# Goddard Geophysical and Astronomical Observatory

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**Abstract**

This report summarizes the technical parameters and the technical staff of the VLBI system at the fundamental station GGAO. It also gives an overview about the VLBI activities during the previous year. The outlook lists the outstanding tasks to improve the performance of GGAO.

## 1. GGAO at Goddard

The Goddard Geophysical and Astronomical Observatory (GGAO) consists of a radio telescope for VLBI, an SLR site to include MOBLAS-7, SLR-2000 (development system), a 48" telescope for developmental two color Satellite Ranging, a GPS timing and development lab, meteorological sensors and a H-maser. In addition, we are a fiducial IGS site with several IGS / IGSX receivers.

Figure 1. Installation of new wide band dewar on MV3 antenna.

GGAO is located on the east coast of the United States in Maryland. It is about 15 miles NNE of Washington D.C. in Greenbelt, Maryland (Table 1).

## 2. Technical Parameters of the VLBI Antenna at GGAO

The radio telescope for VLBI at GGAO (MV3) was originally built as a mobile or transportable station. It was previously known as Orion and was part of the original CDP. It is now being used as a fixed site, having been moved to Goddard and semi-permanently installed here since the spring of 1991. In the winter of 2002 the antenna was taken off its trailer and permanently installed at GGAO. The design criteria were:

- transportability on two tractor trailers utilizing a 5 meter dish size to maximize reception and mobility considerations,
- setup of the radio telescope within eight hours (although it has been used as a fixed site since the spring of 1991)

Table 1. Location and addresses of GGAO at Goddard.

| | |
|---|---|
| Longitude | 76.4935° W |
| Latitude | 39.0118° N |
| MV3<br>Code 299.0<br>Goddard Space Flight Center, (GSFC)<br>Greenbelt, Maryland 20771 | |
| `http://www.gsfc.nasa.gov` | |

The technical parameters of the radio telescope are summarized in Table 2.

Table 2. Technical parameters of the radio telescope of GGAO for geodetic VLBI.

| Parameter | GGAO-VLBI |
|---|---|
| Owner and operating agency | NASA |
| Year of construction | 1982 |
| Diameter of main reflector $d$ | $5m$ |
| Azimuth range | $0 \ldots 540°$ |
| Azimuth velocity | $3°/s$ |
| Azimuth acceleration | $1°/s^2$ |
| Elevation range | $0 \ldots 90°$ |
| Elevation velocity | $3°/s$ |
| Elevation acceleration | $1°/s^2$ |
| X-band | $8.18 - 8.98\,GHz$ |
| Receiving feed | Cassegrain focus |
| $T_{sys}$ | $24\,K$ |
| Bandwidth | $800MHz, -2dB$ |
| $G/T$ | $32.1\,dB/K$ |
| S-band | $2.21 - 2.45GHz$ |
| Receiving feed | Primary focus |
| $T_{sys}$ | $19\,K$ |
| Bandwidth | $240MHz, -2dB$ |
| $G/T$ | $21.2\,dB/K$ |
| VLBI terminal type | Mark IV |
| Recording media | Mark 5A |
| Field System version | 9.10.2 |

## 3. Technical Staff of the VLBI Facility at GGAO

The GGAO VLBI facility gains from the experiences of the Research and Development VLBI support staff. GGAO is a NASA R&D and data collection facility, operated under contract by Honeywell Technology Solutions Incorporated (HTSI). Table 3 lists the GGAO station staff that are involved in VLBI operations.

Table 3. Staff working at the MV3 VLBI station at GGAO.

| Name | Background | Dedication | Agency |
|---|---|---|---|
| Jay Redmond | Engineering technician | 100% | HTSI |
| Skip Gordon | Engineering technician | 20% | HTSI |

## 4. Status of MV3 at GGAO

GGAO participated in the VLBI experiments that are listed in Table 4. In addition to these scheduled experiments, MV3 participated in several unscheduled experiments for VLBI developmental purposes and various other developmental activities.

Table 4. Participation of GGAO in scheduled VLBI experiments.

| Date | Experiment |
|---|---|
| 2007-03-13 | RDART4 |
| 2007-05-15 | T2050 |

MV3 has installed Mark 5 and e-VLBI hardware and continues to test real-time VLBI from GGAO to Haystack. On January 26, 2007, MV3 recorded two 480MHz bands that covered all of the X-band IF, with two-bit sampling, for an aggregate data rate of ∼4Gb/s. Two VSI data streams (each ∼2Gb/s) were recorded on two Mark 5B's and the data were transferred to the Haystack correlator via high-speed internet connections. It was also demonstrated, by comparing to simultaneously recorded Mark IV data, that there appear to be no major sources of signal loss in the Digital Back End (DBE) system.

MV3 is a major component in the program to demonstrate that the VLBI2010 broadband delay concept is feasible. In 2007 MV3 participated in two demonstrations. In April the Digital Back End (DBE) and two Mark 5B+'s were used to demonstrate the high data rate acquisition components. Data were recorded at 2 Gigabits per second (Gbps) with the standard geodetic S/X system. Because of the limited bandpasses, the resulting data rates were only 0.9 Gbps at S-band (the full bandwidth) and 1.6 Gbps at X-band (the upper half of the band). After a successful fringe test, a six-hour geodetic session was run.

A major modification of MV3 began in October in order to install the prototype VLBI2010 RF system. The geodetic S/X feed, receiver and supporting structure were replaced with a dewar, constructed by Haystack, containing the broadband Lindgren feed, two low noise amplifiers, and cryogenic refrigerator. Considerable time was spent trying to understand why the efficiency of

the new system is lower than expected, but even with this limitation strong fringes were finally obtained with Westford at X-band in November. This was a major milestone in the VLBI2010 program since it demonstrated one band of the complete broadband signal chain which included the feed, LNAs, Up-Down converter (UDC), digital back end, Mark 5B+ recorder, and for one polarization, the use of optical fiber to bring the RF signal from the antenna to the control room.

## 5. Outlook

In its present configuration, GGAO will mainly support VLBI2010, e-VLBI, and other developmental activities during the upcoming year. Basic plans for 2008 consist of:

1. Continued testing of pre-release versions of PC-FS and new Linux kernel releases.
2. Continued support of Mark 5 and Digital Back End (DBE) hardware development.
3. Continued support of the development and testing of VLBI2010 hardware and software.
4. Continually striving to improve the performance of the entire Mark 5 data collection and station specific equipment.

MV3 is also the other antenna used with Westford as a test bed for e-VLBI research because of the high data rate internet connection through GSFC. In 2007 this connection was used to transfer the data from the VLBI2010 tests soon after the observations, for confirmation of successful fringes. One of the first projects in 2008 will be an attempt to demonstrate an aggregate data rate of approximately 2 Gbps in real time by using two 1 Gbps channels.

Haystack is constructing a second dewar for Westford, as well as seven more UDC's and DBE's so that a full 4-band, two polarization system can be demonstrated. The four bands will span the range from approximately 3 GHz to 12 GHz. In anticipation of this test, time will be spent trying to understand the reduced efficiency and installing optical fiber for both polarizations.

In early January 2008 there will be a six-hour session on one source to evaluate possible systematic differences between the two polarizations.