Special Activity Utilization of GDSCC Antennas During 1980

E. B. Jackson
Goldstone Operations Section

J. W. Hudson
Bendix Field Engineering Corp.

In addition to direct spacecraft project support, the GDSCC antennas also support "special" activities. These activities can be categorized as Advanced System Program, Crustal Dynamics Program, and Radio Astronomy Program activities.

This article briefly discusses the goals, and categorizes each of these types of activities that received tracking support at Goldstone. All Goldstone stations (DSSs 11, 12, 13, and 14) provided a total of 2814.5 tracking hours to "special" activities during the period January through December 1980.

I. Introduction

The antennas at the Goldstone Deep Space Communications Complex (GDSCC), in addition to providing telemetry, ranging, and commanding support to spacecraft projects, also support a number of other tasks that require tracking. These special activities are categorized into Advanced Systems Program, Crustal Dynamics Program, and Radio Astronomy Program. This article discusses these special activities that GDSCC antennas supported with tracking during the period January through December 1980.

II. Advanced Systems Program

Activities in this category are funded by NASA through the Office of Space Tracking and Data Systems (OSTDS). This is the development work that culminates in provision, to the Deep Space Network (DSN) stations, of new capability with which each spacecraft project's needs can be met. These activities are organized into Research and Technology Operating Plans (RTOPs).

A. RTOP 60: Radio Metric Analysis, Demonstration, and Instrumentation Development

The goal of this effort is the development and demonstration of advanced radio metric systems for navigation and radio science, with a specific angular accuracy goal of 50 nanoradians for delta VLBI measurements.

In general, using VLBI, this RTOP generates a catalog of suitable (strength and location) quasar calibration sources. Using this catalog of quasars, the ephemerides of the planets,

particularly Mars, is tied into the "quasar reference frame." Then, techniques are developed for differential measurements between spacecraft and quasars that locate the spacecraft within the quasar reference frame and hence the spacecraft with reference to the target planet(s). Table 1 lists the various activities within the RTOP that received tracking support from GDSCC during 1980.

B. RTOP 61: VLBI Development and Analysis

This activity is closely associated with, and builds upon the results of, RTOP 60. Within this group of activities, experiments are conducted that demonstrate the capabilities of the Block I VLBI technology, which is planned to provide 50-nanoradian angular accuracy, 10-nanosecond clock synchronization between widely separated sites, and measurement of frequency standard stability with accuracies of parts in 10^{13}, also between widely separated locations.

The activities within this RTOP that received tracking support at GDSCC are also listed in Table 1.

C. RTOP 65: Antenna Systems Development

In recognition of the necessity of increasing antenna performance to provide increased planetary communications capability, this activity's goal is to improve antenna technology. Specifically, this RTOP looks at possible improvements in electronic – microwave capabilities, and mechanical – structural design. Application of technology to provide increased frequency operation of existing antennas, with improved techniques of antenna pointing, is also a part of this activity.

As part of the analysis performed in this area, techniques for measurement of antenna gain were refined and used to make extensive measurements at DSS 12 and DSS 14. These antenna gain measurements were used to quantify the improvements resulting from the modifications to the microwave system at DSS 14 and the increase in aperture at DSS 12.

The particular activity supported during 1980 was "Analytical Techniques and Procedures," which has as its objective the development of analysis software for application to antenna structural and mechanical performance. This activity also aims to extend the capability for automatic antenna structural design optimization and organize existing software to simplify maintenance and execution of improvements. Again, Table 1 illustrates tracking during 1980.

D. RTOP 68: Station Monitor and Control Technology

Recognizing that a substantial portion of the operating cost for DSN stations is allocated to personnel, this RTOP seeks to develop automation technology that will allow entire station operation from a remote point and prove the reliability, safety, and efficiency of unattended operation. Additionally, this RTOP plans to develop the data base with which reliability, costs, and productivity can be monitored, using DSS 13 as a demonstration unattended station.

Table 1 lists only tracking support to this activity; substantial other work was also ongoing at DSS 13 during the year as the equipment used to make DSS 13 operate in the unattended mode evolved and additional systems were added to those controlled remotely.

E. RTOP 70: High-Speed Signal Processing Research

The objective of this RTOP is to develop high-speed digital signal processing techniques for use in the DSN. A major part of this task is the development of a test bed as a research tool used to explore high-speed techniques. The test bed is to be used for demonstrations of various development capabilities, such as high-performance array processors, and wideband correlation subsystems. This work also demonstrates commercial LSI signal processing building blocks and utilizes promising commercial design systems.

The particular activity supported at GDSCC during 1980 was the Radar Data Acquisition, which uses various planets and asteroids as targets for demonstration of signal processing techniques.

In Table 1 are listed the various targets which were explored during 1980 as the demonstration test bed was used to develop signal processing techniques.

III. Radio Astronomy Program

Activities in this category are either sponsored by the Office of Space Science (OSS) or authorized by the Radio Astronomy Experiment Selection (RAES) Panel.

Experimenters within NASA who desire OSS support of their activities submit an observing plan in the form of an RTOP. If approved, OSS requests OSTDS to provide support, and time is made available on suitable facilities of the Deep Space Network (DSN). Experimenters from universities who have observing plans that require NASA facilities submit their observing plan to the RAES Panel. If approved, time is made available through an agreement whereby NASA makes avail-

able a percentage of the operational time on DSN facilities. Table 2 depicts the support at GDSCC in this area during 1980.

A. OSS Sponsored Activities

1. **Pulsar rotation constancy**. This experiment seeks to monitor short-term variations in the period of the relatively young VELA pulsar (PSR 0833-45). Additionally, by observing twenty-three older, more stable pulsars, this experiment hopes to obtain data that will provide further tests of the hypothesis that pulsars are neutron stars resulting from supernova explosions, which impart high velocities to the resulting pulsar.

2. **Interstellar microwave spectroscopy**. This experiment conducts fundamental research into questions of stellar and galactic evolution by observations of atomic and molecular spectral lines and related radio-continuum observations. Among the questions that these data may help to answer are (1) the distribution of interstellar gas/dust clouds, (2) the chemistry of dense interstellar clouds, and (3) the interactions of young stars with the surrounding clouds.

3. **ALSEP-quasar VLBI.** By means of astrometric observation of moon-based ALSEP transmitters and quasar radio sources using differential VLBI, the lunar orbit can be ascertained with reference to the inertial quasar coordinate frame. Such referencing of the lunar orbit to the quasar frame also has application to relativity and cosmological theories, in addition to its obvious space program application.

4. **Planetary radio astronomy**. This experiment has the dual objectives of studying the properties of the planet Jupiter's radio emission and measurement of the thermal emission from the atmosphere of the outer planets. Both of these observations will aid construction of improved models of Jupiter's radiation belt environment as well as atmospheric models of the outer planets, particularly Uranus.

B. RAES Panel Sponsored Activities

1. **Quasar patrol (RA 137).** By use of very long baseline interferometry (VLBI) techniques, this experiment systematically monitors time variation in the small-scale structure of quasars and radio galaxies, particularly 3C273, 3C279, and 3C120. Past observations have shown changes in small-scale structure taking place in a period of a few weeks. These changes, in the case of the three objects mentioned above, seem to require highly relativistic velocities to explain the observed separation or expansion of the small components. In the particular case of 3C273, the observed expansion proceeds at apparent velocities in excess of the speed of light.

2. **Compact nuclei VLBI (RA 169).** Using only United States based baselines, VLBI observations of many quasars, radio galaxies, spiral and elliptical galaxies have detected compact radio nuclei at the center. These nuclei typically have measured angular dimensions of less than 0.001 arc seconds and flux densities of approximately 0.1 Jansky. This experiment utilizes two 64-m antennas with an Australian – United States baseline for higher resolving capability. The experiment also uses both S- and X-band for greater sensitivity along with greater resolving power.

3. **M87 interstellar scintillation VLBI (RA 171).** A dynamical study of the velocity dispersion of stars in and around the nucleus of M87 provides evidence that an extremely massive dark object, or group of objects, exists in the nucleus. Detection of interstellar scintillation from this nucleus would provide evidence of a possible black hole. These VLBI observations are made at S-band and utilize DSS 14 at GDSCC and DSS 63 in Madrid, Spain.

4. **VLBI investigation of SS-433 (RA 175).** SS-433 has a bizarre optical spectrum that exhibits three sets of emission lines. One of these three emission lines shows near-zero radial velocity, while the other two show large and variable shifts to the blue and the red. The variability is periodic, with a period of about 164 days.

This experiment conducts regular VLBI observations of this source, using many simultaneous baselines. The multiple baselines should enable determination of the source angular size and structure, which will aid modelling. The involved stations at GDSCC include DSS 13 and DSS 14, along with a number of other radio observatories in the United States and Europe.

5. **VLBI investigation of "twin" quasi-stellar objects (QSOs) 0957 + 561A, B (RA 176).** These QSOs, designated 0957 + 561A, B, are separated by only 6 arc seconds in angle and have equal optical redshifts and remarkable similiarity in their optical spectra. This similiarity is inconsistent with chance alone, so the objects are in some manner physically associated. One theory proposes that there is only one object, whose radiation is gravitationally bent about an intervening massive lens, a "gravitational lens."

This experiment uses VLBI observations with many simultaneous baselines to provide data with which detailed structure maps can be prepared. Repeated observations could monitor

changes in the radio brightness distribution. At GDSCC, the involved antenna is DSS 14.

IV. Crustal Dynamics Program

A Crustal Dynamics Program goal is the demonstration of the capability of VLBI Systems to make highly accurate geodetic measurements. The particular activity supported at GDSCC during 1980 is Astronomical Radio Interferometric Earth Surveying (ARIES) data collection. The thrust of the ARIES activity is to demonstrate the geodetic performance of highly mobile VLBI stations while providing accurate data of significant geophysical interest. By moving around Southern California, and making VLBI measurements with base stations located at Goldstone and other fixed points, the ARIES activity is able to accumulate data on regional deformation and strain accumulation, particularly as associated with the San Andreas Fault.

These measurements are usually scheduled for periods in excess of 24 hours at a time, and a number of suitable radio sources are observed simultaneously and repeatedly by all the stations involved. During the period January 1 through December 31, 1980 DSS 13 (Venus Station) provided 367.75 hours of tracking support to these measurements of crustal deformation along the San Andreas Fault.

Table 1. Advanced systems program utilization of GDSCC antennas during 1980

Activity	Station and tracking hours provided			
	DSS 11	DSS 12	DSS 13	DSS 14
RTOP 60: radio metric analysis, demonstration and instrumentation development				
Clock synchronization VLBI				57.25
Ecliptic source catalog development			57.25	14.00
Mark IV Differential One-Way Range (DOR) Systems development			34.25	0.50
Mark IV Radio Metric Systems development			77.50	
Viking Delta VLBI			40.75	
Voyager Delta VLBI				1.00
Voyager VLBI				169.50
RTOP 61: VLBI development and analysis				
VLBI systems design and analysis			54.25	7.00
Microwave phase center calibration			19.25	28.00
Radio source catalog development			22.25	
RTOP 65: antenna system development				
Analytic techniques and procedures		96.50[a]	19.25	129.00[a]
RTOP 68: station monitor and control technology				
DSS 13 S-X unattended systems development			62.25	
RTOP 70: high-speed signal processing research				
Radar data acquisition				
Asteroid Apollo				12.75
Asteriod Toro				18.25
Comet Bradfield				2.25
Planet Mars				126.00
Planet Mercury			16.25	17.00
Planet Venus	93.75		73.50	224.00
TOTALS	93.75	96.50	476.75	806.5

[a]Antenna gain measurements.

Table 2. Radio astronomy utilization of GDSCC antennas during 1980

Activity	Station and tracking hours provided			
	DSS 11	DSS 12	DSS 13	DSS 14
OSS sponsored activities				
Pulsar rotation constancy	87.45	54.75	188.25	80.75
Interstellar microwave spectroscopy			19.25	39.50
ALSEP-quasar VLBI			53.25	
Planetary radio astronomy		13.75	162.00	
RAES panel sponsored activities				
Quasar patrol – RA 137				15.75
Compact nuclei VLBI – RA 169				11.50
M87 interstellar scintillation VLBI – RA 171				15.75
VLBI investigation of SS-433 – RA 175			224.00	
VLBI investigation of "twin" quasi-stellar objects (QSOs) 0957 + 561A, B – RA 176				10.00
TOTALS:	84.75	68.50	646.75	173.25