N95- 17225

110810

346-66
31782
p- 8

MISSION OPERATIONS MANAGEMENT

David A. Rocco
Loral AeroSys
7375 Executive Place
Seabrook, MD. 20706

ABSTRACT

Redefining the approach and philosophy that operations management uses to define, develop, and implement space missions will be a central element in achieving high efficiency mission operations for the future. The goal of a cost effective space operations program cannot be realized if the attitudes and methodologies we currently employ to plan, develop, and manage space missions do not change. A management philosophy that is in synch with the environment in terms of budget, technology, and science objectives must be developed. Changing our basic perception of mission operations will require a shift in the way we view the mission. This requires a transition from current practices of viewing the mission as a unique end product, to a "mission development concept" built on the visualization of the end-to-end mission. To achieve this change we must define realistic mission success criteria and develop pragmatic approaches to achieve our goals. Custom mission development for all but the largest and most unique programs is not practical in the current budget environment, and we simply do not have the resources to implement all of our planned science programs. We need to shift our management focus to allow us the opportunity make use of methodologies and approaches which are based on common building blocks that can be utilized in the space, ground, and mission unique segments of all missions.

INTRODUCTION

Over the last several decades the space program has moved from an unbroken series of spectacular successes to a disquieting number of stunning failures. These failures have affected all participants in the space community: DoD, NASA, NOAA, and the commercial sector. On the surface there appears to be no common thread: booster failures; kick motor failures; unsuccessful shroud separations; component level failures; or operator error at the command console.

We seem to be back on the road to success. The Hubble Servicing Mission and GOES 8 launch have broken the streak of recent failures, but have we really solved the underlying problems that have been causing our recent failures?

The space community, like government and industry in general, has become a victim to a system of management that has become mired in bureaucracy and inefficiency.

TOTAL MISSION MANAGEMENT

The first, and possibly most important, step in redefining mission management, is the development of an integrated management approach. In our current organizational environment there are simply too many levels of management, too many discrete organizations, and a diluted system of responsibility, authority, and accountability.

This type of organizational structure fosters inefficiency, duplication of effort, convoluted lines of communications, and in the final stages of a mission, cost and schedule overruns or total mission failures.

Placing a satellite into orbit and conducting mission operations is an immensely complex task in its own right. Adding in additional levels of confusion and complexity that are a function of over management just makes a difficult task harder to accomplish and adds unnecessary risk to the program.

A typical DoD or NASA mission possesses three major management tiers:

1. Program Management
2. Project Management
3. Mission Management

Below these major tiers are the subsystem level management groups that oversee the design and implementation of mission components and functionality. This multi-tiered approach lends itself to inefficiency, redundancy, and duplication of effort. Each lower tier of management is larger than its preceding tier and adds to the bureaucracy, extends lines of communication, and dilutes authority.

The only way to eliminate this problem is to redefine the management organization. While the three levels must continue to exist, the numbers of personnel and the functions performed must change radically.

Program Management

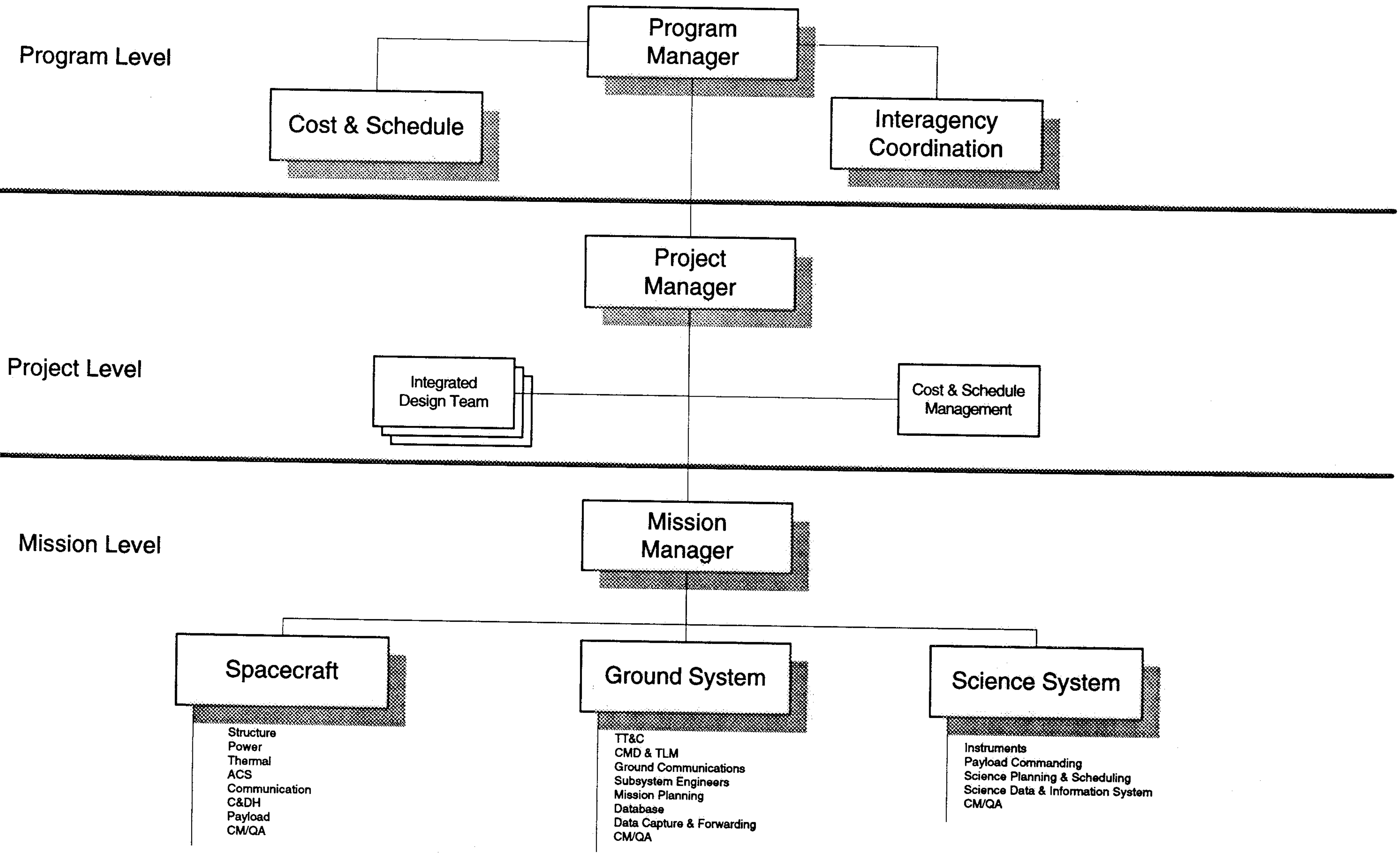
Program Management must continue to exist at the agency level. The Program Level is responsible for overall budget, schedule, and interagency coordination, but these must be the *only* functions that Program Level management performs. Micro managing the spacecraft, ground segment, or science compliment should not be the concern of this level of management.

Project Management

Project Management should continue to exist at the implementing center, but the focus of Project Management should change drastically. Project Management should shift its level of activity from overseeing the overseer of implementation to serving as the spearhead for planning mission operations. This planning should be performed with a core team of representatives from the space, ground, and science communities from the very beginning of the mission planning process.

With the major mission segments participating in an integrated initial mission planning process directed by the Project Manager, problems that are normally identified late in the implementation phase can be rectified or even avoided early in the mission development process.

Mission design should be the operational focus of Project Management, with cost and schedule management as a secondary responsibility. An organization tasked with this responsibility would significantly shrink the personnel requirements of the Project Level. The mission design itself should be driven by what is most practical in terms of meeting the science mission objectives and allow the scientific and ground system considerations to drive the design of spacecraft subsystems as opposed to our current method of building the mission around the platform. Figure 1 depicts the proposed organization structure.



Mission Management Organization

July 14, 1994

Most missions that actually achieve orbit and successfully complete the early orbit checkout phase tend to outlive their effective design lives by several hundred percent. This stretching of the on-orbit operations phase of the system lifecycle tends to make Operations & Maintenance (O&M) one of the most expensive elements of the mission. For example, on the Hubble Space Telescope, the cost to place the spacecraft into orbit with its supporting ground system was approximately $ 2.1 billion. The O&M budget estimated in 1990 was $ 200 million per year. With a fifteen year on orbit life, the cost of O&M will exceed the cost to launch by 50%.

Other missions which have exceeded their planned lifetime such as NIMBUS-7, ICE, IUE, ERBS, IMP, Solar Max, and Landsat 4 & 5 have exceeded this O&M cost factor by several hundred percent as depicted in Figure 2.

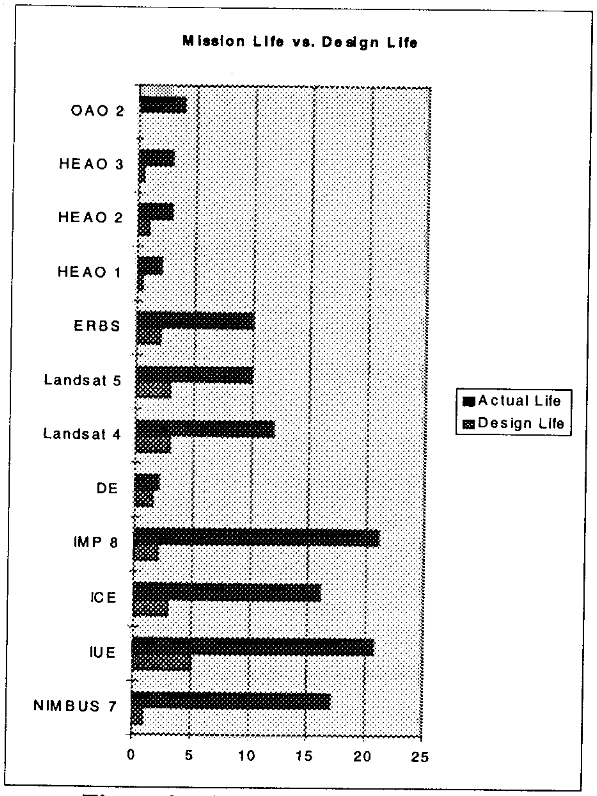


Figure 2 Mission Life vs. Design Life

By allowing the science and ground system elements to drive the design of the spacecraft, and by updating the technology that is used to control the spacecraft and process the mission data, significant reductions in O&M costs can be realized. The fact that these savings can be real and significant over time are borne out by the high level of interest in low cost mission operations concepts such as JPL's LOCOMO and GSFC's Renaissance programs.

This macro level of mission design and sustaining support is where the Project Level should concentrate its efforts.

Mission Management

Mission Management which currently lives as a small component of the Project Level, and the major component of the on-orbit level of management should shift its focus from a mostly on-orbit organization to the management of the mission implementation as well as conducting day-to-day mission operations.

By placing responsibility and authority for the implementation into the hands of the organization which must live with the results of the final system, two key outcomes will materialize:

1. A system development monitored and managed by the actual users will result in a system that is designed with operations in mind.

2. The operations managers become a true stakeholder in the total mission system and an organization that can blame no one but themselves for a poor or overly complicated system.

METHODOLOGY

With an organizational structure in place which has the authority and accountability to make major design decisions, the primary methods required to create a successful design are:

1. A systems approach to the mission.
2. An understanding of what technology is available that can support a low cost mission design.
3. A clear vision (operations concept) of how the mission will be conducted.

Systems Approach

Under a systems approach, the mission is viewed as a total system that consists of five major components:

1. A science objective.
2. A management approach.
3. A spacecraft and instrument suite.
4. A ground support system.
5. A mission operations plan.

These components exist as individual threads which are intertwined to form a common cord of mission design. As a system, any changes to any given thread will have some impact on the overall mission design. As a system these threads must function in concert to achieve the end goal of a space mission that meets its scientific objectives for a reasonable cost.

Technology

When a clear vision of what the mission is intended to look like is developed, the integrated design team must evaluate the available technology and determine what components or approaches will best meet the requirements for the total mission. From a technology standpoint the following questions must be answered:

1. How can technology be used to lower mission risk while reducing overall costs?
2. Where will technology take us in terms of spacecraft, ground systems, and support infrastructure?
3. How can operations concept developers use evolving technology to lower O&M costs?
4. How can we plan and design for tomorrow's missions when the state-of-the-art is advancing so rapidly?

The intelligent use of technology has to be an integral element of operations management's philosophy. We are beginning to see this happen as concepts from Total Quality Management (TQM) move from a buzz word phase into actual implementation. Integrated product teams are becoming more common, and in some agencies are officially tasked to develop designs driven by a low risk and low cost operations model.

Technology is also important in terms of consolidating operations to achieve budget goals. The USAF and NOAA are currently heavily involved in planning for a converged polar meteorological program where a single spacecraft type and single ground control element operate a mission to serve both civil and military users.

Spacecraft Trends

The spacecraft itself can become a major means of reducing both cost and risk to the total mission design. New generation On-Board Computers (OBCs) are capable of providing 256K of memory, coupled with micro-processor controlled instrument and spacecraft subsystems, a capability exists to build very high levels of autonomy into the spacecraft itself. The addition of products into the spacecraft such as Global Positioning Satellite (GPS) receivers can provide a spacecraft capable of generating its own on-board ephemeris, performing fine attitude determination (2 receiver/4 antenna configuration), and configuring itself for ground contacts. All of this can be done now, with greater accuracy than is currently provided by ground or TDRSS based tracking. It can also be done at a fraction of the staffing levels we currently need to perform these services on the ground.

The questions that need to be asked at the design phase are:

1. Is this capability required for this mission?
2. Will this capability save me money and reduce risk over the total lifecycle of the mission?

If the answers to either of these questions are yes then a cost/benefits analysis must be conducted to determine:

1. If these capabilities are needed to ensure mission success and reducing risk.
2. How much money can be saved during on-orbit operations by spending a more on the spacecraft.

This may make life more complicated for the spacecraft designer, but the spacecraft designer is only one player in the mission systems.

Ground Systems

Ground system design and capabilities have matured at the greatest rate because the ground system is not constrained by the environmental requirements the spacecraft must withstand. Ground system technology is also directly tied to computer hardware, software, and networking technology, and we have the ability to access the ground system on a daily basis. Although the potential capability in this area has improved significantly, the implementation of this technology has lagged.

The centralized ground system support architecture was designed and implemented in the 70's using a mainframe based approach. This approach made sense because an economy of scale could be achieved when many missions shared a common service. However, advances in ground system technology have made the cost savings of the 70's a cost sink in the 90's.

Existing Commercial-Off-The-Shelf (COTS) hardware and software have the ability to reduce or eliminate our reliance on large institutional support elements which have extensive O&M requirements. Advances in ground system telemetry front-end processors have reduced the workload now performed by Pacor to the level of a few programmable cards which perform all tasks from bit synch through Reed Solomon correction. A two GPS configuration on the spacecraft itself can reduce support requirements from the Flight Dynamics Facility (FDF) from daily staffing to launch and accent support only.

In the final analysis the ground system can be reduced to four major components:

1. A tracking facility.
2. A communications segment.
3. A control center.
4. A science operations center.

This approach provides a control center capable of directly providing Level 0 data and telemetry directly to a science operations center. The key infrastructure support element in this scenario is a reliable communications infrastructure.

Science Operations Centers (SOC)

The availability of inexpensive multi-processor workstation technology has an unlimited capability to reduce the costs associated with science data processing and product generation in terms of both the computer resources required to perform the tasks, and the science operations staffing levels needed to control and monitor the product generation process.

With science data and supporting telemetry being provided directly to the SOC by the flight control center, a multiprocessor product generation environment can allow science product operations to be reduced to a single shift activity, and at the same time minimize the physical facilities and personnel requirements in the SOC.

Operations Concepts

The final element in redefining operations management is the development of mission operations concepts that will allow automation and smart technology to provide the majority of the "cradle-to-grave" monitoring and support tasks for on-orbit missions. How this task is handled can have a considerable impact in reducing O&M costs. These tasks are now performed by implementing round the clock staffing. To cover a nominal mission day, a staffing factor of 4.0 persons per position is required to provide the *minimum* level of staffing needed to provide real-time spacecraft services. In the typical control center this factor is applied to the Shift Supervisor, Command Controller, Ground Controller, and Payload Evaluator.

Using approaches such as compressed health and safety telemetry schemas, on-board ground contact configuration capability, and exception reporting, can significantly contribute to reduced (50-66%) control center staffing requirements.

The same types of multiprocessor technology recommended for use in the SOC combined with COTS statistical analysis software can be employed in the area of spacecraft subsystem analysis. Traditionally this function is performed using custom developed software, and resides on either a dedicated machine, or is resident within the command and telemetry processing system.

This newer technology approach provides scalability and portability that does not currently exist in off-line ground systems tasks, and reduces the operational load on the real-time system. These off-line tasks; such as mission planning and scheduling, subsystem level telemetry analysis, and long term performance trending lend themselves to this type of solution because the are normally Monday through Friday day shift tasks which do not require sustained levels of time-critical performance.

This scalable approach also allows the addition of increased capability to be achieved by using board level components and cross compiling existing software as opposed to adding new workstations or personnel into the control center to meet new requirements. In its most advanced phase, this architecture can conceivably provide multiple satellite support from a single operations center.

CONCLUSION

We must begin to embrace the mission as a comprehensive system, not as a series of discreet components which are pulled together to and literally beaten into a configuration to perform a unified task.

With proper levels of planning and the support of high level agency management, a macro-level mission approach can be developed that will allow resources to be re-directed into new missions. As a result of organizational downsizing on a mission level project, we can minimize some of the confusion and develop clear lines of communication, authority, and responsibility.

In the final analysis people will always be the most expensive component of any mission. Any personnel resources that can be eliminated from a mission provide two benefits:

1. A real cost reduction for the current mission.
2. A resource which can be applied to a new mission which up to now have not been able to secure the resources required to move from the concept into the implementation phase.

REFERENCES

Barter, N. (1992) TRW Space Data, TRW Space & Technology Group, Redondo Beach, CA.

Davis, E. (1993) A New Paradigm for Very Low Cost Mission Operations, JPL, Pasadena, CA.

Larson, W. and Wertz, J. (1992) Space Mission Analysis and Design, Second Edition, Microcosim Inc., Torrence, CA.

Lillesand, T. and Kiefer, R., Remote Sensing and Image Interpretation, Second Edition, John Wiley and Sons, New York, NY.

NASA GSFC, (1994) Mission Requirements and Data Systems Support Forecast, Greenbelt, MD.

NASA GSFC, (1994) Renaissance, Greenbelt, MD.