# Initial Acquisition Planning

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*Each spacecraft supported by the DSN must be acquired and tracked by a deep space station (DSS). The first acquisition, generally referred to as initial acquisition, is unique for each spacecraft and presents problems that must be recognized and resolved long before a launch actually takes place. This article tells how plans are developed and implemented to ensure the successful beginning of DSN tracking support.*

## I. Introduction

### A. Definition of Initial Acquisition Phase

For any mission, the initial acquisition phase is defined as the period of time starting at liftoff of the spacecraft booster and ending when a selected DSIF station has:

(1) RF acquisition and has auto-tracked the spacecraft using the Acquisition Aid Antenna (SAA).

(2) Transferred auto-track to the main 26-m dish feed (SCM).

(3) Established a coherent RF link, up and down, between the spacecraft and the DSIF station, if applicable.

(4) Obtained a specified continuous period of angular position and two-way doppler data.

Before a DSIF station can be designated an initial acquisition station, it must be capable of accomplishing all of these items. The criteria to accomplish items 1 and 2 are outlined in paragraph B below, item 3 is discussed in paragraph C, and item 4 is outlined in paragraph D.

### B. Criteria for RF and Auto-Track Acquisition

(1) The station designated as an initial acquisition station must be equipped with an SAA antenna system.

(2) The spacecraft's elevation angle must be higher than 10 deg above the local land mask *for a minimum of 20 min* and within antenna mechanical limits.

(3) Initial auto-track attempts must be on the SAA antenna system, but auto-tracking may not begin until the spacecraft's elevation angle is 10 deg above the local land mask and within antenna mechanical limits.

(4) Angular tracking rates, except during the period specified in item 5, must not exceed 0.5 deg/sec in the HA or Dec axis.

(5) Switch from SAA auto-track to SCM auto-track cannot be made until the angular tracking rates are equal to or less than 0.25 deg/sec in both axes.

(6) The phase error, due to the doppler rate, in the selected loop bandwidth of the DSIF receiver shall not exceed 30 deg rms during the acquisition period.

(7) The carrier level, based on SAA antenna gain, must not drop below −135 dBm during the period specified in item 2.

### C. Station Status After Completion of Paragraph B

At the end of the *20-min period* specified in item B.2, the initial acquisition station will be in two-way lock, furnishing good angle, doppler, and telemetry data. Also, the station will be available for sending commands to the spacecraft.

### D. Data Requirements

After a coherent uplink and downlink have been established, the spacecraft will be auto-tracked for at least 10 min to furnish precision angle and doppler information for use in orbit determination calculations.

## II. Initial Acquisition Study

An initial acquisition study must be conducted to determine if the DSIF can meet the requirements to acquire the spacecraft and provide data to the Flight Project. The study consists of analyzing the probable spacecraft trajectories to determine if initial acquisition criteria are violated; analyzing Flight Project data requirements, plans, and operating modes; and analyzing DSIF capabilities.

The Flight Project selects a group of trajectories based on mission objectives, range safety requirements, tracking and data acquisition requirements, and many other variables affecting the final decision. Each trajectory presents a different set of problems to DSIF planners. Station view periods vary, doppler and angle rates vary, and the launch window itself is another factor to be considered. Since the cost of analyzing all the variables existing in all possible trajectories would be prohibitive, representative conditions are chosen for the first and last days of the window and for one day near the middle. For each day chosen, there may be a substantial variation in launch time; therefore, it is generally necessary to perform a detailed analysis of doppler and angle rates and data system performance margins for three launch times on three different dates, resulting in nine cases being considered.

There are usually some special requirements for the launch phase that specify that telemetry data must be continuous, uplink signal level must not exceed some specified maximum level, and/or command readiness must be achieved by a certain time. These requirements must be given consideration during the acquisition study.

Capabilities of the DSIF stations are given in Ref. 1. That document is the primary reference for determining whether Project requirements have exceeded DSIF capabilities.

The results of the acquisition study are presented in mission-dependent documentation for the use of the initial acquisition station. Examples of these documents are Refs. 2 and 3.

Figure 1 shows an example of a downlink signal level plot, Fig. 2 shows an example of a plot of angle rates, and Fig. 3 depicts a plot of doppler rates.

## III. Operations Plan

### A. Station Countdown

In preparation for launch, the initial acquisition station must perform a countdown which takes 8 hr, on the average, and consists of a comprehensive check of all station equipment committed for support of the Flight Project. Both primary and backup systems are checked in all configurations in accordance with Ref. 4.

At the conclusion of the countdown, the station must interface with the rest of the DSN to ensure that simulated spacecraft data will properly flow through the entire integrated system, from input at the DSIF station to output on control center displays at JPL.

### B. Predicts Strategy

*1. Preflight nominal tracking predicts.* The day before a scheduled launch, three (window open, mid-window and window close) sets of nominal trajectory predicts containing doppler, angle, and range information are generated and transmitted to the initial acquisition station(s). Telemetry performance predicts containing uplink and downlink signal level and signal-to-noise ratio (SNR) information are also transmitted.

2. *Launch predicts.* The Real Time Computing System (RTCS), a JPL-manned facility located at the Air Force Eastern Test Range (AFETR) in Florida, generates and transmits predicts to the initial acquisition station 1 hr before launch as a backup to the JPL-Pasadena predicts. The RTCS normally transmits two sets of predicts after spacecraft launch, based on C-band metric data received from near-Earth-phase tracking stations.

### C. Sky Coverage Strategy

To prepare for possible azimuth anomalies in the spacecraft trajectory, sky search patterns are generated and transmitted 1 day before a scheduled launch. The basic pattern places the antenna 10 deg above the local horizon (in observance of the constraint levied in paragraph I.B.3) at spacecraft rise. If the spacecraft does not come into view at the expected time, a $\pm 8$ deg azimuth search (SAA antenna beamwidth = 16 deg) is commenced at a predetermined time. Procedures for use of the sky coverage pattern are documented in Ref. 5. Figure 4 is a sample sky coverage plot.

### D. Initial Acquisition Sequence

The initial acquisition configuration and nominal procedures are presented in mission-dependent documentation that is provided to the station(s) several months before launch. The final sequence is documented in the Mission Sequence of Events (SOE), distributed a few days before launch. Table 1 is an example of the sequence that would be followed at a station.

## IV. Training

### A. Station On-Site Training

The Station Director is responsible for conducting on-site training using the documented results of the acquisition study. The training normally involves conferences and airplane tracks at the signal levels and rates approximating those expected during the actual launch phase.

Coordination on details continues between JPL planners and station personnel until launch time.

### B. DSIF Control Team Training

Several conference-type sessions are held at JPL between planners and the DSIF Operations Control Team (OCT) to develop a clear understanding of acquisition conditions and to refine plans.

### C. Operations Verification Tests (OVTs)

OVTs are conducted to verify that personnel, procedures, and equipment configurations are adequate to accomplish the job. These tests employ the services of the DSN Simulation Center, which provides simulation of a launch environment; the DSN Network Analysis Team, which provides predictions and system performance analysis; and the DSN Operations Control Team (OCT), which supervises operations. These tests are obviously conducted under conditions as close to the actual event as possible.

### D. Operations Readiness Tests (ORTs)

ORTs are Flight Project tests that serve as full-dress rehearsals for launch. It is intended that any holes or pitfalls not previously recognized will surface during this period. These tests are supported by all committed DSN facilities.

## V. Launch Phase Operations

Launch phase operations are the culmination of years of planning, training, and testing. DSN operations are under the control of the DSN OCT, which is supported, in an advisory role, by those who have planned the DSN support of the mission. All actions and events related to this mission phase are documented in the DSN SOE, which is in the hands of all participants.

## VI. Summary

The techniques described herein have evolved from approximately 14 years of experience with tracking operations at JPL. To date, the DSN record for performing initial acquisitions is perfect, with no spacecraft having been lost as a result of DSN anomalies.

# References


1. *DSN/Flight Project Interface Design Handbook,* Document 810-5 (JPL internal document).
2. *DSN Operations Plan for Pioneer F Mission,* Document 616-26, Vol. VIII (JPL internal document).
3. *DSN Operations Plan for Mariner Mars 1971 Mission,* Document 610-84, Vol. VIII (JPL internal document).
4. *DSN Standard Test/Training Plan and Procedures,* 853-series Documents (JPL internal documents).
5. *Standard DSN Operations Plan and Procedures,* 843-series Documents (JPL internal documents).

**Table 1. Initial acquisition procedure**

| Step | Time from launch (TFL) | Event |
|---|---|---|
| 1 | L − 50 min | TRAKON specifies predicts to use |
| 2 | L − 30 min | Confirm SEARCH PATTERNS |
| 3 | L − 10 min | Verify ETR prelaunch predicts |
| 4 | | Verify JPL prelaunch predicts |
| 5 | L | LIFTOFF: ___ : ___ : ___ Z |
| 6 | L + 10 min | Complete preacquisition checkout |
| 7 | L + 15 min | ANTENNA to Point A (Fig. 4) |
| 8 | L + 18 min | Recorders ON, TDH sampling |
| 9 | L + 19 min | Commence RCV search |
| 10 | | Signals heard. If no signals heard by Point A, go to Step 27 |
| 11 | | RCV 2 in lock |
| 12 | | RCV 1 in lock |
| 13 | | Point A: SAA/AUTO |
| 14 | | SCM/AUTO |
| 15 | | SDA 1 in lock |
| 16 | | Frame in lock |
| 17 | | Bit lock |
| 18 | L + 23 min | TRAKON confirms TXR ON time and EXC VCO setting XA at (time to be supplied in DSN SOE). |
| 19 | L + (per SOE) | TXR ON-1kw-SAA. |
| 20 | TXR ON + 1½ min | RCV out of lock, CMD MOD ON (If RCVs do not drop lock by turn-on + 3 min or TXR switch-on is delayed, go to Step 29.) |
| 21 | | RCV 1 in lock |
| 22 | | RCV 2 in lock |
| 23 | | AUTO SCM |
| 24 | | Frame in lock |
| 25 | | Bit in lock |
| 26 | TXR ON + 2 min | TRAKON confirms 2-way |
| 27 | | No signals heard at Point A<br>EXECUTE SKY SEARCH PROCEDURES. If spacecraft is acquired, return to Step 11 |
| 28 | | If spacecraft is not acquired:<br>(a) Return to predictions<br>(b) Reset TXR to 10 kw SAA<br>(c) Await instructions from TRACK CHIEF |
| 29 | TXR ON + 3 min | Tune EXC VCO per real-time input from NAT TRK |

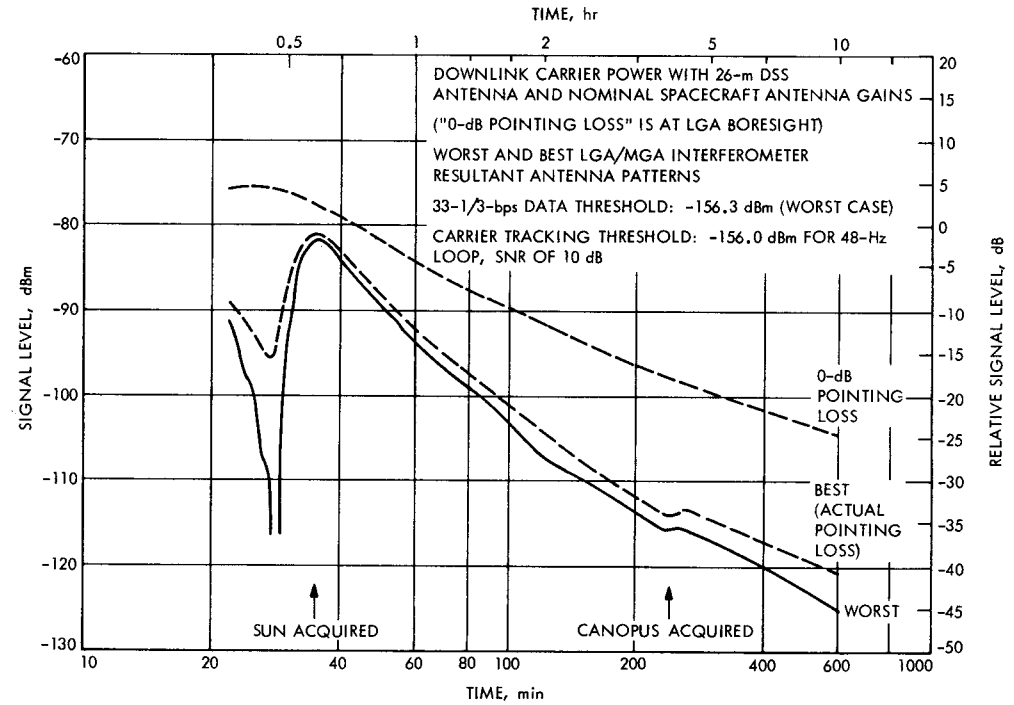


**Fig. 1. Johannesburg nominal Mission A downlink power with interferometer effect**

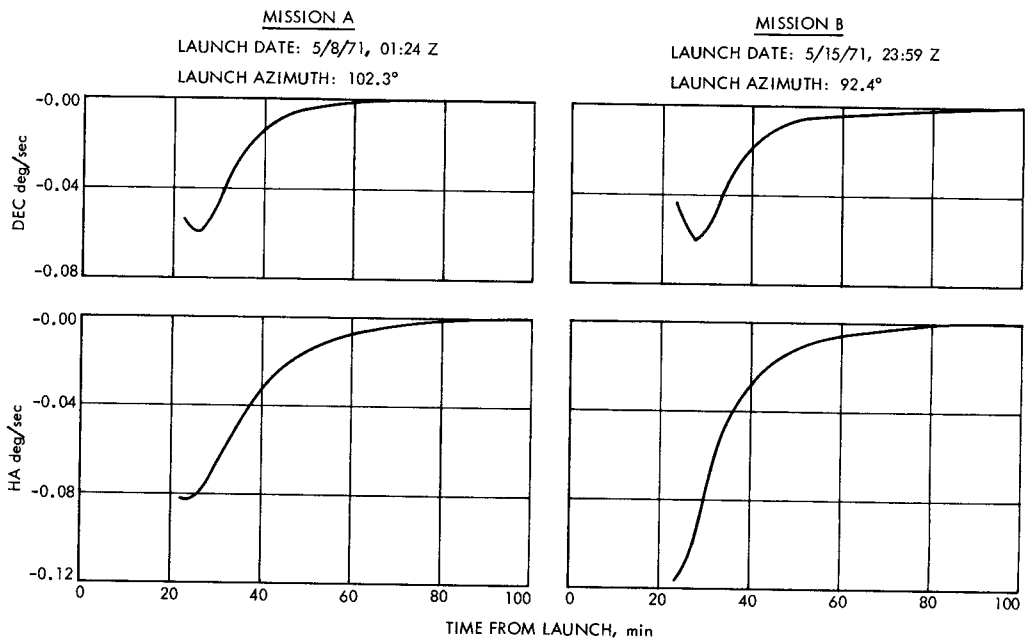


**Fig. 2. DSS 51 angle rates vs TFL (window open, Missions A and B)**

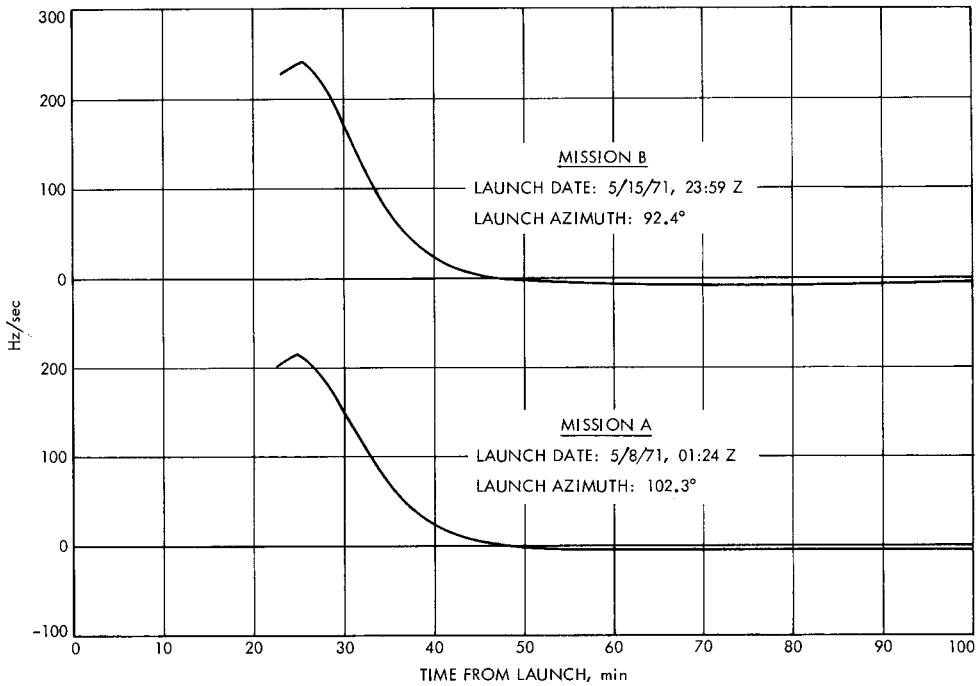


**Fig. 3. DSS 51 two-way doppler rates vs TFL (window open, Missions A and B)**

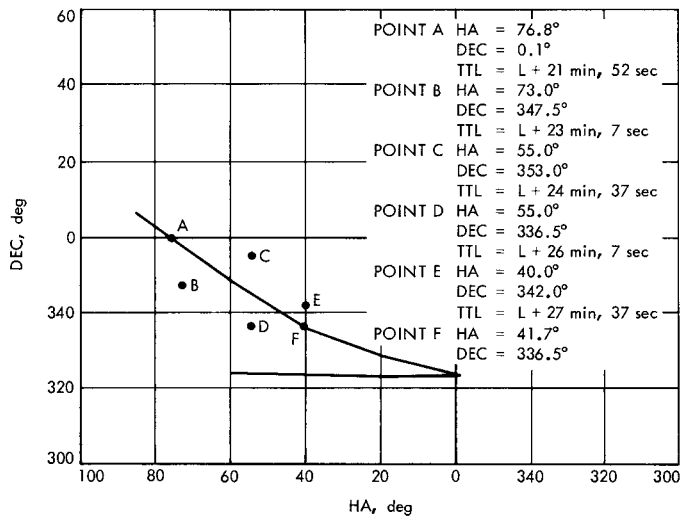


**Fig. 4. DSS 51 sky coverage plot for 3/19/72 launch**