DSN Tracking System Predictions

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The Deep Space Network Tracking System predictions include angles, frequencies and ranges for use by the Deep Space Stations in the acquisition and tracking of spacecraft. These predictions are also used to validate the radio metric data generated by the Deep Space Stations.

I. Introduction

The Network Operations Control Center Sigma 5 computer will assume the responsibility of generating the DSN predictions which are currently computed by the Mission Control and Computing Center. Since the Deep Space Network tracking prediction capability will be a phased implementation, the transfer of prediction capability from the Mission Control and Computing Center to the Network Operations Control Center will be incremental.

II. System 1: Network Operations Control Center, Block I

System 1 became operational March 1, 1974. In this phase the Sigma 5 computer assumes the responsibility of transmitting the predicts to the Deep Space Stations. The Mission Control and Computing Center generates the predictions and provides a magnetic tape of the prediction transmission file. The prediction tape is converted for high-speed data transmission on the off-line Sigma 5 computer and a high-speed data formatted tape is outputted for transmission by the on-line Sigma 5 computer (see Fig. 1).

III. System 2: Network Operations Control Center, Block II

The Sigma 5 computer will provide a capability of generating predictions from a project supplied "phi factor polynomial" magnetic tape interface. The predictions

generated on the Sigma 5 computer will contain the same prediction data output that was previously generated by the Mission Control and Computing Center.

The Sigma 5 batch process mode system (off-line computer) generates the predictions and converts these predictions to a high-speed data formatted magnetic tape. The predictions are then computed from the project-supplied phi factor polynomial tape. The prediction transmission on the on-line Sigma 5 will be the same as System 1 (see Fig. 1).

IV. System 3: Network Operations Control Center, Block III

System 3 will provide a capability of generating predictions from project-supplied state vector or probe ephemeris tape (Ref. 1). The state vector will simplify the DSN/Project interface from a magnetic tape interface to a six-parameter administrative interface. The state vector interface would be used for DSN acquisition studies and for DSN prediction generation in support of spacecraft tracking.

The DSN Tracking System predictions will utilize a special program designed specifically for generating accurate station prediction data. Economics, simplicity, size, and speed dictate its design. Program capabilities include the following:

(1) The ability to generate the trajectory of a spacecraft or landed probe utilizing adequate force models and to write a trajectory tape.

(2) The ability to process a trajectory tape generated by the Project's Double Precision Trajectory Program (DPTRAJ).

(3) The ability to write a tape with station observables and events (rise, set, occultations, etc.) for up to 10 stations.

(4) The ability to correct for range bias, antenna cone offsets, and angular observables correction (geodetic, aberration, refraction, and structural).

(5) The ability to utilize accurate time transformation and polar motion data.

The trajectory portion includes mathematical models of the forces which influence the space probe's motion. These forces are integrated numerically (Cowell method) to generate a probe trajectory in the inertial 1950.0 Earth mean equator frame (EME 1950.0) utilizing planetary ephemerides generated in the same coordinate system. Accurate time and coordinate transformation capabilities provide the ability to represent the trajectory profile and probe's accelerations in their natural or desired frames.

A single "calibration station" is used in the interactive light times calculation instead of an actual station. Actual station light times are analytically related to the calibration station. The calibration or reference station is placed on the surface of a transparent Earth, and is located at longitude and latitude zero for maximum diurnal signature. Upleg and downleg light times are independently calculated at selected times corresponding to the natural frequencies of Chebyshev polynomials of the first kind and specified degree. This automatically yields the best least squares fit of the calculated qualities in polynomial form.

Analytic methods are introduced to calculate the viewability windows of up to 10 stations, the Chebyshev polynomial coefficients of the light time solutions and other useful quantities within the windows. The independent variable for all calculated polynomials is ephemeris time. Consequently, actual events and types of observables in any time scale can all be calculated from the polynomials.

Station observables such as range, range rate, transmitted frequency shifts, and angular data are all accurately calculated. The calculations include precise station location, antenna and media corrections, and relativistic effects on radio signals and coordinates of the time clock and probe. More efficiency is achieved by utilizing selective double precision as contrasted to blanket double precision in the calculations. The program generates a trajectory tape for later use or processes a trajectory tape generated by Project navigation programs. Reference station polynomials are saved for processing different sets of stations. The station polynomials are output and saved for processing observables at densities specified by the user.

The phi factors generated by the Fast Phi Factor Generation Program are stored on a phi factor file and a phi factor save tape. The phi factors stored on the phi factor file are interpolated to produce the prediction data. The prediction data are converted for high-speed data transmission to the Deep Space Stations and to the Network Operations Control Center radio metric monitor for system validation (Fig. 1).

V. Summary

System 1, which is operational, will transmit predictions to the DSSs. System 2 will complete acceptance testing in September 1974 and will generate predictions using a project-supplied phi factor polynomial tape. System 3 will generate phi factors from a state vector or project-supplied trajectory tape. The phi factors will be interpolated to produce predictions. The predictions will be transmitted to the Deep Space Stations and to the Network Operations Control Center.

Reference

1. Khatib, A. R., "The Fast Phi-Factor Generator Program," Document 900-628, Jet Propulsion Laboratory, Pasadena, Calif., July 7, 1973 (an internal document).

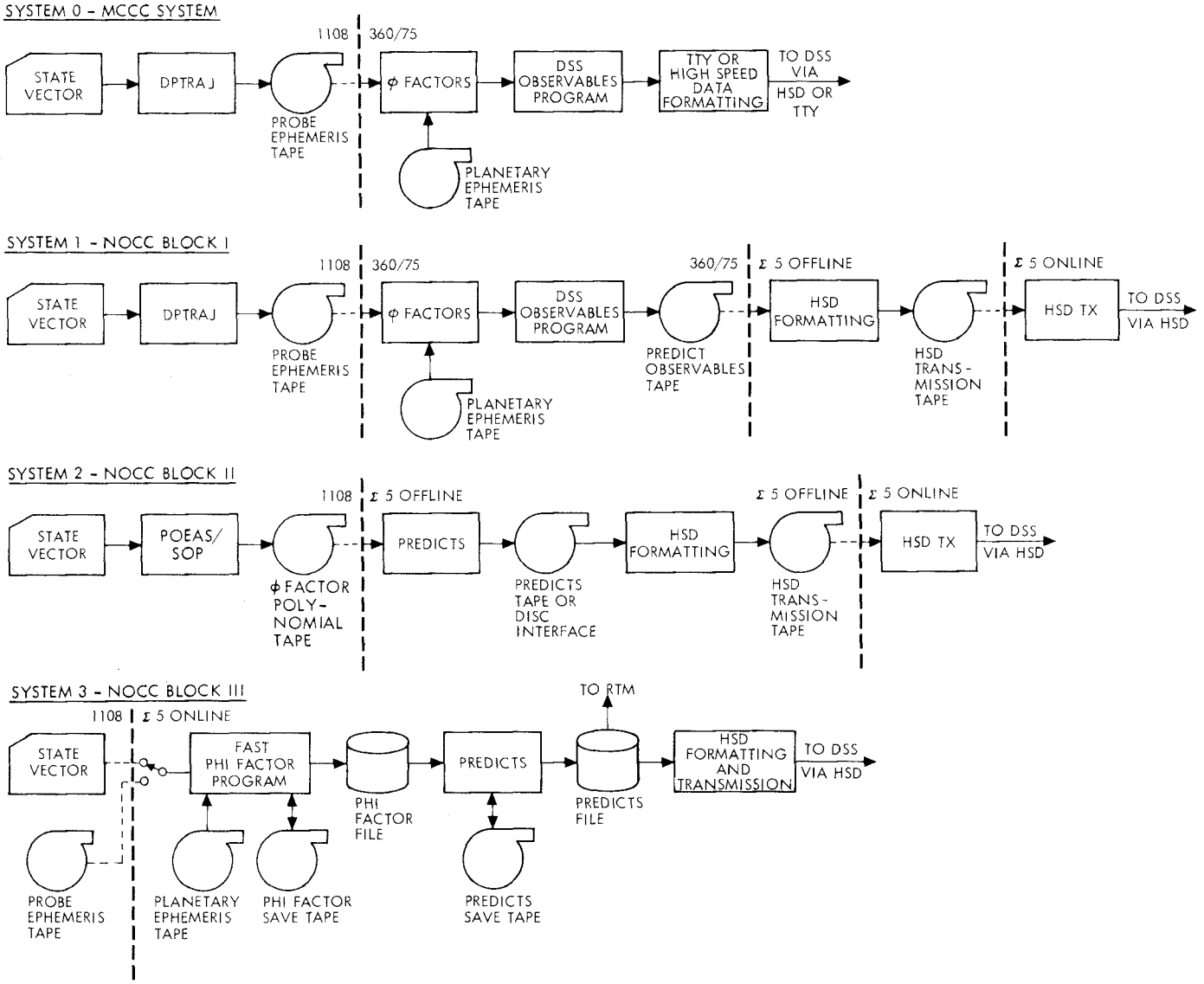

Fig. 1. The DSN prediction configuration