DSN/MSFN Antenna-Pointing and Tracking Implementation

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The antenna-pointing and tracking-data processing functions at the three DSN/MSFN joint-usage ("wing") tracking stations have been altered to implement a commonality between the two networks. The changes affect both hardware and software and produce station configurations that differ from those of other DSN stations.

I. Introduction

In the latter half of calendar year 1970, a program of reconfiguration of the three DSN/MSFN joint-usage tracking stations was initiated. The goal of the DSN/MSFN integration program was the functional integration of the several equipment subsystems employed by the Deep Space Network and the Manned Space Flight Network (MSFN) at DSSs 11, 42, and 61. Part of the equipment involved was formerly included in the DSN's station hardware complement, and the remainder was formerly unique to the MSFN. As a result of the implementation of this integration program, there is now one set of joint-usage equipment which serves the needs of both networks.

II. Original Configuration, Antenna-Pointing and Tracking-Data Processing

As the joint-usage stations were originally configured, the DSN and MSFN each had a complete and separate complement of equipment to effect antenna pointing and the processing of metric data. The DSN equipment was that of a standard 26-meter station. The MSFN control facility employed a UNIVAC-1218 computer coupled to an Antenna Position Programmer (APP) to control the antenna servo system. A Tracking Data Processor (TDP) processed MSFN metric data through-put and delivered both teletype and (MSFN-formatted) high-speed data communications outputs to the MSFN.

III. Effects of Integration on Antenna-Pointing and Tracking-Data Processing

It was determined at the start of the DSN/MSFN Integration Program that the UNIVAC-1218 computers were needed by MSFN for other applications and, conversely, that the DSN could make advantageous use of the High-Speed Data Line (HSDL) metric data reporting capability afforded by the TDP. It was decided at that time, therefore, that the various equipment should be merged by removing the UNIVAC-1218 computers and substituting the XDS-910 computers which formed a part of the DSN's Antenna Pointing Subsystem (APS) and by deleting the DSN's Tracking Data Handling Subsystem (TDH) and using the TDP as the source of DSN radio metric data for the affected stations (see Ref. 1).

The original concept would have made use of a common hardware configuration and a single computer program (for the XDS-910) capable of separate operating modes for the DSN and MSFN. During software development, however, it rapidly became apparent that the limited memory capacity of the XDS-910 (8192 words, decimal) precluded such commonality. In consequence, the final integration provided a common hardware set (not all of which is used in both operating modes) and separate operational computer programs for the DSN and MSFN operating modes (see Refs. 2, 3, and 4).

IV. Integrated Configuration—MSFN Mode

The MSFN mode of operation of the integrated station equipment employs the hardware configuration of Fig. 1 and provides the functional and operational features described in the following paragraphs.

As indicated in Fig. 1, metric data processing is entirely in the province of the TDP. Inputs from the various data sources (antenna, receiver, etc.) are automatically combined and formatted to MSFN specifications and are transferred directly from the TDP to the MSFN communications system. In this operating mode, there is no functional tie between the TDP and the APS.

Antenna pointing is accomplished by the APP under the control (either direct or indirect) of the APS XDS-910 computer. Antenna-pointing predict sets are received at the station via standard teletype. The teletype (i.e., Baudot-code) predict messages may be in either MSFN 29-point format or Inter Net Predict (INP) format. In either predict-format case, the predict teletype message tape is read directly into the XDS-910 computer via its optical tape reader. A maximum of two predict sets may be held in the computer at one time.

Once a predict set has been input, the processing proceeds at the option of the operator. Normally, the computer will be instructed to generate and verify an interpolated, time-sequenced drive tape (punched paper tape) for the APP. The use of this drive tape is considered to be a "back-up" mode of operation for the APP and the generation of the drive tape is a requirement when time permits. Approximately 2.25 minutes per hour of pass duration are required for punching and, in addition, approximately two minutes per hour of the pass for tape verification. APP drive tapes normally are computed for 10-second interpolation points, and the time figures quoted are for this interval. After the APP back-up drive tape has been produced and verified, the only APS operation remaining is real-time computer control of the antenna.

Real-time computer control of the antenna (via the APP) requires an instruction from the operator to the computer with an identity code for the appropriate predict set, the "start time" for antenna movement, and (if desired) a time offset to adjust the predict time values in the event that they do not properly coincide with real time. This latter feature is convenient for test purposes and also for the case where a standard sidereal predict is to be used instead of a current predict set.

APP drive tape punching and verification are considered functionally separate from real-time control and may or may not be employed on any specific occasion. Simultaneous real-time control and punching and/or verification is not possible due to timing limitations within the XDS-910 computer.

V. Integrated Configuration—DSN Mode

The DSN's operating mode at the joint-usage stations requires the equipment configuration shown in Fig. 2. The functional and operational features of this mode of operations, at once both similar to and divergent from those of the MSFN mode, are discussed below.

Metric data, formatted by the TDP to MSFN communications system HSDL specifications, must be reformatted for DSN use to permit transmission over GCF NASCOM HSD circuits. This reformatting is effected in the APS XDS-910 computer. Input of these data to the XDS-910 is via Simulation Conversion Assembly (SCA) HSD Receive Channel No. 2 which has been modified to permit acceptance of such nonstandard inputs.

The metric data reformatting requirements consist primarily of a "bunching" process whereby five of the relatively short TDP HSD "blocks" are assembled into one standard NASCOM HSD message block. In addition, the APS computer performs a statistical sampling function to reduce the data rate to that required by the SFOF. Sample rates can be selected in real time in the range between one sample per second and one sample per minute. Also, certain unnecessary fields of the original TDP data block are suppressed and various items of initialization and real-time, manual-input data (from the Receiver Data Entry Panel) are merged into each sample. The reformatted tracking data are transmitted to the SFOF via HSDL and are also recorded on a digital magnetic tape recorder to provide an Original Data Record

(ODR) so that any data lost in transmission may be recovered to complete the SFOF's Master Data Record (MDR).

DSN-mode antenna pointing is similar to that described under the MSFN mode above, except that the teletype predict messages may be in either JPL/DSN standard format or INP format. In addition, the DSN mode permits transmission of antenna-pointing predict data via direct HSDL connection to the APS computer. Once predict data are input, either by teletype tape or HSDL, processing proceeds as previously described.

Status information covering various significant functions and interfaces is passed to the Digital Instrumentation Subsystem (DIS) at regular intervals for reporting to the SFOF Monitor function.

VI. Summary and Conclusions

The operational equipment concerned with antenna pointing and the processing of tracking data has been integrated at the joint-usage stations. The two operating modes of the integrated stations, although related and overlapping in some degree, are structurally different. The MSFN mode is the simpler of the two from a functional point of view. The DSN mode places a considerably heavier load on the APS computer, both as to core loading and processing time.

To a considerable extent the various items of hardware are not ideally suited to the operational and functional interaction that is required and this is reflected (although not explicitly set forth herein) in some of the functional limitations that will appear obvious to those familiar with either or both of the two systems which previously operated independently.

References

1. *Modification Procedure, DSN/MSFN Integration (APS/APP/TDP/SCA/GCF),* Procedure No. AP506074A, Oct. 18, 1971 (JPL internal document).
2. *DSN/MSFN Integration, Antenna Pointing Subsystem Software Requirements Document,* IOM 3384-71-218, Nov. 19, 1971 (JPL internal document).
3. *Operation Procedure, APS Operational Program (DSN Mode),* Procedure No. OP506142A, Mar. 1, 1972 (JPL internal document).
4. *Operating Instructions, APS Operational Program (MSFN Mode),* IOM 3384-72-016A, Mar. 13, 1972 (JPL internal document).

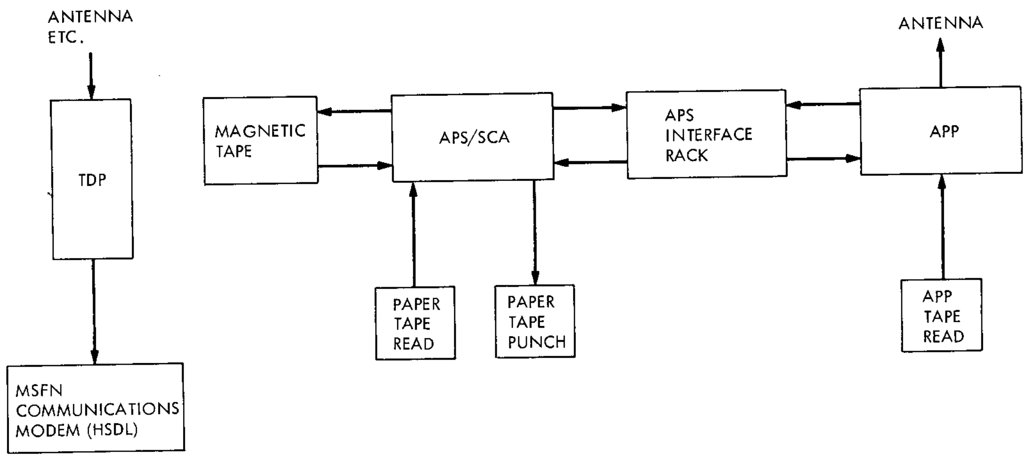

Fig. 1. DSN/MSFN integration (APS/APP/TDP/SCA/GCF), MSFN operating mode

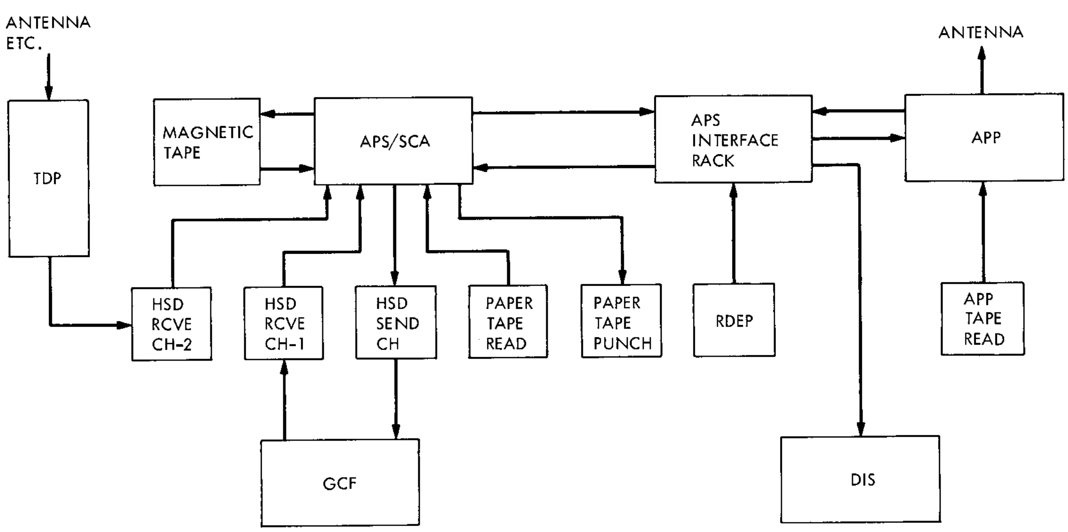

Fig. 2. DSN/MSFN integration (APS/APP/TDP/SCA/GCF), DSN operating mode