PREPARING THE DSN OPERATIONS CONCEPTS

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ABSTRACT

Operations concepts are prepared to support a specific application and can, therefore, be classified accordingly. Studies of NASA and military operations concepts suggest three major types: data services, customer services, and systems oriented. Data services concepts concentrate on data types (e.g., telemetry and command) and how these data are processed and delivered to the user. Such concepts are normally used by data-processing centers to describe data-coding schemes and data formats. Customer services concepts concentrate on the customers' requirements and describe how these requirements are met using the systems available to the operation. Project centers use such concepts to describe the various types of data as they flow from the source (e.g., a spacecraft) to the end user (i.e., the customer). Systems oriented concepts concentrate on the use of systems for processing and delivering customer data. This paper examines the latter type and the "concepts" that are inherent within them.

Key Words: Network operations, system requirements

1. THE ERA OF APPLICABILITY

The era of applicability for any operations concept is directly related to its purpose. If the purpose of an operations concept is to describe operations in the present environment, then its era of applicability is now, until the environment changes. But if that purpose is to guide the system development activities and establish the amount of operational resources required to operate the network, then its era of applicability is some time in the future.

1.1 Operations in the Future

System oriented concepts are better suited for environments that change over time, in preconceived ways. The Deep Space Network (DSN) is such an environment, and its operations concept was chosen so that its system design plans satisfy the primary requirement of maximizing services to DSN customers.

1.2 Selecting the Era

To choose the era of applicability, one must know the design plans for the network. For example, the DSN plans call for a slow evolution from extremely complex operations to increasingly automated systems that will be easier to operate. The changes are planned to occur over the next ten years, and thus the era of the operations concept was chosen to be midway in that evolution. About five years hence, operations of the network will be different from today's, yet not so different that today's operations cannot be recognized. If the plans hold, it should not be difficult to derive from the operations concepts the amount of operational resources required to operate the network.

2. BEGIN WITH THE BASICS

An operations concept, whether prepared for a data-processing center, project operations, or a tracking network, must begin with a definition of the basic purpose for which the entity was created. This must be done first in order to build the foundation of the operations.

2.1 An Example — the DSN

The basic definition of a tracking station's purpose is that a spacecraft tracking network

exists for network customers to communicate with their spacecraft. In other words, the network is the vehicle for obtaining data from a spacecraft, for sending data to a spacecraft, and for providing tracking data to help the customer navigate the spacecraft. The network must therefore provide the means for accomplishing these tasks, always striving for one-hundred percent customer satisfaction. The relation of this operations requirement to the design of network systems is implicit.

2.2 Building the Foundation

Before constructing an outline, the most critical operation (i.e.,the foundation of the operations concept) must be defined. The best way to do this is to begin with the basics and chart out the process from beginning to end. For example, in the DSN data are acquired, preprocessed, and delivered to the project centers or the spacecraft. The spacecraft data must be acquired for the other processes to exist. Therefore, one can emphatically state that data acquisition (including radio frequency signal acquisition) is the most critical operation. The foundation for the DSN operations concept then is data acquisition, as performed by the tracking antennas and front-end systems at the tracking complexes.

2.3 Using the Foundation

Having identified the critical operation, the next step should be to describe this operation. This should be fairly simple for operations concepts that describe operations of current systems. The task is more difficult for operations concepts that describe operations of partially implemented and future systems. Obviously, this will take a considerable amount of time and coordination. Other concepts, described below, must be also be considered, and if necessary, solidified.

3. OTHER CONCEPTS

3.1 The Congruency Factor

The DSN continues to do everything possible to satisfy the end customer. In the past, this objective was accomplished by designing systems that provided the required technical capabilities with little regard for what it took to operate them. System operability was considered, but these capabilities were, as a rule, determined by the large amount of operations resources available at that time and the simplicity of the systems. However, as systems requirements became more stringent, network systems became more technically complex and thus more difficult to operate. It is understood that systems of this type will always have flaws, regardless of how careful the designers might have been. Experience also shows that the more complex the systems are, the more complex the flaws are, and the harder it is to develop "workarounds" or to fix them.

3.2 New Strategies

Recent directions are stimulating questions such as, How will the system designers ensure that the impact of any flaws is minimized? How will the designers ensure that data return to the end customer is maximized? This is where investment in an operations concept of the type described here will pay large dividends later. Knowing how the system will be operated in order to fulfill the basic purposes for which the center or network was created is another form of stating operational, and hence customer, requirements.

3.3 On Systems Capabilities

The operations concept should not have to acknowledge design flaws and deficiencies and allocate resources accordingly to operate, maintain, and sustain the network around them. Clearly, this is a waste of budgets and resources. Should the operations concept therefore "define" the type of systems that will reduce operational costs and increase data return to network customers? We contend that describing "workarounds" to account for system deficiencies is simply a way of describing system deficiencies. Thus, the rules for designing systems that operations may use must first be changed for the operations concepts to have any effect.

3.4 The Concept of Service

Businesses have shown us that the ability to make strict definitions is the direct result of making right or wrong assumptions. These assumptions lead to definite commitments by management as to where, when, and how much of a company's resources are to be deployed to increase sales, and thus are the key to profitability. In technical applications, such as the DSN, profitability is not a motive, but the deployment and use of resources to provide the best possible service to its customers is of paramount importance to network businesses. The operations concept, like its counterpart, the operations plan in a business, must identify how resources will be utilized to increase network (i.e., product) availability without increased costs. This means that it is necessary to define concepts that best fit the "industry" and to demand that systems be made more capable, robust, and operable.

3.5 Using the Service Concepts

The term "service" is often used in various contexts to describe the operations of a center, or network. Defining service is key to the way in which an operations concept will be prepared. One may begin by establishing a distinction between "data services" and "network services." Data services include telemetry data service and command data service. Network services, on the other hand, refer to the data services modified by the "goodness" of the resources that provide the data services. It could be argued that the data services encompass network services, but that depends on one's perspective. That is, "data services" (of the network) are most likely defined from the customer's perspective, while "network services" are defined from the perspective of network operators and customers alike. A tracking network's operations concept comprises more than data flowing from A to B—it accounts for the hardware, the software, the procedures, and the people who satisfy the requirements of network customers—a strict definition.

3.6 The Meaning of Transparency

With the present technology, it is possible for a spacecraft user (an experimenter) to sit at home and utilize command data services to send command data to his or her instrument on board a given spacecraft. He or she may also utilize telemetry data services to receive data from the instrument. In this case, the user does not have to worry about transmission protocols, nor concern himself or herself with how the data get to the spacecraft and back. So, as far as the user is concerned, the network is transparent. However, for the Project Operations Control Center (POCC) and the tracking network, such is not the case. Realistically, the user's command and spacecraft data (for spacecraft safety and security reasons) are preprocessed by the POCC and the network. The handshake between the POCC and the network is an established interface—strict and unforgiving. Therefore, from the operations concept standpoint, the network is not transparent, and the interfaces, as well as all the factors affecting these interfaces, must be allocated within the overall cost of operations.

3.7 The Interfaces

The operations concept must address all interfaces and describe how they will be operated in a particular era. The description should include the fact that the funnel (i.e., the network) can choke any data passing through it. That is the best way to illustrate that the network is transparent only when all data are delivered to the customer. When data are lost, the network is no longer transparent. The operations concept must include such facts as well as the desired recovery activities that will minimize future data loss.

3.8 On Data Latency

Does it make sense for a network to record the data and play it back to the customer at a later time, or to transmit the data to the customer as soon as it arrives in the network (i.e., in real time)? If it is indeed true that the

higher the latency, the higher the cost, then what is the latency, or cost trade-off, that our network can afford? The job of our operations concept writers is by no means easy—the answers to questions like this are constrained by system capabilities and management direction. The operations concept must address these types of issues because to be cost-effective is to deliver products to the customer quickly and economically.

4. BUILDING THE FRAMEWORK

4.1 Extensible Facilities

Extensible facilities complement the basic operation. For example, in the DSN these facilities are the Ground Communications Facilities (GCF) and the Network Operations Control Center (NOCC). Any support facilities and their functions should also be described. In the DSN, the extensible facilities include the DSN Logistics Facility (DLF), the Complex Maintenance Facilities (CMF), and the Depot Maintenance Center (DMC). Each of these facilities plays a significant role in all network activities. Without them, the basic operation would not be able to meet customer requirements.

4.2 Facility Interfaces

The operations concept must describe the internal and external interfaces for all the on-line facilities. The description should not be at the bit level; other documents exist that provide these details. Rather, the description should concentrate on how the interfaces are used and the products that these interfaces support. The aim is to provide system designers with a basic knowledge of operations to make network designs more effective and less costly.

4.3 Network Availability

Network systems availability is key to the quantity, quality, and timeliness of data delivered to network customers. Of course, the goal is 100 percent, but this figure is reduced by the negative characteristics of the systems' performance-modifying factors: operability, reliability, and repairability. Availability can be increased by the use of redundant systems, but these systems do not improve operability, reliability, or repairability.

4.3.1 Reliability

The operations concept cannot contribute much toward highly reliable systems designs. No matter how reliable a system is, someday it will fail. Providing data to designers after the fact is, however, a significant operations role which should be addressed in these types of operations concepts.

4.3.2 Operability

More can be said about highly operable systems. Descriptions of reduced complexity in the human interface of the systems should be included. In the DSN, the trend is toward high-level operator commands, high-level displays, and manageable lower level displays. Thus, the activities described in the DSN operations concept assumes that these capabilities already exist and are guiding the design of operable systems.

4.3.3 Repairability

A true measure of repairability is the mean-time to repair (MTTR). This measure of MTTR is a figure of merit that indicates how well systems maintainers were trained on systems' maintenance and operations. It also indicates how well the systems were spared and the quality of the tools provided for system repair. More often than not for new designs, the operations cost is assumed to be the same as that for the operation of current facilities. Thus, if properly prepared and used, the operations concept can play a significant role in the allocation of design costs. Typically systems maintenance requires a large operations budget. Maintenance costs can be minimized with a sound maintenance philosophy. Therefore, we suggest the use of an operations concept to promote this philosophy at a high level. The operations concept must candidly describe how maintenance of these systems will be performed and what spares and maintenance tools must

be provided for the maintenance program to be effective.

4.4 On Customer Requirements

In the DSN, the implementation of customer requirements is based on the ability to satisfy the technical and operational requirements. The operations concept must distinguish between these requirements clearly and concisely. Operations play a role analogous to frontline salespeople in business, relaying customer requirements to product designers. The thought here is that ultimately, operations (the salespeople) will be blamed for the quality of the product, and not development (the product designers).

5. CONCLUSION

We have described the types of operations concepts, provided a definition for each one, and then attempted to document the concepts that should be considered with the third type, the systems oriented operations concept as used in the DSN. We have provided concepts that could be useful in preparing operations concepts of this type. We have used the DSN example, defined its basic operation as the foundation, and then followed through by completing the framework. By sharing our experiences, we hope to have outlined some of the pitfalls and problems associated with this task. Whatever type of concept is used, an operations concept is by no means easy to prepare—the support of management is essential.

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