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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:

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NSF 04-589 **07/16/05**

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UNAVCO, Inc.
6350 Nautilus Dr.
Boulder, CO. 803015553

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TITLE OF PROPOSED PROJECT **Workshops to Establish a Stable North America Reference Frame for EarthScope**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **40,314**	**24** months	**01/01/06**	

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CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

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The undersigned certifies, to the best of his or her knowledge and belief, that:

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(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

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PROPOSAL SUMMARY
Workshops to Establish a Stable North America Reference Frame for EarthScope

The Plate Boundary Observatory (PBO) component of EarthScope will use the science of geodesy to measure the slow deformations in the Earth's crust that are driven by plate tectonics and magmatism. Specifically, the Global Positioning System (GPS) will be used to measure the movements of approximately 1000 points spanning the North America-Pacific plate boundary. These motions must be defined relative to a terrestrial reference frame. Such a frame requires the definition of its Cartesian coordinate axes (including origin, orientation, and scale) and the evolution of these axes in time, as well as precise models of the dynamic Earth. The motions of the Earth's surface due to tectonic processes the region spanning the North America-Pacific plate boundary (the focus of PBO) are most naturally expressed with respect to the stable interiors of either the North America or Pacific plates. A standard reference frame will therefore make it easier to interpret the geodetic data in terms of where the total budget of relative plate motion is being accommodated (for example, how much deformation can be inferred to be offshore?), and how deeply the plate boundary dynamics penetrate into the plate interior (is the Rio Grande Rift in New Mexico still active?). It will also provide a common frame by which to compare results from different analysis groups.

For these reasons, UNAVCO formed the Stable North American Reference Frame (SNARF) working group to define the reference frame to be used for PBO. A series of 4 small NSF EarthScope workshops have so far been held over a two-year funded period (Jan 2004-Dec 2005; P.I.s Larson and Davis) to develop SNARF and to educate the community. The SNARF working group is comprised of ~16 geodesists with expertise in developing and testing reference frames. The SNARF working group has significant links to developers of the International Terrestrial Reference Frame (ITRF) and the national geodetic surveys of the U.S. (NGS) and Canada (NRCan), who have committed experts to collaborate with the university research community toward this effort.

Now 1.5 years into the project, an initial reference frame has been developed and publically released (at the 2005 UNAVCO Meeting). The goal of this proposal is to continue research to improve and further develop SNARF, with the eventual goal of handing off operational and regular maintenance to the joint auspices of the US and Canadian national geodetic surveys, as part of their joint remit to maintain the "North American Datum". We request that EarthScope support the travel of the SNARF meeting participants and the costs of renting meeting rooms over the next two years (Jan 2006 - Dec 2007). The research of the SNARF Working Group is based on a volunteer effort and would come at no cost to this grant. UNAVCO Inc. would absorb the cost of logistical and web-based support within its regular funded activities for community support.

In terms of science benefits to EarthScope, the accurate realization of the terrestrial reference frame in terms of scientific models (rather than arbitrary convention) will add significant interpretive value to measured station motions. SNARF will provide a common framework for comparison of geodetic data and geophysical models. Defining a stable frame at the sub-millimeter level requires adequate characterization of Earth deformation processes across the "stable plate interior," a region that by definition is relatively unaffected by plate boundary process. This plate interior provides a stable platform from which to view plate boundary deformation. Despite its name, the stable plate interior actually deforms very slowly in a complex way due to phenomena such as glacial isostatic adjustment and other mantle-scale processes, coupled to a heterogeneous lithosphere which is occasionally host to large intra-plate earthquakes. Until recently, such slow intra-plate processes have been ignored in the underlying models of reference frames. The SNARF WG will address the many aspects of what is required to realize a N.A. frame with sub-mm stability, including required observations, kinematic characterization, dynamic models, possible inferences from seismic anisotropy, reference frame theory, and also on limiting factors that control the level of stability that might be achieved in the foreseeable future.

In terms of broad impacts, the outcome of the SNARF workshops will be a published series of incrementally improved reference frames that accurately define the precise coordinates and time evolution of a set of stations representing "stable North America," thus enabling the broad scientific community to realize a common, accurate reference frame for their own research purposes. The SNARF Working Group will provide tools and products for performing model calculations and model-data comparisons in the EarthScope reference frame. The EarthScope initiative will significantly broaden the community using geodetic techniques to study the Pacific-North American plate boundary. Therefore the SNARF working group will not only develop an accurate and stable reference frame, but will also properly describe the use of that reference frame to this larger scientific community. This has been achieved by special sessions at AGU meetings, and at SNARF forums at UNAVCO meetings, where future users were informed of developments by the working group, and feedback from the scientific community was encouraged. Educational information on using the frame correctly will be made available online. From a national perspective, the SNARF research product will become the US and Canadian national reference frame "NAREF" (North American Reference Frame) to supercede the current definition of the North American Datum (NAD83). This will have profound implications for the US geospatial infrastructure, and all govermental and commercial enterprises who depend on it.

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Workshops to Establish a Stable North America Reference Frame for EarthScope

Purpose

The Plate Boundary Observatory (PBO) component of EarthScope will use the science of geodesy to measure the slow deformations in the Earth's crust that are driven by plate tectonics and magmatism. Specifically, the Global Positioning System (GPS) will be used to measure the movements of approximately 1000 points spanning the North America-Pacific plate boundary. These motions must be defined relative to a terrestrial reference frame. Such a frame requires the definition of its Cartesian coordinate axes (including origin, orientation, and scale) and the evolution of these axes in time, as well as precise models of the dynamic Earth. The motions of the Earth's surface due to tectonic processes the region spanning the North America-Pacific plate boundary (the focus of PBO) are most naturally expressed with respect to the stable interiors of either the North America or Pacific plates (Figure 1). A standard reference frame will therefore make it easier to interpret the geodetic data in terms of where the total budget of relative plate motion is being accommodated, and it will help answer EarthScope's "big questions" (see below). It will also provide a common frame by which to compare results from different analysis groups.

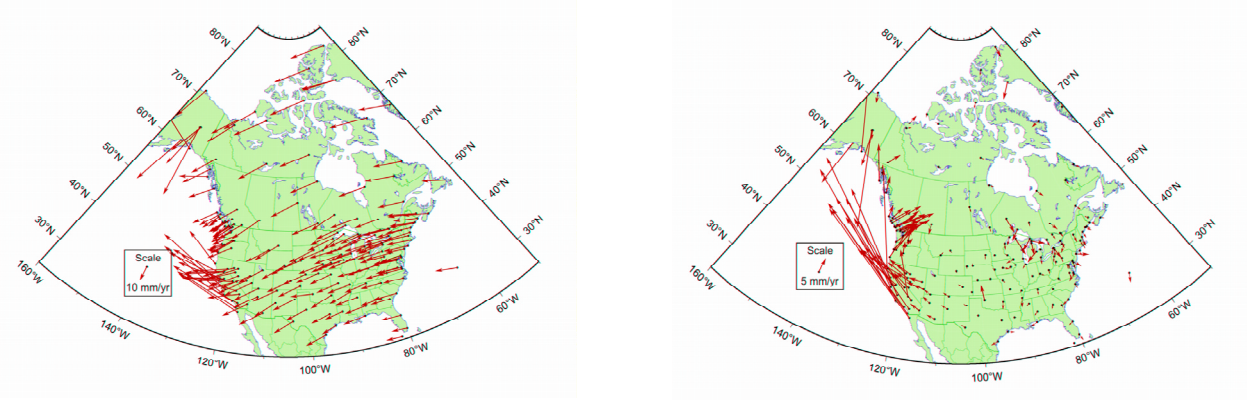

Figure 1: (Left) GPS site velocities expressed in reference frame ITRF2000. (Right) The same velocities expressed in the North America reference frame defined by model NUVEL-1A. Whereas NUVEL-1A is now known to have numerous problems (for example, it considers Africa as one plate), this figure does illustrate how an ppropriate choice of reference frame can greatly simplify interpretation of the same data set.

For these reasons, UNAVCO formed the Stable North American Reference Frame (SNARF) working group in 2003 with the remit to define the reference frame to be used for PBO. Recognizing the importance of this activity, in 2003 at Sapporo, Japan, the SNARF Working Group gained the stamp of approval as part of the International Association of Geodesy's Working Group "NAREF," providing an international framework for cooperation between Canada and the United States on defining a common North American frame to satisfy the legal and most stringent technical requirements of the broader geospatial community. This aspect will have far reaching broader impacts through the geospatial infrastructure, for example, in the definition of products distributed to surveyors through the California Spatial Reference Center

(CSRC). Letters of support and commitment to the development and implementation of SNARF are attached from NGS, NRCan, and CSRC, each of which are represented on the SNARF Working Group and have been instrumental in its success.

The Stable North America Reference Frame (SNARF) Working Group

G. Blewitt (Chair), D. Argus, R. Bennett, Y. Bock (CSRC), E. Calais, M. Craymer (NRCan), J. Davis, T. Dixon, J. Freymueller, T. Herring, D. Johnson, K. Larson, M. Miller, G. Sella, R. Snay (NGS), and M. Tamisiea

Starting in January 2004, NSF funded a series of small workshops by UNAVCO's Stable North American Reference Frame (SNARF) Working Group to define the reference frame to be used for EarthScope. Such a frame would be important to describe relative motions of Plate Boundary Observatory sites spanning the North America - Pacific plate boundary. The goal was to facilitate geophysical interpretation and inter-comparison of geodetic solutions through standardization and documentation.

Fundamentally a reference frame is required because GPS alone does not provide unambiguous coordinates: GPS data are relatively insensitive to global rotations of the entire system. Fixing the rotation according to a well-documented scientific rationale and procedure can facilitate geophysical interpretation. Early on, the SNARF working group identified that current frames such as NUVEL-1A have significant deficiencies, particularly as the East African Rift was not taken into account. Moreover, glacial isostatic adjustment (GIA) is known to produce greater intraplate deformations than plate tectonics across a large portion of the North America, and so GIA would need to be considered in the reference frame. Furthermore, research by the SNARF group indicated that GIA models are very sensitive to model parameters, and it is important to define a frame that does not come into systematic conflict with GPS data from well-established sites. For example, models of lateral variations in Earth structure can change predicted horizontal motions by a few millimeters per year in some locations.

The release of an initial version of SNARF was announced at the 2005 UNAVCO Members Meeting [Blewitt et al., 2005], which including an interactive session with potential users on the scientific rationale, procedures, with a discussion on how to use the products. In October 2005, this intial version of SNARF is scheduled to be routinely applied to geodetic products from the Plate Boundary Observatory (PBO) Analysis Centers. This represents a natural end to the first phase of SNARF research and development, which stands on its own as an important achievement that will have a significant positive impact on the utility of PBO analysis products, and on the ability of the broader principle investigator community to compare results within a common frame, that is well-defined and well-justified scientifically.

What is now proposed is for the SNARF Working Group to continue research into improving this initial reference frame, and within a 2-year period hand off operational and regular maintenance of the reference frame to the joint auspices of the US and Canadian national geodetic surveys, as part of their joint remit to maintain the "North American Datum". This proposal would fund a small group of the leading reference frame researchers in North America today to meet regularly and work toward the common goal of developing the methodology and procedures that could be applied routinely toward continuous improvement of SNARF. Some

of the procedures that have been developed so far (as described below) have been very innovative, and go far beyond what could normally be achieved by an operational agency alone. As such, the SNARF model fully embraces the need for both innovation at the development level by leading university researchers, followed by a dedicated effort to spin off the research into a working operational practice for benefit of both scientific researchers, and the broader geo-spatial community in North America.

EarthScope: The "Big" Questions

Driving the design of SNARF at the highest level are the "big questions" that EarthScope is being designed to answer. The SNARF Working Group identified four such questions:

(1) Where does the plate boundary begin, and why? What is the extent of the stable plate interior, and how tectonically stable is the plate interior? Is the Colorado Plateau still rotating, and how active is the Rio Grande Rift? Is Alaska rigidly attached to North America (as current empirical evidence is weak).

(2) What is the vertical velocity field across North America? What is GIA versus tectonic? What is the role of body forces and mantle dynamics? A deceptively simple question whose answer is completely reference frame dependent is whether the Basin and Range going up or down?

(3) What signals are natural versus anthropogenic? What signals are due to ground fluid withdrawal, aquifer deformation, hydrological and atmospheric pressure loading? How do we disentangle these signals from GIA and tectonics? How do we define an unbiased reference frame in light of these effects?

(4) How can we design geodetic products that are stable over decadal time-scales and beyond? Will we be able to detect a 5+ year transient? Can we detect the "ghosts" of historic earthquakes? Is tectonic activity steady state, or does it switch on and off spatially and temporally? Can we confidently compare and understand differences between geodetic rates and geologic rates?

In terms of science benefits to EarthScope, the accurate realization of the terrestrial reference frame in terms of scientific models (rather than arbitrary convention) will add significant interpretive value to measured station motions. SNARF will enable a more robust determination of changes in strain in the Earth's crust associated with the earthquake cycle, and will provide a common framework for comparison of geodetic data and geophysical models. Defining a stable frame at the sub-millimeter level requires adequate characterization of Earth deformation processes across the "stable plate interior," a region that by definition is relatively unaffected by plate boundary process. This plate interior provides a stable platform from which to view plate boundary deformation. Despite its name, the stable plate interior actually deforms very slowly in a complex way due to phenomena such as glacial isostatic adjustment and other mantle-scale processes, coupled to a heterogeneous lithosphere which is occasionally host to large intra-plate earthquakes. Until recently, such slow intra-plate processes have been ignored in the underlying models of reference frames. The SNARF WG is addressing the many aspects of what is required to realize a N.A. frame with sub- millimeter stability, including required observations (old and new, geodetic and otherwise), kinematic characterization, dynamic models, possible inferences from seismic anisotropy, reference frame theory, and also on limiting factors that will likely

control the level of stability that might be achieved in the foreseeable future.

These issues provide the scientific motivation toward providing an accurate and appropriate reference frame for PBO. Providing the ability to answering the "big questions" has guided the development plan of the SNARF Working Group, and eventually the actual answering of these questions by the EarthScope scientific community will be a measure of SNARF's success.

SNARF Development: Summary of Progress to Date

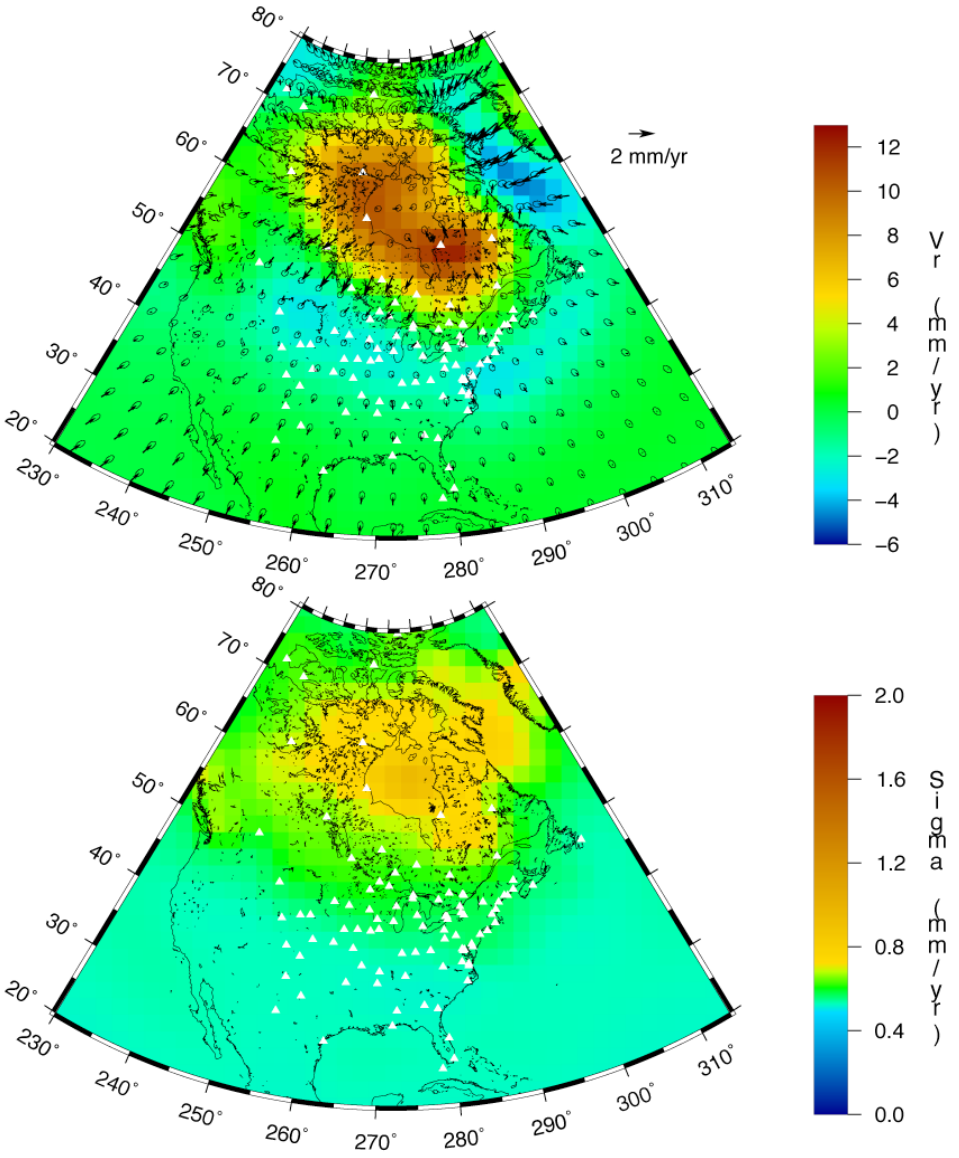

Figure 2: SNARF 1.0 GIA velocity field derived by a data assimilation approach.

Guided by these questions and the ensuing research, the SNARF Working Group has identified and tackled several major issues [*Blewitt et al.,* 2005[, including

(1) the production of a GPS velocity field that is accurate (representative) and relatively dense to select a base model for GIA,

(2) the selection of "frame sites" based on geological and engineering criteria,

(3) the selection of a subset of "datum sites" that represent the stable plate interior and will be used to define a no-net rotation condition, and

(4) the definition of products to be distributed for general use.

Also, the SNARF Working Group made the important decision that vertical datum should in priniciple be consistent with the international standard ITRF2000, in that the center of mass of the whole Earth system is taken to be the origin, and the horizontal datum will differ by a rotation rate that brings the rotation of stable North America to rest. In the first release of SNARF 1.0, the product consists of (a) a rotation rate vector that transforms ITRF2000 velocity components into SNARF velocities, (b) an initial reference frame, defined as a list of selected sites, epoch coordinates, and site velocities, in the geocentric Cartesian system (X, Y, Z). SNARF will be adopted by PBO Data Analysis Centers which are scheduled to be in production-mode by October 2005.

The release of SNARF Version 1.0 was announced at the UNAVCO/IRIS Joint Workshop in June 2005 [*SNARF Working Group*, 2005]. The current estimated accuracy of SNARF 1.0 is ~1 mm (+30% radial / - 30% horizontal). For comparison, estimated rotations/translations (from a nominal NA-fixed frame that does **not** account for GIA amounts to < 1.5 mm/yr in NA station velocities. In terms of geodynamics that EarthScope hopes to address (for example, the "big questions" listed above) 1.5 mm/yr is a large number, which indicates that our research into developing SNARF was well justified.

The method adopted for SNARF is just briefly described here for completeness. First we assume that a given geodetic solution of GPS site velocities can be modeled by the following equation:

$$\vec{V}_{\rm GPS}(\lambda,\phi) = \vec{V}_{\rm GIA}(\lambda,\phi) + \delta\vec{\Omega} \times \hat{r}(\lambda,\phi) + \delta\vec{T}$$

which accounts for a GIA velocity field, and 6 parameters that define a global rotation and translation vector. Thus, ideal site velocities that are given with respect to SNARF should only include the GIA term. For now, the SNARF WG has concluded that currently there lacks a concensus concerning the viscocity structure and ice history in GIA models. Modles for lateral variations are even more problematic. To create SNARF Version 1.0, the SNARF WG therefore had to address the difficult problem of how to deal with GIA, considering that many possible GIA models can fit the currently available GPS data sets.

The innovative solution that could only have arisen from in-depth workshop discussion, was to develop a method to "assimilate" GPS data into a GIA stochastic model. That is, a suite of "reasonable" GIA models were pre-selected, and the ensemble prediction of site velocities at each grid point was used to define an a priori error ellipse. This Bayesian approach avoids the

current problem of an unwarranted choice of specific GIA model at these early stages, and has the advantage that in principle it allows for other data sets to be assimilated (for example, campaign GPS, and non-GPS data). Moreover, the development of this methodology may serve as a new tool for GIA scientific research, and may help guide us towards the most favorable GIA models.

The data assimilation model starts by assuming a null-field GIA model, and adopts the Gaussian covariance model for assimilated data:

$$\Lambda_{ij} = \langle w(\lambda_i \phi_i)\, w(\lambda_j \phi_j) \rangle = \sigma^2 \exp(-d_{ij}^2/D^2)$$

where d_{ij} is the angular distance between locations, D = 10 degrees, and σ = 1 mm/yr. A Kalman filter is then used to assimilate GPS data into the a priori GIA model. Parameters that are estimated include 6 rotation and translation parameters, and GIA velocities at n grid locations and m GPS sites. The GIA values at the grid locations are adjusted through the covariances calculated from the suite of model predictions. For SNARF version 1.0, n = 1537, m = 99, and the number of parameters = 4617. Thus the resulting model is GPS-observation driven (designed not to introduce tension with the data), but uses GIA in a statistical manner to come up with a realistic interpolation between the GPS sites (one of the problems being sparsity of data).

Workshops for a Stable North America Reference Frame (SNARF)

The SNARF Working Group of 16 core members (with others also making contributions at various stages) has had 4 workshops since it commenced research and development in early 2004:

(1) The first workshop was held in Boulder, CO, January 27, 2004. At this workshop the working group developed a research plan that would be required toward producing a SNARF that would meet the stringent requirements implied by EarthScope science goals. Representatives from both the National Geodetic Survey and Natural Resources Canada were invited at this early stage with the idea that eventually SNARF would become part of the national infrastructure, and so we needed to consider how to evolve SNARF from a pure research phase, through development, and into production and maintenance phases.

(2) The second workshop was held at Montreal, Canada, during the week of the Joint Assembly of the AGU and CGU, 17-21 May, 2004. This workshop was in two parts: (a) a special session on SNARF was convened at the Joint Assembly for SNARF working group members to present preliminary findings from their research on the issues identified in the first meeting, and (b) a working group meeting was held at a Montreal hotel so that details of the research could be discussed, and so that ideas could be presented on ways toward realizing an initial version of SNARF.

(3) The third workshop was held near Albuquerque, NM, March 2005, which was a time to make hard decisions among the various options suggested by research to specify precisely how SNARF would be constructed. At this stage, some very innovative ideas emerged regarding a long standing problem, on how to develop a frame that accomodates glacial isostatic adjustment (GIA) without being in conflict with current GPS measurements (see further below).

(4) A fourth mini-workshop was held at the Joint IRIS/UNAVCO Workshop in Stevenson WA, Annual Members Meeting in June 9-11, 2005. This was an "open" meeting with the goal of informing principle investigators on SNARF developments, and the release of the first SNARF products, and to receive feedback on ideas suggested by the SNARF Working Group.

Now only 1.5 years into the project, an initial reference frame has been developed and publically released, with important scientific breakthroughs made in learning how to accommodate GIA into the SNARF model.

Proposed Workshops

The goal of this proposal is to continue research to improve and further develop SNARF, with the eventual goal of handing off operational and regular maintenance to the joint auspices of the US and Canadian national geodetic surveys, as part of their joint remit to maintain the "North American Datum". Such a "volunteer" group effort can only realistically be conducted if at a minimum travel expenses are paid for, along with the associated costs of renting a meeting room.

We request that EarthScope support a series of 4 workshops over the 2006 and 2007 calendar years. The research of the SNARF Working Group is based on a volunteer effort and would come at no cost to this grant. The P.I. would continue as Chair of the SNARF Working Group at no cost to this grant. UNAVCO Inc. would absorb the cost of logistical and web-based support within its regular funded activities for community support.

At least two of the four proposed workshops would be held in conjunction with one of the National EarthScope Meetings, and one of the UNAVCO Members Meetings. The other two venues will likely be in Boulder CO, and in conjunction with one of the main geophysical conferences, such as the AGU.

This mix of venues is intentional. The two workshops held in conjuction with EarthScope and UNAVCO meetings will provide an opportunity to hold a user's forum to educate the community on SNARF developments and use of products, and to get feedback from users. The workshop held in conjunction with the AGU conference will be strongly focused on research that will lead to improvements in SNARF, and will likely include an AGU Special Session (as we did in Montreal, 2004). The workshop held at Boulder CO will act more as a retreat away from competing activities, and will allow for a more strategic decisions to be made.

The topics of each of the four workshops will be based largely on advances made in research, however the general theme of each meeting will be as follows:

(1) The first workshop of 2006 will consolidate what we have learned from the experience of developing the first SNARF, and outline a research plan toward improving the next version of SNARF.

(2) The second workshop of 2006 will focus on research results that can then be used to further improvements in SNARF, and on a specific plan to produce a new version of SNARF immediately following the meeting.

(3) The first workshop of 2007 will consider strategies to spawn off the SNARF activities into a more routine production and maintenance mode to be conducted by the US and Canadian national geodetic surveys (NGS and NRCan). This workshop will also assess how SNARF is meeting the needs of EarthScope investigators, and on how to improve meeting their needs.

(4) The second workshop of 2007 will be aimed at developing a version of SNARF to be used to benchmark future versions that would be updated and maintained by NGS and NRCan. Final technical documentation, user's guides, and web tools will be assessed. A plan to maintain some level of future interaction between NGS, NRCan, and the SNARF Working Group will be developed, including a method of feedback with regard to the performance of SNARF toward meeting the requirements of EarthScope.

SNARF workshops are not closed meetings, however this proposal would only support the workshop travel expenses of bona-fide members of the SNARF Working Group. The initial membership of the SNARF WG was appointed by the UNAVCO Governing Board. Since thne, the SNARF WG has always welcomed new members who have expressed a commitment to volunteer and devote their time to attending the workshops and participating in the development of SNARF. It is assumed for budgetary purposes that an average 12 WG members will attend each workshop, and will therefore be eligible for participant support.

Dissemination of Products

As an official UNAVCO Working Group, the SNARF WG has access to the assistance of UNAVCO Inc. administrative staff and the UNAVCO facility. Products of the SNARF WG are disseminated by the UNAVCO web pages through the introductory URL:

http://www.unavco.org/research_science/workinggroups_projects/snarf/snarf.html

Through this portal, users can find the following types of products available:

1. Workshop reports and summary papers on various aspects of SNARF.
2. Copies of workshop presentations.
3. Documentationon SNARF data products.
4. SNARF data products, including
   (a) 3-d rotation vector from ITRF2000 into SNARF
   (b) a table of selected sites forming SNARF, including epoch coordinates and velocities.

This web site will continue to be updated as more workshops are held and as further improvments are made to SNARF products. As SNARF moves closer toward being adopted as a national standard, SNARF data and products derived using SNARF will be disseminated through web sites of the national and state geospatial agencies, including the National Geodetic Survey, Natural Resources Canada, and the California Spatial Reference Center.

Information on products will also be disseminated during UNAVCO Members Meetings and EarthScope National Meetings breakout session, where SNARF working group members will generally give a presentation followed by a question and answer session. Also, more technical aspects of SNARF research will be presented at national conferences, such as the AGU meeting.

Broader Impacts

In terms of broad impacts, the outcome of the SNARF workshops will be a published series of incrementally improved reference frames that accurately define the precise coordinates and time evolution of a set of stations representing "stable North America," thus enabling the broad scientific community to realize a common, accurate reference frame for their own research purposes. The SNARF Working Group will provide tools and products for performing model calculations and model-data comparisons in the EarthScope reference frame. The EarthScope initiative will significantly broaden the community using geodetic techniques to study the Pacific-North American plate boundary. Therefore the SNARF working group will not only develop an accurate and stable reference frame, but will also properly describe the use of that reference frame to this larger scientific community. This has been achieved by special sessions at AGU meetings, and at SNARF forums at UNAVCO meetings, where future users were informed of developments by the working group, and feedback from the scientific community was encouraged. Educational information on using the frame correctly will be made available online.

From a national perspective, the SNARF research product will become the US and Canadian national reference frame "NAREF" (North American Reference Frame) to supercede the current definition of the North American Datum (NAD83). NAREF is formally a working group under the auspices of the International Association of Geodesy. The adoption of SNARF as the future NAREF will have profound implications for the US geospatial infrastructure, and all govermental and commercial enterprises who depend on it, including the National Geodetic Survey (NGS), Natural Resources Canada (NRCan) and the California Spatial Reference Center (CSRC). (Letters of support and committment are attached).

References: Bibliography of Research Related to the SNARF Working Group

Altamimi, Z., D. Angermann, D. Argus, G. Blewitt, C. Boucher, B. Chao, H. Drewes, R. Eanes, M. Feissel, R. Ferland, T. Herring, B. Holt, J. Johannson, K. Larson, C. Ma, J. Manning, C. Meertens, A. Nothnagel, E. Pavlis, G. Petit, J. Ray, John Ries, H.-G. Scherneck, P. Sillard, and M. Watkins, The terrestrial reference frame and the dynamic Earth, Eos, Transactions, Am. Geophys. U., Vol. 82, No. 25, p. 273-279 (2001).

Argus, D. F., M. B. Heflin, G. Peltzer, F. H. Webb, and F. Crampe, Interseismic strain accumulation and anthropogenic motion in metropolitan Los Angeles, J. Geophys. Res. 101, B04401, doi:10.1029/2003JB002934, (2005).

Argus, D. F., and R. G. Gordon, Present tectonic motion across the Coast ranges and San Andreas fault system in central California, Geol. Soc. Am. Bull. 113, 1580-92 (2001).

Argus, D. F., W. R. Peltier, and M. M. Watkins, Glacial isostatic adjustment observed using very long baseline interferometry and satellite laser ranging,J. Geophys. Res. 104, 29077-29083 (1999).

Bennett, R.A., Shift happens: quantifying the time-dependence of plate boundary deformation using continuous GPS, Pardee Symposium Keynote presentation, GSA Annual meeting, 2005

Bennett, R.A., Geodetic deformation rates in the eastern California shear zone, Penrose Conference Keynote presentation, April 2005.

Bennett, R.A., L. Lavier, M.L. Anderson, J. Matti, R.E. Powell, Holocene deceleration of the San Andreas fault zone in San Bernardino and implications for the eastern California shear zone rate debate, Eos trans. AGU, 86(18), Jt. Assem. Suppl., 2005.

Blewitt, G., Fundamental ambiguity in the definition of vertical motion, Cahier du Centre Européen de Géodynamique et de Séismologie, Ed. T. van Dam & O. Francis, Vol. 23, p. 1-4, 2004

Blewitt, G., D. Argus, R. Bennett,Y. Bock, E. Calais, M. Craymer, J. Davis, T. Dizon, J. Freymueller, T. Herring, D. Johnson, K. Larson, M. Miller, G. Sella, R. Snay, and M. Tamisiea, Workshops for Establishing a Stable North American Reference Frame (SNARF) to Enable Geophysical and Geodetic Studies with EarthScope:Annual Report 2004-2005, EarthScope National Meeting, New Mexico, 2005.

Blewitt, G., R. Bennett, E. Calais, T. Herring, K. Larson, M. Miller, G. Sella, R. Snay, and M. Tamisiea, First report of the Stable North America Reference Frame (SNARF) Working Group, Eos Trans. AGU, 85(17), Jt. Assem. Suppl., Abstract G21C-01, 2004.

Blewitt G., K. Larson K, R. Bennett, E. Calais, M. Craymer, T. Herring, M. Miller, G. Sella, R. Snay, and M. Tamisiea, First report of the Stable North America Reference Frame (SNARF) Working Group, Abstracts of the UNAVCO 2004 Annual Meeting, p. 21, Boulder, Colorado, held Feb 25-27,2004.

Blewitt G., Loading effects and reference frame definition, Abstracts of the UNAVCO 2004 Annual Meeting, (invited plenary talk) p. 22, Boulder, Colorado, held Feb 25-27,2004.

Blewitt, G., P. Clarke, D. Lavallée, R. Gross, K. Nurutdinov, and T. van Dam, Relationahips between surface mass, station position, geocenter, & Earth rotation: IGS GNAAC results, IGS Workshop & Symposium Abstracts, p. 38, University of Berne, Switzerland, held March 01-05, 2004.

Blewitt, G., Self-consistency in reference frames, geocenter definition, and surface loading of the solid Earth, Journ. Geophys. Res., Vol. 108(B2) 210, doi: 10.1029/2002JB002082, 2003.

Blewitt, G., A reference frame for PBO: What do we have; what do we need? Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract G32B-02 INVITED, 2003

Blewitt, G., P. Clarke, D. Lavallée, and K. Nurutdinov, Application of Clebsch- Gordan Coefficients and isomorphic frame transformations to invert Earth's changing geometrical shape for continental hydrological loading and sea level's passive response, Int. Assoc. Geodesy Symp. Vol. 128, 6 pp. (in press, 2005)

Blewitt, G. and P. Clarke, Inversion of Earth's changing shape to weigh sea level in static equilibrium with surface mass redistribution, Journ. Geophys. Res., 108 (B6), 2311, doi:10.1029/2002JB002290, 2003.

Bock, Y., Spatial and temporal filtering for high-rate GPS regional networks: Implications for reference frame definition (2004), Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G21B-02.

Calais, E., J. Han, and C. DeMets, Testing intraplate deformation in the North American plate interior from a combined geodetic solution: implication for strain accumulation on potentially seismogenic faults in the central and eastern U.S., Fall AGU, 2004.

Craymer, M., North American Reference Frame (NAREF) Working Group (oral). 2nd SNARF Workshop, Montreal, May 19, 2004.

Craymer,M., R. Snay, The NAREF Perspective on a New Plate-Fixed Reference Frame for North America (abstract/poster). AGU/CGU Joint Assembly, Montreal, May 17-21, 2004.

Craymer, M. International Reference Frames: ITRF/IGS, NAREF and SNARF. Presented at the Canadian Geodetic Reference System Committee, Ottawa, April 18-20, 2005.

Craymer, M. Canadian GPS Networks in the Great Lakes Region. Presented at the 78th Meeting of the Coordinating

Committee on Great Lakes Basic Hydraulic and Hydrologic Data, Ottawa, May 10-11, 200
Craymer, M., J. Henton. NAREF Analysis and ITRF2004 Densification. Presented at the 3rd SNARF Workshop, Santa Ana Pueblo, NM, March 28, 2005.
Craymer, M., G. Blewitt, D. Argus, R. Bennett, Y. Bock, E. Calais, M. Craymer, J. Davis, T. Dixon, J. Freymueller, T. Herring, D. Johnson, K. Larson, M. Miller, G. Sella, R. Snay, M. Tamisiea. Defining a Plate-Fixed Regional Reference Frame: The SNARF Experience. 2005 IAG Scientific Assembly, Cairns, Australia, August 22-26, 2005.
Dong, D., L. Prawirodirdjo, S. Kedar, P. Fang, B. Newport, P. Jamason, F. Webb, Y, Bock (2004), Improved GPS time series in Southern California through the combination of SOPAC and JPL solutions, Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G21A-0128.Gonzalez-Garcia, J., R.A. Bennett, K. Hudnut, C. Walls, USMX and YESX: Continuation of United State's PBO into Mexico's mainland, EarthScope National Meeting, 2005.
Heflin, M., D. Argus, D. Jefferson, F. Webb, and J. Zumberge, Comparison of a GPS-defined global reference frame with ITRF2000, GPS Solutions 6, 72-5, (2002).
Henton, J.A., J.O. Liard, M.R. Craymer, T. James, C.G. Gagnon, E. Lapelle, Absolute Gravity and Global Positioning System Measurements of Glacial Isostatic Adjustment in Eastern Canada (abstract/poster),. AGU/CGU Joint Assembly, Montreal, May 17-21, 2004.
Henton, J.A., J.O. Liard, M.R. Craymer, C. Gagnon, E. Lapelle. Absolute Gravity and Global Positioning System Measurements of Uplift in Quebec and Eastern Ontario, Canada. Presented at the AGU Fall meeting, San Francisco, December, 2003.
Henton, J.A., M.R. Craymer, M. Piraszewski, E. Lapelle. Crustal Deformation Velocities from Episodic Regional Measurements at Canadian Base Network Sites (abstract/poster). AGU 2004 Fall Meeting, San Francisco, December 13-17, 2004.
Hernandez, D, W. Holt, R.A. Bennett, A.J. Haines, L. Dimitrova, Estimation of a Time-Dependent Strain Rate Field in Southern California using Continuous GPS Stations in the SCIGN Network, EarthScope National meeting, 2005.
Hernandez, D, W. Holt, R.A. Bennett, C. Li, A.J. Haines, L. Dimitrova, Estimation of a Time-Dependent Strain Rate Field in Southern California using Continuous GPS Stations in the SCIGN Network, UNAVCO/IRIS meeting, 2005.
Johnson, D.J., 2005, Seasonal variations in GPS site positions in a center of lateral figure (CL) reference frame, European Geosciences Union General Assembly, April 24-29, 2005, Vienna Austria (poster).
Johnson, Daniel J., 2004, The vertical component in raw GPS observations, in Proceedings of the workshop: The state of GPS Vertical Positioning Precision: Separation of Earth Processes by Space Geodesy, April 2-4, 2003, Luxemburg, edited by T. van Dam and O. Francis. v. 23, p. 155-160.
Latychev, K., J. X. Mitrovica, M. E. Tamisiea, J. Tromp, and R. Moucha, Influence of lithospheric thickness variations on 3-D crustal velocities due to glacial isostatic adjustment, GRL, 32, doi:10.1029/2004GL021454, 2005.
Lavier, L., R.A. Bennett, M.L. Anderson, J. Matti, Constraints on lithospheric rheology from fault displacement rate histories and numerical experiments, Eos Trans. AGU, 86(18), Jt. Assem., Suppl. 2005.
Li, C., R.A. Bennett, Hernandez, D., W. Holt, Analysis of time dependent velocity in southern California, using Continuous GPS stations in the SCIGN network, UNAVCO/IRIS meeting, 2005.
M. M. Miller, V.M. Santillan, and D. J. Johnson, 2004, Application of a North America reference frame to regional GPS arrays in the deforming plate boundary region: Example from the Pacific Northwest Geodetic Array (PANGA). Eos, Transactions, American Geophysical Union 85(17), Joint Assembly Supp., Abstract G21D-06.
Mazzotti, S., J. Henton, J. Adams. Crustal Strain Rates and Seismic Hazard from Seismicity and GPS Measurements Along the St. Lawrence Valley, Quebec (abstract/oral). AGU/CGU Joint Assembly, Montreal, May 17-21, 2004.
Menges, C.M., Pavlis, T.L., McMackin, M.R. Serpa, L., Bennett, R.A., Geomorphic and structural evidence for significant noetectonic contractional strain within southern Death Valley and bordering areas, eastern California, GSA Annual meeting, October 2005.
Mitrovica, J. X., K. Latychev, M. E. Tamisiea, J. Tromp, and G. A. Milne (2004), GIA-Induced 3-D Crustal Velocities Predicted Using a New Generation of Viscoelastic Earth Models, Eos Trans. AGU, 85(17), Jt. Assem. Suppl, Abstract G51A-08.
Prawirodirdjo, L., Y. Ben-Zion, and Y. Bock (2004), Observation and Modeling of Thermoelastic Strain in SCIGN Daily Position Time Series, Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G53A-109.
Prawirodirdjo, L. and Y. Bock, Instantaneous Global Plate Motion Model from 12 Years of Continuous GPS Observations, J. Geophys. Res., 109, doi: 10.1029/2003JB002944, 2004.
Sella, G.F., S. Stein, S. Wdowinski, T.H. Dixon, M. Craymer, T. James. Direct Constraints on GIA Motion in North America Using GPS (abstract/oral). AGU/CGU Joint Assembly, Montreal, May 17-21, 2004.
Sella, G.F., S. Stein, S. Wdowinski, T.H. Dixon, M. Craymer. Glacial Isostatic Adjustment in North America

Observed by Continuous and Episodic GPS. Presented at the AGU Fall meeting, San Francisco, December, 2003.

Smith, K.D., D. von Seggern, G. Blewitt, L. Preston, J.G. Anderson, B.P. Wernicke, J.L. Davis, Evidence for deep magma injection beneath Lake Tahoe, Nevada-California, Science, doi:10.1126/science.1101304, 2004.

SNARF Working Group, Stable North America Reference Frame: Version 1.0, Splinter Group Meeting Presentation at the Joint UNAVCO/IRIS Workshop, Stevenson, WA, June 2005.

Snay, R., M. Cline, W. Dillinger, and T. Soler. Relating tide gauge records of sea level change to local vertical motions, (abstract), EarthScope 2005 National Meeting, Santa Ana Pueblo, NM, 2005.

Soler T., and R. Snay (2004) Transforming positions and velocities between the International Terrestrial Reference Frame of 2000 and North American Datum of 1983, Journal of Surveying Engineering, doi: 10.1061/(ASCE)0733-9453(2004) 130:2(49).

Snay R., and M. Craymer (2004) Evolving from NAD 83, Eos. Trans. AGU, 85(17), Joint Assembly Suppl., Abstract G21D-01.

Tamisiea, M. E., J. X. Mitrovica, and J. L. Davis (2004) The Plausible Range of GIA Contributions to 3-D Motions at GPS Sites in the SNARF Network, Eos Trans. AGU, 85(17), Jt. Assem. Suppl, Abstract G21D-03.

Williams, S. D. P., Y. Bock, P. Fang, P. Jamason, R. M. Nikolaidis, L. Prawirodirdjo, M. Miller, and D. J. Johnson, Error Analysis of Continuous GPS Position Time Series, J. Geophys. Res., 109, B03412, doi: 10.1029/2003JB0022741, 2004.

Webb, F., Y. Bock, R. Chang, D. Dong, P. Fang, J. Genrich, P. Jamason, S. Kedar, N. King, D. Malveaux, B. Newport, S. Owen, L. Prawirodirdjo, M. Scharber, and K. Stark (2004), GPS Data Products for the Earth Sciences, Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract SF53A-0736.

BIOGRAPHICAL SKETCH: Geoffrey Blewitt

a. Professional Preparation

Queen Mary College, University of London	Physics	BSc with highest honors, 1981
California Institute of Techology	Physics	Ph.D., 1981-1986

b. Appointments

1999-present	Research Professor, jointly at Nevada Seismological Laboratory and Nevada Bureau of Mines and Geology, University of Nevada, Reno
1999-present	Visiting Professor, School of Civil Engineering and Geosciences, University of Newcastle, UK
1994-1999	Professor of Space Geodesy, Department of Geomatics, University of Newcastle upon Tyne, UK
1985-1994	Group Supervisor, Space Geodesy and Geodynamics Systems Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena
1981-1985	Graduate Research Assistant, Department of Physics, California Institute of Technology, Pasadena

c. Publications (i) Five most relevant publications

Blewitt, G., Self-consistency in reference frames, geocenter definition, and surface loading of the solid Earth, **Journ. Geophys. Res., Vol. 108**(B2) 210, doi: 10.1029/2002JB002082, 2003 http://www.nbmg.unr.edu/staff/pdfs/Blewitt%20ref%20frame%202002JB002082.pdf

Smith, K.D., D. von Seggern, **G. Blewitt**, L. Preston, J.G. Anderson, B.P. Wernicke, J.L. Davis, Evidence for deep magma injection beneath Lake Tahoe, Nevada-California, **Science**, doi:10.1126/science.1101304, 2004. http://www.nbmg.unr.edu/staff/pdfs/science8_5_04.pdf

Blewitt, G., M.B. Heflin, K.J. Hurst, D.C. Jefferson, F.H. Webb, and J.F. Zumberge, Absolute far-field displacements from the 28 June 1992 Landers earthquake sequence, **Nature, Vol. 361**, p. 340-342, 1993 http://www.nbmg.unr.edu/staff/pdfs/Blewitt-1993-Nature.pdf

Blewitt, G., D. Lavallee, P. Clarke, and K. Nurutdinov, A new global mode of Earth deformation: Seasonal cycle detected, **Science, Vol. 294**, No. 5550, pp.2,342-2,345, 2001. http://www.sciencemag.org/cgi/content/full/294/5550/2342?ijkey=HHrLqXyCijOrI&keytype=ref&siteid=sci

Blewitt, G., Geodetic network optimization for geophysical parameters, **Geophys. Res. Lett., Vol. 27**, No. 22, pp. 3,615-3,618, 2000. http://www.nbmg.unr.edu/staff/pdfs/Blewitt%20network%20design%20GRL.pdf

(ii) Five other significant publications

Blewitt, G., Fundamental ambiguity in the definition of vertical motion, Cahier du Centre Européen de Géodynamique et de Séismologie, Ed. T. van Dam & O. Francis, Vol. 23, p. 1-4, 2004 http://www.nbmg.unr.edu/staff/pdfs/blewitt_vertical.pdf

Blewitt, G. and P. Clarke, Inversion of Earth's changing shape to weigh sea level in static equilibrium with surface mass redistribution, **Journ. Geophys. Res.**, **108** (B6), 2311, doi:10.1029/2002JB002290, 2003. http://www.nbmg.unr.edu/staff/pdfs/2002JB002290%20blewitt%20and%20clarke.pdf

Blewitt, G., GPS data processing methodology: From theory to applications, chapter in **GPS for Geodesy**, p. 231-270, Eds. P.J.G. Teunissen and A. Kleusberg , Springer-Verlag, Berlin, ISBN 3-540-63661-7, 1998.

Blewitt, G., and D. Lavallée, Effect of annual signals on geodetic velocity, **Journ. Geophys. Res., Vol. 107**(B7), 10.1029/2001JB000570, 2002. http://www.nbmg.unr.edu/staff/pdfs/2001JB000570%20Lavallee%20and%20Blewitt%20Annual%20Signals.pdf

Blewitt, G., P. Clarke, D. Lavallée, and K. Nurutdinov, Application of Clebsch- Gordan Coefficients and isomorphic frame transformations to invert Earth's changing geometrical shape for continental hydrological loading and sea level's passive response, Int. Assoc. Geodesy Symp. Vol. 128, 6 pp. (in press, 2005 http://www.nbmg.unr.edu/staff/pdfs/blewitt_clebsch.pdf

d. Synergistic Activities - Five Areas of Broader Community Activities

(1) Service to the EarthScope research community:

- Chair of Board of Directors, UNAVCO Inc. (2001-2003)
- Chair, UNAVCO Stable North America Reference Frame (SNARF) Working Group (2004-present)
- Organizing Committee, EarthScope's GreatBREAK Workshop, Granlibakken, CA (June 2004)
- Member, EarthScope Plate Boundary Observatory Extension Siting Committee (2004-present)
- Governing Board, International GPS Service (1996-2001; 2003-present).

(2) Award-winning technology and knowledge transfer to broader scientific and engineering community

- Co-author of GIPSY-OASIS II GPS software used by ~100 research institutions/industry worldwide
- 2004 Space Foundation's Space Technology Hall of Fame, Certificate of Commendation, for "creation of Precision GPS Software System technology" and "successful transfer of space technology to Earth applications"
- 2004: Geological Society of America Burwell Award: "Land subsidence in Las Vegas, Nevada, 1935-2000"
- 2003: Geothermal Resources Council Award for "Targeting of potential geothermal resources in the Great Basin from regional to basin-scale relationships between geodetic strain and geological structures."
- 2002:Association of Engineering Geologists Award: "Land subsidence in Las Vegas, Nevada, 1935-2000"
- 1997: Shell Expro Technology and Innovation Award

(3) Educational outreach to the broader science community and school teachers:

- 2004 National Science Teacher Convention Guest Lecture: "GPS: the Modern Swiss Army Knife".
- 2002 American Geophysical Union Featured Lecture "GPS, the interdisciplinary chameleon, How does it do that?" http://www.agu.org/webcast/SF2002Union.html

(4) Sample of recent media articles (too many to list here):

- National Geographic: http://news.nationalgeographic.com/news/2004/08/0806_040806_tahoe_magma.html
- Geotimes article "Why the Wobble?" http://www.geotimes.org/june04/NN_wobble.html
- USA today article http://www.usatoday.com/tech/news/2004-05-17-why-earth-wobbles_x.htm
- Science Daily article http://www.sciencedaily.com/releases/2004/08/040811075453.htm
- Los Angeles Times article: http://www.latimes.com/news/nationworld/nation/la-sci-briefs7.1aug07,1,106052.story?coll=la-headlines-nation
- Los Angeles Daily News article: http://www.dailynews.com/Stories/0,1413,200~20954~2334917,00.html
- Discover Magazine, interviewed for lead article "Season of Fire", Feb. 2003.

(5) Educational book chapters and articles

- Evans, A.G., (ed.), R.W. Hill (ed.), G. Blewitt, E. Swift, T.P. Yunck, R. Hatch, S.M. Lichten, S. Malys, J. Bossler, and J.P. Cunningham, "The Global Positioning System Geodesy Odyssey," Navigation, Journ. of the Inst. of Navigation, Vol. 49(1), 7-34., (invited), Spring 2002.
- Blewitt, G., GPS Data Processing Methodology: From Theory to Applications, in *GPS for Geodesy*, p. 231-270, Eds. P.J.G. Teunissen and A. Kleusberg , Springer-Verlag, Berlin, ISBN 3-540-63661-7(1998).
- Blewitt, G., Global Positioning Satellites, in *Macmillan Encyclopedia of the Earth Sciences*, p. 432-436, Macmillan, New York, ISBN 0-02-883000-8 (1998).
- Blewitt, G, Basics of the GPS Technique: Observation Equations, in *Geodetic Applications of GPS*, p. 10-54, ed. B. Johnson, Nordic Geodetic Commission, Sweden, ISSN 0280-5731(1997).

e. Collaborators and Other Affiliations

(i) Project Collaborators and Co-Authors on Papers and Abstracts (2001- 2005 inclusive)

D. Argus, R. Bennett, Y. Bock, E. Calais, M. Craymer, J. Davis, T. Dixon, J. Freymueller, T. Herring, D. Johnson, K. Larson, M. Miller, G. Sella, R. Snay, M. Tamisiea , B. Wernicke, W. Holt, R. Gross, P. Clarke, T. Van Dam, F. Amelung, J. Bell, J. Wahr, G. Taylor, W. Hammond, H.-P. Plag.

(ii) Graduate Advisor

John LoSecco, Notre Dame.

(iii) 9 Ph.D. Students Advised:

P. Davies, T. Gregorius, D. Sanli, D. Lavallee, and D. Page, at Newcastle University.
E. Hill, R. Briggs, A. Pancha, and C. Goudy at University of Nevada, Reno.

4 Postdoctoral Scholars Sponsored:

R. Kawar and K. Nurutdinov at Newcastle University.
D. Lavallee and C. Kreemer at University of Nevada, Reno.

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **UNAVCO, Inc.**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Geoffrey Blewitt**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Geoffrey Blewitt - none**	**0.00**	**0.00**	**0.00**	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**0.00**	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **18,000**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**18,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**2,000**	
TOTAL OTHER DIRECT COSTS				**2,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**20,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **General & Administrative (Rate: 7.5400, Base: 2000)**					
TOTAL INDIRECT COSTS (F&A)				**151**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**20,151**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **20,151**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Geoffrey Blewitt**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
UNAVCO, Inc.

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Geoffrey Blewitt

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Geoffrey Blewitt - none**	**0.00**	**0.00**	**0.00**	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**0.00**	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **18,000**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**18,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**2,000**	
TOTAL OTHER DIRECT COSTS				**2,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**20,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **General & Administrative (Rate: 8.1400, Base: 2000)**					
TOTAL INDIRECT COSTS (F&A)				**163**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**20,163**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **20,163**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Geoffrey Blewitt

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **UNAVCO, Inc.**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Geoffrey Blewitt**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Geoffrey Blewitt - none**	**0.00**	**0.00**	**0.00**	$ **0**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**0.00**	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**0**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**0**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**0**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**0**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **36,000**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**36,000**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**4,000**	
TOTAL OTHER DIRECT COSTS				**4,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**40,000**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**314**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**40,314**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **40,314**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Geoffrey Blewitt**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification Page

As a workshops proposal, funds are only requested for SNARF Working Group members to attend 2 workshops each year for 2 years, and for associated costs for subcontracting the use of a small conference facility. Based on an assumed average attendance of 12 people per meeting, at $750 per head, travel costs per year are estimated to be $18,000. Subcontracts for small conference facilities are estimated to be $1,000 per meeting. UNAVCO Inc. would absorb the cost of logistical and web-based support within its regular funded activities for community support.

Current and Pending Support: Geoffrey Blewitt

Project Title: Geodetic Monitoring of the Yucca Mountain Region using Continuous GPS
Source of Support: DOE
Project Location: University of Nevada Reno, Caltech, and Harvard-Smithsonian Center for Astrophysics
Total Award Amount: $8,656,182
Starting Date (MM/DD/YY): 10/01/03
Ending Date (MM/DD/YY): 09/30/08
Support Type: (Current, Pending, Submission Planned in Near Future): Current
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 2.00 Calendar

Project Title: Synthesis of NASA Data on Earth's Changing Geometrical and Gravitational Shapes to Assess Change in Terrestrial Water Storage and Its Effect on Sea Level, Lithospheric Loading, and Earth Rotation
Source of Support: NASA
Project Location: University of Nevada Reno, and Jet Propulsion Laboratory, Pasadena.
Total Award Amount: $500,100
Starting Date (MM/DD/YY): 07/01/04
Ending Date (MM/DD/YY): 06/30/07
Support Type: (Current, Pending, Submission Planned in Near Future): Current
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 2.00 Calendar

Project Title: Terrestrial reference frame theory and practice for solid Earth and global change research
Source of Support: NASA
Project Location: University of Nevada Reno
Total Award Amount: $276,211
Starting Date (MM/DD/YY): 10/01/03
Ending Date (MM/DD/YY): 09/30/06
Support Type: (Current, Pending, Submission Planned in Near Future): Current
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 1.00 Calendar

Project Title: Targeting potential geothermal resources in the Great Basin using geodetic strain
Source of Support: DOE
Project Location: University of Nevada Reno
Total Award Amount: $236,532
Starting Date (MM/DD/YY): 07/01/05
Ending Date (MM/DD/YY): 09/30/07
Support Type: (Current, Pending, Submission Planned in Near Future): Current
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 2.00 Calendar

Project Title: Developing NASA's space geodetic systems into an integrated, multi-scale sensor of water storage
Source of Support: NASA
Project Location: University of Nevada Reno, and Jet Propulsion Laboatory, Pasadena
Total Award Amount: $594,923
Starting Date (MM/DD/YY): 07/01/05
Ending Date (MM/DD/YY): 06/30/08
Support Type: (Current, Pending, Submission Planned in Near Future): Pending
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 2.00 Calendar

Project Title: This proposal
Source of Support: NSF
Project Location: UNAVCO Inc.
Total Award Amount: $40,000
Starting Date (MM/DD/YY): 01/01/06
Ending Date (MM/DD/YY): 12/31/07
Support Type: (Current, Pending, Submission Planned in Near Future): Pending
Person Months/Year Committed to Project (Calendar, Academic, Summer, ##.##): 1.00 Calendar

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory: **N/A for a workshops proposal.**

Clinical: **N/A for a workshops proposal.**

Animal: **N/A for a workshops proposal.**

Computer: **UNAVCO Inc. will make available (at no cost to this grant) web-hosting facilities and a webmaster to develop a portal for SNARF users and for disseminating information from the SNARF Working Group.**

Office: **N/A for a workshops proposal.**

Other: **N/A for a workshops proposal.**

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

N/A for a workshops proposal.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

UNAVCO Inc. will make available (at no cost to this grant) administrative support to arrange for travel and to arrange for subcontracting the conference facilities needed for the proposed workshops.

California Spatial Reference Center
Scripps Institution of Oceanography
IGPP, 9500 Gilman Drive, Mail Code 0225
La Jolla, CA 92093-0225
Ph: (858) 822-2156 (Maria Turingan, Coordinator)
Fax: (858) 534-9873
Email: csrc@ucsd.edu

July 15, 2005

Dr Geoffrey Blewitt
Professor of Space Geodesy
NV Bureau of Mines & Geology, and NV Seismological Laboratory
University of Nevada, MS178
Reno, NV89557, USA

Dear Geoff,

On behalf of the California Spatial Reference Center (CSRC), I would like to express our support for the work of the UNAVCO SNARF working group and our commitment to the development of the Stable North America Reference Frame. SNARF is important for providing a stable external reference frame with respect to North America for the California Spatial Reference System (CSRS) developed and maintained by the CSRC with funding from NOAA/NGS and the California Department of Transportation (Caltrans). As you well know, California is subject to significant crustal deformation and land subsidence, which complicates the maintenance of a stable reference frame for the State.

Personally, I look forward to continue to work as a member of the SNARF working group.

Sincerely,

Yehuda Bock
Director, CSRC

Cc: Don D'Onofrio (CSRC Chair), Maria Turingan (CSRC Coordinator),Mark Turner (Caltrans)

Natural Resources Canada | Ressources naturelles Canada

July 18, 2005

Dr. Geoff Blewitt
Professor of Space Geodesy
University of Nevada, MS178
Reno, Nevada, 89557
Email: gblewitt@unr.edu

Dear Dr. Blewitt:

On behalf of both Natural Resources Canada and the International Association of Geodesy's Sub-Commission 1.3c (Regional Reference Frames for North America), I am pleased to offer our continued support of the collaborative development of a Stable North American Reference Frame (SNARF) together with the UNAVCO SNARF Working Group.

We believe such a reference frame will form the foundation for the evolution from the current North American Datum of 1983 and fully expect it to eventually become a new standard for geospatial positioning needs throughout North America.

My colleagues and I at NRCan plan to continue our collaboration with the SNARF Working Group to implement and further improve this reference frame over the next few years. Although our contributions are subject to the availability of our own resources and operational requirements, we full expect to meet this commitment given the great fundamental importance of this new reference frame.

We look forward to working with you on this project.

Sincerely,

Dr. Michael R. Craymer
Head, Geodetic Networks & Standards and
Co-Chair, IAG Sub-Commission 1.3c
Geodetic Survey Division, Natural Resources Canada
615 Booth Street, Ottawa, ON K1A 0E9
Tel. 613-947-1829, Fax. 613-992-6628
Email: craymer@nrcan.gc.ca

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
National Geodetic Survey
Silver Spring, Maryland 20910-3282

July 18, 2005

Dr. Geoff Blewitt,
Professor of Space Geodesy
University of Nevada, MS178
Reno, NV 89557

Dear Geoff,

NOAA's National Geodetic Survey (NGS) highly endorses the development of a stable spatial reference frame for North America.

My NGS colleagues and I will continue to collaborate with other members of your UNAVCO Working Group to implement the first realization of such a reference frame and to refine this frame over the next few years.

I look forward to developing a product that will support the work of the entire geospatial positioning community in North America.

Sincerely,

Richard A. Snay

Richard A. Snay
Chief, Spatial Reference System Division