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## STUDY OF ORBITAL MAINTENANCE CONCEPTS

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### ABSTRACT

An approach to orbital maintenance is examined, using a maintenance element with the capability of providing a pressurized environment for personnel to perform maintenance functions unhampered by pressure suits. Design of an ideal element is reviewed incorporating limited habitability, electronic and pneumatic bench maintenance capability, critical spares storage racks and bins, manipulators to assist in EVA, and a maintenance/repair area. The element may be utilized for extended periods of orbital maintenance for providing maintenance services to other orbiting vehicles.

### INTRODUCTION

With the number of space orbiting vehicles that will be employed in the latter part of this century, a requirement becomes evident for a method of performing maintenance in space. Many concepts will be studied during this time period, and the one area that tends to lend itself to the requirement is an orbital maintenance element. My technical briefing, therefore, is based on this concept.

### MAINTENANCE AND REPAIR ELEMENTS

#### Prime Requirements

- Perform scheduled maintenance on orbiting systems in space
- Perform emergency repair in space
- Provide a hangar for maintenance and repair
- Provide satellite maintenance, modifications and repair
- Provide payload repair capability

#### Requirements

##### Problems:

- Long term mission requirements
- Establishes need for scheduled maintenance and repair
  - . Avionics
  - . Servicing
  - . On-Board Checkout System (OBCO)

Present designs dictate only maintenance and repair capability by EVA

No maintenance access available under current designs

Various orbiting systems do not have resupply capability

##### Solutions:

Provide an element compatible with the various orbiting systems. This element would include an inflatable boot to provide a seal between the element and the outside diameter of the orbiting systems. Capability would also be provided to mate with the docking ports of these systems.

Design interior for limited habitability, resupply, and maintenance and repair

Provide the maintenance element with neuter docking latching so as to provide a spacer for docking to allow fueling and maintenance activities simultaneously

## Maintenance Element Concept

### Elements for Consideration:

1. Maintenance element - manned version
2. Manipulator available to work as part of or remote for removal and replacement
3. Maintenance element placed in earth orbit via current boosters or space shuttle
4. Element satisfies mating and sealing requirements for shirtsleeve crew environment
5. Utilizes current tooling and design capabilities
6. Maintenance element has neuter docking capability to act as link
7. Maintenance element can be utilized for extended periods of maintenance
8. Maintenance on a call basis only
9. Crew supplied via shuttle service
10. Maintenance element and shuttle crew same personnel - cross trained
11. Off-time maintenance element availability could lend concept for support of other vehicles such as Tug, Orbital Propellant Station, Space Station, etc.
12. Lower cost
13. Could be sectionalized for launch in increments, as required
14. Three or four-man crew when maintenance element is utilized on extended maintenance schedule

### Orbital Maintenance Element Concept

The approach for accomplishing maintenance functions can range from utilization of EOS delivered EVA crew to elaborate space hangars. These extremes are too hazardous or too costly in concept postulation for performing space maintenance operations. Use of a maintenance element, with the capability of providing a suitable environment for personnel performing maintenance operations not hampered by pressure suits and reducing to a minimum or eliminating the need for EVA, is considered the most desirable means of accomplishing the maintenance function.

One concept evaluated considered the use of a maintenance element whose geometry would match the capacity of the EOS cargo bay (15 feet in diameter x 60 feet long).

A 33-foot diameter maintenance element, although not compatible with an EOS launch, can be launched with the RNS tank on an INT-21. Design of the maintenance element could provide for future growth through modular expansion. Provisions can be made for the maintenance element to service other program elements such as the space station or the propellant depots presently being postulated. At present, no maintenance operations are anticipated in lunar orbit. Should the need arise, the maintenance element could be transported to lunar orbit.

A maintenance concept which utilizes the capability and flexibility of man in those areas where radiation is not a hazard, and remote manipulators in areas where hazards to humans cannot be avoided, will provide for a reasonable man-machine relationship. Extensive manipulator development costs could be avoided in those areas where man can function efficiently and safely.

### Space Systems

#### Problems

Scheduled and unscheduled maintenance requirements exist with no means of accomplishment at present

Modifications to present and future hardware exist so mission objectives and state-of-the-art can be maintained

#### Solutions

Design a maintenance and repair element capsule for limited habitability

Design to accept end items in a pressurized area for maintenance, repair and modification activity

### CONCLUSIONS

This concept appears feasible, however, continued studies should be made to assure that adequate maintenance in space capability is provided.