INCREASING THE COST-EFFICIENCY OF THE DSN

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ABSTRACT[1]

JPL has operated the Deep Space Network (DSN) on behalf of NASA since the 1960's. Over the last two decades, the DSN budget has generally declined in real-year dollars while the aging assets required more attention, and the missions became more complex. As a result, the budget has been increasingly consumed by Operations and Maintenance (O&M), significantly reducing the funding wedge available for technology investment and for enhancing the DSN capability and capacity. Responding to this budget squeeze, the DSN launched an effort to improve the cost-efficiency of the O&M. In this paper we:

- *Analyze the components of O&M. We note for example that, for the DSN, less than 20% of the staff engage in the traditional "human-in-front-a-console" role, so any effort to increase the cost efficiency must go beyond reducing the number of "Real-time operators".*

- *Explain the underlying organizational and cultural structures. Any cost-efficiency activities changes either accept, or carefully modify these structures. For example, the DSN O&M is based on the concept that there are three nearly identical antenna complexes separated by approximately 120^0 in latitude and that each antenna complex is operated by a different contractor (driven by international agreements).*

- *Explore planned changes in the customer interface, e.g. web-based automated scheduling, and the processes required for a transition. Changes have to be evaluated in the larger end-to-end context, e.g. do the changes provide a net cost-efficiency for the DSN and the missions, or do they merely shift cost from the DSN to the missions.*

- *Consider possible significant changes in real-time pass management, e.g. full-remoting of operations, and "lights-dim" operations, while maintaining (or improving) the performance metrics of the DSN*

- *Investigate how procedural and administrative changes could increase cost-efficiency, in conjunction with changes in the customer interfaces and real-time pass management. Examples would be handling of inter-governmental agreements, improved sharing of resources with other agencies, and better use of commercial (rather than government) resources*

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1.0 ZEROING ON AREAS FOR COST EFFICIENCY

The DSN consists of three Deep Space Communication Complexes (DSCCs) where the DSN antennas are located and a set of central facilities. The DSCCs are at Goldstone, CA, near Canberra, Australia, and near Madrid, Spain. They are essentially small communities operated by three different contractors, that include antennas, electronics, facilities (roads, fences, cafeterias, power generators, etc), and the staff required to operate and maintain them. The set of central facilities are located at and near JPL where operations and maintenance activities are performed, as well as development and technology activities

The DSN categorizes its costs into five major categories:

1. Network Service Operations – All direct operations at DSCCs and central associated with tracking passes, including customer interface, scheduling, pass preparations, pass conduct, data delivery to customers and post-pass analysis, exclusive of maintenance activities

2. Support infrastructure – All DSCC-centered support functions (Management, configuration management, cafeterias, security, janitorial, supplies, transportation, outreach, logistics, information technology services, human resources, business support, travel, rent, etc) and DSCC-centered utilities (Power, Diesel, water, Internet, etc)

3. Routine maintenance – Changes to hardware and software with no/minimal change in design, e.g. spares installation and repair, replacement of fluids, shimming of antenna tracks and computer system administration for DSCC-centered Admin/Ops networks.

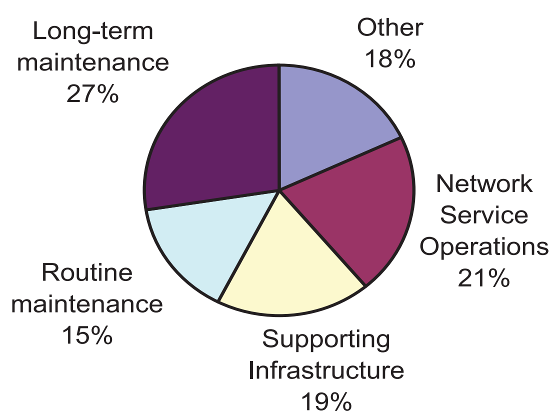

Figure 1 – Allocation of the DSN Budget

4. Long-term maintenance – Changes to hardware and software that are driven by the need to maintain performance, e.g. replacing obsolete components and upgrading computer operations systems..

5. Other – Management and system engineering, capability upgrades, long-term technology, etc

The focus often is on reducing the recurring cost of “operations”. ”Operations” is vague enough to be as narrowl as “people-in-front-of-screens” (a subset of the first category) or as broad as all the activities needed to maintain mission support, including long-term building of new assets to replace obsolete ones (most of the categories above).

Figure 1 shows a typical budget allocation. Not surprisingly, only 21% of the budget is allocated to “Network Service Operations” where all the “human-in-front-of-the-console” is included. This is significantly less than the percentage 25 years ago when human-in-the-loop involvement was much more intensive. In this paper to illustrate the cost reduction process we will focus on examples of reducing the recurring cost of “human-in-front-of-the-console”.

Figure 2 shows the components of that budget segment. In the remainder of this paper, Section 2 discusses organizational and cultural underlying structures while sections 3, 4 and 5 explore reducing the cost of the customer interface, real-time pass management, and other administrative/procedural aspects, respectively.

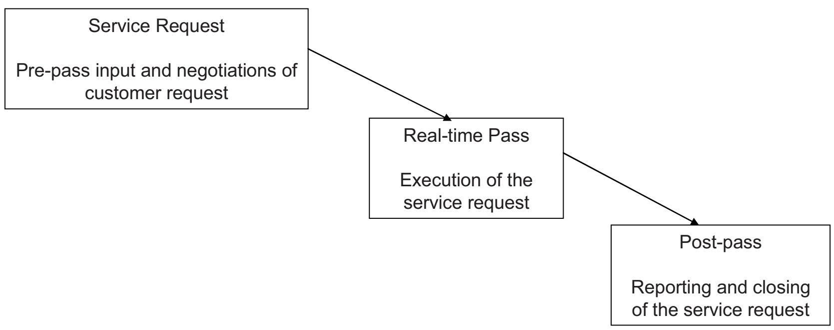

Figure 2 – Components of “Network Service Operations”

We also observe that while there are two basic approaches to improving cost efficiency of mission operations: produce more mission services, with the same expenditure, and reduce the recurring cost of providing the existing level of mission services, in this paper we focus on the latter.

2.0 UNDERLYING ORGANIZATIONAL AND CULTURAL STRUCTURES

To reduce the recurring cost of “Network Service Operations” we need to address both the technical challenges (which are often easier to solve) and organizational/cultural boundaries. These could often be quite complex to address effectively. Let us list some of these factors from the perspective of a manager facing this challenge, using the DSN as a case study.

The impossibility of the “blank slate” approach. When one looks for getting to a organization and system that operates at lower recurring cost, nothing is more tempting that to imagine “how would I organize the system, if I had a blank slate?” Alas, budgetary limitations make the likelihood of the “Blank Slate” approach very low. So the manager has to resort to identifying the elements that are unlikely to be changed and accept them as boundary conditions. For the DSN, these could including accepting the three existing sites, even though their geographic and climate environments are not ideal.

“Ownership” issues. Given that we cannot proceed with a “blank slate” but will vary the existing organization, we have to contend with the fact that each sub-organization has been assigned a specific role and responsibility and has been performing that function, often very well. Changing the scope of responsibility, for the sake of cost reduction, could result in a degradation of performance. While these problems exist in any organization, they are multiplied in the space operations business where high levels of “ownership” and commitment to high performance are common.

Let us illustrate this with a DSN example. Historically, each DSCC’s was vested with the responsibility of maintaining and real-time operations of their assets. As a result, each DSCC has a 24x7 operations team and supportive management structure. We are considering changing that to have (effectively) one 24x7 team that runs all the DSN assets. This would mean that each DSCC will no longer be responsible to operating its assets 24x7. Potentially, we could damage the commitment of the existing very dedicated DSCC teams that often have saved the day. Any plan has to address carefully such changes.

Existing External Agreements. Often, there is a framework of agreements that either cannot be broken, or could be renegotiated only infrequently. The agreements can be viewed as assets (e.g. guaranteed use of a foreign facility) or a liability (e.g. commitment to allocate a percent of one’s antennas to the host country). From a cost reduction perspective, every proposed change must be weight against these agreements. Changing these existing agreements imposes both complexity (more people in the negotiating loop) and the schedule (delaying until the agreements can be effectively changed). For the DSN the two key classes of agreements to consider are the international agreements that govern the overseas DSCCs and the local contractor agreements that control the operations of the DSCCs.

Different cultural norms. For an organization like the DSN that is spread over multiple continents and spans multiple countries and cultures, the general approach was to require uniformity, where needed, but allow local cultural norms to prevail otherwise. Thus, for example, all DSN operational equipment is designed to operate on USA standard power (110V / 60 cycles) and provisions were made for such power to be available in Australia and Spain. On the other hand, each DSCC had organized the teams that provide the 24x7 operations differently, conforming to local norms (e.g. length of annual vacations and workweek). If we consider some merging the 24x7 operations teams to reduce recurring costs, the new format will have to function well for all three DSCCs, while meeting the missions’ needs.

3.0 SERVICE REQUESTS – PRE-PASS

In this “Era of the Internet” it appears that there is no reason why the customer interfaces should not be fully automated and on-line. With few exceptions for manual over-ride, we are proceeding in this direction. The transition poses several challenges relative to present operations. Key areas of challenge:

1. Lack of standard interfaces. While there has been significant progress in defining the CCSDS Service interfaces, there are no agreed international protocols. Thus whatever interface is selected is ad-hoc. And it tends to evolve slowly.

2. Legacy missions. The DSN accommodates many legacy missions; often well past their prime mission. Such missions often operate on shoe-string budgets and cannot continually update to interface changes.

3. Difficult-to-prioritize (and automate) scheduling. The DSN has multi-mission assets: no antenna is dedicated to a mission and many missions are vying for tracking times on the same antennas. To automate the scheduling process, there needs to be a prioritization process to resolve conflicts. But since so many of the DSN missions are one-of-a-kind, the resulting process requires a judgment call, and often compromise between the missions, to resolve the conflict – all manual steps.

Nevertheless, the DSN is in the midst of significant changes in the customer pre-pass interface tools that will move the majority of this interface to fully-automated, on-line mechanisms.

4.0 REAL-TIME PASS MANAGEMENT

Probably the biggest area where cost reduction can be accomplished is in the real-time pass management. The reason is that over the last 40 years the DSN has established four staffed 24x7 real-time centers – one at each DSCC and one at JPL. The majority (>80%) of the staff engaged in real-time operations are Link Operators Controllers (LOC) whose primary function is to manage a single spacecraft-antenna link. Less often, LOCs handle arrays (multiple antennas per one mission) or MSPA (Multiple Spacecraft per Antenna) links.

Over the years, the DSN installed Monitor& control tools that allow automation of many of the LOC functions. We believe that the path to cost efficiency involves the gradual move to:

1. One LOC handles multiple antennas, rather than one antenna. As a baseline we plan to move from 1-link-per-LOC to 3-links-per-LOC

2. A single DSN M&C 24x7 control point, rather than four of them. As a baseline, we plan to rotate the control point between the day-shifts at the three DSCC's, as shown in Figure 3.

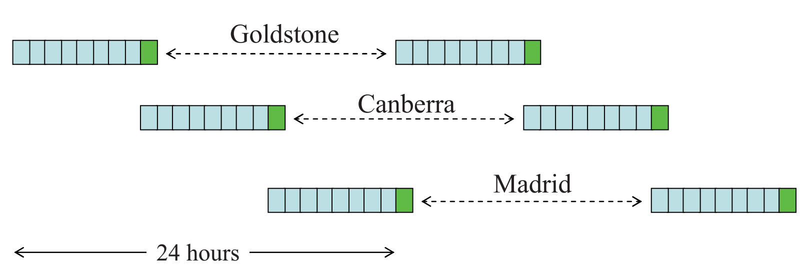

Figure 3 – Rotating 24x7 Control point

While the rotating control point is more complex administratively than a single, fixed control point, it maintains the DSN ability for local M&C control in case of emergencies and critical event.

Our assessment is that implementing the steps involved in real-time pass management will reduce the workforce by approximately 75%.

From a technical viewpoint, implementation requires a large number of modest changes in three areas:

1. Changes in the M&C software, e.g. summary displays and alarms

2. Changes in customer interfaces, primarily reducing the number of phone calls and last minute parameter changes

3. Changes in applicable subsystems to enable remote operations, e.g. Remoting safety video and audio.

5.0 PROCEDURAL AND ADMINISTRATIVE CHANGES

While the technical changes are modest in nature, the procedural and administrative changes are significant.

The prime change is in the role of the DSCCs. They are no longer stand-alone entities. Since each DSCC's real-time team will handle the antennas of the other DSCCs, we will have a true single network of antennas, rather than a network of three DSCCs. But it requires a redefinition, and renegotiation, of the international agreements between NASA and the cooperating governments, between those governments and the contractors operating the DSCCs, and likely some local agreements (labor, utilities, etc).

Secondly, the changes will require a well-planned transition of staff as the DSCC's role is focused on maintenance (and perhaps engineering) and less on 24x7 operations.

Thirdly, the change will require a significant number of new procedures and many hours of training. Someone has compared making changes in a 24x7 network to fixing a locomotive's engine while moving at full speed – no simple and risk-free feat.

6.0 Summary

The DSN has embarked on an effort to reduce the cost of real-time operations through remoting and moving to three-links-per-operator. In this paper we explored key elements and challenges in this effort.