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SATELLITE SERVICES OVERVIEW

HUMAN ROLE IN SPACE WORKSHOP
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INTRODUCTION

The Space Transportation System (STS) is a developing national resource that will open a new era of space exploration, utilization and research. In view of the world's growing dependence on the use of space, particularly the use of satellites for communications, monitoring weather and earth resources, navigation, surveillance and astronomy, plans are being made to dedicate a substantial portion of future STS activity to deployment, service, and retrieval of earth orbiting satellites.

SATELLITE SERVICE

Satellite service is a generic term for STS orbital operations associated with satellite payloads. Satellite operations can be partitioned into three categories of orbital work activity:

Deployment - Operations involving delivery of Shuttle Orbiter satellite payloads to earth orbit, including reboost of satellites back to prescribed operational orbits.

Service - Operations associated with resupply, refurbishment, and repair of satellites. Examples include inspection, photography, film or module replacement, fluids replenishment, and antenna replacement.

Retrieval - Operations associated with returning free-flying space objects to the Shuttle Orbiter, stabilization of spinning or tumbling space objects, and satellite-to-Orbiter docking.

In the past satellites were not designed for orbital service because in-flight satellite servicing had not been available. Satellite system design philosophy to date has been to dictate stringent requirements for high reliability to satisfy mission life requirements. Already, the Space Telescope, Solar Max Mission, Long Duration Exposure Facility, Advanced X-Ray Astrophysics Facility and Space Platform, representing next-generation satellites, are designed for orbital service. With future development of reusable Space-Tugs and Teleoperators for transferring satellites between Low Earth Orbit (LEO) and Geosynchronous Orbit (GEO) virtually all earth orbiting satellites will become candidates for LEO service.

Satellite payload activation and servicing may be carried out by any combination of three operational modes:

Automation - This mode of operations requires that the vehicle or payload conduct operations automatically. This is the most common for satellite deployment and has been the form of all satellite on-orbit activity to date. This mode requires redundancy of actuators, components and subsystems so that any single failure will not incapacitate a satellite or the Shuttle Orbiter and jeopardize mission success.

EVA - Describes activities performed by the crewmember outside the pressurized spacecraft environment. There are three basic classes of EVA:

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- Scheduled EVA - tasks included in the planned mission time line scheduled to support Shuttle or payload operations.

- Unscheduled EVA - an EVA task not included in scheduled mission activities, but which may be required to achieve payload operation success or to enhance overall mission success.

- Contingency - EVA required to effect the safe return of crewmembers.

<u>RMS, Teleoperators, Robotics</u> - Conduct tasks in which man directed artificial intelligence mechanisms approach a payload, dock to it, conducts remote from the Orbiter a preprogrammed set of tasks or returns the payload to the Orbiter for earth return or refurbishment.

In performing satellite servicing via the aforementioned methods, the mission planner is provided substantial flexibility in realizing benefits afforded by satellite servicing. These benefits impact all areas of program management, from financial (cost) to operations (extended mission life). To exploit satellite servicing capability fully, service provision should be designed into the satellite. Projected satellite serviceability design considerations are summarized in Table I.

- MECHANICAL LOADS
- SAFE SURFACES AND EDGES
- ACCESSIBLE MAINTENANCE AREAS
- REPLACEABLE SUBSYSTEM MODULES
  - PAYLOAD INSTRUMENTATION
  - ATTITUDE CONTROL AND PROPULSION
  - POWER
  - DATA PROCESSING AND TELEMETRY
- FLUID SUBSYSTEMS
  - REFUELING
  - SAFETY VENTING
  - FAIL-SAFE PRESSURE VESSELS
- DIAGNOSIS AND CHECKOUT CAPABILITY
- STANDARD INTERFACES
  - SAFETY INTERLOCKS
  - DIAGNOSTIC AND CHECKOUT CONNECTOR
  - DISCONNECTS, FITTINGS AND FASTENERS
  - REMOTE MANIPULATOR
  - CREWMEMBER RESTRAINTS AND HANDHOLDS

TABLE I. DESIGN CONSIDERATIONS FOR SATELLITE SERVICEABILITY

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Proper inclusion of satellite service features are necessary for on-orbit maintenance time optimization. Table II lists projected service tasks for satellite subsystems and major components that appear practical to perform on-orbit.

- INSPECTION, PHOTOGRAPHY, AND POSSIBLE MANUAL OVERRIDE OF PAYLOAD SYSTEMS AND MECHANISMS
- INSTALLATION, REMOVAL, AND TRANSFER OF FILM CASSETTES, MATERIAL SAMPLES, PROTECTIVE COVERS, AND INSTRUMENTATION
- OPERATION OF EQUIPMENT, INCLUDING STANDARD OR SPECIAL TOOLS, CAMERAS, AND CLEANING DEVICES
- CLEANING OF OPTICAL SURFACES
- CONNECTION, DISCONNECTION, AND STOWAGE OF FLUID AND ELECTRICAL UMBILICALS WHEN SAFED
- REPLACEMENT AND INSPECTION OF MODULAR EQUIPMENT AND INSTRUMENTATION ON THE PAYLOAD OR SPACECRAFT
- REMEDIAL REPAIR AND REPOSITIONING OF ANTENNAS AND SOLAR ARRAYS
- ACTIVATING/DEACTIVATING OR CONDUCTING EXTRAVEHICULAR EXPERIMENTS
- PROVIDING MOBILITY OUTSIDE THE CARGO BAY AND IN THE VICINITY OF THE ORBITER USING MANNED MANEUVERING UNITS (MMU'S)
- MECHANICAL EXTENSION/RETRACTION/JETTISON OF EXPERIMENT BOOMS
- REMOVAL/REINSTALLATION OF CONTAMINATION COVERS OR LAUNCH TIEDOWNS
- TRANSFER OF CARGO
- LARGE SPACE STATION CONSTRUCTION
- ON-ORBIT SATELLITE SERVICING

TABLE II. SERVICE TASKS

STS provides a baseline capability for performing a range of satellite servicing tasks. Baseline equipment includes the Shuttle Orbiter, Remote Manipulator System (RMS), Extravehicular Mobility Unit (EMU), Manned Maneuvering Unit (MMU), and an assortment of hand tools, foot restraints, handholds and storage capability for supporting satellite deployment, service and retrieval operations.

Deployment

Normal deployment of Shuttle Orbiter satellite payloads is expected to be automated, with crew activities conducted from the Orbiter cabin. The satellite to be deployed would first be elevated in the Orbiter payload bay by either a flight support platform or the Remote Manipulator System (RMS). Satellite antennas and solar panels would then be deployed by remote control actuators. Satellite systems would be checked out prior to satellite release from the flight support platform, with release effected by a spring actuator mechanism or using the RMS. Platforms could be designed to impart spin to spin-stabilized satellites. Following release, thruster activation would propel the satellite to the prescribed operational orbit.

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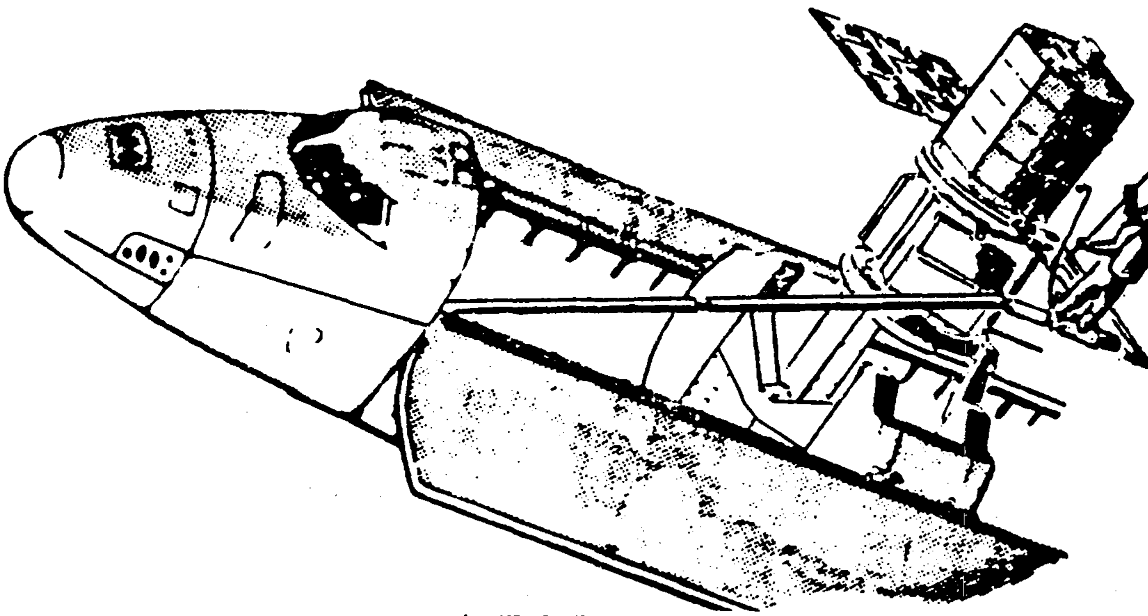
Contingencies could alter the normal deployment sequence. For example, a satellite solar panel could fail to self-deploy requiring use of the RMS or EVA as contingency backup for panel release. EVA might be required for inspection, evaluation of anomalies, and repair activities prior to or following release of the satellites. Figure 1 depicts an EVA astronaut engaged in a deployment contingency operation. The astronaut is restrained by a foot restraint platform attached to the RMS. An Open Cherry Picker (OCP) (a portable work station which can be attached to the RMS) is being considered as a near term capability improvement for STS. The EVA astronaut shown is equipped with the Shuttle Extravehicular Mobility Unit (EMU) which provides environmental protection and life support.



PAYLOAD DAMAGE-CONTINGENCY

FIGURE 1. CONTINGENCY DEPLOYMENT

Service

Shuttle/Spacelab missions will fly with a baseline EVA capability supported by the Manned Maneuvering Unit (MMU). Figure 2 depicts an EMU-MMU equipped astronaut. The current MMU design uses a nitrogen cold gas which provides astronaut propulsion. The EMU equipped crewmember dons the MMU by backing into its latching mechanisms. The MMU will not be required if EVA is limited to the payload bay. In addition to the MMU, the EVA crewmember will have portable foot restraints, tools, and work aids to use to support satellite service tasks. These tasks range from payload inspections to module changeouts.

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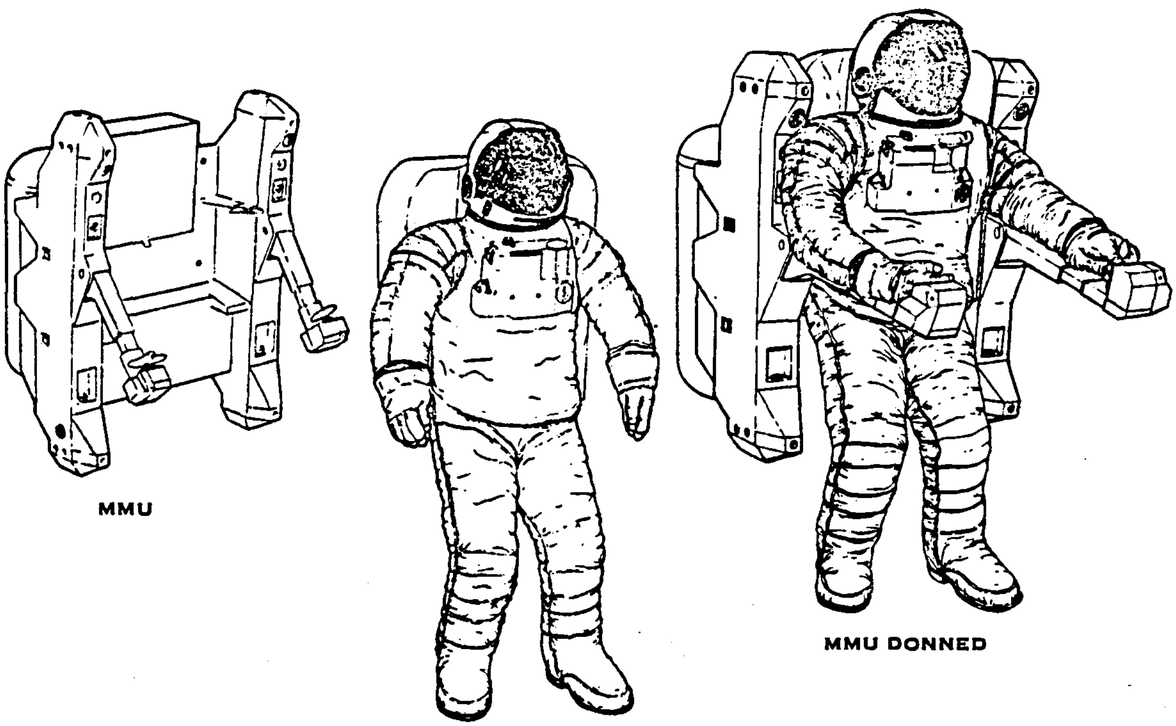

FIGURE 2. SPACE SHUTTLE MANNED MANEUVERING UNIT (MMU)

Retrieval

Present retrieval planning calls for berthing satellites to the support platform in the Orbiter payload bay using the RMS. Extensions of this technique under study include use of orbital transfer vehicles (access to GEO) and use of EVA for satellite guidance. In all retrieval techniques, chief among concerns are:

- Satellite/Orbiter/RMS approach and docking
- Orbiter thruster induced satellite translation
- Satellite dynamics and capture
- Satellite-Orbiter relative motion
- Mission time and propellant required
- Safety

SUMMARY

One of the objectives set forth for the Space Transportation System is the increased utilization of man in space. Projected manned activity encompasses such on-orbit operations as satellite deployment, service, and retrieval;

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space construction; and Shuttle Orbiter repair. The effectiveness with which each of these operations is conducted will depend to a large extent on implementation of service design features in component, systems and operations.

The range of potential satellite servicing tasks and techniques available provides substantial flexibility to payload design and mission planning. Satellite servicing benefits include extended mission life and overall program cost savings.

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