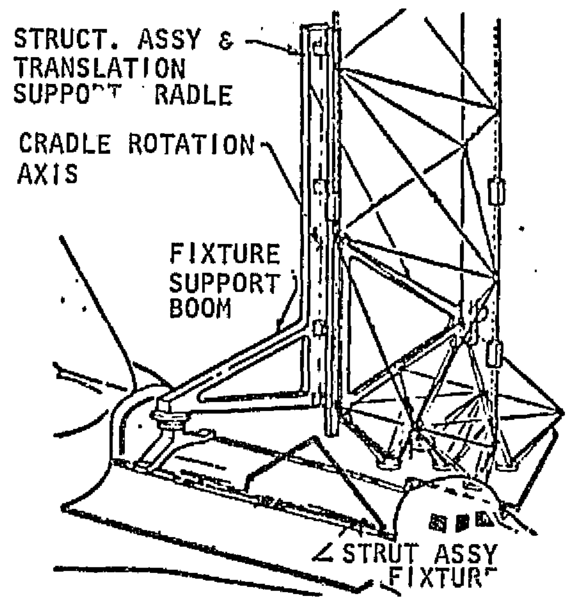
Physical Situation

- The basic pentahedral platform is complete.
- Platform is supported by the construction fixture.
- Pivotable swing cradle for thrust structure assembly is attached to lower portion of the construction fixture.

FUNCTION	JOIN	CODE	02	05 01.2	00
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD		PAGE	2 of 2		
SUBJECT	ALTERNATE METHODS				



MANUAL



AUTOMATIC

The following methods have been identified:

Manual

1. RMS assembly of individual (five) propulsion module support structures with cherry picker for joining to platform.

2. Cherry picker placement of ground assembled propulsion module support structures on swing support cradle.

3. EVA/MMU (with RMS assist) joining of individual struts, etc., directly to platform.

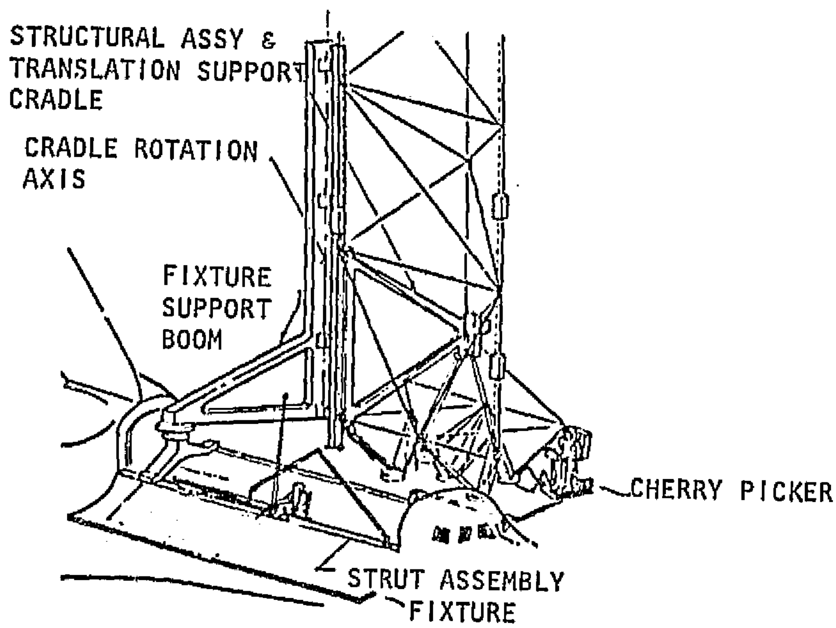
Automated

4. RMS joining of struts, etc., directly to platform.

5. RMS joining of struts, etc., on swing cradle.

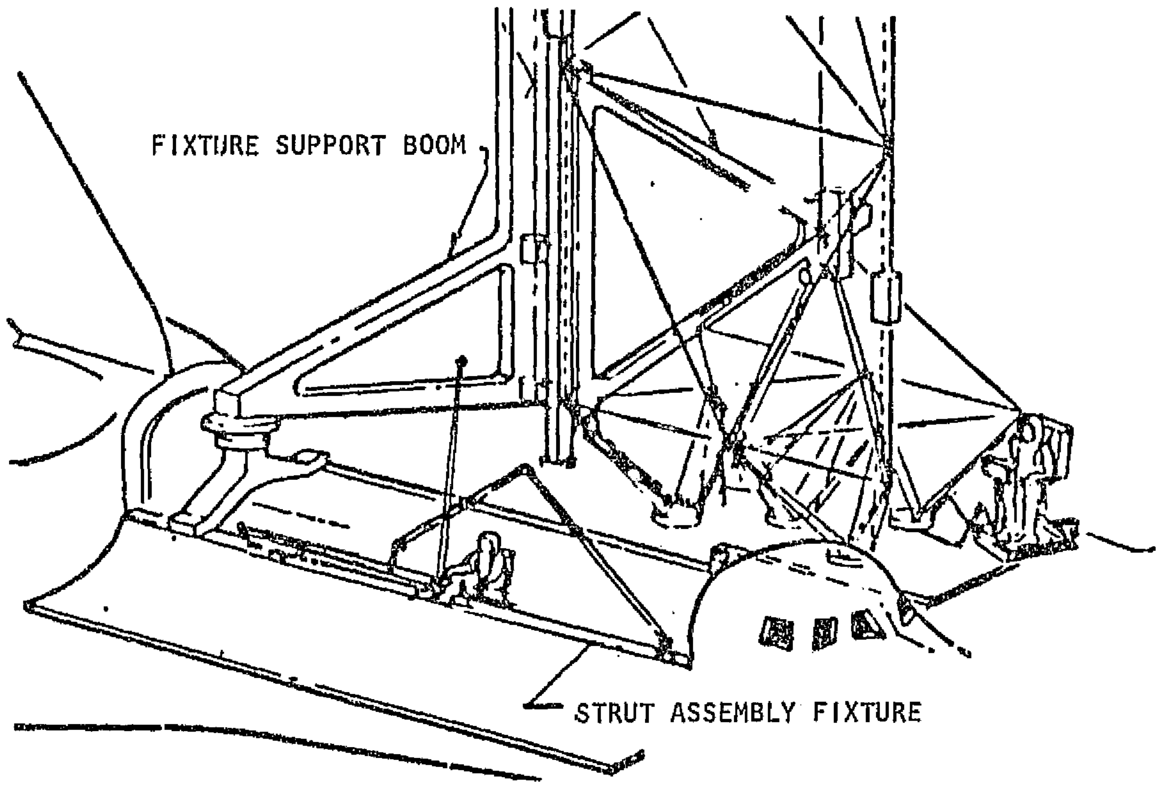
Methods 1 and 2 are detailed.

FUNCTION	JOIN	CODE	02	05 01.2	03.1
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	CHERRY PICKER	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- Starboard mounted RMS removes hinged struts, unions and berthing ports from orbiter bay.
- Struts, unions and berthing ports are joined at the strut assembly fixture to form one of the five propulsion module support structures.
- Port side RMS with cherry picker picks up assembly and translates it to a location on the end of the platform for attachment.
- Astronaut in cherry picker attaches assembly to platform.
- Sequence is repeated until all five propulsion module support structures are attached and aligned on the platform.

FUNCTION	JOIN	CODE	02	05 01.2	03.1
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	CHERRY PICKER	PAGE	2	of	6
SUBJECT	OPERATIONS				

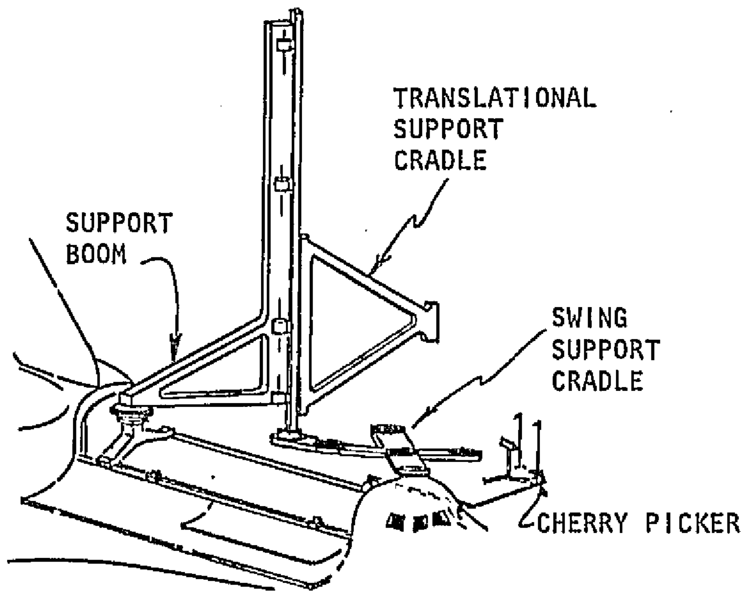


Manpower

- o One Cherry Picker operator
- o One RMS Operator (AFD)

Activity Time

o	Struts (6) removal from orbiter bay	18 min.
o	Struts assembly at strut assembly fixture	30 min.
	Total per propulsion module support structure	48 min.
o	Transport assembly to platform structure	.5 min.
o	Attach assembly to platform	10 min.
	Total assembly time per cluster	63 min.
o	Assemble/attach remaining four clusters	252 min.
	Total for thrust structure	315 min. (5.25 hrs.)

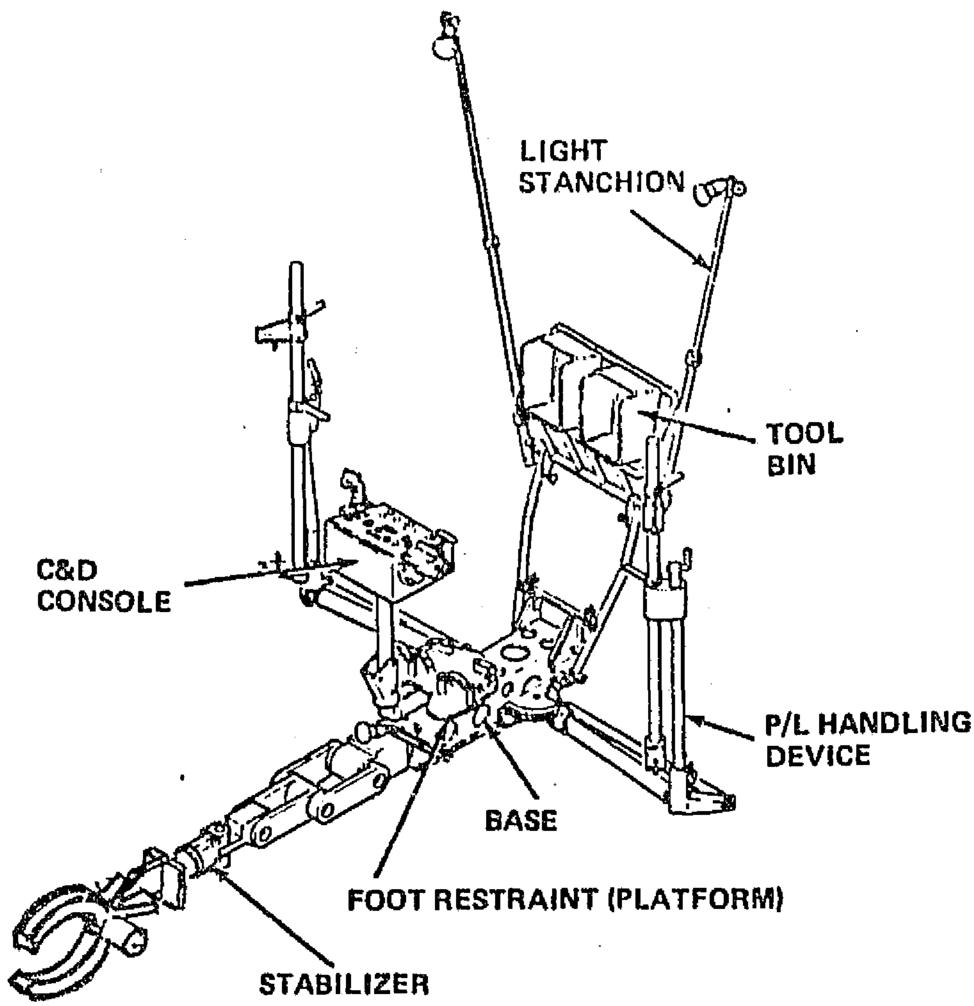


CONSTRUCTION FIXTURE

Items

- Starboard and port RMS
- Cherry picker
- Special end effector for cherry picker stabilizer arm (see Page 4)

FUNCTION	JOIN	CODE	02	05 01.2	03.1
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	CHERRY PICKER	PAGE	4	of	6
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS (Continued)				



FUNCTION	JOIN	CODE	02	05 01.2	03.1
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	PAGE	5 of 6		
METHOD	CHERRY PICKER				
SUBJECT	SUPPORT SERVICES				

Crew - One cherry picker operator

One RMS operator (AFD)

Power - RMS operation 1.0 - 1.8 kW

Cherry picker operation 0.5 kW

Lighting & TV -

Standard cherry picker, RMS and payload bay

Computer/Software -

RMS coordinate transform system

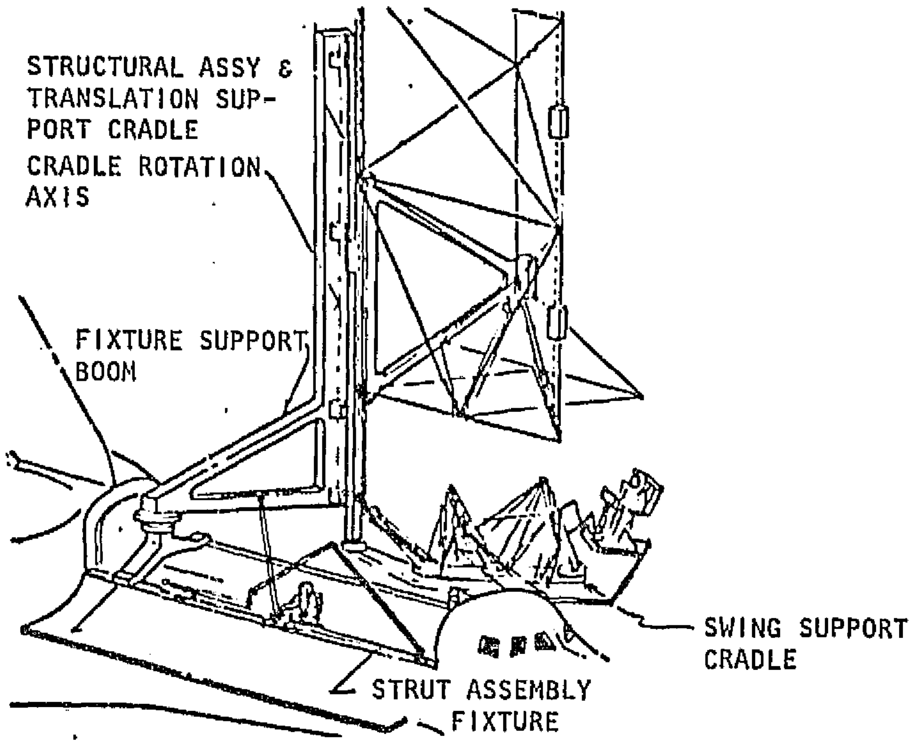
Stowage - Cherry picker - 0.9 x 1.6 x 1.1m

FUNCTION JOIN ITEM THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	CODE	02	05 01.2	03.1
METHOD CHERRY PICKER	PAGE	6 of 6		
SUBJECT SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS (First)	0	0	--	1.8	TBD	--	NC
RMS (Second)	411	0	--	1.8	TBD	--	TBD
Cherry Picker	273	1.6	--	0.5	TBD	--	212
Cherry Picker End Effector	3	NEG	--	TBD	TBD	--	
Support Services							
Crew	--	--	2/1.5	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Project Modification							
None							
Operations	--	--	2/1.5	--	--	315	NA*

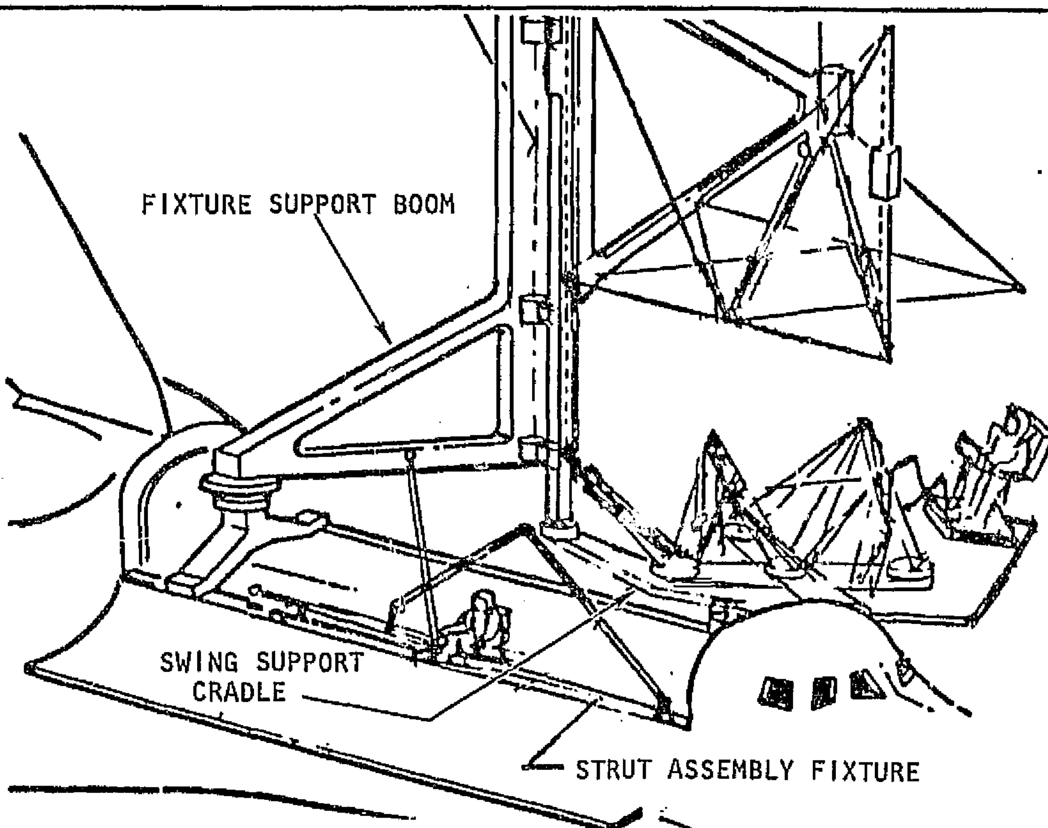
*Not appropriate, see page 6.

FUNCTION: JOIN	CODE	02	05 01.2	03.2
ITEM: THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD: CHERRY PICKER - SWING SUPPORT CRADLE	PAGE	1	of	6
SUBJECT: METHOD DESCRIPTION				



- Assembled platform is elevated by translation cradle.
- Swing support cradle is rotated clockwise over orbiter bay.
- Ground fabricated propulsion module support assemblies are removed from the orbiter and attached to the swing cradle by the cherry picker.
- After the five assemblies are attached, the swing cradle is rotated counter clockwise to align with the platform.
- The platform is lowered and attachment to the thrust structure assembly is made.

FUNCTION: JOIN ITEM THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	CODE	02	05 01.2	03.2
METHOD CHERRY PICKER - SWING SUPPORT CRADLE	PAGE	2 of 6		
SUBJECT OPERATIONS				



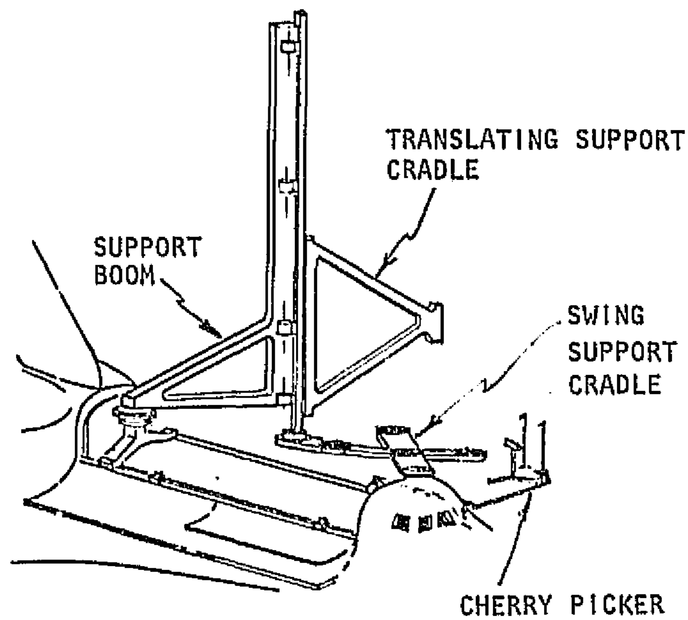
Manpower

- One cherry picker operator

Activity Time

o Rotate swing cradle to assembly position	5 min.
o Transport propulsion module support assembly to cradle	5 min.
o Attach assembly to cradle	3 min.
o Transport and attach remaining four assemblies	32 min.
o Rotate swing cradle to align with platform	5 min.
o Attach thrust structures to platform	50 min.
Total	100 min.

FUNCTION	JOIN	CODE	02	05 01.2	03.2
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	CHERRY PICKER - SWING SUPPORT CRADLE	PAGE	3	of	6
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				

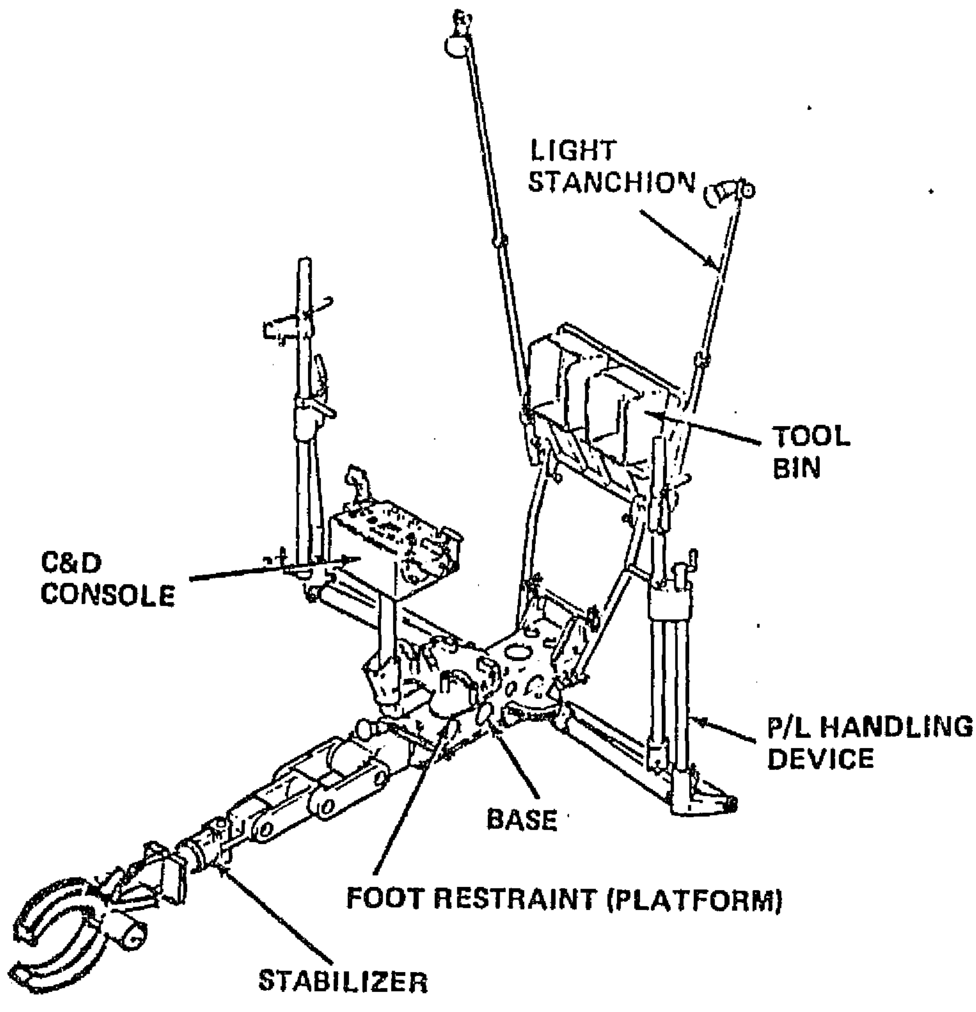


CONSTRUCTION FIXTURE

Items

- RMS
- Cherry picker
- Swing support cradle
- Special end effector for cherry picker stabilizer arm (see Page 4)

FUNCTION	JOIN	CODE	02	05 01.2	03.2
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	CHERRY PICKER - SWING SUPPORT CRADLE	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS (Continued)				



Crew - Cherry picker operator

Power - Cherry picker operation 0.5 kW

RMS operation 1 - 1.8 kW

Lighting & Television -

Standard cherry picker and payload bay

Computer/Software -

RMS coordinate transform system

Stowage -

Cherry picker - 0.9 x 1.6 x 1.1m

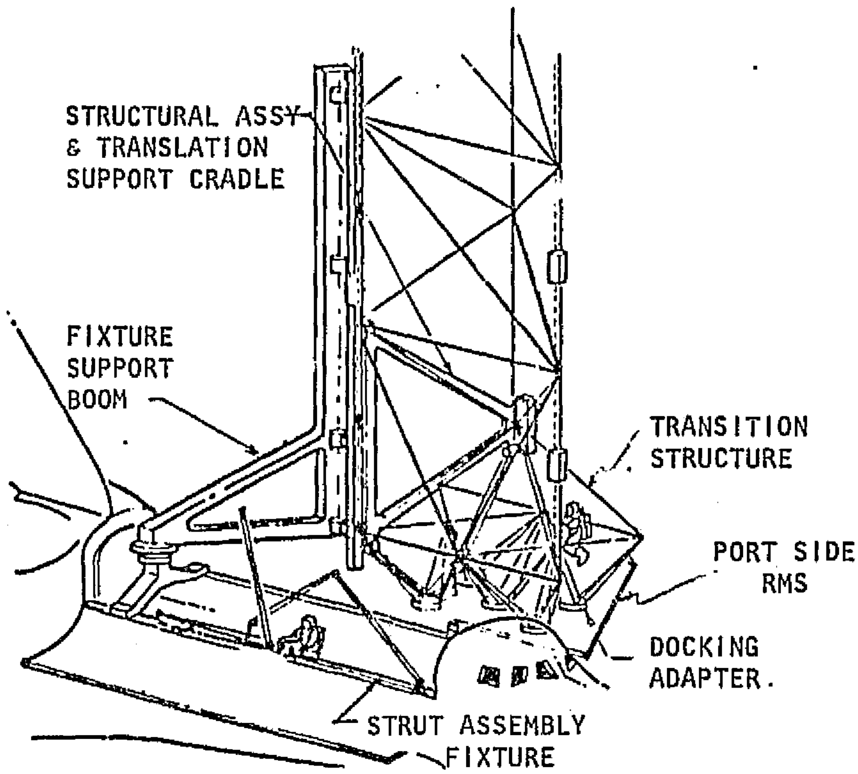
Swing support cradle - 3 x 3 x 4m

FUNCTION JOIN ITEM THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	CODE	02	05 01.2	03.2
METHOD CHERRY PICKER - SWING SUPPORT CRADLE	PAGE	6 of 6		
SUBJECT SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	--	1.8	TBD	--	NC
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
Swing Support Cradle	250	36.0	--	TBD	TBD	--	3839
Cherry Picker End Effector	3	NEG	--	TBD	TBD	--	212
Support Services							
Crew	--	--	1	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Other							
Project Modification							
None							
Operations	--	--	1	--	--	100	NA*

*Not appropriate, see page 6.

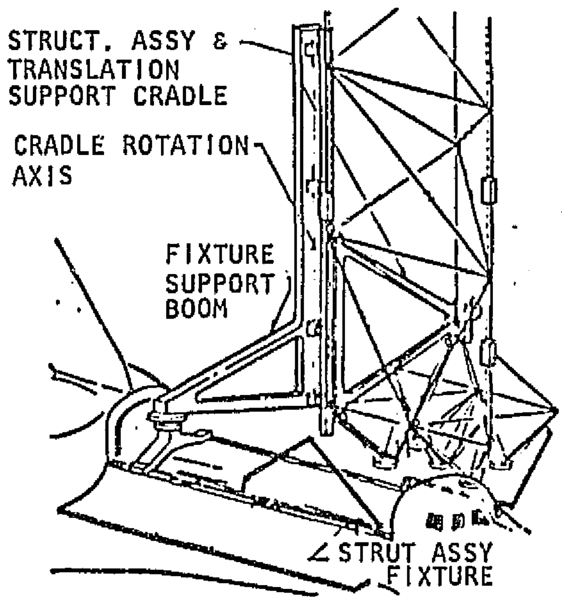
FUNCTION·	JOIN	CODE	02	05 01.2	02.1
ITEM	THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD	EVA/MMU	PAGE	1 of 1		
SUBJECT	METHOD DESCRIPTION				



- RMS removes hinged struts and unions from orbiter bay and assembles them at the strut assembly fixture.
- RMS transports finished assemblies to platform position.
- Astronaut/MMU makes attachment of strut(s) to basic platform structure.
- Provisions are required to properly align thrust structure berthing adaptor to the basic pentahedral structure.

NO ADDITIONAL DETAILS ARE PROVIDED

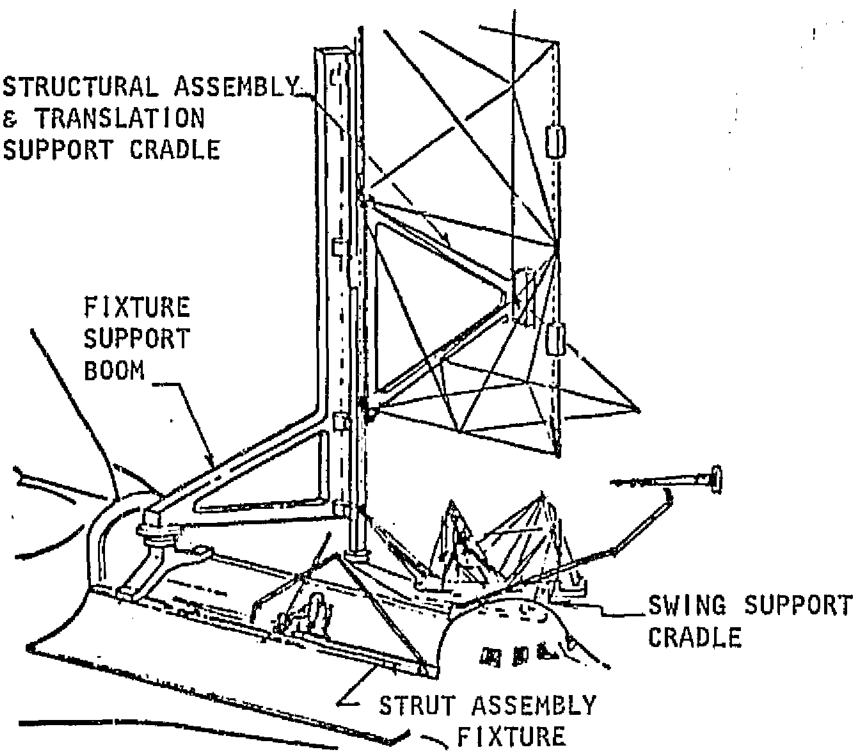
FUNCTION · JOIN	CODE	02	05 01.2	04.1
ITEM. THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM				
METHOD RMS	PAGE	1 of 1		
SUBJECT METHOD DESCRIPTION				



- RMS removes hinged struts and unions from orbiter bay and assembles them at the strut assembly fixture.
- RMS transports the assemblies and joins them to the platform.
- Provisions are required from the orbiter to properly align the thrust structure berthing adaptors with the basic pentahedral.

NO ADDITIONAL DETAILS ARE PROVIDED

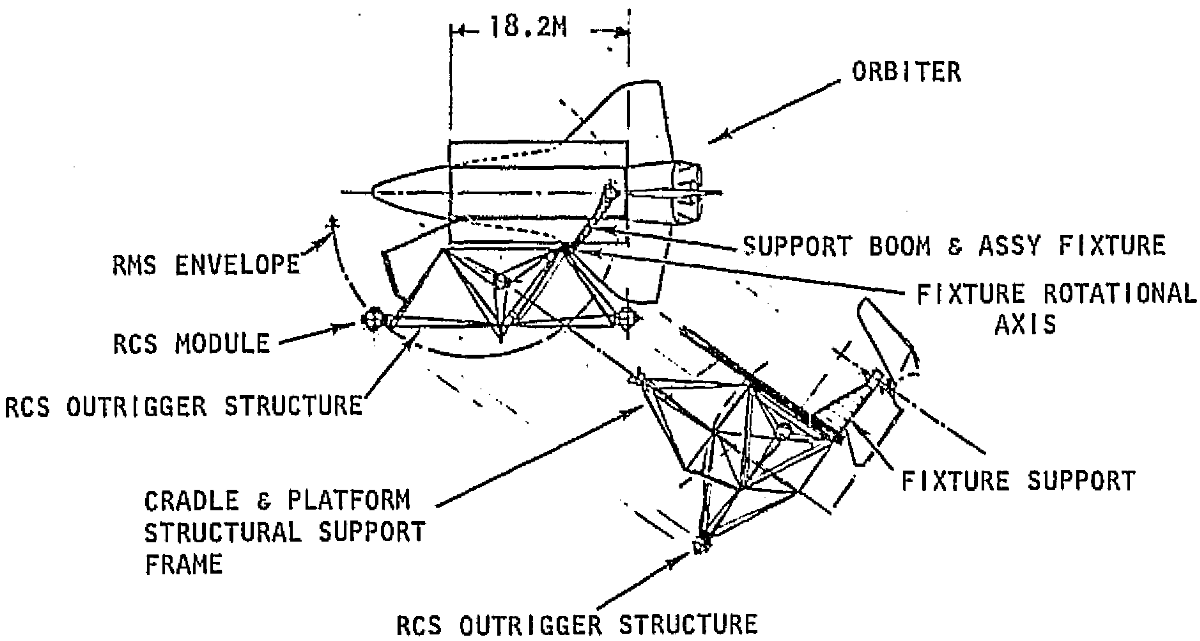
FUNCTION: JOIN ITEM THRUST STRUCTURE STRUTS, JOINTS, PORTS/PLATFORM	CODE	02	05 01.2	04.2
METHOD RMS - SWING SUPPORT CRADLE	PAGE	1	of	1
SUBJECT METHOD DESCRIPTION				



- RMS removes hinged struts and unions from orbiter bay and assembles them at the strut assembly fixture.
- RMS transports the assembly to the swing platform for joining into one of the propulsion module support structures.
- With all five mini thrust structures in place on the swing cradle, the basic pentahedral structure is lowered for attachment to the thrust structure supported by the swing cradle.
- Alignment is assured because all berthing adaptors were supported during assembly by the swing cradle.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	00
METHOD		PAGE	1 of 2		
SUBJECT	OPERATION IDENTIFICATION				



Project System

- Erectable Advanced Communications Platform

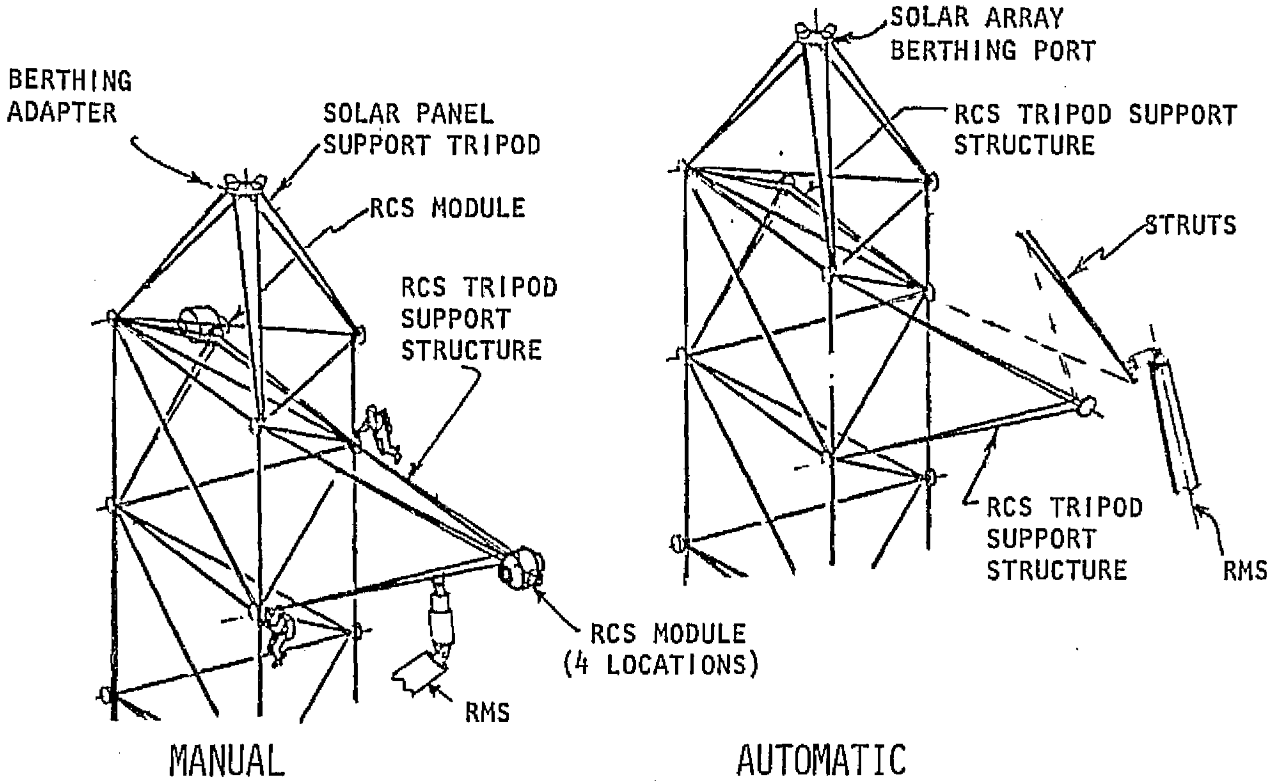
Operation

- Install RCS support structure and RCS modules and associated wiring to basic structure at four locations (two at each end of platform)

Physical Situation

- The basic pentahedral structure is complete.
- Structural assembly is supported by the assembly fixture which is attached to a boom docked in the orbiter bay.
- The individual, folded, nested struts are stored in cargo bay.
- Berthing ports, RCS modules, and electrical wiring in cannisters are separate cargo items.
- Electrical junction boxes are mounted on the unions.

FUNCTION / ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	00
METHOD		PAGE	2	of	2
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

Manual

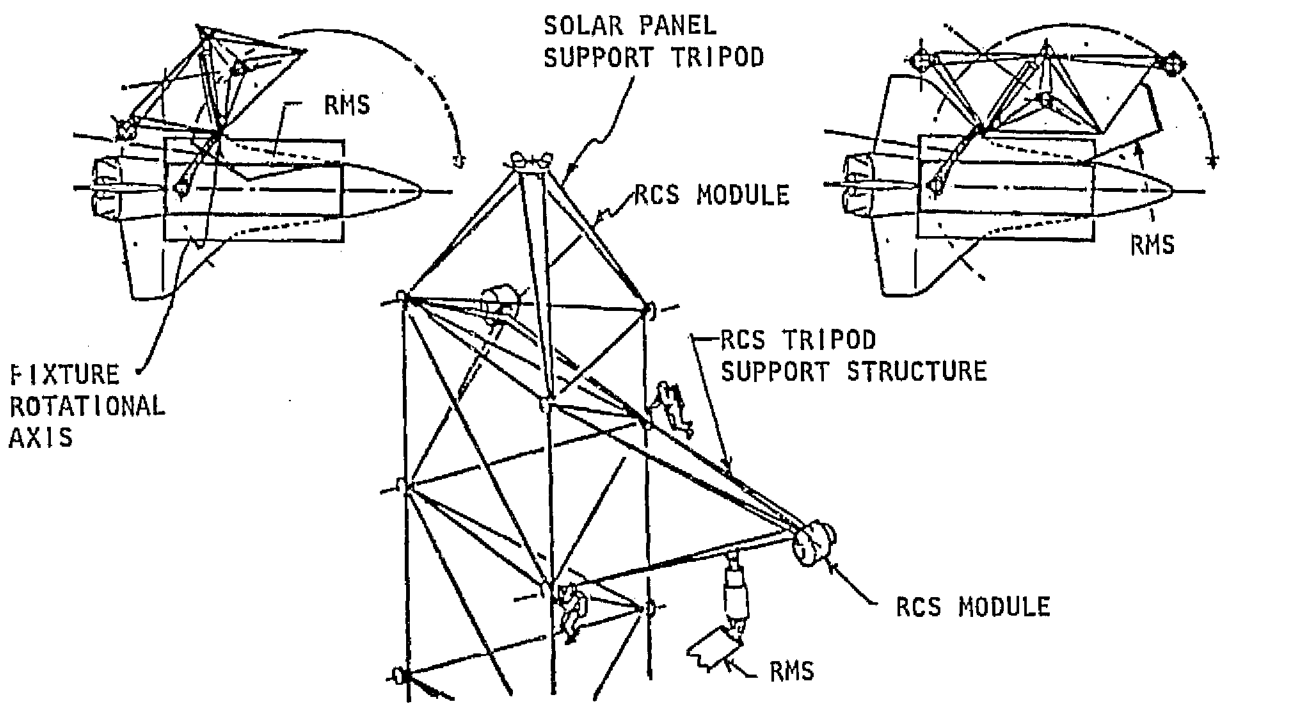
1. RMS delivers assembled tripod structure (including RCS module) from the orbiter bay to the platform for installation with assistance from the astronauts located at interface locations.
2. Identical to Concept Method #1, except RCS module is installed after tripod structure is attached to platform -- requires 2nd RMS.
3. Astronaut in cherry picker performs all assembly operations (RCS module installed at strut assembly fixture).

Automatic

4. Automated/articulating fixture to position structure within reach of RMS.

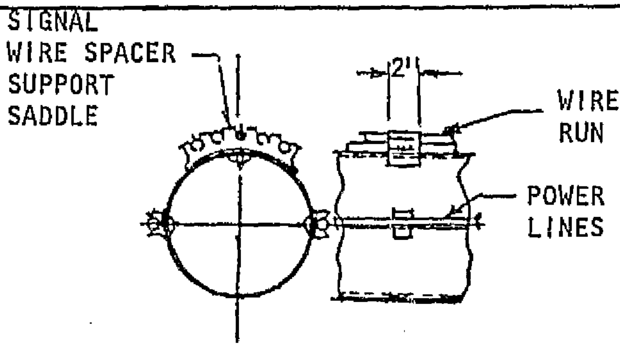
Methods 1, 2 and 4 are detailed.

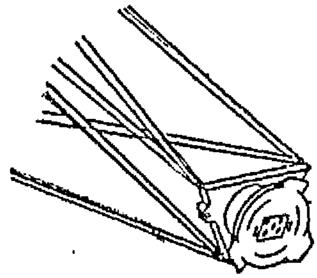
FUNCTION	INSTALL	CODE	02	06 01.1	02.1
ITEM	RCS STRUCTURE, MODULE & WIRING	PAGE	1 of 6		
METHOD	EVA/MMU - RMS				
SUBJECT	METHOD DESCRIPTION				



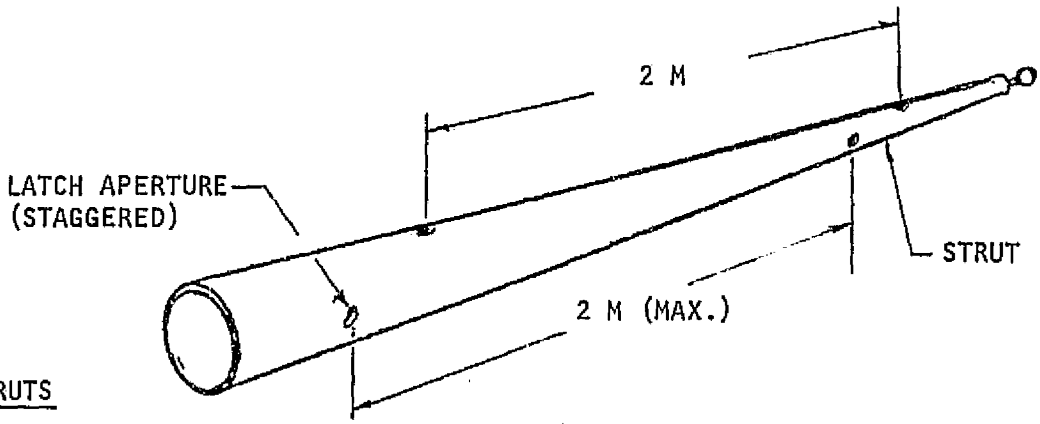
- Struts are transported from storage location to assembly area in cargo bay by EVA/MMU astronauts.
- Struts are unfolded, berthing port is retrieved and joined to struts and electrical wiring installed by astronauts.
- RMS retrieves RCS module and joins it to strut assembly. Astronaut connects wiring to module.
- Fixture is rotated outward towards the orbiter tail to move the platform within the RMS reach envelope.
- RMS transports RCS tripod assembly to location at platform.
- EVA/MMU astronauts join strut ends to platform and connects wiring to platform wiring at J-box on basic structure union.

FUNCTION ·	INSTALL	CODE	02	06 01.1	02.1
ITEM ·	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU — RMS	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				





FIXED UNION



STRUTS

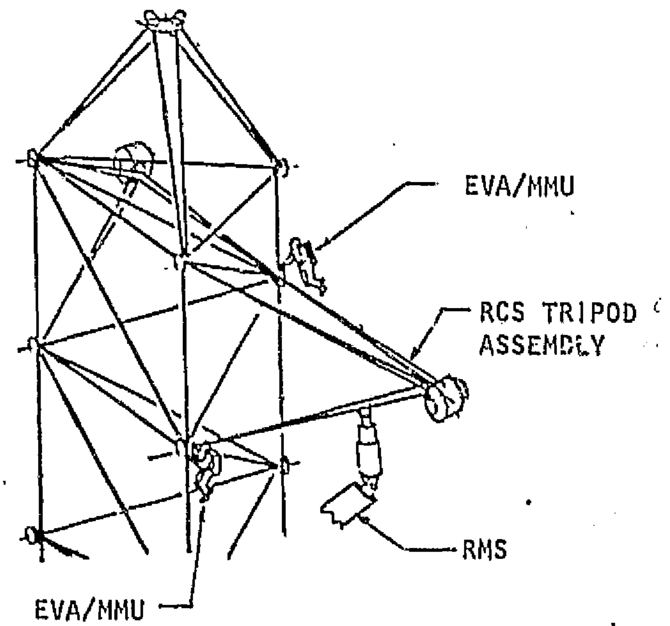
Struts (2) Wire Support

- Four holes 90° on center at 2.0m spacing staggered along length to support electrical wires.

RCS/Struts Union

- Fixed (moment carrying) struts to RCS module support union.

FUNCTION ·	INSTALL	CODE	02	06 01.1	02.1
ITEM ·	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU -- RMS	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

- RMS Operator at AFD
- Two EVA/MMU Astronauts

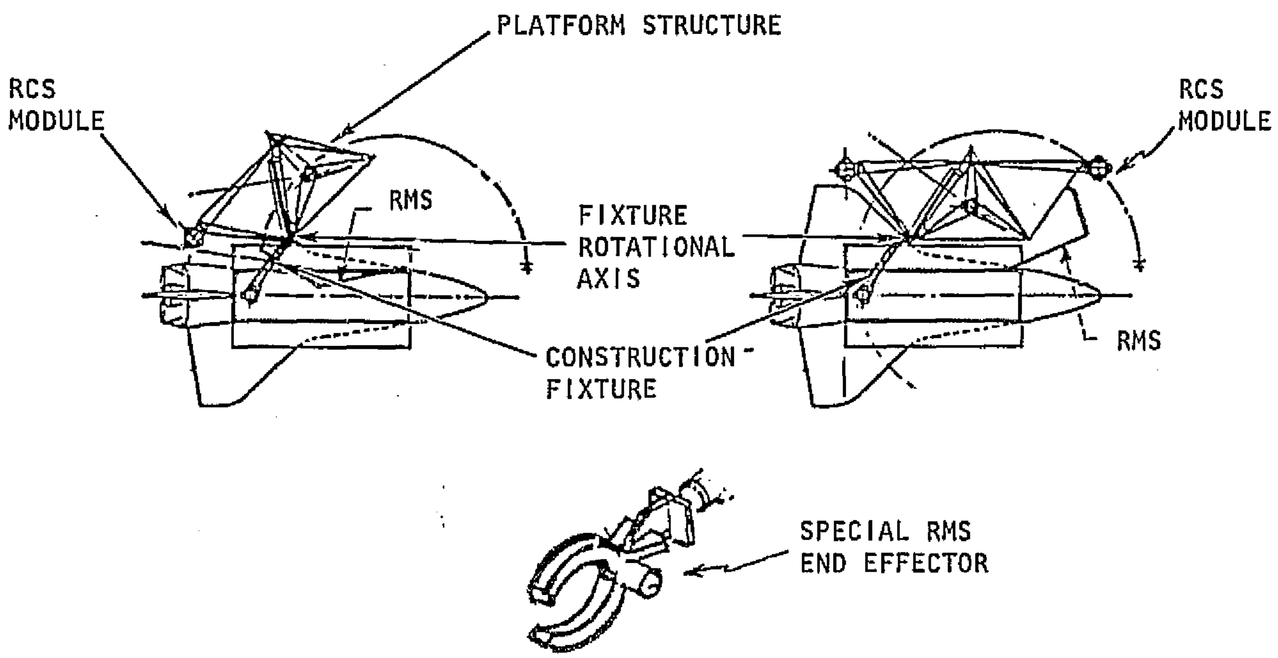
Activity Time

-	Remove struts, berthing port and RCS module and wiring from orbiter bay and assemble.	60 min.
-	Transport assembly to platform and position	25 min.
-	Connect electrical wires (3 connectors)	10 min.
	TOTAL PER RCS ASSEMBLY	95 min.

Other

- Installation of strut/module assembly can be performed in daylight portion of orbit to reduce lighting requirements.

FUNCTION	INSTALL	CODE	02	06 01.1	02.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU -- RMS	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



<u>Items</u>

- MMU
- RMS with special end effector to handle struts

FUNCTION	INSTALL	CODE	02	06 01.1	02.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU -- RMS	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

Crew - Two Astronauts with MMU's

- One RMS Operator at AFD

Power - RMS Operation 1 - 1.8 kW

- MMU Recharge TBD

Lighting & TV

- Standard Orbiter Bay RMS and MMU

Computer/Software

- RMS Coordinate Transform System

Stowage - Special RMS end effector 0.3 diameter x 0.5m

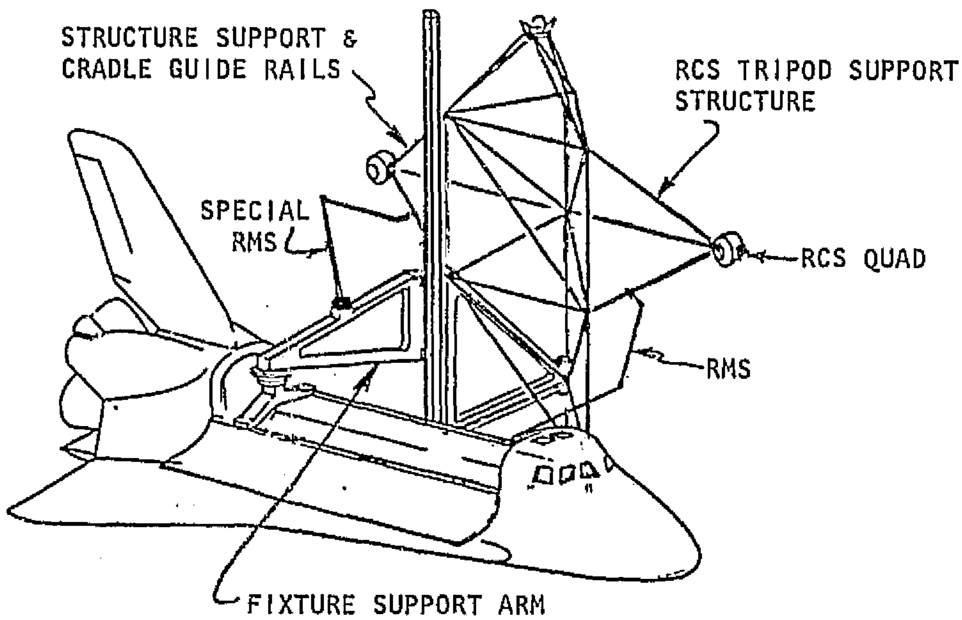
Other - MMU Propulsion Recharge

FUNCTION ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	02.1
METHOD	EVA/MMU -- RMS	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
RMS	0	0	--	1.8	TBD	--	NC
Two MMU's	220	2.2	--	TBD	TBD	--	200
End Effector	3	NEG	--	TBD	TBD	--	212
<u>Support Services</u>							
Crew	--	--	3/2.5	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
<u>Project Modification</u>							
Fixed Joint	30	NEG	--	--	--	--	672
Drill Holes in Strut							21
<u>Operations</u>	--	--	3/2.5	--	--	95	NA*

*Not appropriate, see page 6.

FUNCTION· ITEM ·	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	02.2
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- Struts are transported from storage location to assembly area in cargo bay by EVA/MMU astronauts.

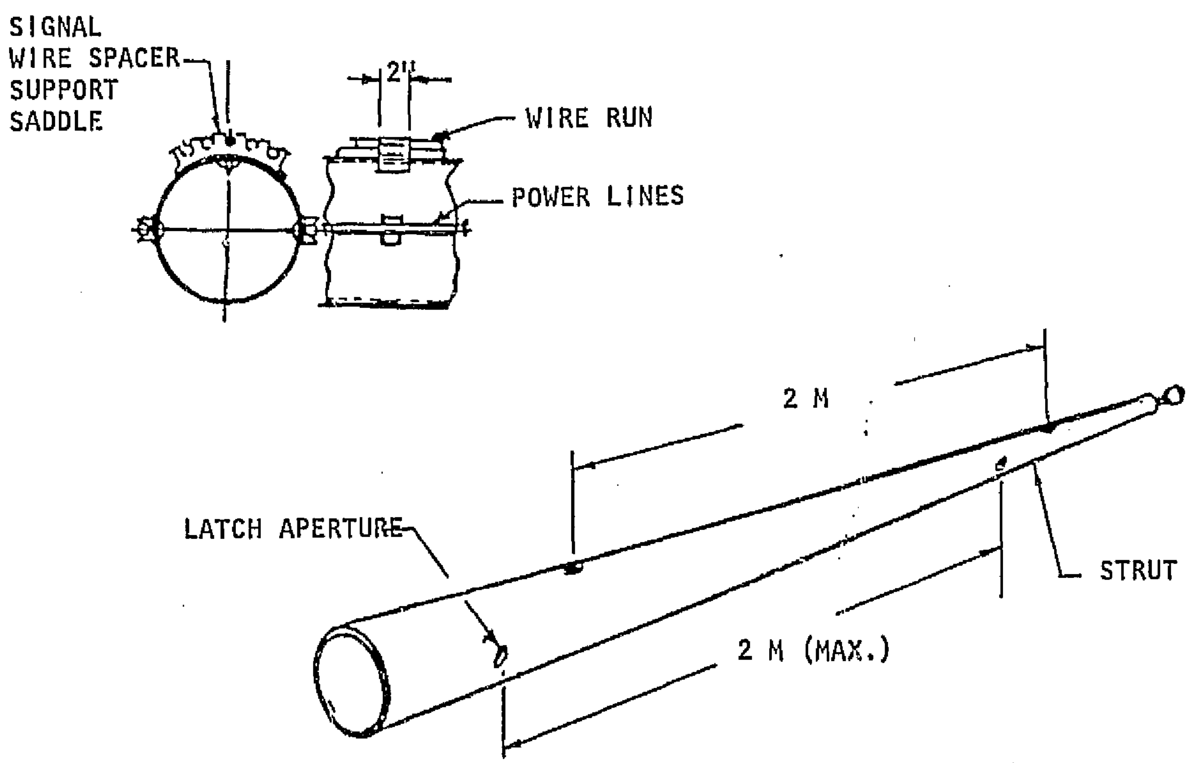
- Struts are unfolded, berthing port is retrieved and joined to struts and electrical wiring installed by astronauts.

- RMS transports RCS tripod assembly to location at platform.

- EVA/MMU astronauts join strut ends to platform and connects wiring to platform wiring at J-box on basic structure union.

- Standard RMS retrieves RCS module and berths it to port facing forward (in rotation to the orbiter). Second RMS mounted on fixture support arm retrieves RCS module and berths it to aft facing port. The two arms are not operated simultaneously. Astronaut connects wiring to module.

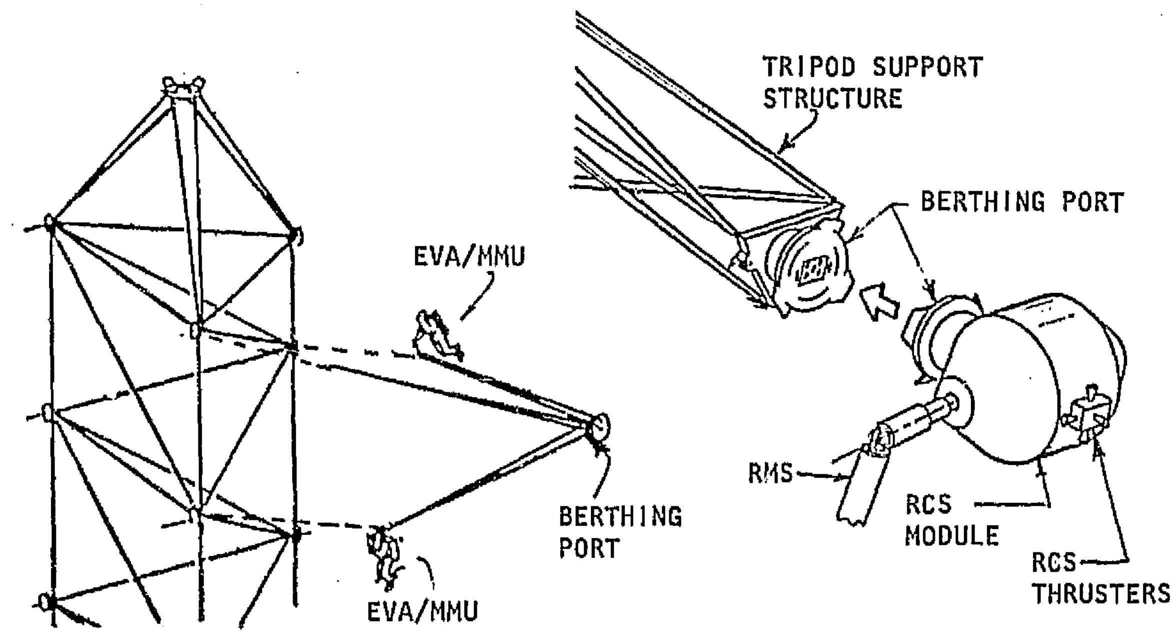
FUNCTION	INSTALL	CODE	02	06 01.1	02.2
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



Struts (2) Wire Support

- Four holes 90° on center at 2.0m spacing staggered along length to support electrical wires.

FUNCTION· ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	02.2
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	3 of 6		
SUBJECT	OPERATIONS				



Manpower

- RMS Operator at AFD

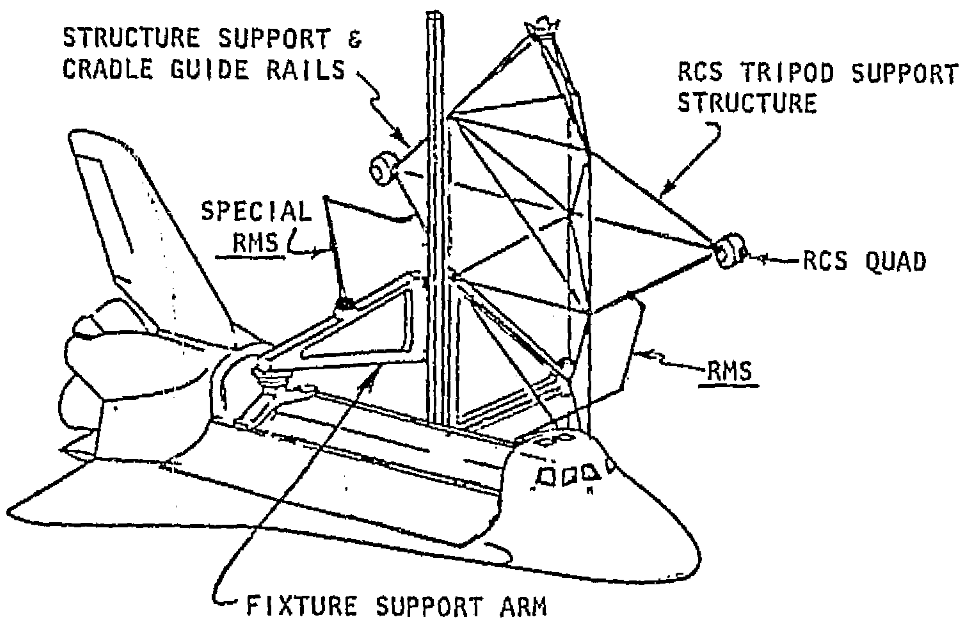
Activity Time

- Remove struts, berthing port and wiring from orbiter bay and assemble.	55 min.
- Transport assembly to platform and position.	15 min.
- Join struts to unions (6 struts)	10 min.
- Connect electrical wires (3 connectors)	6 min.
- Remove RCS module from bay and install on berthing port.	25 min.
TOTAL PER RCS	111 min.

Other

- Installation of strut assembly and module can be performed in daylight portion of orbit to reduce lighting requirements.

FUNCTION	INSTALL	CODE	02	06 01.1	02.2
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	4 of 6		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- MMU
- Two RMS (One mounted on fixture support arm)
- RMS special end effector to handle struts

FUNCTION	INSTALL	CODE	02	06 01.1	02.2
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	5 of 6		
SUBJECT	SUPPORT SERVICES				

Crew - Two Astronauts with MMU's

One RMS Operator at AFD

Power - RMS Operation 1 - 1.8 kW

- MMU Recharge TBD

Lighting & TV

- Standard Orbiter RMS and MMU

Computer/Software

- RMS Coordinate Transform System

Stowage - Special RMS End Effector 0.3 diameter x 0.5m

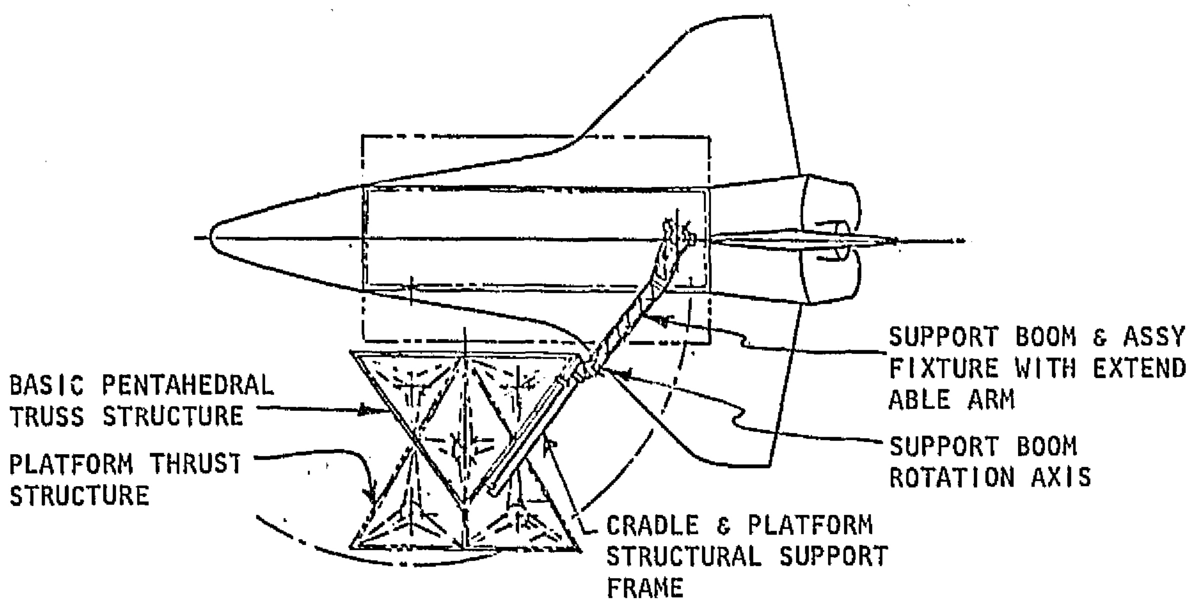
Other - MMU Propulsion Recharge

FUNCTION	INSTALL	CODE	02	06 01.1	02.2
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	EVA/MMU SPECIAL RMS (MODULE SEPARATE)	PAGE	6 of 6		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Construction Support Equipment</u>							
RMS (First)	0	0	--	1.8	TBD	--	NC
RMS (Second)	411	0	--	1.8	TBD	--	NC
Two MMU's	220	2.2	--	TBD	TBD	--	200
End Effector	3	NEG	--	TBD	TBD	--	212
<u>Support Services</u>							
Crew	--	--	3/2.5	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Other							
<u>Project Modification</u>							
Drill Holes in Strut							21
<u>Operations</u>	--	--	3/2.5	--	--	111	NA*

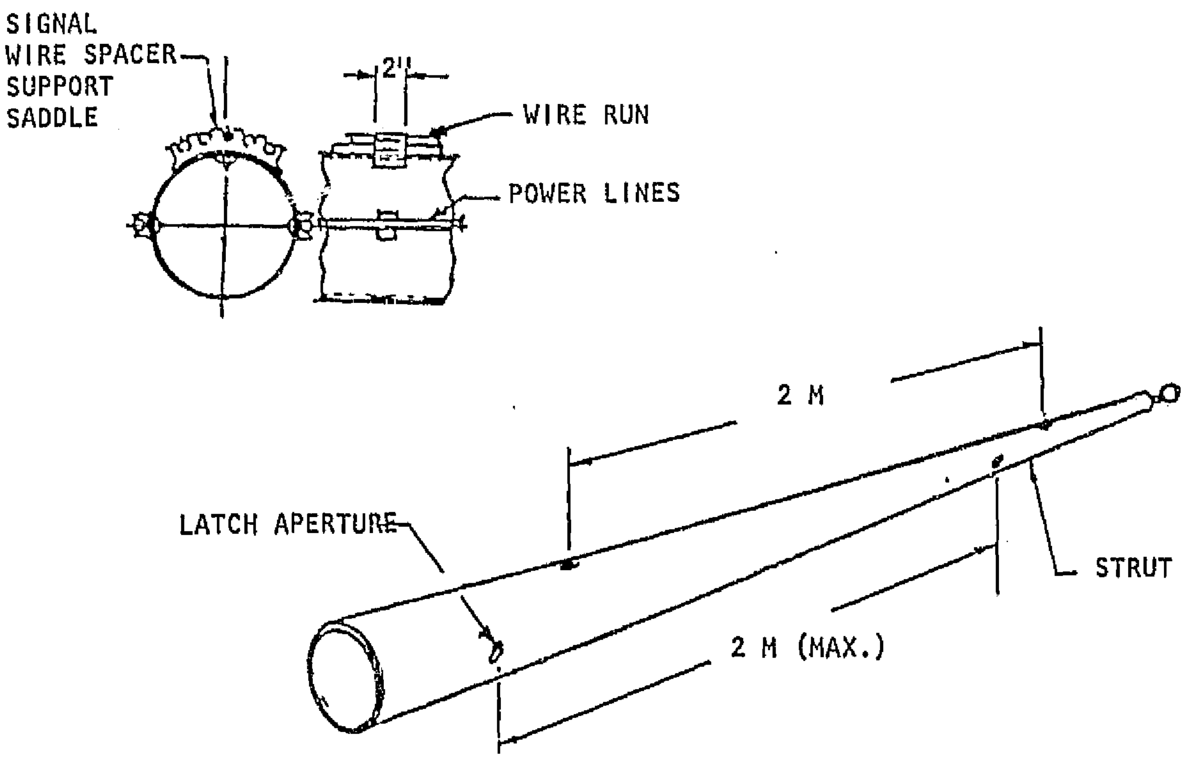
*Not appropriate, see page 6.

FUNCTION·	INSTALL	CODE	02	06 01.1	04.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	RMS/FIXTURE	PAGE	1 of 6		
SUBJECT	METHOD DESCRIPTION				



- o Struts are transported from storage location to assembly area in cargo bay by RMS.
- o Struts are unfolded, berthing port is retrieved and joined to struts, and electrical wiring is installed.
- o Support arm is extended and platform rotated to bring the platform within reach of the RMS.
- o RMS transports RCS tripod assembly to location at the platform and connects struts and electrical to basic platform.
- o RMS picks up RCS module from bay and installs it to structure. Electrical connections are made as module is installed on berthing port.
- o Strut assembly procedure is repeated and construction fixture/platform is rotated to provide RMS access to other side of structure.
- o RCS tripod assembly and module are installed separately to platform.
- o Fixture is rotated to translation position, platform is translated and procedure is repeated at other end.

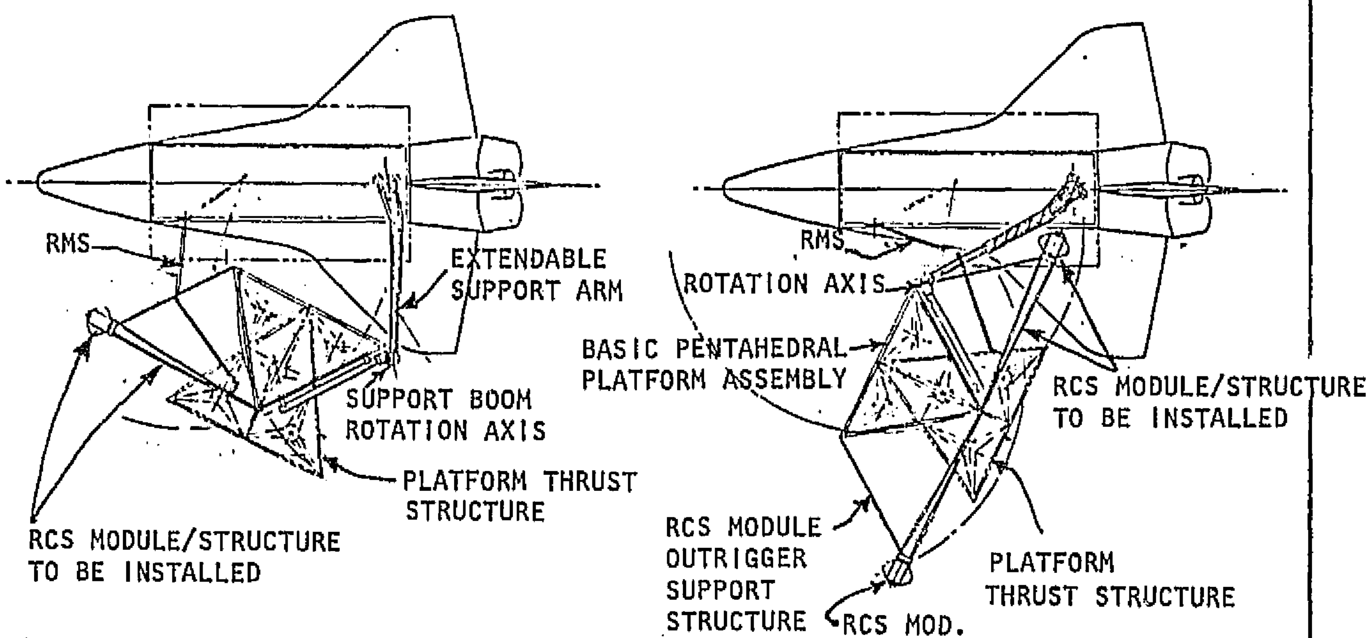
FUNCTION · ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	04.1
METHOD	RMS/FIXTURE	PAGE	2 of 6		
SUBJECT	PROJECT MODIFICATIONS				



Struts (2)

- Four holes 90° on center at 2m spacing staggered along length to support electrical wires.

FUNCTION · ITEM	INSTALL RCS STRUCTURE, MODULE & WIRING	CODE	02	06 01.1	04.1
METHOD	RMS/FIXTURE	PAGE	3	of	6
SUBJECT	OPERATIONS				



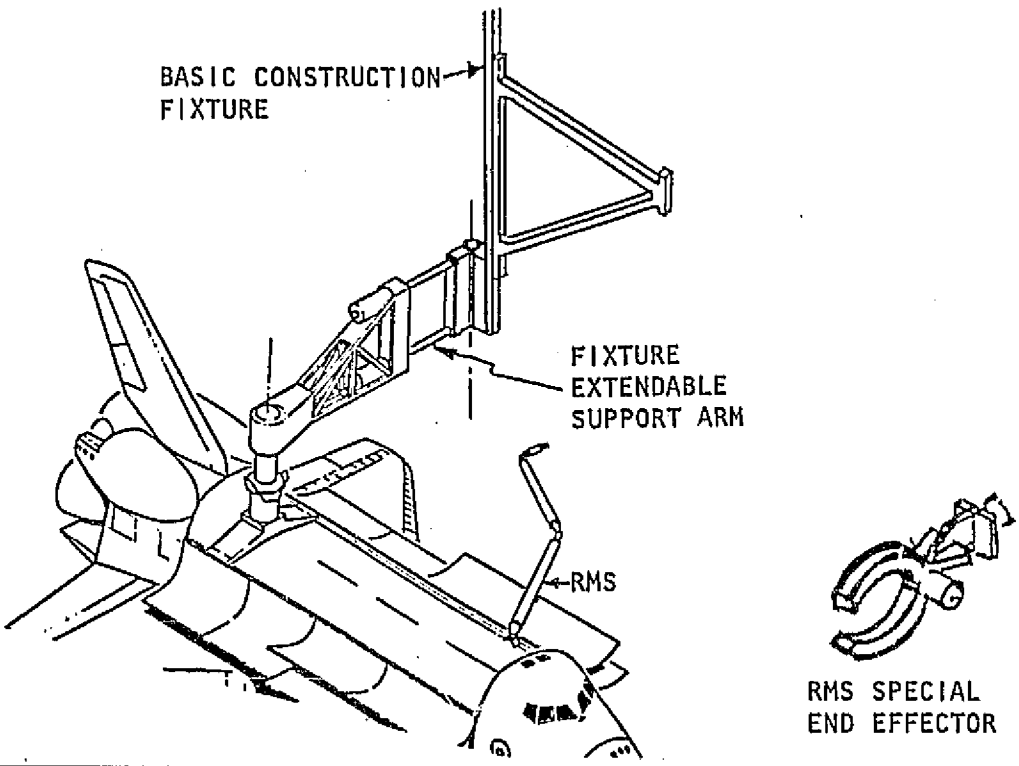
Manpower

- RMS Operator at AFD

Activity Time

- Remove struts, berthing port and wiring from orbiter bay and assemble (fixture repositioning accomplished simultaneously).	55 min.
- Transport assembly to platform and position.	15 min.
- Join struts (6) to union on platform.	30 min.
- Connect electrical wires (3 connectors)	15 min.
- Install RCS module	25 min.
TOTAL PER RCS ASSEMBLY	140 min.

FUNCTION	INSTALL	CODE	02	06 01.1	04.1
ITEM	RCS STRUCTURE, MODULE & WIRING	PAGE	4 of 6		
METHOD	RMS/FIXTURE				
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS with special end effector to handle struts.
- Construction fixture modified to include extendable support arm for cradle and platform structural support frame.

FUNCTION	INSTALL	CODE	02	06 01.1	04.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	RMS/FIXTURE	PAGE	5	of	6
SUBJECT	SUPPORT SERVICES				

<u>Crew</u> – One RMS Operator at AFD

<u>Power</u> – RMS Operation 1 - 1.8 kW

– Fixture Operation (only that peculiar to this method) TBD

<u>Lighting & TV</u>

– Standard Orbiter Bay and RMS

<u>Computer/Software</u>

– RMS Coordinate Transform System

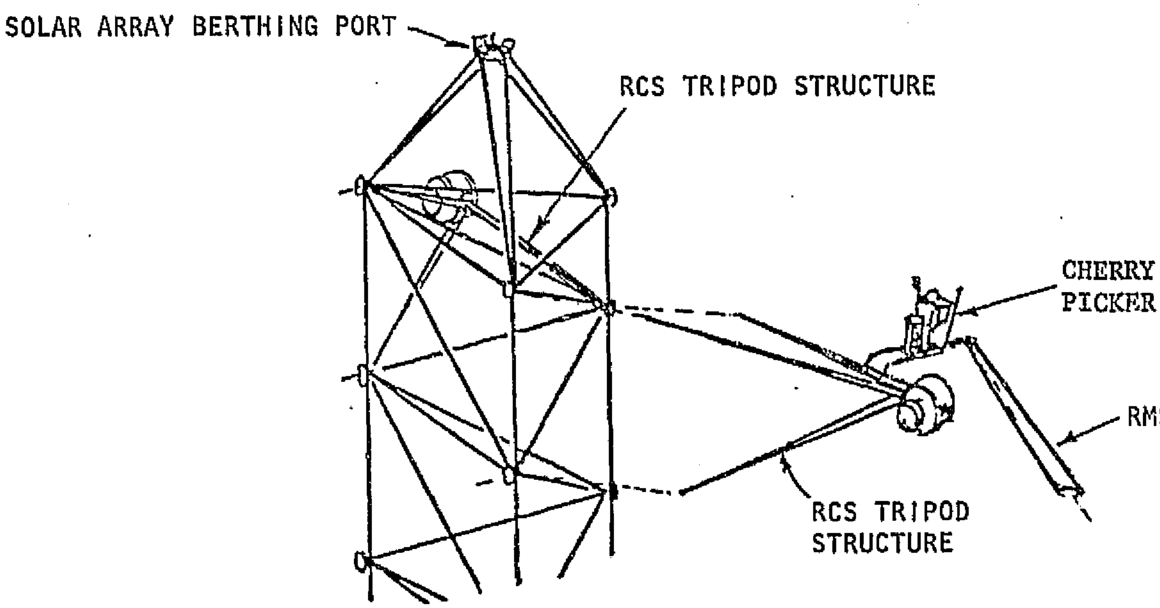
<u>Stowage</u> – Special RMS End Effector 0.3 diameter x 0.5m

FUNCTION	INSTALL	CODE	02	06 01.1	04.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	RMS/FIXTURE	PAGE	6 of 6		
SUBJECT					

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
RMS	0	0	--	1.8	TBD	--	NC
Fixture Mods	900	10	--	TBD	TBD	--	6348
RMS End Effector	3	NEG	--	TBD	TBD	--	212
Support Services							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Project Modification							
Drill Holes in Strut							21
Operations	--	--	1/1	--	--	140	NA*

*Not appropriate, see page 6.

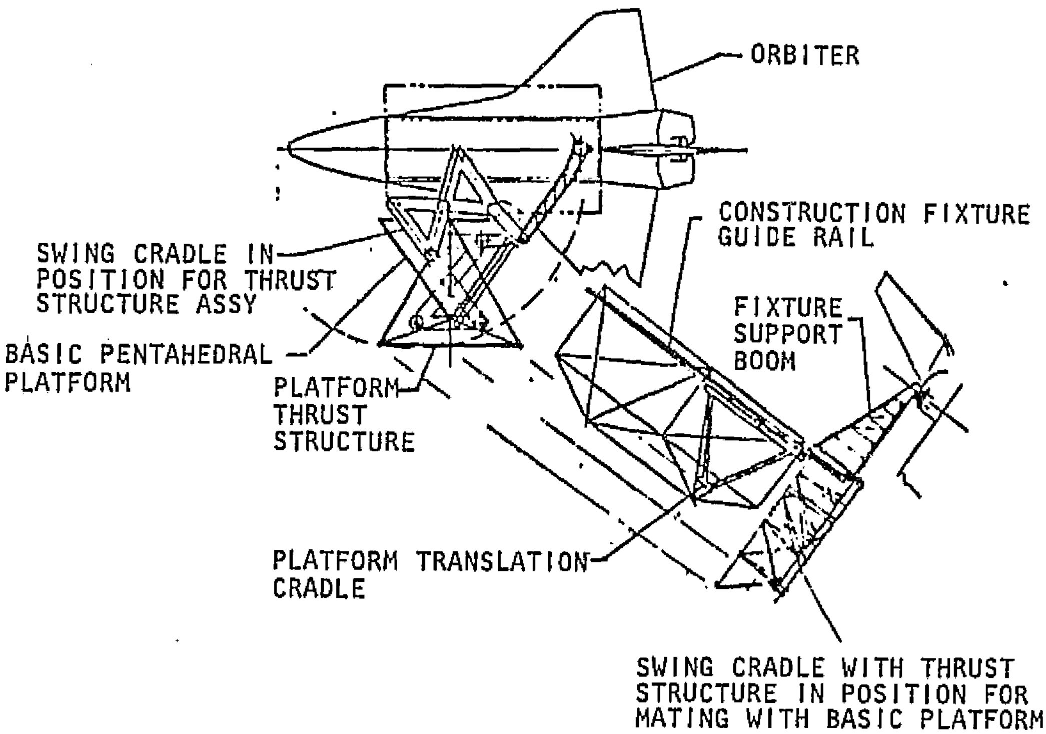
FUNCTION·	INSTALL	CODE	02	06 01.1	03.1
ITEM	RCS STRUCTURE, MODULE & WIRING				
METHOD	CHERRY PICKER	PAGE	1	of	1
SUBJECT	METHOD DESCRIPTION				



- o Struts are transported from storage location to assembly area in cargo bay by cherry picker.
- o Struts are unfolded, berthing port is retrieved and joined to struts and electrical wiring installed.
- o Cherry picker retrieves RCS module and joins it to strut assembly and connects wiring to module.
- o Cherry picker transports RCS tripod assembly to location at platform.
- o Cherry picker join strut ends to platform and connects wiring to platform wiring at J-box on basic structure union.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	00
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				



Project System

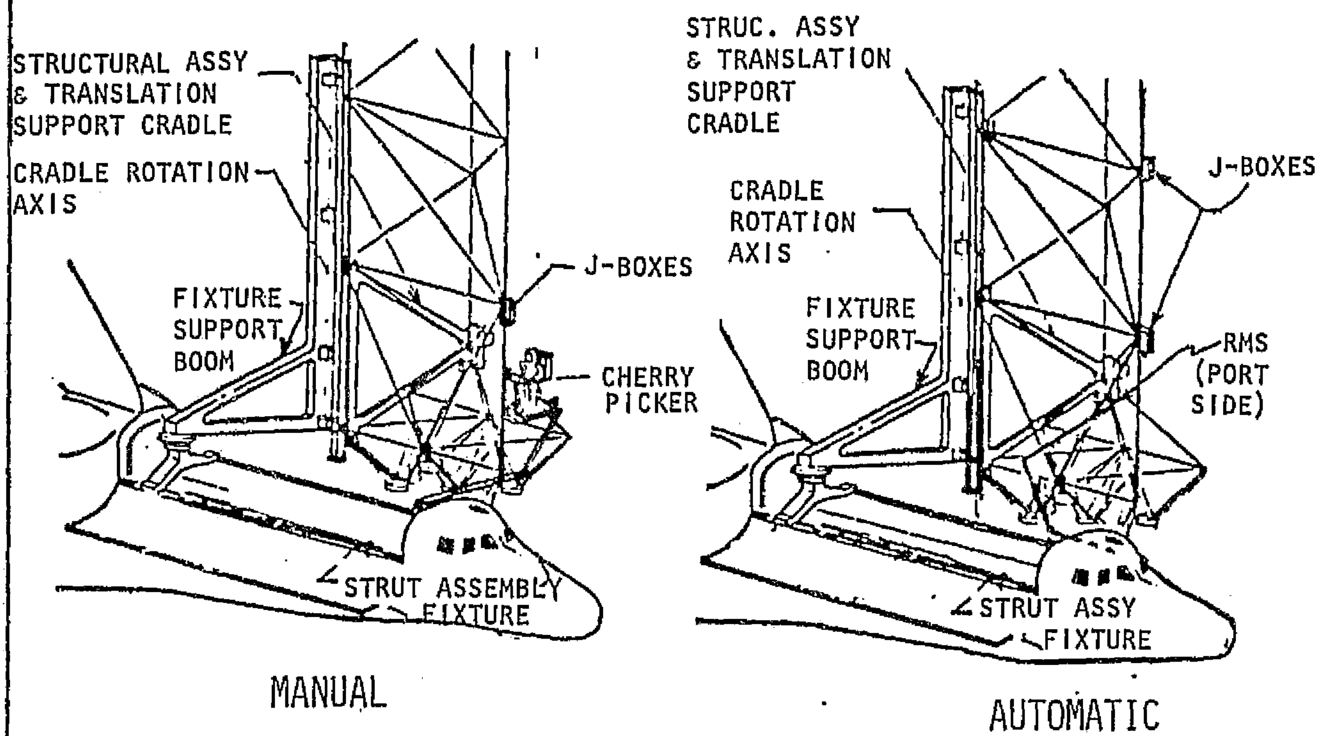
- Erectable Advanced Communications Platform

Operation

- Install wiring and J boxes

Physical Situation

- The basic pentahedral structural is complete.
- Wire support saddles are installed.
- Platform is supported by the construction fixture



The following methods have been identified:

<u>Manual</u>

1. Astronaut in cherry picker installs and attaches "J" boxes to unions and lines to struts as platform makes downward pass thru construction fixture.

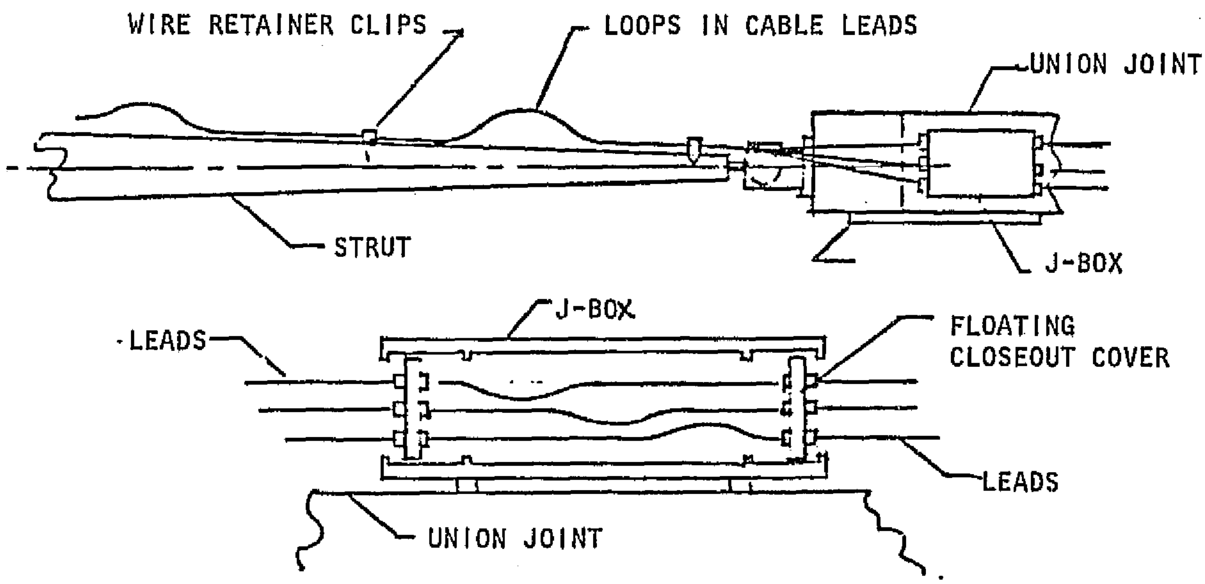
2. Astronaut with MMU attaches lines and "J" boxes to platform unions as platform makes downward pass thru construction fixture.

<u>Automatic</u>

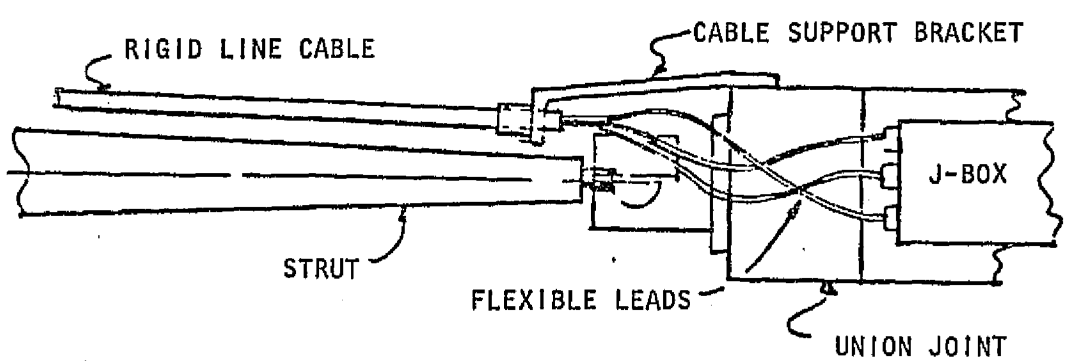
3. RMS with special end effector installs lines and "J" boxes to unions of the platform as it passes thru the construction fixture.

Methods 1 and 2 are detailed.

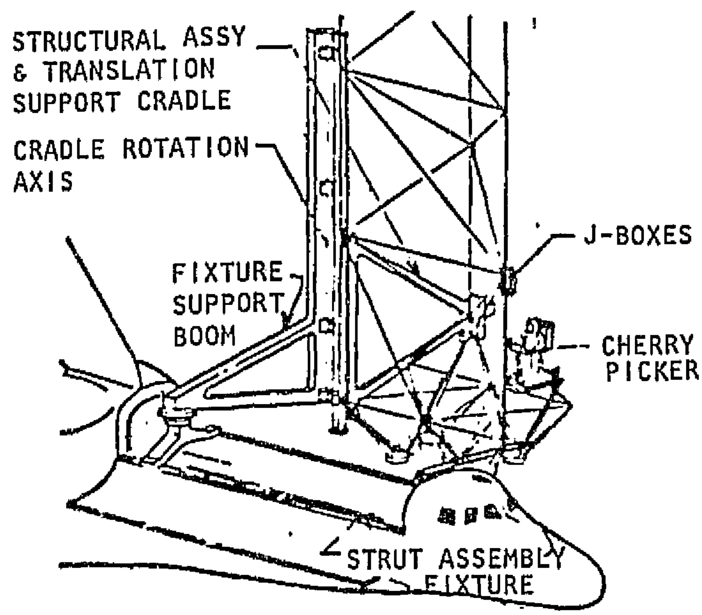
FUNCTION	INSTALL	CODE	02	06 03.1	00
ITEM	WIRING & "J" BOXES				
METHOD		PAGE	3	of	3
SUBJECT	WIRING EXPANSION OPTIONS				



FLOATING END PLATES - JUNCTION BOX

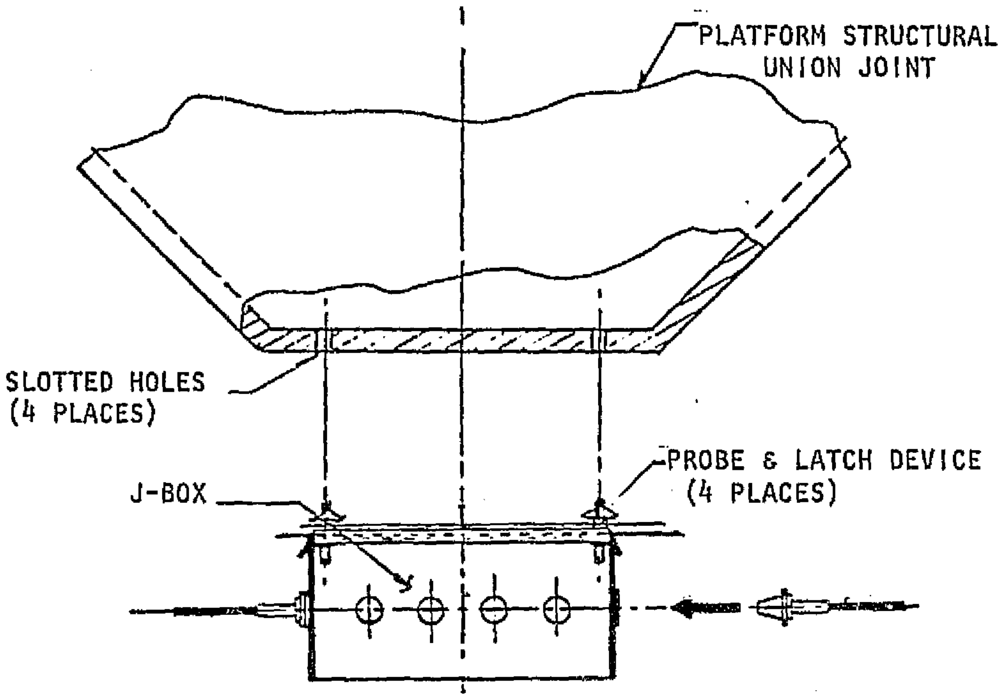


FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	03.1
METHOD	CHERRY PICKER	PAGE	1 of 7		
SUBJECT	METHOD DESCRIPTION				



- Cherry picker operator transports "J" boxes to position near platform union joints.
- "J" boxes are attached to mounting interface on union joint.
- Power leads, coax leads and data buses are distributed along struts between "J" boxes.
- Attachments of lines to struts is accomplished by probe and latch clips that penetrates pre-located holes in strut members.
- Loops or other expansion capability for lines is provided to allow for expansion/contraction of cable lengths.

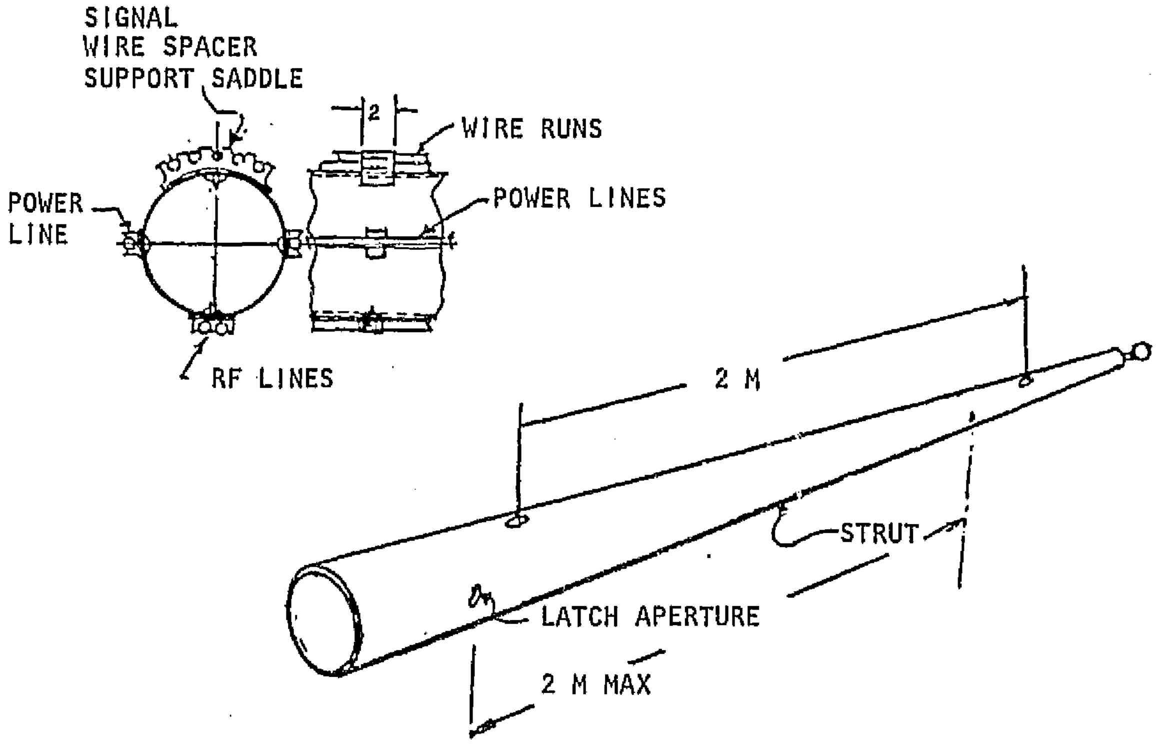
FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	03.1
METHOD	CHERRY PICKER	PAGE	2 of 7		
SUBJECT	PROJECT MODIFICATIONS				



Structural Joints

- Four slotted holes required to match probe and latch device on junction box.

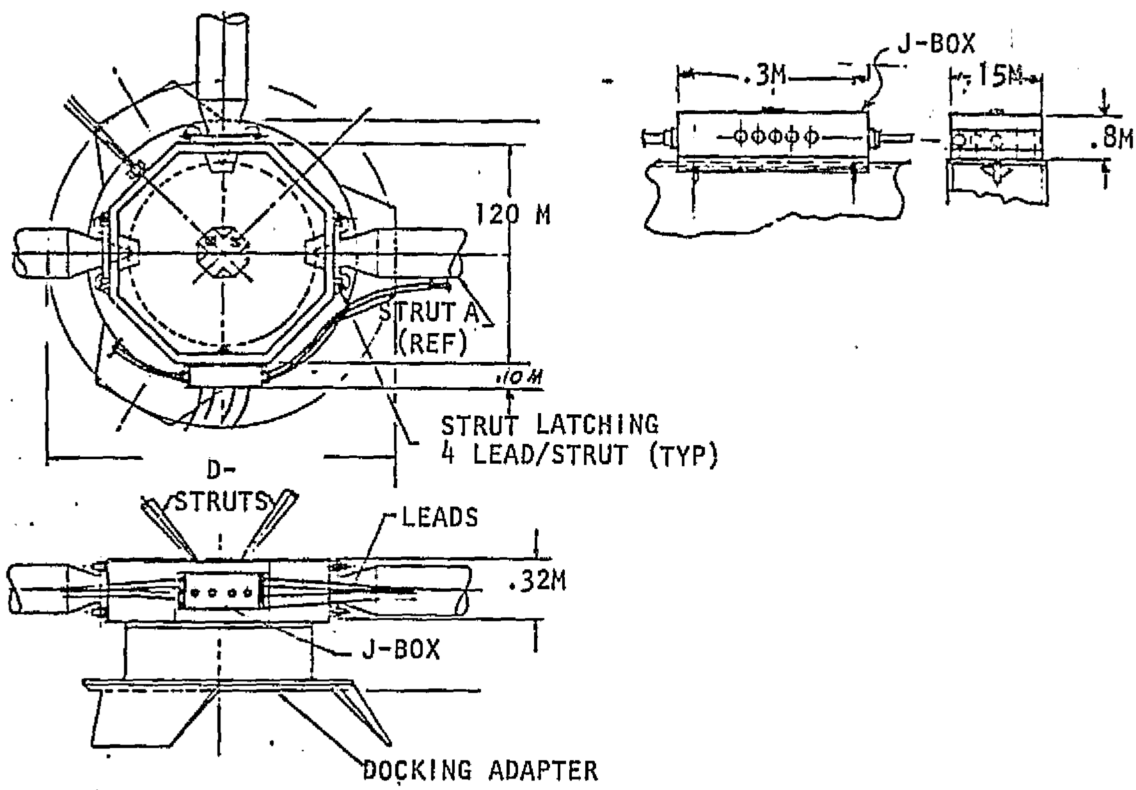
FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	03.1
METHOD	CHERRY PICKER	PAGE	3 of 7		
SUBJECT	PROJECT MODIFICATIONS (Continued)				



Struts

- Four holes staggered at 2.0m spacing along length for wiring support saddles.

FUNCTION · ITEM	INSTALL · WIRING & "J" BOXES	CODE	02	06 03.1	03.1
METHOD	CHERRY PICKER	PAGE	4	of	7
SUBJECT	OPERATIONS				



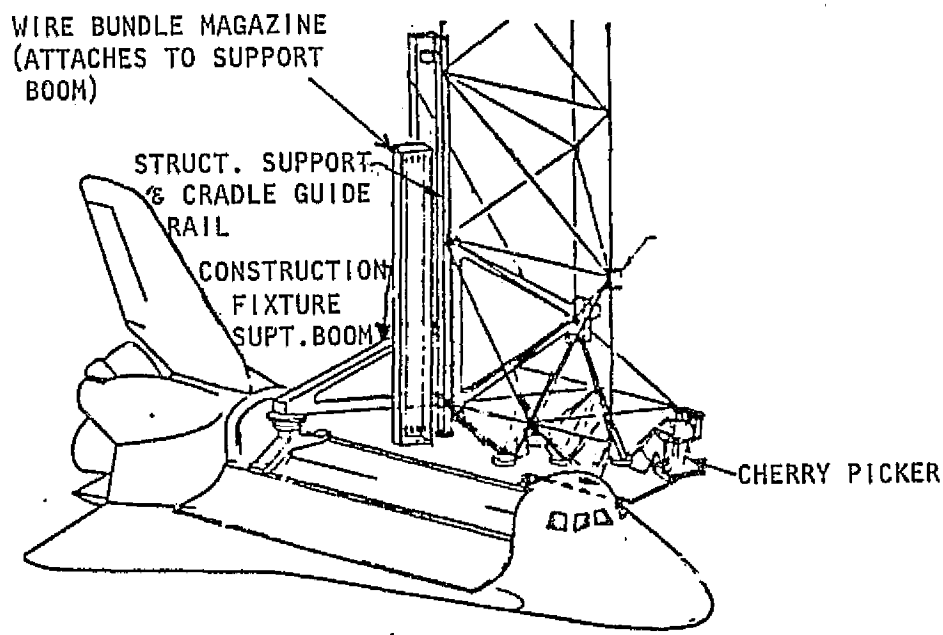
Manpower

- Cherry picker operator

Activity Time

• "J" box removal from orbiter supported magazine	10 min.
• Translation to union interface on platform	5 min.
• Attach "J" box to union	5 min.
• Attachment of lines to struts between unions (9 lines per longitudinal strut)	60 min.
• Connector attachment at each strut end (9 at 2 places)	30 min.
Total time per union/strut	110 min.

FUNCTION	INSTALL	CODE	02	06 03.1	03.1
ITEM	WIRING & "J" BOXES				
METHOD	CHERRY PICKER	PAGE	5 of 7		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



Items

- RMS
- Cherry Picker
- Wire Bundle Magazine

FUNCTION	INSTALL	CODE	02	06 03.1	03.1
ITEM	WIRING & "J" BOXES	PAGE	6 of 7		
METHOD	CHERRY PICKER				
SUBJECT	SUPPORT SERVICES				

Crew - Cherry Picker Operator

Power - RMS 1 - 1.8 kW

Cherry Picker 0.5 kW

Lighting & TV -

Standard Cherry Picker Illumination

Computer/Software -

RMS coordinate transform system

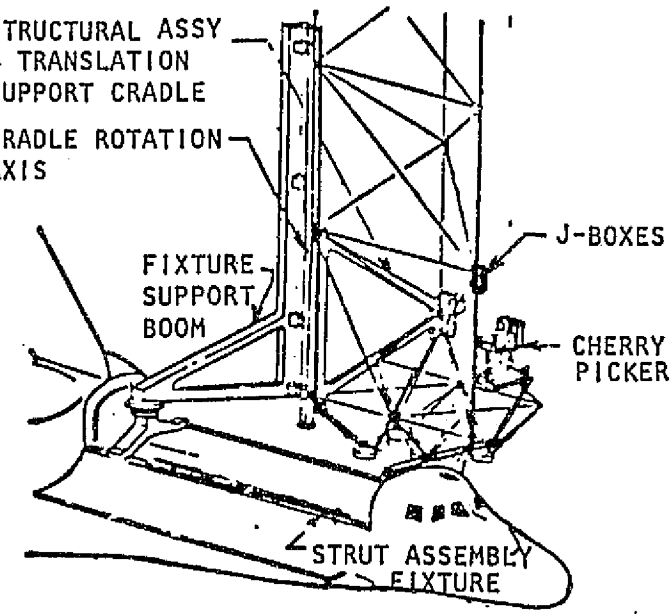
Stowage - Cherry Picker 0.9 x 1.6 x 1.1m

FUNCTION	INSTALL	CODE	02 | 06 03.1 | 03.1
ITEM	WIRING & "J" BOXES		
METHOD	CHERRY PICKER	PAGE	7 of 7
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
Cherry Picker	273	1.6	--	0.5	TBD	--	TBD
RMS	0	0	--	1.8	TBD	--	NC
Wiring Magazine	50	13	--	0	0	--	441
Support Services							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	2.3	TBD	--	TBD
Project Modification							
Union & Strut holes	0	0	--	--	--	--	NC
Operations	--	--	1/1	--	--	110	NA*

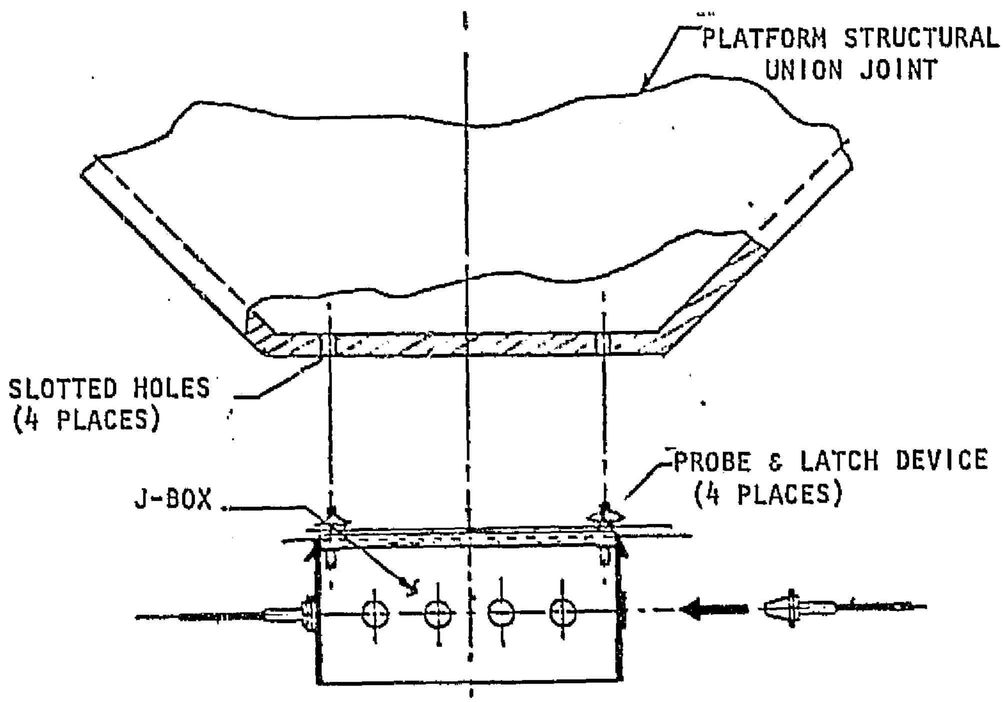
*Not appropriate, see page 6.

FUNCTION· ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	02.1
METHOD	EVA/MMU	PAGE	1 of 7		
SUBJECT	METHOD DESCRIPTION				



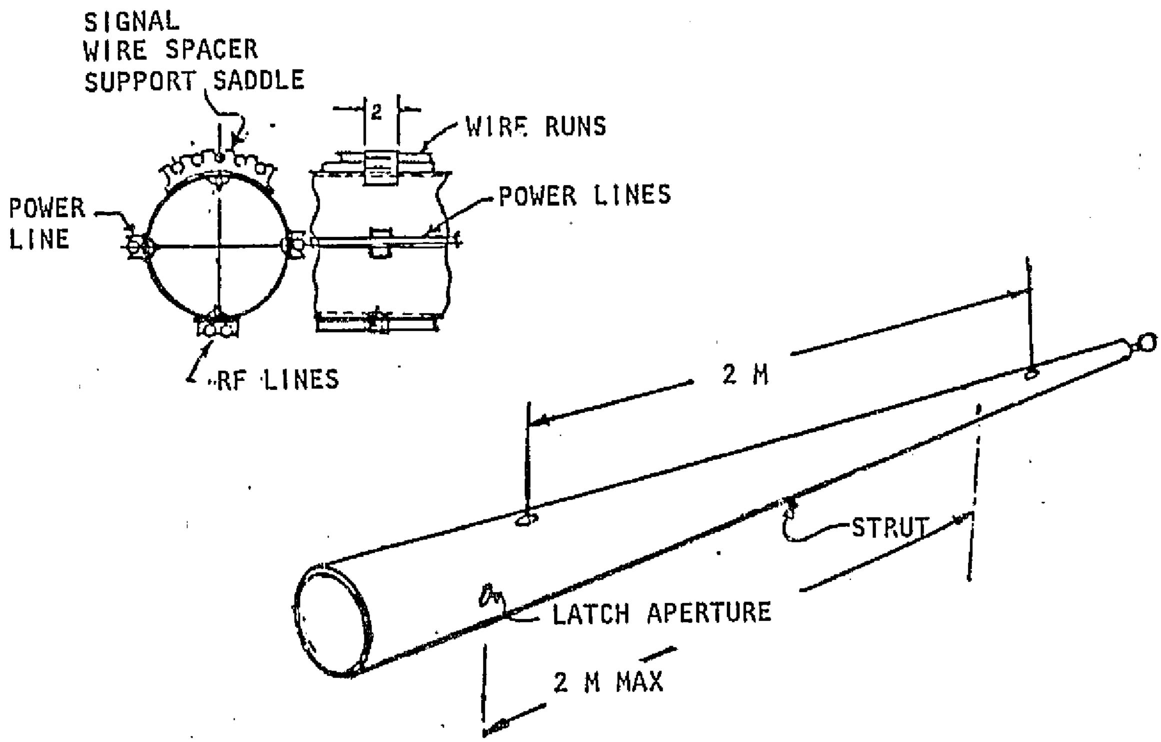
- Astronaut with MMU transports "J" boxes to position near platform union joints.
- "J" boxes are attached to mounting interface on union joint.
- Power leads, coax leads and data buses are distributed along struts between "J" boxes.
- Attachments of lines to struts is accomplished by probe and latch clips that penetrate pre-located holes in strut members.
- Loops or other expansion capability for lines is provided to allow for expansion/contraction of cable lengths.

FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	02.1
METHOD	EVA/MMU	PAGE	2 of 7		
SUBJECT	PROJECT MODIFICATIONS				



Structural Joints

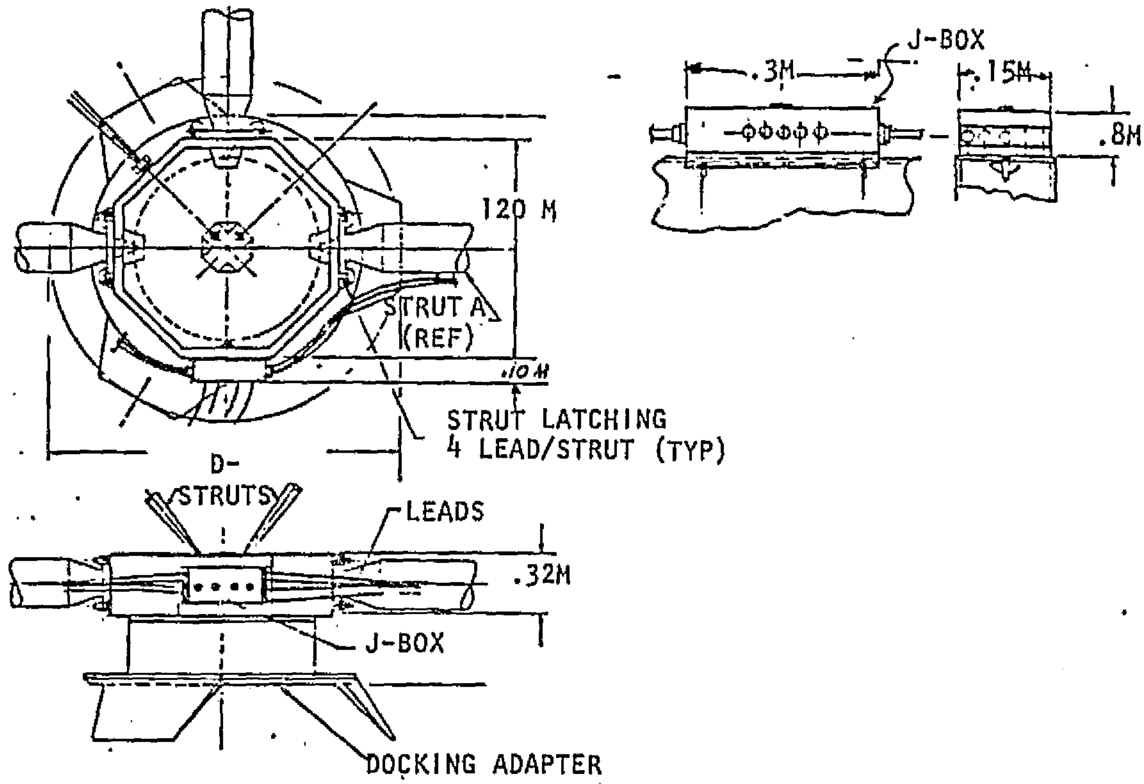
- Four slotted holes required to match probe and latch device on junction box.



Struts

- o Four holes staggered at 2.0m spacing along length for wiring support saddles.

FUNCTION · ITEM	INSTALL WIRING & "J" BOXES	CODE	02	06 03.1	02.1
METHOD	EVA/MMU	PAGE	4	of	7
SUBJECT	OPERATIONS				



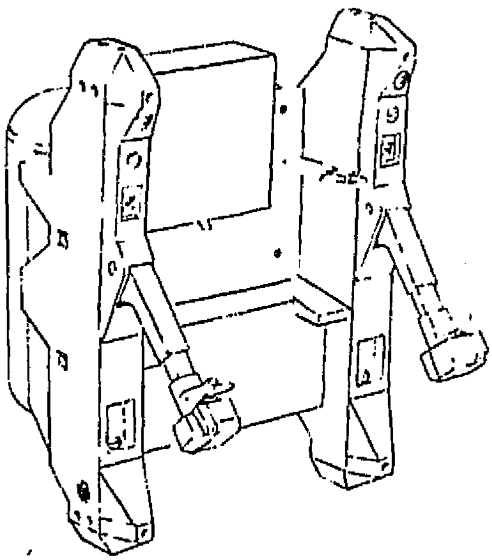
<u>Manpower</u>

- o EVA/MMU operator

<u>Activity Time</u>

o	"J" box removal from orbiter supported magazine cradle	10 min.
o	Translation to union interface on platform	5 min.
o	Attach "J" box to union	5 min.
o	Attachment of lines to struts between unions (9 lines per longitudinal strut)	60 min.
o	Connector attachment at each strut end (9 at 2 places)	30 min.
	Total time per union/strut	110 min.

FUNCTION	INSTALL	CODE	02	06 03.1	02.1
ITEM	WIRING & "J" BOXES				
METHOD	EVA/MMU	PAGE	5 of 7		
SUBJECT	CONSTRUCTION SUPPORT EQUIPMENT REQUIREMENTS				



MMU

Items

- o MMU
- o Wire Bundle Magazine

FUNCTION	INSTALL	CODE	02	06 03.1	02.1
ITEM	WIRING & "J" BOXES	PAGE	6 of 7		
METHOD	EVA/MMU				
SUBJECT	SUPPORT SERVICES				

Crew - One EVA/MMU operator

Power - MMU recharge TBD

Lighting & TV -

Standard MMU lighting

Computer/Software - None

Stowage - None

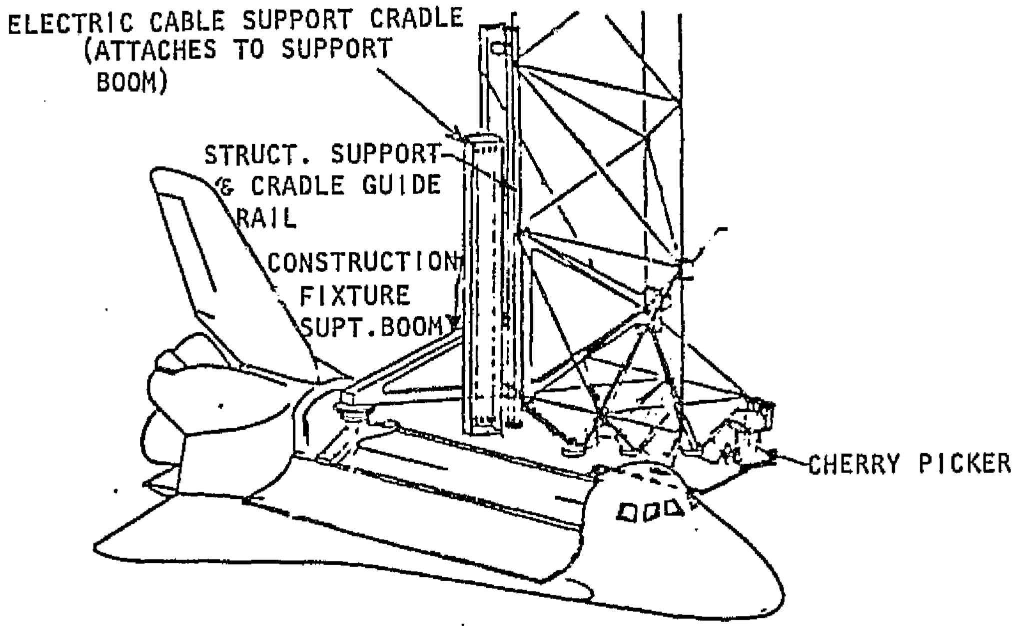
Other - MMU propulsion recharge

FUNCTION	INSTALL	CODE	02	06 03.1	02.1
ITEM	WIRING & "J" BOXES				
METHOD	EVA/MMU	PAGE	7 of 7		
SUBJECT	SUMMARY				

	WT. (KG)	VOL. (M^3)	CREW (MAX/ AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Construction Support Equipment							
MMU	110	1.1	--	TBD	TBD	--	100
Wiring Magazine	50	13	--	0	0	--	441
Support Services							
Crew	--	--	1/1	--	--	--	--
Power (Total)	--	--	--	TBD	TBD	--	TBD
Other							
Project Modification							
Union & Strut	0	0	--	--	--	--	--
Operations	--	--	1/1	--	--	110	NA*

*Not appropriate, see page 6.

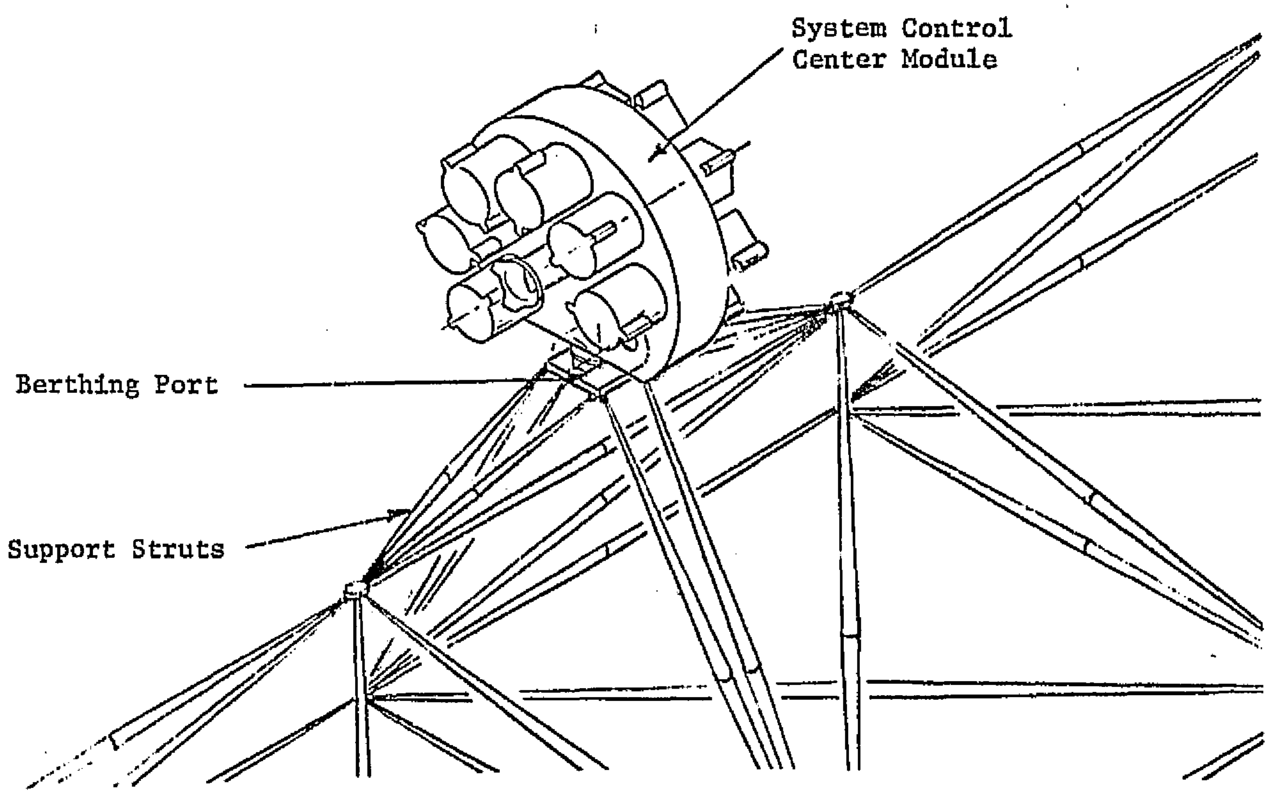
FUNCTION	INSTALL	CODE	02	06 03.1		04.1
ITEM	WIRING & "J" BOXES					
METHOD	RMS	PAGE	1	of	1	
SUBJECT	METHOD DESCRIPTION					



- RMS transports "J" box units to platform structural unions and installs.
- Power line, coax leads and data buses are attached to struts by inserting probe and latching clips into pre-located holes in strut members.
- Expansion capability of line is provided by loops in the line.

NO ADDITIONAL DETAILS ARE PROVIDED

FUNCTION· ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	00
METHOD		PAGE	1 of 3		
SUBJECT	OPERATION IDENTIFICATION				



Project System

- Erectable Advanced Communications Platform

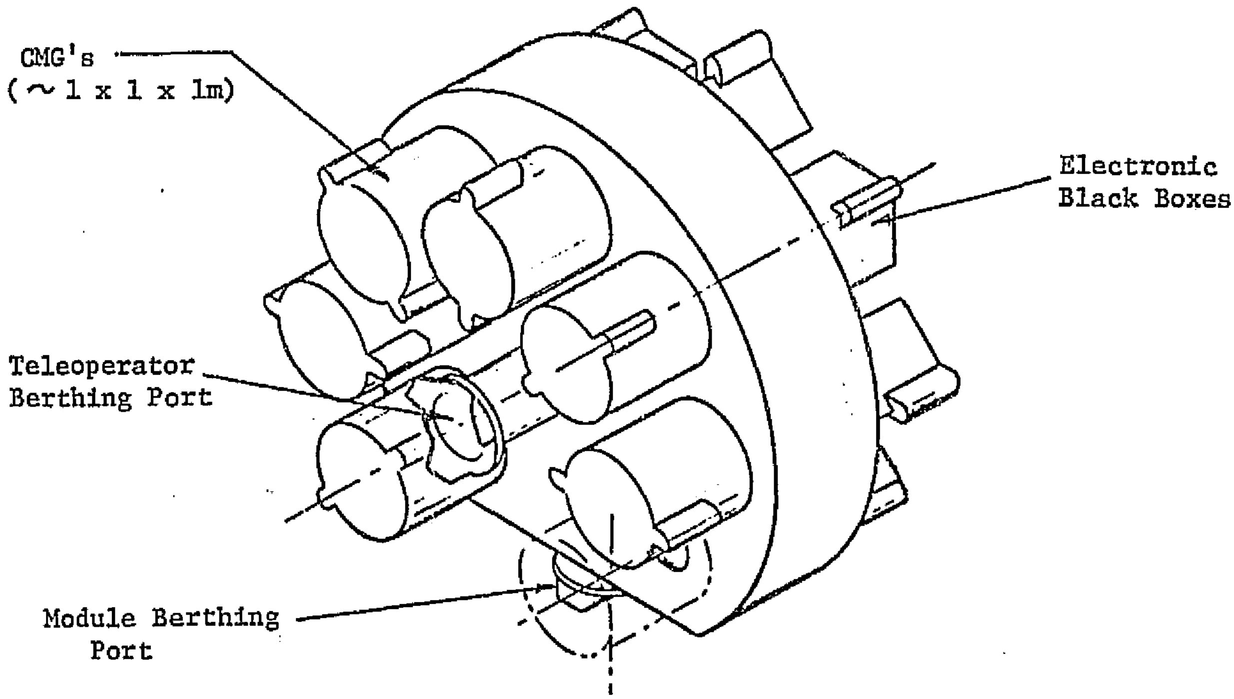
Operation

- Changeout of control moment gyro (CMG) at GEO (also applicable to packages other than CMG's)

Physical Situation

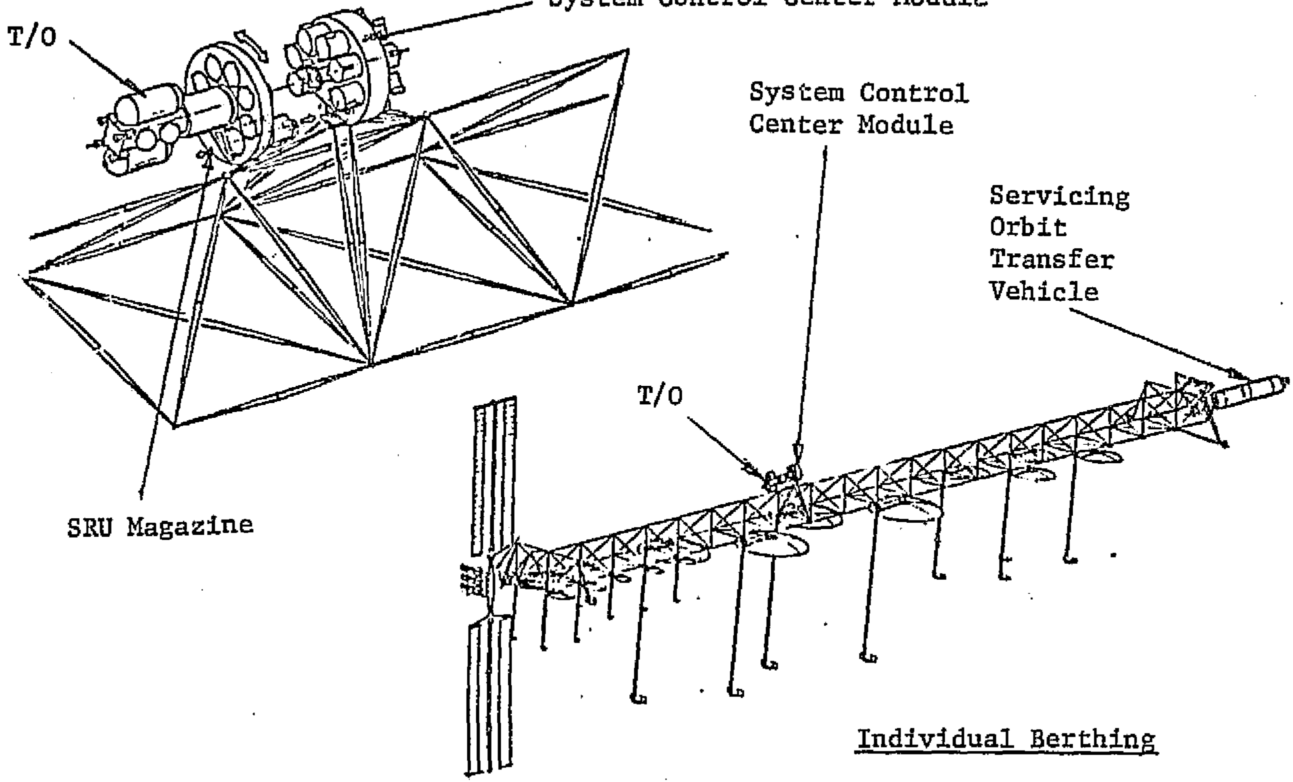
- Platform in operation at GEO
- Teleoperator type vehicle (T/O) is delivered to platform by orbital transfer vehicle (OTV)
- Assume payload of OTV is 11,300 Kg
- Servicing is scheduled with multiple changeouts to be accomplished
- Servicing is accomplished by man-in-loop (not automatic)
- Servicing will not interrupt platform operation

System Control Center Module Configuration



- Wired to permit isolation of individual units (permits continuous operation)
- T/O docking aids
- Capability to identify failed units from ground and T/O
- All exchangeable items mounted on outside faces with one or two attachments
- Electrical and heat transfer interfaces made simultaneously with physical mating of units

FUNCTION ·	SERVICE (EXCHANGE)	CODE	02	08 04.1	00
ITEM ·	CONTROL MOMENT (CMG) AT GEO				
METHOD		PAGE	3 of 3		
SUBJECT	ALTERNATE METHODS				



The following methods have been identified:

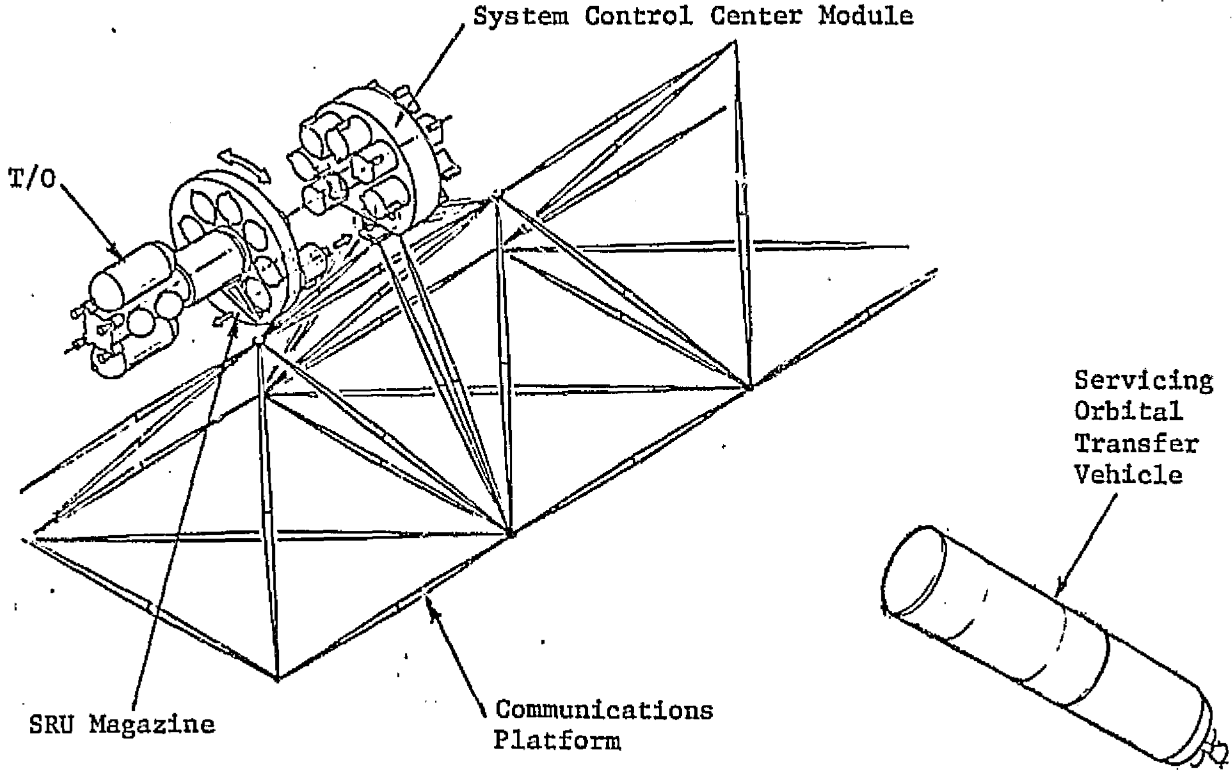
1. T/O with spares magazine delivered by OTV. T/O docks to CM and exchanges units using servicing arm.

2. T/O delivered (no spare parts) at end of platform construction process. OTV with spares docks to CM and T/O shuttles between OTV and CM exchanging units. T/O remains at platform for next servicing operation.

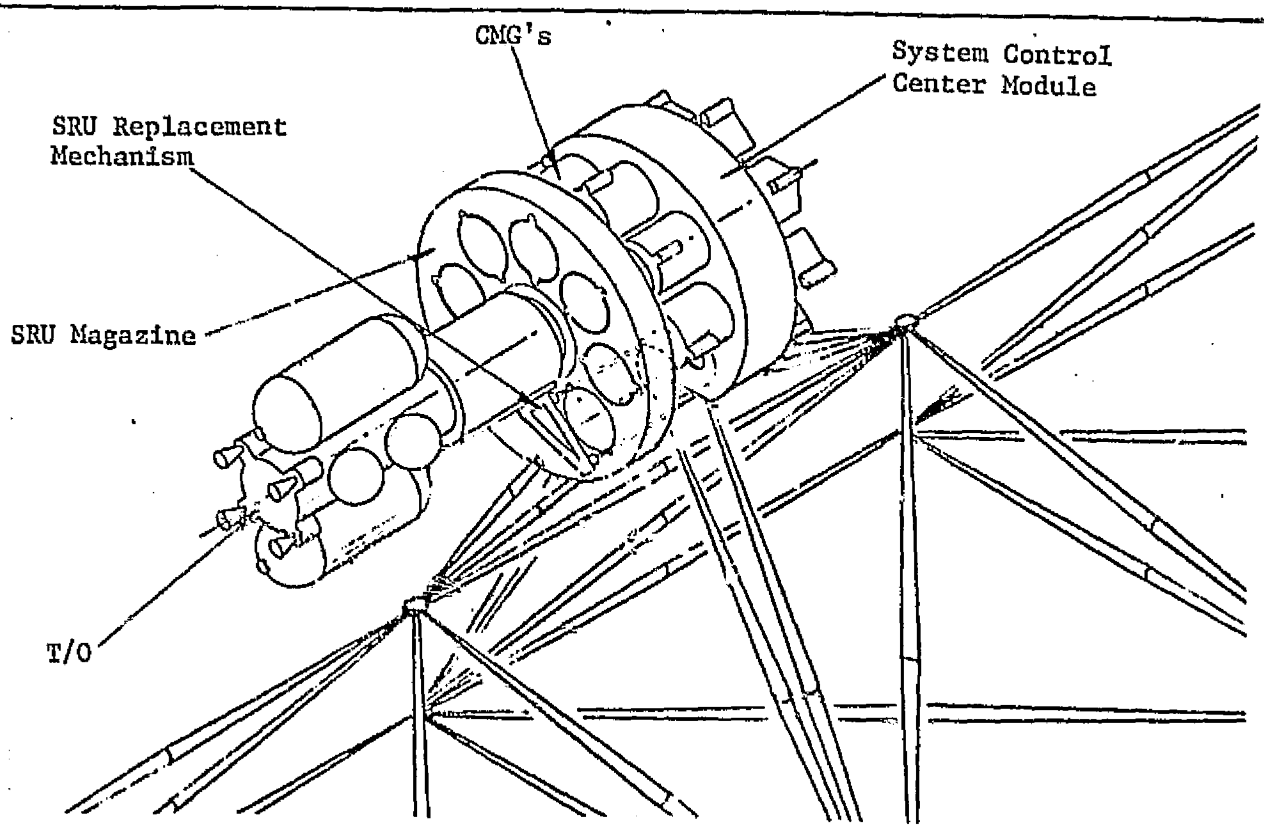
3. T/O delivered (no spare parts) at end of platform construction process. OTV delivers spares magazine to platform vicinity. T/O retrieves magazine from OTV and docks to CM. Exchange operation accomplished with servicing arm.

Methods 1 and 2 are detailed.

FUNCTION·	SERVICE (EXCHANGE)	CODE	02	08 04.1	06.1
ITEM	CONTROL MOMENT GYRO (CMG) AT GEO				
METHOD	CENTRAL DOCKING LOCATION	PAGE	1	of	4
SUBJECT	METHOD DESCRIPTION				



- T/O with replacement packages separates from OTV and flys to docking port on control module (CM)
- T/O servicing arm removes first package from CM and places it in empty storage location in magazine
- New package is removed from magazine and installed at vacated CM position
- Exchange operation is repeated for remaining units
- T/O and OTV put into non platform interference orbit



Manpower

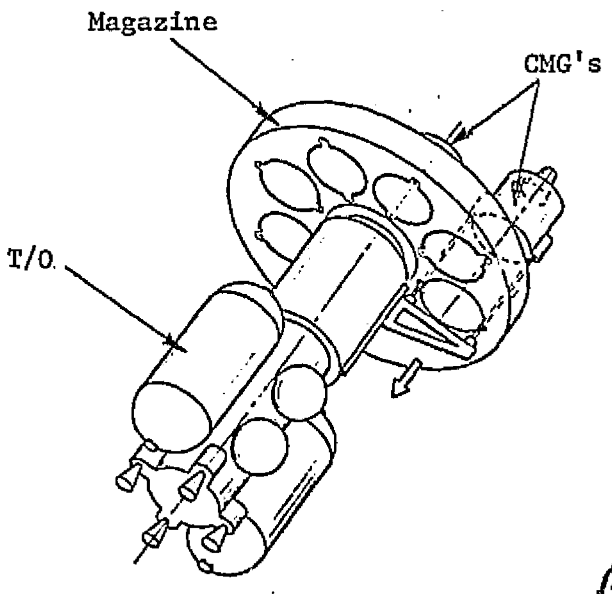
- Ground monitor and control of OTV and T/O

Activity Time

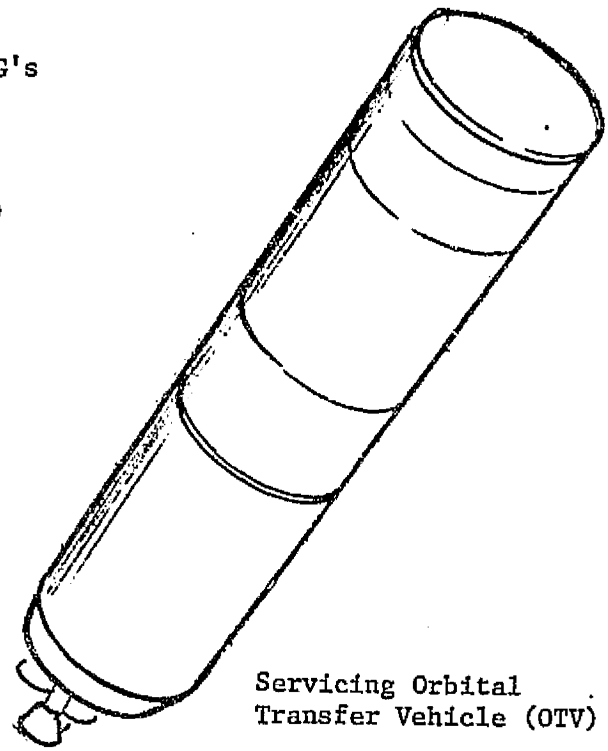
- T/O Translation to CM Docking Port, Align and Dock	(10 min.)
- Removal of Old CMG Unit and Storage	10 min.
- Retrieval of CMG from Magazine and Installation	10 min.
Total Per Unit	20 min.
- Repeat Exchange Operation for Remaining 6 Units	120 min.
- T/O Undock from CM and Place Itself and Old CMG's in Non Interference Orbit with Platform	(10 min.)
Total	160 min.

( ) One Time Operation

FUNCTION · ITEM ·	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	06.1
METHOD	CENTRAL DOCKING PORT	PAGE	3 of 4		
SUBJECT	SUPPORT EQUIPMENT REQUIREMENTS				



Teleoperator (T/O)
with SRU Magazine



Servicing Orbital
Transfer Vehicle (OTV)

Items

T/O

- CMG Storage Magazine
- TV Communications and Control from Ground
- Illumination for TV
- Servicing Arm (~ 5M reach)
- 6800 KG Payload Capability
- Non Reusable (single servicing operation)

OTV (Reference)

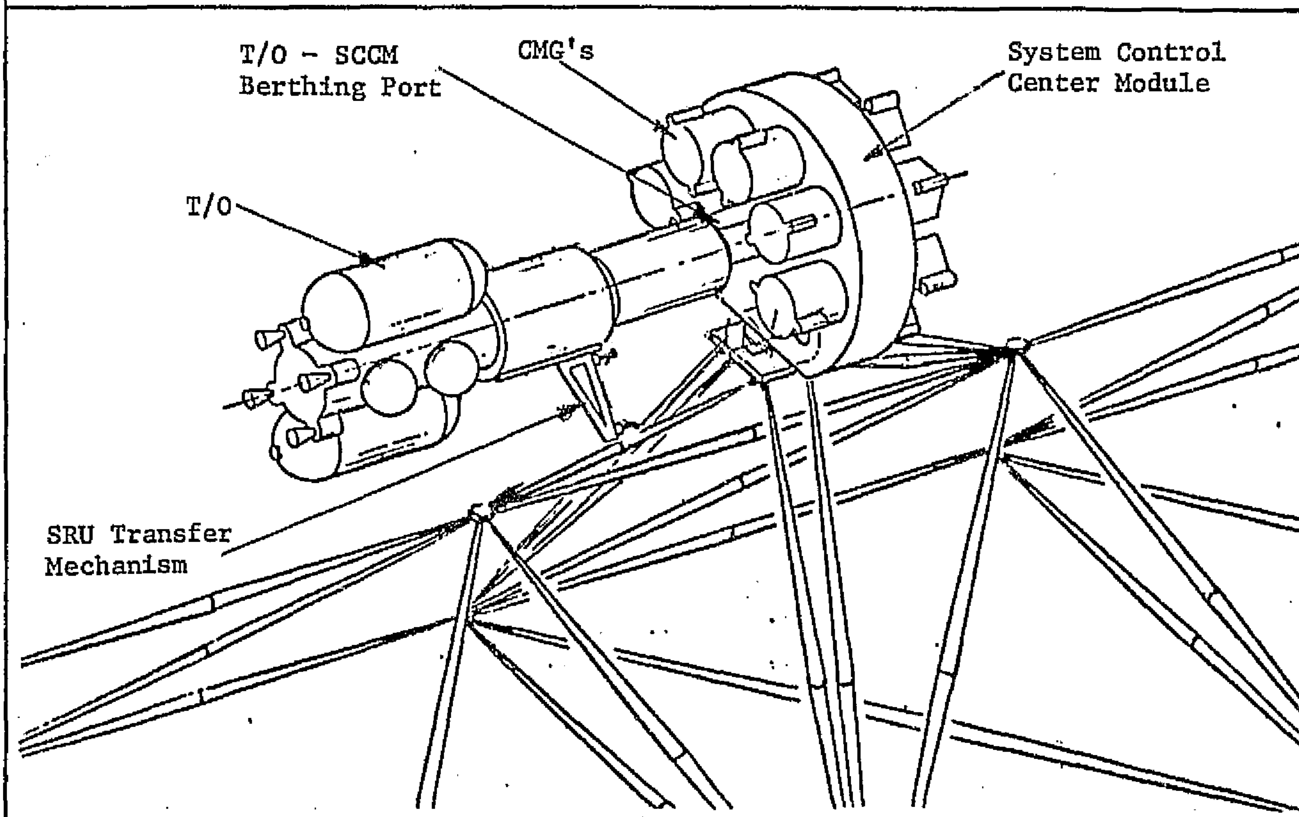
- Rendezvous Capability
- Propulsion to establish non platform Interference Orbit after usage

FUNCTION ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02 | 08 04.1 | 06.1
METHOD	CENTRAL DOCKING LOCATION	PAGE	4 of 4
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
Support Equipment							
T/O SRU Magazine	4500	TBD	–	–	–	–	1550 14855
Support Services							
Crew – (Ground Controllers for T/O's and OTV)	–	–	TBD	–	–	–	–
Power (Self Contained)	–	–	–	–	–	–	–
Project Modification							
None							
Operations	–	–	TBD	–	–	160	NA*

*Not appropriate, see page 6.

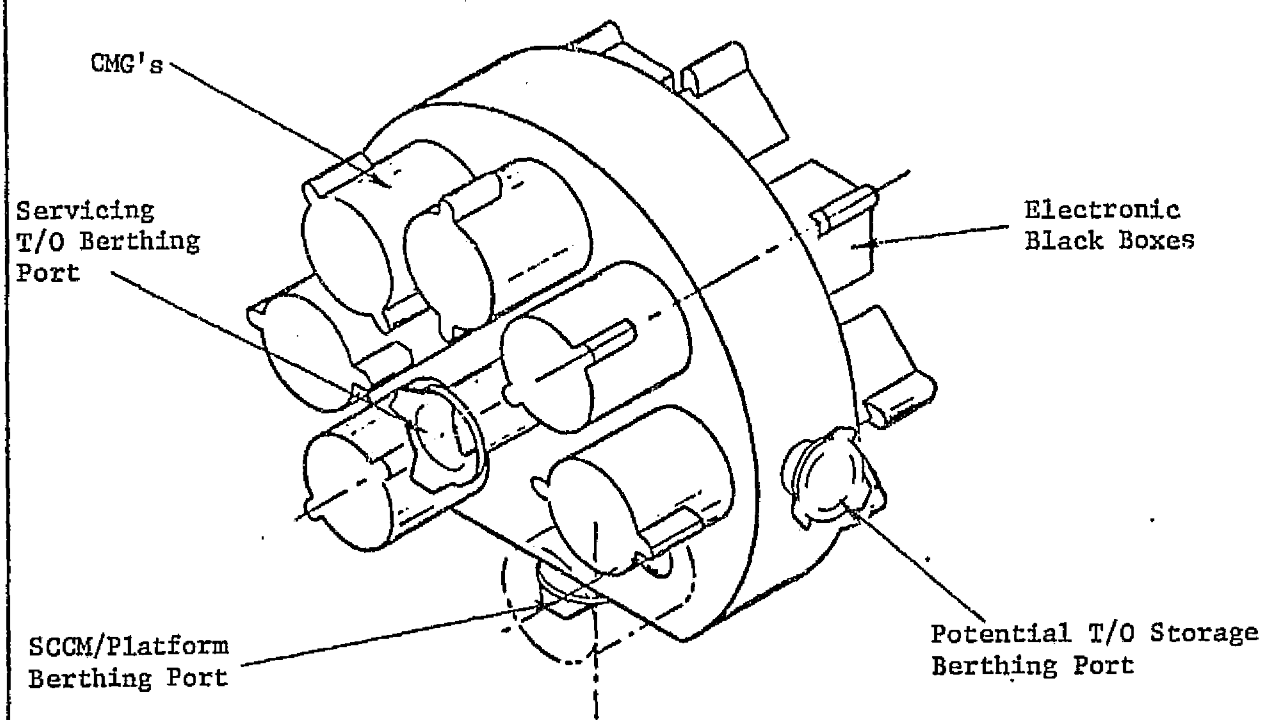
FUNCTION ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	06.2
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	1 of 5		
SUBJECT	METHOD DESCRIPTION				



- T/O parked at platform (delivered during construction)
- OTV with new units flys from orbiter and docks with platform at now empty orbit transfer propulsion module port
- T/O flys to CM, removes unit, flys to OTV and exchanges old for new unit
- T/O flys to CM and installs new unit at vacated interface
- T/O flys to next unit to be exchanged, removes it, flys to OTV and exchanges for new unit
- T/O returns to CM and repeats operations until all (planned) units have been exchanged
- T/O returns to stowage docking port on CM
- OTV is separated from platform and placed into non interference orbit with platform

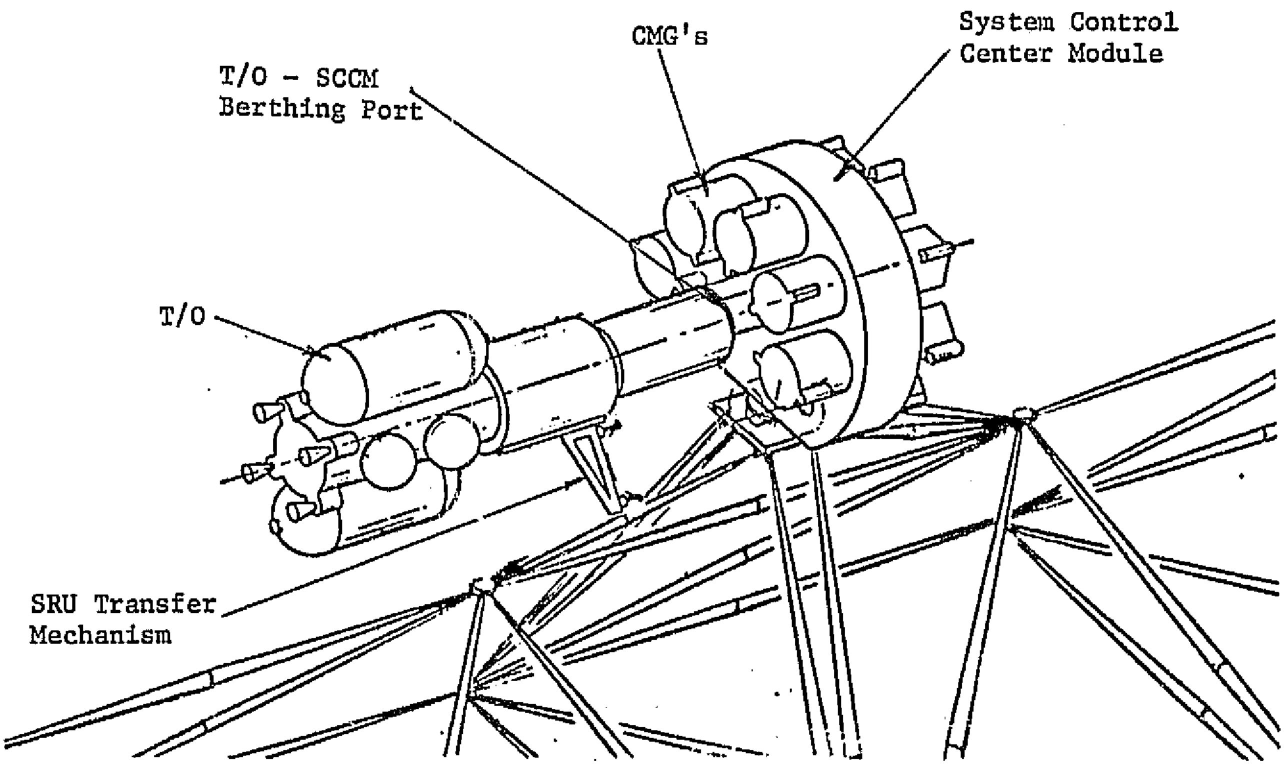
FUNCTION	SERVICE (EXCHANGE)	CODE	02	08 04.1	06.2
ITEM	CONTROL MOMENT GYRO (CMG) AT GEO	PAGE	2 of 5		
METHOD	T/O REUSABLE/MULTIPLE DOCKING				
SUBJECT	PROJECT MODIFICATIONS				

System Control Center Module



- Storage docking port on control module for T/O (potential)

FUNCTION · ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	06.2
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	3 of 5		
SUBJECT	OPERATIONS				



Manpower

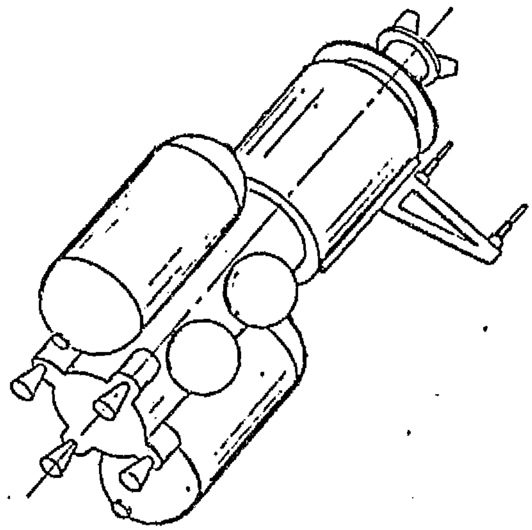
- Ground monitor and control of OTV and T/O

Activity Time

- T/O undock, move to CMG on CM, and dock	(3 min.)
- T/O remove CMG, fly to OTV and place unit in container	20 min.
- T/O move to new CMG on OTV and dock	6 min.
- T/O remove new CMG, fly to OTV and install new unit	20 min.
Total Per Unit	46 min.
- Repeat exchange operation for 6 remaining units	276 min.
- T/O undock with last unit, fly to stowage docking port and dock	(6 min.)
Total	331 min.

(   ) One time operation

FUNCTION · ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	06.2
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	4 of 5		
SUBJECT	SUPPORT EQUIPMENT REQUIREMENTS				



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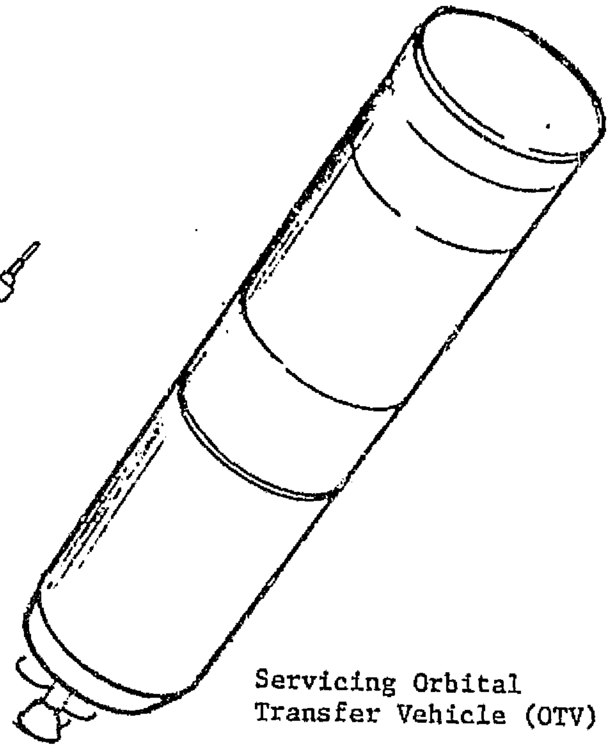


Servicing Orbital Transfer Vehicle (OTV)

Items

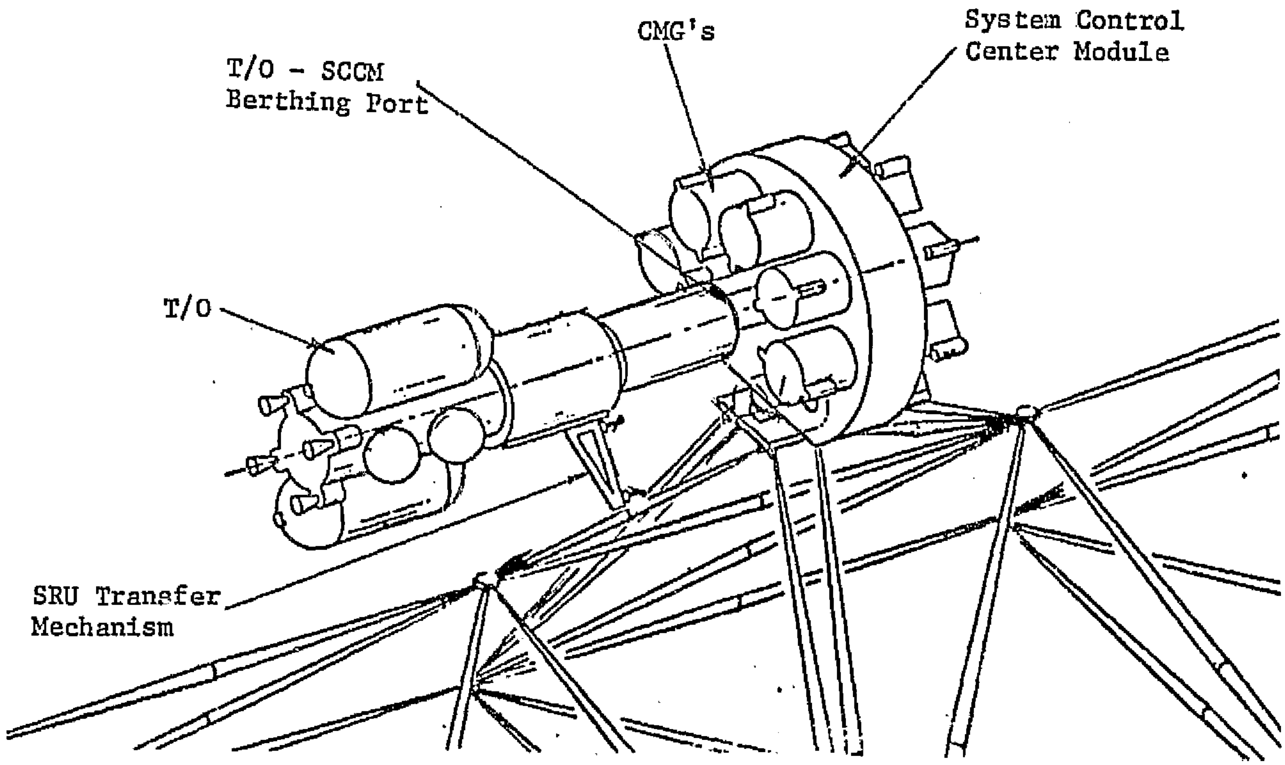
T/O

- TV Communications and control from ground
- Illumination for TV
- 4500 KG payload capability
- Propulsion sized for total servicable life of platform (multiple servicing operations)

OTV (Reference)

- Rendezvous and docking capability

FUNCTION· ITEM	SERVICE (EXCHANGE) CONTROL MOMENT GYRO (CMG) AT GEO	CODE	02	08 04.1	06.2
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	3 of 5		
SUBJECT	OPERATIONS				



Manpower

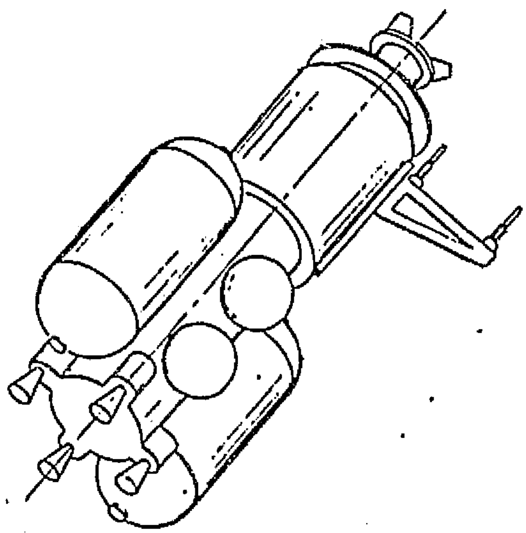
- Ground monitor and control of OTV and T/O

Activity Time

- T/O undock, move to CMG on CM, and dock	(3 min.)
- T/O remove CMG, fly to OTV and place unit in container	20 min.
- T/O move to new CMG on OTV and dock	6 min.
- T/O remove new CMG, fly to OTV and install new unit	20 min.
Total Per Unit	46 min.
- Repeat exchange operation for 6 remaining units	276 min.
- T/O undock with last unit, fly to stowage docking port and dock	(6 min.)
Total	331 min.

(   ) One time operation

FUNCTION ·	SERVICE (EXCHANGE)	CODE	02	08 04.1	06.2
ITEM ·	CONTROL MOMENT GYRO (CMG) AT GEO				
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	4 of 5		
SUBJECT	SUPPORT EQUIPMENT REQUIREMENTS				



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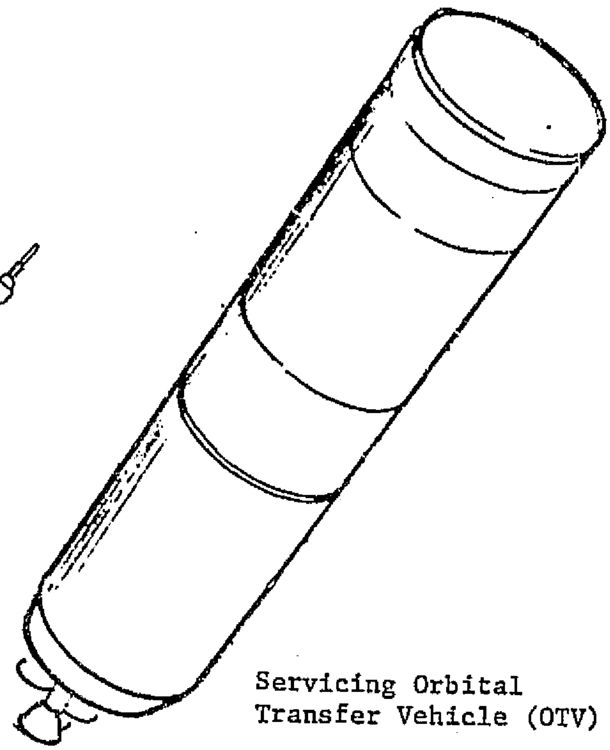


Servicing Orbital Transfer Vehicle (OTV)

Items

T/O

- TV Communications and control from ground
- Illumination for TV
- 4500 KG payload capability
- Propulsion sized for total servicable life of platform (multiple servicing operations)

OTV (Reference)

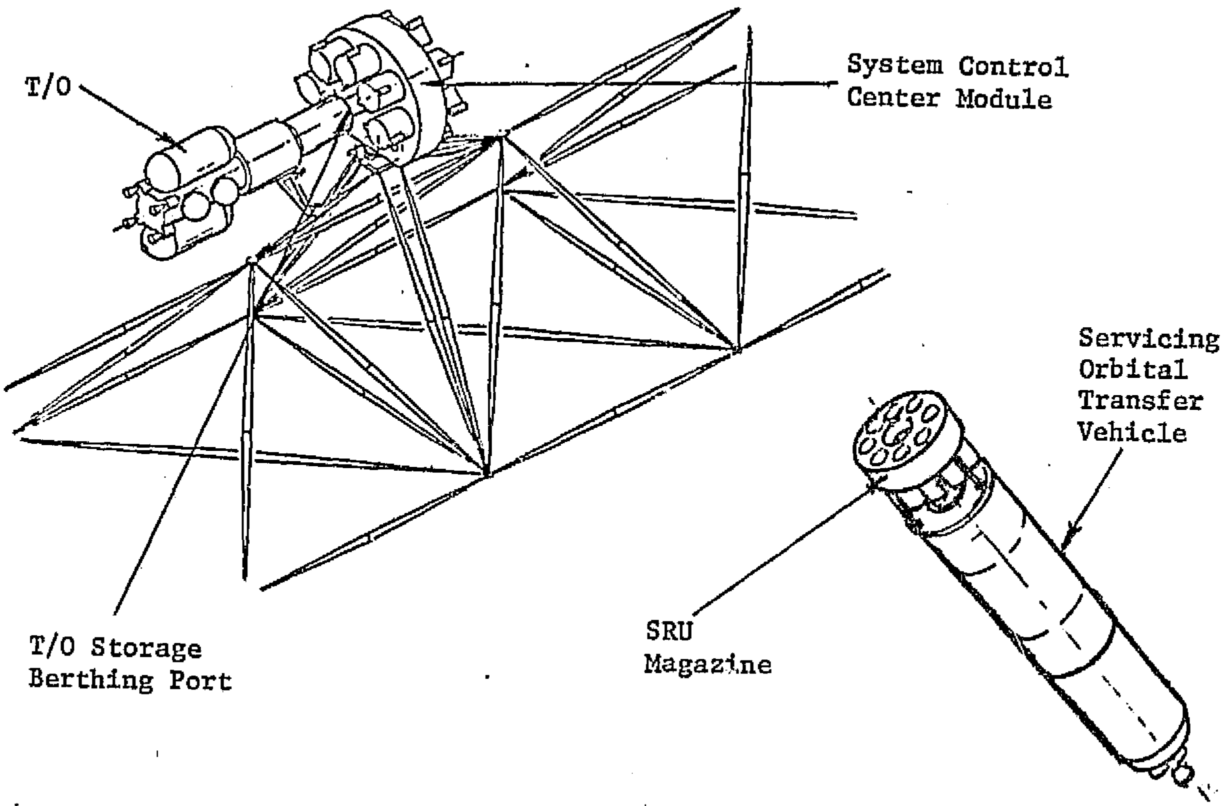
- Rendezvous and docking capability

FUNCTION	SERVICE (EXCHANGE)	CODE	02	08 04.1	06.2
ITEM	CONTROL MOMENT GYRO (CMG) AT GEO		
METHOD	T/O REUSABLE/MULTIPLE DOCKING	PAGE	5 of 5
SUBJECT	SUMMARY		

	WT. (KG)	VOL. (M^3)	CREW (MAX/AVG)	ELECTRICAL POWER (KW)	ELECTRICAL ENERGY (KWH)	TIME (MIN.)	COST ($K)
<u>Support Equipment</u>							
T/O	3000	TBD	-	-	-	-	1550
<u>Support Services</u>							
Crew (Ground Controllers for T/O and OTV)	-	-	TBD	-	-	-	-
Power (Self Contained)	-	-	-	-	-	-	-
<u>Project Modifications</u>							
Stowage Docking Port for T/O	110	1.0	-	-	-	-	473
<u>Operations</u>	-	-	TBD	-	-	331	NA*

*Not appropriate, see page 6.

FUNCTION ·	SERVICE (EXCHANGE)	CODE	02	08 04.1	06.3
ITEM	CONTROL MOMENT GYRO (CMG) AT GEO				
METHOD	T/O REUSABLE/SINGLE DOCKING	PAGE		1 of 1	
SUBJECT	METHOD DESCRIPTION				



- T/O parked on platform (delivered during construction)
- OTV with spare units in canister flys to vicinity of platform
- T/O undocks from platform, flys to OTV, retrieves canister
- T/O flys to platform and docks with central docking port on CM
- Servicing arm on T/O exchanges old units on CM with new units in canister
- T/O exchanges used for new canister on OTV as required
- After servicing operation is complete T/O redocks with CM to await next servicing operation and OTV is placed in non interference orbit with platform

NO ADDITIONAL DETAILS ARE PROVIDED

SECTION III

CONSTRUCTION SUPPORT EQUIPMENT

This section contains descriptions of the standard pieces of support equipment—namely, the MMU, MRWS, RMS, and beam builder. The information was extracted directly from the latest documentation concerning each piece of equipment. A brief description of the construction fixtures used in generating the data in Section II has also been included to aid the users of the Data Base.

A. STANDARD EQUIPMENT DESCRIPTION

There are several pieces of construction support hardware which have been designated "standard" as they are being developed or planned for use as general support items for future space operations. They have been used extensively in the operations described in Section II. Therefore, a brief description of each is given below. Additional information can be obtained by a review of the referenced documentation.

Manned Maneuvering Unit (MMU)

The MMU is being developed by the Martin Marietta Corporation. The data presented in the following paragraphs have been taken from their Users' Guide for the MMU, dated May 1978 (MCR 78-517, NAS9-14593).

General

The principal elements of the MMU (Figure 3-1) are its basic structure, a propulsion subsystem, two hand controllers, and a control electronics assembly (CEA). Twenty-four fixed-position thrusters utilizing gaseous nitrogen (GN_2) provide full six-degree-of-freedom control by reacting to commands from the three-axis translational hand controller (THC) and the three-axis rotational hand controller (RHC). Electrical power is supplied to the MMU subsystems from two batteries mounted at the top rear of the unit between the GN_2 pressure vessels. Command logic, power conditioning equipment, and gyroscopes are mounted in the control electronics assembly (CEA) located behind and below the batteries.

The MMU is a fail-safe system in that any single failure does not preclude the astronaut from returning safely to the orbiter vehicle. The thrusters are separated into two independent systems (12 thrusters each), each of which provides full six-degree-of-freedom control in the event of a failure in the other system. The control electronics are also redundant such that at least one set of 12 thrusters can always be commanded.

In addition to the manual commands which are applied by the astronaut from the hand controllers, an automatic attitude hold (AAH) capability is also

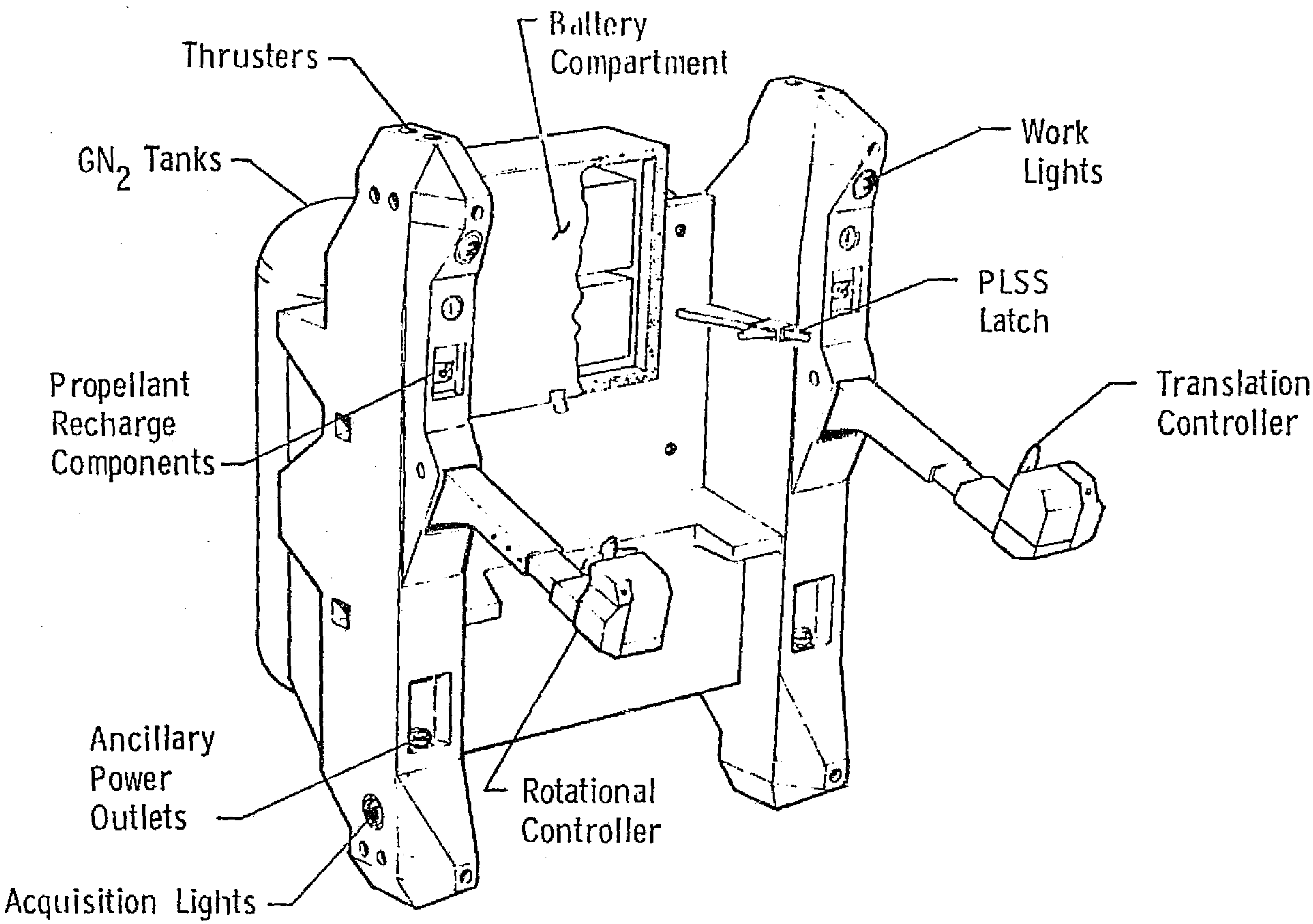


Figure 3-1. Manned Maneuvering Unit

C-5

available. By activating a switch located on top of the RHC grip, the astronaut can command attitude hold and the MMU will maintain attitude in three axes of rotation by firing thrusters automatically, as required. Three rate gyros sense rotations and attitudes in each rotational axis, and the MMU control logic uses these data to command the thrusters. If rotational rates are already present when attitude hold is commanded, the control logic will fire thrusters to cancel those rates.

The two propellant tanks contain a total of 40 lb (18 kg) of GN_2 at 4500 psia and 70°F, on initial charge on the ground prior to a mission. These pressure vessels are rechargeable during EVA by an unassisted crew member. The initial charge provides sufficient propellant for an equivalent ΔV of 110 to 135 fps; subsequent recharges on orbit will provide a minimum equivalent ΔV of 72 fps (36 fps per GN_2 tank). The control logic of the MMU is designed to maintain fuel consumption from each tank at a relatively even level. In addition, the logic is designed to select the optimum combination of thrusters in order to conserve propellant when mass offsets are present or multiple axis commands occur simultaneously.

The MMU is stowed for launch and reentry in the Flight Support Station (FSS) located in the payload bay of the orbiter (Figure 3-2). The FSS structure provides environmental protection to the MMU during launch, on-orbit (nonoperational) periods, reentry and landing. The FSS also contains the necessary attachment provisions, foot restraints and handholds for donning/doffing and servicing the MMU in orbit by an unassisted EVA crew member. One FSS can be mounted on each side of the payload bay so two MMU's can be carried on each orbiter flight.

Flight Characteristics

The maneuvering unit responds to direct manual commands input by the crew member via the two hand controllers. For a nominal system mass, translation accelerations are 0.3 ± 0.05 ft/sec^2 and rotational accelerations are 10.0 ± 3.0 deg/sec^2. Since the MMU operates in a direct flight mode, these acceleration levels are present whenever either hand controller grip is displaced from the center or null position. Acceleration commands are terminated when the grip is returned to the center position. Simultaneous commands in several axes (multi-axis commands) are possible at reduced acceleration levels.

Each MMU thruster develops approximately 1.4 lb of thrust; therefore, single axis translation commands generate 5.6 lb of thrust in the normal operations mode, and 2.8 lb of thrust in the backup operations mode. Rotational torques are the same for the prime and backup modes. For multi-axis commands up to six thrusters can be firing simultaneously.

The automatic attitude hold (AAH) capability of the MMU allows the crew member to maintain attitude in any or all of the axes of rotation. The MMU control logic automatically fires thrusters as required to hold a position within a deadband of ±0.5 to ±2.0 degrees (premission selectable) in any rotational axis, as sensed by the rate gyros. Drift rates across this deadband (if, for example, the crew member is relatively still while inspecting or photographing a payload) are on the order of 0.02 deg/sec.

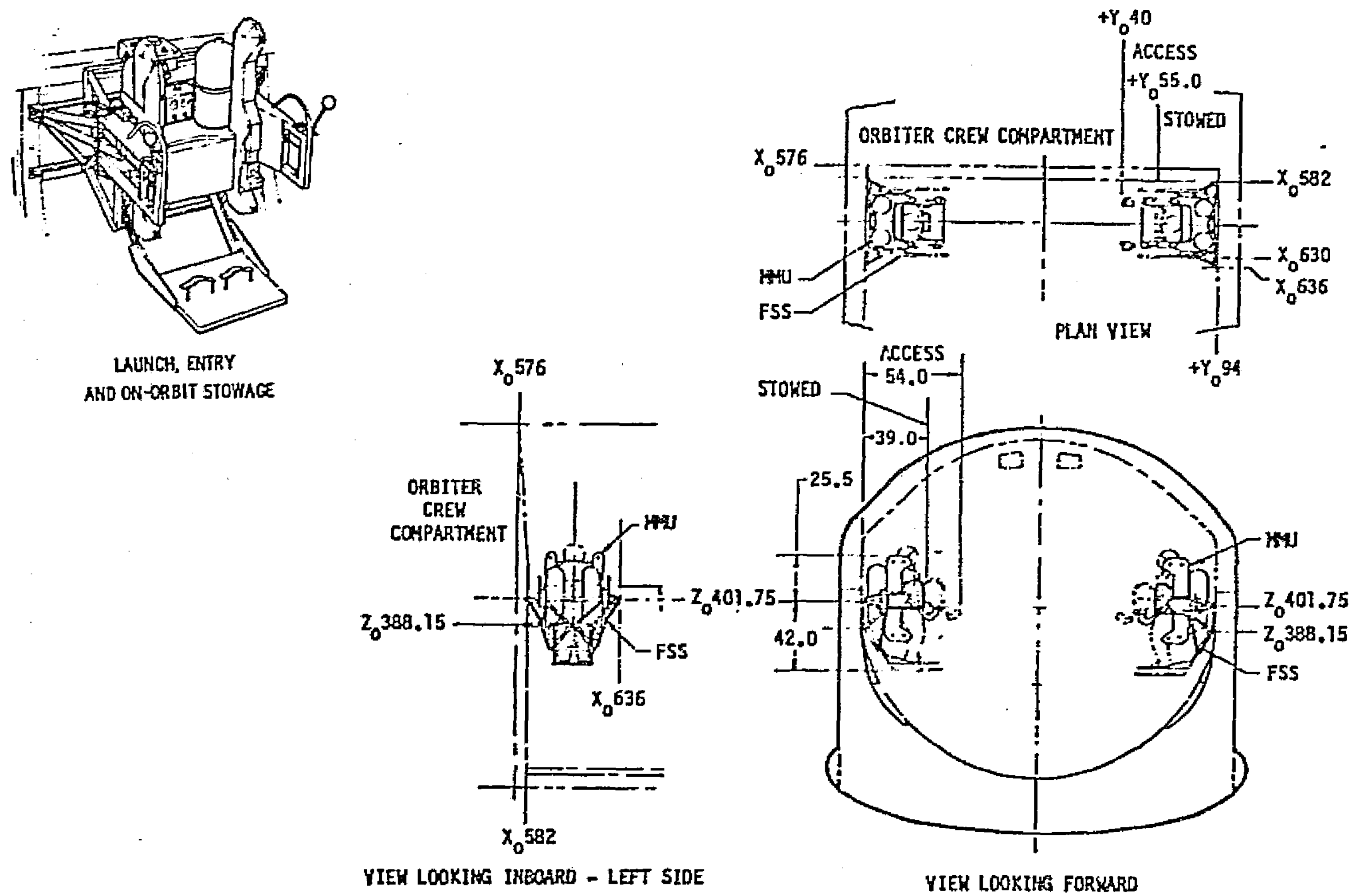


Figure 3-2. MMU/FSS Configuration in Payload Bay

In the AAH mode, highly developed control logic incorporating limb motion filters and limited minimum impulse thrust repetition rates allows a tight limit cycle deadband that is relatively insensitive to large crew member limb motions and is fuel conservative in the presence of the cyclic disturbance torques.

Three-axis attitude hold can be commanded during translation in any axis. Attitude hold can be inhibited independently in the roll, pitch or yaw axes when the crew member inputs via the RHC a manual rotation command in that axis.

Table 3-1 summarizes the flight characteristics of the MMU.

Table 3-1. MMU Flight Characteristics

- Six-Degrees-of-Freedom Control Authority
- Spacecraft-type Piloting Logic
  - 3-Axis Translational Controller (Left Hand)
  - 3-Axis Rotational Controller (Right Hand)
  - Independent or Multiple Axis Commands
  - Pulse or Continuous Commands
- Manual (Direct) Translation and Rotation Control
- Automatic Attitude Hold
  - Deadband Adjustable ± 0.5 to $\pm 2.0^{o}$
  - Inertial Drift less than 0.01^{o}/sec
- Response
  - Translational Acceleration 0.3 ± 0.05 ft/sec^2
  - Rotational Acceleration 10.0 ± 3.0^{o}/sec^2
- Audio Feedback for Thruster Operation

Operational Guidelines

Although the MMU cold gas propulsion system is essentially noncontaminating, the EMU life support system does vent water vapor to space (approximately one pound of water per hour). In almost all cases for specific payload operations, this level and type of contamination is well within acceptable limits.

The MMU cannot be effectively utilized as a stable platform from which large forces and torques can be exerted; that is, the MMU should not be considered a mechanism through which large forces or torques can be reacted to do work. Additional restraints are required in such cases. The MMU can be utilized, however, to counter light loads such as might occur during simple tasks.

Work Site Aids/Ancillary Equipment

The MMU contains provisions to attach cargo or equipment for transport during maneuvers. These attachments allow the crewmember's hands to remain free to operate the MMU hand controllers. Three types of attachments are available. Telescoping, lockable arms with grappling end effectors (Figure 3-3) can be extended from each side of the MMU to hold cargo in front of and below the hand controllers. Soft tethers can be attached to the cargo and to the pressure suit waist ring, or the side of the MMU. Finally, attachment mechanisms can be mounted at the end of each handcontroller housing (Figure 3-4) to carry a smaller cargo item directly in front of the crewmember's hands.

These attachment provisions are generally intended to allow easy transport of relatively small (less than 50 lb) cargo items. The MMU system is capable, however, of transporting larger masses (up to several hundred pounds) when operating free of external forces. The MMU control system compensates for changes in center of gravity and the torques which result from attaching such additional cargo. Exact limiting criteria are dependent on the total task requirements (e.g., distances, time constraints), in addition to the cargo mass and location.

The electrical system of the MMU provides auxiliary power which can be utilized to operate tools or other equipment at the task site, once translation to the site has been accomplished. Two power outlets supply 28V dc and 2 amps maximum; each outlet is operated by a switch accessible to the crewmember in flight. In addition, a floodlight which provides local work site illumination is mounted over each shoulder of the crewmember in the MMU.

Tethers can be utilized to establish a soft attachment between the crewmember/MMU and work site. A temporary system is also available to establish a more rigid attachment between the MMU and the work site. This system is designed to allow the crewmember to apply moderate forces at the work site without generating intolerable reactions or torques. It should be noted that additional work site dedicated restraints may be required if large forces or torques must be applied by the crewmember at the site. These restraints must be supplied by the user, or be built into the work site. A variety of standard Shuttle equipment is available for such support (see JSC-10615, "Shuttle EVA Description and Design Criteria").

The arms on which the MMU hand controllers are mounted can be folded down to provide clearance for the crewmember to approach the work site more closely.

Additional functional capability can be kitted into the MMU if required by a specific operational mission. Additional propellant tanks and navigation aids can be attached to the baseline MMU system to allow extended excursions farther away from the orbiter vehicle. Although design concepts for these kits have not been finalized, potential MMU users should be aware that such capability will become available as part of the basic MMU configuration as the Shuttle flight program progresses.

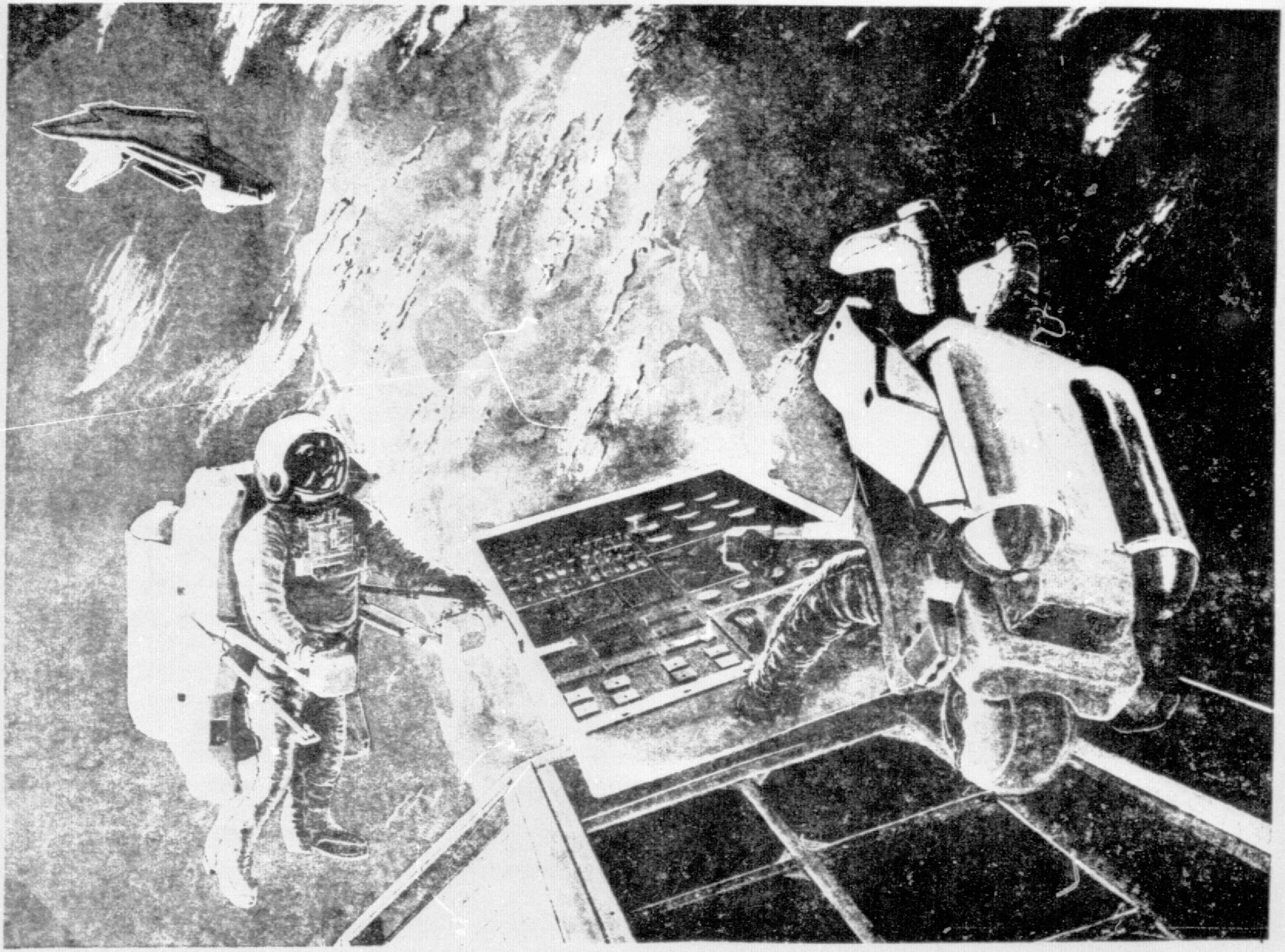


Figure 3-3. MMU Cargo Attachments—Side Grapplers

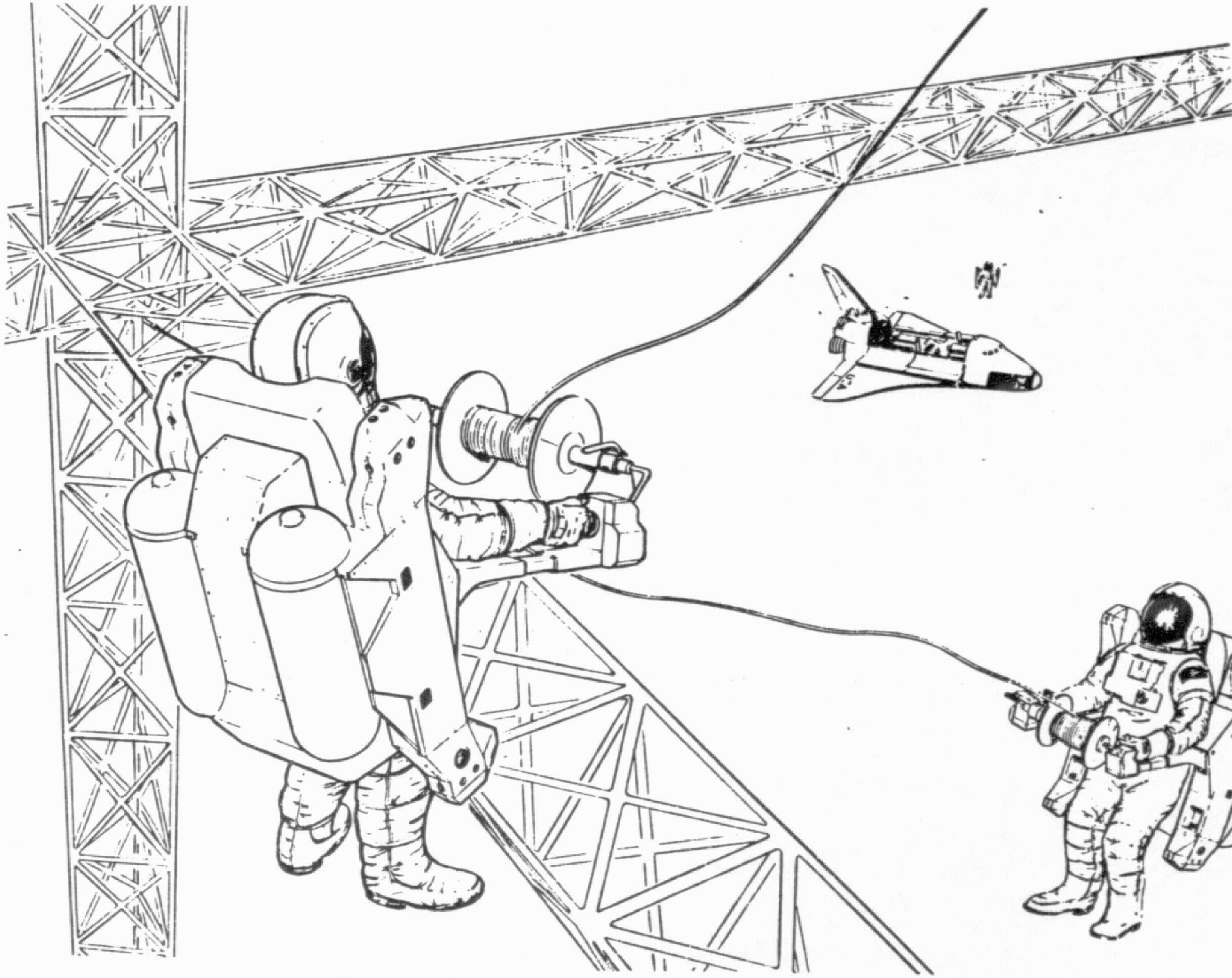


Figure 3-4. MMU Cargo Attachments—Front Mount

Servicing

The MMU can be serviced by a single crewmember while it is mounted in the FSS. Spare batteries, stowed in the pressurized crew compartment, can replace used batteries in the MMU; battery replacement takes less than five minutes. Two fully charged batteries provide 540 watt-hours of power; the nominal MMU load is 30 watts. (Battery recharge, if required, is accomplished in the pressurized airlock of the orbiter using the EMU recharge system. Up to 16 hours are required to establish a full charge.)

Recharge of the MMU nitrogen propellant tanks can be performed at the FSS using a pressurized nitrogen supply (3000 psi maximum) available from the orbiter. A quick disconnect establishes the connection between the orbiter supply and the MMU. Gauges and toggle valves mounted on the MMU and FSS are utilized to monitor and control repressurization. Propellant recharge of both tanks can be completed in less than 10 minutes.

Since the orbiter supply (3000 psi maximum) is less than the initial ground charge of the MMU (4500 psi), the delta velocity available from the recharge will typically be 80 to 100 fps. A full ground charge provides 110 to 135 fps delta velocity capability.

Mass Properties

The total weight of the MMU is approximately 243 lb (110 kg), including a full charge of propellant (40 lb GN_2). Figure 3-5 depicts the reference coordinate axis and shows the location of the center of mass of the EMU/MMU system. The maneuvering unit will accommodate personnel within the range of the 5th percentile based on anthropometric data for 1968 USAF women officers, to the 95th percentile based on data for 1980 male flying officers.

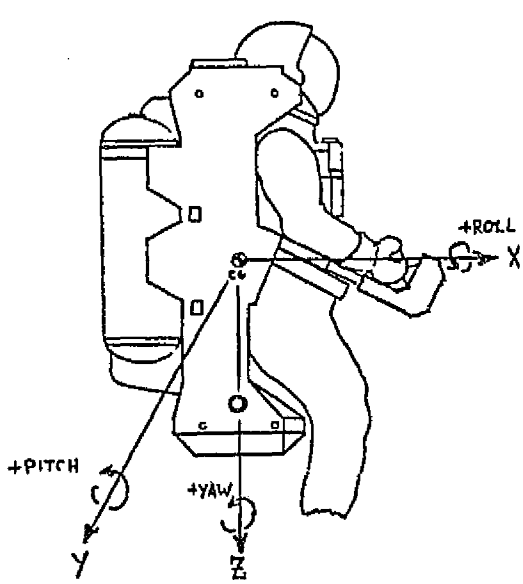


Figure 3-5. MMU Reference Coordinate System

For each MMU carried aboard the orbiter, a Flight Support Station (FSS) is required. The FSS is a structure to which the MMU is attached for launch and reentry of the orbiter. The weight of the FSS is approximately 50 lb (23 kg); hence, the payload launch weight penalty for one MMU is approximately 293 lb (133 kg). It should be noted that the weight of the flight operational MMU system includes the astronaut and the extravehicular mobility unit (EMU). The astronaut weight can vary between 100 and 215 lb (45 to 100 kg); the EMU weight is approximately 175 lb (80 kg).

. Manned Remote Work Station, MRWS (Cherry Picker)

The MRWS is being developed by the Grumman Corporation. The data presented has been taken from their final report, "Manned Remote Work Station Development Article," Volume I, Book 1, Flight Article Requirements, Report NSS-MR-RP008, dated 3-1-79.

Flight Article System Requirements

The following defines the overall configuration, safety, reliability, maintenance, and interface requirements.

Open Cherry Picker MRWS (Figure 3-6)

The MRWS shall support the EVA astroworkers and provide unobstructed reach for the astroworker to perform space tasks. The MRWS shall consist of:

- A platform with a restraint system to secure the EVA astroworker
- Stabilizer attached to the platform
- Illumination
- Stabilizer controls and displays
- RMS controls and displays
- Tool storage (small hand tools)
- Provisions for large tools
- Payload handling devices
- RMS mechanical and electrical interfaces
- Provisions for storage in payload bay

The platform shall be mounted to the orbiter RMS utilizing the stabilizer fixture that interfaces with standard snare-type end effector.

Electrical power, controls, and data shall be routed through the RMS internal cabling utilizing the payload mounted grapple fixture special-purpose end effector connector.

The open cherry picker MRWS shall fold for storage in the orbiter payload bay. Its folded volume shall not exceed 1.5 m^3 and it shall be mounted adjacent to the EVA hatch at the starboard manned maneuvering unit (MMU) donning station attachment points.

Open Cherry Picker Subsystem Requirements

Structure/Mechanical

All major load-carrying structures of the structural subsystems shall be designed to a safe life of a minimum of 10 years in orbit with a scatter factor of 4.0. Life limitations shall be identified.

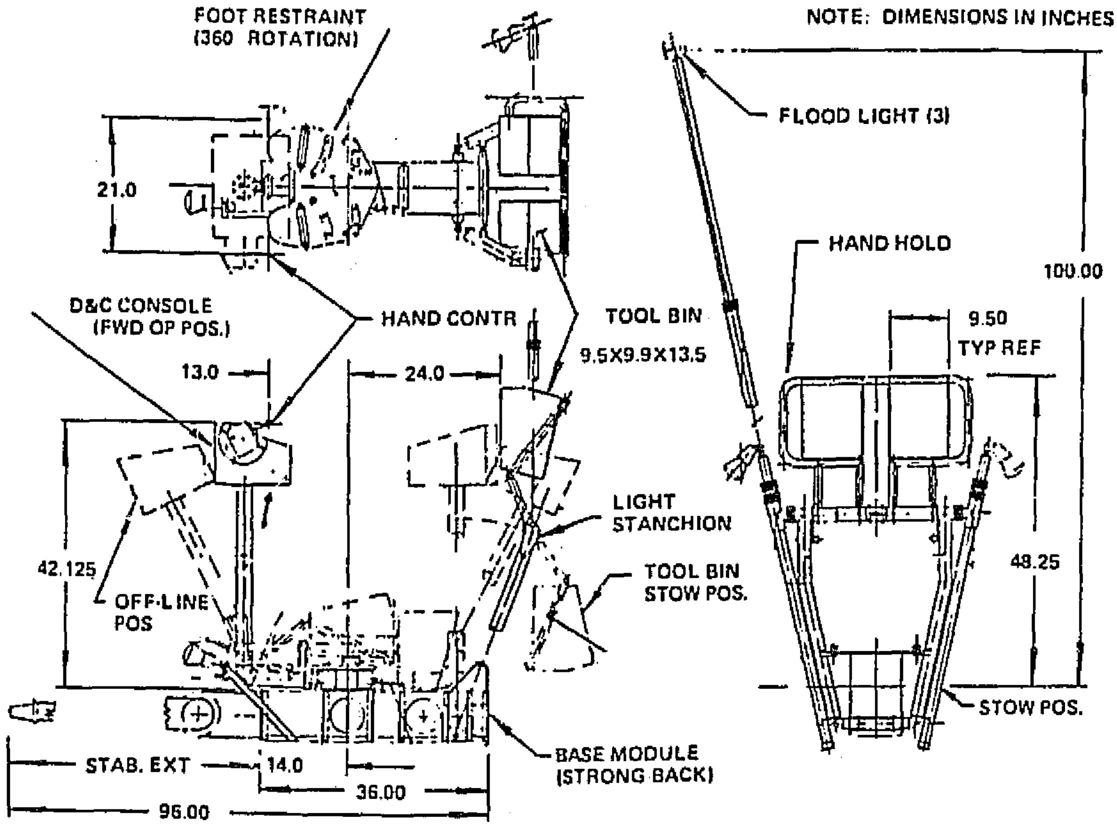


Figure 3-6. OCP-DTA General Arrangement

As a goal, fail-safe design concepts shall be applied to all critical structure so that failure of a single structural member shall not degrade the strength of stiffness of the structure to the extent that the crew is in immediate jeopardy.

The structure shall be designed to resist damage resulting from accidental impact during crew activities.

Safety factors used for structural design shall be consistent with those currently used for manned operations.

- Primary Structure
  - Ultimate strength: A factor of 1.5 x limit load shall be applied.
  - Yield strength: A factor of 1.2 x limit load shall be applied.

Structures shall be designed to withstand temperature cycling between -433°K to 366°K.

The structure shall be designed to withstand orbiter launch and landing oads specified in JSC-07700, Volume XIV.

The open cherry picker (OCP) shall be designed to be folded and unfolded by an EVA astronaut to facilitate orbiter payload bay storage.

Communications

The OCP operator shall utilize the EMU for communications with the orbiter, EVA astroworker and space construction base as applicable.

Electrical Power

The open cherry picker MRWS shall receive 28 V dc orbiter power, up to 250 W, via the RMS grapple fixture electrical connector.

The distribution system shall provide circuit protection devices for all power equipment.

The electrical power subsystem (EPS) shall have a maintained lifetime of not less than 10 years. Elements may be replaced in total or in modular form for maintenance or for growth up-rating.

Environmental Control and Life Support (ECLS)

The OCP operator shall utilize the extravehicular mobility unit (EMU) for ECLS.

Thermal Control

Passive thermal control approach should be utilized where appropriate, or if not feasible, the design should minimize system complexity and weight.

The subsystem shall not require selected orientation in orbit to maintain its thermal control function.

Crew Accommodations

An existing foot restraint that is mounted to a rotating platform (Figure 3-7) will be utilized for the OCP.

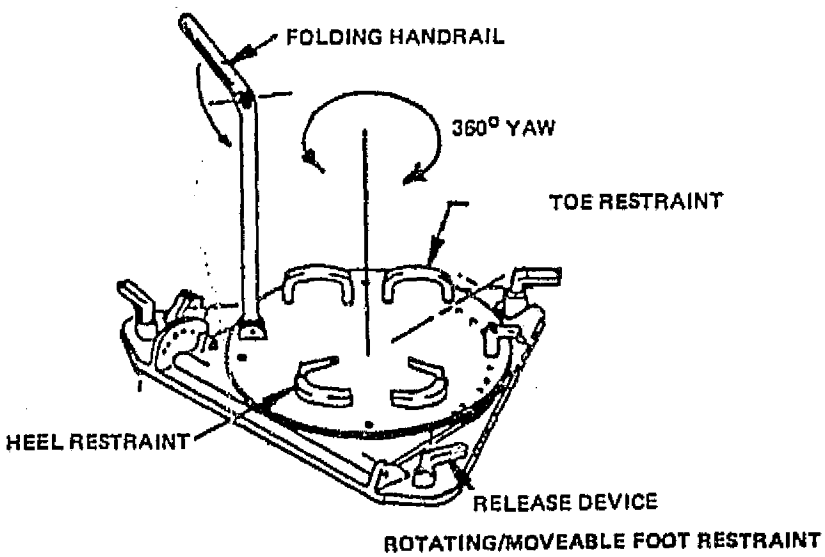


Figure 3-7. Foot Restraint

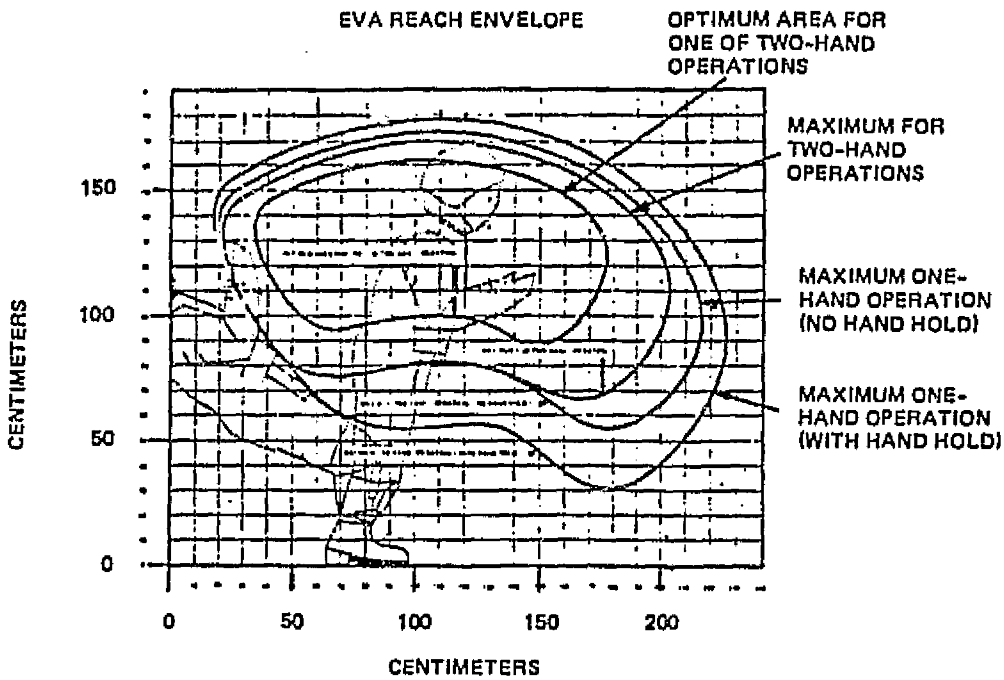
A safety tether shall be provided. Also provided will be a waist restraint to be used in conjunction with foot restraint as needed.

The open platform equipment shall not inhibit crew reach (Figure 3-8) to perform assembly tasks.

Stabilizer (Controller and Slave)

The OCP MRWS shall have one stabilizer located on the platform extending forward and shall be capable of being installed/detached in orbit. The stabilizer shall have 3 DOF as defined in Figure 3-9. The stabilizer characteristics are:

Reach	1.3 m
Tip force (locked)	40 lb
Tip moment (locked)	4000 in.-lb
Accuracy	± 1 cm
Resolution	± 2 mm
Velocity	1.1 cm/sec



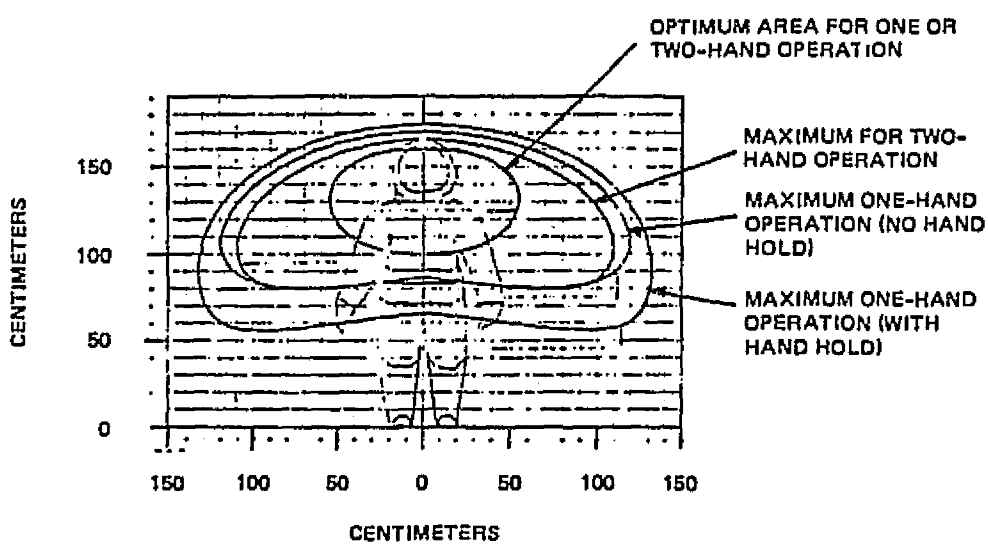


Figure 3-8. EMU Reach Capability

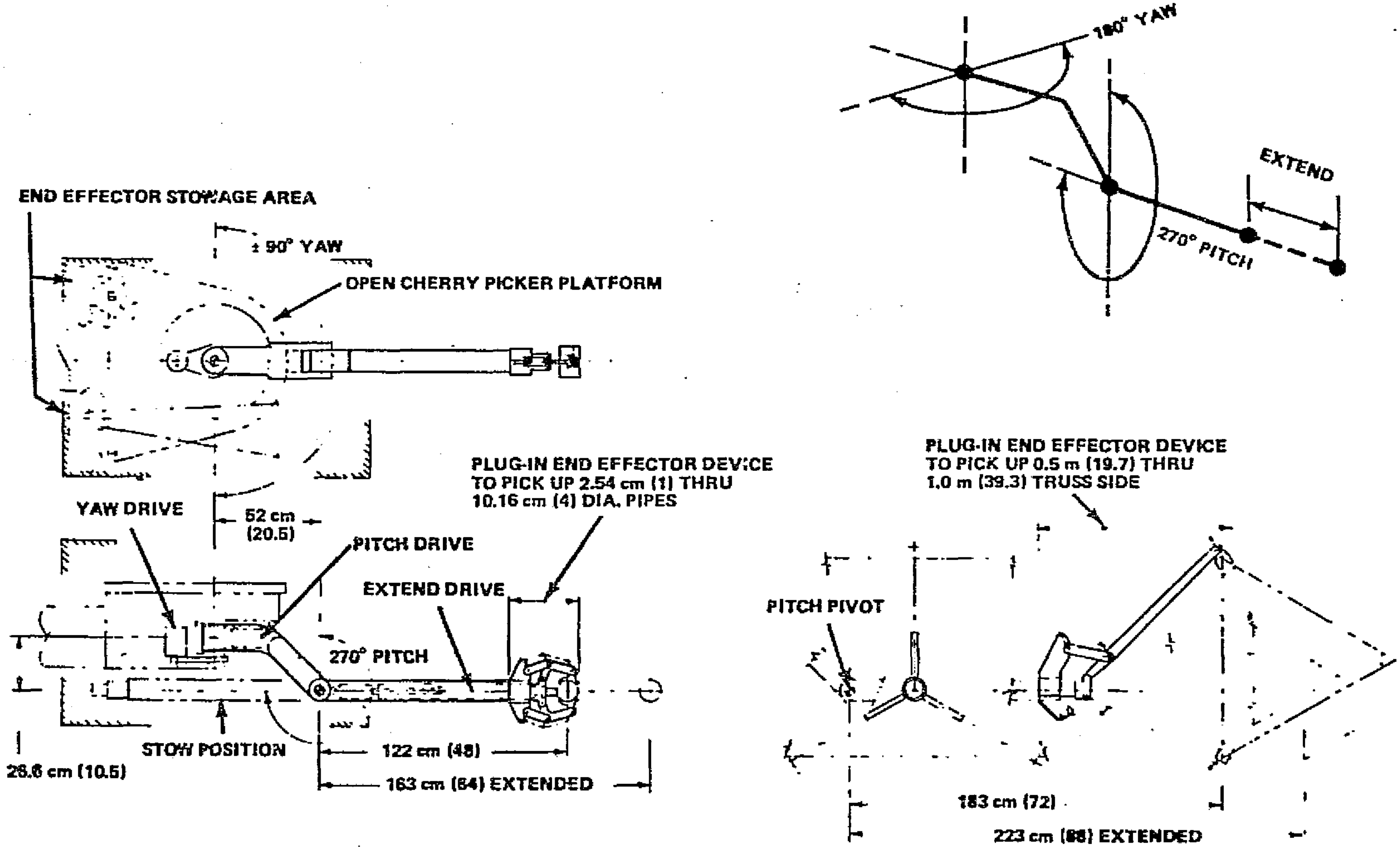


Figure 3-9. Three-Degree-Of-Freedom Stabilizer

Satellite Systems Division
Space Systems Group
Rockwell International

- The stabilizer master control shall be a resolved rate controller(s)
- The tip shall have mechanical and electrical interfaces to accept end effectors.
- Provide controls to actuate end effector functions, eg., open/close jaws.
- The stabilizer joints shall lock in existing position at power removal.
- Back driving shall not damage the stabilizer.

Cherry Picker Arm Control

- Provide orbiter RMS/cherry picker arm control from the OCP utilizing the same type of controllers used for the orbiter RMS.
- The capability shall be available to select control of an alternate RMS/crane arm.
- The capability shall be available to the OCP operator to control individual RMS joints.
- Interface units shall be provided for open cherry picker RMS control as shown in Figure 3-10.

Illumination

Lights shall be mounted on the OCP to provide 50 ft-c of luminous intensity within the reach of the OCP operator. The lights shall be adjustable by the OCP operator for direction and reach.

Controls and Displays (C&D)

A C&D console shall be mounted convenient to the operator during OCP RMS maneuvers and when controlling the stabilizer. The panel shall provide accommodations for mounting the RMS and stabilizer controllers. Controls and displays panel shall be moveable so that the operator is not constrained while performing space tasks.

Software

Utilize existing orbiter software for control of the RMS.

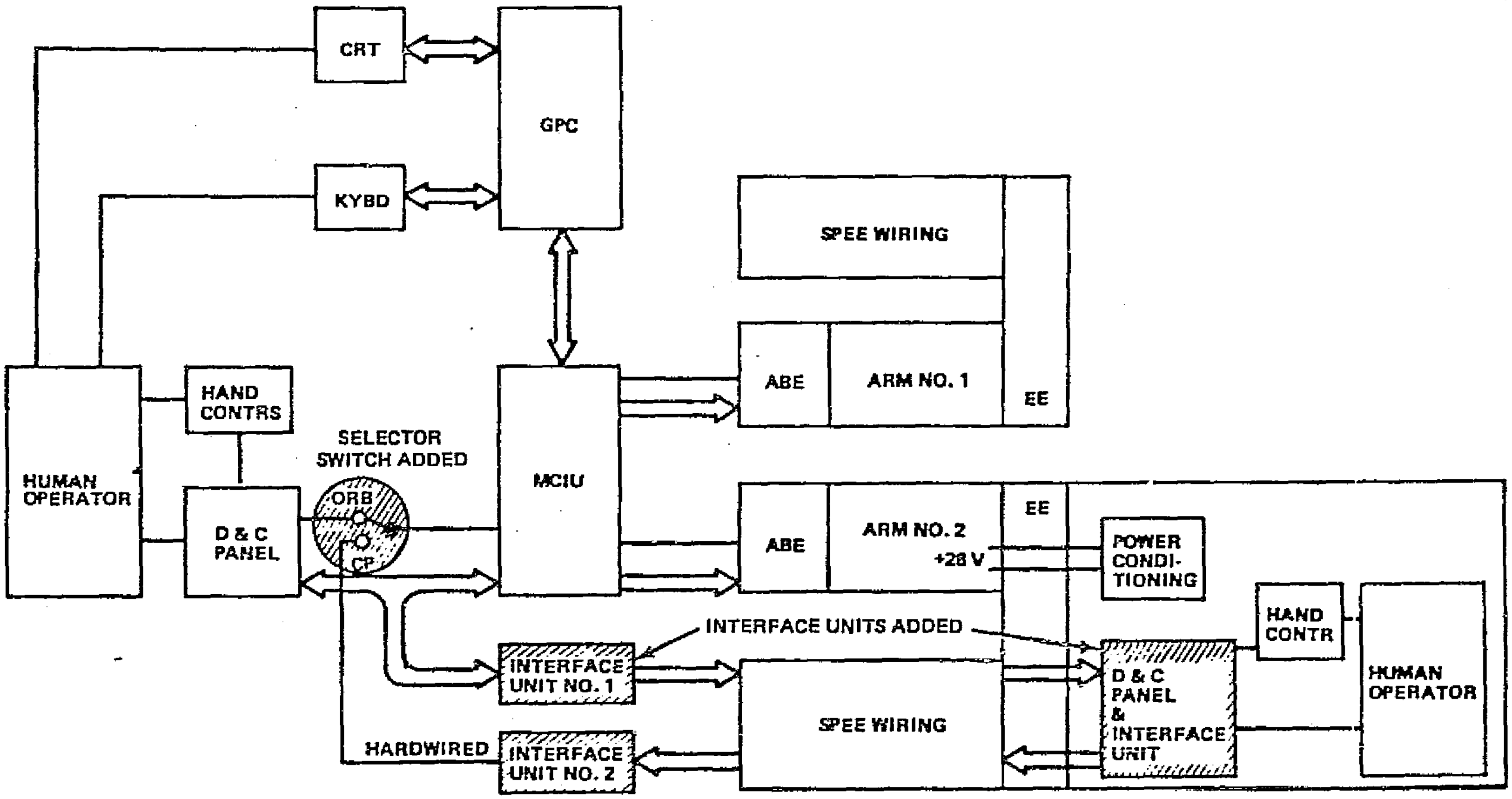


Figure 3-10. Orbiter/RMS/OCP Block Diagram

. Remote Manipulator System (RMS)

The RMS is being developed by SPAR of Canada for the Shuttle program. These data have been taken from the Space Shuttle System Payload Accommodations, JSC 07700, Volume XIV, Revision F, dated 9-22-78.

The RMS is shown in Figure 3-11. A single manipulator of 50 feet, 3 inches (15,316 mm) in length is normally located on the port side of the vehicle, as shown in Figure 3-12. The RMS is stowed outside the payload dynamic envelope and is charged to orbiter weight. Detailed arm dimensions and joint angle limits are shown in Figure 3-13.

A second manipulator arm can be installed on the starboard longeron if compatible with STS operational constraints. The weight of the second manipulator is weight chargeable to the payload. This weight is 905 lb, including the standard end effector and TV at the wrist (TV also mounted at the elbow is an additional 28 lb). Capability is provided to operate two manipulators in serial-only (non-simultaneous) operations. Capability is provided to hold the payload with one manipulator arm in a chosen position while operating the second manipulator arm.

The capability is provided to jettison each manipulator arm assembly. Sufficient redundancy is provided to insure that the payload can be released prior to RMS arm jettison.

General RMS Capabilities

a. In orbit, the manipulator is capable of deploying a maximum envelope (approximately 15 feet diameter x 60 feet long), maximum weight 65,000 lb (29,484 kg) payload. Under normal operational conditions, the RMS is capable of retrieving a 32,000-lb (14,515-kg) payload and placing it in a position for engagement with the cargo retention system in the cargo bay for return to earth. Under clearly defined contingency conditions, the RMS is capable of retrieving a maximum weight payload (65,000 lb) in a non-time constrained operation. (The requirement for retrieval of a payload weighing more than 32,000 lb could be to correct a malfunction in the payload and subsequently redeploy the payload. The orbiter entry and landing is normally constrained to payloads weighing less than 32,000 lb.

Deployment of a maximum envelope, maximum weight payload can be accomplished in approximately 25 minutes from release of payload tiedown to release of the payload at the manipulator fully deployed position.

The RMS is capable of supporting up to a maximum weight payload in the preplanned deployed position under the attitude stabilization loads imposed by the orbiter vernier RCS (operating in min impulse mode).

Within the operational reach limits of the manipulator the orbiter vehicle will have the capability to deploy and/or retrieve single or multiple payload elements on orbit during a single flight. Within defined limitations, the RMS may also be used to place payloads on or dock payloads with, a suitably configured and stabilized body.

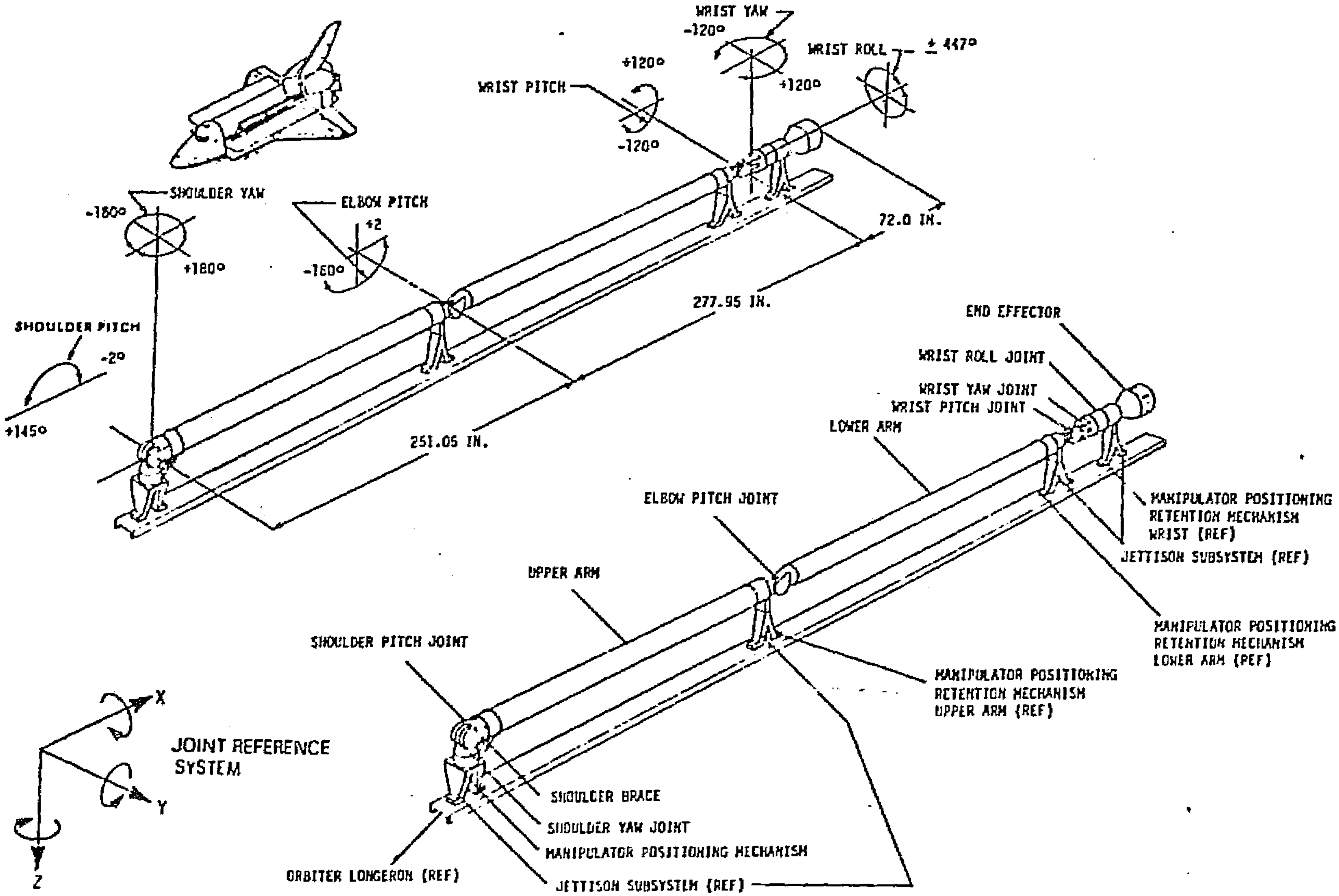


Figure 3-11. Orbiter Remote Manipulator System

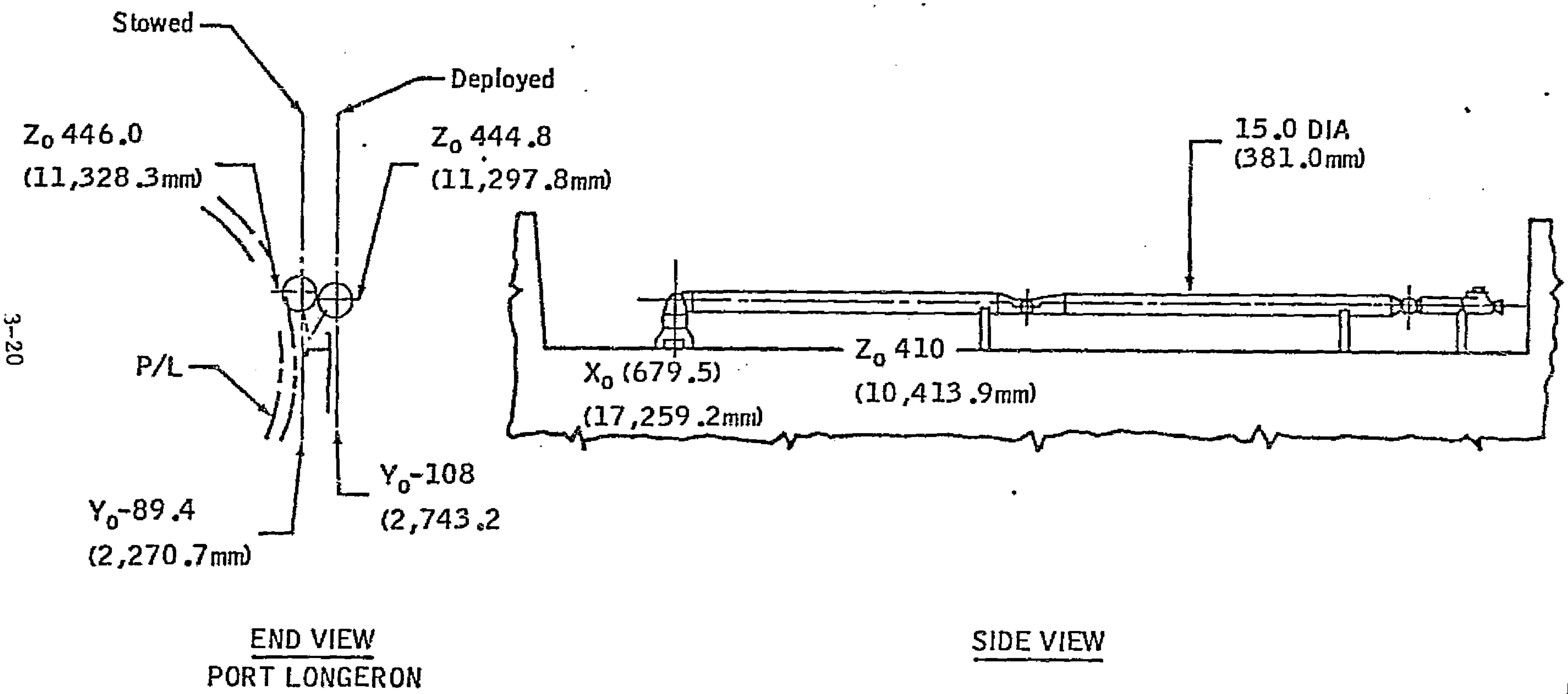


Figure 3-12. RMS Location

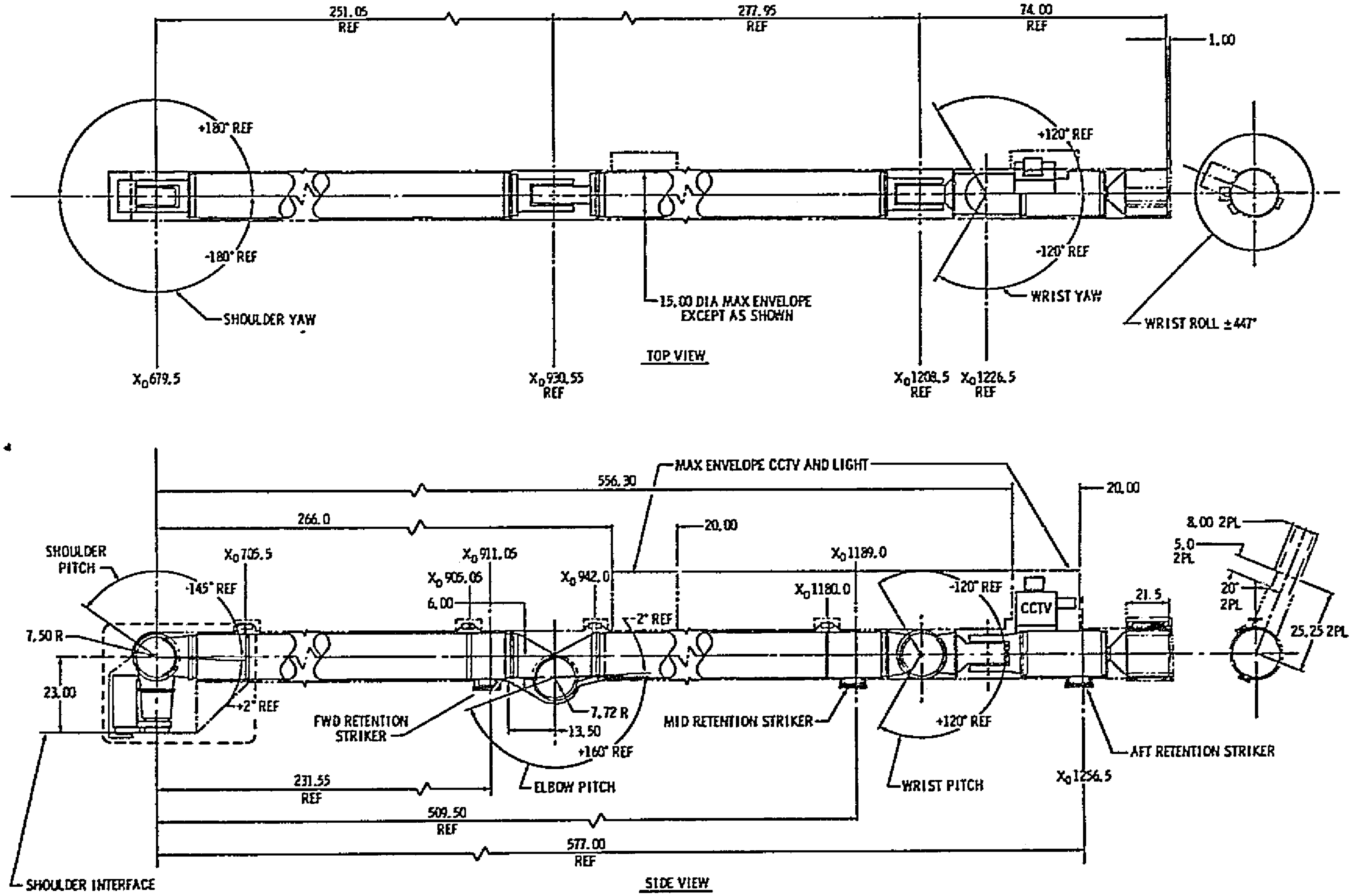


Figure 3-13. RMS Arm Dimensions and Joint Angle Limits

b. The standard end effector provided with the RMS and its associated grapple fixture (payload provided) are shown in Figures 3-14, 3-15, and 3-16. The capture and rigidize sequence is shown in Figure 3-17. The RMS also has the on-orbit capability of grappling a special-purpose end effector (payload provided) and providing an electrical connection across the interface for control of the special end effector. This connection may also be used to provide power and/or signals to payloads, if the payload provides the compliance and mating connector within its grapple fixture. The electrical connector is fitted on the outside of the standard end effector at the end effector/payload interface as indicated in Figure 3-14. The power for the special purpose end effector or payload is taken from the 28 V arm power bus. Wiring is provided from the orbiter flight deck on-orbit station distribution panel to the RMS shoulder interface, and from there to the face of the standard end effector. Controls and displays for command or signals to the special purpose end effector or to payloads must be provided by the payload. The wire gauging and quantities available for this interface are shown in Figure 3-18. On-orbit stowage of any special purpose end effector must be provided by the payloads. The RMS standard end effector may be exchanged on the ground with a special end effector for use on orbit.

c. Figure 3-19 depicts the maximum reach capability of the RMS. The figure indicates the end effector tip reach limitation, but does not imply that the full arm torque/force capability exists along the reach arcs described. The limits shown in Figure 3-19 are actually "contours" with respect to the axis that is orthogonal to the plane of the paper. The contours shown do not account for orbiter structure/RMS interference. Total reach accessibility within the contour envelopes may, therefore, not be available. The actual reach capability for a flight or payload task will be analyzed prior to flight.

d. Insofar as it is intrinsic in the RMS design for payload deployment and retrieval, the RMS may also be used to perform other tasks in support of payload servicing and as an aid in translating an EVA crewman to assist in extravehicular activities. An EVA handhold is an integral part of the RMS end effector.

RMS Performance Characteristics

The velocity of the loaded RMS end effector is controlled such that the kinetic energy of the payload will not exceed that of a 32,000-lb payload moving at approximately 0.2 ft/sec. The velocity of the unloaded RMS end effector is limited to 2.0 ft/sec.

Within 5 minutes following extension of the RMS/payload and deactivation of the orbiter VRCS, the RMS will be capable of releasing a 32,000-lb maximum envelope payload within the following limits:

- Attitude within 1° of a specified orientation, relative to the RMS shoulder attach point. Attitude relative to orbiter is TBD.
- Position within 2.0 in. of a specified position relative to the RMS shoulder attach point.
- Angular momentum of the payload relative to the orbiter less than or equal to 10 slug-ft^2/sec.
- Linear motion of less than 0.10 ft per second.

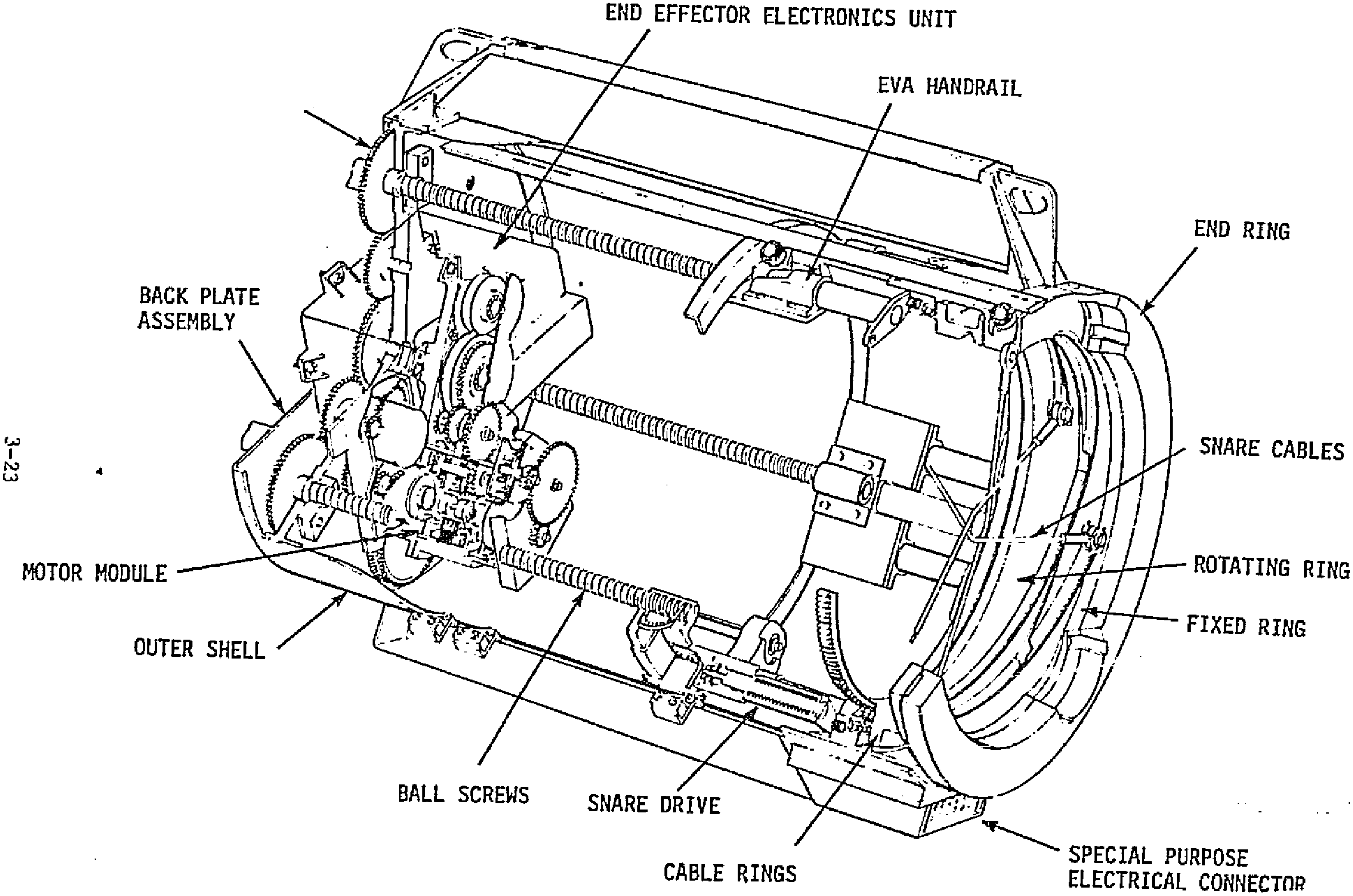


Figure 3-14. Standard End Effector

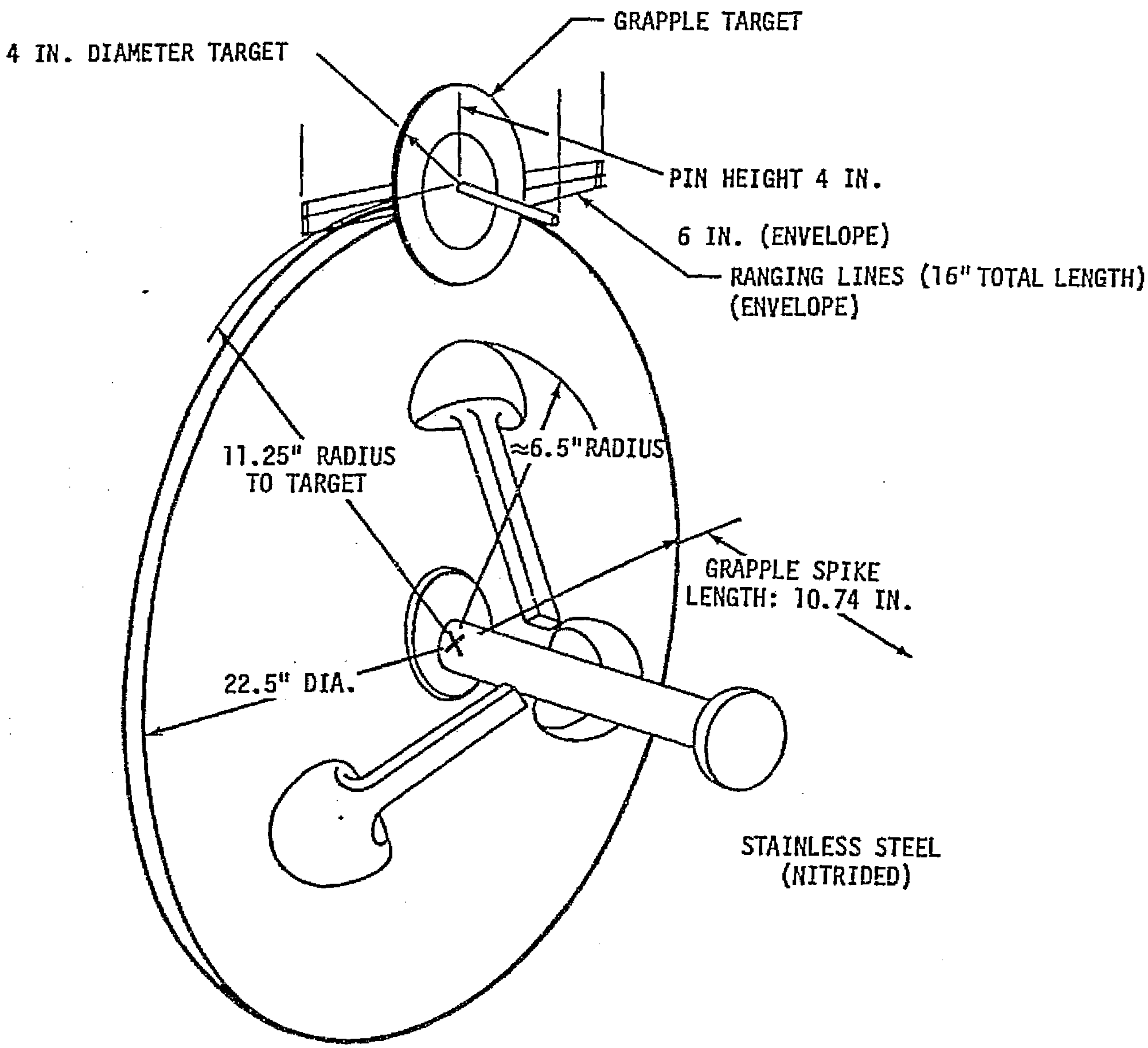


Figure 3-15. Standard Grapple Fixture and Target

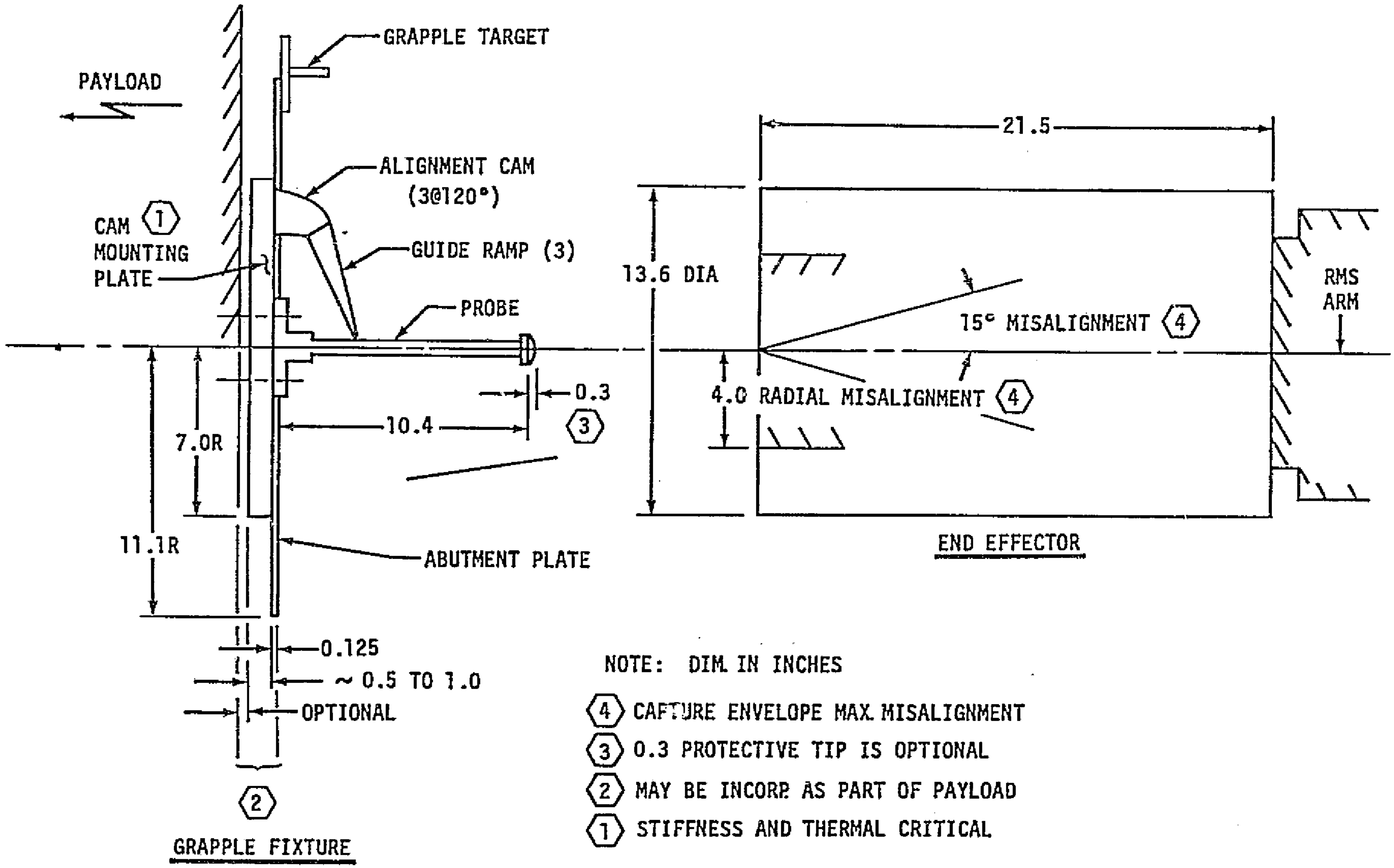


Figure 3-16. RMS Standard End Effector and Grapple Fixture Envelope Schematic

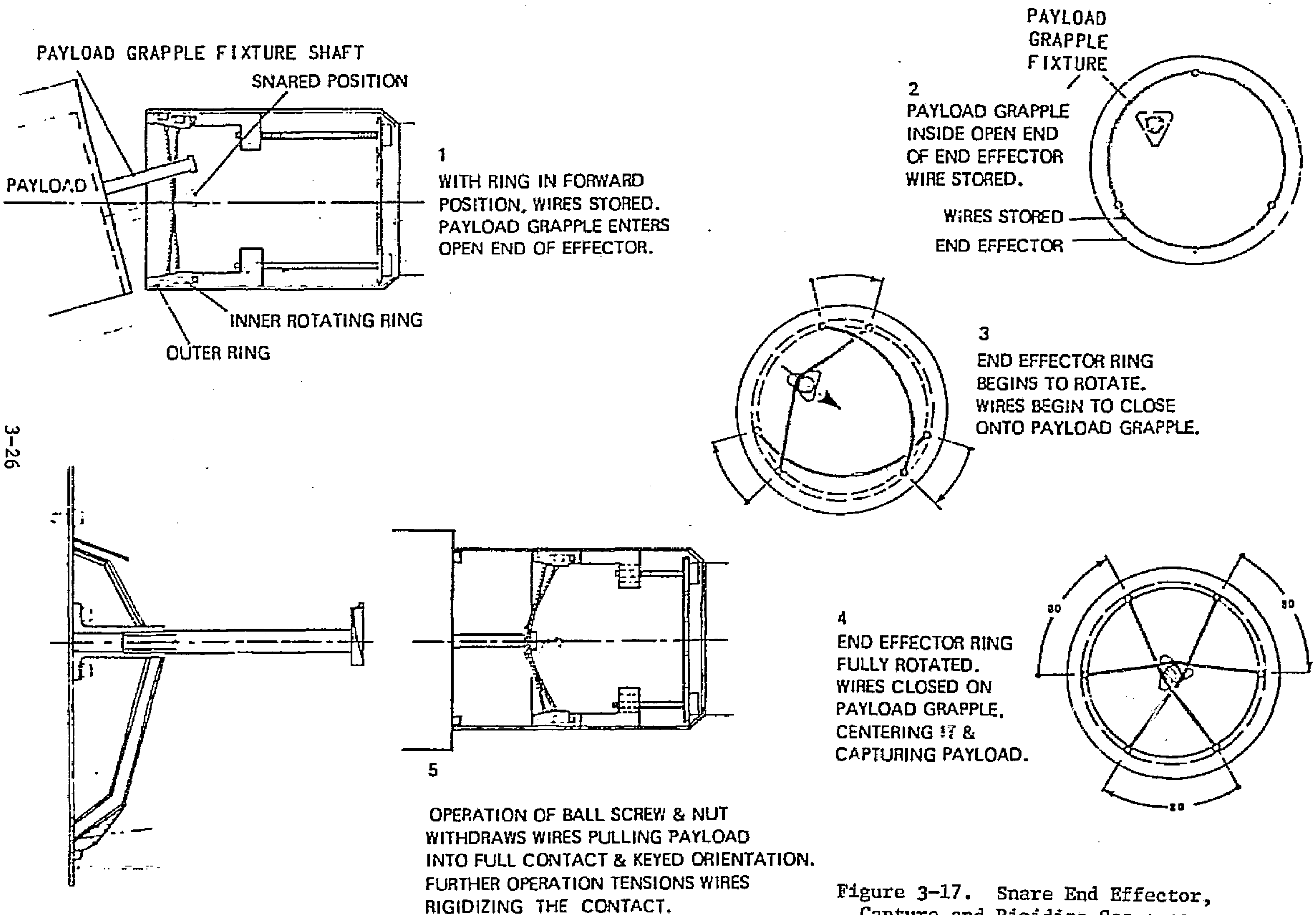


Figure 3-17. Snare End Effector, Capture and Rigidize Sequence

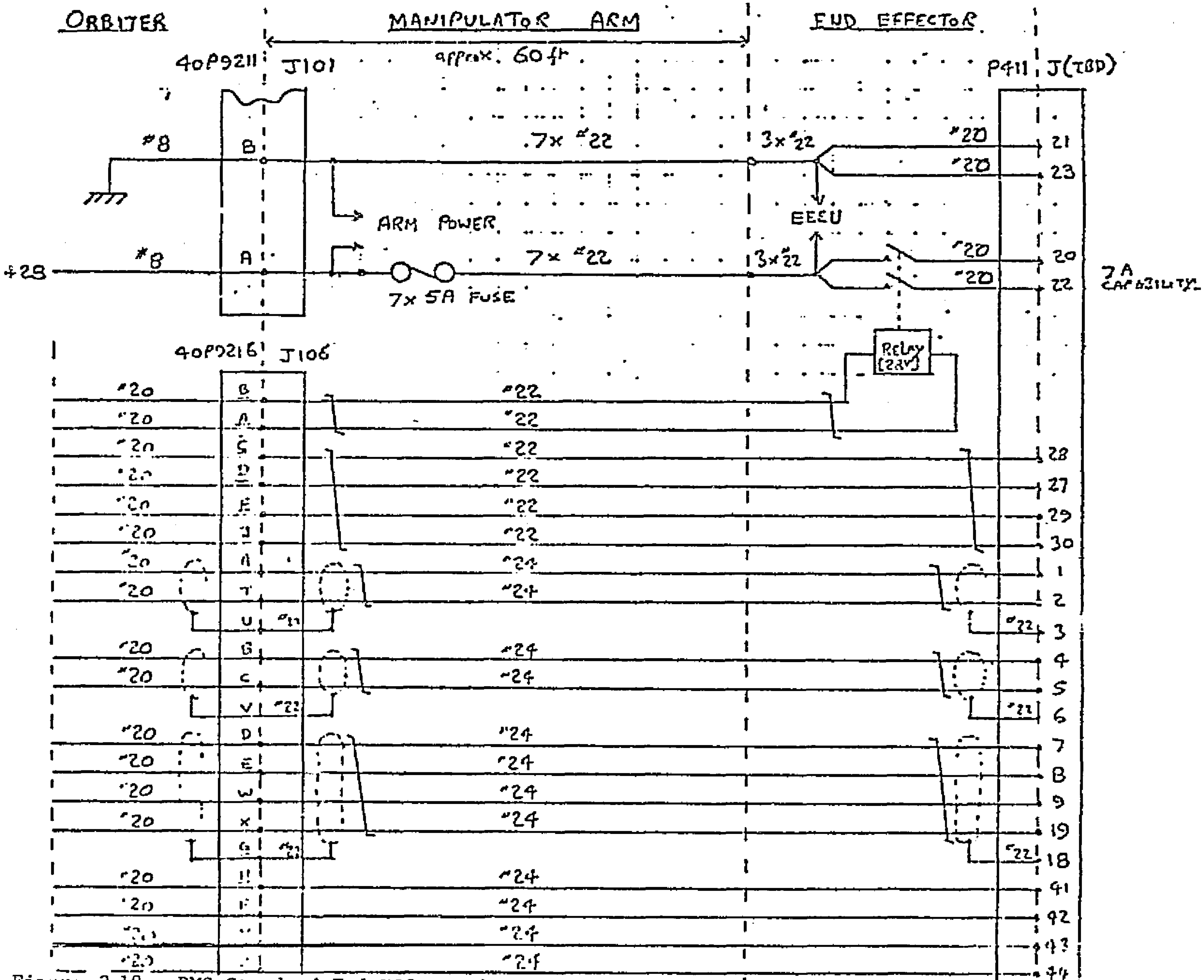


Figure 3-18. RMS Standard End Effector/Special-Purpose Electrical End Effector Interface

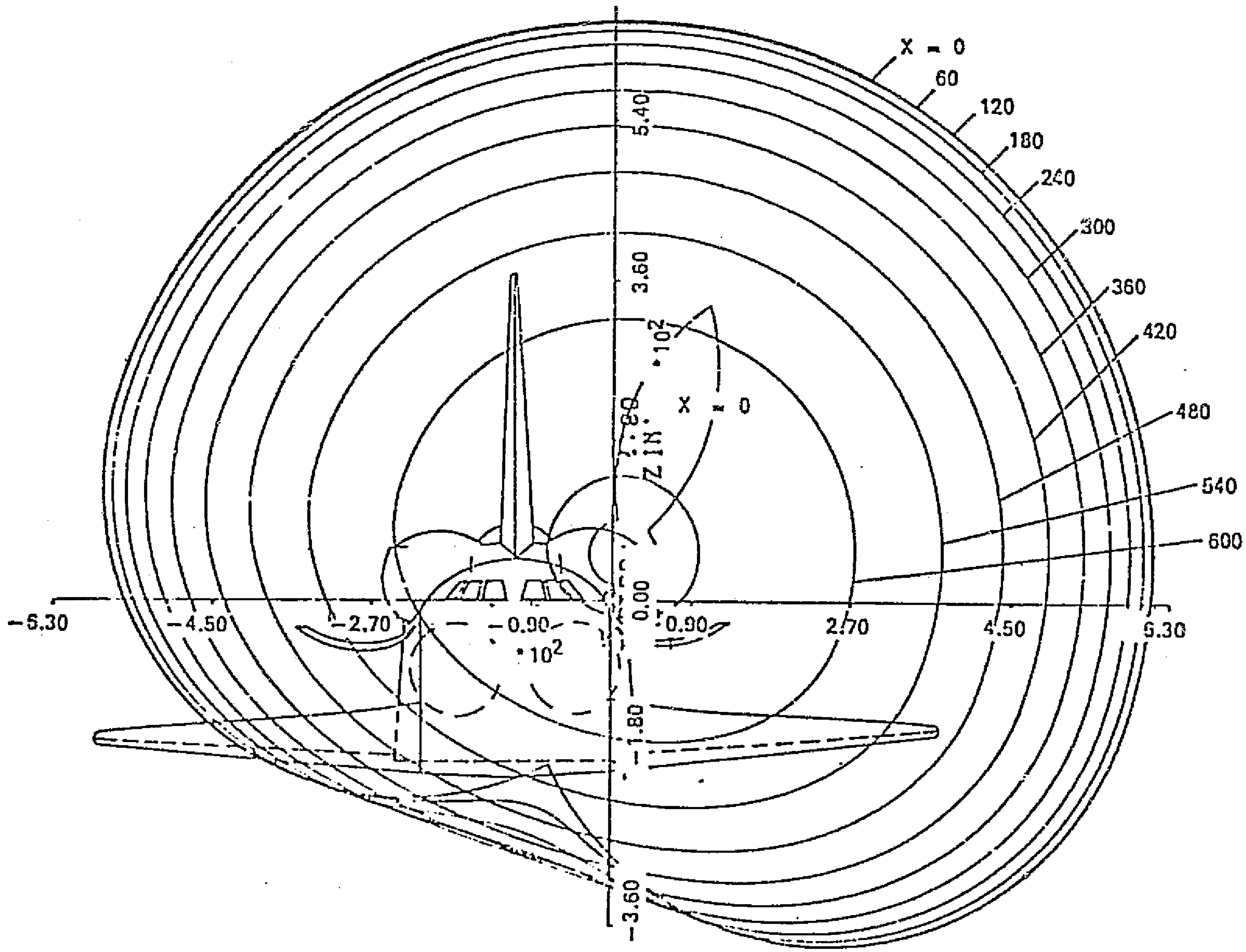


Figure 3-19 (a). Front View of Orbiter and X-Contours

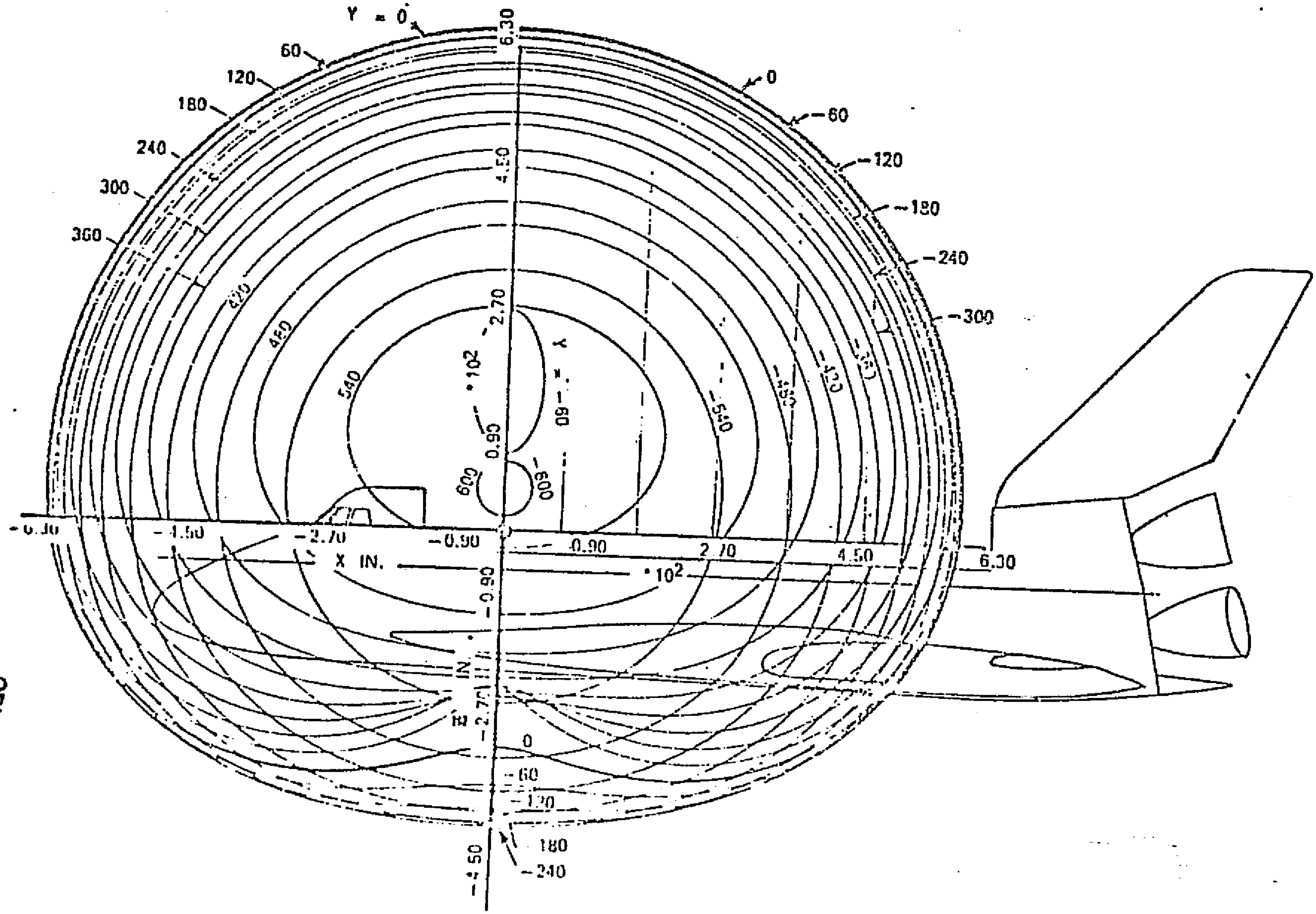


Figure 3-19 (b). Side View of Orbiter and Y-Contours

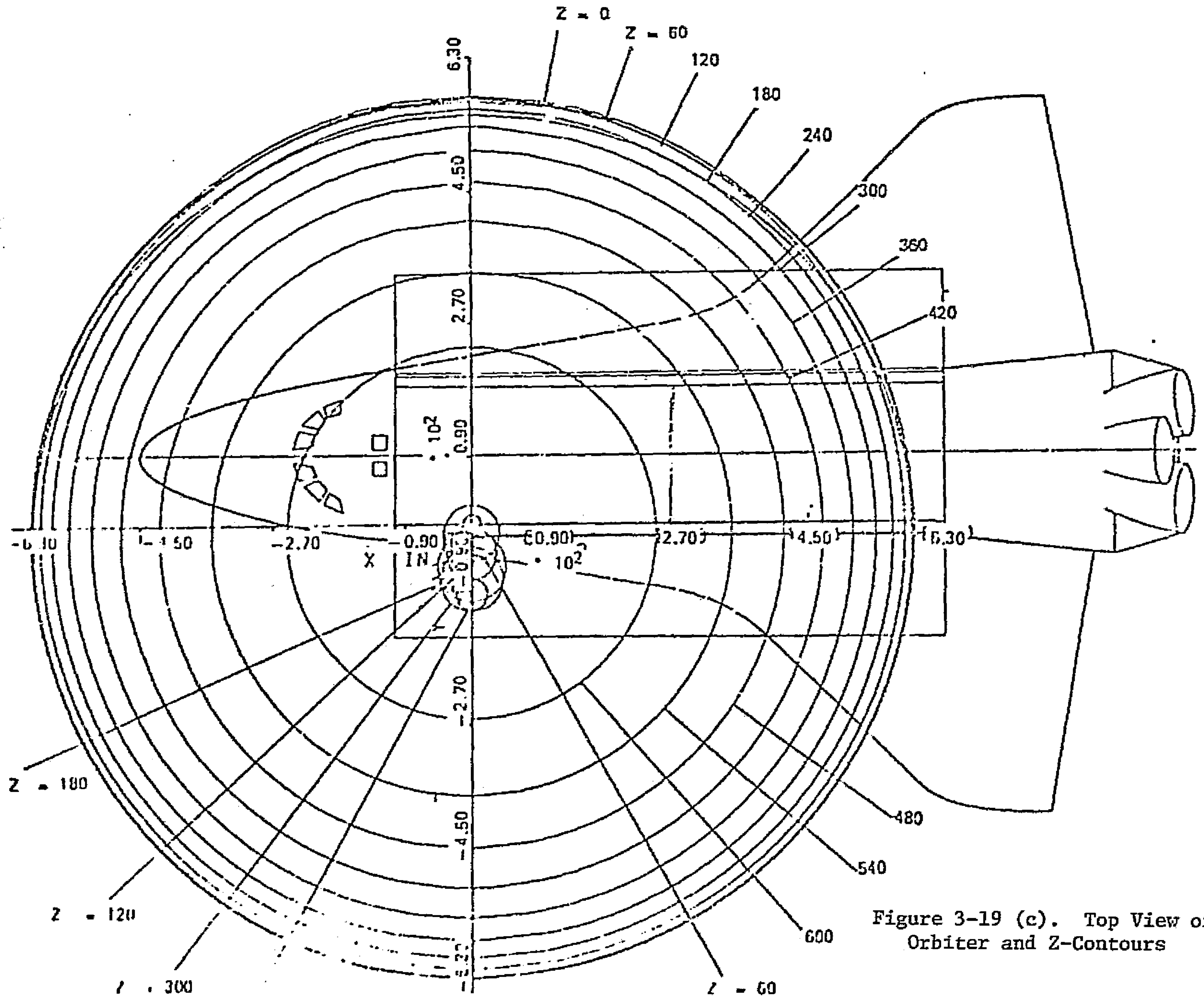


Figure 3-19 (c). Top View of Orbiter and Z-Contours

A 65,000 lb payload can be released within TBD limits.

In the automatic mode, the RMS is capable of accurately positioning the end effector (loaded or unloaded) within ±2.0 inches (50.8 mm) and ±1° relative to the shoulder attach point. In the manual augmented mode the end effector positioning accuracy is primarily a function of operator visibility.

The manipulator arm will transmit, when fully extended and attached to a payload, loads not exceeding the following:

a. A combined 12-lb shear force and 160 ft-lb bending moment at the end effector.

b. A 230 ft-lb torque about the end effector axis. An example of the forces and torques that are applied by the end effector for various arm configurations are shown in Table 3-2.

Table 3-2. Force Torque Capability at End Effector

	Torque Range (ft/lbs)		Force (lbs)		
	Min	Max	Min	Max	Condition
Shoulder Yaw	772	- 1158	15.44	- 23.2	Straight Arm
Shoulder Pitch	772	- 1158	15.44	- 23.2	Straight Arm
Elbow Pitch	528	- 792	18.41	- 27.3	Bent Arm Overall Length < 42 Ft.
Wrist Pitch	231	- 347	37.97	- 57.0	Bent Arm Overall Length < 20 Ft.
Wrist Yaw	231	- 347	54.35	- 81.6	Bent Arm Overall Length < 14 Ft.
Wrist Roll	231	- 347		-	

Note: All values are quotes for the arm under steady state rigid body static condition. E.G. In Payload Bay - And Single Joint Drive

The manipulator arm is capable of operating (when exposed to direct and/or reflected sunlight) for not less than:

- 30 minutes when operating in the cargo bay
- 120 minutes when operating outside the cargo bay

RMS Control System

Control of the RMS is effected by the operator from the RMS D&C panel in the aft flight deck. The operator has access to four prime control modes, in which he has varying degrees of software support, and a back-up mode which completely bypasses the control and display software. The control modes that can be selected by the operator are as follows:

a. Manual Augmented Mode - The operator issues commands through two 3-DOF hand controllers for commanding resolved rates for the six degrees of freedom of the arm. The rotational controller provides for resolved roll, pitch, and yaw without inducing translation at the point of resolution. The translation controller provides for resolved up/down, left/right, fore/aft translation without inducing rotation.

b. Automatic Mode - The manipulator arm movement can be controlled automatically along a prespecified trajectory. This trajectory is defined by a series of predefined positions and orientations stored in the GPC. The operator can select up to four preprogrammed automatic trajectories from the D&C panel mode select rotary switch. Up to 200 points (total) can be stored for auto trajectories, each point defined by orbiter reference position x, y, z, plus yaw, pitch, roll orientation.

A second type of automatic trajectory can be initiated by the RMS operator through the D&C select switch and the GPC keyboard. This is the operator commanded auto sequence mode and is initiated by input of the required position and orientation of the end effector or payload. A straight line trajectory is then performed from the current position and orientation to the desired position and orientation.

The above automatic sequence capabilities are available to be negotiated by payloads on an individual basis.

c. Single-Joint Drive Mode - The operator commands, through D&C panel switches, movements of individual arm joints. These commands are made through the RMS software, which controls the position of all joints, limits drive speeds, provides joint position displays, and indicates when joint angle reach limits are encountered.

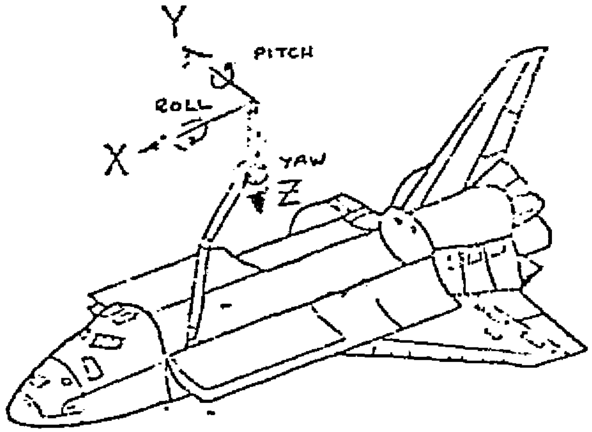
d. Direct-Drive Mode - Direct drive control of the RMS is by the operator command of individual joints, using hardwired commands from the D&C panel. This is a contingency mode which bypasses the software when driving the motors (software data are normally displayed).

e. Back-Up Drive Mode - Back-up control of individual joints by operator commands through unique hardwired channels. No position data are displayed.

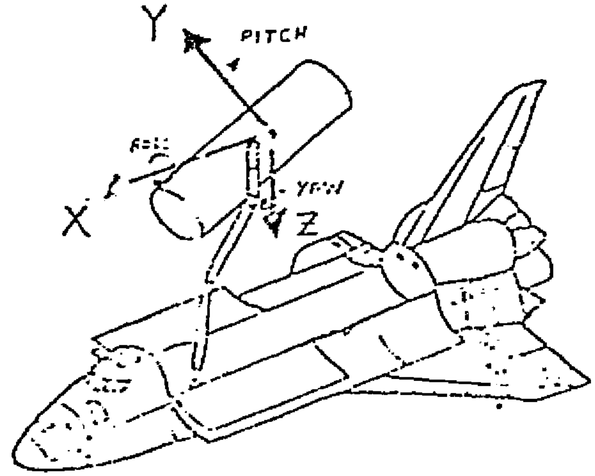
The combined operations of the six joints of the manipulator arm, through one of the appropriate control modes above, enables the operator to move the end effector in six degrees of freedom (3 degrees of motion in translation, 3 in rotation). The coordinate systems relating these travel directions are shown in Figure 3-20. In the manual modes, the operator commands movement of the end effector using the THC and RHC in the selected coordinate system. Operations in the automatic control mode will utilize the orbiter referenced coordinate system.

RMS Software

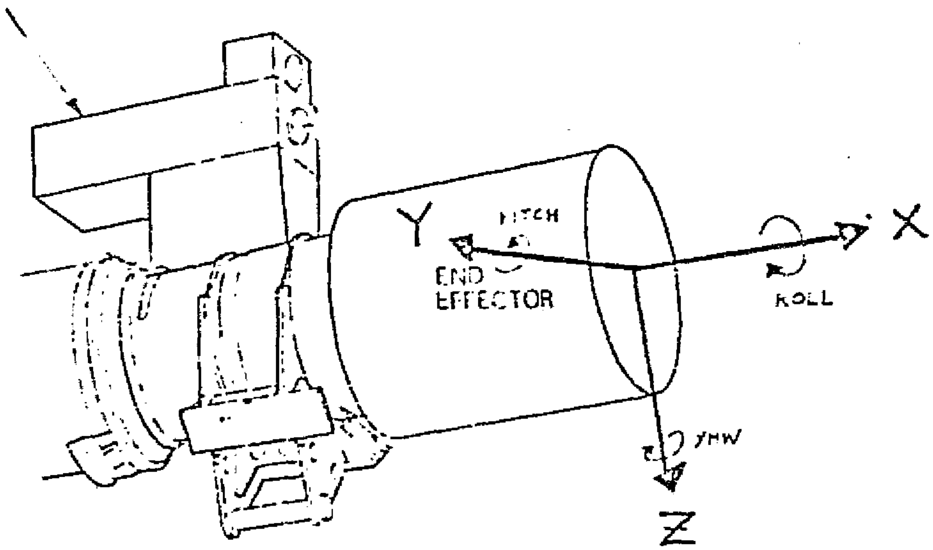
The RMS software, under which most RMS operations are performed, resides in the orbiter general-purpose computer (GPC). The RMS software performs the following functions:



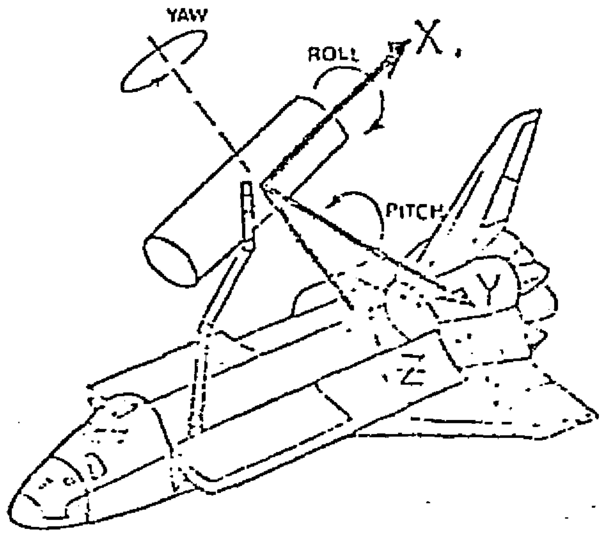
ORBITER UNLOADED. POINT OF RESOLUTION IS TIP OF END EFFECTOR.



ORBITER LOADED. POINT OF RESOLUTION IS MASS OR GEOMETRIC CENTER OF PAYLOAD.



END EFFECTOR. POINT OF RESOLUTION IS TIP OF END EFFECTOR.



PAYLOAD. POINT OF RESOLUTION IS MASS OR GEOMETRIC CENTER OF THE PAYLOAD.

Figure 3-20. Control Coordinate Reference Systems

- Translates operator commands into RMS arm operations and motions.
- Monitors RMS status
- Performs display computational tasks for information to the RMS operator, including caution and warning.

Control algorithms contained in the RMS software convert operator commands (normally input by the hand controllers at the D&C panel) into output rates resolved for each joint of the arm. The rate demands to the joint servos are output within limits defined according to arm and individual joint loading conditions present at the time of computation.

Initialization Data

Parameters with which the RMS software is initialized may vary from flight to flight. These parameters may be RMS hardware dependent (generally called I-loads) or flight and payload dependent (generally called Level C data). The hardware dependent parameters include: (a) end effector length, (b) hand controller biases, and (c) tachometer biases, etc. The flight and payload dependent parameters include the following (nominal values for a 32K payload are indicated:

	Coarse	Vernier
Maximum payload translation rate	0.2 fps	0.01 fps
Maximum payload rotation rate	0.0083 rad/sec	0.00415 rad/sec
Joint angle course rate limits	--	--
Joint angle vernier rate limits	--	--
Payload to end effector transformation matrix		
Automatic trajectory parameters		

The RMS initialization parameters (I-load and Level C) are identified in SD 77-SH-0002A, Level C Functional Subsystem Software Requirements (FSSR) document. Some of these quantities can be changed on orbit through GPS keyboard input. To generate the payload dependent RMS software parameters, payload characteristics should be provided approximately one year prior to flight. These characteristics, and their allowable variations, are as follows:

- Payload mass to ±10%
- Payload center of mass to ±6 inches, defined in Payload Coordinate System
- Moments of inertia about payload principal axes to ±10%
- Payload cross-products of inertia, to ±10%
- Grapple fixture location(s) and installation orientation, in payload coordinates. If the payload has no preference, NASA will select grapple fixture orientation. The grapple fixture will normally be located within 5% (of payload length) of the Y-Z plane of the payload center of mass.

Downlist Data

A number of RMS parameters are on the GPC downlist. These measurements are signals which are used directly or indirectly to provide data to the flight computers, the RMS operator, the ground mission controllers, or flight planners regarding the systems performance, component status, or condition of hardware and/or software elements. Each measurement is given a unique identification number to identify its signal source or location, sample rate, range, and units. The available RMS downlist parameters are listed in SD 77-SH-0002A, Level C Functional Subsystem Software Requirements (FSSR) document.

Orbiter Crew Station

The orbiter aft flight deck contains the primary stations for payload deployment and retrieval operations. The RMS D&C is located at panel A-9 as shown in Figure 3-21. All RMS D&C, including the hand controllers (but excluding RMS software initialization controls), are located at this port side of the on-orbit station. In addition, CCTV monitors and exterior-viewing windows are located at this RMS operator's station. The starboard side of the on-orbit station contains the displays and controls required for orbiter vehicle translation and attitude control. The mission station will contain the CRT and keyboard utilized to initialize the RMS software and checkout sequences and to provide messages for operator information and action. Two aft windows and two overhead windows are located to provide direct exterior viewing for two operators at the on-orbit station.

Orbiter Exterior Lighting

The orbiter exterior lighting in the vicinity of the cargo bay is described in ICD-2-19001. This lighting is used to provide illumination to aid direct and, at times, indirect (CCTV) viewing of payload handling and proximity operations. In addition to the cargo bay bulkhead and overhead lights, a light is located on the wrist segment of the RMS arm, to provide illumination for grappling or for illumination to areas that may be shadowed by elements within the payload bay. This RMS light, along with a CCTV camera, is fixed-mounted to the rolling member of the RMS wrist joint, as shown in Figure 3-22. The RMS light brightness is 3 ft-candles at 30 feet, diminishing to 0.15 ft-candle at 200 ft.

Closed Circuit Television (CCTV) System

The orbiter CCTV system is described in ICD-2-19001. The orbiter can accommodate up to five CCTV camera locations within the cargo bay. The standard locations are considered to be one of the mirror image positions on the forward and aft bulkheads, plus one of four keel positons. In addition, the RMS can accommodate two camera positions on the manipulator arm; one wrist and one elbow location. The CCTV D&C panel at the aft crew station is used to control all exterior CCTV cameras, including serial operation of the two RMS cameras. CCTV cameras are generally considered as kittable with any mix, up to five cameras, installed to support mission requirements. These installations may include, on occasion, cameras mounted on payload-provided cradles

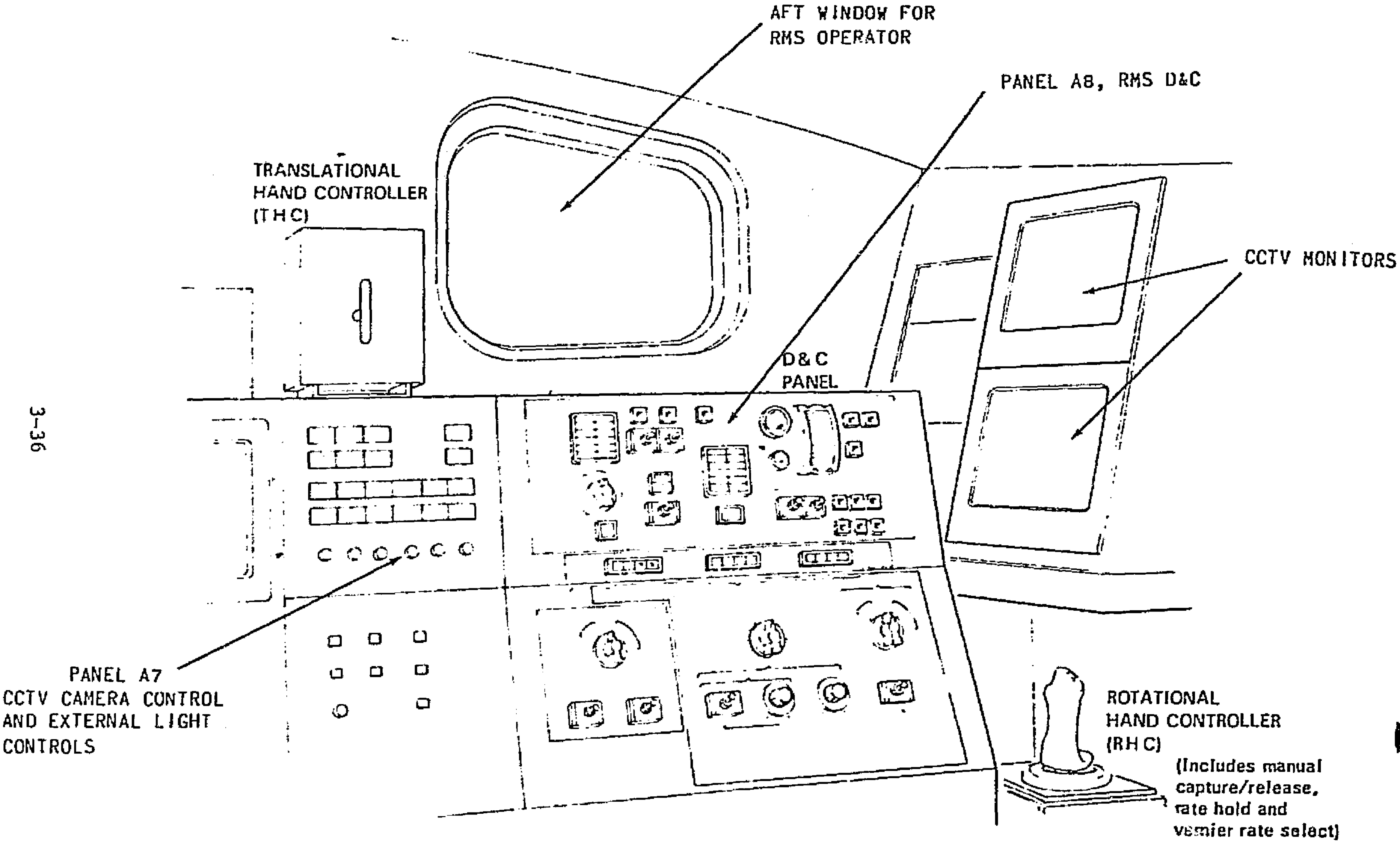


Figure 3-21. RMS Operator Station

Satellite Systems Division
Space Systems Group
Rockwell
International

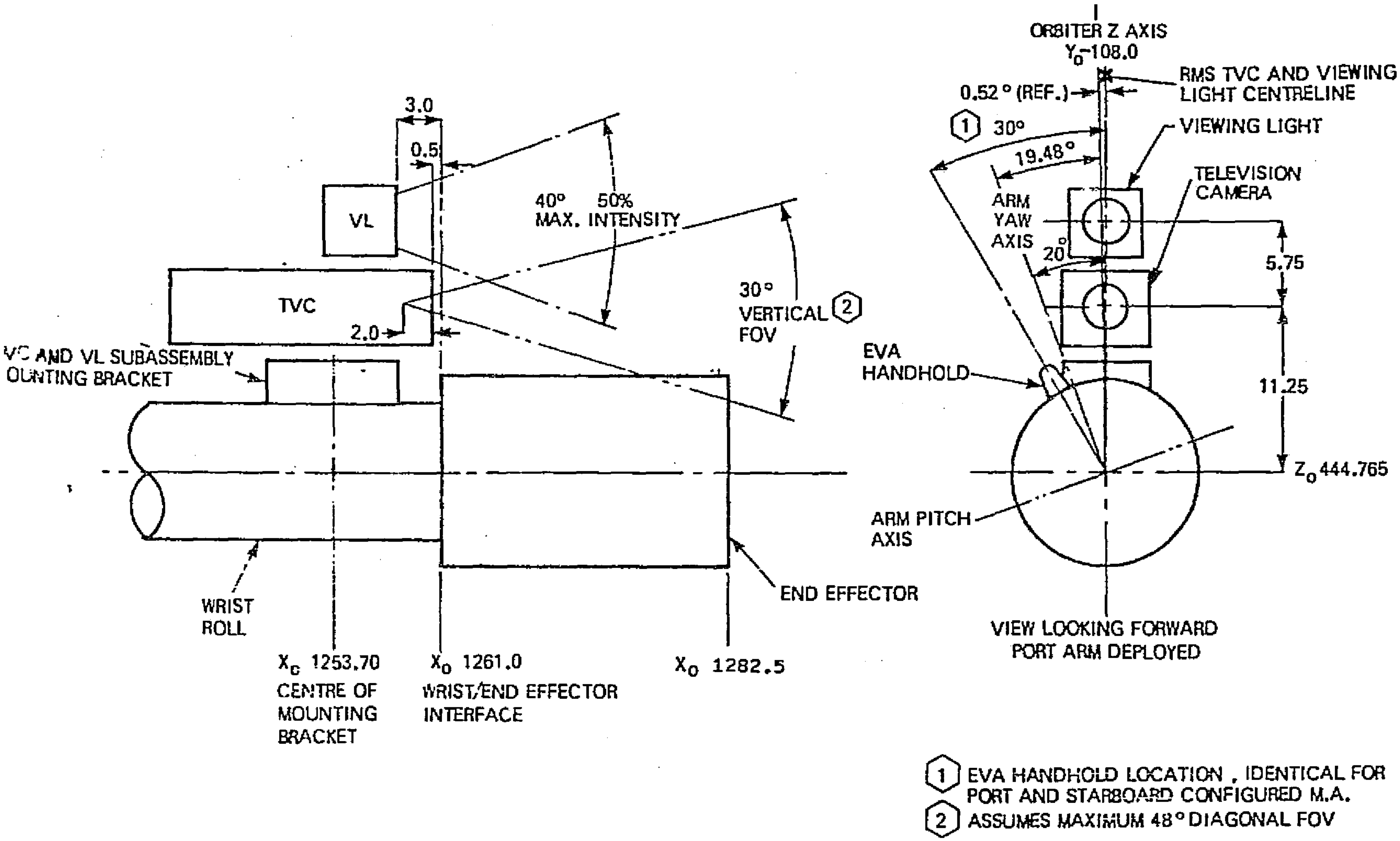


Figure 3-22. RMS CCTV Wrist Camera and Light Subassembly Design Configuration

or hardware (utilizing orbiter junction and wiring capability) to support the viewing requirements for the payload deployment or berthing operations. The CCTV mounting location payload options are indicated in Figure 3-23. All CCTV cameras will haze zoom and iris control. In addition, the forward and aft bulkhead cameras and the optional RMS elbow camera have pan and tilt control, with pan and tilt angles displayed on the CCTV monitors. The TV cameras will be capable of accommodating a range of lenses for special payload applications; the TV lenses may be removed and replaced prior to flight. The field of view for the standard lens varies from approximately 48.0° diagonal, to approximately 8.5° diagonal, when focused at infinity.

Beam Builder

The beam builder is under development by General Dynamics Convair Division. The information on the following pages was taken from "Space Construction Automated Fabrication Experiment Definition Study (SCAFEDS)" final report, Volume II, Study Results, CASD-ASP77-017, dated 5-26-78.

The SCAFE beam builder is an automatic machine process which fabricates beam assemblies from non-metallic materials stored within the machine. The materials are preconsolidated thermoplastic graphite/fiberglass composites which are manufactured in a convenient form for small volume storage. The thermoplastic composite materials not only provide excellent properties for space structures, but lend themselves to automatic fabrication techniques because they are heat formable and can be joined by efficient spot welding techniques.

The beam builder concept satisfies the following design criteria:

- Power utilization well within orbiter capability
- Automatic quality control
- Least amount of material
- Fewest number of beam weld joints
- No growth limitations
- Low weight

Beam Builder Concept

The basic processes of the beam builder are illustrated schematically in Figure 3-24. The beam is constructed of three formed caps, joined to channel-shaped cross-members, and stabilized with six zig-zag plyed tension cord diagonals. Fabrication of this beam requires these processes:

a. Storage. Flat strip material for the caps and cross-members, and the cord for the diagonals are stored by a process which provides safe, positive containment and dispenses the material with ease.

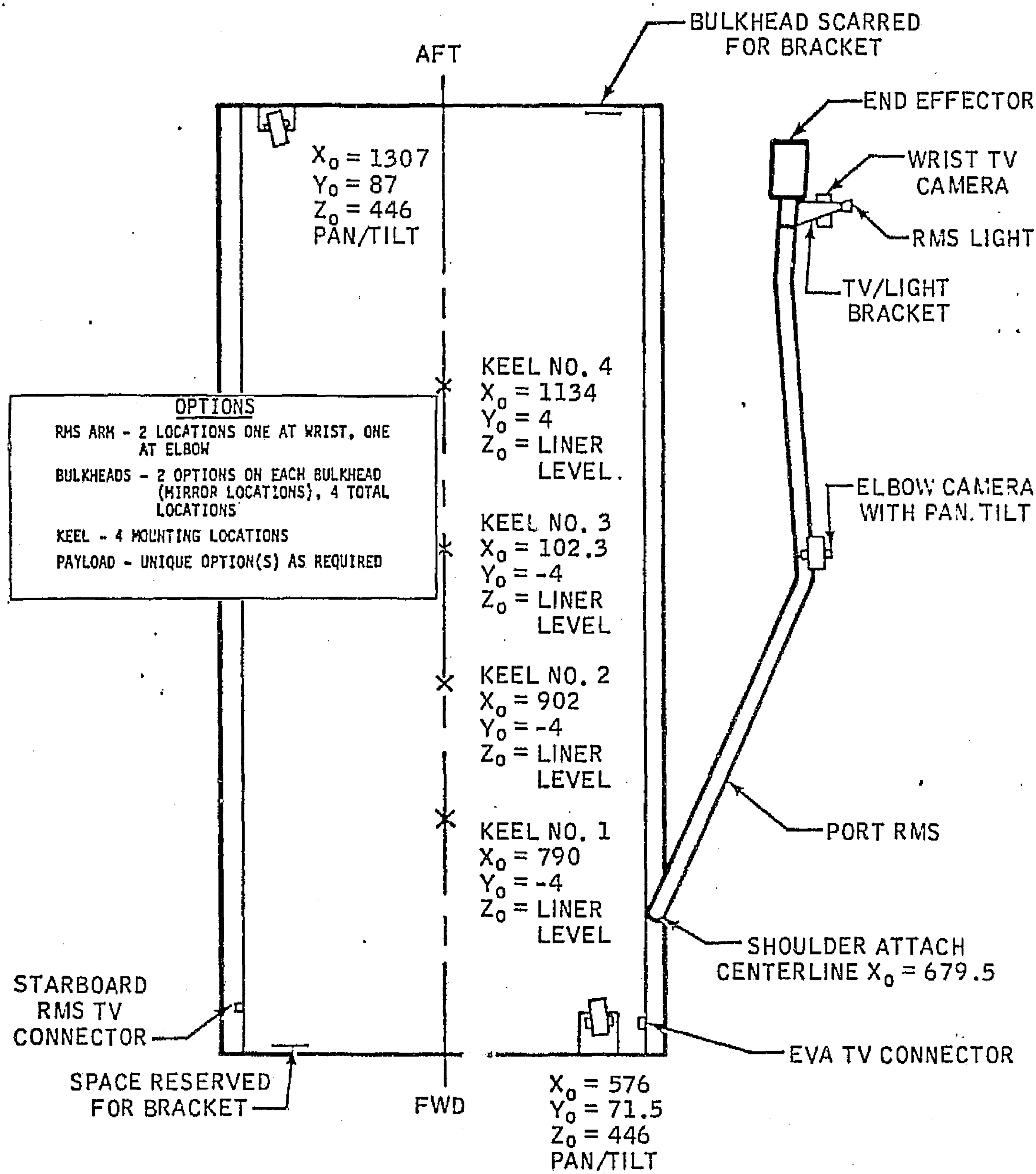


Figure 3-23. CCTV Camera Mounting Options

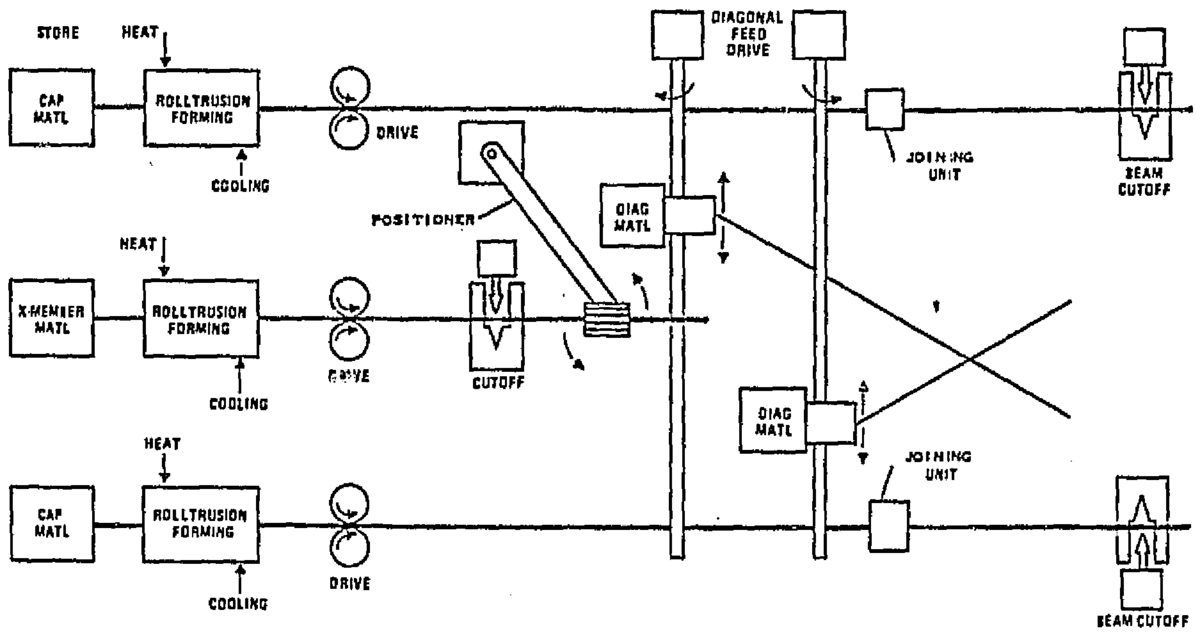


Figure 3-24. Cyclic Feed Fabricator Functional Schematic

b. Heating. The flat strip material for the caps and cross-members is fed through a heating section in preparation for forming. The heating section applies heat only to bend zones in order to conserve energy. The bend zones are heated to the plastic state prior to entering the forming section.

c. Forming. The heated caps and cross-members are formed to the desired cross sectional shape by the Convair-developed rolltrusion process.

d. Cooling. On exit from the forming process, the beam members are cooled to a satisfactory use temperature before exposure to load.

e. Drive. The beam is moved through the fabrication process and deployed into space by a drive mechanism on each cap member. The drive mechanism also provides the force necessary to extract the cap and cross-member material from storage and pull it through the forming process.

f. Diagonal Cord Applicator. As the beam advances through the fabrication process, the diagonal cord members are plyed across each face of the beam. The cords are properly tensioned and positioned for joining.

g. Cross-Member Positioner. Before the finished cross-members are cut to length, a positioner grasps the member. After cutoff, the positioners rotate and translate the cross-members into position for joining to the caps.

h. Joining. When the cross-members are positioned and the cords are positioned and tensioned, the joining process permanently joins the beam elements together.

i. Cutoff. Cutoff devices are required to cut cross-members to length and to cut off finished lengths of beam.

The cyclic-feed beam builder (Figure 3-24) operates for a 40-second run period during which the caps and beam are advanced at 2.2 m per minute. After 1.434 m beam extension, a pause of 40 seconds is made for cross-member and diagonal cord attachment. During the pause period, the formed cross-members are grasped by the positioner, cut off, and positioned on the caps. The diagonal cords are aligned between the ca, and cross-member by the cord feed mechanisms and the cord and cap are ultrasonic weld joined to the cap. The beam builder then repeats the operating cycle. The configuration of the machine is shown in Figure 3-25.

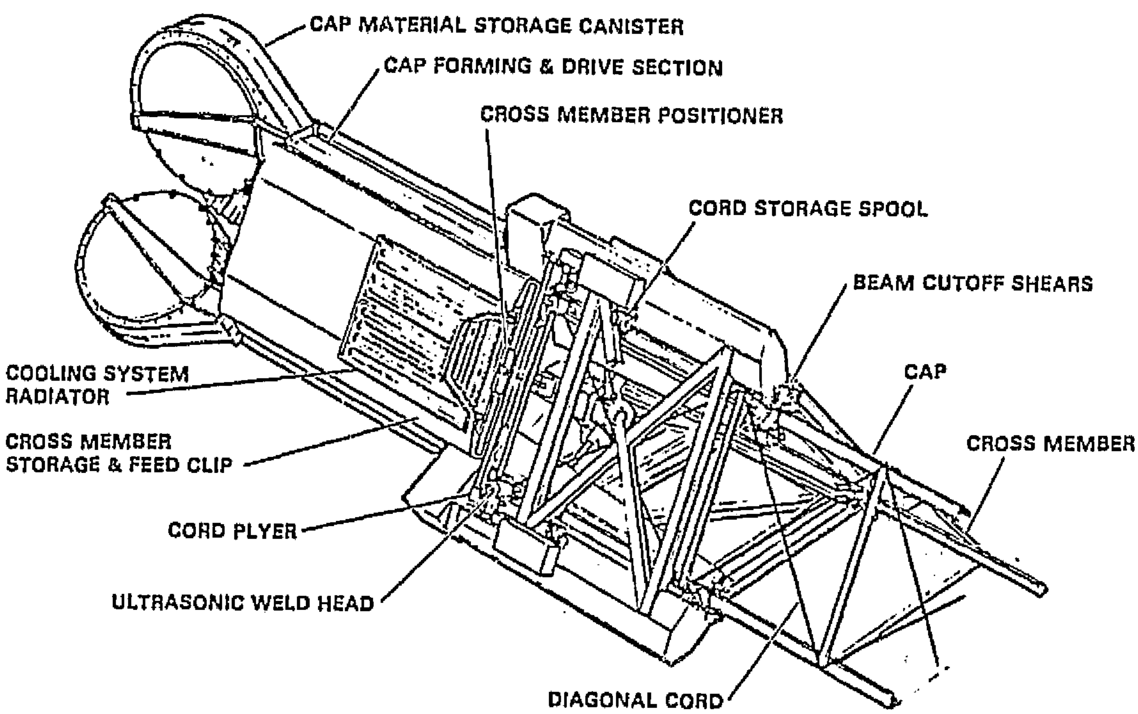


Figure 3-25. SCAFEDS Beam Builder Concept

Preliminary Design Description

Preliminary performance data are summarized in Table 3-3.

Cap Forming Machine Subsystem

The cap forming machine assembly contains all elements necessary to continuously process flat strip glass/graphite/thermoplastic material into the baseline cap configuration. Approximately 918 m of material is coiled in the roll retained in the storage canister. The roll turns freely on bearing-mounted rollers and unwinds uniformly as material is used. The canister is in two halves, with one half hinged to permit the material roll to be inserted. When the canister is closed and latched, an access panel in the hinged half is opened to allow the material to be manually routed over the heating section guide rollers into the forming section manual feed rollers.

Table 3-3. Beam Builder Preliminary Design and Performance Data

PROCESS OR SUBSYSTEM	PARAMETER	LIMITS OR TOLERANCE
Material Storage	Roll O.D.	121.4 cm Max
	Roll I.D.	60 cm Min
	Roll Length	918.2 m
	Roll Width	19.05 cm
	Roll Weight	262.2 kg
Heating	Temperature Limits:	
	1st Stage	482°K
	2nd Stage	707°K
	Forming Section	707°K
	Start-Up Time	430 seconds
Forming	Forming Section Length	
	Max. Forming Rate	Not Determined
Cooling	Actuation Time	0.2 seconds
	Actuator Stroke	0.32 cm
	Max. Cooling Time	12 seconds
Drive	Cap Stroke Tolerance	± TBD
	Cap Speed	3.585 cm/sec
	Max. Acceleration	1.3 cm/sec^2
	Max. Force Capability	533N
	Max. Force Required	311N
	Run Time	40 seconds
	Pause Time	40 seconds
Cord Storage	Cord on Spool:	
	Length	1219 m
	O.D.	13.12 cm
	I.D.	7.62 cm
	Width	13.12 cm
	Weight per Spool	2.13 kg
	Spool Drag Torque	56.5 ± 5.6 N-cm
Cord Tensioner	Tensioning Force	44.5 ± 8.9 N
	Spring Stroke	21.2 cm
	Spring Load Rating	89 N
	Max. Cord Speed	11.3 cm/sec
	Pulley Diameter	7.1 cm
Cord Plyer	Travel Speed	10.7 cm/sec
	Pulley Diameter	7.1 cm

Table 3-3. Beam Builder Preliminary Design and Performance Data (Cont.)

PROCESS OR SUBSYSTEM	PARAMETER	LIMITS OR TOLERANCE
Clip Storage and Feed	Capacity	650 pieces
	Weight of Cross-Members	79.8 kg
	Feed Rate	0.4 cm/sec
Cross-Member Positioner	Time to Position Cross-Member	3 sec
	Separation Time	1 seq
	Return Time	4 sec
Welding Mechanism	Stroke	4 cm
	Time to Engage and Pierce	3 sec
	Time to Engage for Weld	0.2 sec
	Weld Time	2 sec
	Cooling Time	1 sec
	Retraction Time	3 sec
Cutoff Mechanism	Time to Engage and Shear	1 sec
	Time to Retract	1 sec

The heating section is partially built into the storage canister with resistance strip heaters and parabolic reflectors mounted on the access panel. The heating section extends from the access panel up to the point where the material starts to form.

The material passes from the heating section through the forming section. The rolltrusion forming section is also equipped with strip heaters which heat the partially formed material in preparation for start-up of the machine.

The material then passes from the forming section into the cooling section where it is contact cooled by aluminum platens. Cooling fluid is supplied to the inside cooling platens and expelled as waste heat by an independent cooling system in the beam builder. Waste heat is also extracted from the heater reflectors by the cooling fluid loop. The cooling platens cool one bay length of cap section during the 40-second pause period.

The drive section has four friction-drive rollers which provide the necessary pull force on the cap to draw the material from the storage roll through the heat/form/cool sections. The three cap drive sections also provide the push force to advance the beam out of the beam builder.

Cross-Member Subsystem

The cross-member clip is constructed of machined aluminum sections. Two mating center support panels are joined by two end piece assemblies to form the basic clip structure.

The stack of cross-members is supported and fed to the beam assembly process by four timing belts. The clips are indexed on the belts by serations on the mating surfaces of the belts. The belt drive and belt pulleys are mounted on the center support panels. The clip holds 650 cross-members.

The clip is loaded and assembled by laying the stack of cross-members on one of the center support/belt drive subassemblies. The second center support/belt drive subassembly is then layed on the stack and all belts inspected for proper mesh with the cross-members. The end pieces, which consist of two mated halves, are bolted to the center supports.

The feed drive is a redundant motor drive which provides simultaneous output to all four feed belts. The retainer mechanisms at the output end of the clip are described below.

Mounting pads on the inboard center support allow the clip assembly to be bolted to the beam builder structure.

The cross-member positioner/handler mechanism transports one cross-member at a time from the storage clip to the installation position on the beam. During the run period, when the beam is advancing one bay length, the positioner/handler is fully retracted with the handler below the plane of the beam side. This allows the last cross-member installed to clear the handler and also allows the cord plyers to pass over the handler/positioner.

At some time after the cord plyers have completed their stroke, each position arm is rotated and translated into position for receiving the next cross-member from the clip. The cross-member retainers on each end of the next cross-member are retracted and the clip drive stepper motors are activated. When the stack has moved about 0.4 cm, a sensor in the cross-member handler is triggered. This causes the clip drive motors to stop and cross-member retainers to engage and retain the next to last cross-member. The fingers on the handler also close and grasp the next cross-member to be installed.

The cross-member positioner arm is rotated and translated to remove the cross-member from the clip and lay it in proper position for welding to the cap members. After welding is complete, but before the beam is advanced, the handler fingers are opened and the positioner arm rotated to drop the handler below the plane of the beam side.

Diagonal Cord Applicator Subsystem

The cord plyer mechanism consists of six reciprocating cord plyer subassemblies. Each plyer is driven along a guide beam by a motor-driven ball reverser lead screw. Each guide beam is equipped with position sensors to monitor the six positions of each cord plyer. Cord is supplied to each plyer from a storage spool over a series of pulleys. The inboard pulleys on the cord plyers are mounted on swivels to allow the cord to be properly aligned as the cord plyer changes position.

Forward and aft cord plyers permit the two cords on each side of the beam to be applied without interference between the moving plyers. The aft cord plyers have a longer stroke than the forward cord plyers because they are set back 13.5 cm from the forward cord plyers. This requires more lateral motion to achieve the required angle between the cord and the caps.

The forward cord plyer must always complete its stroke to the outboard position ahead of the aft cord plyer to avoid a collision with the cord of the aft plyer at the apex of the beam. Similarly, the aft cord plyer must always move from the outboard position first.

The forward and aft cord plyers each have redundant motor drives. Two of the three lead screws are motor driven while the third is driven at either end by a flexible drive shaft. Should one of the two drives fail, the other would drive all three lead screws. The cord plyers are all driven at an average velocity of 10.7 cm/sec.

The cord tensioner mechanism operates in two modes. The first mode is the supply mode where cord passes freely from the storage spool to the cord plyers. The second mode is the tensioning mode whereby the free-turning capstan is stopped and held by an electric-operated clutch brake. This causes the traveling pulley to extend under the force applied by the constant-force spring. A tension force equal to one-half the spring force is thus applied to the cord. Total spring force is measured by a force transducer attached to a guide pulley.

A cord tension force of 44.5 ± 8.9 N is applied to each cord during assembly. This preloads the cords sufficiently to preclude any slackening or over tensioning due to thermal and deflection effects. The ±8.9 N variation limits the theoretical twist and deflection in the beam to less than 1.2° of twist and 0.5 cm of tip deflection for a 200 m beam.

The stroke of the traveling pulley assures that a constant force is maintained on the cord throughout the assembly sequent. As the cord plyers move from the outboard position to the ready-to-weld position, the traveling pulley automatically compensates for the change in cord length.

As the beam starts to advance in the beam builder, the cord tensioners are in the free feed mode and the forward cord plyer drive is activated. A 3-second delay is provided before start of the aft cord plyer drive so that the forward cord plyers reach their outboard position first.

The cord plyers stop at their outboard positions and, after 23 seconds, the cord tensioner capstan brakes are applied. The beam drive thus applies the necessary force to extend the cord tensioner constant force springs to the proper stroke.

After the beam is stopped and the cross-members to be attached are in position, the ultrasonic welding heads are advanced and activated momentarily to allow a pin on each weld head to pierce the cross-member and cap just below each cord. When the piercing is completed, the aft cord plyer drive is activated. A 2-second delay permits the aft cord plyer cords to move clear of the forward cord plyers before the forward plyers start to move. The forward and aft cord plyers move to the ready-to-weld position while the cord tension is maintained by the cord tensioning mechanism.

At the ready-to-weld position, the cords have been strung over the piercing pins and are at their final assembled angle to the beam caps. At the conclusion of the welding operation, the cord tensioner capstan brakes are released and the next cycle is ready to begin.

Beam Welding Subsystem

The beam welding mechanism has six ultrasonic weld head assemblies which are driven in pairs by a redundant motor drive for each pair. The three weld head positions are: (1) fully retracted to allow the cross-members to be positioned by the cross-member positioners; (2) pierce position, where the piercing pin on each weld horn has penetrated the cross-member and cap; and (3) the weld position, where the weld horn is engaged and properly loaded to enable the welds to be accomplished.

Each weld horn is equipped to perform two dimple spot welds and one special cord capturing weld simultaneously. The weld horns act against internal anvils, which are extended against the inside surface of the caps by a common dual motor-driven cam mechanism. The weld station is supported and sized by the combined action of the weld anvils and the beam support rollers located on the centerline of the weld station. A spring cartridge on each anvil actuator-rod limits the engagement force. The weld anvils are retracted to allow the weld dimples to pass and to minimize friction drag on the caps.

Beam Support Subsystem

The beam is supported at two stations by precision located metal rollers. The roller support stations fall on the centerline of the beam cross-members when the beam builder is in the assembly pause mode. The rollers maintain beam straightness during assembly and react bending moments during beam extension.

Coolant Subsystem

The coolant (F-21 or equivalent) is circulated through the cooling platens and heater reflectors in the heating and forming sections of the three cap forming machines. The coolant removes an estimated 448 watts total from the platens and reflectors. The high temperature coolant then flows through the radiator panel where the excess heat is radiated to space. The radiating area is sized to reject the 448 watts cooling load under maximum solar heat influx conditions. The silver backed teflon tape provides high emittance and low absorptance to minimize the thermal impact of solar heating.

The pump operates with a power demand of 58 watts. Overall system weight is estimated to be 15.3 kg.

The radiator for this system is mounted to one of the clip housings. The remaining components are installed inside the beam builder structure beneath the clips.

Beam Cutoff Subsystem

The beam cutoff mechanism shears each cap and cord member to separate a complete beam from the beam builder. The clamping device is normally retracted to allow the cross-members to travel past the outer clamps.

In preparation for beam cutoff, a short cutoff bay (60 cm) is manufactured by the beam builder. The cords are layed along the caps within this short bay rather than crossing over in diagonal directions as they do in normal bay construction. The short bay is advanced to the point where the cutoff shears are in the center of the short bay as the next complete bay is in assembly. When the next bay is assembled, the beam builder sequence is interrupted to permit beam cutoff and beam builder or platform repositioning.

Dual motor drives operate each cutter. As the actuators are extended, the clamps engage the internal backup mechanism and force the backups into position. The shear blades are spring loaded to allow the clamps to fully engage before the shear blades penetrate the cap. The shear blades are then driven through the caps as the actuators continue to extend. This also shears the cords as they lay along the sides of the cap.

Beam Builder Structural Subsystem

The beam builder structure is composed of welded aluminum elements. A preliminary analysis indicates a weight of 660 kg for the complete assembly.

The structure consists of three major segments: a forming section support, a central "spider", and an assembly section support. The forming section support is a trussed hexagonal system whose external surfaces provide support for the three machine storage/forming sections and the three cross-member storage clips. To maintain precise alignment of machine elements, local pads, machined after weld completion are provided at machine/structure interfaces.

The central spider is a three-legged box structure providing a transition load path from the internal forming section support to the external portions of the assembly section supports. It also provides an interface with the beam builder roll/turn positioning mechanism as well as supporting three cantilevered internal support beams and a support pedestal for the cross-member handler and weld anvil actuators.

The three external beams in the assembly section support provide mounting for the cord plyer/tensioner mechanisms, the ultrasonic weld station, the cut-off mechanism, and guiderollers at the weld and exit stations. One of these three beams also supports the beam builder/assembly jig latch system. As a consequence of this eccentric support, the three beams are connected by a cross-bracing system to provide system torsional rigidity, particularly needed in view of the reduced beam section, near the spider attachment plane, to accommodate cord plyer installation.

Beam Builder Support Subsystem

The support subsystem includes the mechanisms and controls which support the beam builder during platform fabrication.

A handling arm assembly attaches to the spider section of the beam builder structure. The handling arm is connected to a mechanism on the assembly jig which positions the beam builder.

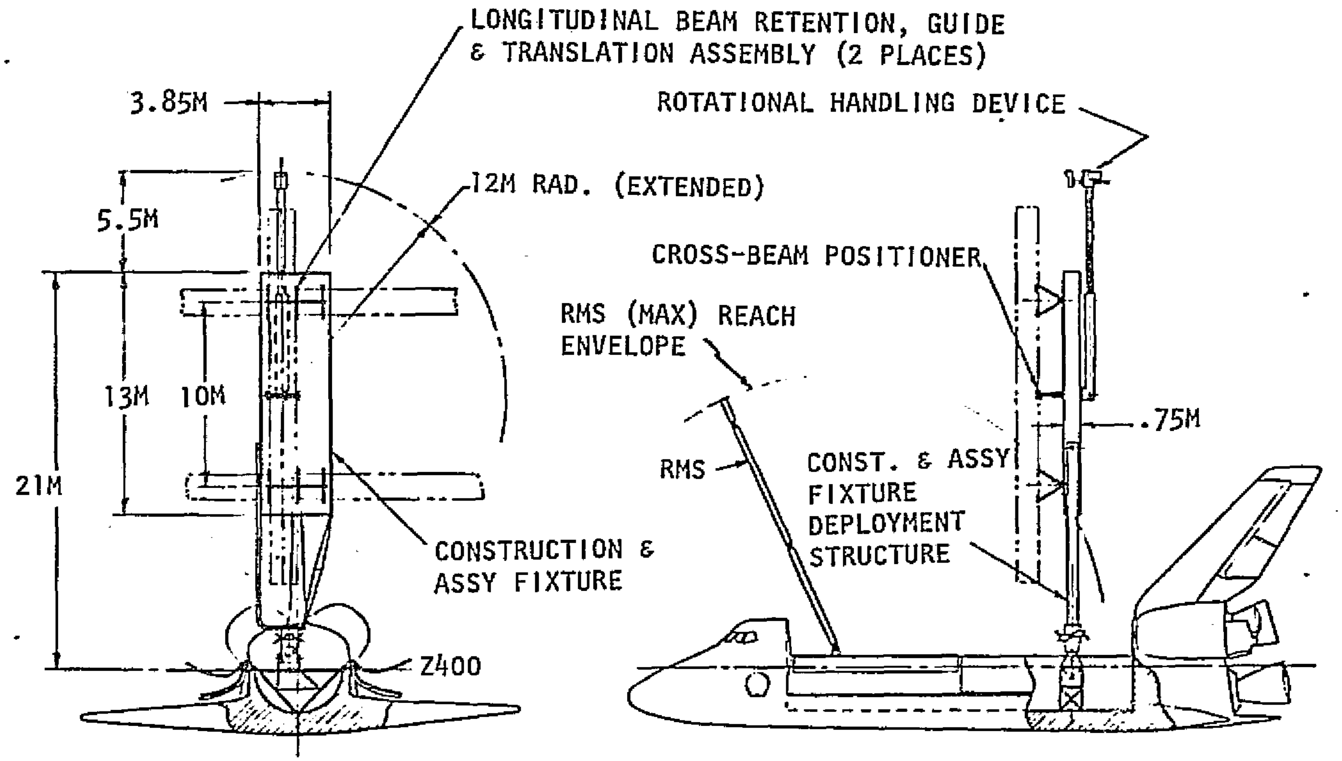
A longitudinal beam latch mechanism aligns and couples the beam builder with the assembly jig. It provides the added support necessary to prevent relative motion between the beam builder and assembly jig during longitudinal beam fabrication. A cross-beam latch mechanism is also required to align and support the beam builder during cross-beam fabrication.

B. CONSTRUCTION FIXTURES

The fixture plays a very significant role in the construction on any large project. As such, it in most applications is designed specifically for a particular project. The three projects which were the basis for this data base were sufficiently different in their structural and systems installation approach to require unique construction fixtures. The descriptions of these fixtures which follow are provided so that the data base user has all the information pertinent to the construction methods described in Section II.

SPS Test Article Fixture

The construction fixture concept for the fabrication and assembly of the SPS test article is illustrated in Figure 3-26. The figure consists of a structure to which the test article retention arms, beam positioner, and rotational handling device are mounted. The rotational handling device supports the beam builder during fabrication, and also supports other special construction devices. The test article translation is accomplished by providing articulation of the retention arms which permits the cross-beams to be "stepped" through the retention arms during the translation operations.



SCALE: 1/200

Figure 3-26. SPS Test Article Construction Fixture Concept

The total construction fixture is attached to the orbiter via a berthing port and appropriate structural members to raise the fixture to permit translation of the completed SPS test article.

Erectable Advanced Communications Platform Construction Fixture

The construction fixture developed for the assembly of the erectable communications platform concept is illustrated in Figure 3-27. The fixture consists of a single post/guide rail that supports the translation cradle. The guide rail/translation cradle assembly is supported from the orbiter. The translation cradle supports struts in their proper relationship during assembly and also provides the capability to translate the total platform the distance of one pentahedral bay. Platform supporting clamps secure the platform to the post of the upper end of the support post, permitting the translation cradle to release the platform and return to the assembly location.

The thrust structure support cradle locates and supports the thrust module attach tripods in their proper relationship. A rotation capability of of thrust structure support cradle permits the assembly of the thrust module support pods to within the reach envelope of the orbiter RMS.

Space-Fabricated Advanced Communications Platform Construction Fixture

The construction fixture for the tri-beam structure is illustrated in Figure 3-28, and provides the support and location of the beam builders during fabrication, the support and translation capability of the platform, the location of the cross-beams, and the provisions for the attachment of the cross-beams to the longitudinal beams via welding.

The translation of the project system is accomplished by providing articulation of the holding arms, thus permitting the cross-beams to be stepped through the holding arms during the translation operation.

Cross-beam positioning devices accept the fabricated beams from the RMS and precisely locate the beams for attachment. After the tri-beam structure has been completed the beam builder support arm and the beam positioner support structure are removed, thus clearing the fixture for the installation of the subsystems.

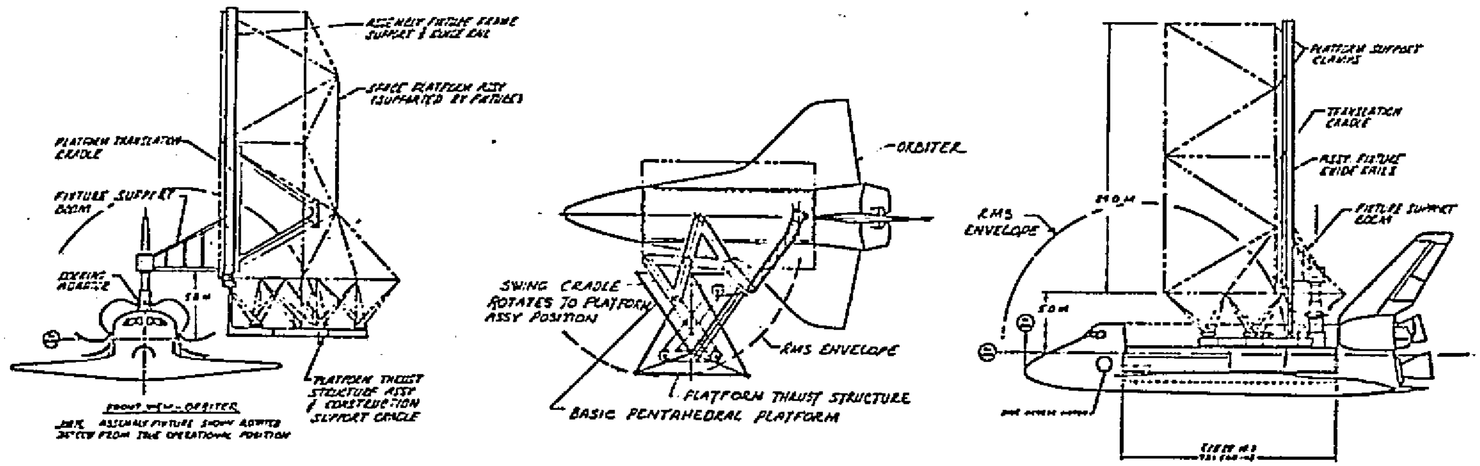


Figure 3-27. Erectable Communications Platform Construction Fixture Concept

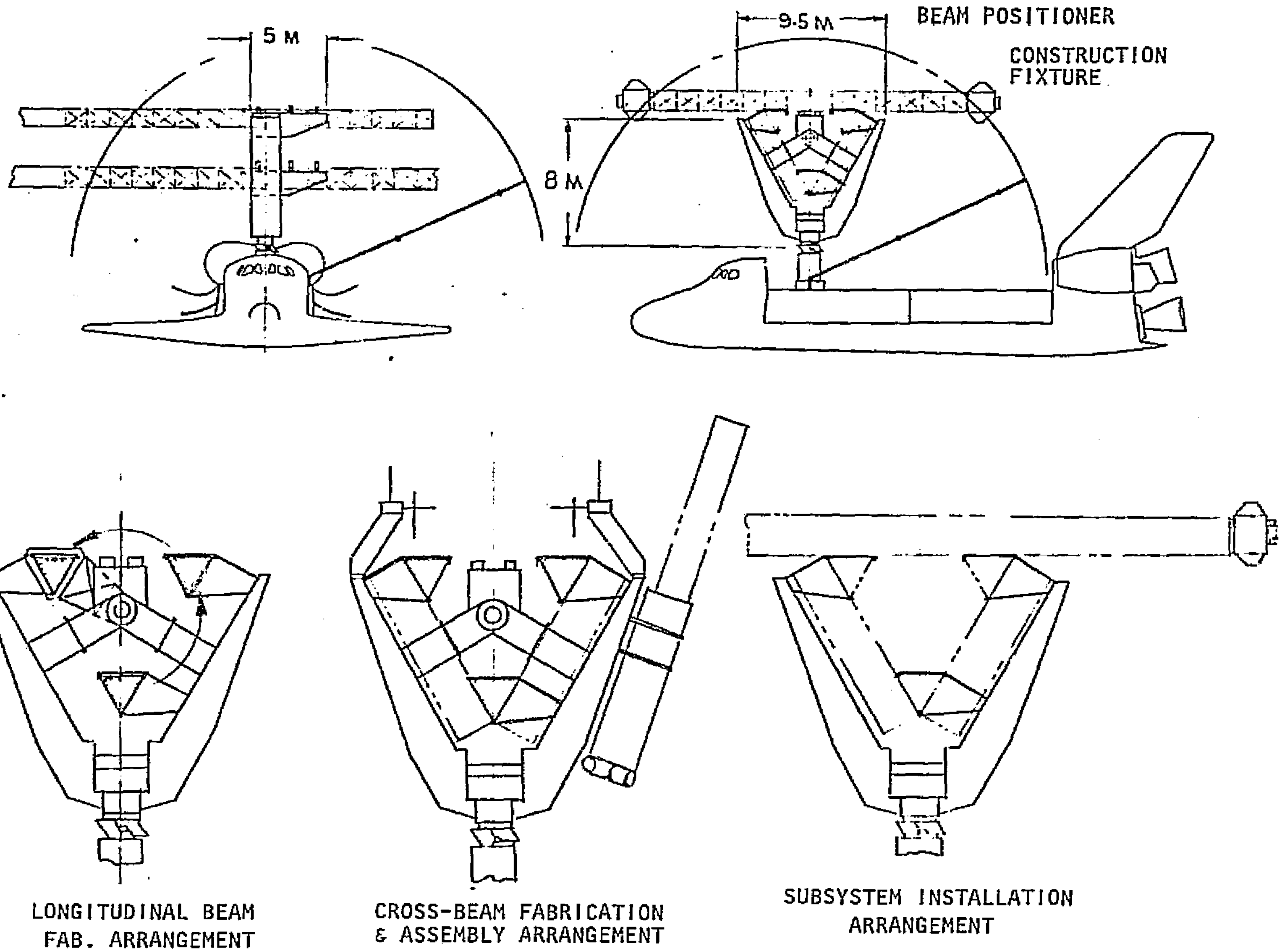


Figure 3-28. Space-Fabrication Communications Platform Construction Fixture Concept

SECTION IV

INDEXES

Section II indexes the 76 construction methods (22 operations) by project (Erectable, Space-Fabricated, or Deployable). This section includes indexes by Function (Table 4-1), Item (Table 4-2), and Method/Key Equipment (Table 4-3). These titles are the various headings associated with code number explained in Figure 1 of the Introduction.

Table 4-1. Function Index

FUNCTION		CODE NUMBER		OPERATION
01	DEPLOY			
02	FABRICATE			
03	TRANSPORT	01	0301.1	TRANSPORT BEAMS
04	POSITION			
05	JOIN	01	0501.1	BERTHING PORTS
		01	0501.2	THRUST STRUCTURE
		01	0501.3	SWITCH BOX ATTACH FITTINGS
		02	0501.1	STRUTS/UNIONS
		02	0501.2	THRUST STRUCTURE
06	INSTALL	01	0601.1	CROSS-BRACING WIRES
		01	0603.1	ELECTRICAL LINES
		01	0604.1	SYSTEM CONTROL MODULE
		01	0604.2	RCS MODULES
		01	0604.3	INSTALL ANTENNAS
		01	0604.4	SEPS MODULES
		01	0605.1	SOLAR BLANKETS
		02	0601.1	RCS & STRUCTURE
		02	0603.1	WIRING & J-BOXES
07	CONNECT	01	0703.1	CROSS-BEAM ELECT./J-BOXES
		01	0704.1	ANTENNA ELECTRICAL
08	SERVICE	01	0804.1	CMG's
09	QUALITY ASSURANCE	01	0901.1	STRUCTURE ALIGNMENT
		01	0903.1	ELECTRICAL CHECKOUT
		01	0904.1	ANTENNA ALIGNMENT

Table 4-2. Item Index

	ITEM	CODE NUMBER		OPERATION
01	STRUCTURAL ELEMENTS	01	0301.1	TRANSPORT BEAMS
		01	0501.1	JOIN BERTHING PORTS
		01	0501.2	JOIN THRUST STRUCTURE
		01	0501.3	JOIN SWITCH BOX ATTACH FITTINGS
		01	0601.1	INSTALL CROSS-BRACING WIRES
		01	0901.1	STRUCTURE ALIGNMENT
		02	0501.1	JOIN STRUTS & UNIONS
		02	0501.2	JOIN THRUST STRUCTURE
		02	0601.1	INSTALL RCS & STRUCTURE
02	ASSEMBLIES			
03	WIRING/LINES	01	0603.1	INSTALL ELECTRICAL LINES
		01	0703.1	CONNECT CROSS-BEAM ELECT/J-BOXES
		01	0903.1	ELECTRICAL CHECKOUT
		02	0603.1	INSTALL WIRING & J-BOXES
04	MODULES	01	0604.1	INSTALL SYSTEM CONTROL CENTER
		01	0604.2	INSTALL RCS
		01	0604.3	INSTALL ANTENNA
		01	0604.4	INSTALL SEPS
		01	0704.1	CONNECT ANTENNA ELECTRICAL
		01	0904.1	ANTENNA ALIGNMENT
		02	0804.1	SERVICE CMG's
05	BLANKETS/MEMBRANES	01	0605.1	INSTALL SOLAR ARRAY BLANKETS
06	SYSTEM			
07	COMPONENTS			

Table 4-3. Method/Key Equipment Index

METHOD/KEY EQUIPMENT	CODE NUMBER	OPERATION
01 EVA (5/3)	* 01 0601.1	CROSS-BRACING WIRES
	* 01 0603.1	ELECTRICAL LINES
	* 01 0603.1	ELECTRICAL LINES
	01 0704.1	ELECTRICAL CONNECT ANTENNAS
	02 0501.1	JOIN STRUTS/UNIONS
02 MMU (11/8)	* 01 0301.1	TRANSPORT BEAMS
	01 0501.1	BERTHING PORTS
	* 01 0501.3	SWITCH BOX ATTACH FITTINGS
	01 0501.3	SWITCH BOX ATTACH FITTINGS
	* 01 0601.1	CROSS-BRACING WIRES
	* 01 0703.1	ELECT CONNECT X-BEAMS/J-BOX
	* 01 0704.1	ELECTRICAL CONNECT ANTENNAS
	02 0501.2	THRUST STRUCTURE
	* 02 0601.1	RCS & STRUCTURE
	* 02 0601.1	RCS & STRUCTURE
	* 02 0603.1	WIRING & J-BOX
03 CHERRY PICKER (13/11)	* 01 0301.1	TRANSPORT BEAMS
	* 01 0501.1	BERTHING PORTS
	* 01 0501.3	SWITCH BOX ATTACH FITTINGS
	01 0501.3	SWITCH BOX ATTACH FITTINGS
	* 01 0604.2	RCS MODULES
	* 01 0604.2	RCS MODULES
	* 01 0604.3	INSTALL ANTENNAS
	* 01 0704.1	ELECT CONNECT ANTENNAS
	* 02 0501.1	JOIN STRUTS, UNIONS
	* 02 0501.2	THRUST STRUCTURE
	* 02 0501.2	THRUST STRUCTURE
	02 0601.1	RCS & STRUCTURE
	* 02 0603.1	WIRING & J-BOXES
04 RMS (23.10)	* 01 0301.1	TRANSPORT BEAMS
	01 0301.1	TRANSPORT BEAMS
	01 0301.1	TRANSPORT BEAMS
	* 01 0501.2	JOIN THRUST STRUCTURE
	01 0501.2	JOIN THRUST STRUCTURE
	* 01 0604.1	SYSTEM CONTROL MODULE
	* 01 0604.1	SYSTEM CONTROL MODULE
	01 0604.1	SYSTEM CONTROL MODULE
	01 0604.2	RCS MODULES
	* 01 0604.3	INSTALL ANTENNAS
	01 0604.3	INSTALL ANTENNAS
	* 01 0604.4	SEPS MODULES
	* 01 0604.4	SEPS MODULES
	01 0604.4	SEPS MODULES
	01 0604.4	SEPS MODULES
	01 0604.4	SEPS MODULES

Table 4-3. Method/Key Equipment Index (Cont.)

METHOD/KEY EQUIPMENT	CODE NUMBER	OPERATION
04 (Cont.)	01 0703.1	ELECT CONNECT X-BEAMS/J-BOX
	* 02 0501.1	JOIN STRUTS, UNIONS
	* 02 0501.1	JOIN STRUTS, UNIONS
	02 0501.2	THRUST STRUCTURE
	02 0501.2	THRUST STRUCTURE
	* 02 0601.1	RCS & STRUCTURE
	02 0603.1	WIRING & J-BOXES
05 CRANE/BOOM (3/2)	* 01 0301.1	TRANSPORT BEAMS
	* 01 0704.1	ELECT CONNECT ANTENNAS
	01 0704.1	ELECT CONNECT ANTENNAS
06 SPECIAL TOOL (7/5)	* 01 0501.1	BERTHING PORTS
	* 01 0501.1	BERTHING PORTS
	01 0501.1	BERTHING PORTS
	* 01 0605.1	SOLAR BLANKETS
	* 02 0804.1	SERVICE CMG's
	* 02 0804.1	SERVICE CMG's
	02 0804.1	SERVICE CMG's
07 SELF-ACTUATING (2/0)	01 0604.1	SYSTEM CONTROL MODULE
	01 0704.1	ELECT CONNECT ANTENNAS
08 ELECT C/O TESTER (3/1)	* 01 0903.1	ELECTRICAL C/O
	01 0903.1	ELECTRICAL C/O
	01 0903.1	ELECTRICAL C/O
09 MISCELLANEOUS (5/4)	01 0501.2	JOIN THRUST STRUCTURE
	* 01 0901.1	STRUCTURAL ALIGNMENT
	* 01 0901.1	STRUCTURAL ALIGNMENT
	* 01 0904.1	ANTENNA ALIGNMENT
	* 01 0904.1	ANTENNA ALIGNMENT
10 CONSTRUCTION FIXTURE (4/3)	01 0501.3	SWITCH BOX ATTACH FITTING
	* 01 0601.1	CROSS BRACING WIRES
	* 01 0604.2	RCS MODULES
	* 01 0703.1	ELECT CONNECT X-BEAMS/J-BOX
TOTAL (76/47)		

NOTE: THE NUMBERS IN THE METHOD/KEY EQUIPMENT COLUMNS REFER TO THE TOTAL NUMBER OF TIMES IT HAS BEEN LISTED AND THE NUMBER OF DEFINED METHODS USING IT, RESPECTIVELY. THE "OPERATIONS" WITH THE ASTERISKED CODE NUMBERS ARE THOSE WHICH ARE DEFINED IN SECTION II.