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**REENGINEERING
NASA's SPACE COMMUNICATIONS
TO REMAIN VIABLE
IN A CONSTRAINED FISCAL ENVIRONMENT**

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ABSTRACT

Along with the Red and Blue Teams commissioned by the NASA Administrator in 1992, NASA's Associate Administrator for Space Communications commissioned a Blue Team to review the Office of Space Communications (Code O) Core Program and determine how the program could be conducted faster, better, and cheaper. Since there was no corresponding Red Team for the Code O Blue Team, the Blue Team assumed a Red Team independent attitude and challenged the status quo, including current work processes, functional distinctions, interfaces, and information flow, as well as traditional management and system development practices. The Blue Team's unconstrained, non-parochial, and imaginative look at NASA's space communications program produced a simplified representation of the

space communications infrastructure that transcends organizational and functional boundaries, in addition to existing systems and facilities. Further, the Blue Team adapted the "*faster, better, cheaper*" charter to be relevant to the multi-mission, continuous nature of the space communications program and to serve as a gauge for improving customer services concurrent with achieving more efficient operations and infrastructure life cycle economies. This simplified representation, together with the adapted metrics, offers a future view and process model for reengineering NASA's space communications to remain viable in a constrained fiscal environment.

Code O remains firm in its commitment to improve productivity, effectiveness, and efficiency. In October 1992, the Associate Administrator reconstituted the Blue Team

as the Code O Success Team (COST) to serve as a catalyst for change. In this paper, the COST presents the chronicle and significance of the simplified representation and adapted metrics, and their application during the FY 1993-1994 activities.

Key Words: Blue Teams, Complexity Reduction, Economies of Scale, "*Faster, Better, Cheaper*," Life Cycle Effectiveness, Mission Operations, Operations Concepts, Operations Technology, Process Improvement, Reengineering, Reusability, Reuse, Simplicity, Space Communications, Systems Engineering

1. INTRODUCTION

In addition to but separate from the Red and Blue Teams commissioned by the NASA Administrator, NASA's Associate Administrator for Space Communications commissioned a Blue Team to review the Office of Space Communications (Code O) core program and advise, within six weeks, how the program could be conducted faster, better, and cheaper. With no corresponding Red Team for the Code O Blue Team, the Blue Team was empowered to take an unconstrained, non-parochial, and imaginative look at the program and to explore strategic options for change. The Blue Team met during June-July 1992 and filed its report on July 15, 1992. The report contained findings, recommendations, and initiatives in three areas: (1) People, (2) Technical, and (3) Financial. (Hornstein et al., 1993)

At the heart of the technical initiative is a simplified representation and characterization of the space communications infrastructure that transcends organizational and functional boundaries, as well as existing systems and facilities. This simplified representation results from the Blue Team's discovery that the numerous and seemingly diverse infrastructure systems and facilities can be represented by only two functional categories.

These categories are (1) **Information Handling** and (2) **Resource Management and Control**. Information Handling is the universe of activities associated with data/information receipt, processing (RF and digital), storage, retrieval, formatting, distribution, and transmission, including sensing of nominal and fault conditions. Resource Management and Control is the process of making decisions about which resources will be used for which activities at which times; control of operations; and assuring the allocation decisions are executed properly through all life cycle phases, including execution of recovery from unplanned events and circumstances, to satisfy operations goals and objectives.

The fulcrum of the simplified representation is the set of "*faster, better, cheaper*" metrics as adapted to fit the multi-mission, continuous nature of the space communications program. The non-conventional adapted metrics are **realistic, credible, responsive** ("*faster and cheaper*"), **simpler and smaller** ("*better*") and are to be employed over both customer and infrastructure life cycles, rather than optimizing, for example, over the development phase to constrain initial development costs at the expense of the operations and maintenance phase.

The technical initiative is designed to reverse the trend of planning, designing, developing, maintaining, and operating costly one-of-a-kind systems and facilities. The initiative, as submitted on July 15, 1992, reads as follows: Create, evaluate, and select a wholly integrated operations concept, leading to an end-to-end systems architecture, with full participation of Code O service providers and customers. The concept is to be applicable across organizational and functional boundaries, and not limited to the in place infrastructure or configuration of existing systems and facilities. The evaluation factors and selection criteria will focus on customer satisfaction, life cycle effectiveness, and the adaptation of the "*faster, better, cheaper*."

The simplified space communications representation and adapted metrics are shown in Figure 1. In October 1992, the Code O Blue Team was reconstituted as the Code O Success Team (COST) to serve as a catalyst for changing the process from

engineering systems to systems engineering. The focus of this paper is on laying the groundwork for process change, promoting the teamwork to accomplish change, and highlights of the FY 1993-1994 activities.

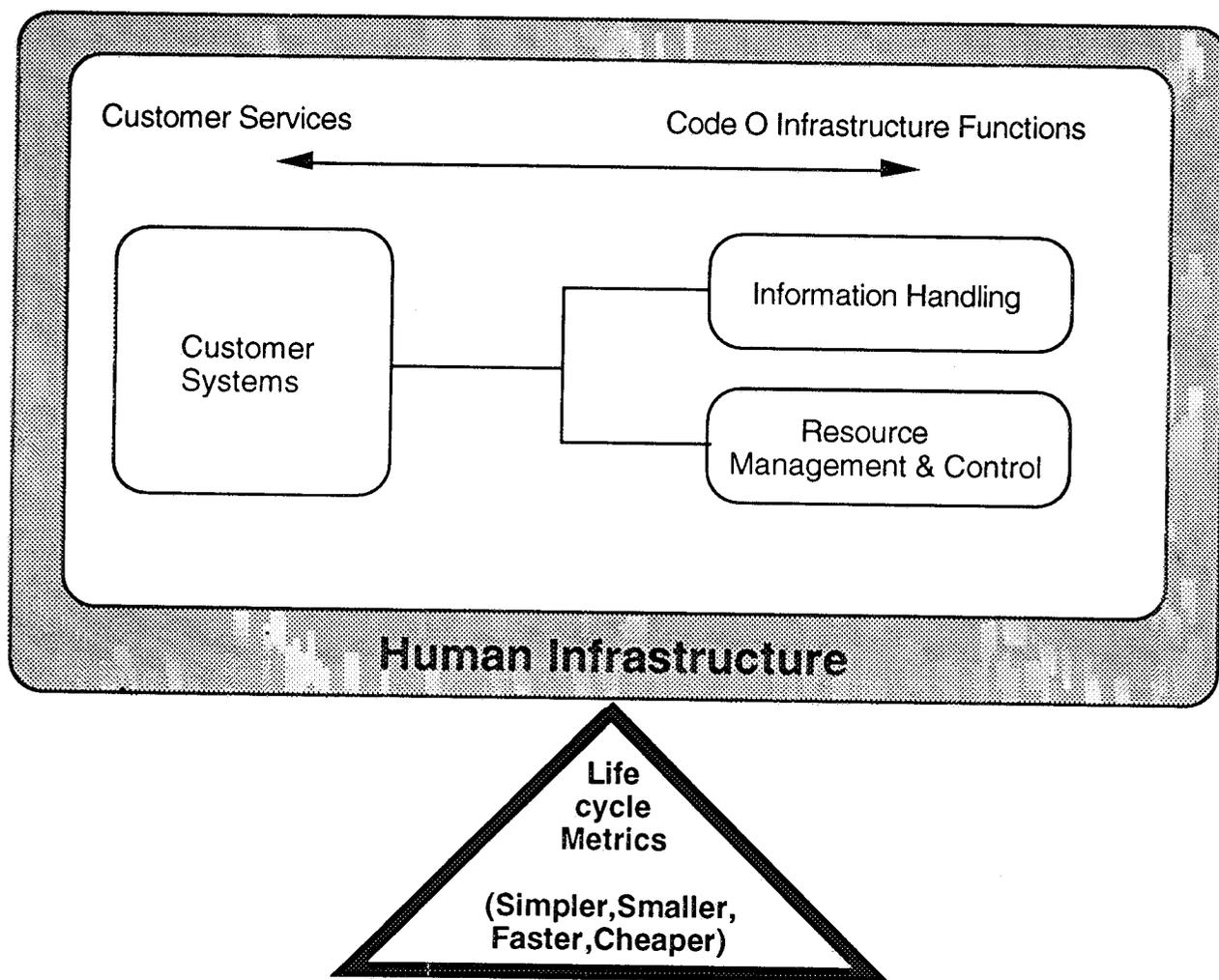


Figure - 1: Space Communications Representation and Metrics

2. LAYING THE GROUNDWORK FOR INNOVATION

In less than six weeks during June-July 1992, the Code O Blue Team examined a plethora of unique systems and facilities, all

engaged in providing space communications services to space communications customers, some of whom are now labeled NASA Strategic Enterprises. The systems and facilities were unique in their names and titles,

organizations and architectures, technical components, and budget line items. To facilitate the examination of what appeared to be vastly distinct and divergent entities, the Blue Team diagrammed the systems and facilities to seek and formulate comparative relationships. However, substantive progress did not occur until the team stopped scrutinizing how the systems and facilities were engineered and started to question their purpose(s). A simplified representation of the space communications infrastructure then began to emerge. Through repeated examination of *similarities in purpose vice differences in engineering*, the Blue Team was able to group the space communications infrastructure systems and facilities into five functional categories at first, and finally to collapse them into only two functional categories: (1) **Information Handling** and (2) **Resource Management and Control**.

This discovery by the Blue Team (i.e., that the numerous and seemingly diverse infrastructure systems and facilities can be represented by only two functional categories) led to the recognition that there are considerable economies of scale to be gained and problems to overcome. We, organizationally, have become shaped by our emphasis on uniqueness. We tend to engineer systems rather than conduct systems engineering. This practice produces locally optimized, narrowly focused, and somewhat short-sighted solutions that contribute to overall infrastructure complexity through the accumulation of these many special solutions for similar purposes. Our heritage of unique solutions (i.e., systems and facilities) has fragmented our perspective and created barriers. One clearly visible barrier is language or vocabulary. Heretofore, when defining requirements for space communications services, the requirements have been described in terms of an implemented, or to be augmented, system or facility. This approach tends to limit the field of potential and available solution sets, and continues to perpetuate the proliferation of unique

solutions. This entrenchment is adversely impacting mission operations through ineffective analysis of trade space alternatives. This entrenchment is not restricted to the space communications program, but occurs throughout NASA's strategic enterprises and functions.

A second key Blue Team finding or 'eureka' deals with the adaptation of the "*faster, better, cheaper*" charter to reflect the multi-mission, continuous nature of the space communications program. Further, this adaptation may be used to guide the improvement of customer services while accomplishing more efficient operations and infrastructure life cycle economies. The derivation of **realistic, credible, responsive, simpler and smaller** from "*faster, better, cheaper*" is as follows: The Blue Team began its examination with "*faster*" and "*cheaper*." Both concepts seemed obvious, i.e., do whatever in less time and with less money. Without giving it a second thought, 'doing whatever in less time' was related to accelerating system delivery schedules or receiving data more rapidly at higher rates. On second thought, "*faster*" was less obvious. "*Faster*" was meaningful only in the context of being responsive to customer needs. Delivering a system capability two years prior to need (e.g., launch or encounter) may not be advantageous if the implementation of that capability creates restrictions in current operations or introduces additional costs in maintaining and operating the capability. "*Cheaper*" was looked at in terms of the agency flight program model and the multi-mission, continuous nature of an infrastructure model. Using the flight program model, costs are tracked, on a per mission or spacecraft basis, from beginning to end or womb to tomb. However, an infrastructure (now labeled as strategic functions in the NASA Strategic Plan) spans multiple missions and spacecraft. Economies are achieved by leveraging the needs of multiple customers and accommodating these needs through modifications to the infrastructure. The Blue Team probed and found that emphasis was placed on engineering systems, on a mission by

mission basis, with restrained and controlled implementation costs. Although economies were gained, the results were sub-optimal when one considers that the majority of a system's life cycle is spent in the maintenance and operations phase, not in the design and development phase. Investigating the meaning of "better" proved to be both enlightening and revealing. In the minds of many good engineers, "better" readily translates to more whiz bang, e.g., state of the art, advanced technology, enhanced performance, and inevitably more complexity. However, complexity often translates into cost and schedule risk throughout a system's life cycle.

From these deliberations and non-conventional exchanges of views, it became evident that "faster, better, cheaper" was being discussed in terms of their units of measure. Traditional units of measure (i.e., time and dollars) were being used for "faster" and "cheaper," but non-traditional units of measure (i.e., complexity and size) had surfaced for "better." In all cases, value had to be measured across life cycles, both customers and service providers alike. Value for "faster and cheaper" became **realistic, credible, responsive**. Value for "better" became **simpler and smaller**.

The two Blue Team discoveries described in this section -- (1) that the numerous and seemingly diverse infrastructure systems and facilities can be represented by only two functional categories and (2) that "faster, better, cheaper" is more appropriately portrayed as **realistic, credible, responsive, simpler and smaller**, across life cycles -- constitute a new working paradigm for preparing and delivering space communications services. This new paradigm strongly suggests that we depart from our legacy of engineering systems to establish the practice of true systems engineering. Additionally, it must be acknowledged that focusing on similarities, rather than on differences, expands the solution set for achieving economies of scale, while creating opportunities for reducing infrastructure complexity.

3. PROMOTING TEAMWORK TO ACCOMPLISH CHANGE FY 1993

In October 1992, the Code O Blue Team was reconstituted as the Code O Success Team (COST) to serve as a catalyst for change. The COST role was further clarified to include complementing line management and fostering cooperation (not competition) across the Code O Family. In addition, the COST accepted the challenge to include a tactical emphasis in its planning and to maintain a balance between this tactical emphasis and the strategic (1) People, (2) Technical, and (3) Financial Blue Team initiatives. Consistent with this clarified role, the COST set out to:

- . Promote cooperation and collaboration across traditional boundaries
- . Nurture innovation by seeking ideas for near term across-the-board opportunities for savings
- . Advocate **realistic, credible, responsive, simpler and smaller** solutions
- . Actively solicit customer participation
- . Encourage use of the simplified space communications representation and adapted metrics in evaluating system implementation projects

The COST entered into dialogues within the Code O Family of service providers and customers at Headquarters and the field centers. These dialogues disclosed that many of us were in violent agreement on the need to change. While we recognized that we shared a heritage of success, we also acknowledged that the challenge was to reduce the cost of success. This challenge, "to reduce the cost of success" became the hallmark of the FY 1993 activities.

The FY 1993 activities included strategic and tactical elements. Formulation of the Code O Family vision was a strategic endeavor to integrate the simplified space communications representation, the adapted metrics, the Blue Team initiatives, and the challenge "to reduce the cost of success." The one-page statement and illustration was signed by the Associate Administrator for Space Communications in June 1993. The Code O Family vision statement is to reduce the cost of success through (1) increased cooperation, (2) improved service to and partnership with customers, and (3) decreased cost and complexity of the space communications infrastructure.

Two tactical activities were conducted during FY 1993. They centered on remaining viable in a constrained fiscal environment, while pursuing the vision. The COST organized and hosted the first Space Communications Programmatic and Tactical Planning Workshop. Attendees included space communications service providers and their customers. There were two key objectives:

- . Develop a technical foundation and teamwork base to facilitate work on operations concepts
- . Develop an investment strategy that included areas for near term savings

The workshop teams presented their results and recommendations to Code O Senior Management, including the Associate Administrator. The recommendations were synthesized into six areas for tactical savings and incorporated in the budget guidelines. In retrospect, the workshop set the stage for teaming across organizational boundaries and for testing the value of proposed infrastructure modifications in terms of customer benefit.

Also incorporated in the budget guidelines, was the announcement of the Code O Investment Program. This program provided an open channel for the field centers to submit proposals that reduced costs, improved services to customers, or otherwise contributed to making the Code

O infrastructure of systems and operational services simpler, cheaper, or more customer friendly. The proposal selection criteria were based on (1) Contribution to the Code O Family vision and (2) Rapid Investment Payback - within three years. The Code O Investment Program was intended to build on the teaming started at the workshop and create near term across-the-board opportunities for savings. In retrospect, it was difficult to shed local institutional perspectives. Only ten tactical winners were selected from sixty-three proposal abstracts and twenty full proposals.

4. REDUCING THE COST OF SUCCESS FOR NASA's MISSION OPERATIONS FY 1994

Early in the year, the COST determined that going after strategic and tactical results concurrently was not leading to the desired state. Line management was proceeding with business as usual, i.e., working within organizational boundaries and motivating their employees to do the same. Meanwhile, circumstances had overtaken the tactical program.

Process changes to realize substantive economies of scale would have to be strategic, and technical innovation to reduce cost and complexity would have to be strategically motivated. Further, "reducing the cost of success" actually meant reducing the cost of success for mission operations for NASA's strategic enterprises and strategic functions. With active and intense involvement by the Associate Administrator for Space Communications, the COST role was broadened to encompass agency mission operations.

The COST organized and hosted a mission operations workshop. Participants were a non-parochial cross section of mission operations experience from NASA, industry, academia, and another government organization. They had been selected using the same criteria used to select members of the initial Code O Blue Team:

- . Independent Thinkers, yet Team Players
- . Recognized for Technical Expertise and Professional Integrity
- . Prepared to Challenge the Status Quo
- . Able to Resist Engineering the Solution Before Understanding the Problem
- . Experience in engineering systems and Systems Engineering; able to distinguish
- . Willing to be Unconstrained, Non-parochial, and Imaginative
- . Empowered to Explore Strategic Options rather than Producing a Quick Fix
- . Perseverance and Commitment Post-Workshop (1-year continued teaming)

The workshop theme was NASA Teaming Across Organizational Boundaries to Reduce the Cost of Success for End-to-End Mission Operations. The workshop goal was to expressly begin work on changing the culture to stimulate innovation and promote cooperation and collaboration across traditional boundaries for the good of NASA. The workshop was to be considered as the kick-off meeting for building relationships and creating teaming arrangements to step up to the challenge of reducing life cycle costs for NASA mission operations. The principal workshop objective was to articulate a common baseline for services and functions necessary to conduct end-to-end mission operations. In order to emphasize *similarities in purpose vice differences in engineering*, the descriptions of these services and functions were to be independent of existing systems, facilities, technologies, organizations, and personalities.

The workshop announcement stated that many of us believe the big payoff will come from reversing the trend of engineering special solutions for similar problems, through the identification, development, and deployment of reusable components that

simplify engineering (building and maintaining) and operating systems for end-to-end mission operations. Achieving an agreed to baseline of services and functions was seen as a mandatory first step on the road to payoff.

The opening session of the workshop was a dialogue between the participants and the NASA Administrator. His presence reinforced the priority of cooperating and collaborating across organizational boundaries. At the conclusion of the session, he invited workshop representatives to continue the dialogue at the next Senior Management Meeting to be held June 9, 1994. The invitation was accepted.

Preparation for the Senior Management Meeting energized the representatives to form a non-standard alliance of Code O Success Team/Lifecycle Effectiveness for Strategic Success (COST LESS) for Mission Operations. This alliance established the following goals, technical approach, and people process:

Goals

Redefine Success in a Constrained Fiscal Environment
Reduce the Cost of Success for End-to-End Mission Operations

Technical Approach

Reverse the Trend of Engineering Special Solutions for Similar Problems

People Process

Break Down Barriers and Team Across Traditional Boundaries

The alliance presented to NASA Senior Management that the goals would be met, and significant savings could be realized by improving processes and incorporating them into the line organizations. The COST LESS for Mission Operations alliance also reported that "across traditional boundaries" included life cycles, functions, programs and projects, as well as organizations. The effort envisioned would be multi-dimensional and multi-disciplinary in order to achieve example

results such as (1) Common Vocabulary, (2) Reusable Solutions to Simplify Engineering and Operations, and (3) Operations Concepts to Maximize Value.

5. NEXT STEPS FOR FY 1995

In the NASA Senior Management Meeting of June 9, 1994, the Administrator noted that the key to success is the cross-cutting nature of the COST LESS team for Mission Operations. It allowed the group to review NASA objectively versus as individual organizations. With this endorsement, the team is reconvening during August-September 1994 to prepare for the next steps between NASA's strategic enterprises and functions.

6. REFERENCE

Hornstein, R.S. et al. (October 1993). A Systems Engineering Initiative for NASA's Space Communications. Proceedings of AIAA Computing in Aerospace 9 Conference (AIAA-93-4696) (pp. 1282-1289). San Diego, CA.