

Preliminary Space VLBI Requirements for Observing Time on Ground Radio Telescopes

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Abstract

An initial estimate has been made of the observing time required on ground radio telescopes by the space VLBI missions **Radioastron** and VSOP. Typical science programs have been adopted for both missions. The missions were assumed to be in orbit simultaneously with each being operated 85% of the time. For the largest telescopes, typically 17% of the hours in a year is required for most telescopes, with notable exceptions being Arecibo (4%), Ooty/GMRT (4%), and **Ussurijsk** (52%), the latter of which is assumed to be largely dedicated to space **VLBI**. For the VLBI arrays, typically about 30% of the hours in a year is required for the telescopes of the VLBA and much of the EVN, while 25% is required for a Southern Hemisphere-Pacific VLBI array. Larger time commitments are desired from some telescopes: 52% at Bologna, Noto, Shanghai, Torun, and **Urumuqi**, and 72% at Algonquin. The scheduling of the space VLBI missions would be most efficient if the missions were able to request time from the ground observatories as needed and return the unused time to the observatories. If a ground observatory wished to set a minimum length of a space VLBI observing period at their telescope, that minimum should be no longer than eight hours. If an observatory wished to set a minimum length on a returned time period, that minimum should also not exceed eight hours.

Radioastron and VSOP, the first two space VLBI observatories, will require joint observations with ground-based radio telescopes (**GRTs**). In order that the ground observatories can plan their support of these missions, they need to understand the requirements on co-observing time and technical configuration. This paper summarizes the results of a report on the subject to the Interagency Control Group and the Global VLBI Working Group, which represents the world's **GRTs**. Further analysis and negotiations will certainly be needed before final allocations can be determined.

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In our study we have simulated all the major stages of scheduling the actual missions. The mission definition phase, which attempts to understand the details of how science observations would be done by the space observatories, has been studied over the last few years by science simulation teams associated with both missions and support teams at the University of Calgary and at JPL. In the nominal observing plan developed for Radioastron, an observation would last one orbit (28 hours) and require that at least two GRTs form ground-space baselines all the time. For VSOP, an imaging mission, the nominal observing period is 24 hours (four orbits) and would require an array of five or more GRTs throughout the observing period. The proposal and review process was simulated by developing a plausible science program with proposed targets using input from the science simulations teams, the U.S. space VLBI Project Science Group, and other VLBI radio astronomers at large. For Radioastron the resulting program devotes 65% of its observations to high brightness temperature surveys or fine structure modeling, 18% to monitoring a few AGN or QSOs for structural changes, 10% to interstellar scattering studies, 5% to maser spot size measurements, and 2% to radio star observations. For VSOP the sample program devotes 30% of its observations to strong source imaging and 5% to weak source imaging, 50% to AGN/QSO monitoring, 9% to galactic maser studies and 4% to extragalactic masers, and 2% to radio star observations. For each of these subprograms we specify a different number of small ($10^2 \text{ Jy} < T_{\nu} < 10^3 \text{ Jy}$), large ($10 \text{ Jy} < T_{\nu} < 10^2 \text{ Jy}$), and giant ($T_{\nu} < 10 \text{ Jy}$) telescopes and the fraction of time each is needed during the observation. To simulate the actual scheduling of observations and telescope time, we developed a new computer program - **SVLBSCHED** - and generated schedules for periods in the range of 1-12 months. Input to the program included: 1) a list of ground and space radio telescopes, their positions or orbital parameters, their operating frequencies and sensitivities, and their availability and scheduling policies; 2) a list of tracking stations and their policies on tracking each spacecraft; 3) a list of science subprograms, which frequency to observe in each, the number of radio telescopes in the various sensitivity classes required, and specific targets for space VLBI observations (roughly 1000 of the most compact VLBI sources) with different scientific priority. GRTs were assumed to be available continuously, but GRT time which was not needed to satisfy the requirements of the space VLBI science programs was not allocated for space VLBI. A synthesis of our results, along with our additional assumptions, is given in the abstract.

The actual amount of GRT time "charged" to the missions depends strongly on each ground radio observatory's time allocation policies (the minimum allowed observing period and the minimum gap between space VLBI observations) and can be much greater than the hours needed to obtain the science. For example, if the VLBA can make use of gaps between observations as small as 3 hours, then only 30% of the hours in the year is required, whereas 50% is required if the VLBA cannot handle gaps smaller than 24 hours! Our suggestions for a compromise policy for all GRTs are in the abstract.