Scientific Background

(1) Objective

The objective of this program is to verify the astrometric stability of a catalog of stars to be used as the reference grid for SIM's wide-angle astrometric science. The final catalog will comprise a minimum of 1306 stars, distributed quasi-uniformly across the sky. Grid stars serve as the fundamental reference for the SIM instrument as it performs astrometric observations. A description of the SIM instrument and its observing modes may be found on the SIM web site at http://sim.jpl.nasa.gov.

This program addresses a key aspect of the performance of SIM: the ultimate accuracy of global astrometry with SIM will be limited, in part, by the stability of the grid stars themselves. The program is limited to investigating astrophysical sources of `jitter' in the star positions; specifically, stellar motion about the system center-of-mass for binary or multiple star systems. The SIM Project is responsible for the design and construction of the SIM instrument to meet its measurement accuracy requirements.

Initial work on the grid star problem began in 1998 through the SIM Preparatory Science Program (http://sim.jpl.nasa.gov/research-opps.html). The results of that program are a list of candidate SIM grid stars. The selected candidate stars are metal-poor K-giants at a typical distance of 1-2 kpc. Low-resolution spectroscopic follow-up is underway to confirm the metal-poor K-giants selection. Additional candidates will be found from catalog searches.

The Program described here will verify the suitability of each candidate star for inclusion in the grid, or to reject it, if it fails to meet the necessary criteria. This will require large observing programs. The full-sky radial velocity (RV) monitoring program should deliver at least 17000 RV measurements on R=12 stars, at a precision of at least 50 m/s, with most of the observations taken within the first 3 years.

(2) Requirements on the candidate grid catalog

SIM requires grid stars to be stable to better than 4 microarcseconds (muas) at any epoch during its nominal 5-year mission, in a quasi-inertial reference frame. SIM will observe a number of quasars to `anchor' the grid against a rigid rotation of the entire reference frame. Tying the grid to an inertial frame is the responsibility of the SIM Science Team (http://sim.jpl.nasa.gov/ao_support/ao_abstracts.html) and the SIM Project, and is not part of the SIM Grid Star Verification program.

The stability requirement of 4 muas is set to be less than the expected accuracy of individual SIM measurements, which are nominally 10 muas in one dimension. Therefore, by design, errors in the measurements by SIM dominate over all sources of `astrophysical jitter'. The SIM grid performance, and hence the ultimate global astrometry accuracy, should be limited by the instrument, not `noise' in the grid star

positions. Overall, the mid-epoch positional accuracy of the SIM grid, given a scenario of multiple observations of each star, will be 4 muas in one dimension.

Grid stars will have R-band magnitudes in the range R = 11.0 - 12.5. Closer K-giants are brighter, but their astrometric jitter due to companions is poorer. Fainter stars require longer integration times to achieve the nominal 10 muas single measurement accuracy; magnitudes down to about R = 13.0 are feasible. However, we expect a more practical limitation to be the total required ground-based observation time needed for the verification program. This will limit the candidate magnitudes to R = 12.5.

(3) Verification of grid candidates

This RFP solicits proposals for precision radial velocity (RV) monitoring observations of grid star candidates.

Radial velocities will be used to screen the grid stars for planetary sub-stellar and stellar companions over orbital periods ranging from days to years. Very short period companions are not a concern, because the corresponding astrometric jitter is small. Long-period companions are a concern for SIM's science program, because RV data are insensitive to long-period orbits.

Screening candidates adequately will require a minimum of four measurements to a precision of 50 m/s, referred to the Local Standard of Rest (LSR). To probe the period space adequately, measurements will be performed (approximately) at four epochs spaced at t=0, t=4 months, t=2 years, and t=5 years. The basic contract will cover the first three epochs; JPL expects to extend the contract(s) to cover the final epoch and observations of any replacement candidates. JPL may extend the contract by a further one year option if the candidate failure rate is significantly higher than expected.

The observation programs will be subdivided into smaller ‘work packages’ (see Exhibit II).

Because of the critical importance of the grid to SIM's science objectives, the Project requires a high level of confidence in the grid performance at SIM launch. The Grid Star Verification Program must not only deliver a catalog of grid stars for SIM to observe, but also estimate the confidence that the RMS stability actually observed by SIM meets the original specification, with a high degree of confidence.

To improve confidence in the catalog at launch, the initial catalog will be overpopulated. The starter catalog will contain ten possible candidate stars for each possible grid star, or 13,060 objects. The SIM Project will choose the four or five top candidates for each brick to be observed during Epoch 0, for a total of up to 6,530 stars. The top three candidates will be observed four months later (Epoch 1); if any candidates fail, they will be replaced so that at least three survive to Epoch 2. Two candidates surviving Epoch 2 and Epoch 3 of Option No. 1 will leave a prime and backup grid star candidate. If the

attrition rate is low, then the SIM project will select stars based on their performance margin against the acceptance criteria.

If the rate of candidate attrition is high (projecting more than 75% rejection by launch), RV on a `secondary candidate' list will be initiated as early as possible. This will be done by substituting fresh candidates in the same region of sky to replace the rejected candidates. The table below compares different observing scenarios for different attrition rates:

	50% Failure Rate in initial catalog				80% Failure Rate in Initial catalog		
	Candidates				Candidates		
Time	Observed	Failed	Added	Action	Observed	Failed	Added
t=0	ABCDE	n/a		Pick top 3 candidates to observe in the following epoch	ABCDE	n/a	
4 months	ABD	BD	CE	Replace any failed candidates with 1) backups from 5 observed at t=0, or 2) backups from original list of 10.	ABD	B,D	C,E
8 months	CE			Observe replacements. Replace any failed candidates as above.	C,E	C	F
12 months	—			Observe replacement	F		
16 months	—			Observe replacement	F		
2 years	AC	A	E	Pick top 2 candidates to observe at the two year epoch. Replace failed candidates	AE		
2 yr 4 months	E			Observe replacement			
5 years	CE			Replace any failed candidates as above.	AE	AE	F
5 years 4 months				Observe replacement	F		
Final Catalog	CE				F		
Total Measurements	15				17		

For the above observing scheme, we expect to make between 15-20 RV measurements for every two of the 2600 grid stars that survive to enter the catalog at SIM launch. Thus the RV monitoring program is large. Even with no dropouts, it must deliver a minimum of 17000 RV measurements on R=12 stars, at a precision of 50 m/s, with most of the data taken within 3 years.

(4) Role of the selected Grid Groups

The SIM Project is ultimately responsible for ensuring the grid meets the Project's goals. The successful proposers, referred to here as `Grid Groups', will be expected to work closely with JPL toward the Project's goals, but their formal responsibility is limited to delivering the products defined in their contracts with JPL, per the Statement of Work in the Specimen Contract.

Please note that scientific analysis beyond that needed for the SIM grid, and publication costs, time to write scientific articles, and travel costs to general conferences will be deemed beyond the scope of the contract with JPL.

Proposers are encouraged to be `creative' in developing their observing plan. This might include, for instance, the purchase of observing time from an institution that operates a suitable telescope via this means of operation. Or it might include the provision of, or shared development and building of, a facility instrument in exchange for sufficient observing time for SIM's needs. Such arrangements, even if only tentative, should be included as part of the proposal, with a corresponding estimate of the required budget.

This represents a departure from the traditional means of securing observing time for astronomy. The sheer size of the expected SIM grid program, plus the fact that this work is essential to the success of a NASA mission with a significant public investment, requires approaches to instrumentation and observing which better match the needs of SIM.

Proposals will be evaluated using the evaluation criteria and factors given in the RFP sections “Volume I: Technical/Management Instructions.” Please note that scientific merit of any research based on observations supported under this RPF is not part of the evaluation. Scientific expertise is considered. `Creative' arrangements will be evaluated on the basis of meeting SIM's grid requirements, not scientific merit, although the Project will encourage the scientific use of the results from such a large observing program.

Initial contracts will be made for 2.5 years. However, JPL recognizes that the scientific validation of grid stars is best served by a long-term monitoring program, and that continuity of observing and analysis methods is important, and that is why JPL has included two options in the Contract to potentially extend it to five and six years, respectively.

(5) Budget resources

There are no pre-determined allocations of funds to the six work packages. The actual total will depend on the recommendations of the proposal review team, and also the number of Grid Groups that are selected. JPL recognizes that the most effective overall program may require the work packages to be funded at very different levels, depending on availability and cost of required resources.

(6) SIM Project Milestones and Schedule

Date	Milestone
January 2003	RFP issued
February 2003	Letters of Intent to propose due at JPL
April 2003	Proposals due
May 2003	Selection of contract(s) announced
July 2003	Contract(s) funded and grid work begins
September 2005	Nominal end of basic Contract period
July 2009	Nominal end of Option Period
December 2009	SIM launch
June 2010	Start of full science operations
June 2015	Nominal end of mission