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Preliminary Concept of Operations for the Deep Space Array-Based Network

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The Deep Space Array-Based Network (DSAN) will be an array-based system, part of a >1000 times increase in the downlink/telemetry capability of the Deep Space Network. The key function of the DSAN is provision of cost-effective, robust telemetry, tracking, and command services to the space missions of NASA and its international partners.

This article presents an expanded approach to the use of an array-based system. Instead of using the array as an element in the existing Deep Space Network (DSN), relying to a large extent on the DSN infrastructure, we explore a broader departure from the current DSN, using fewer elements of the existing DSN, and establishing a more modern concept of operations. For example, the DSAN will have a single 24 × 7 monitor and control (M&C) facility, while the DSN has four 24 × 7 M&C facilities.

The article gives the architecture of the DSAN and its operations philosophy. It also briefly describes the customer's view of operations, operations management, logistics, anomaly analysis, and reporting.

I. System Architecture

A. Introduction

The Deep Space Array-Based Network (DSAN) is part of a >1000 times increase in the downlink/telemetry capability of the Deep Space Network (DSN), as given in Table 1. The key function of the DSAN is the provision of telemetry, tracking, and command (TT&C) services to the space missions of NASA and its international partners.

The DSAN will be deployed at three sites at, or near, the longitudes of the existing DSN sites. The architecture of the DSAN is shown in Fig. 1. DSAN Central is connected to the three Regional Array Centers (RACs), one at each of the three longitudes. Each RAC is connected to a cluster of downlink antennas at that longitude and to one collection of uplink assets. To improve weather immunity, additional

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Table 1. Components of the >1000 increase.

Source improvement	Level of improvement	Comments
G/T due to area	×10	Three sets of 400 12-m antennas, ten-fold increase in collecting area relative to the 70-m subnet
G/T due to frequency increase	×4	Transition from X-band to Ka-band
Spacecraft components	×50	Move to 10-m inflatable antennas
	×25	Move from a tens of watts transmitter to a few kilowatts transmitter power

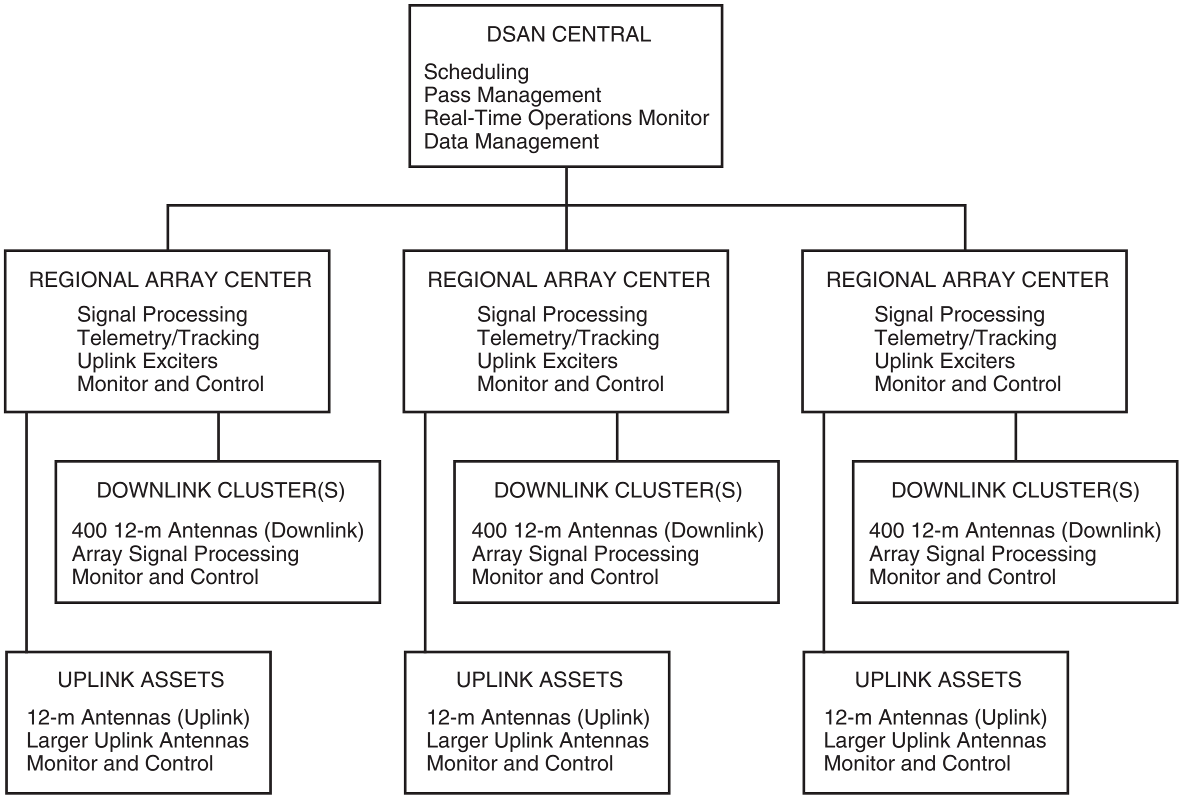


Fig. 1. DSAN block diagram.

clusters may be located farther from the RAC, but the first cluster at each longitude will be colocated with the RAC. Each cluster will include 12-m antennas for receive [downlink only, at 8.4 GHz (X-band) and 32 GHz (Ka-band)], a total of 400 12-m antennas per longitude. The cluster also will include the electronics and facilities needed to support the facility.

Uplink assets will be associated with the RAC and will support the cluster(s) in the longitude. Initially, the DSAN will rely on the DSN uplink assets. Later, the DSAN could use a few (6 to 8) 12-m antennas with a to-be-determined (perhaps 3.5-kW) X-band transmitter on each antenna and a few (2 to 3) larger (possibly 34-m) antennas. Arraying of uplink signals is not baselined in this concept of operations (ConOp) but may be added later, subject to technology feasibility validation and evaluation of cost effectiveness.

The cluster(s) will occupy approximately 2 to 4 square miles, including the downlink antennas, processing facility, and support facilities. Uplink assets may share physical location with the cluster or may be physically elsewhere.

Most TT&C applications will use arrays of 12-m antennas for downlink and a single 12-m or 34-m antenna for uplink. "Very high" uplink power will be used rarely, e.g., for emergencies, and could represent (due to its rarity) an exception to the "hands-off" operation.

If 34-m antennas are included to meet uplink needs, they will be equipped with limited downlink capability so that radio science observation or other non-standard science capabilities, like low Allan standard deviation (ASD)/phase noise performance, can be supported.

The DSAN ConOp should allow for straightforward, modular expansion of the downlink capability by adding clusters and/or antennas and/or uplink assets. Under consideration are the following possible expansions:

(1) Addition of Ka-band transmitters on 6 to 8 antennas

(2) Addition of solar system radar capability on a to-be-determined (TBD) number of antennas

(3) Addition of 2.3 GHz (S-band) capability

(4) Addition of near-Earth Ka-band capability (26 GHz)

B. Operations Approach

1. The Link and the Pass. In this ConOp, links and passes are the basic components of DSAN support, used in a similar way to their use in the current DSN.

A pass is a continuous period of support. The support can be to a single customer or multiple customers (the latter occurs in relay operations and in multiple spacecraft around a planet (MSAP) scenarios). Each pass contains periods of setup and teardown before and after the actual tracking support.

A link is defined as the logical aggregation of assets for a pass. A link will consist of some dedicated assets (antennas, arraying equipment, transmitters, and telemetry equipment) and portions of shared assets (frequency and timing systems (FTS), communications lines, switching equipment). The link gets formed in the beginning of the pass, from assets in a general pool, and is dissolved after the pass, returning the assets to the general pool. A link can include assets in a single cluster, multiple clusters, or even multiple regions.

When the teardown of one pass is immediately followed by the setup of the next pass, potential efficiencies could be achieved by reducing the transition between passes. The DSAN will incorporate pass-combining optimization for such scenarios if it is cost effective to do so.

2. The Antenna as a Line Replaceable Element. The DSAN will, to the extent possible, treat an antenna as a line replaceable element (LRE). If the antenna becomes unusable during a pass due to a mechanical or electronic component (and cannot be restored to service quickly), the support will continue with the remaining antennas, if the margin allows, or another antenna will be brought into service. The fault isolation and restoration will be deferred to the next 8×5 shift. The antenna allocation process will include provision to add reserve capacity consistent with the criticality of the supported event.

3. Automation. The DSAN will not be operated as a "lights-out" network—the complexity of space operations, and the uniqueness of each mission, would make such a capability not cost effective. Instead, this ConOp is based on having a small number of 24×7 personnel at DSAN Central and the RACs. Automation will be focused on providing real-time, and non-real-time, tools that will handle, without human intervention, nominal operations and selected non-nominal failures, and will free the 24 × 7 staff to attend to non-routine events.

Automation tools also will be provided for the non-real-time operations, both to reduce the manual/human intervention and to enable extensive data mining in the resulting data bases.

4. Operations Philosophy. This ConOp is based on the following assumptions:

(1) The DSAN will maximize schedule-driven operations and minimize human-in-the-loop intervention. Real-time operation staffing will be 24 × 7 only at the DSAN control, primarily to monitor schedule-driven operations and correct exceptions. The RACs will have 24 × 7 staffing for light repairs, if needed to meet reliability/maintainability/availability (RMA) requirements.

(2) Resource allocation will be performed online, based on a priority algorithm approved by NASA Headquarters, with minimal human intervention at the central DSAN facility.

(3) Setup, start, execution, and teardown of passes will be schedule- and script-driven and will not require human intervention. The customers will be responsible for providing correct mission parameter files (MPFs) to drive the passes; the DSAN will not plan on staff to respond to real-time verbal or e-mail updates. Note that the MPF should require little knowledge of the deep-space mission system (DSMS) hardware. It should include data on spacecraft, modulation formats, and data rates, and a timeline of spacecraft events, not directions on how to configure specific DSMS assets. The DSAN may provide tools (e.g., "friend of the telescope") to perform a sanity check on the input data before the pass.

(4) The DSAN hardware and software will be configured based on the customer inputs, or data automatically derived from it, and will not require human intervention for normal TT&C passes.

(5) Output data will be stored automatically for a pre-specified duration in a to-be-determined format, and authorized users can directly access their data (after proper user authentication).

(6) Monitor and control of the DSAN will be via Web interfaces, with access available to authorized users (customers, DSAN real-time and non-real-time staff, management, etc.) through an Internet connection, from any location where such a connection exists.

(7) When practical, the DSAN will allow easy replacement of hardware and restoration of service by employing simple interfaces and maximum use of self-configuration of new hardware and software components ("plug and play").

C. Regional (RAC/Cluster/Uplink) Architecture

The components of the regional assets are shown in Fig. 2. Each of the 12-m downlink antennas will have right circular polarization (RCP) and left circular polarization (LCP) capability at X-band (8 to 8.8 GHz) and RCP and LCP capability at Ka-band (31.8 to 38 GHz). Each antenna will produce two simultaneous intermediate frequency (IF) signals with selectable polarization and frequency band, each with up to 500-MHz bandwidth. (An option is that each antenna will produce all four simultaneous IF signals.) The IF signals from all antennas in a cluster will be brought together to the cluster control building for further signal processing.

The signal processing equipment for each cluster will produce up to 16 phased-array signals with one antenna contributing to a maximum of four phased-array beams at a time. In the initial deployment, each phased-array signal would represent a (sampling) bandwidth from 125 kHz to 128 MHz, within the 500-MHz bandwidth of the antenna IF signal. Subsequently, if the mission needs justify it, the digital

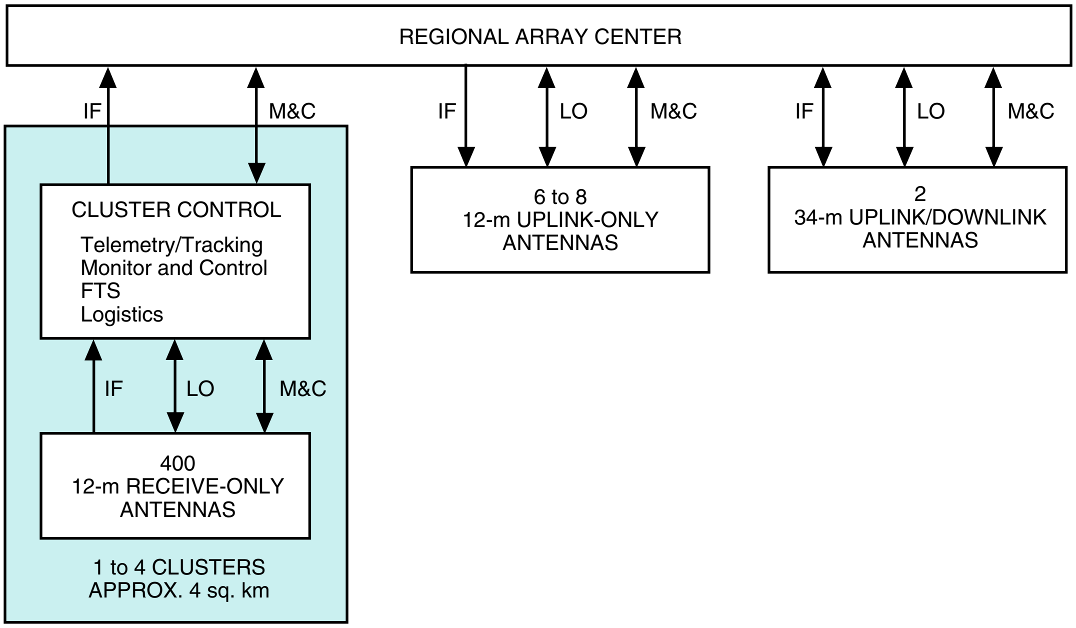


Fig. 2. DSAN cluster block diagram.

electronics can be upgraded to the full 500-MHz bandwidth. IF bandwidth expansion beyond 500 MHz, if required, will necessitate upgrade of the downconverter/IF, local oscillator (LO) electronics, and the digital electronics.

The phased-array IF signals will be routed from the cluster(s) to the RAC. At the RAC, there may be further arraying of the IF signal from the cluster(s)s if inter-cluster arraying is required. The resulting IF signals will be routed to DSN-type or commercial telemetry processing equipment at the RAC to produce Consultative Committee for Space Data System (CCSDS)-compatible-format telemetry and tracking data. The same IF signals may be routed to other special processing equipment (e.g., very long baseline interferometry for delta differential one-way ranging) at the RAC.

There also will be a correlation capability to measure autocorrelation and cross-correlations between IF signals from individual antennas over any part of the signal with bandwidth ranging from 125 kHz to 512 MHz using 2-bit correlation. The correlator is required for smooth operations and calibration of the array and may enable use of the array for emergency search for a class of “lost” spacecraft.

The uplink antennas may be physically separated from the downlink antennas to minimize radio frequency interference (RFI) and regulatory concerns. In Fig. 2, the uplink assets are shown as separate assets. Note that, once uplink arraying is proven, the uplink capability could share antennas with the downlink capability.

When a 34-m antenna is used with the array, its receive system will be useable as part of the receive array (i.e., a 34-m antenna will be one of the receive elements in the array).

The DSAN will include safety devices and procedures to ensure that the equipment and the operations do not pose a risk to the staff and equipment and to surrounding areas, including the air space. This is particularly critical for the uplink assets of the DSAN.

D. DSAN Central Architecture

1. Real-Time Operations. In general, the generation of TT&C products (e.g., frames for telemetry, radio-metric observables for tracking) will be script- and schedule-driven, without a requirement for human intervention. The operator at DSN Central will oversee all the processing, whether done at the cluster or the RAC, but will intervene only during anomalies or when an override is required.

Processing at DSAN Central is required only for the cases that require participation of multiple regions, such as

(1) Three-way Doppler and ranging between regions
(2) Automatic acknowledgment protocols
(3) Handover between regions

Again, the processing at DSAN Central will be schedule-/script-driven.

2. Non-Real-Time Operations. DSAN Central will perform several functions in addition to overseeing the real-time operations of the assets in the three regions. Most of these functions will be controlled by software/scripts. The following list identifies which functions will be performed by the 24 × 7 staff and which by the 8 × 5 staff:

(1) Priority and array time allocation: software-/script-driven, with overrides by the 24 × 7 staff
(2) Resource allocation and scheduling: software-/script-driven, with overrides by the 24 × 7 staff
(3) Validation of customer-provided MPFs: software-/script-driven, with instant feedback to the customer
(4) Generation of observation control files (OCFs): software-/script-driven
(5) Addition of pre-pass and post-pass calibrations to OCFs, if required: software-/script-driven, with overrides by the 24 × 7 staff
(6) Instrument calibrations and routine test observations (passes): 8 × 5 staff
(7) Maintenance of calibration catalogs and tables: 8 × 5 staff, with support of software/scripts
(8) Maintenance planning: 8 × 5 staff, with support of software/scripts
(9) Data calibration: 8 × 5 staff, with support of software/scripts
(10) Data quality analysis: 8 × 5 staff, with support of software/scripts and engineering staff

3. Inter-Cluster and Inter-Region Operations. The DSAN will have the following limitations on inter-cluster and inter-region operations:

(1) The DSAN will have the ability to array IF signals between clusters. However, the DSAN will not have (in the baseline configuration) a capability for routine arraying of IF signals from multiple regions.
(2) The DSAN will have a limited capability to array IF signals from multiple regions for delta differential one-way ranging (DDOR) type of activities.

II. Staffing

A. Approach

The DSAN will have staffing at the DSAN Central, at the RACs, and at the clusters.

B. Roles and Staffing Levels (Initial Estimates)

Figure 3 shows the estimated staffing levels for a full DSAN with 3×400 12-m antennas and the ancillary uplink assets.

DSAN Central real time will be staffed by five 24×7 operators. The operators will monitor real-time performance and intervene if needed. Recall that the default is for the passes to be run from the schedule, and the customers are responsible for the provision of correct inputs via proper MPFs.

Across all assets in a longitude (RAC, clusters, uplink) there will be 8×5 staff who will perform all the maintenance on the 400 12-m antennas, the uplink antennas, and the other equipment. Estimates of work hours, from an independent reliability assessment, are under development. It will depend on the spacing between the assets and on whether the same staff can handle all the assets or several staffs will be needed for the various physical sites. These staff members will handle the logistics and perform the first level of failure analysis and corrective actions (see Section V.A).

DSAN Central non-real-time operations will be staffed by 8×5 positions. This staff will conduct customer interfaces, handle the logistics, and perform analysis, as needed.

DSAN Central will be supported by an engineering organization that has the ultimate expertise in the details of the equipment. This staff, in addition to designing and deploying new equipment, will be available to provide support to the staff at the RAC/clusters, and to conduct the final root-cause analysis and closure of failure/anomaly reports (FARs) (Section V.A).

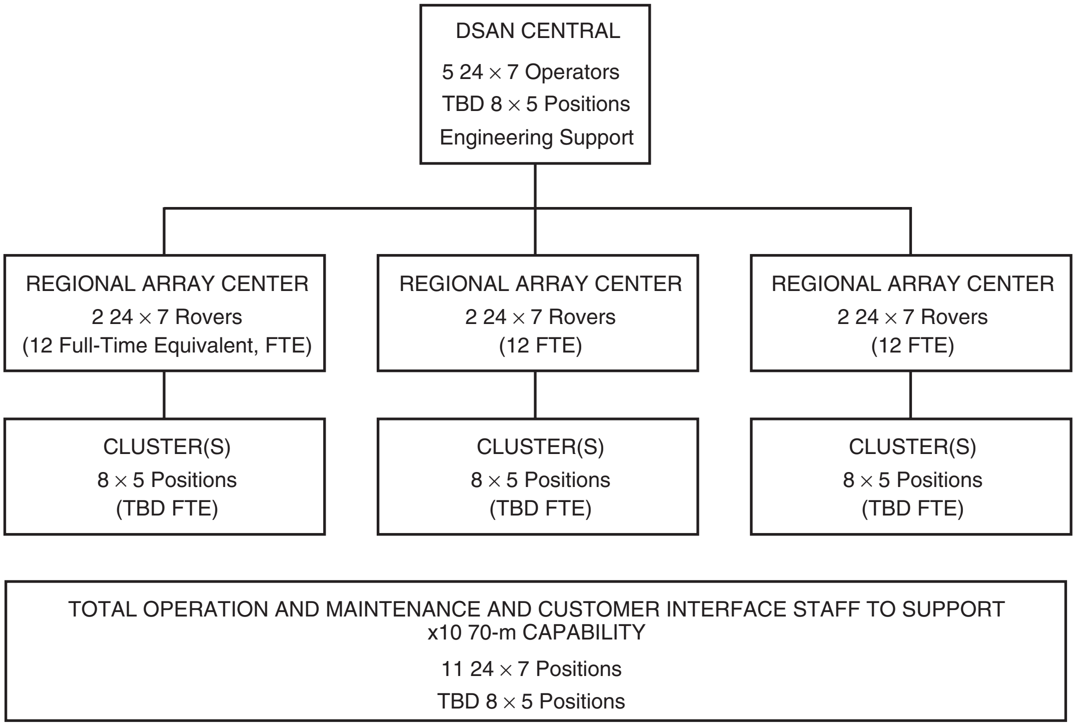


Fig. 3. Staffing levels for the DSAN.

At the RAC, there will be two 24×7 rovers. The rovers will be authorized to perform light maintenance (e.g., some board replacement) as needed to keep the system operational. With experience, and better RMA data, the need for the rovers will be reassessed.

III. DSAN Operations—Customer View

A. Scheduling

1. Scheduling. Customers will be assigned passes and priorities on-line. The allocation process will incorporate a Headquarters-approved priority algorithm.

2. Validation. Once the pass has been allocated, the customer will submit a mission parameter file (MPF) in a pre-defined format. (The MPF is likely to be limited to the parameters that the mission must define.) The DSAN will validate the MPF and reject any deficient MPFs, with a notification to the customer. Passes without a validated MPF will not be executed. The correctness of the parameters in the MPF is the user's responsibility. The customer can update the MPF as often as needed; however, updating the MPF during the pass may result in data discontinuity and/or loss of data.

B. Real-Time Operations

During the pass, the customers will be able to supply modified MPFs, if needed, to be applied by the DSAN (see Section IV.B). The customers also will be able to monitor the progress, using a subset of the monitor displays available to DSAN Central.

C. Post-Pass Operations

After the pass, the customers will get a pass report accounting for the actual performance of the DSAN, as evaluated by the DSAN. The customers also will be encouraged to feed back to the DSAN, as soon as practical, any discrepancies they identified in the pass results. Note that some discrepancies in the DSAN cannot be detected without active feedback from the customers, e.g., errors detectable only by comparing radio-metric data to the actual trajectory.

IV. DSAN Operations—Pass Management

Staff at the central DSAN facility, and any authorized person with Web access, will be able to observe selected DSN monitor data and access a real-time view of DSAN assets through closed-circuit TV, wherever practical, and to call for help in case of emergency.

A. Functional Modes

1. TT&C. The most common operational mode will be TT&C. The DSAN will have telemetry, tracking (ranging, Doppler, DDOR), and command capabilities, with largely the same functional capabilities as those of the DSN, but at significantly higher telemetry and command rates.

2. Calibration/Science. A less common operational mode will be the calibration/science mode. This mode will be used for clock calibration, antenna location determination, array gain and delay calibration, and direct acquisition of radio-science data, etc. The DSAN will have largely the same functional capabilities as those of the DSN.

3. Maintenance and Testing. Maintenance and testing generally will be conducted during times (and with assets) that are reserved on the schedule for non-operational use.

4. User-Controlled Mode. The DSAN will allow for a set of assets to be partitioned and assigned to a user for a non-operational (or non-committed) pass. In a user-controlled pass, the user takes the responsibility for operating these assets and for the success of the pass. The DSAN operators are involved only as needed to ensure equipment and personnel safety and compatibility with the other users during any overlaps.

B. Operations Scenarios

The following is an example of activities for a standard spacecraft pass.

(1) A customer (user) requests a DSAN pass using a Web interface. The request generally will be focused on time and capability (e.g., required G/T), not on specific assets.

(2) The DSAN validates the completeness of the request and either asks for a corrected request (if an error is found) or acknowledges acceptance of the request (if the request is error-free).

(3) The DSAN assigns priority and commits certain capability based on a Headquarters-provided algorithm and the resources available.

(4) The DSAN schedules the requisite allocatable resources (primarily antennas, but they also could include array signal processing and telemetry equipment, communication bandwidth, etc.). These are documented in a resource allocation file (RAF). The RAF may contain reserve equipment, if it is a high-priority pass.

(5) The user prepares and provides an appropriate MPF in advance of DSAN scheduling. The DSAN checks the MPF and informs the user of any problem with its validity.

(6) Prior to the pass, DSAN scheduling merges the user-provided and validated MPF with the RAF containing resources allocated to the pass, and generates an observation control file (OCF), as shown in Fig. 4.

(7) The link is formed, based on the schedule, by drawing equipment from the equipment pool, and the pass is conducted, including setup and calibrations.

(8) During the pass,

    (a) The equipment performance and status of the pass can be checked by the customers, operators, and other interested (and authorized) parties, by way of monitor data accessible using the Internet.

    (b) The customer can make changes to the MPF, if needed. Any change then is sent to DSAN Central, where it is automatically merged with the RAF to generate a new OCF. The DSAN will be designed to minimize the adverse impact of the change, but it should be noted that at times the change will interrupt the data flow. An end-to-end change should last no more than about one minute from the time the customer submits the updated MPF until it is applied at the cluster.

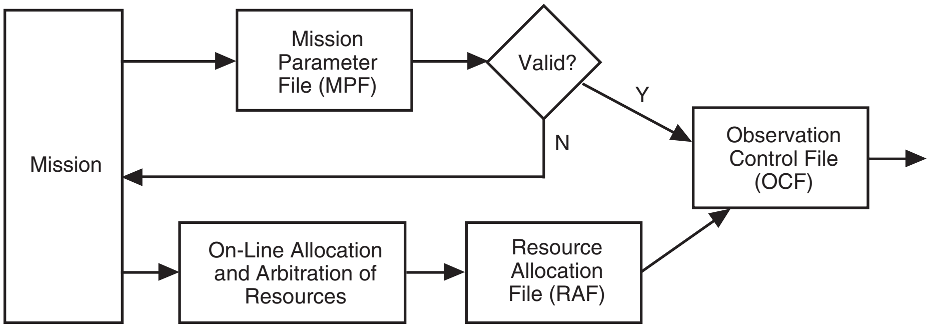
    (c) If performance falls below the committed level, reserves (if available) are applied by an internal DSAN process.

(9) At the end of the pass (including post-pass calibrations), the assets are released to the equipment pool.

C. Post-DSAN Processing and Feedback

To the extent practical, the DSAN will conduct consistency checks on the collected data and either take automated corrective action or report discrepancies. Examples are checking for missing telemetry blocks or checking (and eliminating) outliers in radio-metric data.

However, some flaws caused internally to the DSAN cannot be detected internally by the DSAN. A typical case could be a flaw in the ranging/Doppler data that can be detected only when the navigators



- RAF defines the resources that require an allocation (antenna, communication capability, etc.)
- MPF defines the pass parameters, which the mission must define.
- MPF and RAF can be produced long before the pass or during the pass.
- OCF is generated just-in-time.

Fig. 4. Scheduling and support product generation.

compare the ranging/Doppler data to the trajectory data. The feedback from the post-DSAN analysis will be provided through an FAR and will be processed using the FAR process described in Section V.A.

D. Definitions of Event Criticality

The DSAN will use the same event criticality definitions as the DSN.

E. Non-Sequence Operations, Emergencies

The DSAN will process spacecraft emergencies in a similar manner to that of the DSN. The key difference is that the decision process by which allocated assets will be de-allocated, if needed, and assigned to the spacecraft in need of emergency support will include the Headquarters-defined priority algorithm.

The DSAN will have a limited capability to identify deviations from the spacecraft sequence (MPF) and notify affected parties. This will include events such as loss of signal due to safe mode. Response to these non-sequence events will require human intervention.

F. Weather Resilience Approach

The DSAN will be designed to accommodate degradation due to weather by using spatial diversity and inter-cluster arraying. The DSAN will use inter-cluster arraying to increase immunity to weather if the clusters are spaced apart so they reside in different weather cells. A detailed methodology is to be determined.

G. Setup and Teardown Approach

Each pass will have a period of setup and a period of teardown. During setup, the following activities will be conducted:

(1) Construction of a link, i.e., assigning assets to a link

(2) Creation and receipt, at the RAC and cluster, of equipment configuration data

(3) Configuration of all equipment, based on the configuration data

(4) Other preparations, range calibration, moving of antennas, warm-up of transmitters, etc.

During teardown, the reverse will be conducted as needed for the next use of the equipment. The following will guide the setup/teardown: Setup time will not exceed 15 minutes (5 minutes for more than

95 percent of the passes), plus the time to move the antennas and warm the transmitters. Teardown time will not exceed 5 minutes, plus the time to move the antennas and restore the transmitter to a standby state.

H. Demand-Access and Beacon Mode Operation

In demand-access and beacon mode, the spacecraft will initiate an unscheduled transmission, either confirming a healthy state or alerting the mission operations center that attention is required. The beacon, or demand-access signal, is either a tone or a very low data-rate signal that can be detected with a smaller ground antenna.

The DSAN will support detection of demand-access and beacon mode signals. The support normally will be provided by a single 12-m antenna. The method of requesting the service is to be determined. The DSAN will not provide automated response; it will be the mission's responsibility to define the response and issue appropriate support requests to the DSAN.

V. DSAN Operations—Logistics

A. Maintenance Philosophy

To the extent possible, the DSAN will leverage the fact that there will be a large number of identical 12-m antennas to simplify the maintenance process and decouple maintenance from operational commitments. (The DSN antennas tend to be unique; thus, the decoupling is more difficult.) As a goal, the DSAN will reserve 5 percent of the antennas, at any time, to be in a maintenance pool.

The technical staff at the clusters (including RAC and uplink assets) will work 8 × 5. However, contractual provisions will be included to facilitate the presence of staff at the clusters during critical events. The key roles of the cluster staff will be the maintenance and repair of hardware and the initial disposition of the FARs.

Cluster staff will have access to monitor data, test tools, and suitable checking algorithms to support these roles. Cluster staff also will conduct array calibrations and diagnostic observations periodically or as needed to pinpoint problems. There will be three levels of repair:

(1) Equipment swaps and simple repairs can be performed by the 24 × 7 rovers. Recall that the design will incorporate redundancy to minimize the need for intervention by the rovers.

(2) More complex swaps and modest repairs will be done/coordinated by the 8 × 5 cluster staff, either during the regular working hours or, in rare cases, during an emergency visit to the cluster.

(3) More complex repairs ("depot level") will be done by the original vendors (or by the engineering staff), coordinated via the logistics function at DSAN Central.

B. Shipping and Inventory

The DSAN will use a methodology for shipping and inventory similar to that used by the DSN. The DSAN will investigate whether the DSN tools and processes can be adopted as is.

C. Spares Management

The DSAN will use a method for spares management similar to that used by the DSN. The DSAN will investigate whether the DSN tools and processes can be adopted as is.

D. Configuration Management

1. General. The DSAN will use a method for configuration management similar to that used by the DSN. The DSAN will investigate whether the DSN tools and processes can be adopted as is.

2. Software. All configuration of the operational software will be managed centrally and will be installed across the DSAN remotely by the central configuration management (CM) organization. Non-operational software may be installed locally under to-be-determined CM.

E. Non-Antenna Facilities

The DSAN will handle non-antenna facilities (roads, buildings, power, etc.) in a manner similar to that used by the DSN. The DSAN will investigate whether the DSN processes can be adopted as is.

F. Physical Security

The DSAN will handle physical security in a manner similar to that used by the DSN. The DSAN will investigate whether the DSN processes can be adopted as is.

G. Information Technology Security

The DSAN will handle information technology (IT) security in a manner similar to that used by the DSN. The DSAN will investigate whether the DSN processes can be adopted as is. However, the DSAN will rely heavily on multi-layered authenticated access via the Web and will deploy IT security assets accordingly.

VI. DSAN Operations—Analysis and Reporting

A. Failure/Anomaly Report Processing

1. General. The DSAN will use a single failure/anomaly report (FAR) processing/tracking system to capture failures, anomalies, or other issues/concerns in hardware, software, procedures, documentation, and data capture and delivery (discrepancy report).

FARs will be tracked and closed. Closure could be via repair of hardware, new hardware design, new software, updated procedures or documents, or acknowledgment that the root cause is outside DSAN control (e.g., weather, RFI, or spacecraft event). The FAR tracking system will be an on-line system and will be accessible worldwide via the Web.

2. Roles and Responsibilities. Roles and responsibilities for reporting and analysis of failures and anomalies will be as follows:

(1) Opening a FAR: All personnel in the DSAN are authorized, and encouraged, to initiate FARs. The FAR system will be available to entry by user/customer representatives.

(2) Initial processing of FARs: Initial processing will be by the 8×5 staff at the RACs/clusters. We estimate that 90 percent or more of the FARs will be resolved by the RAC/cluster staff.

(3) Final processing and closure of FARs: The final root-cause analysis and the confirmation of closure will be conducted at DSAN Central.

B. Reporting Metrics

Both standard and customer reporting metrics will be created.

VII. Re-Use

To enable cost-effective initial development and expansion, the DSAN will re-use elements wherever possible. For example, all of the 12-m antennas will use the same mechanical structure, servo drive, and control software. They may be modified for X-band uplink, X-/X-/Ka-band uplink/downlink, Ka-band uplink, S-band uplink/downlink, 26-GHz uplink/downlink, or other applications through the use of different feeds and electronics, but the mechanical structure and drive hardware and software will be the same.

VIII. Summary

This article described current ideas for the architecture and operations concept for the Deep Space Array-Based Network. It is at Revision B level at present and will be further refined; a revised version(s) will be issued as it becomes available.