Evolution of a Technical Management Organization

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To accept that a particular philosophy or system of management is superior or even applicable, it is essential that its basis be identified and understood. To satisfy that objective and to provide some insight into what has and is working in the successful management of projects at the George C. Marshall Space Flight Center (MSFC) we first need to understand the background and evolution of the Center organization and then how major adjustments were made to accommodate the changing objectives. We can then examine specific "lessons learned" from the Spacelab Program, a highly successful, international cooperative program involving the United States and a consortium of 10 European countries.

BACKGROUND

MSFC was formed in 1960 from the nucleus of the Wernher von Braun team which, until it became a part of NASA, had functioned primarily as a propulsion development organization under the "arsenal concept" with the U.S. Army Ballistic Missile Defense Agency (ABMA). This concept was simply that all aspects of design, development, and initial production were under the direct control of ABMA. The concept worked well for limited production of research and development projects. In fact, it was under this concept that the first Redstone and Jupiter missiles and the first stages of Saturn I and IB and Saturn V launch vehicle systems were designed, manufactured, and tested at Redstone Arsenal and successfully launched by the Missile Firing Laboratory, which later formed the core of the Kennedy Space Center organization.

The apparent disadvantage to this concept was that it did not lend itself to high production or to optimum utilization of the U.S. aerospace industry, which was recognized in the early 1960s as essential to meeting the established lunar landing goal within the decade. Thus, the first major adjustment of the MSFC organization was recognized almost coincidentally with its establishment as a part of NASA in 1960. The challenge was to capture the very valuable experience and knowledge gained from in house design and development and to build an industrial management organization around it. The organization that ultimately evolved was not a unique management concept. It was patterned after other programs in which the project or program manager was given full responsibility for managing the available resources and for establishing the proper balance among performance, cost, and schedule. During the Apollo era, the MSFC role was primarily development of all propulsive stages of the launch vehicle systems; therefore, a simplified matrix organization was adequate to accomplish the technical management of the program. The technical capability resulting from the in house efforts of the late 1950s and early 1960s, coupled with a proven systems management approach, contributed significantly to the success of the Apollo program.

The second most important adjustment in the MSFC organization came at the end of the Apollo era. There were no agreed-to plans to build on or even maintain the experienced government and industry manned systems teams destined to become surplus in the late 1960s and early 1970s. This was particularly important to MSFC because its primary focus remained launch vehicle development. The solution encompassed two very important items for any dynamic technical management organization: the ability to (1) reorganize and (2) diversify while maintaining its vitality. Once the decision was made to diversify, detailed planning, both short and long range, was essential. The MSFC success in this endeavor came in the recognition that the project management team and the majority of the technical disciplines which had worked well for the Apollo Program were relatively easy to adjust to meet the short-term needs of the Skylab Program. This program, a spinoff of Apollo, was assigned to MSFC for management. The major organization adjustment was to introduce a full matrix organization to accommodate multiple program/project assignments.

The most difficult task was the development of long range plans. MSFC's 1969 reorganization established a major new organizational entity: the Program Development Directorate, chartered to identify the most feasible future program(s) compatible with the Center's technical expertise, and then to ensure the proper skill mix for their accomplishment. At that time, NASA's declining workforce introduced an additional complication in that reductions-in-force at MSFC were the rule rather than the exception.

SPACELAB

One program which gave NASA and MSFC the opportunity to exercise its system of technical management and expand its diplomacy came with the approval of the Spacelab Program, an international cooperative program between the European Space Agency (ESA), representing 10 European countries, and NASA, representing the United States.

The genesis of this program came from the 1969 Space Task Group (STG) report to President Nixon. Two of the STG recommendations concerned a reusable launch system later to become the Space Transportation System (STS); another covered the internationalization of space. These recommendations had a major impact on Marshall. The early concept and definition phase of STS utilization was performed by the newly established Program Development Directorate. This effort identified the need for a manned laboratory to be carried in the orbiter payload bay. The Laboratory would accommodate the experiments, which were to remain attached to the orbiter in low Earth orbit and which would require human interface.

The Europeans joined the Spacelab Program primarily to acquire a manned space flight development capability within the European Space Agency and the European aerospace industry. The basic arrangement was for ESA to manage, at its expense, and to an agreed-to set of requirements, the production and operation of the Spacelab spacecraft. Phases A and B were performed in house by an MSFC-designated task team as part of the NASA Shuttle payload planning and definition effort. The principal drivers of the configuration during the definition phase were Shuttle accommodation (functional and physical interfaces) and user requirements. Both were significant variables throughout the program.

The fact that MSFC had the assignment to gather Shuttle user requirements for NASA provided the opportunity to canvass the U.S. scientific and applications users for their needs, and to synthesize these into a practical set of requirements in the areas of power, data rate, weight, pointing accuracy, volume, cooling, etc. The Shuttle accommodations available to the payload--weight, power, heat transfer, center of gravity (CG) constraints and data capability were utilized to bound the Spacelab system capabilities. Once the initial user requirements and Shuttle accommodations were established, even though both continually changed, the problem facing the Phase B definition effort was to optimize the Spacelab configuration to provide a feasible system with maximum capability for the user. The output of the study came in the form of (1) a preliminary orbiter interface document, (2) preliminary U.S. user requirements which were later integrated with European user requirements, and (3) preliminary Spacelab system specifications. With these, NASA had a good understanding of the program requirements and a skeleton management organization at MSFC and Headquarters. This early program understanding proved to be invaluable through the entire program. When ESA agreed to participate in the program in 1973, the results of all Spacelab-related study efforts were provided directly to the Europeans. MSFC terminated any further system definition studies in order to concentrate the available manpower resources on working with ESA and its contractors.

MSFC's early involvement in Spacelab planning and definition, its experience with manned spaceflight from Skylab, and its long history of large pressure vessel (propellant tanks) design and development made MSFC the logical NASA lead center for Spacelab Program management.

At the beginning of the program, the political planning phase was to some people on both sides of the ocean as important to program success as program technical definition. It is not the intent here to downplay that importance. On the contrary, it proved during implementation and operation to be vital. This planning culminated in two very significant documents: (1) a Memorandum of Understanding (MOU) signed by the respective heads of NASA and the European Launch Development Organization (ELDO), later renamed the European Space Agency, and (2) a country-to-country agreement approved by the U.S. State Department and a representative of the 10 participating European countries.

It was evident that considerable thought and time were spent to make the MOU clear, concise, and easy to understand, yet general enough to allow the implementers flexibility to complete the program without the need to exercise the disputes clause. In fact, the document was so well written that during the development program there was never a disagreement sufficient to warrant changing the document.

IMPLEMENTATION

With such detailed planning, the implementation and development phases would appear to be relatively straightforward. In most programs, a high degree of early planning will minimize the problems commonly found in schedules, cost and performance during the development phase. This was true in Spacelab; however, a new set of variables was introduced in working with the Europeans. First, their industry did not have in place boilerplate standards and specifications for manned systems; these had to be developed. Second, ESA had to translate NASA requirements and specifications into its documentation system, which resulted in a pyramid of very fluid controlling documents, some of which required joint signatures by NASA and ESA. One of the more complex was the Interface Control Document (ICD) for Spacelab and the orbiter, requiring approval by NASA, ESA and the prime contractors for both Spacelab and the orbiter. The complexity was compounded by the Spacelab's dependence on the orbiter for accommodations and the fact that the two programs were being developed in parallel.

MSFC's early detailed planning revealed the requirement for considerable NASA resources to perform the technical evaluation and monitoring necessary to ensure that the overall system requirements and specifications were met, and to perform the operations development planning at KSC, JSC, and MSFC. It came as a surprise to MSFC management when, early in the program, the NASA Administrator questioned the level of effort required by NASA civil servants to technically evaluate and operate what was concluded to be a free Spacelab.

NASA found itself in unfamiliar waters in working with the Europeans, for whom a standard mode of operation is to develop systems through multi-national involvement. The key features of this mode are the geographical distribution of funds to each contributing country in an amount comparable to that pledged to the program and the introduction of the prime contractor and co-contractor rather than subcontractor relationships. These features were new to NASA but not to ESA, and the anticipated shortcoming, i.e., the inability to select the most competent subsystem contractor from each country, was only a short-range concern. Until the program had progressed beyond the critical design reviews, and subsystem and component development was well under way, there was a constant concern that ESA lacked the technical depth and breadth to manage such a large undertaking. MSFC, however, took comfort in the fact that an experience base did reside within NASA and that the ESA management team was dedicated to doing an outstanding job.

If one area had to be identified as a significant concern resulting from NASA's lack of familiarity with the ESA technical management system, it would be the assurance that top level specifications and requirements flowed from the prime contractor to the co-contractor and ultimately to the vendors and suppliers. This included traceability to indicate how and if the requirements and specifications were met. This became a real concern late in the program, when adequate recorded evidence of successful completion of qualification and acceptance testing was sometimes lacking. There was no question on the part of NASA engineers, who had worked closely with ESA and its contractors, that the qualification testing had taken place; it was simply a matter of formally documenting the data. This problem came about because no contractual requirements for formal documentation were placed on the co-contractor by the prime contractor.

One of the first management decisions the Spacelab Program Office made was to maintain heavy MSFC engineering involvement from the beginning to the end of the program. This involvement was used to generate and approve all technical requirements in a way that the engineers felt accountable for the technical performance of the Spacelab system even though the overall responsibility resided with the program manager. With the exception of propulsion, all MSFC technical disciplines were involved.

OPERATION

When the time came to provide the manpower resources, there were three alternatives: (1) utilize civil servants, (2) contract with a European contractor, or (3) contract with a U.S. aerospace firm. Using civil servants was not practical. Contracting with the European Spacelab contractor clearly had positive points; however, when long-term cost implications of retaining a foreign contractor in this country, not to mention that the only past experience in the required mission integration and launch operations resided in this country, the decision to contract with the U.S. aerospace industry came easily. The contract was written with two schedules, one to include launch operations and integration activities managed by KSC, and the sustaining engineering and hardware control administered by MSFC. The intent of the latter schedule was to phase down the MSFC civil service personnel from a peak during the development phase as the contractor came on board and the operations were well defined. This was accomplished as planned. The program was well into development when it was recognized that an organizational interface with the user community independent of the program office responsible for the design and development should be established at MSFC. This organization (Payload Project) would ensure that the user requirements were properly considered and ultimately satisfied where practical. The new organization reported to the center director, as did the Spacelab Program Office, and assumed the very significant role of payload mission planning and experiment analytical and physical integration. The efforts of this organization led to the establishment of the payload and mission specialists training facility and the Payload Operations Control Center (POCC) at MSFC. The Spacelab payload mission successes can be attributed more to this organization than to any other single organization in NASA. This organization and mode of operation will be used as a model for the Space Station Freedom Program.

CONCLUSION

MSFC's approach to project management and organizations has changed over the years, first to develop a project management capability and then to adapt to multiple projects utilizing a matrix approach. The center weathered this to become a very competent well-balanced research and development organization with flexibility to adjust to the nation's future space policy.

Building and maintaining such an organization demands the constant attention of the entire management structure. Even though it is not practical or feasible to establish a detailed set of standards and procedures to be used by each manager and supervisor, there are a number of common groundrules which allow any organization to function efficiently and effectively. The following are a few of the more important groundrules that have proven to be helpful to MSFC:

(1) Emphasize the planning phase as the most important part of any program. The more detailed the program plan, the better it is understood, and the more likely it is to be successful. Proper organizational placement and competence levels are essential.

(2) Develop and maintain an in house technical capability through the careful selection of in house projects and the recognition of the skills required for future programs.

(3) Establish a good understanding with Headquarters concerning what is expected of the Center. This should be done on a project-by-project basis.

(4) Require substantial involvement by the technical discipline from the planning phase through development and operation, but ensure that overall program responsibility (cost, schedule and performance) remains with the program or project manager.

(5) Establish a Center strategic plan which is understandable, realistic, and communicates to every person at the Center his or her respective role.

To manage a complex technical program through a matrix organization with involvement from other development and/or operation centers demands constant attention to detail and involvement by all levels of center management. The concept of armchair management, where the majority of the manager's time is spent in the management information control center concerning himself or herself only with cost and schedule, has not been acceptable in the past nor is it an acceptable mode for the future of NASA.