Performance Measurement: A Tool for Program Control

by Nancy Abell

The NASA program and project managers of the 1990s will continue to work in the environment of constrained resources in terms of reduced budgets, limited staffing, and tight schedules. In a speech to the Explorers Club in January 1989, former NASA Administrator James Fletcher stated: "The funds being requested do not permit us the luxury of backups, of alternatives, of programmatic robustness. Virtually every element of the program is being pursued on a success schedule — and we know in advance that there will be unforeseen technical problems to solve and dilemmas to face which will require internal adjustments and constraints." In this environment there are focused efforts to improve program and project management. One potentially powerful tool available to the project manager which has been used successfully in many government agencies is performance measurement.

Performance measurement is a management tool for planning, monitoring, and controlling all aspects of program and project management — cost, schedule, and technical requirements. It is a means (concept and approach) to a desired end (effective program planning and control). To reach the desired end, however, performance measurement must be applied and used appropriately, with full knowledge and recognition of its power and of its limitations — what it can and cannot do for the project manager.

Performance measurement is not a new concept to the government or to the aerospace industry. It has its origins in the Department of Defense (DoD) programs of the 1960s. Interest and application of the performance measurement concept spread to other government agencies in the 1970s and 1980s. Today performance measurement is being applied to major programs of the DoD, National Security Agency, Department of Energy, Federal Aviation Administration, and NASA. Performance measurement is widely endorsed as a valid approach to controlling contract performance.

The Goddard Space Flight Center (GSFC) has been implementing performance measurement system (PMS) requirements since 1983 on major research and development (R&D) contracts with a price of $25 million or more and a period of performance longer than one year. GSFC's PMS policy was established by the Center director to provide for consistent application on all major Center acquisitions. Use of performance measurement is also encouraged on R&D contracts in the $10-25 million range, but applied on a case-by-case basis. GSFC currently has 12 contracts in various project phases that have PMS requirements. With the large number of major independent spacecraft and instrument development contracts at GSFC, such as the various meteorological spacecraft and instruments of the Geostationary Operational Environmental Satellite and Television and Infrared Observational Satellite programs, we have had the opportunity to continually improve our implementation of PMS through a "lessons learned" approach. Many project managers have had the opportunity to test the effectiveness of this management tool. At GSFC, some of the more effective PMS applications have been on the Gamma Ray Observatory and the Tracking

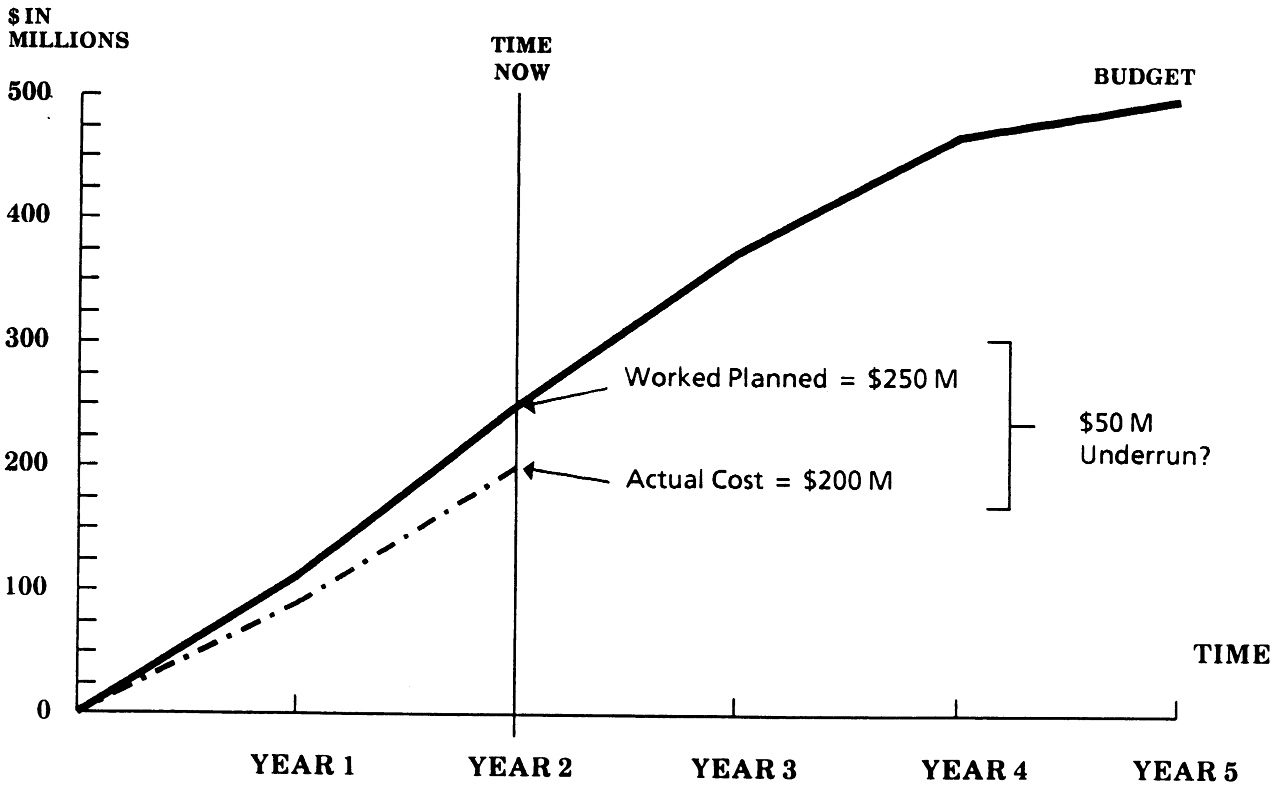


Figure 1. - Traditional Plan vs. Actual Technique

and Data Relay Satellite System spacecraft contracts.

What is the potential of this management tool? What does performance measurement do that a traditional plan vs. actual technique cannot do? Performance measurement provides an improvement over the customary comparison of how much money was spent (actual cost) vs. how much was planned to be spent based on a schedule of activities (work planned). This commonly used plan vs. actual comparison, however, does not allow one to know from the numerical data if the actual cost incurred was for work intended to be done. With performance measurement, actual work progress (work done, also known as earned value) is quantified by an objective measure of how much work has been accomplished on the program. This added dimension of a quantitative assessment of work accomplished allows for comparisons to be made between the value of work that was done vs. the work that was planned to be done (schedule variance). It also allows for a comparison of the actual cost of work that was done vs. the planned value of the work that was done (cost variance). This analysis then provides for early identification and quantification of cost and schedule problems.

A graphic depiction of the data available from the traditional plan vs. actual technique compared to those available from a performance measurement system may serve to more clearly illustrate the concept. A hypothetical spacecraft program is expected to take five years to build at a cost of $500 million. Figure 1 shows the traditional plan vs. actual technique. If "time now" is the completion of year 2, the graph indicates that we had planned to spend $250 million. The actual cost (i.e., time card charges, material expenses, etc.) reported to the government is $200 million.

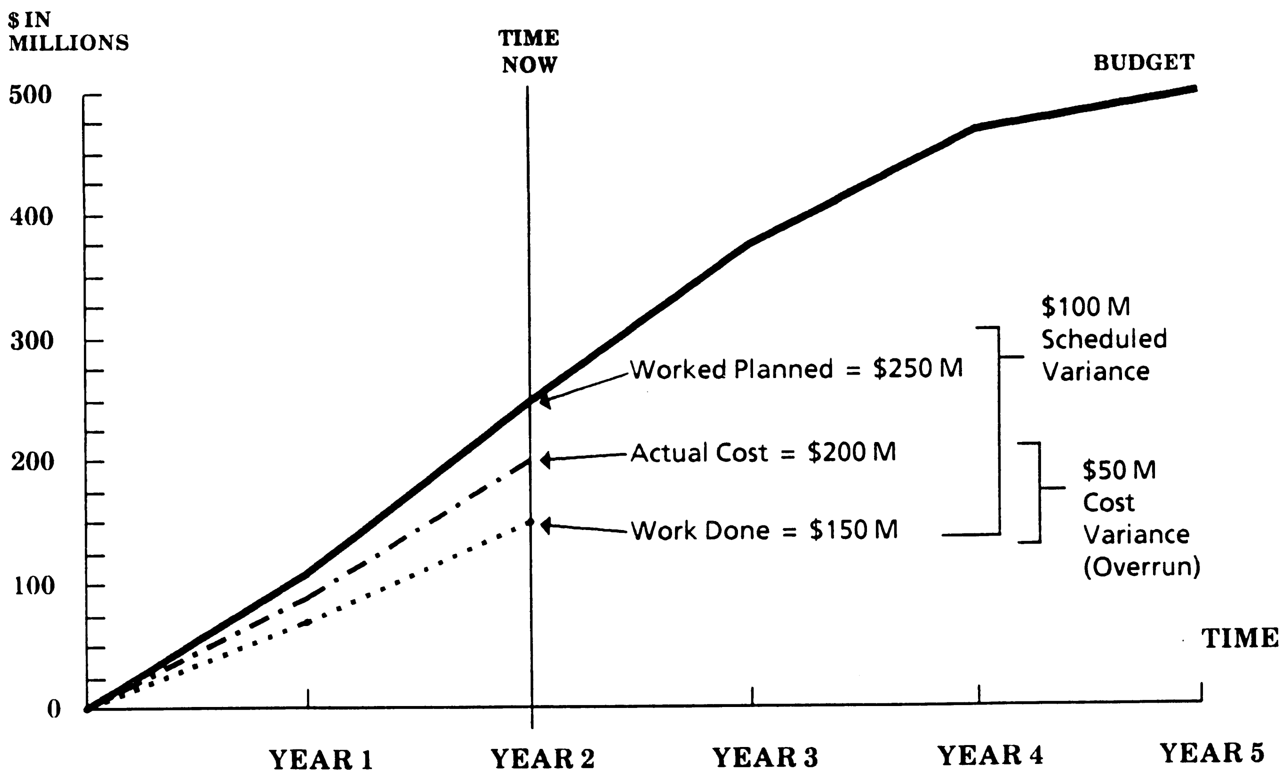


Figure 2. - Performance Measurement Technique

What can a project manager conclude from this information? Is it possible to determine if this program is overrunning or underrunning? With this limited information available, a project manager may assume that the contract is underrunning and would have no basis to question the assumption that this program will underrun at completion. At a minimum it currently appears that the $500 million funding estimate is adquate to complete this effort.

In Figure 2 an additional data point has been added to the same hypothetical spacecraft program. The contractor has assessed the value of the work accomplished (or earned value) to date. This new information reveals that of the $250 million of work planned to be done to date, only $150 million has been done. Some work that was planned to be done has not been done and is reflected as a $100 million scheduled variance. Also the $150 million worth of work done can be compared with the actual cost of $200 million. This comparison shows the planned value of the work vs. the actual cost of that same piece of work. Now the project manager can see that this program is actually overrunning by $50 million to date. We now have enough data to question the validity of the $500 million funding estimate for completion of this effort. We can begin to see that this program is headed for an overrun of costs at completion along with potential schedule slippage.

As a result, the project manager having the PMS data available in Figure 2 is better able to estimate early the total costs and projected period of performance of this program, therefore avoiding being surprised by an overrun much later in the program. If the data yield a "doom and gloom" assessment, there is opportunity to make decisions early to avoid an approach that is too costly or that takes too long.

The basic objective of performance measurement systems is to provide a suitable basis for responsible decision-making by both the contractor and the government management by ensuring that (1) the contractor is using effective internal cost and schedule management control systems and that (2) the government can rely on valid, timely, and auditable data to be produced by those systems to determine program status.

Unfortunately there has not been a consistent experience within the agency regarding PMS implementation. Personnel at various NASA Centers and in the aerospace industry believe that while some NASA applications of PMS have been successful and effective, other attempts to use PMS as a management tool have actually been counterproductive. In some instances, performance measurement systems have not always provided accurate reporting of cost and schedule status, and there are differing opinions about why PMS did not work in these instances. The most prevalent of these is that in the NASA environment and culture, a disciplined approach to program management is not appropriate or applicable. While it is healthy to question the worth and applicability of PMS for NASA programs, it is also beneficial to explore some of the commonsense features of PMS that have proven effective in controlling project costs and schedules in many government agencies for the past 22 years.

Some Basic Principles

Performance measurement can work for you if you apply some basic principles.

1. **Plan the entire contractual effort.** It is essential to plan the work for the entire period of performance. Near-term work is planned in detail while future work can be planned at a summary level. Failure to recognize all of the work to be done makes it impossible to properly allocate resources. Programs could consume too many of the resources on the near-term work and not leave enough to do the work downstream.

2. **Maintain baseline integrity.** The measurement of actual conditions against a disciplined or controlled plan reveals performance trends that can help to predict future conditions and to determine a future course of action.

3. **Determine accomplishment at the level at which the work is performed.** Who can better assess the work that has been done and the work remaining to be done than the manager responsible for performing the work?

4. **Measure accomplishment objectively.** The most valuable status assessment of a piece of work is based on pre-defined milestones as opposed to personal feelings and prejudices lacking reality or substance.

5. **Summarize for higher levels of management.** While accomplishment is assessed at a relatively low level, summary reporting to higher levels of management, where resources are made available, is also essential for control.

6. **Analyze variances and forecast impact.** Variances are simply indications that actual conditions are different from the original assumptions, and variances may indicate the existence of current or potential problems. Analysis of the variances allows management to correct problems or to redirect efforts to avoid potential problems, as well as to project cost at completion.

In summary, the concept of performance measurement is good, common sense program management that NASA project managers have always practiced, but perhaps not in a formal way.

Specifying Customer Requirements

NASA authority for performance measurement is based on the agency requirement specified in NASA Management Instruction 9501.1 "NASA Contractor Financial Management Reporting System" and NASA Handbook 9501.2B Procedures for Contractor Reporting of Correlated Cost and Performance Data. The NASA Form 533P (where "P" represents performance) has been used by contractors to report performance data to NASA, unless the contractor has another format that serves as the equivalent. The 533P is essentially a minimum NASA requirement for data reporting purposes only. It does not require that an identifiable system or set of subsystems support the data. As the contractors are free to generate data in any way they desire, there is the high potential for invalid or misleading data if this is the only requirement placed on a contractor related to performance measurement. Without a system requirement for visibility and control of the baseline, for objectivity in measuring accomplishment, or for discipline in forecasting estimates to completion, then performance measurement may not yield valuable information. While data can be reported on a 533P, a more disciplined approach to the management system is needed to identify some rules for performance measurement systems. These rules are known within the government and aerospace industry as the "criteria."

The performance measurement criteria do not identify a specific management control system to be applied to a program; but rather, they represent a set of standards against which to measure the acceptability of a contractor's cost and schedule control system. There is, in fact, a variety of equally effective ways for contractors to meet the criteria requirements. The criteria allow a company to organize in any way that suits the company's philosophy and style. The criteria also allow a company to develop any desired policies, procedures, or methods that meet the requirements. The criteria address the age-old questions of any project manger: What work is to be done? Who will do it? When is it going to be done? How much will it cost? Where is the program heading? What has changed? The contractors address these questions through their management systems' integrated set of subsystems. These are subsystems that would be required to manage a program whether or not a performance measurement requirement was imposed. Performance measurement criteria simply require that a more disciplined approach be applied to each subsystem. The PMS subsystems are (1) work authorization, (2) budgeting, (3) scheduling, (4) data accumulation, (5) variance analysis and estimate at completion, (6) subcontract and material control and accountability, (7) indirect expense management, and (8) change baseline control. PMS, then, does not address just the accounting system, but rather it addresses the integrated set of subsystems that constitute all elements of program planning and control.

A Good Management System

The key to the power of performance measurement is that performance measurement data are only as valid as the management system that provides them. If a contractor operates a sound internal management system , the customer should be able to extract summary data from that system that reflect project status. To have a valid management system applied to NASA work in contractor plants, several conditions need to be met.

First, a **management commitment** from the top down is required — all levels of management support are essential. It is not enough to have project financial or resources support personnel discussing PMS with the contractor. The involvement of technical personnel is critical. PMS involves all aspects of program management and needs to be viewed in this way by NASA project and functional management personnel to be effective.

Second, management system **discipline** must be stressed and required. While it may be desirable to maintain a spirit of cooperation and non-adversarial relations with our contractors, PMS is not of any value without a disciplined approach to management. Without a requirement for the contractor to maintain a baseline, to apply objective techniques for performance measurement, or to reliably forecast the cost to completion, there can be no confidence in the value of the data that the management system generates and that the contractor reports to NASA on a monthly basis.

Third, use of **data generated by the PMS** is essential. A few simple mathematical formulas and computations yield very revealing information about the project status and potential future of the program. Use of data serves to facilitate communications internally and between NASA and the contractor.

Fourth, **corrective action** needs to be taken when problems are identified. A management system supplies data points, not solutions. It provides visibility into cost, schedule, and technical status. A system, however, does not manage the project, people do. A system cannot eliminate schedule slippages or stop overruns, but it can help the project manager to understand the potential impact if trends are allowed to continue without mid-course correction.

Fifth, an **in-plant review** of the contractor's management system applied to your program and conducted by a NASA team of interested and knowledgeable technical and resources personnel is critical. The NASA personnel gain invaluable knowledge of the policies, methods, and procedures used by the contractor to generate monthly status reports. By understanding the source of the data, we can calibrate the validity of our monthly customer reports and require the contractor to revise procedures that do not produce valid data.

PMS is not intended to replace traditional management tools — it should enhance them. Day-to-day program management is essential. In fact, if managers are relying solely on performance measurement data generated at month-end, they will be learning of problem situations much too late to be effective. Periodic status reviews, "kicking the tires," and routine communication internal to the contractor and between the contractor and government managers are critical in managing a program. PMS may identify a new problem; but, in most cases, it allows quantification of a known problem through all elements of the work breakdown structure and through the functional organizations to provide a basis for improved management decisions.

Cost Effectiveness

In times of constrained resources it is reasonable for managers to question the cost effectiveness of PMS. What are the benefits and associated costs? The question is difficult to answer, however, since both the benefits and costs are nearly impossible to quantify.

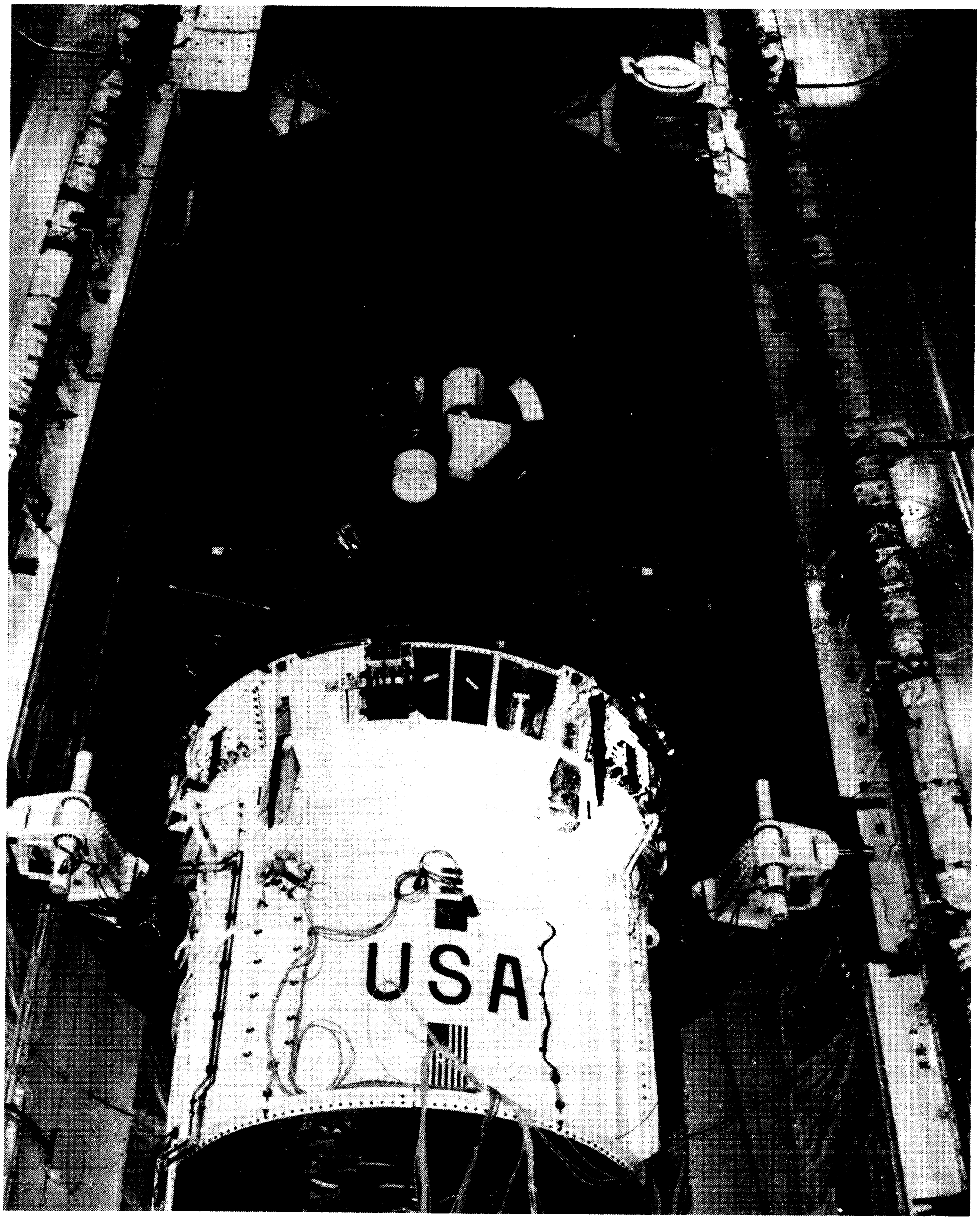
PMS results in a better controlled project with improved communication, both internally and with the customer. To quantify the benefits is to ask, "What is the value of good management?" It is not evident how a cost savings (or cost avoidance), a shortened schedule, or improved technical performance through corrective action can be clearly associated with results or a specific cost.

The costs of PMS have also defied quantification for 22 years. The PMS-unique costs on the total contract cannot be separately identified from the management costs that would be incurred in any case. They are not routinely collected by contractors, nor is it considered practical to do so. This was illustrated in a 1987 survey of GSFC contractors who had implemented a PMS requirement. In the survey, some contractors suggested that the costs of PMS beyond the usual management costs may be expressed as a percentage ranging from 2 percent to 6 percent of total contract costs. In each case, however, the contractor could not substantiate the percentage. It was someone's "non-scientific estimate," as stated by one contractor. Surveys conducted by the DoD show that there is no correlation between the cost of PMS and the contract costs.

This is not to say that there cannot be cost associated with PMS requirements. In fact, the cost of implementing PMS is in direct proportion to the quality of the existing management system. The poorer the state of the contractor's system, the greater the need for improvement and the more it will cost to improve. Contractors who maintain discipline in their systems would incur very low cost for implementing PMS on subsequent contracts. If the same contractors did not maintain their systems, over time the cost to implement PMS on future contracts would be greater as the need for improvement becomes greater. Further, if there is not an existing integrated cost and schedule management system, the contractor will certainly incur cost to develop one. GSFC experience, however, has been that contractors awarded major development procurements that contain PMS requirements are contractors who already have operational PMS systems as a result of their dealings with the DoD. Costs of PMS have been minimal compared to the significantly greater value added.

There is one additional factor to consider in a discussion of the costs of PMS. Typical points of contention between the government and industry concerning PMS implementation include the levels of detail identified for management and reporting, and the variance analysis thresholds identified for customer reporting. It is possible to avoid incurring unnecessary cost to the government and frustration for the contractor by not requesting reports that no one reads or uses, or "nice to have" items or analyses.

In summary, with the focus on efforts to improve program and project management, PMS is a potentially valuable tool. Like any tool, however, it is only as valuable as the user chooses to make it. Implemented properly, PMS can ensure the generation of valid cost and schedule performance data to ease the manager's decision-making process and can result in more effective program planning and control.



Galileo and its Inertial Upper Stage (IUS) were installed in Atlantis' payload bay at the end of August 1989. Six hours after launch the IUS was ignited, sending Galileo in a planetary trajectory past Venus once and Earth twice before swinging out to explore Jupiter, the Solar System's largest planet. SMR&QA engineers had to identify and analyze potential hazards related to the spacecraft's nuclear power source.