# The Second

# Announcement of Opportunity

# VLBI Space Observatory Programme

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Institute of Space and Astronautical Science

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# 1 Introduction

This Announcement of Opportunity (AO) invites proposals for the second phase of scientific programs to be carried out by the VLBI Space Observatory Programme (VSOP) mission, a Japanese-led international scientific project involving joint observations by the orbiting radio telescope HALCA and several ground-based observatories and networks. The international scientific community is invited to participate in the scientific program of the mission by submitting proposals for General Observing Time (GOT), which will be reviewed by an independent international Scientific Review Committee (SRC). This AO outlines the procedures for submitting proposals, which cover the use of both HALCA and ground radio telescopes in the GOT observations, and for participating in the VSOP Survey Program. Proposers are strongly advised to refer to the VSOP Proposer's Guide for further details of the VSOP mission. This AO solicits proposals for AO2 observations, which cover the 12 months from January to December 1999, although some AO2 proposals may be scheduled as early as October 1998 if this enables better $(u,v)$ coverage to be obtained. Proposers wishing to continue, or complete, programs started during the first AO period must submit a proposal in response to this Announcement of Opportunity. Proposals must arrive at the Institute of Space and Astronautical Science (ISAS) by 8 May 1998. Proposals received after that date will not be accepted.

The current schedule for VSOP-related events is as follows:

- Release of the second AO (AO2) ..... 12 February 1998
- **Proposals to be received at ISAS ..... by 8 May 1998**
- SRC review of proposals complete ..... August 1998
- Notification to Principal Investigators ..... September 1998
- First AO2 observations may be scheduled ..... 1 October 1998
- Official AO2 observation period starts ..... 1 January 1999
- Last AO1 observations may be scheduled ..... 28 February 1999
- End of AO2 period ..... 31 December 1999

# 2 Mission Overview

Very Long Baseline Interferometry (VLBI) enables high angular resolution images to be made at radio wavelengths. The angular resolution of ground-based VLBI at a given wavelength is limited by the Earth's diameter. Space VLBI is a natural extension of ground-based VLBI, with one additional telescope in Earth orbit added to the ground radio telescope array. The high data rate necessary for high sensitivity requires the down-linking of data from the satellite in real time. This in turn requires a world-wide network of telemetry stations to receive and record this data and, just as importantly, to up-link the reference frequency to the satellite.

The VLBI Space Observatory Programme (VSOP) is a project of Japan's Institute of Space and Astronautical Science (ISAS) in close collaboration with the National Astronomical Observatory (NAO). In addition, the National Aeronautics and Space Administration (NASA) in the USA and a number of organizations around the world are providing facilities which are essential components of the science mission. The mission elements are described briefly below, and in more detail in the VSOP Proposer's Guide (see §5.1 for more details of the Proposer's Guide).

A paper giving details of the VSOP mission and describing results from In-Orbit Check-out observations will be submitted in February 1998 for publication in an international scientific journal. Publication details will be made available from the VSOP WWW site (http://www.vsop.isas.ac.jp) and in the VSOP newsletter (see §5.5).

## 2.1 The HALCA Satellite

During its development the VSOP satellite was referred to as MUSES-B, as it was the second in the series of ISAS's Mu Space Engineering Satellites. After launch on 12 February 1997, the satellite was renamed HALCA – the 'Highly Advanced Laboratory for Communications and Astronomy'. The launch was followed by an intensive In-Orbit Checkout period, during which the end-to-end VSOP elements – HALCA, tracking stations, orbit determination, data recorders, correlators and reduction software – were checked and debugged to form a fully integrated network. The mission is made available to the astronomical community on a best-efforts basis. The expected lifetime of the satellite is 3–5 years.

HALCA was launched from the Kagoshima Space Center into Earth orbit on the first flight of ISAS's M-V rocket. The orbital parameters are given in Table 1. Over the life of the mission the precession of the satellite's orbit will allow good $(u,v)$ coverage over the whole sky. However, it is recommended that before submitting a proposal one of the simulation software packages described in §5.2 be used to determine whether sources of interest can be observed during the AO2 period. The apogee height allows baselines three times longer than on the Earth, while the perigee height is low enough to fill in the intermediate baselines and to aid with calibration of data obtained on ground–space baselines by comparison with data from ground-only baselines. Typically, an observation of a source will last 7–14 hours, although various constraints result

in the loss of ground–space baselines for some part of each observation. A full description of observing constraints is given in §4 of the VSOP Proposer's Guide.

Table 1: Orbital Parameters

| Element | Value |
|---|---|
| Period | 6.3 hours |
| Inclination | 31 degrees |
| Apogee altitude | 21,400 km |
| Perigee altitude | 560 km |

HALCA's parabolic main reflector is composed of a thin flexible mesh that was deployed in orbit and fixed in position by a set of cables attached to a support structure. The aperture has a physical area of 50 $m^2$, equivalent to an 8 m diameter reflector. A concentric feed is located at the Cassegrain focus, followed by left-hand circular polarizers and receivers at 1.6, 5, and 22 GHz. The observing bands include standard VLBI continuum frequencies and the frequencies of OH and $H_2O$ masers. However early in HALCA's In-Orbit Checkout it was discovered that the performance at 22 GHz was severely impaired. **No proposals for observations at 22 GHz will be accepted for the period covered by the second Announcement of Opportunity** – see §3.2.5 for more details. A summary of observing parameters and sensitivities is given in Table 2.

Table 2: Observing Bands and Sensitivities

| Band | 1.6 GHz | 5 GHz |
|---|---|---|
| Frequency | 1.60–1.73 GHz | 4.7–5.0 GHz |
| Polarization | LCP only | LCP only |
| $T_{sys}$ | 75 K | 95 K |
| Aperture Efficiency | 24% | 34% |
| System gain | 4.3 mK $Jy^{-1}$ | 6.2 mK $Jy^{-1}$ |
| $T_{sys}$ (Equivalent Flux Density) | 17,400 Jy | 15,300 Jy |
| Typical Coherence Time ($\tau_c$) | 600 s | 400 s |
| $7\sigma$ Sensitivity to VLBA Antenna: | | |
| Continuum source (1) | 131 mJy | 147 mJy |
| Line source (2) | 4.2 Jy/ch | 4.7 Jy/ch |

(1). For a 16 MHz bandwidth, with an integration time of $\tau_c$, typical for observations within two hours of apogee. See §9 of the VSOP Proposer's Guide for details of these calculations.
(2). As for (1), with 1024 channel correlation. See §9.11 and §12 of the VSOP Proposer's Guide for details of the spectral line capabilities of correlators.

HALCA observations are subject to a number of constraints, which are described in detail in

§4 of the Proposer's Guide. The position of the Sun relative to the source imposes a major constraint. The sun angle, defined as the angle between the Sun and the source being observed, must be greater than 70° as otherwise the main antenna shadows the solar panels. The sun angle ranges have been further limited to 80°–110° and 145°–180° because of excessive angular momentum build-up at other angles. Proposers requesting observations outside the current limits should realise that such observations may not be able to be scheduled.

HALCA is also unable to observe when sunlight falling on the solar panels is eclipsed by the Earth or moon. Furthermore, after each eclipse an amount of time approximately equal to the eclipse duration is required to fully recharge the batteries. A series of long eclipses is predicted to take place when HALCA is near apogee between 9 October 1998 and 3 November 1998 (before the beginning of the nominal AO2 period), and the observing efficiency during this time will be limited.

Three combinations of bandwidth, sampling and channelization are available, under the constraint of a total bit rate of 128 Mbps. The mode with two channels of 16 MHz bandwidth and 2-bit sampling is the standard mode for scientific observations, and is the only mode compatible with VLBA, Mk IV and S2 recording systems. (The VSOP-T recording system can handle two other modes of recording – see §3 of the VSOP Proposer's Guide for more details.) The default observing mode has the two observing channels side by side; however the channels can be separated within the allowed observing band. The two channels cannot be assigned the same frequency range. The channels can be selected on HALCA so that one channel is in the 1.6 GHz range and the other is in the 5 GHz range. Such a mode is not supported at most ground radio telescopes, but frequency-agile telescopes can switch frequencies regularly so that observations with one 16 MHz channel are interleaved at the two frequencies (see §3.2.1 for more details).

## 2.2 Ground Facilities

HALCA is commanded via 2.1 GHz (S-band) telemetry from ISAS's Kagoshima Space Center. ISAS is also providing a 15 GHz (Ku-band) tracking and data link station at Usuda (Japan). Four similar tracking and data link stations are being provided by NASA: three Deep Space Network sites, at Goldstone (USA), Robledo (Spain), and Tidbinbilla (Australia), and one at the National Radio Astronomy Observatory (NRAO) site at Green Bank (USA). (See §6 of the VSOP Proposer's Guide for more details.) Orbit determination teams at ISAS and JPL use data from the tracking stations to derive precise reconstructed orbits for data correlation, and to provide predicted orbits for future tracking passes.

A number of ground radio telescopes (GRTs) have committed time for simultaneous observations with space VLBI observatories; these are listed in Table 3. Participating VLBI networks include the Very Long Baseline Array (VLBA), operated by the NRAO, and the European VLBI Network (EVN). Other individual telescopes are also providing time (see §7 of the VSOP Proposer's Guide for more details). Participation of ground-based observatories and allocations of ground telescope time are arranged under the auspices of the Global VLBI Working Group (GVWG), currently chaired by R. Schilizzi (JIVE).

Table 3: Participating Ground Radio Telescopes and VLBI Networks

| GRT/Array | Location | System Equivalent Flux Density (Jy) 1.6 GHz | 5 GHz |
|---|---|---|---|
| Arecibo | Puerto Rico | 2.5 | 3.5 |
| ATCA (Narrabri) | Australia | 60 | 80 |
| Ceduna | Australia | — | 500 |
| EVN: | | | |
| Cambridge | UK | 212 | 136 |
| Effelsberg | Germany | 19 | 20 |
| Jodrell (Lovell) | UK | 44 | — |
| Jodrell (Mk II) | UK | — | 320 |
| Medicina | Italy | 582 | 296 |
| Noto | Italy | 784 | 260 |
| Onsala | Sweden | 390 | 600 |
| Shanghai | China | 1088 | 520 |
| Torun | Poland | 200 | 220 |
| WSRT | Netherlands | 120 | 108 |
| Goldstone | USA | 49 | — |
| Green Bank | USA | † | † |
| Hartebeesthoek | South Africa | 370 | 680 |
| Hobart | Australia | 1300 | 1300 |
| Mopra | Australia | 350 | 450 |
| Robledo | Spain | 49 | — |
| Tidbinbilla | Australia | 49 | — |
| Usuda | Japan | 69 | 69 |
| VLA-27 | USA | 14 | 14 |
| VLBA (10 sites) | USA | 300 | 290 |

The system equivalent flux density (SEFD) is given for frequency bands that will be supported during the AO2 period (see §7 of the VSOP Proposer's Guide for more details.) The SEFD, also known as the system temperature in jansky, is the ratio of the system temperature in K to the antenna sensitivity in K $Jy^{-1}$.

† Telescope availability at Green Bank for the AO2 period is presently under consideration.

The VSOP Science Operations Group (VSOG) will allocate GRTs for VSOP observations (see §6.3), and any special requirement of particular GRTs must be clearly justified in the proposal. Preparation of observing files for all telescopes will also normally be done by the VSOG, although involvement of the Principal Investigator (PI) may be necessary in the scheduling of more complex observations. Scientific observations with HALCA will depend strongly on the availability of GRT time, so all proposers should carefully consider their demands on these resources. Policies of the individual ground observatories will be respected in the VSOP scheduling process.

There are three different tape formats used for VSOP observations: VSOP-T, VLBA/MkIV, and S2. Most GRTs can record in only one format. Experiments involving two or more formats will thus require conversion of some tapes before correlation. Data will be correlated at the VSOP correlator in Mitaka (Japan), the S2 correlator in Penticton (Canada) and at the VLBA correlator in Socorro (USA). Although proposers may nominate a preferred correlator, the correlator used for a certain observation will normally be determined during the scheduling process by the VSOG. Correlation facilities are described in more detail in §12 of the VSOP Proposer's Guide.

The NRAO AIPS software package has been upgraded to Space VLBI capability for all aspects of data reduction, and the Caltech DIFMAP program is also space-VLBI capable for imaging, model-fitting, and self-calibration. Further details of these software packages and additional sources of information related to data reduction are available from the VSOP WWW site (http://www.vsop.isas.ac.jp/obs/Reduction.html) – see also §15 of the Proposer's Guide.

User-support facilities to assist investigators in analysis of their VSOP observations are operated on a regional basis by ISAS (for Japan), by NRAO (for the USA), by JIVE (for Europe) and by the University of Calgary for observations correlated at the Penticton correlator.

## 2.3 Mission Organization

The VSOP mission is led by the Project Manager, H. Hirosawa, and the Project Scientist, H. Hirabayashi. The mission is overseen by the VSOP International Science Council (VISC), a fifteen member group consisting of representatives of the participating organizations and several 'at large' representatives. The VISC is currently co-chaired by H. Hirabayashi (ISAS) and D. Jauncey (ATNF). The day-to-day operation of the mission is undertaken by the VSOP Science Operations Group (VSOG), comprising members from ISAS and NAO, with support from visiting staff at ISAS and other institutions.

# 3 Observing Opportunities

It is expected that approximately 300 target pointings will be made during the AO2 period — from 1 January to 31 December 1999. This section describes the nature of the observing opportunities open to the astronomical community and provides some details on the types of observations that are possible.

## 3.1 Nature of Observing Opportunities

There are three categories of VSOP scientific observations: (1) General Observing Time, (2) the VSOP Survey Program, and (3) Target of Opportunity Observations. The astronomical community is invited to participate in these observational categories by submitting proposals in response to this Announcement of Opportunity for General Observing Time, or contacting the Project Scientist regarding participation in the VSOP Survey Program or Target of Opportunity observations, as described below.

As an ISAS engineering mission, VSOP has no dedicated technical support in Japan, and hence the local radio astronomical community is responsible for all elements of HALCA operations, scheduling observations and operating the VSOP correlator. However, since the project is being run as an international endeavour, on a best-efforts basis, all investigators are strongly encouraged to consider contributing some of their time to working on details of the mission operation in return for their scientific rewards. Anyone interested in assisting with VSOP operations should contact the VSOP Project Scientist (e-mail: vsop_ps@vsop.isas.ac.jp).

### 3.1.1 General Observing Time

General Observing Time is open to the astronomical community through peer-reviewed proposals. This will be the most common means for astronomers to take part in the VSOP mission. The GRT time used to support General Observing Time observations will be drawn from the pool of telescope time that has been negotiated through the GVWG for support of space VLBI (the General Observing Time pool).

It is envisaged that the General Observing Time pool is sufficient to support scientific observations for approximately half of HALCA's in-orbit time, although the exact proportion will depend critically on HALCA constraints and the demand on GRT resources. Long observations, or observations requiring a large number of GRTs, will deplete the pool faster than those with more modest needs. It is envisaged that approximately 200 target pointings will be made in General Observing Time during the AO2 observing period, with the remaining pointings being devoted to the VSOP Survey Program. A typical General Observing Time observation is likely to use a large array of ground telescopes (e.g., the VLBA or the EVN, or both) and last 7–14 hours.

All proposals for General Observing Time will be reviewed by the Scientific Review Committee (SRC). If experiments for the same or similar investigations are received two or more proposals, the SRC may choose only the best rated experiment, recommend a merging of the proposal teams or, if the scientific goals are sufficiently different, recommend that the data is shared between the teams (see §6.2). Potential proposers of similar investigations are encouraged to form teams before submitting a proposal. A list of the observations scheduled over the complete AO1 period (showing source and observation band) is available from the VSOP WWW site and in the VSOP Proposer's Guide: proposers may wish to refer to this list while planning their proposal. Further details of the scheduled observations are also available from the VSOP WWW site.

A limited number of the best scientific experiments may be recommended by the SRC to form Key Science Programs, to ensure that important scientific goals of the mission are realized. Inclusion in KSPs will take place only with the concurrence of the VISC and the proposers. Each KSP observation will be led by its original PI (unless there are proposal mergers as discussed above), with the VSOG paying closer attention to the planning, scheduling, and calibration of the observation. In return, the mission may request that one or two VSOG members be added as co-investigators to the KSP observation.

### 3.1.2 The VSOP Survey Program

The VSOP Survey Program is led by the VSOP mission through the Survey Working Group (SWG). Surveys of active galactic nuclei and maser sources are being conducted as part of the Survey Program. These surveys increase the scientific output of the mission by increasing the percentage of time during which scientific observations occur over that possible with General Observing Time, since they will utilize GRT time devoted directly to the surveys, as arranged by the mission. The survey results are essential for planning future VLBI observations (including those with VSOP) and for designing future space VLBI missions. A survey observation will typically last 4–7 hours and be made with no more than 3–4 ground telescopes, thus providing significantly less data than normal imaging observations. Details of the Survey Program, including the source lists, are available from the VSOP World Wide Web site (http://www.vsop.isas.ac.jp).

The SWG encourages contributions of telescope time, other resources or coordinated observing programs. Interested scientists should contact the VSOP Project Scientist (e-mail: vsop_ps@vsop.isas.ac.jp).

The survey data on individual sources will be made available concurrently for scientific use to other investigators who have successfully proposed more detailed observations of those sources at the survey frequency. If General Observing Time observations of Survey Program sources are made before the survey observations are scheduled, the Principal Investigators may be asked for permission to share a portion of their data – for a limited period from a limited number of ground radio telescopes – with the Survey Working Group in order to increase the overall efficiency of scheduling the survey sources.

### 3.1.3 Target of Opportunity Observations

A Target of Opportunity (ToO) is an astrophysical phenomenon which cannot be predicted and for which observations cannot be proposed in the normal manner. Target of Opportunity proposals may be submitted at any time, in the same format as normal proposals, to the VSOP Project Scientist. Before submitting a ToO proposal, proposers should use the simulation software packages to ensure the source is in a region of sky which HALCA can observe. Proposals should also indicate the timescale for which ToO observations are requested. A minimum time period of four days should be assumed from receipt of a ToO proposal to the earliest possible observation being made. ToO proposals requiring a rapid (i.e. less than 2 week) change of HALCA and ground radio telescope schedules will be permitted only in exceptional circumstances. ToO observations will require the approval of the VSOP Project Scientist and his VISC co-chair. Given the time-critical nature of these observations, Target of Opportunity proposals may be submitted in their entirety by e-mail and/or fax (see Appendix B for contact details).

## 3.2 Types of General Observing Time Proposals

General Observing time proposals may fall into one of the following categories:

### 3.2.1 Single Observations

A proposal contains one or more *experiments*, each of which contains one or more *observations*. Each observation will last typically 7–14 hours. Many of the VSOP programs will be single observations made in order to produce high-resolution images. Source changes with HALCA will typically take several hours, so programs requiring rapid switching among sources will not be possible. Limited frequency changes *within* a band are possible during single observations (see §4.8 of the VSOP Proposer's Guide). A change *between* frequency bands in either of HALCA's channels marks a separate observation.

HALCA can observe with one 16 MHz channel at 1.6 GHz and the other at 5 GHz. Frequency-agile ground radio telescopes can then alternate between 1.6 GHz and 5 GHz to enable images at both frequencies to be made. This observing mode can be selected on the proposal Cover Sheets, however proposers should note that these observations will be made with GRTs recording only one 16 MHz channel: polarization mode observations may not be combined with this mode.

### 3.2.2 Monitoring Observations

Experiments proposed for multi-epoch observations are referred to as monitoring observations. As HALCA's orbit precesses rapidly, the $(u,v)$ coverage for any given source changes substantially from month to month. In addition, a Sun avoidance angle of 70° implies that there will be periods of up to 5 months when observations of some sources will be impossible. As mentioned in §2.1, other sun angle restrictions (which currently limit the allowed range to 80°–110° and 145°–180°) further limit the periods in which reasonable $(u,v)$ coverage can be obtained for some sources.

Because of these complications, monitoring programs are significantly more complex than those traditionally carried out in ground-based VLBI. Proposals for monitoring observations should include suggested observing dates which are consistent with the HALCA constraints and the goals of the experiment.

### 3.2.3 Polarization Observations

HALCA receives only left circular polarization (LCP). However, the use of dual-polarization radio telescopes on the ground may enable images of the polarized intensity to be made. The VISC has established a Polarization Study Team to investigate the feasibility of polarization imaging with HALCA. The Study Team believes that the polarization impurity of HALCA's feed is sufficiently small that useful polarization observations are possible, although the means of reliable calibration of the impurity are still being evaluated. Proposers are reminded that, unlike most ground-based telescopes used for VLBI polarimetry, HALCA does not rotate about the source direction and cannot slew to calibrators, and this significantly complicates calibration of the polarization impurity. When combined with HALCA's small aperture and limited polarized $(u,v)$ coverage (only LCP) it is clear that VSOP polarization imaging proposals should be considered with great care (see §9.10 of the VSOP Proposer's Guide for more details).

The default observing mode for polarization experiments is for ground radio telescopes to record one, 2-bit sampled, 16 MHz channel each in both LCP and RCP, however 'double-rate' recording (i.e. two, 2-bit sampled, 16 MHz channels each in both LCP and RCP) is possible with VLBA/MkIV systems and will be considered if a significantly strong scientific case is made. As the Study Team continues its investigations, details regarding the polarization calibration of HALCA will be reported on the VSOP WWW site (http://www.vsop.isas.ac.jp).

### 3.2.4 Time-Critical Observations

Scheduling constraints limit the ability to make time-critical observations such as coordinated observations with other satellites or ground telescopes. Proposers wishing to make coordinated observations should provide as much detail as possible about the acceptable scheduling dates. Information on acceptable scheduling dates that becomes available after the VSOP AO2 proposal has been submitted should be e-mailed to vsog@vsop.isas.ac.jp, quoting the assigned VSOP proposal code.

Some proposed VSOP experiments may be scientifically enhanced by additional ground-only VLBI observations at another frequency. For example VSOP observations at 5 GHz and global VLBI observations at 15 GHz will have about the same resolution and accurate spectral properties of the source can be obtained. The amount of the ground-only observations and the closeness in time to the VSOP observations will depend on the source properties and goals of the experiment.

The VSOP and ground-VLBI proposals must be proposed independently, although each proposal should acknowledge the other as part of the general scientific justification. For AO2 observations (which may be as early as 1 October 1998 – see §4.1), proposals for the ground-VLBI observations may have to be submitted as early as June 1998 to meet ground-array deadlines.

During most VSOP observations, there are periods of time when no HALCA signal can be received by any of the tracking stations. During these periods the ground array will observe calibrator sources or continue observing the source at the same frequency. If the VSOP observations are scheduled to use frequency-agile arrays (such as the VLBA), one option for obtaining the ground-only observations at a different frequency is to submit a proposal for the use these gaps in the VSOP observations (typically ∼20% of an observation). Please indicate in your ground-array proposal if this relatively small amount of data taken during the 'gaps' in the VSOP observation is sufficient to meet the goals of the ground observations.

### 3.2.5 22 GHz Observations

During the In-Orbit Checkout phase of the mission it was discovered that there was an attenuation of more than 10 dB between the feed and the receiver in the 22 GHz system. It is likely that only the very strongest sources in the sky may be detectable at 22 GHz, and that any successful 22 GHz observations will require considerable effort on the part of mission personnel. As a result, **22 GHz proposals will not be accepted in response to this Announcement of Opportunity.** The mission is continuing its efforts to assess the characteristics of the on-board observing system at 22 GHz.

### 3.2.6 Spectral Line Observations

OH maser and molecular absorption spectral line VSOP observations are able to be made. Proposers are reminded that the two observing channels on HALCA cannot be assigned the same frequency range as this adversely affects the characteristics of the downlink data stream. The actual frequency ranges used for spectral line observations will be determined during the scheduling of the observation by the VSOG and checked with the PI or contact person of the proposal. The spectral line will be offset by 1–2 MHz from the center of the observing band to avoid contamination from spurious signals at the band center which are known to exist for HALCA and some GRTs.

All proposals, including proposals for spectral line observations, must contain information about the correlated flux density of the source(s) on long Earth baselines. Spectral line proposers are encouraged to nominate a preferred correlator for each experiment after considering the spectral resolution required to meet their scientific goals (see §9.11 of the Proposer's Guide for more details). The choice of correlator will largely determine which telescopes can be selected for the observation, as the amount of translating able to be accommodated between VLBA/MkIV and VSOP-T or S2 formats is limited.

# 4 Proposal Preparation and Submission

This section describes the preparation and submission process for proposals for General Observing Time. The process for participation in the VSOP Survey Program is described in §3.1.2.

## 4.1 Period Covered by Announcement of Opportunity

This AO invites proposals for the 12-month period from 1 January to 31 December 1999. Some observations from AO1 proposals will be scheduled in the first two months of 1999 if better $(u,v)$ coverage is obtainable at that time. Similarly, observations from AO2 proposals may be scheduled as early as 1 October 1998 if a strong scientific case is made for scheduling in this period. (Proposers are reminded of the reduced observing efficiency between 9 October and 3 November 1998 – see §2.1.)

All AO1 Principal Investigators (or their designated contact persons) were contacted by e-mail in January 1998 with details of their experiments that have been, or will be, scheduled during the first AO period. **Proposers wishing to continue, or complete, programs started during the first AO period must submit a proposal in response to this Announcement of Opportunity.** Related AO1 proposal code(s) should be listed in item (8) of the AO2 Cover Sheets.

## 4.2 Who May Propose?

Proposals for VSOP observations may be submitted by scientists of any affiliation and from any country. Proposals will be evaluated solely on the basis of their scientific merits and technical feasibility. No letter of intent is required in order to submit a proposal. Each proposal should identify a single individual who will act as Principal Investigator, and may also list any co-Investigators. The PI will be responsible for the scientific and administrative conduct of the proposed project, and would normally be the formal contact for all communications with the VSOG unless a co-investigator is designated as the contact person.

## 4.3 Proposal Format and Content

All proposals must be submitted in the standard format described below. The proposal consists of the Cover Sheets and the scientific and technical justification. Proposers also have the option of submitting $(u,v)$ coverage plots to support their applications. Two paper copies of the proposal (including the Cover Sheets) must be submitted to ISAS and received by 8 May 1998. An electronic version of the Cover Sheets also must be submitted by e-mail. Proposals must be written in English and printed on A4 or $8\frac{1}{2}\times 11$ inch paper. It is essential that the electronic and paper versions of the Cover Sheets are identical.

Each proposal must be completed according to the instructions provided below. Key information from the Cover Sheets will be entered into an electronic database and will be used to track proposals and schedule observations. It is therefore essential that proposers follow the instructions when filling out the Cover Sheets. Failure to follow these instructions may result in the rejection of the proposal.

### 4.3.1 Cover Sheets

The Cover Sheets have a fixed format. The LaTeX template should be obtained electronically (see §5.4). Detailed instructions on completing the Cover Sheets are included in the template. Note that although many observing parameters may be specified on the Cover Sheets, the final observing configuration of ground radio telescopes and HALCA will be determined by the VSOG (see §6.2). Standard options are available for a number of observing parameters. A request for any non-standard observing configuration should be clearly explained in the scientific and technical justification (see below). Information from the Cover Sheets will be made available to the general astronomical community from the VSOP WWW site after an observation is scheduled.

### 4.3.2 Scientific and Technical Justification

The justification can be submitted in free-form. The font size must be 10 pt or larger, and each page of text should be contained within a width of 16 cm and height of 23 cm. The justification must not exceed two pages of text, including the list of references. Up to two pages of figures and tables may optionally be included in addition to the text. Figures and tables should not be embedded in the text, but should follow the text on separate pages. Colour figures may be submitted but all figures are photocopied in black and white before distribution to the Scientific Review Committee. A LaTeX template file is available from the VSOP ftp and WWW sites for the justification section of a proposal.

### 4.3.3 ($u$,$v$) Coverage Plots

In addition, proposers may submit an optional page of ($u$,$v$) coverage plots per source to illustrate their preferences. These plots can be generated with the simulation software described in §5.2. The submission of ($u$,$v$) plots is not essential as the mission will attempt to schedule the observation with the best ($u$,$v$) coverage within the other constraints. Specific ($u$,$v$) coverage properties which are needed, however, should be clearly described and justified.

## 4.4 Proposal Submission

The deadline for receipt of proposals at ISAS is 24:00 UT, Friday, 8 May 1998. It is the responsibility of proposers to send their proposals early enough to ensure arrival by the deadline. Proposals received after the deadline, or proposals that are incomplete, cannot be accepted, and their PIs will be so notified. An acknowledgment of the receipt of complete proposals will be sent to the PI or contact person designated on the Cover Sheets.

Two paper copies of the complete proposal, i.e. the Cover Sheets, the scientific and technical justification and, optionally, $(u,v)$ coverage plots, should be sent — unfolded and unstapled — to the following address:

VSOP Observing Proposals
VSOP Science Operations Group
Institute of Space and Astronautical Science
3-1-1 Yoshinodai, Sagamihara
Kanagawa 229–8510
JAPAN

The completed LaTeX (i.e. <filename>`.tex`) Cover Sheets file should also be e-mailed to

submit@vsop.isas.ac.jp

with the PI's family name and several identifying words from the proposal title as the subject.

# 5 Assistance for Proposers

## 5.1 VSOP Proposer's Guide

Proposers are strongly advised to read the VSOP Proposer's Guide, which provides the technical information necessary to plan and write a proposal. The revised Proposer's Guide will be available from 1 March 1998 from the WWW and ftp sites described in §5.4. The VSOP Proposer's Guide provides technical details on many mission components and activities, including HALCA and its capabilities, and the ground radio telescopes, tracking stations and correlators that support VSOP observations. The scheduling process, HALCA calibration, data analysis tools and simulation software are also described.

## 5.2 Simulation Software

Software for simulating VSOP observations is available, and is highly recommended to those wishing to write a competitive proposal. Software packages have been developed at three different institutions, and detailed comparisons have been made to ensure they are all correct and consistent. Software is available for Unix and PC platforms. Revised versions of the packages will be available from 1 March 1998. The three different packages, including details on how to obtain them, are described in §14 of the VSOP Proposer's Guide.

The software provides the ability to simulate observations and $(u,v)$ coverage at different times of the year, in different parts of the sky, for different combinations of ground radio telescopes. It is recommended that, at a minimum, proposers should determine $(u,v)$ coverages for sources at different times in order to determine when the proposed observations can best be made. The

current sun-angle constraints should be borne in mind during such simulations. The software packages account for all observing constraints with an accuracy sufficient for proposal preparation.

## 5.3 Regional Assistance

Regional assistance for prospective proposers is available from a number of different sites. Questions relating to the AO, proposal submission, technical aspects of the mission, or simulation software that are not answered elsewhere in this document or the VSOP Proposer's Guide, may be addressed via e-mail to these sites. Such questions will also be compiled to create a 'Frequently Asked Questions' file, which can be accessed on the VSOP WWW site (http://www.vsop.isas.ac.jp). Please refer to this file before contacting the appropriate regional site.

Table 4: E-mail Addresses for Regional Help

| Region | e-mail contact |
|---|---|
| Australasia/Africa | vsop_help@atnf.csiro.au |
| Canada | vsop_help@ras.ucalgary.ca |
| CIS | vsop_help@dpc.asc.rssi.ru |
| Europe/China | vsop_help@jive.nfra.nl |
| Japan | vsop_help@vsop.isas.ac.jp |
| USA | vsop_help@sgra.jpl.nasa.gov |
| Elsewhere | vsop_help@vsop.isas.ac.jp |

These e-mail addresses will be valid until the proposal deadline.

Questions directed to the regional sites will be responded to in a timely manner. As the resources for proposal support are limited, however, questions should be asked as early in the proposal period as possible, to avoid any possible congestion during the last weeks before the deadline.

## 5.4 Access to Documentation

Documentation, software, and information related to the mission status and data analysis may be obtained from the VSOP World Wide Web site (http://www.vsop.isas.ac.jp).

The following AO2 documents are also available via anonymous-ftp from ftp.vsop.isas.ac.jp (133.74.2.131):

| | |
|---|---|
| in the directory *pub*: | Guide to the VSOP ftp site (README) |
| in the directory *pub/docs* : | VSOP Announcement of Opportunity |
| | VSOP Proposer's Guide |
| | Cover Sheets template |
| | Examples of completed Cover Sheets |

Printed copies of the documents will be mailed upon request (see Appendix B for contact information).

## 5.5 VSOP newsletters

Mission updates and information of interest to proposers is published regularly in a short newsletter that is distributed by e-mail. Proposers can join the distribution list by sending an e-mail with the subject 'VSOP news SUBSCRIBE' to vsog@vsop.isas.ac.jp .

## 5.6 Financial Assistance

No funding for proposers will be available from the VSOP mission.

## 5.7 Proposal Checklist

- ☐ Obtain VSOP Proposer's Guide (see §§5.1, 5.4)
- ☐ Obtain Cover Sheets template (see §5.4)
- ☐ Obtain simulation software (see §§5.2, 5.4)
- ☐ Simulate proposed observations
- ☐ Determine all observing parameters
- ☐ Prepare Cover Sheets (see §4.3.1)
- ☐ Write scientific and technical justification (see §4.3.2)
- ☐ (Optional) Prepare $(u,v)$ coverage plots (see §4.3.3)
- ☐ Mail two copies of proposal, including Cover Sheets, to ISAS (see §4.4)
- ☐ E-mail Cover Sheets to ISAS (see §4.4)
- ☐ Meet proposal deadline **at ISAS** of 24 UT Friday, 8 May 1998

# 6 Proposal Review and Scheduling

## 6.1 Technical Review of Proposals

The VSOG will review all proposals for technical feasibility. This review will include the simulation of the proposed observations, including all HALCA constraints, and an analysis of the general capability of the satellite to make the proposed observations. A brief technical evaluation of each proposal will be given to SRC members to aid in their deliberations.

## 6.2 Scientific Review of Proposals

The VISC has appointed an independent international Scientific Review Committee (SRC) to evaluate and rank proposals for General Observing Time based on their scientific merit and technical feasibility. The VSOG's technical evaluations may affect the ranking. The SRC may propose that similar proposals be merged or that the data be shared between different proposers. Proposal merging will occur only with the approval of the VISC and the affected proposers. The SRC may grade experiments within a proposal separately; proposals requesting many observations may be only partially accepted. Approximately four months after the proposal deadline, PIs will be notified of the ratings of their proposals and the likelihood that they will be scheduled.

Ground radio telescopes and networks participating in the mission will have the right to evaluate the complete set of observing proposals for General Observing Time if they desire. The purpose of this review is to allow the ground observatories to decide if the scientific value of the proposals as a whole justifies an increase in their commitments to the General Observing Time pool.

Every effort will be made in the entire review process to ensure the confidentiality of proposals. Proposers are reminded that information from the Cover Sheets of proposals from which an observation is scheduled will be made available from the VSOP World Wide Web site.

## 6.3 Scheduling of Observations

Based on the scientific and technical ratings, the VSOG will generate the detailed schedules needed for the control of each mission element. These detailed schedules will depend on the correctness of the information submitted on the proposal Cover Sheets. Negotiation between the VSOG and the PI should not be assumed. One or two months before the time for which an observation has been scheduled, the VSOG will contact the PI with details of the scheduled observation.

Since the orbit changes with time, and the GRT resources are limited, scheduling will be a complicated process that attempts to optimize the total science return from the mission. Therefore, the scheduling group in the VSOG will allocate the GRT facilities as they consider necessary to maximize the total science return. Accepted proposals will not always be scheduled with the

exact dates nor with the GRTs that were suggested in the proposals. Therefore, it is important that the proposers employ the simulation software to determine the resources that are required to achieve the desired scientific results, and that all required parameters be defined clearly on the proposal Cover Sheets. The scheduling process is described in more detail in §11 of the VSOP Proposer's Guide.

A problem at a mission element during an observation may mean the science goals of the observation cannot be met. Some problems (e.g. with HALCA) are apparent immediately, but many are recognized only after initial attempts at the calibration of the data. For this reason, investigators are requested to analyze their VSOP data as quickly as possible. The sooner the mission knows about an unsuccessful observation, the more likely it can be rescheduled. Requests for the re-scheduling of observations should be sent by e-mail to the VSOP Project Scientist (e-mail: vsop_ps@vsop.isas.ac.jp).

# 7 Data Rights

## 7.1 Engineering and Test Data

The entire mission is being operated to produce the best scientific return overall. The VSOG has the right to analyze any of the scientific observations for their potential to enhance the performance of the mission. The VSOG can also collect data specifically for engineering or test purposes. If engineering observations overlap with successful proposals, analysis for engineering performance evaluation will be done by the VSOG, and the proposers will have exclusive scientific rights to the data.

## 7.2 Proprietary Data

All data acquired by VSOP will be the exclusive scientific property of the proposers for 18 months following the date when the correlated data are released to the PI. For monitoring and multi-source proposals, the proprietary period will end until 18 months after the date when the last data from a program are released to the PI. Definition of this date will be the responsibility of the VSOG.

## 7.3 Archive Data

Following the expiration of the period of exclusive data rights, any individual may contact the VSOG requesting the release of some set of VSOP data. The VSOG will direct the appropriate correlator to provide the appropriate correlated data, and notify the PI that the data have been released.

# Appendix A: Acronyms and Abbreviations

| | |
|---|---|
| AO | Announcement of Opportunity |
| AO1 | the first Announcement of Opportunity |
| AO2 | the second Announcement of Opportunity |
| ATCA | Australia Telescope Compact Array |
| ATNF | Australia Telescope National Facility |
| CIS | Commonwealth of Independent States |
| EVN | European VLBI Network |
| ftp | file transfer protocol |
| GOT | General Observing Time |
| GRT | Ground Radio Telescope |
| GVWG | Global VLBI Working Group |
| HALCA | Highly Advanced Laboratory for Communications and Astronomy |
| ISAS | Institute of Space and Astronautical Science |
| JIVE | Joint Institute for VLBI in Europe |
| JPL | Jet Propulsion Laboratory |
| KSP | Key Science Program |
| LCP | Left Circular Polarization |
| NAO | National Astronomical Observatory |
| NASA | National Aeronautics and Space Administration |
| NRAO | National Radio Astronomy Observatory |
| PC | Personal Computer |
| PI | Principal Investigator |
| RCP | Right Circular Polarization |
| SEFD | System Equivalent Flux Density |
| SRC | Scientific Review Committee |
| SWG | Survey Working Group |
| ToO | Target of Opportunity |
| VISC | VSOP International Scientific Council |
| VLA-27 | (the phased, 27 element) Very Large Array |
| VLBA | Very Long Baseline Array |
| VLBI | Very Long Baseline Interferometry |
| VSOG | VSOP Science Operations Group |
| VSOP | VLBI Space Observatory Programme |
| WSRT | Westerbork Synthesis Radio Telescope |
| WWW | World Wide Web |

# Appendix B: Important Addresses

World Wide Web site: http://www.vsop.isas.ac.jp

Anonymous-ftp site: ftp.vsop.isas.ac.jp (133.74.2.131)

Documents listed in §5.4 will also be available from other sites: see the VSOP World Wide Web site for details.

## E-mail Addresses for Regional Help (until the proposal deadline)

| Region | e-mail contact |
|---|---|
| Australasia/Africa | vsop_help@atnf.csiro.au |
| Canada | vsop_help@ras.ucalgary.ca |
| CIS | vsop_help@dpc.asc.rssi.ru |
| Europe/China | vsop_help@jive.nfra.nl |
| Japan | vsop_help@vsop.isas.ac.jp |
| USA | vsop_help@sgra.jpl.nasa.gov |
| Elsewhere | vsop_help@vsop.isas.ac.jp |

## VSOP Proposal Submission

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VSOP Science Operations Group
Institute of Space and Astronautical Science
3-1-1 Yoshinodai, Sagamihara
Kanagawa 229-8510
JAPAN

E-mail address to submit Cover Sheets: submit@vsop.isas.ac.jp

## VSOG

E-mail: vsog@vsop.isas.ac.jp
Fax: +81-427-51-3972

## VSOP Project Scientist — Prof. H. Hirabayashi

E-mail: vsop_ps@vsop.isas.ac.jp
Fax: +81-427-51-3972