Networks Consolidation Program: Maintenance and Operations (M&O) Staffing Estimates

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This article describes the method used to make the initial estimation of M&O staffing for the DSN Mark IV-A design.

I. Introduction

The current Deep Space Network (DSN) configuration, designated Mark III, will be undergoing major changes during its evolution to a network design to be known as Mark IV-A. The Mark IV-A will consolidate Deep Space and High Elliptical Earth Orbiter (HEEO) missions tracking and will implement centralized control and monitoring at the Deep Space Communications Complexes (DSCC). One of the objectives of the new network design is to reduce Maintenance and Operations (M&O) costs. To determine if the system design meets this objective it was necessary to develop an M&O staffing model for Goldstone which could be used to estimate the staffing levels required to support the Mark IV-A configuration. Once a validated model was developed, the staffing estimations for Mark IV-A could be compared to staffing required for the current DSN and STDN configuration to determine if the new design could reduce M&O costs. The study was performed only for the Goldstone Complex and the Program Office translated these estimates for the overseas complexes to derive the Network estimates.

The approach used in developing the staffing model was to first look at the changes to DSCC configurations. As these changes were defined, the impact of the new design on Network Control Center and Network Support staffing was also determined. This developed an image of the new configuration which, measured against maintenance and operations of the DSN Mark III configuration, was used to estimate staffing levels. As will be described later in the article, the maintenance and operations tasks were separated, and the model estimated numbers of persons required for each task. This was just a means of breaking down the total job and sizing it, and should not be construed as being the method the DSN will use in performing the job. Each DSCC will decide what is the best approach for its local conditions and will allocate tasks to the position descriptions justified locally.

The maintenance model used in estimating manpower changes from Mark III to Mark IV-A was validated by using historical results from the Mark II to Mark III Data System transition.

II. Deep Space Communications Complexes

A. Operations

The baseline system design of the Mark IV-A configuration is described in Ref. 1. This design contains some equipment from the current Mark III configuration, some from the STDN configuration, and some new equipment. All of the new equipment, and much of the older equipment, has been instrumented for centralized control and monitoring in the Mark IV-A design. A typical physical layout of the equipment is indicated in Fig. 1. This layout would locate the consoles for the centralized monitor and control adjacent to each other; these are the link monitor and control consoles and the complex monitor and control console. In addition to staffing these consoles, personnel are needed in the Signal Processing Center (SPC) equipment room to operate the locally controlled equipment, and in the recorder area for their operation.

The design process of Mark IV-A, which evolved to the configuration described in Ref. 1, had a continuing participation by operations personnel. As this configuration evolved, it was studied for operational feasibility and possible optimization of operational tasks. The equipment control areas, workload, operational scenarios, and assumed methods of operating equipment were all considered in determining the operational staffing levels. This led to the estimation of nine persons per shift to operate the DSCC as follows: one person to supervise all the complex activity; one person to control the complex resources from the complex monitor and control console; one person for each of four links to operate the monitor and control console devoted to a project; one person to support the locally operated equipment; and two persons to operate and do periodic maintenance of the recorders. The usual operating positions for these personnel are indicated in Fig. 1.

The station's operations personnel requirements were established from a zero base, and we consequently had to add two personnel to the complex staff to assume clerical and documentation work that had been done by deleted station staff. Other operations personnel such as management, clerical, documentation, fire and safety, facilities support, etc., were considered to be the same as required by the current configuration.

B. Maintenance

The staffing necessary for the maintenance tasks at a DSCC were estimated through the following steps:

(1) Established maintenance complexity factors for each of the current subsystems.

(2) Established maintenance complexity factors for the Mark IV-A design using maintenance study team concepts.

(3) Calculated the ratio of Mark IV-A (complexity and quantity) to Mark III (complexity and quantity) to be used as a multiplier factor (MULT).

(4) Weighted (WT) each subsystem by its portion of current overall maintenance workload within that major function: digital, RF, antenna, servo, and communications.

(5) Multiplied factors (MULT) times weighted subsystem workload (WT) to derive equivalency factors (EQ).

(6) Multiplied equivalency factors (EQ) times current staffing levels (MKIII) to derive estimate of Mark IV-A staffing (MKIV).

Table 1 indicates the maintenance complexity factors and quantity factors which were assigned to the current configuration and estimated for the Mark IV-A configuration. The column identified as "MULT" is the ratio of the "Total" column of the Mark IV divided by the "Total" column of the Mark III portion of the table. It can be seen from the "MULT" column of this table that, in general, the maintenance of Mark IV-A is considered to be more difficult than the Mark III system.

Table 2 indicates how the equivalency factors were derived. Where a major function covered the maintenance of more than one subsystem, each subsystem was apportioned the percentage of the total workload it created for that major function. For instance, under "Digital" the command subsystem accounts for 18 percent of the digital workload, the telemetry subsystem accounts for 25 percent of the digital workload, etc. Some major functions such as antenna, servo, and communications consisted of only one subsystem so the equivalency factor was the same as the multiplier factor. For the digital and RF major functions, the weighted subsystem percentages were multiplied by the subsystem multiplier factors to produce the equivalency factor. The individual equivalency factors in the digital and RF functions were summed to give one equivalency factor for the digital function and one for the RF function.

The equivalency factor times the current staffing for each function produced the staffing estimate for the Mark IV-A maintenance task.

The algorithm produced a 33 percent increase in the on-site maintenance organization. In addition to the on-site maintenance at each complex which, in general, requires substitution of a malfunctioning module, board, etc., with an operable one from spares, there is another level of maintenance required at the complex which involves the repair of the module, board, etc. This level of maintenance is performed at the Complex Maintenance Facility (CMF), whose staffing was estimated by multiplying the current CMF staffing by the percentage change (+33 percent) in technicians performing on-site maintenance.

The number of personnel handling logistics for the complex was estimated by multiplying current staffing by the estimated parts percentage increase. The number of parts handled was derived by taking the fraction of total parts used by a major function in the Mark III era and multiplying it by the equivalency factor for that function. The summation of these products is the estimation of the ratio of Mark IV-A parts compared to the current number of parts. This calculation resulted in a predicted 13 percent increase in the Mark IV parts over Mark III and was used to calculate the increase in logistic parts handlers.

III. Control Center Operations Section

The Mark IV-A design has not added or changed any work stations at the Network Control Center (Section 371), but it has changed the workload due to the added set of HEO missions. The Network Operations Planning Engineers (NOPE) and the Scheduling and Analysis Groups required additional staffing to support the added missions. The Operations Control Group needed support because the new mission set creates a much higher quantity of passes per day. The Analysis Group's requirements in radio metric support increased owing to the added missions and numbers of antennas.

IV. Network Support Section

The new configuration support requirements (Section 377) can be absorbed by current staffing once the transition is completed, except that documentation support will increase by one (1) to accommodate the added technical writing and editing required for the HEO missions Network Operations Plans (NOP).

V. Summary

The NCP staffing requirements discussed in this article were developed from the baseline design and were presented in the January 1981 NCP Fourth Formal Review. The staffing study projected that Goldstone (DSN) will require an additional two personnel, the Operations Control Center (Section 371) an additional 10 personnel, and DSN Support (Section 377) an additional person to support the Mark IV-A baseline configuration.

Reference

1. Gatz, E. C., "Networks Consolidation Program System Design," in *The Telecommunications and Data Acquisition Progress Report 42-63, March and April 1981*, p. 150-153, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1981.

Table 1. NCP subsystem complexity

Subsystem	Mark III				Mark IV-A							MULT
	64 m	34 m	26 m	Total	SPC	64 m	34A*	34B*	34C*	9 m	Total	
Ant	10	1	1	12	–	10	1	1	1	1	14	1.17
Servo (APS)	3	1	1	5	–	3	1	1	1	1	7	1.4
RF												1.53
RX/EX	6	2	2	10	20	–	–	–	–	–	20	2.0
TX	3	1	1	5	–	3	1	–	–	1	5	1.0
UWV	4	3	2	9	–	4	3.5	1.5	1	2	12	1.33
Digital												0.95
CMD	2	2	2	6	4	–	–	–	–	–	4	0.67
TLM	2	2	2	6	6	–	–	–	–	–	6	1.0
TRK	1	1	1	3	3	–	–	–	–	–	3	1.0
FTS	1.5	1	1	3.5	2	–	–	–	–	–	2	0.57
RS	1	–	–	1	1	–	–	–	–	–	1	1.0
GCF (tapes)	2	2	2	6	4	–	–	–	–	–	4	0.67
M&C (SSC)	1	1	1	3	4	–	–	–	–	–	4	1.33
TSS	1	1	1	3	2	0.2	0.2	0.2	0.2	0.2	3	1.0
TFC (MMA)	1	–	–	1	2	–	–	–	–	–	2	2.0
Comm term/uwave	1	1	1	3	2	–	1	–	–	–	3	1

*34A = transmit/receive
34B = DSN-X, VLBI and STDN-S
34C = DSN-X and SETI

Table 2. Maintenance and integration, manpower derivation

		Mark III	Mark IV-A
Digital			

SS	WT		MULT		EQ
CMD	0.18	×	0.67	=	0.12
TLM	0.25	×	1.0	=	0.25
TRK	0.21	×	1.0	=	0.21
FTS	0.08	×	0.57	=	0.05
RS	0.04	×	1.0	=	0.04
GCF	0.08	×	0.67	=	0.05
M&C	0.08	×	1.33	=	0.11
TSS	0.04	×	1.0	=	0.04
TFC	0.04	×	2.0	=	0.08
	1.0				0.95

	EQ × MKIII = MKIV-A		Mark III	Mark IV-A
Technicians:	0.95 × 9 = 8.55 = 9 = +0	Technicians	9	9
Engineers:	0.95 × 4 = 3.8 = 4 = +0	Engineers	4	4

RF

SS	WT		MULT		EQ
RX/EX	5/12	×	2.0	=	0.84
TX	3/12	×	1.0	=	0.25
UWV	4/12	×	1.33	=	0.44
					1.53

	EQ × MKIII = MKIV-A		Mark III	Mark IV-A
Technicians:	1.53 × 12 = 18.36 = 19 = +7	Technicians	12	19
Engineers:	1.53 × 3 = 4.59 = 5 = +2	Engineers	3	5

Ant

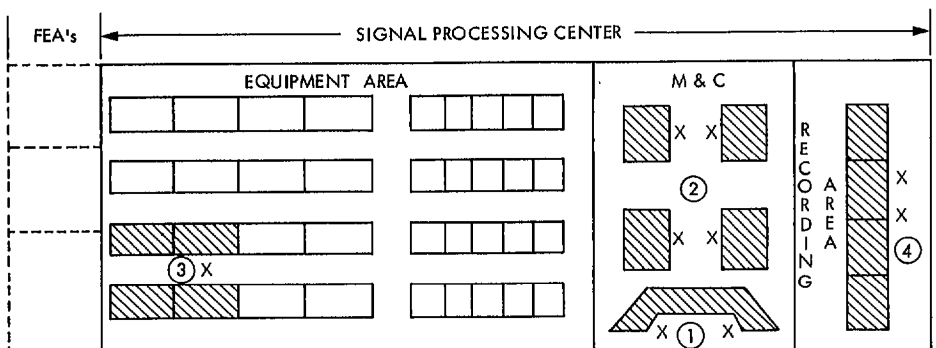
	EQ × MKIII = MKIV-A		Mark III	Mark IV-A
Technicians:	1.17 × 8 = 9.36 = 10 = +2	Technicians	8	10
Engineers:	1.17 × 2 = 2.34 = 3 = +1	Engineers	2	3

Servo

	EQ × MKIII = MKIV-A		Mark III	Mark IV-A
Technicians:	1.4 × 4 = 5.6 = 6 = +2	Technicians	4	6
Engineers:	1.4 × 1 = 1.4 = 2 = +1	Engineers	1	2

Comm

	EQ × MKIII = MKIV-A		Mark III	Mark IV-A
Technicians:	10 × 1.0 = 10 = +0	Technicians	10	10
Engineers:	2 × 1.0 = 2 = +0	Engineers	2	2



CONCEPTUAL CONFIGURATION

AREA	EQUIPMENT
1	COMPLEX M & C CONSOLE
2	LINK CONSOLES
3	RDA, SDA, ODA, 9-M UWV, GSTDN BFS
4	TAPE RECORDERS

LEGEND: X = OPERATOR

= OPERATED EQUIPMENT

Fig. 1. Signal Processing Center conceptual configuration