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SUPPORT AND SERVICING REQUIREMENTS FOR LARGE OBSERVATORIES IN SPACE

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Abstract

The concept of lunar optical and IR observatories is a natural step in the total utilization of the space environent for the benefit of science. Among the challenges associated with this remote observatory concept is the requirement for the support and servicing of the facility.

This presentation will draw on the experience of the Hubble Space Telescope (HST) program on-orbit maintenance design requirements plus the Lockheed on-orbit servicing and assembly activity to develop requirements for the maintenance and construction of a lunar observatory.

Introduction

Often when an important space science program is initiated, the focus of that program is limited to the resolution of the hardware and technology issues of that program alone. What is often missing is an understanding of the relationship of that program to an operational infrastructure. This operational infrastructure includes the launch systems, ground facilities, space operations nodes, and mission control systems, ground facilities, space operations nodes, and mission control systems (figure 1).

The growing cost of program development is starting a trend toward long-term operation of space assets. Now these assets are faced with support and servicing issues associated with these extended life goals.

The lunar basing of large observatories introduces unique requiements which must be addressed early in the sytem concept development and design. This paper will address lunar base support and servicing issues and design requirements and concepts, and recommend areas for near- and far-term action.

Lunar Base Support and Servicing Issues

The concept of lunar basing of assets is faced with some basic issues that affect the design requirements. These issues include human presence requirements; access limitations; site selection and preparation; facility verification requirements; site assembly; basic facility requirements; and precision scheduling.

The human element added to any remote facility requires that the design support humans as well as the experiment. This extends from the construction phase where tools and support equipment is impacted to the operations phase where on-site science evaluations must be traded with remote and delayed observations.

Relying on automation and robotics must be considegfred as an option. Keeping the sytems simple and reliable (i.e., limiting the machine degrees of freedom) is a goal that can only be reached by integrating the design and opertional phases. It has been determined that designing for automated operation simplifies the task for human operation whereas the opposite is not necessarily true.

Access to the facility affects the system reliability design requirements. Serviceable space systems do not relax the reliability requirements or the redundancy in design because the supporting infrastructure cannot guarantee rapid response to a failure. In the case of a remote facility the storage of spares and test and verification equipment onsite impacts the facility size and operations.

The site selection and preparation has some design challenges. The construction of the facility must evaluate the utilization of natural resources to minimize the transportation of materials to the site. Selecting a site that is eary to prepare, contains useful construction materials, and meets the science requirements may require an extensive lunar survey.

Simplifying hardware integration is a goal of any large program. For a space-based facility this may mean preflight assembly and checkout; disassembly for launch; and reassembly and verification on site. These considerations should include evaluation of the impacts system partitioning and modularity present to the basic design. There is also a tradeoff of built-in test requirements versus using support equipment for test and verification.

Construction sites are easily cluttered with packaging materials and equipment used in a particular phase of assembly. Time spent in handling these materials is time lost in actual assembly. Minimizing the tools, hardware, equipment, and time necessary for remote site assembly is important to reducing these logistics support requirements.

Lunar observatory facility requirements are not unlike Earth-based requirements. Cleanliness, reliable power, system alignment, enviornmental protection, and operations are all basic requirements. The biggest challenge will be in the protection of the environment. The lack of atmosphere, necessary for undistorted celestial observation, is a primary attraction of the lunar facility concept. The design must assure that this is not impacted by the construction and operation of the facility. Conversely, the facility must consider the hardening requirements for protection from radiation and potential physical impact of meteors.

Consider the impact of the loss of a facility element during the construction phase. The facility must survive while this element is replaced. Precision scheduling will assure that alternate assembly paths are available to minimize the schedule impacts.

Support and Servicing Design Requirements

Traditionally, space programs reflect a point design. This point design is governed by schedule and technology risks associated with accomplishing a mission in a cost-effective manner but on a mission-by-mission basis. Incorporating support and servicing requirements into any system greatly increases the flexibility of that system to respond to technology enhancements and to accomodate additional science requirements. The HST, for example, is launched with science instruments designed to meet the basic mission requirements. This program has addressed the potential for science changes by incorporating features in the design to accomodate an IR instrument in place of an existing optical instrument.

Another plus to this approach is that the system is no longer constrained by hardware availability. Replacements can be accomplished at various levels of hardware integration (i.e., system, subsystem, box, board, component) depending on where the interface is controlled.

A system with a long operational life will have periodic maintenance requirements. These may include the replenishment of consumables, like purging gases and cryogens, or the replacement of items that have limited life, like bearings and batteries. A servicing design can increase facility availability by responding to problems that would require an operational workaround, reduction in mission capability, or a total system loss.

Design considerations for support and servicing of assets in space require a change to basic design habits. Space systems are often designed for the operational mission alone. This leads to operations panics when a system is sensed to have failed or degraded to a questionable operational level. A servicing design must look at subsystem partitioning on the basis of potential replacement. This may include packaging of low-reliability equipment into easily accessible packages or separating redundancy into separate boxes. The goal is to eliminate the impact of the system loss until an exchange can be accomplished.

The power bus designs must allow for localized power shutoff and potential power changes (i.e., increases or reductions). Data system bus designs must be compatible with system upgrades that might impact data rate increases or changes in system languages.

The systems will require more built-in test equipment and sensing. This equipment will focus on the failure data to assure the trend is not carried in the replacement unit and to minimize the integration time.

In each of these cases modularity and standardization will play a significant role in reducing requirements spares, interface control, and training. This is of particular interest to the science instruments where alignment repeatability may dictate a maximum of +/- 0.076mm (+/- 0.003 in) position shift in every axis. This type of alignment repeatability is achievable in current orbital replacement unit (ORU) designs. Keeping the interfaces simple and standardized will greatly reduce the requirement for support equipment: tools, assembly fixtures, and test equipment. An example of the type of interfaces is shown in figure 2. Here a concept ORU is designed as a module with a single mechanical attachment interface. The design provides for module alignment and ganged connector installation. The simplicity of the interface allows for both robotic and manned installation using an adaptable power tool. Hardware concepts of this type were developed and tested as part of the Space Assembly, Maintenance, Servicing (SAMS) study completed by Lockheed in August 1987.

Conclusions and Recommendations

Current space asset supportability and servicing concepts have direct applicability to the concepts of lunar observatories. It is essential that these servicing concepts be incorporated into the early design concepts to minimize future impacts.

It is highly recommended that the supporters of lunar observatories participate in existing and future servicing workshops and studies.

Reference

1. Styczynski, T., no date available. Space Assembly, Maintenance and Servicing Study: Design Concept Handbook. Lockheed Missiles and Space Company, Sunnyvale, CA.