Operational Responsibilities for VSOP

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Version 3.1

October 28, 1994

I. INTRODUCTION

The following pages contain a list of operational responsibilities for the VSOP mission. Version 1.0 of this document was distributed to the members of the VSOP International Scientific Council and to many other individuals in August 1993. Members of the VSOP Science Operations Group (VSOG) and the JPL Project met in Kyoto in September 1993 and discussed Version 1.0 line-by-line. That interaction and comments from other readers led to production of Version 2.0, which was discussed at the April 1994 JPL/VSOG meeting held in Sagamihara. Alterations discussed in that meeting and suggested until the end of April were included in Version 2.1; further comments on that document have been incorporated in Version 2.2, and in this most recent edition, Version 3.0.

The list of responsibilities is outlined in a nearly chronological order, from preparation of the Announcement of Opportunity to long-term performance analyses and user support, although some discretion is involved in the ordering of the items. Each major section of the outline includes a list of the related key items and responsible organizations, together with a descriptive paragraph. When multiple organizations share the responsibility for a given task, all are listed. When a single organization has primary responsibility, but assistance has been committed or proposed by another organization, the second organization is denoted in parentheses. When possible, the primary responsibility is determined by the role played in the global or international project. For example, the tracking stations of NASA's Deep Space Network (DSN) extract and deliver a variety of data. However, the interface for delivery of most such data is only to the JPL SVLBI Project. Since the primary interface for the global SVLBI community is to the JPL SVLBI Project, that project is listed as having the primary responsibility for the data, with the DSN listed in a secondary role.

In general, the list of responsibilities is intended to describe which organizations are responsible for carrying out each specific task, not the organizations that are responsible for funding the tasks. However, the reader should be aware of the fact that the responsibilities are contingent on funding, and may evolve subject to funding limitations. In particular, fulfillment of many of the NRAO operational responsibilities depends on outside funding from NASA. When appropriate, the division between funding and operational responsibilities is described in the paragraph accompanying each of the separately listed topics.

Mechanisms and responsibilities for data transfer are not yet well established. Therefore, it is intended that this document cover the responsibilities for operational activities that result in the creation of various types of data. The actual mechanism of electronic data transport is, for the most part, not included in this document. Issues such as which organization is responsible for providing specific data on a computer, and which path other mission elements should take to retrieve such data, remain to be settled and will be described in detail in the VSOP Mission Operations Handbook.

A list of acronyms and abbreviations follows the outline of responsibilities. The constitution of most organizations is well-known or self-explanatory, but a few require some definition. The VSOG will consist of employees of the Institute of Space and Astronautical Science (ISAS), the Japanese National Astronomical Observatory (NAO), and foreign members such as representatives of the key science teams. The Satellite Control Group (SCG) is a group in Japan that is responsible for command and control of the spacecraft as well as operation of Japanese communication stations and orbit-determination facilities; its membership has considerable overlap with the VSOG. The Deep Space Network (DSN) is operated by the Jet Propulsion Laboratory (JPL) and is responsible for the spacecraft tracking functions and orbit determination, while the JPL Project is a distinct group that is responsible for all other aspects of Space VLBI within JPL.

II. OUTLINE OF RESPONSIBILITIES

1) Scientific oversight of VSOG operations: VISC

DESCRIPTION: The VSOG is the group responsible for the day-to-day operations of the VSOP mission. The VISC is responsible for the broad oversight of the VSOG in order to ensure the best science return from the mission.

2) AO process

a) Preparation of VSOP AO: VSOG (JPL Project)
- i) Mission user's guide: VSOG (JPL Project)
- ii) Users' guide to simulation software: JPL Project, Calgary
- iii) Simulation software: JPL Project, Calgary
- iv) Suggestion of key science programs: VISC

b) Release of VSOP AO: VISC (ISAS)

DESCRIPTION: The Announcement of Opportunity for proposals will be written by the VSOG, with assistance from the JPL Project. User software will be released by the JPL Project and by the University of Calgary. Software written at ISAS will be used only for detailed simulations within the VSOG. The announcement of opportunity probably will be released formally by ISAS, but it must be approved by the VISC first. The VSOG is responsible for doing the work of advertising the existence of the AO, distributing it, and handling the incoming proposals.

3) Ground radio telescope negotiations: VSOG↔GVWG

The VSOG is responsible for preliminary negotiations with the GVWG for ground radio telescope allocations. These negotiations will continue throughout the lifetime of the mission, and will include both general negotiations of percentages of committed time, and negotiations for specific time slots. Most ground observatories are allocating their time generically to "Space VLBI," and not specifically to VSOP or RadioAstron. In the event that the two spacecraft are in orbit simultaneously, the preliminary allocations must be distributed equitably between VSOP and RadioAstron.

4) Experiment evaluation

a) Proposal submission: Individual scientists
b) Appointment of SRC: VISC
c) Proposal handling: VSOG
d) Technical evaluation: VSOG (JPL Project)
e) Scientific evaluation of proposals: SRC
f) Oversight/interaction with SRC: VSOG
g) Formation of key science teams: VSOG (VISC)
h) Proposals for targets of opportunity: Individual scientists
i) Response to target-of-opportunity proposals: VSOG (VISC, SRC)

DESCRIPTION: Individual scientists will submit their proposals to the VSOP Project. The VSOG will coordinate the handling of the proposals, including distribution to the Scientific Review Committee (SRC), appointed by the VISC. The VSOG, with aid from the JPL Project, will evaluate the technical feasibility of the proposals. This will be done partly in parallel with the scientific evaluation by the SRC, although it is hoped that the results of the technical evaluation will be available to the SRC before they reach their final decisions. The VSOG will coordinate the work of the SRC with the VSOP Project. The VSOG, in consultation with the VISC, will form key science teams and may select key science programs in addition to those suggested in the Announcement of Opportunity. Individual scientists may propose observations of targets of opportunity to the head of the VSOG (or a designated representative) at any time. The VSOG chair will approve or deny the request based on consultation with designated members of the SRC and the VISC.

5) Development of scientific schedule

a) Development of scheduling software: VSOG (JPL Project)
b) Development of scientific schedule: VSOG (JPL Project)
c) Resolution of conflicts between VSOP and RadioAstron: VSOG, RSOG
d) Negotiation of specific times with ground elements: VSOG
e) Responses to scheduling requests
   i) Kagoshima command station: SCG
   ii) Usuda tracking station: SCG
   iii) DSN tracking stations: JPL Project (DSN)
   iv) Green Bank tracking station: NRAO
   v) Nobeyama telescope: NRO
   vi) Usuda 64m telescope: VSOG
   vii) Kashima 34m telescope: CRL
   viii) VLBA, VLA, Green Bank telescopes: NRAO
   ix) DSN 70m telescopes: DSN
   x) Arecibo telescope: NAIC
   xi) EVN telescopes: EVN
   xii) ATNF telescopes: ATNF
   xiii) Other individual telescopes: Individual observatories
   xiv) VSOP correlator: NAO
   xv) VLBA correlator: NRAO

xvi) JIVE/EVN correlator: JIVE

DESCRIPTION: The scientific schedule is defined to be the allocation of scientific observations and ground resources on a daily basis, covering a period of approximately one year. The software for scientific scheduling will be the formal responsibility of the VSOG, although it is expected that they will receive considerable help from the JPL Project. The VSOG will be responsible for the generation of the scientific schedule. The scheduling process will include the negotiation of specific dates and times with the ground elements. For the ground telescopes, the total amount of time allocated will be in accord with the commitments made through the GVWG. If VSOP and RadioAstron are in orbit simultaneously, the VSOG and the RSOG must resolve all conflicts before the negotiations with the ground elements in order to prevent confusion and conflict over limited resources. Currently, there are no concrete plans to put any VSOP spacecraft data on S2 tapes, so S2 correlators have not been included.

6) Detailed schedule

a) Creation of complete schedule file(s) for spacecraft, tracking stations, and ground radio telescopes: VSOG

b) Translation of global files to those needed for operation of specific ground resources

i) Spacecraft and Kagoshima command station: SCG
ii) Usuda tracking station: SCG
iii) DSN tracking stations: JPL Project
iv) Green Bank tracking station: NRAO
v) Nobeyama 45m telescope: NRO
vi) Usuda 64m telescope: VSOG
vii) Kashima 34m telescope CRL
viii) VLBA, VLA, Green Bank telescopes: NRAO
ix) DSN 70m telescopes: DSN
x) Arecibo telescope: NAIC
xi) EVN telescopes: EVN
xii) ATNF telescopes: ATNF
xiii) Other individual telescopes: Individual observatories

DESCRIPTION: The complete detailed schedule file(s) for all space and ground resources will be under the control of the VSOG, with input from all the mission elements being scheduled. The detailed schedule will represent the VSOG's best effort to carry out the observing program defined in the scientific schedule. The VSOG will be responsible for the generation of computer-readable files that define the required parameters for the tracking stations, spacecraft, and telescopes. Each ground element will be responsible for converting those files into the commands necessary for their own operation. The detailed format of the files that the VSOG creates for the tracking stations is under development by the International Mission Operations Group. The details of the files that will be sent to the ground radio telescopes cannot be specified without further input from the GVWG.

7) Purchase of VLBA/Mk IV tapes

a) Usuda tracking station: SCG
b) DSN and Green Bank tracking stations: DSN
c) Nobeyama 45m telescope: NRO
d) Usuda 64m telescope: VSOG

e) Kashima: CRL
f) NRAO telescopes (excess over ground-only usage): NRAO
g) Arecibo: NAIC
h) DSN 70m telescopes: DSN
i) EVN telescopes: EVN, JIVE
j) Other VLBA/Mk IV-equipped telescopes: Individual observatories

DESCRIPTION: In general, the organization owning or operating each participating ground telescope or tracking station will be responsible for purchasing its own VLBA tapes. The number of tapes required will depend on correlator throughput and telescope/tracking time allocations. Extra tapes required for doing Space VLBI using NRAO telescopes will be funded by NASA through the JPL Project, but it is expected that the tape procurements probably will be made by NRAO. Therefore, NRAO is assigned the primary responsibility for the actual process of buying the tapes, but the reader should remember that the tape purchase will depend on funding from NASA.

8) Purchase of VSOP-recording-system cassettes
a) Usuda tracking station: ISAS
b) Nobeyama 45m telescope: NRO
c) Usuda 64m telescope: ISAS
d) Kashima 34m telescope: CRL
e) VSOP correlator (tape-copying): NAO/ISAS

DESCRIPTION: The VSOP data recording system, derived from the K4 system, is used only in Japan at the present time. It records data on large-format video cassettes. The individual mission elements in Japan will be responsible for their own cassette purchases. In addition to the direct recording of data, a supply of cassettes will be required for tape-copying at the VSOP correlator. If the lag time for copying and releasing tapes is longer than that for correlating and releasing tapes at another correlator, this could necessitate a larger VLBA tape supply.

9) Purchase of S2 tapes for S2-equipped telescopes: Individual observatories

DESCRIPTION: The S2 recording systems use commercially available video cassettes that are relatively inexpensive, so their purchase is not as great a financial burden on observatories or tracking stations as the purchase of VSOP or VLBA tapes.

10) Provision of near-real-time correlators
a) Usuda tracking station: NRO
b) Other tracking stations: No current plans

DESCRIPTION: NRO currently is building a near-real time correlator that is likely to be located at Usuda. It is clear that provision of a VLBA-based near-real-time correlator at the Green Bank tracking station would be highly desirable. Although plans for such a system have been made and subsequently cancelled on several occasions, there are no current technical or funding plans for construction of a near-real-time correlator for Green Bank.

11) Provision of autocorrelators
a) Usuda tracking station: NRO
b) Other tracking stations: No current plans

DESCRIPTION: NRO plans to supply an autocorrelator for the Usuda tracking station. It also would be very useful to have such a system in the DSN or Green Bank tracking stations for many purposes, such as real-time analysis of boresighting data. In particular, provision of an autocorrelator at Tidbinbilla might be very useful for pointing checks during the in-orbit-checkout period. However, there is no funding currently available for building an autocorrelator and incorporating it into any DSN station or Green Bank.

12) Spacecraft command transmission: SCG

DESCRIPTION: The Satellite Control Group will be responsible for transmission of commands from ISAS to Kagoshima to VSOP.

13) Tracking station operations

a) Usuda station: SCG
b) DSN tracking stations: DSN
c) Green Bank station: NRAO

DESCRIPTION: Tracking station operations will be the responsibility of the agencies controlling those tracking stations. These operations include the spacecraft tracking, provision of a two-way phase link, recording and delivery of wideband science data, delivery of phase residual data, Doppler data, and other ancillary data. Delivery of downlink science header data is treated separately in the next item because the headers contain both spacecraft performance data and science-payload calibration data, and more detailed explanation seems useful.

14) Extraction and delivery of downlink science headers:

a) Usuda tracking station: SCG
b) DSN tracking stations: JPL Project (DSN)
c) Green Bank tracking station: NRAO

DESCRIPTION: The science header data will be extracted at the Usuda station by the SCG and delivered electronically to ISAS. The data from the DSN stations will be extracted by the DSN and delivered to the JPL Project, which will be responsible for making it available to the SCG and VSOG in near real time. The SCG will analyze the data to determine spacecraft performance, while the VSOG will extract calibration parameters. The header data from the Green Bank station will be extracted by NRAO, which will monitor selected aspects of spacecraft performance and extract calibration information. Results of the processing will be made available to the VSOG and SCG after the conclusion of each tracking pass.

15) Day-to-day spacecraft performance, health, and status: SCG

DESCRIPTION: The SCG will be responsible for the day-to-day performance, health, and status of the spacecraft. This will include analysis of on-board instrument parameters delivered via the downlink science headers as well as a variety of indirect information that can be provided by tracking stations, including items such as link margin, two-way phase residuals, and stability of phase-cal tones.

16) Correlator input files (timing residuals, logs, calibration data)

a) Data from Usuda tracking station: SCG
b) S-band telemetry from Kagoshima: SCG
c) Data from DSN tracking stations: JPL Project (DSN)
d) Data from Green Bank tracking station: NRAO
e) Creation of Space Radio Telescope (SRT) correlator input files: SCG
f) Reconstructed orbit (also listed in item 18): DSN, SCG
g) All ground telescope files: Individual observatories

DESCRIPTION: Each tracking station will deliver its log and telemetry data electronically to the VSOG and hence to the SCG. The Usuda data will be delivered directly from the tracking station to the SCG, as will the S-band telemetry data from Kagoshima. The DSN tracking stations will deliver their data to the JPL Project, which will process it to reduce the data volume and to extract the information needed for correlator operation. Similar processing of the Green Bank data will be performed by NRAO. The SCG will be responsible for collecting the appropriate data and creating the final correlator input files (log input files and timing residual files) for the SRT by processing and/or combining the station log data, the S-band telemetry data, and the information from the science headers; the formats of the correlator input files are not yet completely specified. Correlation facilities will retrieve these files from sites that are yet to be determined.

17) Tape shipment to/from correlators

a) From telescopes: Individual observatories
b) From Usuda tracking station: SCG
c) From DSN tracking stations: DSN
d) From Green Bank tracking station: NRAO
e) From VSOP correlator: NAO
f) From VLBA correlator: NRAO
g) From JIVE/EVN correlator: JIVE

DESCRIPTION: In all instances, the shipment of tapes containing the wideband VLBI data will be the responsibility of the originating party. As stated previously, S2 correlators have not been included because there are no approved plans to record or copy any spacecraft data on S2 cassettes.

18) Tape-tracking and inventory

a) VLBA/Mk IV tapes: NRAO (JIVE)
b) VSOP cassettes: NAO
c) S2 tapes: ???

DESCRIPTION: In general, the tracking and inventory of tapes will be the responsibility of the correlation facilities, using their own monitoring facilities as well as input data provided by the tracking stations and ground telescopes. It is not yet determined if tracking of the tapes will be specific to Space VLBI or part of a more general VLBI system. At some time after it comes on line, the JIVE correlator will maintain an inventory of VLBA/Mk IV tapes separate from the inventory maintained by NRAO for the VLBA correlator.

19) Correlator operations:

a) VSOP correlator: NAO
b) VLBA correlator: NRAO
c) JIVE/EVN correlator: JIVE

DESCRIPTION: Correlator operations will be the responsibility of the institutions where the correlators reside. As mentioned previously, no S2 correlators are included because there are no firm plans to record any spacecraft data on S2 systems.

20) Orbit determination

a) Tracking data (Ku band) from Usuda tracking station: SCG
b) Tracking data (Ku band) from DSN tracking stations: DSN
c) Tracking data (Ku band) from Green Bank tracking station: NRAO
d) Tracking data (S band) from Kagoshima command station: SCG
e) GPS orbit solutions (experimental only): SCG
f) Tracking data exchange: SCG, DSN
g) Predicted orbit for planning: SCG
h) Predicted orbit for Kagoshima command station: NASDA
i) Predicted orbit for Usuda tracking station: SCG (DSN)
j) Predicted orbit for DSN and Green Bank stations: DSN
k) Reconstructed orbit: DSN/SCG

DESCRIPTION: The operators of the tracking stations will be responsible for delivering Ku-band Doppler data or S-band range and range-rate data to the orbit determination groups. Initially, data from Kagoshima and Usuda will be delivered to the SCG, and data from the DSN and Green Bank will be delivered to the DSN navigation team. The SCG and DSN will exchange tracking data and compare orbit solutions. The SCG will be responsible for long-term orbit prediction for mission planning as well as short-term orbit prediction for tracking from Usuda. NASDA will use the Kagoshima S-band data to produce orbit predictions for the Kagoshima command station. The DSN will be responsible for the orbit prediction for the DSN and Green Bank stations. Both groups will generate reconstructed orbits. It is probable that the VLBA correlator will get the reconstructed orbit it requires from the DSN navigation team, while the VSOP correlator will get the reconstructed orbit it needs from the SCG. The site from which the JIVE correlator or any possible S2 correlators retrieve the reconstructed orbit is not determined. The orbits delivered by the two groups should be identical, or at least consistent with each other.

21) Contingencies and status of mission elements

a) Status reports and notification of anomalies: Individual elements
b) Periodic VSOP status summary: VSOG
c) Determination of response to anomalies: VSOG, SCG
d) Response to targets of opportunity: VSOG

DESCRIPTION: Each mission element will be responsible for generating a Space VLBI status report on a weekly or bi-weekly basis. This status report, whether entered on a standard form or prepared in free format, should be electronically available to all VSOG members. The VSOG will produce a machine-readable summary of the VSOP status on a weekly basis; this status report should reside on a computer that is accessible to other mission elements and interested scientists.

In addition, all mission elements will be responsible for notifying the VSOG immediately in case of anomalies. The VSOG and the SCG will determine the response to anomalies and coordinate with the mission elements that must take corrective action.

22) AIPS maintenance and enhancement: NRAO

DESCRIPTION: NRAO is responsible for enhancing the AIPS software package to enable analysis of Space VLBI data, and for testing and maintaining the software releases. This responsibility is contingent upon NASA funding. The Space VLBI software may be moved to AIPS++ at some later date, but no definite plans exist for this process.

23) Long-term performance analyses

a) Spacecraft performance: SCG
b) Kagoshima command station: SCG
c) Usuda tracking station: SCG
d) DSN tracking stations: DSN, JPL Project
e) Green Bank tracking station: NRAO
f) Ground telescopes: Arrays and individual observatories
g) Orbit determination: DSN, SCG, JPL Project
h) Correlators: NRAO, NAO, JIVE
i) Data and image-quality assessment: VSOG, JPL Project
j) Overall assessment: VSOG
k) Recommendations: VISC

DESCRIPTION: The long-term performance of the VSOP mission should be assessed on a periodic basis. The VSOG will lead this assessment by soliciting information from each of the mission elements. They will evaluate both hardware and operational performance. Based on the overall mission performance, they will present the VISC with a set of proposed changes. The VISC will consider the VSOG proposals and make recommendations to the project management that they believe would enhance the science return. For instance, the VISC might recommend a change in the balance between 5 GHz and 22 GHz observations, based on telescope performance and on the early scientific results. Changes in operational procedures could be carried out by the VSOG without formal approval from the VISC.

24) User support: VSOG, NRAO, JIVE, JPL Project

a) Interface to principal investigator for AO, proposals: VSOG
b) Interface for mission information: VSOG
c) User software and simulations: JPL Project
d) Data analysis support: NRAO, JIVE

DESCRIPTION: Individual investigators and key science teams will seek help of various kinds from the different mission elements. The VSOG, NRAO, JIVE, and the JPL Project all will play active roles in user support. Although the strengths of the individual organizations will be in different areas of support, all may play some role in each of the areas mentioned below. It is anticipated that the VSOG will be the primary point of contact for scientists who are interested in the Announcement of Opportunity and for the actual scheduling of scientific observations. The JPL Project may be an important point of contact for potential users who wish to simulate observations in advance of writing proposals. NRAO and JIVE, through their standard support processes for users of their arrays, will play a major role in helping some of the investigators analyze their data.

25) Data release and archiving

a) Usuda tracking station archive: SCG
b) DSN tracking station archive: DSN, JPL Project
c) Green Bank tracking station archive: NRAO
d) Orbit-determination archives: DSN, SCG
e) VLBA correlator output and archive: NRAO
f) VSOP correlator output and archive: NAO
g) JIVE/EVN correlator output and archive: JIVE
h) Requests for release of archived data: VSOG

DESCRIPTION: There are no firm plans yet for a central data archive for the VSOP mission. Instead, archives at various sites will be operational, with the information being archived dependent on the functions performed at those sites. The operators of the tracking stations will be responsible for archiving their ancillary data, including science headers and log files. Orbit-determination information, including trajectory files, will be archived by the DSN and the SCG. Each correlator will maintain an archive of its output data and will be responsible for delivering the output data to the principal investigators for each experiment. A general policy needs to be established for the release of archived data to the general community after a fixed period of time. Requests for such data release should be handled by the VSOG during the life of the mission, but may become the responsibility of the individual correlators at some later time.

III. ACRONYMS AND ABBREVIATIONS

AO	Announcement of Opportunity
ATNF	Australia Telescope National Facility
CR	Communications Research Laboratory (Japan)
DSN	Deep Space Network (U.S.)
EVN	European VLBI Network
GVWG	Global VLBI Working Group (International)
ISAS	Institute of Space and Astronautical Sciences (Japan)
JIVE	Joint Institute for VLBI in Europe
JPL	Jet Propulsion Laboratory (U.S.)
K4	Cassette-based recording system developed in Japan
Mk IV	Video-tape-based data acquisition system developed in U.S.
NAIC	National Atmospheric and Ionospheric Center (U.S.)
NAO	National Astronomical Observatory (Japan)
NASA	National Aeronautics and Space Administration (U.S.)
NASDA	National Space Development Agency (Japan)
NRAO	National Radio Astronomy Observatory (U.S.)
NRO	Nobeyama Radio Observatory (Japan)
RISC	Radioastron International Scientific Council (International)
RSOG	Radioastron Science Operations Group (Russia)
S2	Video-cassette-based recording system developed in Canada
SCG	Satellite Control Group (Japan)
SRC	Scientific Review Committee (International)
SRT	Space Radio Telescope
SVLBI	Space Very Long Baseline Interferometry
VISC	VSOP International Scientific Council (International)
VLA	Very Large Array (U.S.)
VLBA	Very Long Baseline Array (U.S.)
VLBI	Very Long Baseline Interferometry
VSOG	VSOP Science Operations Group (Japan)
VSOP	VLBI Space Observatory Programme