MARS AEROBRAKE ASSEMBLY DEMONSTRATION

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McDonnell Douglas Space System Co.

SSF Evolution - Beyond theBaseline
Houston, Texas

8 August 1991

N92-17362

PROBLEM

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NASA has identified aerobraking as a potentially critical technology for SEI. The size of Mars aerobrakes may be beyond the capabilities of future launch vehicles to place them into orbit in one launch. On-orbit assembly using facilities and operations developed under the SSF program represent one approach for realizing such large structures. The results of early testing in this subject can help influence the future evolution of Space Station Freedom.

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OBJECTIVES

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- Generate empirical data on operational procedures for on-orbit assembly of a large Mars aerobrake
- Develop aerobrake design concepts
- Identify critical issues and requirements associated with SSF utilization
- Stimulate student participation in the Space Exploration Initiative

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SSF FACILITY REQUIREMENTS

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Earlier Space Station Freedom designs incorporated the potential for evolving into an on-orbit assembly facility. This is one such example, where a lower boom has been added to allow the integration of an aerobrake-equipped space transfer vehicle

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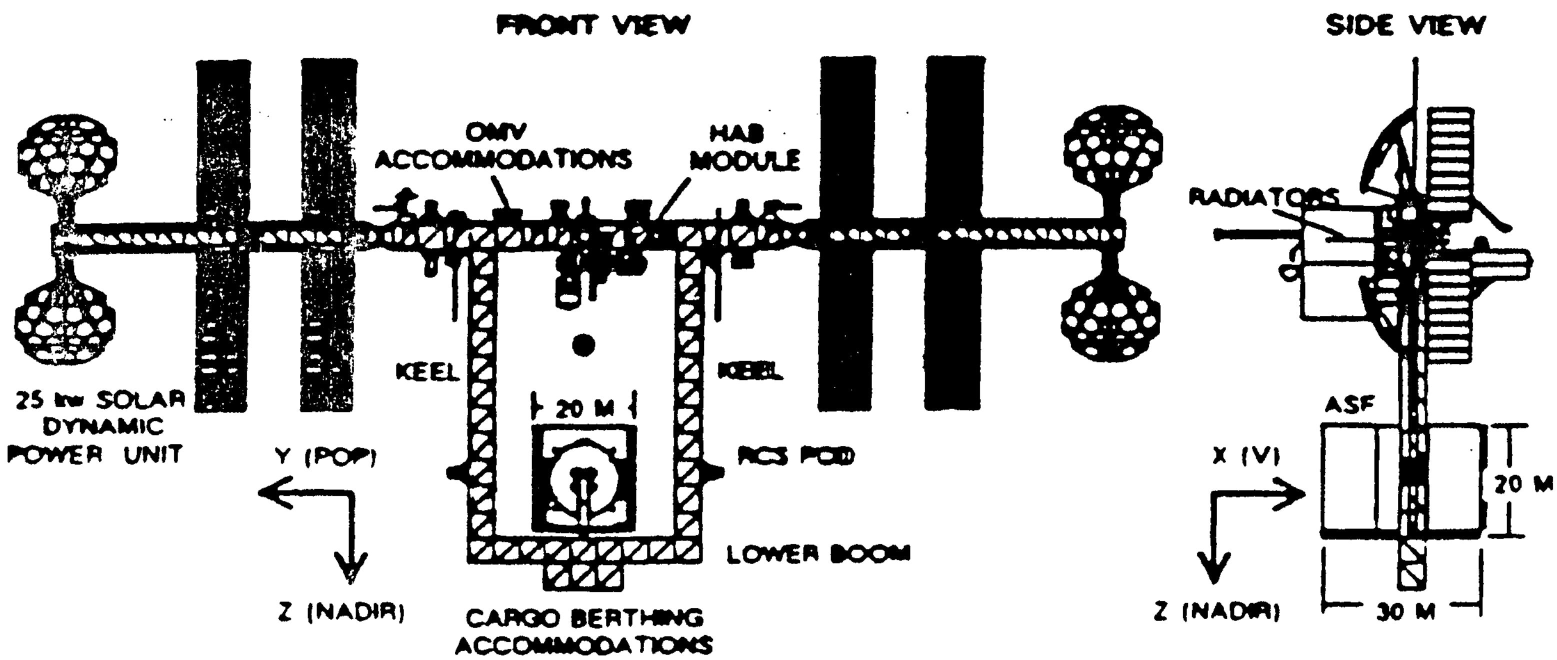
SPACE STATION FREEDOM FACILITY REQUIREMENTS

VJY894

MDSSC-SSD



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ASSEMBLY & SERVICING FACILITY

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This is a more detailed drawing of a candidate Assembly & Servicing Facility (ASF) that would accomodate large space transfer vehicles. In this NASA-Langley concept, the aerobrake is assembled on a rotating "lazy susan" fixture. Our tests followed a similar approach.

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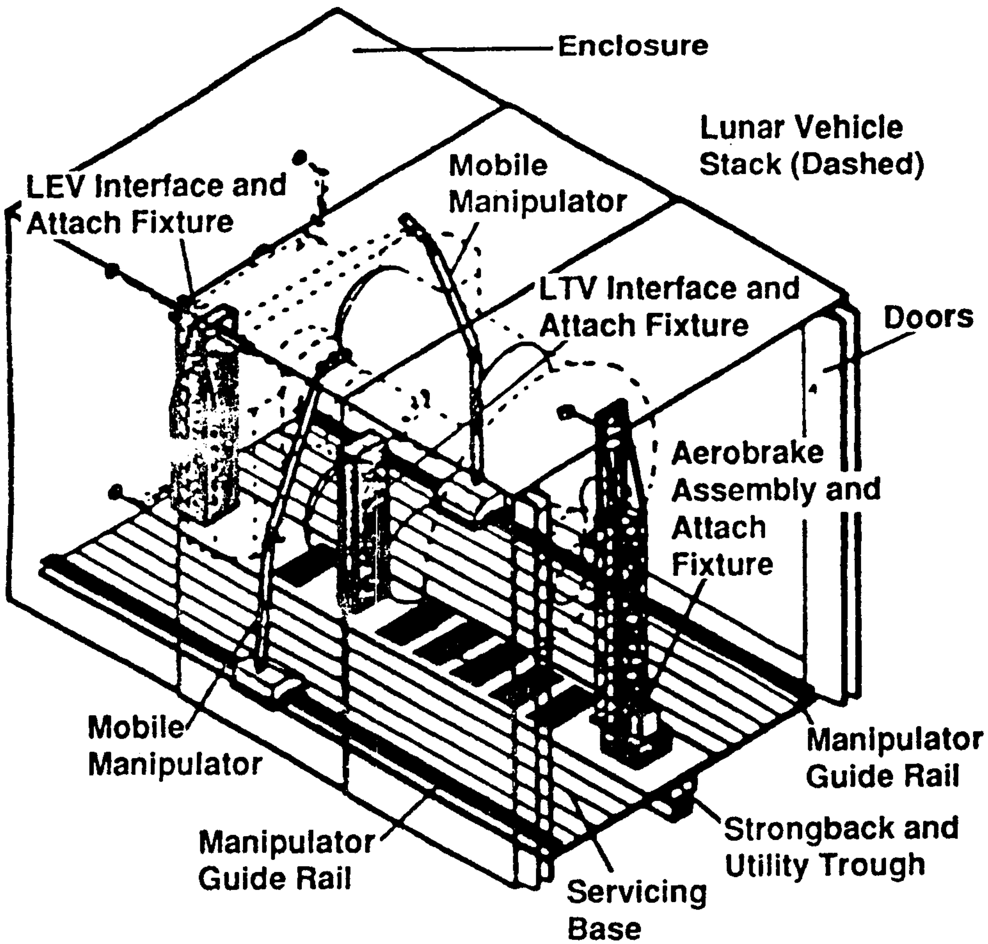
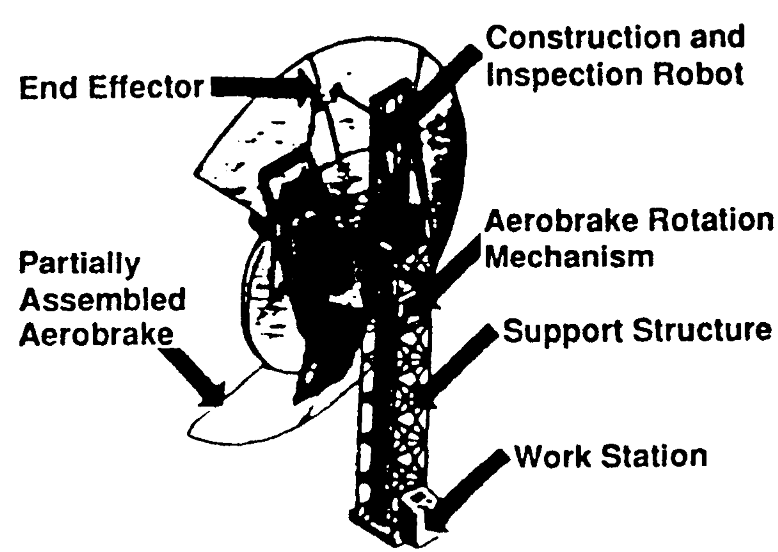


ASF Configuration and Components



Aerobrake Assembly and Attach Fixture

AEROBRAKE ASSEMBLY TEST PROJECT ORGANIZATION

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This is the team that we pulled together to conduct this project. Two parallel IRAD efforts at McDonnell Douglas provided direction and implemented the actual tests, while the Mars Mission Research Center (MMRC) supported mockup design activities, fabricated the mockup and also participated in the neutral boyancy tests. MMRC is a NASA-sponsored Space Engineering Research Center co-located at North Carolina State University and North Carolina Agricultural and Technical State University.

Additional inputs were received from our MDSSC group at KSC, and Langley representatives who provided guidance to MMRC (Langley is the monitoring NASA facility for the MMRC).

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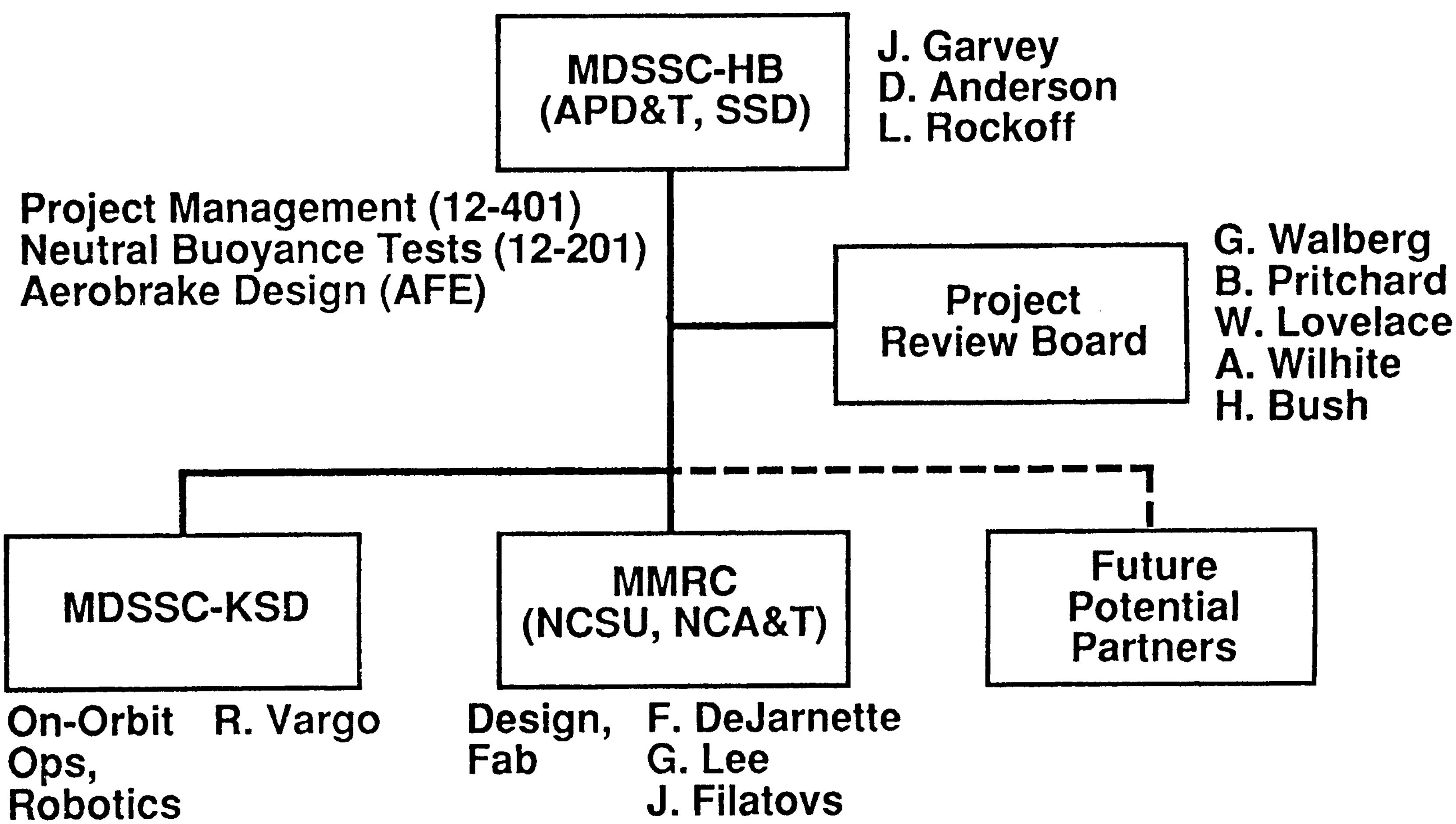
AEROBRAKE ASSEMBLY TEST
PROJECT ORGANIZATION

VJZ243.1 M9BH

MDSSC/MMRC



SCHEDULE

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We began discussions with the MMRC in 1988, shortly after it was created by NASA. By mid-1989, soon after the President's SEI speech, the support was sufficient to start this project. MDSSC gave the MMRC a small contract to initiate student studies in the fall, during which the reference aerobrake was defined. A mockup design and fabrication contract followed in 1990, and six months later the initial swim-through tests using only scuba and surface-supplied-air took place. Using feedback from this initial check-out, full-scale testing with an EVA suit and telerobotic device then occurred in October.

A number of follow-on tasks have been identified, but funding constraints have pushed them to the right.

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MDSSC/MMRC AEROBRAKE ASSEMBLY PROJECT – SCHEDULE

VJZ254.1 M9BH

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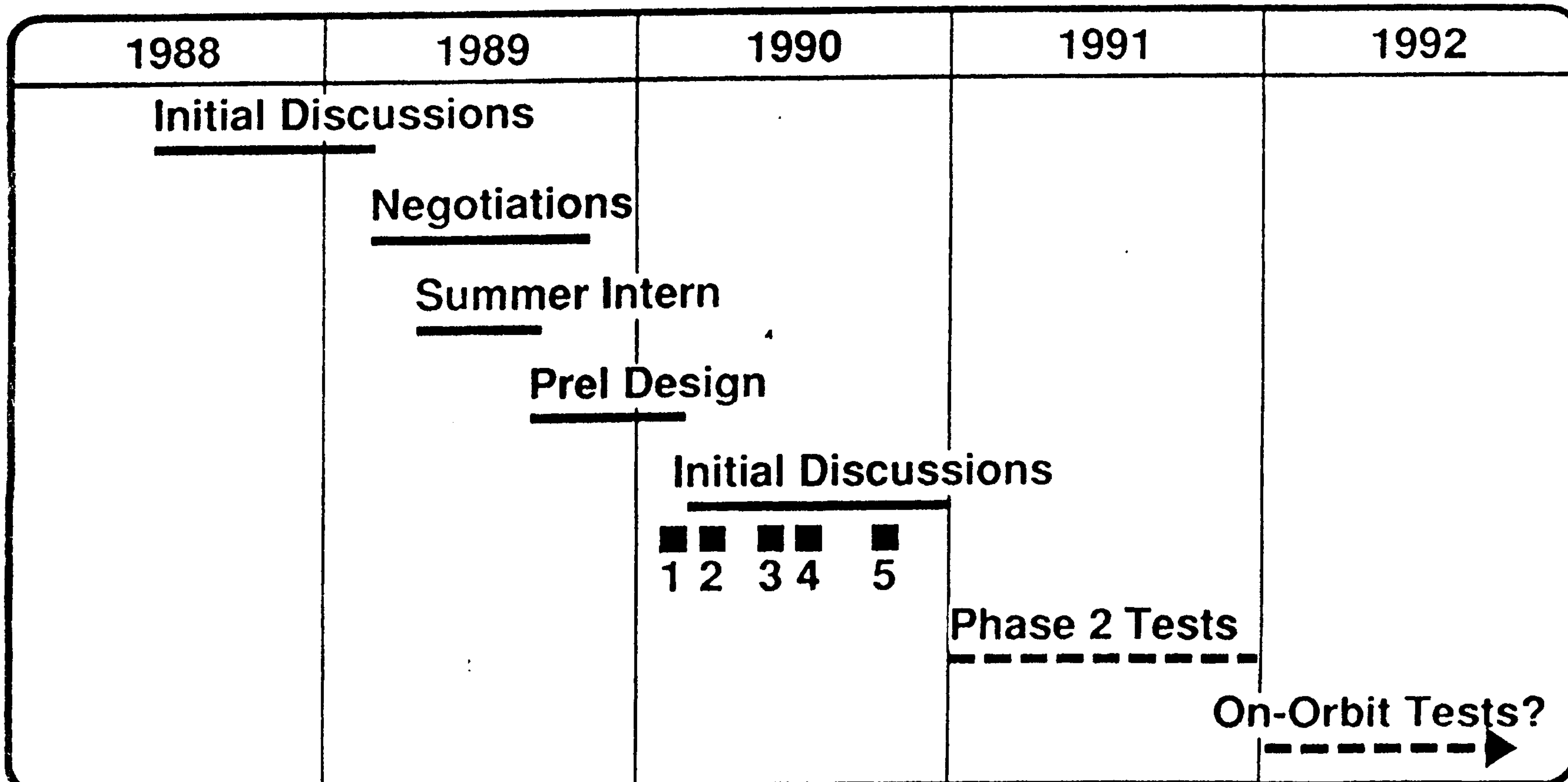

1 PDR
2 CDR
3 Mockup shipment
4 UWTF Tests – scuba swim-through
5 UWTF Test – EVA suited subjects and telerobotic arm

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REFERENCE MARS AEROBRAKE DESIGN

This is the reference Mars aerobrake. It is derived from the AFE design and consists of three main sections - a central monolithic core that is launched in one piece, a symmetrical ring of eight panels or petals around this core, and then an outer, unsymmetrical ring that results in a raked ellipse configuration that can achieve an L/D of 0.3. It is worthwhile to note that the core and inner ring have a high correlation with a candidate lunar STV aerobrake. Thus, such a device and associated facilities could be implemented and tested during the lunar phase of SEI, and then evolved up to this Mars vehicle aerobrake

Because the longest dimension is 105 feet and the MDSSC Underwater Test Facility is only 70 feet wide, we were constrained to only testing several representative components, which are indicated by the shaded areas.

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REFERENCE MARS AEROBRAKE DESIGN

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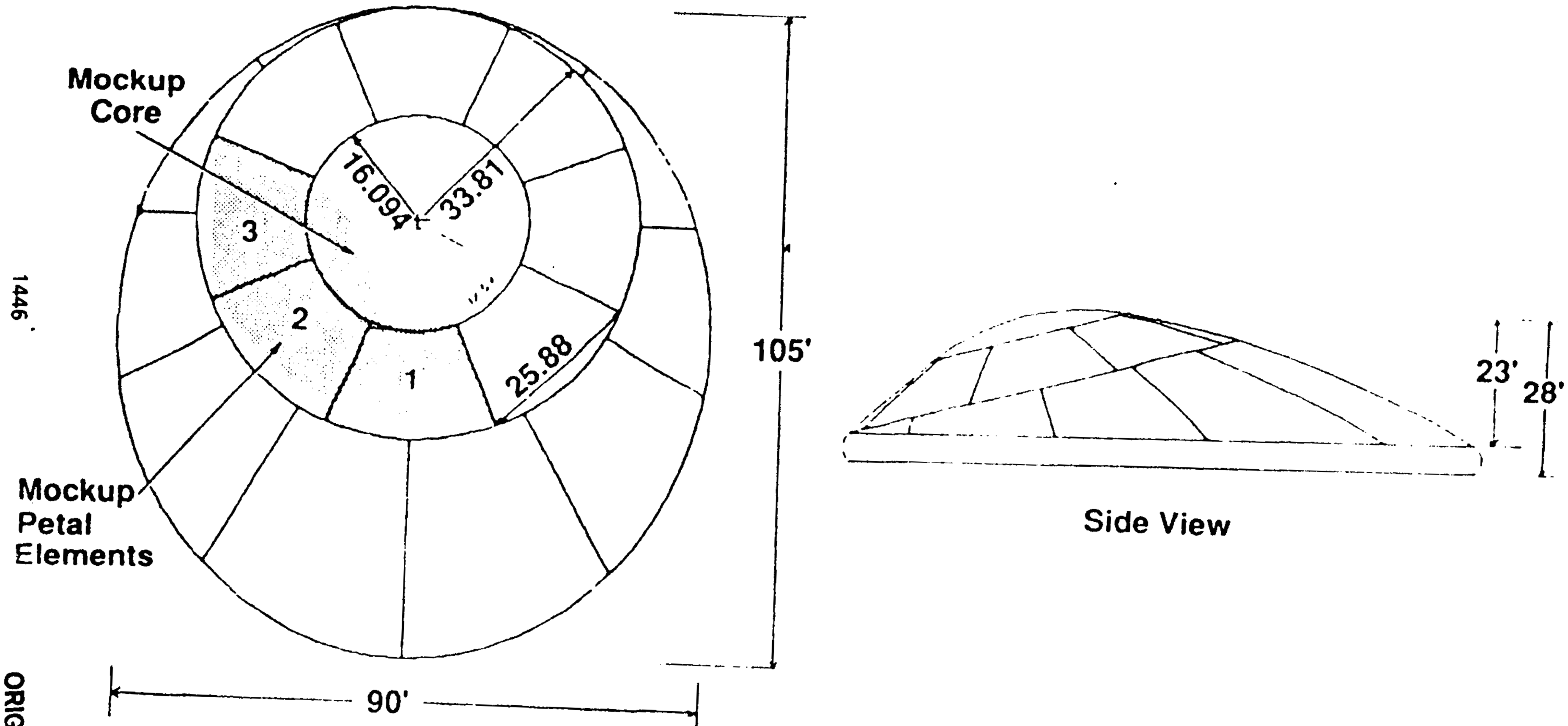
VJY897.2 M3DN



Top View

Side View

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MOCK-UP DESIGN

This is the final configuration drawing for the aerobrake mockup. As will become clearer in later drawings, it consists of three petals and part of the central core. A series of struts were incorporated to enable some study of EVA/telerobotic interaction, however, this truss is not intended to represent a load-carrying structure and requires much more refinement.

Straight elements were used to construct this mockup instead of curved ones in order to keep material costs down. Such approximation was deemed acceptable for initial assembly tests, but future iterations should eventually incorporate higher fidelity components.

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MOCK-UP DESIGN

VJZ632 M10CM

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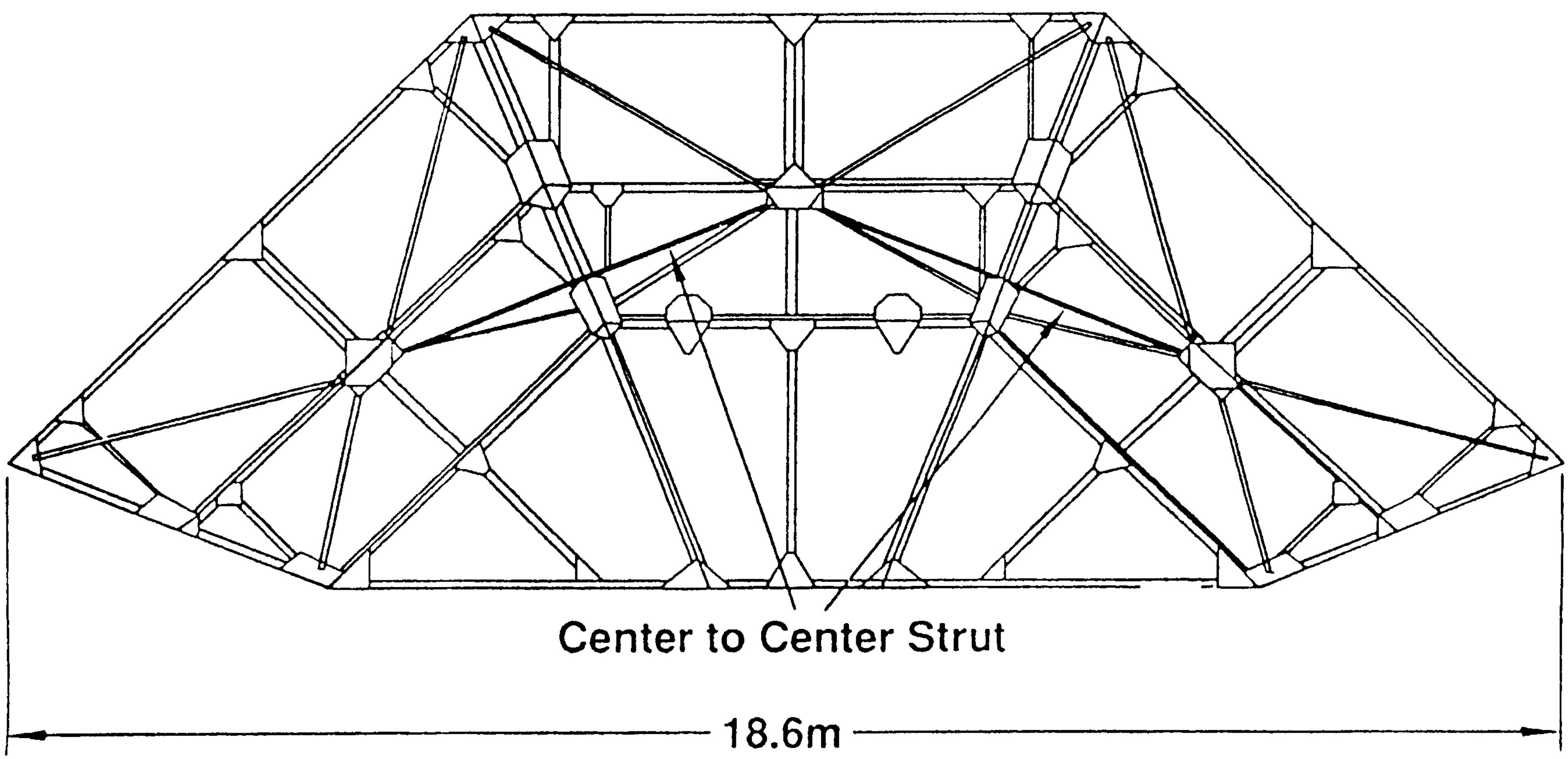

- 3 petals will be used to simulate 3 operations
  - Attachment of the first petal (petal 1)
  - Attachment of additional petals (petals 1 and 2)
  - Attachment of the last petal (petal 2 inserted between 1 and 3)

- The telerobotic arm will translate a petal to its docking station, where the two EVA suited subjects will then complete soft docking and close the hard-dock latch mechanisms

CONFIGURATION IN UWTF

VJY900

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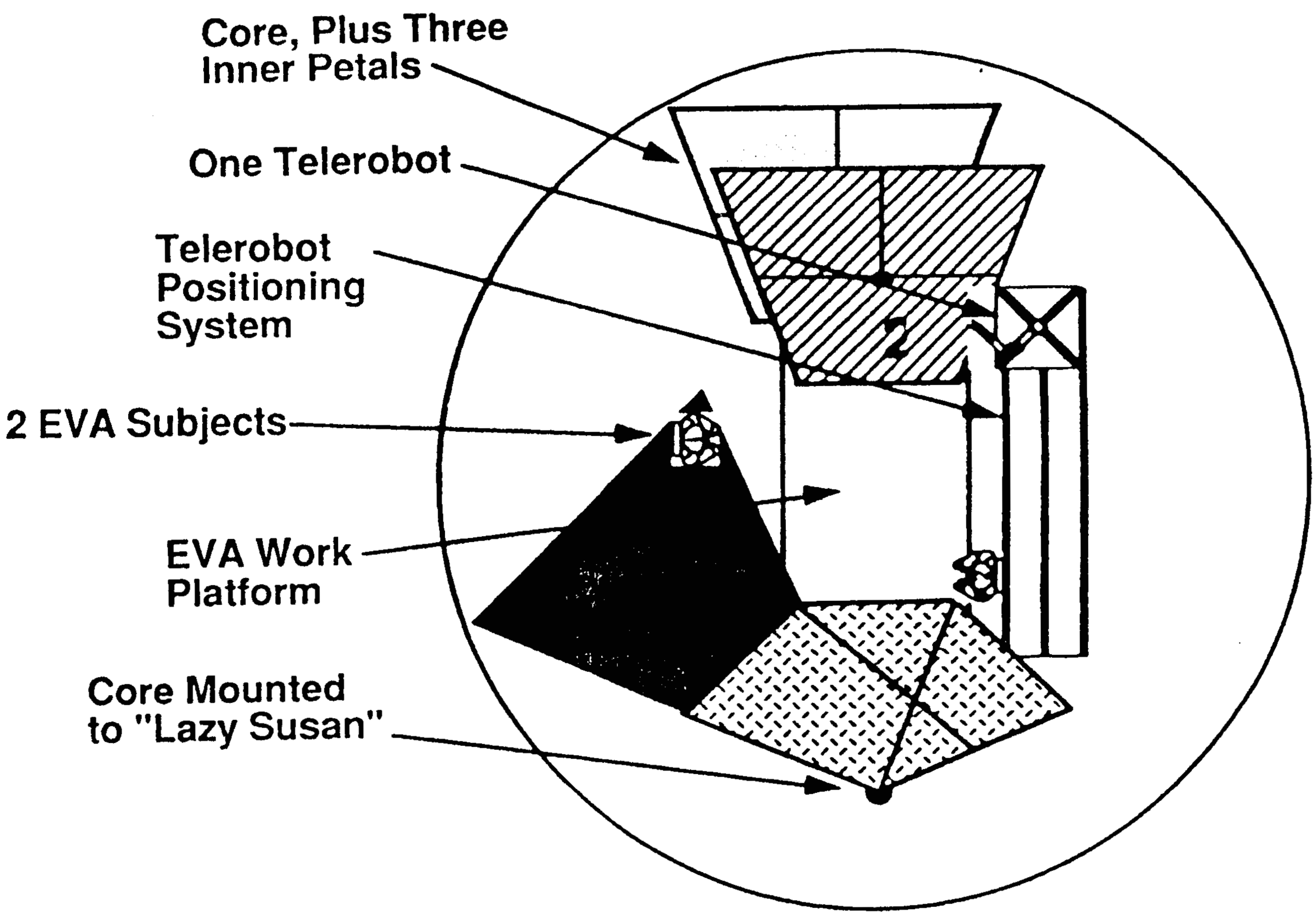

- An integrated latching mechanism was utilized to eliminate loose items (i.e. – bolts, washers). A single tool activates it.

- To minimize cost a $4/unit latch from the housing industry was used. Such a latch was designed to minimize labor requirements for homebuilders. An alternative activation approach is under consideration. By reorienting the latches and connecting them by a drive element, it may be possible to eliminate EVA intervention entirely

HARD-DOCK LATCH REDUCES EVA REQUIREMENTS

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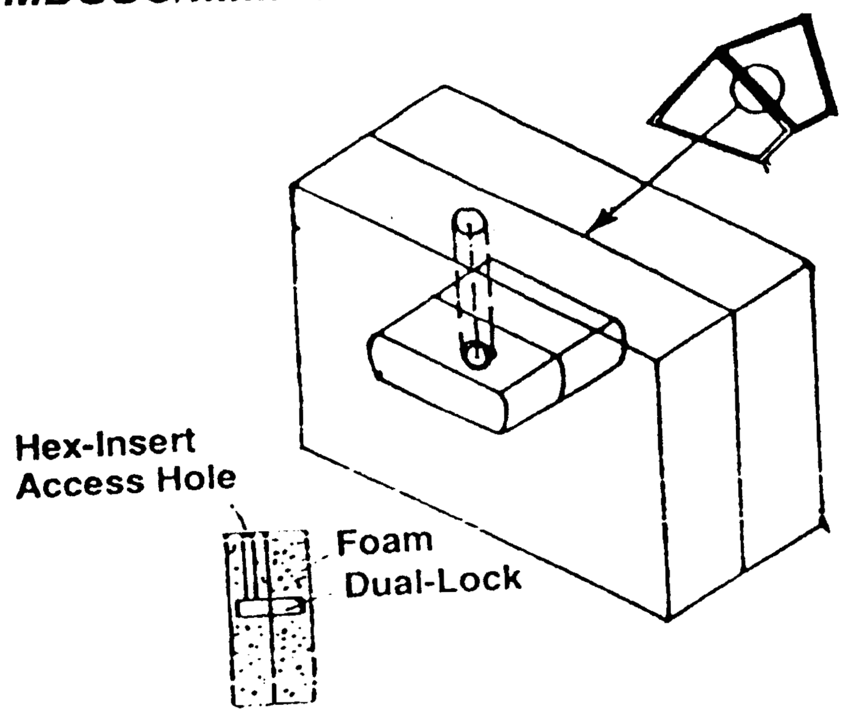
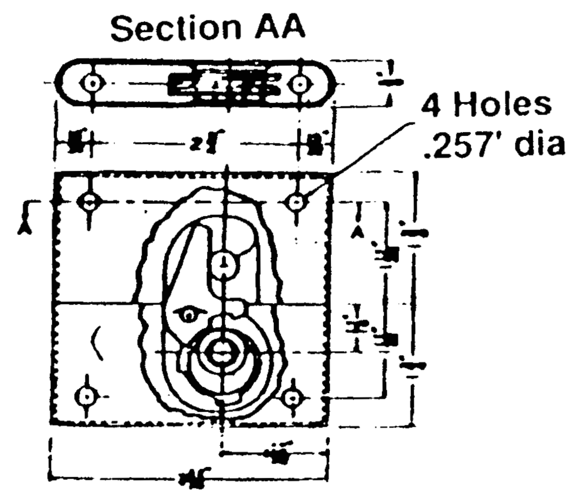
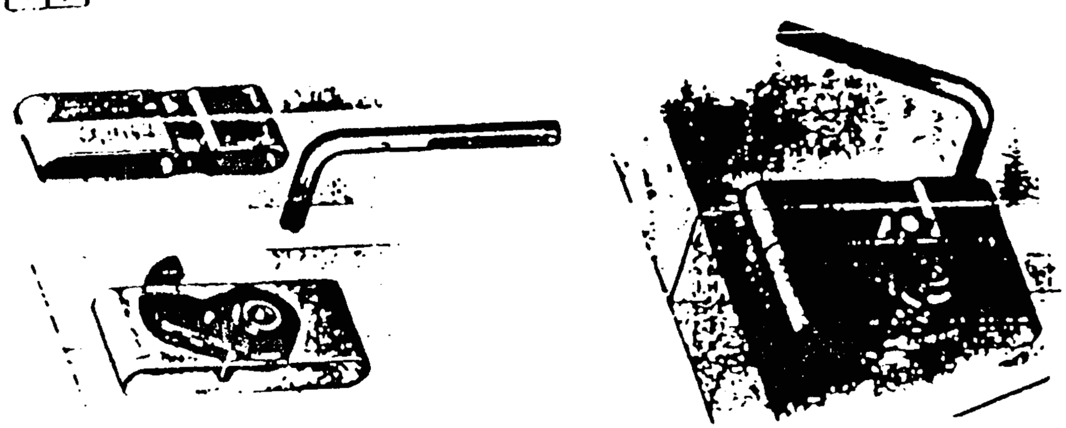




GJF



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ALTERNATIVE LATCHING ARRANGEMENT

If it is determined that closing such latches requires excessive EVA and/or telerobotic support, an alternative arrangement as shown here can greatly reduce such requirements. In this case, the latches are lined up in parallel and closed by a single drive mechanism. This approach is similar to that employed on cargo doors for large aircraft. One of the issues that needs to be considered is the impact if one or more of the latches do not fully close.

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ALTERNATIVE LATCHING ARRANGEMENT

VJZ619 M9BL

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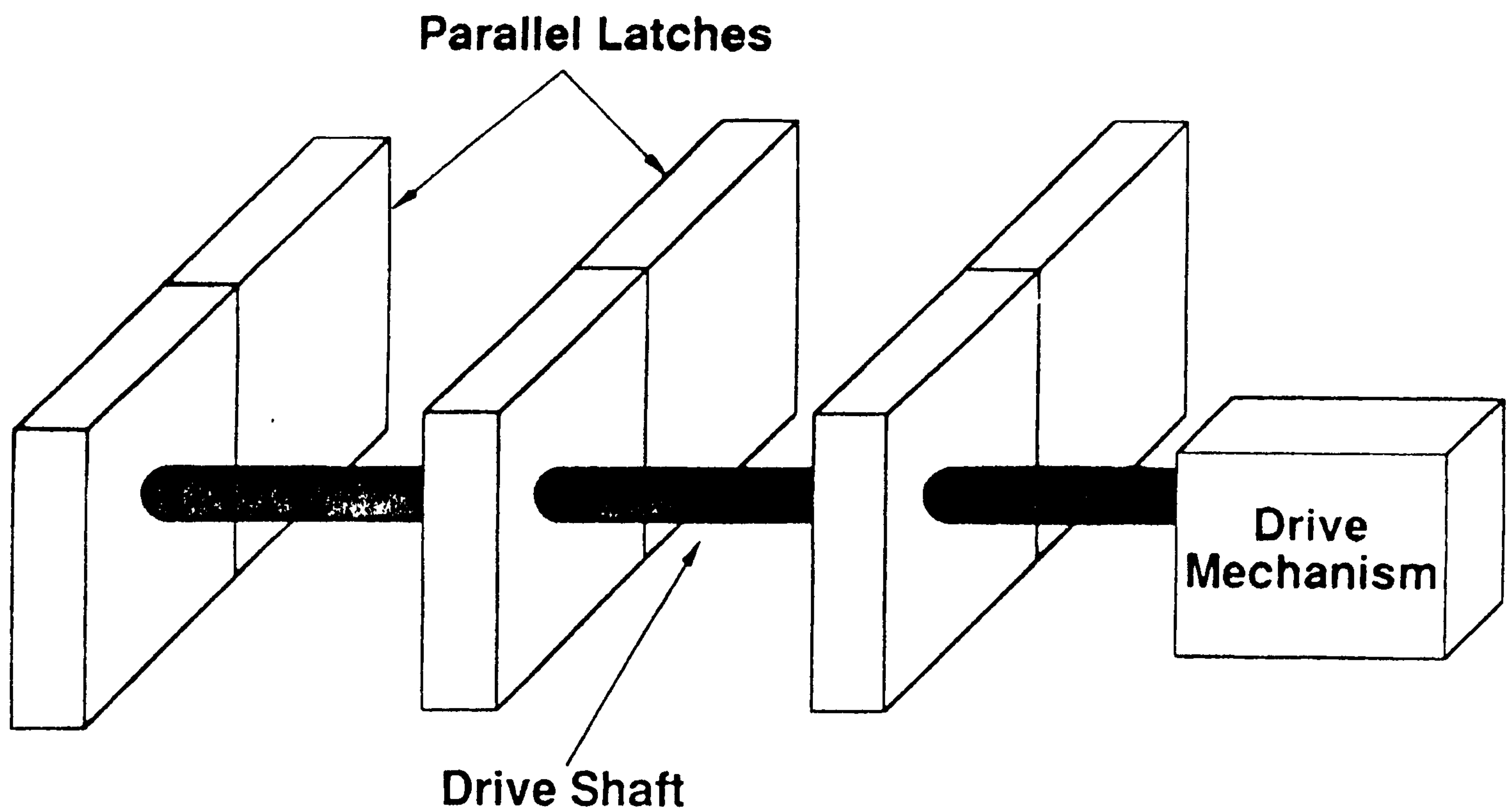

TPS INTERFACE OPTIONS

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One other area that requires further attention is the TPS close-out between adjacent petals. For these tests, we selected an approach similar to that used on the Shuttle, where a separate panel is placed over the bulkhead structure interface.

During testing, inserting and fastening these TPS close-out panels proved to be the most difficult operations, and the results overall were unsatisfactory.

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CANDIDATE TPS INTERFACE OPTIONS

VJZ620.1 M9BL

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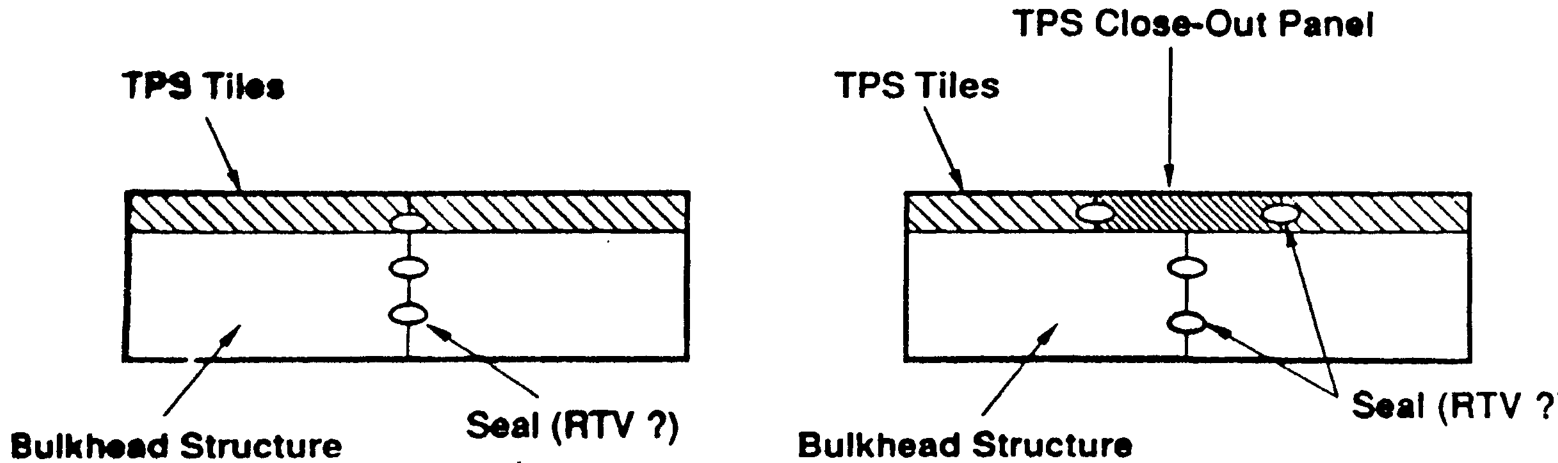
Leading Edge Surface



Trailing Edge

A) Direct Interface

B) Close-out Panel

PETAL INSTALLATION TIMES

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Dave Anderson, co-PI on this project, developed this EVA time break down. It is worthwhile to note that at least three of these time allocations - soft docking, tethers and latches, can be reduced if a greater degree of automation and robotics is available. For example, a "smart" alignment system would significantly reduce the operational complexity of soft docking a petal, while an Astronaut Positioning System (APS) would eliminate much of the tethering activity.

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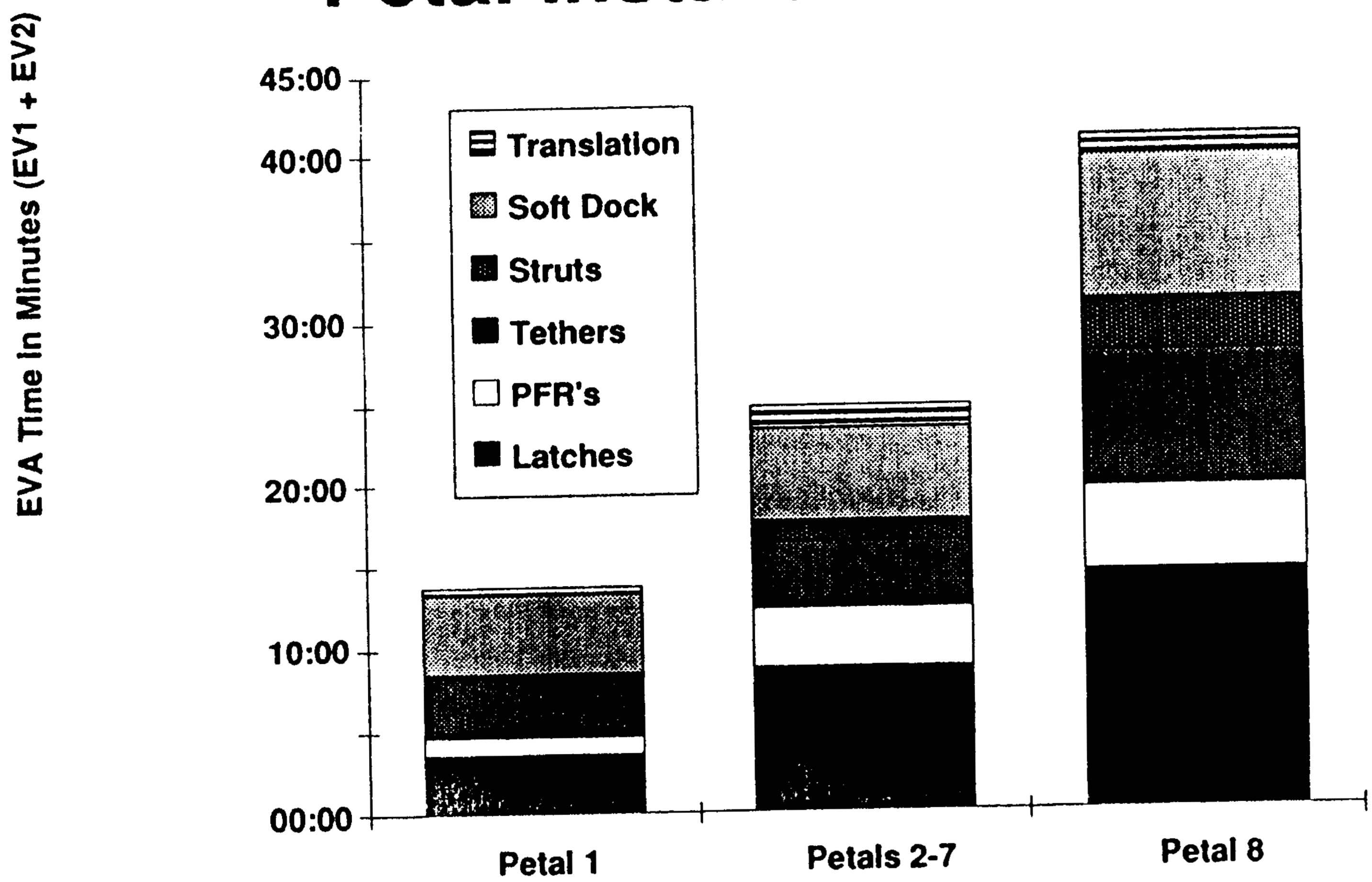
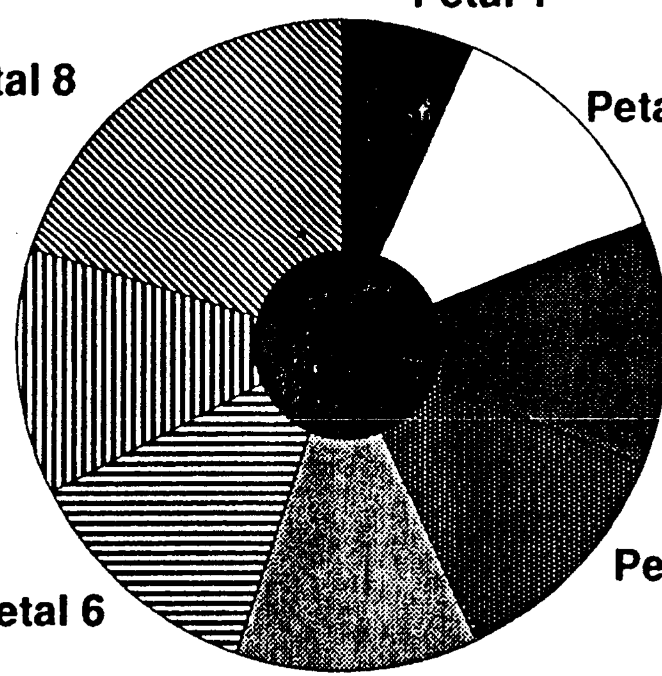
Petal Installation Times



Full Aerobrake Assembly Time



Total 3:23:40 Hours

AEROBRAKE TIMELINE COMPONENTS

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This chart is a breakdown of the task times to assembly the aerobrake from the previous chart. As indicated previously, one could expect some change in at least the struts, tethers and probably soft dock.

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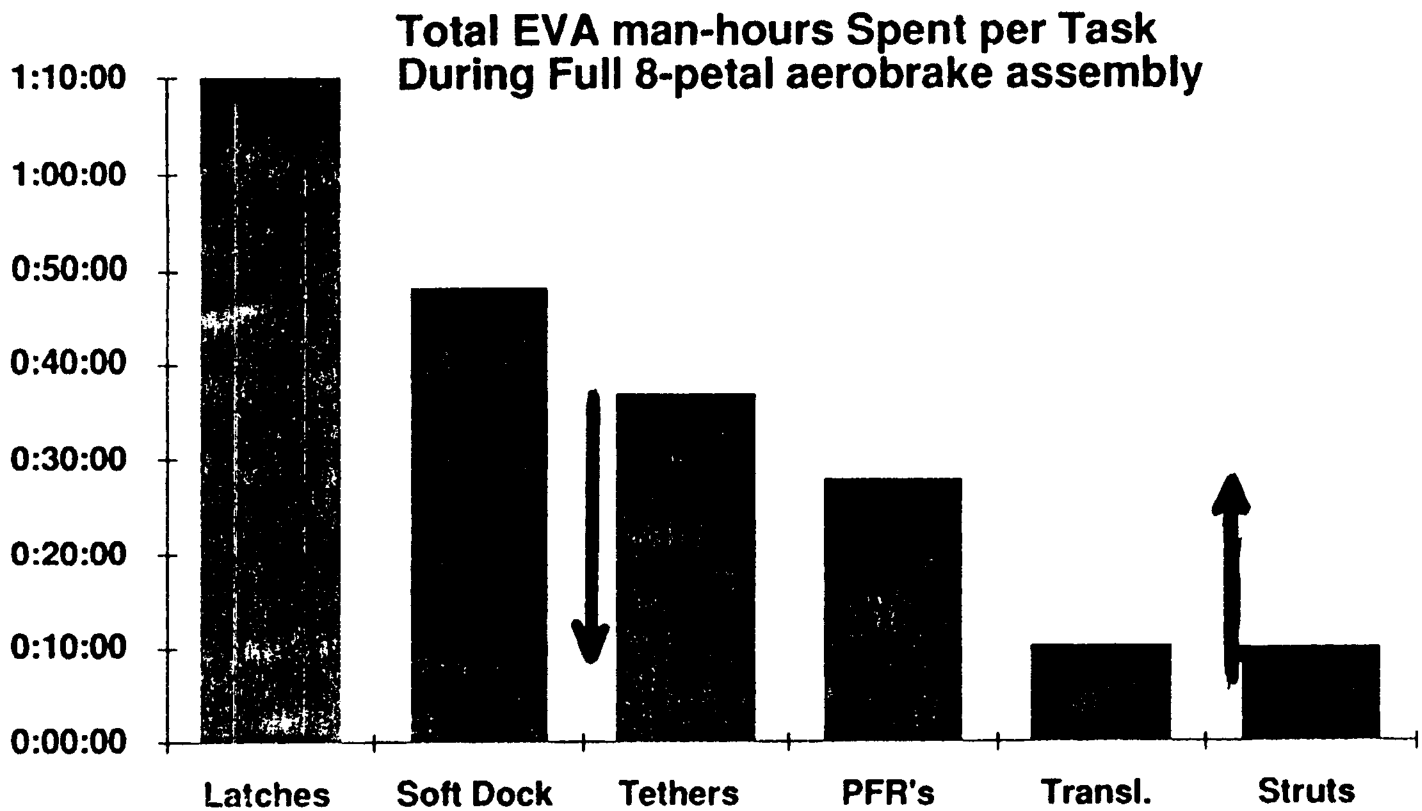
Aerobrake Timeline Components



FOLLOW-ON ACTIVITIES

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We originally planned to fabricate a new, full-scale mockup aerobrake for a Lunar Transfer Vehicle, but a variety of obstacles have delayed that effort indefinately.

Another series of aerobrake assembly tests involving the same basic mockup, with two functional APS mockups and the Ames AX-5 hard suit is now planned for January, 1992.

Work is under way with NASA Langley to test the assembly of their Precision Segmented Reflector mockup this fall.

Attention is also focusing on conducting neutral buoyancy simulation of assemblying and servicing a Nuclear Thermal Rocket mockup in 1992

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1991 AEROBRAKE TEST SET-UP

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The next aerobrake assembly will utilize the same mockup, with two APS arms from the SSF program, a standard EVA suit, and the prototype AX-5 hardsuit that Ames is developing. Such a suit operates at 8 p.s.i. and is intended to improve EVA performance.

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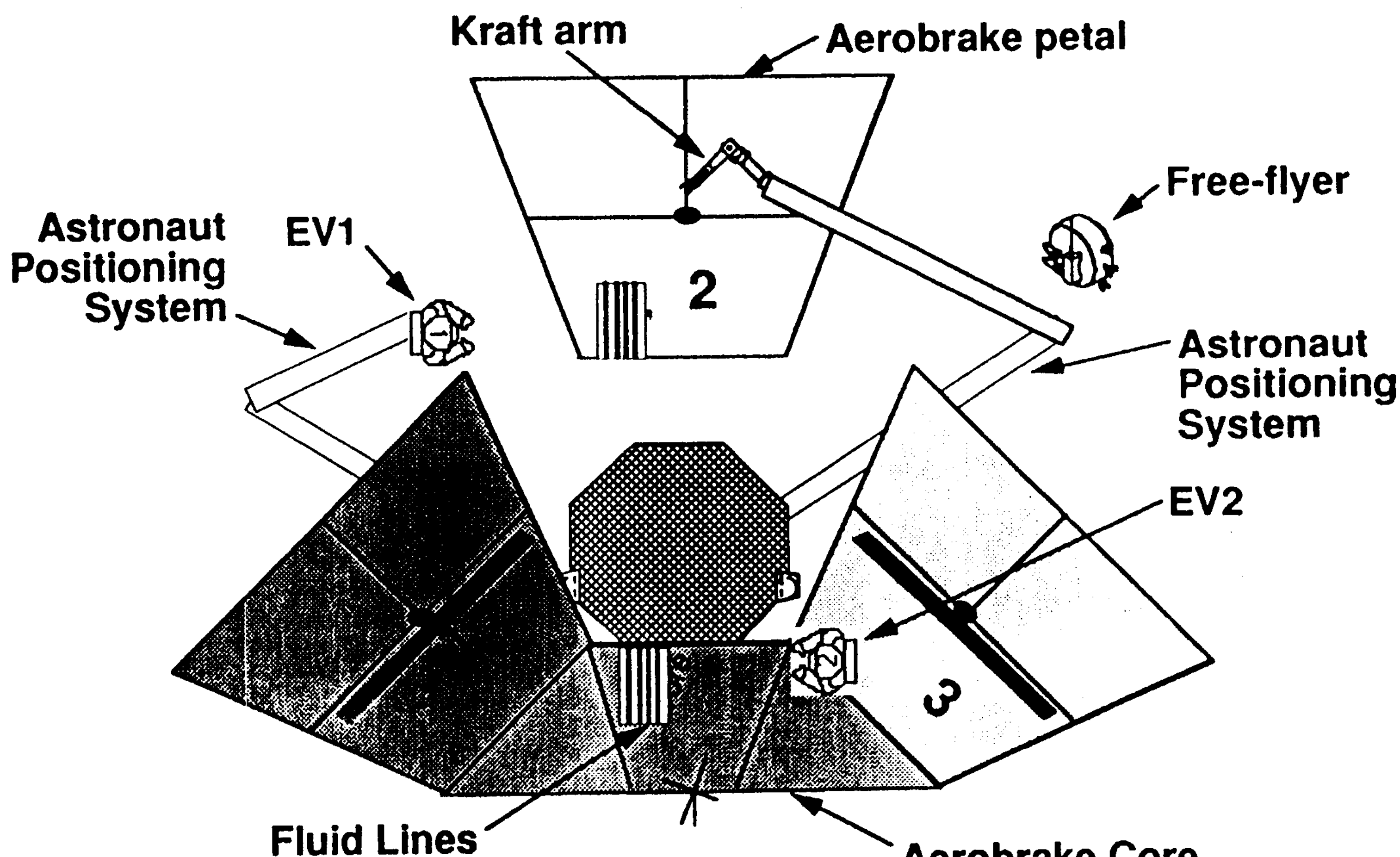
1991 Aerobrake Test Set-up



— Space Station Freedom — McDonnell Douglas • GE • Honeywell • IBM • Lockheed

David E. Anderson 4/17/91-000-6 AB Presentation

LTV AEROBRAKE MOCKUP

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A mockup aerobrake for a Lunar Transfer Vehicle would incorporate several improvements over the initial Mars aerobrake mockup, such as better latch placement and interfaces and a higher fidelity truss structure. It would also be capable of integration with modules that would represent the other components of the LTV.

Because the LTV mockup is small enough to fit in the UWTF, it would be possible to study a larger number of on-orbit assembly and servicing issues. Such research could take place in an evolutionary fashion.

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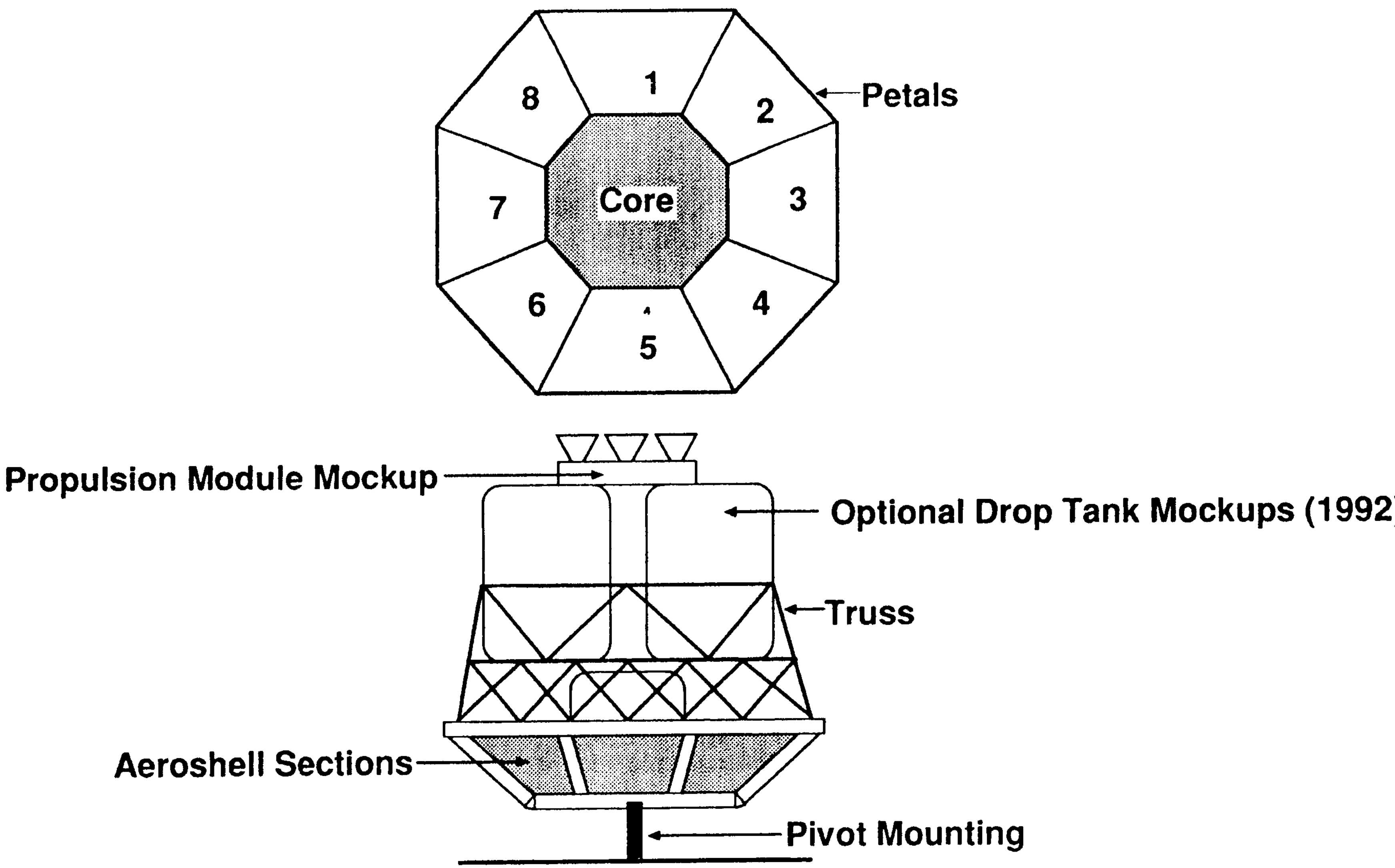
THE NEXT AEROBRAKE MOCKUP WILL GIVE US THE ABILITY TO ASSESS DESIGN AND ASSEMBLY ISSUES ASSOCIATED WITH AN ENTIRE LTV

131.3 12-401



PSR ASSEMBLY

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NASA is developing the technology to construct the Precision Segmented Reflector, which would follow the Great Observatory series of orbiting astronomical platforms. The truss structure will share assembly issues common to aerobrakes and other large space structures.

This test will utilize a Langley mockup for initial neutral buoyancy simulations in the UWTF this fall.

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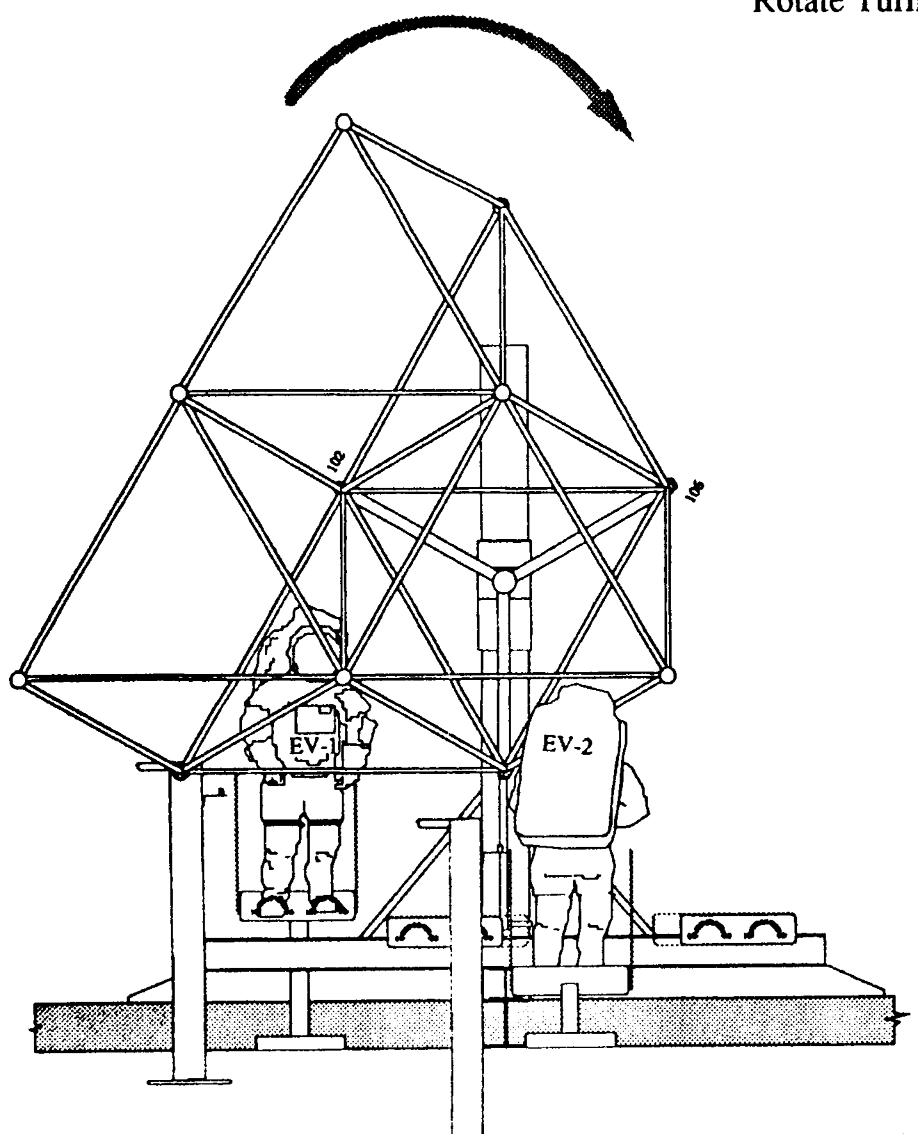
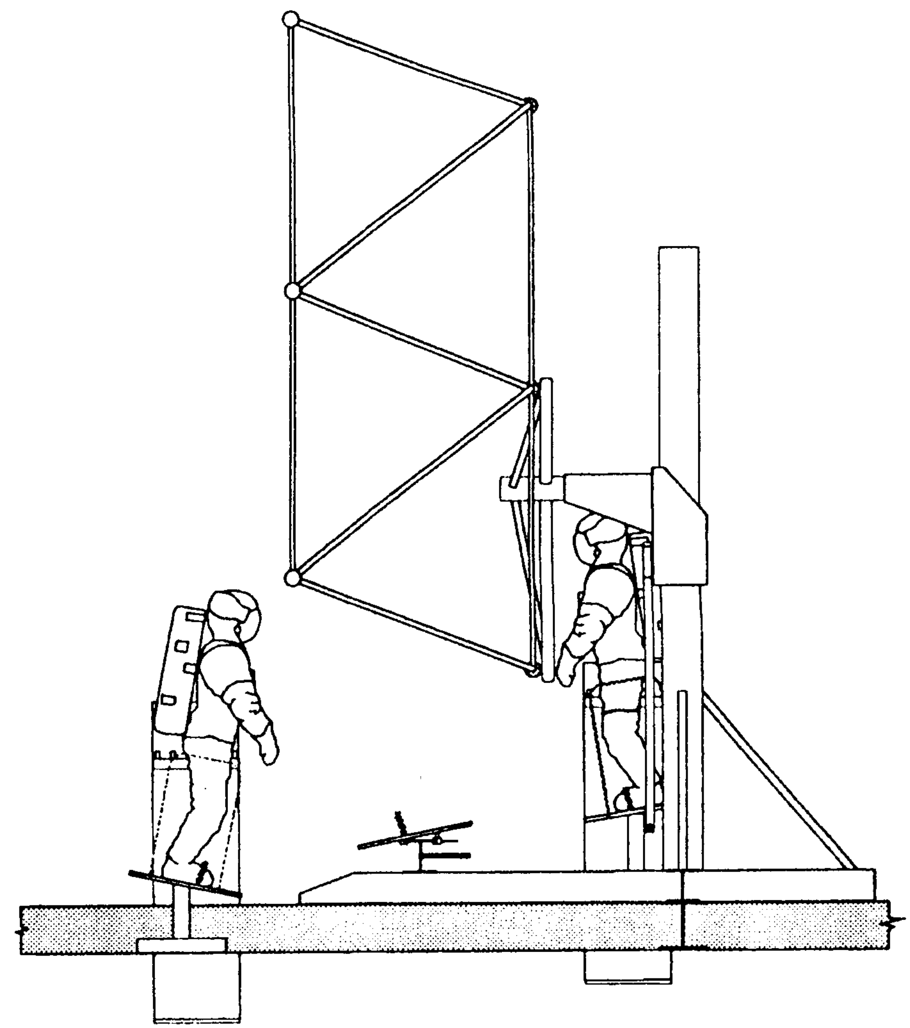
Rotate Turnstile -30°

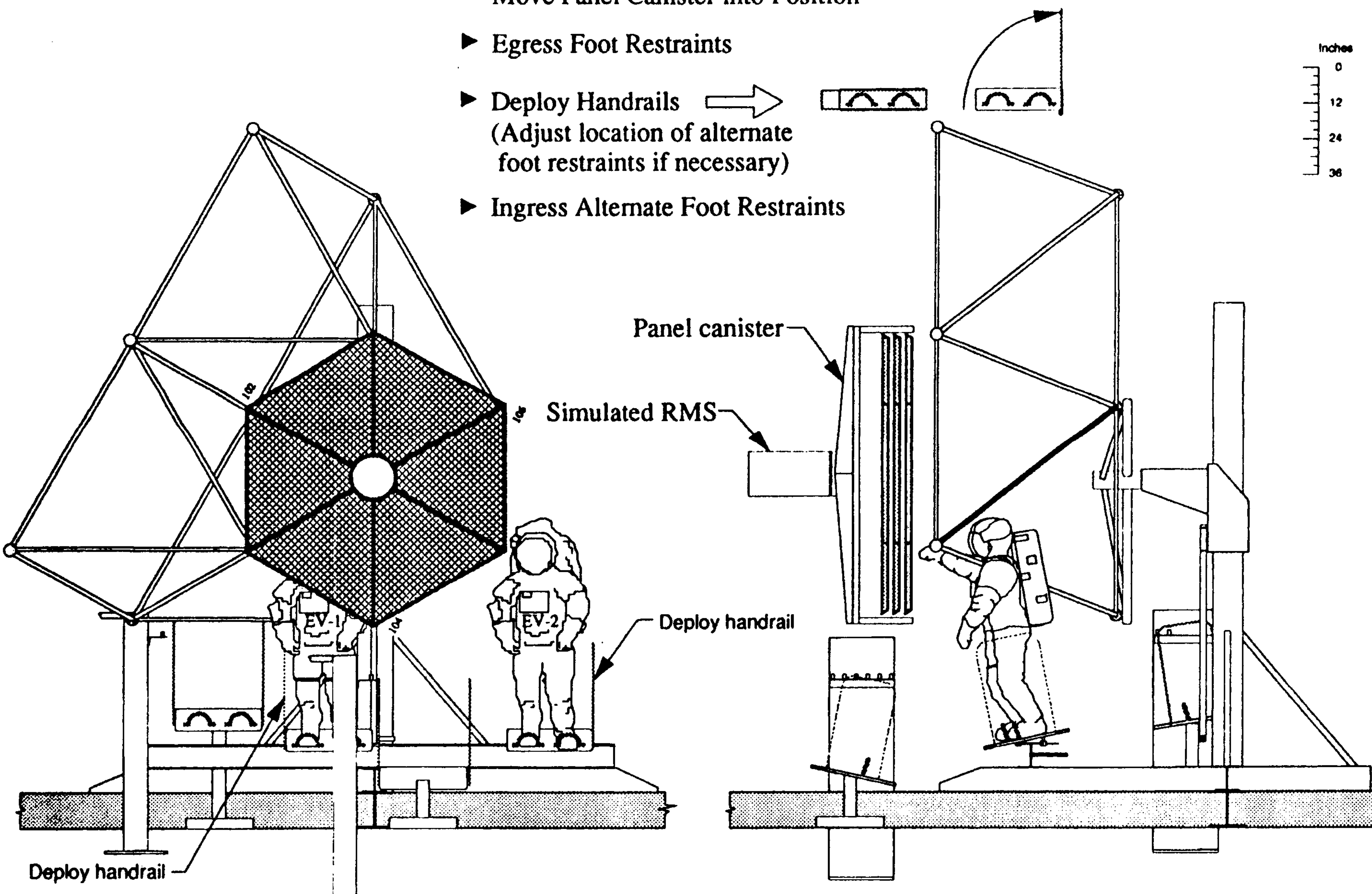




ELAPSED TIME
00:29:40

NASA-Langley

- Move Panel Canister into Position
- Egress Foot Restraints
- Deploy Handrails (Adjust location of alternate foot restraints if necessary)
- Ingress Alternate Foot Restraints



ELAPSED TIME
00:33:40

UWTF Ass'y Proc

NASA-Langley

SUMMARY

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This initial aerobrake assembly demonstration indicates that such an operation could be feasible.

No "show-stoppers" were identified, but much more work is still needed on the supporting truss structure, TPS close-out panels, and associated role of SSF support facilities.

Automation and robotics can play important roles in soft-docking, latch alignment and closing, and astronaut translation.

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