Development of Web Services Infrastructure for Enhanced Access to Synthetic Aperture Radar (SAR) Data from Satellite and Airborne Sensors

A Proposal to the NASA ROSES-08 Advanced Information Systems Technology (AIST)

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Project Description

Overview
UNAVCO and the Alaska Satellite Facility (ASF) propose to develop a seamless distributed archive with a shared catalog for their collections of Synthetic Aperture Radar (SAR) data. To also incorporate the full European Space Agency (ESA) SAR catalog, we will work in an informal collaboration with ESRIN (ESA Centre for Earth Observations). The proposed work fits into the ROSES AIST solicitation category Data Services Management and will increase the accessibility and utility of SAR science data to the scientific user. Currently, to find available SAR data at the three institutions users must first be aware of the existing collections and catalogs. Users are obligated to visit at least three independent access systems through WinSAR, ASF, and ESA. Further, layers of additional complexity for SAR archives include the proper determination of which users may access which data, and providing the user the ability to request tasking for the acquisition of new data. Data providers typically have unique rules about redistributing data, recovering data transcription and distribution costs, and require all users to have signed data policy agreements. Adding to this complexity of multiple archives of data, scientists also have an increasingly broader selection of SAR data to be aware of including data from CSA/Radarsat, JAXA/ALOS-PALSAR, NASA/UAVSAR and AIRSAR, and DLR/TerraSAR-X. The list will continue to expand as missions such as DESDynI are launched.

The goal of this project is to provide credentialed users with simple access tools to view and retrieve SAR data from multiple archives, to place their tasking requests, to order data, and to report results back to data providers; to make a larger pool of data available to scientific data users; to provide information and mechanisms for users to become appropriately credentialed; and to encourage broader national and international use of SAR data, contributing to the broader GEOSS effort. A future goal is to extend the active participation of all space agency SAR data providers. This project will involve multiple partners achieving interoperability in a service-oriented architecture (SOA) through sharing their metadata about SAR data holdings utilizing web services. For this proposal we plan that UNAVCO and ASF will work on the backend web service architecture and the User Interface components. ESA will initially contribute metadata through simple database dumps of their EOLI catalog, and eventually they will also provide their catalogs for special collections or “Super Sites” as they come online. For this project the EOLI catalog metadata will be translated into the web services. The SAR holdings information targeted for the seamless SAR catalog is shown in Figure 1.

Figure 1 The Seamless SAR Catalog will consist of full mission catalogs (rounded boxes) where possible and catalogs of special download-ready collections (ovals) such as UNAVCO’s WinSAR holdings and ASF’s PALSAR L1 Datapool. Dashed boxes and ovals are examples of full mission catalogs and special collections that we intend to incorporate into the Seamless SAR Catalog by the end of the project.
Specific Goals

- Develop a web services-based architecture to enable enhanced SAR data search and access by implementing:
  - Metadata sharing for SAR from distributed archives at ASF and UNAVCO via web services and ESRIN/ESA via a data access layer
  - Metadata sharing for User Credential exchange via web services
- Enhance ASF and UNAVCO/WInSAR graphical user interfaces to use web service

The overarching goal of this project is to simplify data access for scientific users. Currently users cannot do a single search when seeking data but are forced to go to multiple catalogs facing numerous barriers to eventual data access. The benefits of the seamless SAR catalog are shown in Figure 2.

![Figure 2. Use case scenarios for seamless SAR catalog metadata and potential data access to data sources shown in Figure 2. In this example User 1 has credentials to download scenes found in WInSAR and receives a URL to the scene(s) requested. User 2 is not a member of WInSAR and receives instructions to join. User 3’s search results in data that are not yet in any seamless SAR catalog download-ready collection. User 3 can request ordering which will be done subject to WInSAR data quotas and available funds. The seamless SAR catalog greatly simplifies the access to what is currently a set of independent and heterogenous services.](image-url)
Infrastructure to Support Community Scientific Research

The Interferometric Synthetic Aperture Radar (InSAR) technique provides an excellent means of observing motions and deformation over broad areas. It is capable of detecting mm-level changes of the Earth’s land and ice surfaces with decameter-level spatial resolution at monthly or greater intervals. InSAR has proven to be a powerful tool to characterize large-scale deformation associated with active faults. It also can resolve small-scale deformation features such as shallow creep, postseismic and interseismic deformation. It is also an ideal tool for measuring land subsidence and improving digital terrain models.

While scientific research is not directly proposed here, the technologies and infrastructure developed in this effort will support and benefit the diverse scientific goals of the InSAR communities who utilize UNAVCO and ASF InSAR archives. The science themes being investigated span Earth, atmospheric and cryospheric research and include for example:

- The earthquake cycle throughout the world including the San Andreas Fault and Basin and Range
- Volcanic activity throughout the world including South America, Hawaii, Aleutians and Cascade/Yellowstone
- Groundwater and coastal hazards throughout North America
- Mountain building in South America and the Himalayas
- Rifting in Iceland and East Africa
- Motions and deformation of the cryosphere related to global change
- Ionospheric and tropospheric effects
- Anthropogenic changes from oil and water extraction
- InSAR noise source mitigation and time series analysis.

The satellite and airborne imaging choices available to conduct InSAR science investigations continue to grow. All current and past InSAR satellites are operated by foreign space agencies: ERS-1/2 and Envisat are operated by the European Space Agency (ESA), Radarsat is operated by the Canadian Space Agency (CSA), and ALOS is operated by the Japanese Space Agency (JAXA). Unlike most data collected by US satellites, which are freely available to anyone with an internet connection, all scientifically-relevant SAR data have significant costs and copyright restrictions. Such limitations on data exchange impede scientific progress since published results cannot be easily reproduced - the foundation of the scientific method. On the horizon the volume of openly available data will expand rapidly as the NASA airborne UAVSAR becomes operational and when the proposed NASA DESDynI mission is realized. With these missions come the promise of not only large data volumes, but also expanded spatial coverage, more frequent (weekly possible) scans, and even greater utility of InSAR for hazards research and mitigation. With this wealth of data comes the challenge of providing easy access, efficient transfer, and efficient use of SAR data and integration of results with other observations. The web services proposed here form the foundation for enhancing these capabilities and streamlining the work flow.
The WInSAR Consortium, a large group of users accessing UNAVCO and ASF InSAR archives, is primarily engaged in crustal dynamics research. WInSAR was formed to facilitate data access and to maintain a special collection of SAR data obtained from space agency data providers and to archive these data for the scientific research community. WInSAR is now a UNAVCO Standing Committee and its primary archive is hosted by the UNAVCO Facility. Increasingly, integrated research is being conducted by WInSAR scientists taking advantage of the high temporal resolution of surface geophysical instruments and spatial resolution of satellite InSAR. The success of this approach is exemplified by the results from Yellowstone recently published in Nature (Smith, 2007) and shown in Figure 3. We note that Yellowstone is also a primary long term magmatic target for the EarthScope project. As part of this project UNAVCO has instrumented and operates a network of GPS and strainmeter instruments and has acquired a large number of SAR scenes from ESA.

Whereas most of the research to date has used C-band observations (ERS, Envisat), the new L-band SAR data currently being collected by the PALSAR instrument on the JAXA ALOS satellite is getting increased use and is available from ASF and UNAVCO archives. PALSAR is the first L-band synthetic aperture radar having the duration (up to 12 years) and orbital accuracy needed to monitor slow crustal deformation globally. The main advantage of the L-band (23 cm wavelength) PALSAR over C-band (5.8 cm wavelength) is that deeper penetration of vegetated areas results in less temporal decorrelation enabling interferograms having longer time separation. This will facilitate the study of slow crustal deformations in vegetated areas. As the proposed NASA DESDynI will also be L-band, experiences gained managing and processing PALSAR L-band data will be very valuable to DESDynI system development.

Figure 3. Vertical deformation at Yellowstone Caldera between October 8, 2004 and September 23, 2005, derived from Envisat SAR data (Wu-Lung Chang, et al., 2007). One fringe represents 28 mm of line-of-sight motion. Total uplift is about 80 mm.

Broader Impacts
NASA and ESA are both participating in the international “GEOSS” Global Earth Observations System of Systems (http://www.epa.gov/geoss/) which is envisioned as “a large national and international cooperative effort to bring together existing and new hardware and software, making it all compatible in order to supply data and information at no cost. The U.S. and developed nations have a unique role in developing and maintaining the system, collecting data, enhancing data distribution, and providing models to help all of the world's nations.”
Our proposed work encompasses one small, but important component of the GEOSS effort by helping to provide tools for data distribution and data interoperability, in particular for SAR data. The broader goals of GEOSS are focused in this area in part through the Integrated Global Observing Strategy (IGOS) Geohazards Theme which had its third international workshop in 2007 (http://earth.esa.int/workshops/2007Geohazards/programme.html). Of particular interest to ESA, NASA, JAXA, and ISA, and a contributing motivation for this proposal, is the goal of providing easier and more rapid access to data (including SAR data) in areas of potential risk to natural hazards. At the 2007 workshop the concepts of a “Natural Laboratory” (Amelung, 2007) and “Super Site” (Paganini, 2007) proposed natural hazards study areas on various scales in such areas as Yellowstone, Mt. Etna, or South America. In these concepts, data would be continuously acquired and made as openly available as possible to the scientific community worldwide and will help foster integrative research by providing data test beds. While the concept of the Super Site is still under review, the proposed developments of the seamless SAR catalog will be the foundation needed for the realization of effective data access. For this reason, the development of the metadata exchange for the seamless SAR catalog will be closely coordinated with ESA/ESRIN.

**Background Relevant to the Project - Data and IT Infrastructure**

Currently UNAVCO and ASF have collections of data paid for by US sponsors (NASA, NSF, and USGS). The intent of the sponsors is to make these data widely accessible for science. In addition, ESA is reviewing the special “Super Site” collections that would be accessible in a similar manner. Table 1 shows details of these collections, all of which are available to appropriately credentialed users.

<table>
<thead>
<tr>
<th>Entity</th>
<th>Institution</th>
<th>Holdings (Sensor: scene count)</th>
<th>Holdings funded by</th>
<th>Current registered user base</th>
<th>Holdings increasing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WInSAR</td>
<td>UNAVCO</td>
<td>ERS1/2: 6500, Envisat: 900</td>
<td>NSF, NASA, USGS</td>
<td>WInSAR Consortium, 54 institutions, 80 users</td>
<td>Increasing</td>
</tr>
<tr>
<td>EarthScope SAR Collection</td>
<td>UNAVCO</td>
<td>ERS1/2: 23,000, Envisat: 2100, RSAT1: 3600</td>
<td>NSF</td>
<td>20 users</td>
<td>Static</td>
</tr>
<tr>
<td>L1 Datapool</td>
<td>ASF</td>
<td>PALSAR: 7000</td>
<td>NSF, NASA, USGS</td>
<td>60 users</td>
<td>Increasing</td>
</tr>
<tr>
<td>ESA Super Site (concept only)</td>
<td>ESRIN</td>
<td>ERS 1/2: TBD, Envisat: TBD</td>
<td>Various</td>
<td>future</td>
<td>Increasing</td>
</tr>
</tbody>
</table>

**Table** Summary of current and future holdings within special collections of download ready data. These special collections are the datasets that have already been purchased and will be accessible by credentialed users via the seamless SAR catalog. In addition to these collections, ASF holds special collections for AIRSAR (NASA) and the International Polar Year that will also be considered.

UNAVCO hosts the primary node of the WInSAR archive which has holdings of over 7000 SAR scenes. UNAVCO also holds the EarthScope SAR collection, consisting of over 28,000 scenes. The EarthScope SAR collection is intended for solid Earth science research focused on the Western US active tectonics and volcanic areas. ASF holds the L1 ALOS PALSAR Data Pool with over 7000 ALOS frames. The L1 pool is comprised of data purchased for sharing by
NASA, NSF, and the USGS. Each collection has different access categories, and specific steps must be taken to gain access by the scientist who intends to use the data. While the intention is to make the data widely available, the very existence of these three systems with their separate front ends and access protocols presents a significant barrier to the users in that they must learn the specifics of each of the three collections to ascertain applicability to their problem, search, determine if they need to join, sign agreements, establish passwords, etc. The sets of potential users of each of these collections have a high percentage of users in common. The vision of this proposal is to leverage the catalogs maintained by these institutions to greatly simplify search and access for these users in common.

As indicated in Figure 1, these special download-ready collections are only a subset of all possible data that can be purchased from the space agencies or ASF. We therefore also intend to include ESA’s full catalog and ASF’s comprehensive catalogs and to provide a streamlined pathway for purchase of these data.

**WInSAR Archive Infrastructure.** UNAVCO InSAR and ASF archive interfaces have similar user functionality but different backend software and hardware implementations. The WInSAR archive system used by UNAVCO for WInSAR and EarthScope SAR archiving is somewhat more generalized by design and will be describe here to provide background for the proposed technology development. WInSAR currently utilizes a mysql database with a php web-GUI frontend. The architecture currently does not utilize web services. Direct queries are made to the database through the web front end, which accommodates spatial, temporal and metadata searches. Any user can request Google Earth-ready kml files to be generated in response to searches. Only approved users can download data after login. WInSAR users must be affiliated with a consortium member institution, must sign data use agreements, and must use a login system to gain access to data.

Though WInSAR is technically able to share information across a distributed system, in practice, robust mechanisms for sharing metadata for independently evolving nodes were never built. For the present, all of the readily-retrievable data is held at UNAVCO’s WInSAR node. Other nodes can mirror the UNAVCO holdings, but catalog sharing mechanisms that were used at one time have been outgrown. There is a rudimentary search of the ASF L1 data pool, but no retrieval mechanism due to access permission barriers that we will simplify as a part of this proposed development. Note that the WInSAR archive software and database system are non-proprietary and can be distributed to new nodes for use in a distributed archive system. It is anticipated that new services developed for this project will also be openly distributed. The WInSAR system also offers a mechanism for Consortium members to request ordering of particular archived scenes for ERS and Envisat data that are not yet in WInSAR holdings.

The EarthScope SAR Archive is also held at UNAVCO. This archive is modeled after the WInSAR archive, using a mysql database and PHP web-GUI front-end with several differences. The data holdings are about ten times greater than WInSAR and are held inside a firewall. To comply with access restrictions and reporting requirements by ESA, user credentialing involves a “Minicat” proposal. Users select data for packaging and after providing login information users are able to download packaged data. Utilities for data format conversions and slicing or concatenating contiguous scenes are part of the data access process if the user wishes.
I. Applicability to Earth Science missions in the NRC Decadal Survey
One-Page Relevancy Scenario

I. Identify applicable NRC Decadal Survey mission or missions, including page number(s).

This project is applicable to the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynl) Mission (pages 96-99).

II. Indicate whether the technology is on-board the spacecraft, ground based system(s) or both.

The technology developed with this proposal is a ground based data management system.

III. Describe how the proposed technology will enable missions and associated Earth science information challenges.

The proposed seamless SAR catalog will be able to incorporate future DESDynl SAR metadata thereby making data available to a large group of productive users by lowering search and access barriers and ensuring broader access. The project will address the following specific strategic goals or research objectives from the ROSES AIST Solicitation and the NASA Decadal Survey. This project addresses increases the accessibility and utility of science data. In particular, it will increase access to SAR data resulting in more effective data flow to the scientists who will more readily be able to find and retrieve data that are already open to their use. Currently, the partner organizations, ASF and UNAVCO have experience with archiving, preserving, and distributing SAR data to the science community and will make their catalogs available using Service Oriented Architecture.

The Decadal Survey sets out several Strategic Goals and subgoals. This proposal addresses strategic subgoal 3A of Strategic Goal 3: Develop a balanced overall program of science, exploration, and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration. Subgoal 3A: Study Earth from space to advance scientific understanding and meet societal needs. SAR data from satellite and aircraft platforms provides information that is unique in the solid Earth sciences in several ways described elsewhere in this proposal. This project provides knowledge about available SAR data for Earth science research. The successful accomplishment of the goals of the proposed project will provide a foundation for mechanisms of discovery and access to DESDynl SAR data. These data address subgoal 3A, in particular providing data that is of extremely high value for Earth system research with respect to natural disasters and climate change. The partner organizations are well positioned to archive and distribute data from the DESDynl mission. The proposed work will enhance the usability of all SAR data from all missions including DESDynl. This project enables new information products to be delivered based on newly accessible data.

IV. Indicate how the entry TRL and proposed exit TRL will position the proposed technology to meet mission schedules

The DESDynl mission launch date is officially 2015. The proposed technology as it stands is at Technology Readiness Level (TRL) 2 – The technology concept for a seamless SAR distributed archive with a shared catalog has been formulated. The proposed work will advance development towards a completed seamless SAR catalog with user interface capability and will be at TRL-7 in the 2012 time frame assuming a start date of 2009.
I. Description of Proposed Technology

The proposed work will involve a close collaboration between ASF and UNAVCO to build web services and flexible tools that will enhance their web interfaces allowing all users to do searches and credentialed users to also access data from the distributed archives.

Web Services. Currently the WiN SAR archive operates on a relatively simple php/mysql server that provides local database with a web interface that the user accesses via a browser. The proposed seamless SAR catalog system has several components. The first component is the SAR database web service that integrates the mysql SAR database into a web service. There are a number of implementations possible, but for the EarthScope portal project UNAVCO’s archive GPS web service currently utilizes the model and particular software packages shown in the diagram on the right in Figure 4. ASF will construct its own implementation of their SAR database web service and the ESA EOLI catalog will be implemented behind a web service access layer. The power of web services is that the exact implementation is not important, only that the web services definition language (WSDL) request and response defined by the agreed upon WSDL contract definitions are consistent. The distributed database web services are accessed via SOAP/XML exchange protocol.

![Figure 4. Schematic diagram of proposed seamless SAR catalog web Service Oriented Architecture showing the UNAVCO implementation. The user makes a request using the UNAVCO GUI, the web service translation layer makes a distributed query to the three independent web services (UNAVCO service shown in detail on right figure), then packages and returns the responses to the GUI for display. ASF will also implement this capability into their service.](image)

The second component that will need to be developed is the seamless archive catalog distributed query server shown on the left in Figure 4. This query to web service translation layer can access multiple distributed databases via SOAP/XML exchanges, but can be thought of as mimicking a single database query. The query server acts as a broker handling the distributed request, managing asynchronicity in responses, error correction, and packaging up the response for the GUI server or other front end. This application will be jointly developed by ASF and UNAVCO and deployed at both sites. As noted earlier, we do not intend to have a single new GUI but will
integrate distributed query capability into existing ASF and UNAVCO/WInSAR GUIs as described below. We do plan and budget for improvements and modifications needed to enhance the GUI interfaces.

**GUI Development.** The GUI enables users to interact with the seamless SAR catalog web service via a web browser. The associated standalone client does the same but is intended for integration into automated non-interactive data scripts. UNAVCO/WInSAR (Figure 5), ASF (Figure 6), and ESRIN (Figure 7, left), currently have graphical user interfaces (GUIs) to help the user browse and order data. There are common elements of these tools including spatial and temporal query constraints, satellite and sensor selection, data preview capability, and password controlled access. However, each tool is tailored to the particular set of users, access requirements, and local archive IT architecture. Past experience in collaborative portal development shows that it is difficult and costly to develop and more importantly maintain a single new common cross-institutional GUI design that meets every archive’s particular requirements. As shown in the figures below, the state of mapping and web interface technologies such as Google Maps and Earth are rapidly evolving, and opportunities for incorporating such innovations into an evolving web interface occur constantly. For these reasons we have chosen to enhance existing front end systems at UNAVCO and ASF rather than build a single new one from the ground up.

For this project, the primary goal is to establish an SOA that will enable distributed queries using web services. We are focusing on establishing the “backend” infrastructure that allow us to enhance current GUI capabilities and adapt quickly to new technologies and to anticipate the large volumes of data from new missions such as DESDynI. We will co-develop the web services and incorporate new distributed search capability into the existing WInSAR and ASF web tools. The development process, including interactions with the external project advisory team, will ensure that the API definitions meet community and agency needs. Usability studies will be done to improve existing GUI designs. The developments from this project, including enhanced GUIs, web services, and distributed query capabilities will be fully incorporated into ongoing archive operations ensuring long term sustainability.

![Figure 5. (left) Sample of the current WInSAR browser search tool at UNAVCO. The user can query the WInSAR archive using geographical and temporal constraints and can select satellites (ERS1, ERS2, Envisat and ALOS) and their orbits, track and frames. (right) the response shows data available, preview images, baseline information, and allows the authorized WInSAR users to select data from the WInSAR archive collection to be downloaded via ftp. Users can also download metadata from the search into spreadsheet (CSV) and Google Earth formats allowing for further interactions.](image-url)
Figure 6. The ASF URSA web tools have similar query capability for ASF holdings (left) and tabular response and order capability (right). The example above shows the capability to select a polygon area using the Google maps interface. The query response, in this example for NASA AirSAR data, gives preview images and mouse over metadata. Authorized users can select and download data files or metadata in spreadsheet format (CSV) or view in Google Earth.

ESA has developed the very capable EOLI application (Figure 7, right) for searching and ordering data from ESA holdings at ESRIN which includes a number of satellite systems in addition to SAR. EOLI also allows the user to catalog local holdings and data disks. There is also a web browser applet version of EOLI that allows only for search (not ordering) and, unlike the application version, web EOLI is built upon web services technologies. The current version of web EOLI also includes some basic search of ASF data holdings that accesses this information via the NASA ECHO system. While only a preliminary step, this demonstrates how the European community is actively developing web services and incorporating them into their IT infrastructure. It also shows how loosely coupled web services like those employed in NASA ECHO can enable application development by others.

Figure 7. (left) There has been a recent virtual explosion in the use of Google Earth for a wide range of mapping applications. This is an example of the rapidly changing environment of advanced tools being developed in the commercial sector. The UNAVCO WinSAR Google Earth implementation, a display can be made of the frame locations and information about the data obtained by clicking on the frame center. Ground tracks are shown windowed by date range selected in the Google time slider giving additional search interaction. (right) The ESRIN EOLI application. Shown in the example are examples of query results for selected ALOS data that fall within ESRIN’s responsibilities including Europe and Africa.
Another European development currently underway with ESA is incorporating InSAR processing into the web service architecture using “GAMMA” SAR processing. Data access web services developed in this proposal not only will provide enhanced distributed access to data, but also can easily be chained to feed advanced processing web services of this type that are being developed for processes further up the workflow.

The current SAR archive systems have embedded user authentication. Seamless SAR catalog user credentials will be built upon the existing databases and accessed via web services. User credentials include information about which collections the user has rights to. For example, the WInSAR collection at UNAVCO has 80-plus credentialed users affiliated with WInSAR consortium member institutions. The users have signed the appropriate data use agreements. The WInSAR collection is “download-ready” for these users. The EarthScope SAR collection at UNAVCO has 20-plus users. These users have written a brief “Minicat” proposal, signed appropriate data use agreements for the mission(s) they wish to access, and agreed to provide annual summaries of the resulting research. Any researcher may make a Minicat application and potentially become a credentialed user for EarthScope data. ASF through its URSA has similar data use agreements.

As noted, the technologies developed through this project will be fully integrated into UNAVCO and ASF archive systems ensuring long term sustainability. The data access using the seamless SAR catalog will also be included in WInSAR SAR processing classes hosted by UNAVCO and will become the first part of the workflow taught to new researchers.

3. Comparative Technology

The project architecture we describe is based upon well documented and widely deployed SOA elements used in science and business systems. They have not been deployed in the U.S. for SAR outside of limited application with the NASA Earth Observing System Clearing HOuse (ECHO). The ECHO is a catalog of spatial and temporal metadata providing access to a distributed, broad, and diverse set Earth science data and information for a wide variety of observing systems. ASF at the data service source, and ESRIN at the query tool development level, have experience working with the ECHO. The ECHO employs web services allowing users to include their own data sets in ECHO or develop custom clients for searching and ordering the ECHO holdings. In this regard, ECHO acts as a middleware agent, not providing a user interface or holding Earth science data itself. ECHO acts as an order broker, providing orders to the appropriate organization for execution. While valuable for broader simplified access, ECHO is limited in some regards, such as providing specific metadata applicable only to one data set and providing searches of the full metadata holdings and is insufficient for our research project requirements. We anticipate, however, that the new enhanced web services developed for the seamless SAR archive can be integrated into and contribute to ECHO.

4. TRL Assessment

This project entry is TRL 2, the technology concept has been formulated. The advancement of the TRL to the exit level of 7, system prototyping demonstration in an operational environment,
will occur during the project. The basic underlying database and web service architectures to be employed are well documented and widely applied by the PIs and many other groups, but have not been applied in the project context. Web services-based portal catalogs have been applied to other domains and observations and the theories and principles developed will be focused here specifically on distributed SAR catalogs. Level by level advancement is detailed in the Research Management Plan (section 5 below) with associated project development phases, milestones/success criteria, and time line included.

5. Research Management Plan

Management Structure. The project management plan builds upon the collaboration and rigorous project management processes established for the highly successful EarthScope SAR archive project. The excellent working relationships developed between UNAVCO, the EarthScope SAR Working Group that advised the project, WInSAR, ASF who provided support via a subaward from UNAVCO, and the generous contributions from ESRIN in fact provided the encouragement for the development of this seamless SAR catalog proposal.

This is a collaborative project with formal overall project direction and budget responsibility resting with the UNAVCO PI Dr. Charles Meertens. Dr. Meertens will direct the UNAVCO team and ensure that project goals outlined in the project phases and timelines sections below are met. Project Co-I Dr. Nettie LaBelle-Hamer will direct the ASF team and be responsible for the ASF subaward. Project managers Dr. Frances Boler at UNAVCO and Dr. Scott Arko at ASF have considerable experience managing information technology development projects and have experienced and capable technical staff. Each has a Software Engineer to perform software development tasks for this project. A very important part of the management structure is the project advisory committee. Three volunteer members of the WInSAR scientific community will be part of this group. Dr. Wolfgang Lengert of ESRIN also has agreed to participate in the advisory group meetings and to host the project meeting in Frascati. Face-to-face meetings of the project team are budgeted throughout the project and the advisory group will meet in Boulder the first year. These meetings will be supplemented with monthly conference calls.

Statements of Commitment from the Co-I and Letter of Support from WInSAR and commitment to serve on the project advisory working group are attached to this proposal.

Project Phases. The proposed work will involve a close collaboration between ASF and UNAVCO, with input from ESA ESRIN, to build web services and associated front end tools that will allow credentialed users to search and access data from existing special collections and metadata from the available full mission catalog(s) at these three institutions. The work will take place over three years and be divided into six phases. Each phase includes work in parallel at UNAVCO and ASF. Phases 2-6 will include comprehensive testing of the subsystem elements built up to that point. Refinements to earlier elements will be ongoing throughout later phases. Phase 1 is an initial requirements-setting phase. An advisory panel will be assembled that will provide input for the metadata to be exchanged and the SAR search fields to be utilized in the front end systems. The panel and project personnel will meet in Boulder to define requirements. Project managers at ASF and UNAVCO will guide the requirements setting by generating straw
man documents for discussion and will write reports defining the finalized requirements. During **Phase 2**, alpha versions of the SOA shown in Figure 4 will be built at ASF and UNAVCO. During **Phase 3**, Existing front-end systems at ASF and UNAVCO will be expanded to be able to send queries to the web services layer and to receive responses. The front end systems will ultimately include search capability for multi-mission SAR data based on numerous user-definable criteria that will allow selection of the best data for interferometry as defined in Phase 1 by the advisory panel. During **Phase 4**, the proxy web services that provide for querying metadata from ESA’s EOLI catalog database will be built. In order to smoothly incorporate ESA metadata and learn from ESA’s SOA experience, project personnel will visit ESA ESRIN during this phase. **Phase 5** will include implementing web services for user credentials through which the partner archives will merge and share user credentialing information. The GUIs and standalone client front end work will be expanded to incorporate actions dependent on user credentials and the characteristics of the query results. **Phase 6** will involve completion of final refinements of the web services backend and GUI and standalone front ends. In addition, a written plan for moving forward into the future to allow for incorporating new special collections, new mission catalogs, additional credentialing systems, and additional products, will be completed.

**Project Timeline with milestone schedule chart and success criteria**

**Year 1.**

a. **Phase 1.** Requirements-setting
   i. Milestone: Assemble advisory committee and meet in Boulder
   ii. Milestone: Report on requirements completed and vetted by advisory committee

b. **Phase 2.** Develop alpha web services for SAR metadata
   i. Milestone: SOA infrastructure hardware and software installed
   ii. Milestone: WSDL established based on requirements
   iii. Milestone: Basic working query-response system in place utilizing the WSDL. Project at TRL-3

**Year 2.**

a. **Phase 3.** Front end development
   i. Milestone: Web GUI enabled for seamless catalog queries. Released for alpha use. Project at TRL-4
   ii. Milestone: Standalone client enabled for seamless catalog queries

b. **Phase 4.** Proxy database and web services for ESA catalog
   i. Milestone: Project personnel meet with mission and developers at ESRIN
   ii. Milestone: ESA metadata queries through seamless catalog implemented. Project at TRL-5

**Year 3.**

a. **Phase 5.** Develop web services and front end functionality for user credentials metadata
   i. Milestone: User-credential web services implemented
   ii. Milestone: Front-end systems utilize user credentials
   iii. Milestone: Overall system beta release to user community. Project at TRL-6
b. **Phase 6.** Complete final refinements to SOA and front ends
   i. Milestone: Project personnel meet at ASF to identify critical final implementation tasks
   ii. Milestone: Release of fully operational system. Project at TRL-7

6. **Personnel**

PI Dr. Charles Meertens, Director of the NSF and NASA-funded UNAVCO Facility, and Co-I Dr. Nettie Labelle-Hamer, Director of the NASA-funded ASF, will have overall responsibility for this project. Project management tasks will be conducted by Dr. Frances Boler, the head of the UNAVCO GPS and InSAR Data Center, and Dr. Scott Arko, Deputy Director, ASF. Software development and implementation will be conducted by a full time equivalent Software Engineer at and UNAVCO and one at ASF.

7. **Facility and Equipment**

Both UNAVCO and ASF have extensive information technology resources and SAR archive infrastructure and will not be requesting major capital equipment through this project. Lower cost servers and data storage servers specifically needed for system development will be requested.

8. **Special Matters**

**UNAVCO InSAR Archives.** The WInSAR consortium currently has 54 US universities and research institutions whose goals include purchase and distribution of SAR data to scientists doing various aspects of solid Earth, hydrological, cryospheric and human impacts research. The WInSAR archive was originally constructed to handle a limited European Remote Sensing Satellite 1 (ERS-1) and ERS-2 satellite archive with relatively small data volumes. UNAVCO, on behalf of the WInSAR Consortium, assumed responsibility for WInSAR data acquisition and archive software maintenance and development in 2006. UNAVCO has been able to implement some modest changes to accommodate newer satellites (Envisat, ALOS, RADARSAT) and the total holdings are over 7000 SAR scenes. Over the last year, UNAVCO modified the system for EarthScope to meet specific project requirements and data provider access constraints for that project. EarthScope over 28,000 SAR scenes were acquired in the last year by UNAVCO working with ASF and ESA/ESRIN.

**Alaska Satellite Facility Archive.** The Alaska Satellite Facility (ASF) of the Geophysical Institute (GI) at the University of Alaska Fairbanks (UAF) has more than a decade of experience in satellite remote sensing. ASF is involved in a wide range of activities — from downlinking satellite data to developing data-analysis tools, value-added products, and training for Synthetic Aperture Radar (SAR) users. Satellite remote-sensing data are acquired from the ESA's ERS-1 and ERS-2 satellites, the Japan Aerospace Exploration Agency’s (JAXA) Japanese Earth Resources Satellite-1 (JERS-1) satellite, and the Canadian Space Agency's RADARSAT-1 satellite. Data are processed, analyzed, and archived by the various centers of ASF. The data are
distributed to national and international scientists, as well as to government agencies. The primary goal of the ASF staff is to provide expertise and service to the research community. Since beginning operations in 1991, the Alaska Satellite Facility (ASF) has collaborated with researchers and government agencies to leverage NASA's software technology and data holdings to produce a variety of special products. Many of these projects provide opportunities to enhance software technologies related to effective use of SAR data in support of research and applications specific to Alaska or the arctic. ASF has also facilitated strong working relationships between staff, scientists, government sponsors, and industry partners.

**Previous Web Services Experience.** UNAVCO has previous experience with collaborative web services design and implementation for other data sets as part of the EarthScope portal development (Baru, 2007) and the GEON Cyberinfrastructure projects (Seber, 2005). The EarthScope project involving UNAVCO, IRIS, San Diego Supercomputing Center, Stanford and the GeoForschungsZentrum accesses distributed archives of GPS, seismic, tiltmeter, strainmeter, and borehole data. Due in part to the complexities of data itself and access rules, SAR services for EarthScope data are not in the scope of EarthScope-funded work. The technologies developed under the proposed NASA ROSES AIST project will however facilitate integration of SAR data into future EarthScope and other portal developments. UNAVCO has also had experience in constructing a distributed Seamless Archive for GPS data (GSAC). This work was done in with Scripps Institute of Oceanography.
References

Amelung, F., 2007, WInSAR and the Natural Laborator approach to Geohazards, paper presented at the 2007 International Geohazards Week, Frascatti, Italy.


August 27, 2008

Dr. Charles Meertens
UNAVCO
6350 Nautilus Drive
Boulder, CO 80301

Re: Letter of Commitment

Dear Charles,

I acknowledge that I am identified by name as Co-Investigator to the project entitled, "Development of Web Services Infrastructure for Enhanced Access to Synthetic Aperture Radar (SAR) Data from Satellite and Airborne Sensors," submitted by Charles Meertens to the National Aeronautics and Space Administration (NASA) Research Announcement ROSES-2008 NNH08ZDA001N-AIST, Appendix A.20: Advanced Information Systems Technology.

The Alaska Satellite Facility (ASF) intends to carry out the tasks and responsibilities described in the proposal. I understand that the extent and justification of our participation as stated in this proposal will be considered during peer review in determining, in part, the merits of this proposal.

Sincerely,

[Signature]

Nettie La Belle-Hamer, Ph.D.
ASF Director
Dr. Chuck Meertens
UNAVCO
6350 Nautilus Drive
Boulder, CO 80301-5554

Dear Chuck,

We writing to express our enthusiastic support from the members of the Western North America InSAR (WINASAR) Consortium for your NASA ROSES Proposal entitled “Development of Web Services Infrastructure for Enhanced Access to Synthetic Aperture Radar (SAR) Data from Satellite and Airborne Sensors”. WINASAR is a collection of 54 universities and public agencies created to manage the acquisition and archiving of spaceborne InSAR data for their mutual benefit. Our major objectives are to:

- Promote the use and development of InSAR technology for scientific investigations, in particular but not limited to, seismic and magmatic processes, plate boundary deformation, land subsidence, and topographic mapping.
- Acquire SAR imagery globally, archive and catalog the data, and disseminate it for use by member organizations.
- Provide value-added InSAR products and software for use by the scientific community.
- Advocate the open exchange of SAR data by seeking to enlarge the number of member organizations.

Understanding time variations in ground deformation associated with earthquakes, volcanoes, glaciers, and fluids will require the processing thousands of interferograms by many researchers. Over the past decade we have assembled about 10,000 scenes of raw SAR data and have made them freely available to the US research community through a web-based archives now located at UNAVCO and ASF. This archive is growing very rapidly yet much of this data has not been analyzed because the catalogs and metadata are challenging to navigate and there is no easy-to-use production-level InSAR software for large-scale processing. The InSAR software is currently being developed by the InSARProc Working group in preparation for UAVSAR and the DESDYNI missions. Your proposal is essential for integrating the catalogues and archives so scientists will be able to accurately assemble large data sets for their research. Seamless integration of the diverse catalogues at ESA/ESRIN, ASF, and UNAVCO will be a challenging undertaking. WINASAR scientists wish to participate in the planning and development of the seamless archive and many would be happy to serve on an advisory committee for this effort.
If you have any questions or require any additional information, please do not hesitate to contact any of the members of the WinSAR Executive Committee. Our website is http://winsar.unavco.org/main.php

Sincerely,

WinSAR Executive Committee

Falk Amelung – University of Miami

Sean Buckley – University of Texas at Austin

Yuri Fialko – Scripps Institution of Oceanography

Rowena Lohman – Cornell University

David Sandwell (Chair) – Scripps Institution of Oceanography
Budget Justification

The seamless SAR catalog and distributed archives project will require a total of $878,274 (Table 1). For project management, software development, hardware infrastructure, travel for personnel and participant support. The project involves close collaboration and parallel work at UNAVCO and the Alaska Satellite Facility. The project tasks supported and the level of effort required at each institution are very similar. The detailed ASF subaward budget is shown in Table 2.

The personnel budget for UNAVCO includes 3 weeks of support for the project manager per year for all three years, and full time support for a software developer for all three years. The project manager at UNAVCO will direct the efforts of the software developer, interact with his/her counterpart at ASF, and fulfill reporting requirements. Salaries are budgeted to increase by 3% each year. UNAVCO’s personnel costs are 37% of the project MTDC not including the ASF sub-award.

The travel budget for UNAVCO varies from year to year and does not include travel for the first year because meetings with partners and the advisory committee will take place in Boulder. Support is requested for foreign travel during the second year for planning and technology transfer with partners at the European Space Agency’s ESRIN facility in Frascati, Italy. During the third year, support is requested for technology review with ASF with a trip to Fairbanks scheduled for UNAVCO personnel.

Participant support is requested to bring a 3-member advisory committee to Boulder during the first year of the project. The advisory panel will provide input during the remainder of the project by teleconferences and by meeting with project personnel at conferences such as AGU.

UNAVCO requests support for the purchase of two midrange servers such as Sunfire v245s to be used as development and production systems. RAID storage for database and test data sets storage needs will be purchased as well. All hardware is purchased in the first year. Each year $100 is requested to cover supplies. Under other costs, $100 per year is requested for each of the communications and mailing categories.

A sub-award to the Alaska Satellite Facility for project management, software development, hardware, and travel is requested for each year of the project. The costs at ASF parallel in nearly every respect the costs at UNAVCO. Travel costs from Alaska to Frascati are higher than from Boulder. The reporting requirements are less at ASF, so the project management is budgeted at a lower FTE level than for the project manager at UNAVCO.

[detailed budget tables and PI boilerplate removed for this public release of the proposal]