B. Project Summary

Intellectual Merit: Discovery may start in isolation, but grows through discourse and collaboration. Throughout the Americas, geographically distributed researchers, students, and instruments need a seamless cyber-infrastructure to inquire and discover collaboratively. We propose WHREN (Western Hemisphere Research and Education Networks) to address the existing and future needs for improved North American (especially U.S.)–South American connectivity. This proposal specifically focuses on the need for connectivity through new links, LILA (Links Interconnecting Latin America).

The success of WHREN is assured by the commitment to the sharing of resources and participation in the management and governance by institutions representing the entire Western Hemisphere: Cooperación Latino-Americana de Redes Avanzadas (South and Central America: CLARA), Internet2 (Abilene), Red Universitaria Nacional (Chile:REUNA), Academic Network at Saõ Paulo SP (ANSP: São Paulo), Corporación Universitaria para el Desarrollo de Internet (Mexico:CUDI), Rede Nacional de Pesquisa (Brazil:RNP), Canadian Advanced Research and Education Network (CANARIE), StarLight, the TransLight initiatives, Corporation for Education Network Initiatives in California (CENIC) and the Pacific Northwest GigaPoP (PacificWave), and the Southeastern University Research Association (SURA) and Florida International University (AtlanticWave and AMPATH).

The time is right to undertake this challenge. U.S. researchers are part of communities of scientists undertaking experiments that require increased and improved network resources throughout the Americas. WHREN will promote more efficient peering of existing academic networks through a distributed exchange model and will foster a cogent plan to support evolving researchers' needs. The WHREN project acts as a flexible inter-regional infrastructure, enabling communities of scientists to expand their research activities, teaching, and learning. LILA provides the missing links between existing networks.

A rational global research and education network can be achieved when people, technology and the operational processes evolve to perform effective and efficient provisioning of resources to support the global e-Science community. Through WHREN, we can interoperate with established and emerging African, Asian, European, and Australian network governance groups. The U.S., participating as a member of a hemispheric team cooperating for science throughout the world, both contributes to and benefits from the efforts of its neighbors in the Americas.

The approach for LILA is to (A) complement the existing intra- and interregional networking activities with an infrastructure that interconnects North America (US, Mexico, and Canada) to emerging aggregation points in South America, (B) to evolve the connections as resources and economies permit to 2.5 Gbps and (C) implement a multi-service network infrastructure that will provide a hybrid of scheduled temporary use and permanent use network resources to support discipline-specific and general-purpose high-performance computing and networking services over wide geographical distances. We are requesting funding to provide three of the four missing links, which will interconnect: Miami to São Paulo, Santiago to Tijuana, and Tijuana to San Diego. The fourth link, São Paulo to Santiago, will be provided by Florida International University.

The performance, reliability, and engineering of LILA will be ensured by FIU and CENIC using both in-house and WHREN member resources, and through forming strategic partnerships with other network experts. LILA staff will work closely with researchers, carriers, and peer networks to ensure the communities' needs are met.

Education, Outreach and Broader Impact: WHREN will serve to increase the rate of discovery both in the U.S. and across the Western Hemisphere. Faster discovery means a quicker focus on what will have the greatest benefit for society. WHREN will act as a catalyst for new communities of researchers and learners. A new bridge will be built linking together Spanish speakers of the Western Hemisphere, benefiting U.S Hispanic students, teachers and researchers. As part of LILA, CENIC and FIU are committed to incorporating graduate, undergraduate education into the use of LILA through models that bring together the networking community with scientists from all domains.

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D. Project Description

D.1. WHREN: Increasing the Rate of Discovery and Enhancing Education across the Americas

We are proposing the Links Inter-connecting Latin America (LILA) to initially provide four circuits as part of WHREN:

- 1.2 Gbps----Miami to São Paulo; evolving to 2.5 Gbps
- 155Mbps ---São Paulo to Santiago; funding provided by FIU
- 310Mbps----Santiago to Tijuana; evolving to 622 Mbps
- 2 strands of dark fiber—Tijuana to San Diego, evolving from 1 Gbps to 4 Gbps

There is currently a large gap between the level of connectivity from the U.S. to Latin America, and the level of connectivity from the U.S. to Asia and Europe. U.S. science and education interests throughout the Americas are today on par with interests in Europe and Asia. This schism represents a digital divide in the ability to participate in modern science projects. The bottleneck for the community is both available network capacity and a methodology for network cooperation[1].

The proposed links address this bottleneck by partnering with regional, national, and state networks to ensure advanced (gigabit or better) last mile connectivity in Mexico, Chile and Brazil, providing economical and advanced interregional infrastructure, as well as broad and effective distributed interregional peering through consortium with regional networks such as CLARA, Internet2, NLR, and CANARIE.

For the first time, there will be sufficient network resources to incrementally enable the dynamic provisioning of optically switched circuits to support the next-generation of e-Science across the entire Western Hemisphere and to other global regions where US scientists and instruments are located.

A rational, elegant approach for leveraging the Western Hemisphere's existing and future research networks, WHREN's LILA project provides the greatest benefit possible to regional science and education in conjunction with a flexible design that grows with the needs of the U.S. research and education community.

Cooperative Governance for Network Management: WHREN

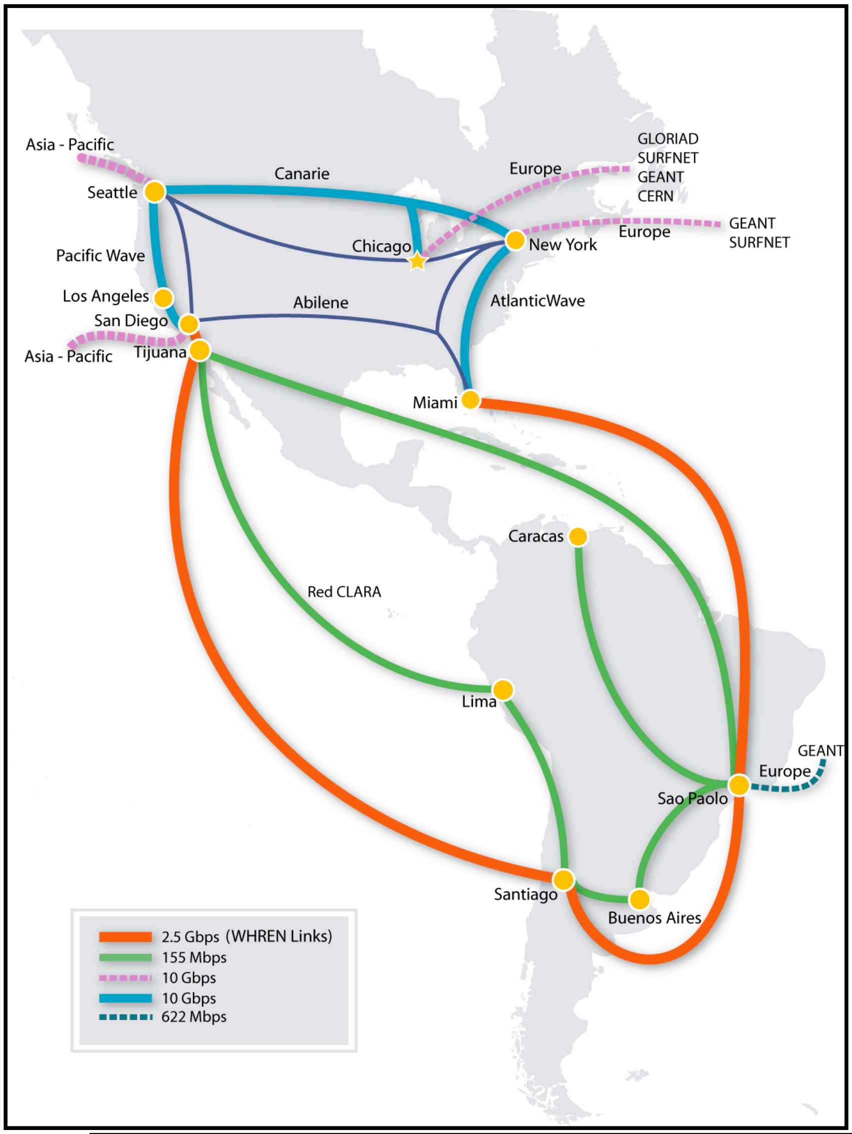
Inside the U.S., the NSF-chaired and NCO-supported Joint Engineering Task force acts as a venue and a methodology to foster inter-agency network peering and international exchange point planning. But, no such methodology exists for the Western Hemisphere.

Today, researchers and educators are empowered through the certainty of available bandwidth and predictability of latency that advanced networks provide through policy-driven configuration[5]. Effectively establishing such policies requires participation and end-to-end planning of all the networks that are involved. The consortium provides that framework for the Western Hemisphere -- a collaborative where researchers, educators, network managers, and administrators can establish relationships, overlay needs with resources and utilize advanced network facilities.

D.1.1. New Infrastructure: LILA

Four links are proposed herein which become the infrastructure that ties together the major research networks of five of the larger countries in the Americas (Brazil, Canada, Chile, Mexico, and the United States).

- Miami to São Paulo
- São Paulo to Santiago
- Santiago to Tijuana
- Tijuana to San Diego



These links also leverage the new research network for South and Central America, CLARA, which enables connectivity to fourteen Latin American national research and education networks. Figure 1 shows the overall topology and interconnections of WHREN participants.

The ultimate goal of the consortium is to establish a 10 Gbps international peering network across Canada and the US and a 2.5 Gbps international peering network in the rest of the Western Hemisphere.

However, current telecom submarine carrier costs, and prices in Latin America are too high for the NSF IRNC program to reasonably support the network envisioned. The goal network is possible with significant monetary support from ANSP, FIU, CENIC, SURA, and CUDI, network resources from CANARIE, CLARA, REUNA, and Internet2.

Participant	**Name**	**Geography**
AtlanticWave	FIU and SURA	US East-Coast International Exchange
CANARIE	Canadian Advanced Research and Education Network	Canada
CENIC	Corporation for Education Network Initiatives in California	California
CLARA	Cooperación Latino Americana de Redes Avanzadas	South America
CUDI	Corporación Universitaria para el Desarrollo de Internet	Mexico
ANSP	Advanced Network at São Paulo ANSP is founded by FAPESP, the NSF equivalent in Sao Paulo, Brazil (grant no. 03/13708-0).	São Paulo, Brazil
FIU - AMPATH	Florida International University	Miami, Florida international R&E exchange point
Internet2	same	US
MANLAN	Manhattan Landing	US Northeast International Exchange Point

Pacific Wave	CENIC AND PNWGP	US West Coast International Exchange
REUNA	Red Universitaria Nacional	Chile
RNP	Rede Nacional de Pesquisa	Brazil
StarLight	same	Chicago International Exchange Point
SURA	Southeastern University Research Association	US East Coast

Table 1 Participants

D.2. Merit Review Criteria

D.2.1 Intellectual Merit

D.2.1.1. Advancing Knowledge and Understanding

WHREN itself is an approach to solve the problem of interconnecting not just advanced networks, but the core communities and needs behind them in the Western Hemisphere. Today's research is being adversely impacted by the lack of capacity, especially to valuable resources in South America[2].

By providing a methodology for participation of network leaders and the engagement of the research and education communities served, the rate of discovery and success of scholarship will increase. For many years, we have seen the dramatic benefits of high performance networking in all areas of science and engineering. WHREN provides the structure and LILA provides the resources to empower researchers and educators in the Western Hemisphere whose activities have their own intellectual merit. These successes do present themselves qualitatively in the creation of geographically distributed research groups using the network, working groups formed through common interests developed on the network, and publications made possible through the network. Many researchers now need to take advantage of the increase in network capacity. Examples of these applications are detailed in Section D.3.

The engineering and utilization of lambda networking will be advanced by WHREN. The South American Crossing submarine cable, one of only two Pan-South-American cables, needs a new management and configuration structure which can be demonstrated through a pilot project with LILA. We will be working with our partners to provision unprotected lambdas on this infrastructure. This technology transfer will demonstrate the potential benefits for the research and education community, and the commercial network community in the Western Hemisphere. More information is available in Sections D.4. and D.8.

D.2.1.2. Qualifications of Proposers

FIU and CENIC have formed a collaboration to leverage their individual strengths to establish and participate in WHREN and to build, coordinate, and manage LILA, as a critical resource to the success of WHREN.

For the past three years, FIU's AMPATH project has been the research and education network connection between the U.S. and Latin America, including Argentina, Brazil, Chile, Panama, and Venezuela. AMPATH has developed into a functional and strategic R&E network for several South American countries[3]. These network services and the AMPATH exchange point have been operating with 99.99% availability. Without funding from the NSF, FIU worked with the incumbent (then monopoly) owner of the Southern Crossing cable system to bring the next generation Internet to Latin America. Working with Latin American research and education networks, a truly novel infrastructure was created. With NSF support, FIU has held workshops and fostered a thriving community of scientific interest between the U.S. and Latin America.

With "leading the way to tomorrow's Internet" as its motto, CENIC has been building research and education networks in California since 1997. With the installation of its optical fiber infrastructure, CENIC built and now operates one of the fastest networks in the nation with multiple 10G Ethernet backbones, 10G connections to all major research institutions in California and other connections to most public universities, community colleges, and K-12 institutions in the state. CENIC currently serves millions of faculty, staff, and students with production and research network facilities. CENIC also values its close connections with Mexico and for three years has operated the only terrestrial research and education network connection south of the U.S. border.

No other U.S. organizations have the depth of expertise in creating LILA and maintaining and operating links across the Western Hemisphere as do the proposers and their collaborators. More information can be found in Section D.5.

D.2.1.3. Proposal's Creative and Original Concepts

WHREN is a unique concept for the Western Hemisphere. Based on cooperative networking models such as National LambdaRail and GLIF[4] and internetworking management organizations such as JET, WHREN provides a new way for research networks to identify their specific needs and, in cooperation with other partners, build a network where capabilities are flexible and circuits can be allocated as needed. It is open to all interconnects and enables new opportunities for collaboration. This new pool of resources is available to all and is driven by user needs. More details are in section D.5.1 and D.4.

D.2.1.4. Overall WHREN Concept and Organization

WHREN and LILA represent a two-pronged approach that conceptually fills the many gaps that often encumber similar projects. By tying together monetary investments from Latin America, the LILA has real buy-in, and thus a greater likelihood to succeed. By involving all parties and valuing their non-cash participation, the WHREN fosters broad community commitment. This magic combination of monetary commitment and community support is the concept and organization that will allow LILA and WHREN to succeed.

D.2.1.5. WHREN's Available Resources

An unprecedented Western Hemisphere partnership has resulted in over $7 million dollars of non-NSF supported resources committed to the activities proposed here. The committed resources are detailed in section D.8.

D.2.2. Broader Impacts

D.2.2.1. Advancing Discovery and Understanding While Promoting Teaching, and Learning

As the network ties together more instruments and research groups at higher speeds, the result will be an increase in the rate of gathering, processing and sharing data. This will produce an increase in the rate of discovery. This impact is so broad that it is impossible to measure. From biodiversity research, identifying specimens faster to collaborative biomedical engineering and nuclear physicists discovering drug treatments more quickly the impacts are vast. A similar increase can be observed between the U.S. and Asia and Europe over the previous five-year period of NSF support[5].

Scholarship in the Americas will improve through new opportunities for collaborative teaching, technology-augmented student mobility, and an infrastructure for inquiry-based learning. The network will allow U.S. classrooms to share a window to classrooms throughout the Western Hemisphere. More information is in Section D.3.

D.2.2.2. Broaden Participation of Underrepresented Groups

The NSF designates Hispanic Americans as a disadvantaged community. This infrastructure gives Hispanic Americans a new and unique advantage -- the opportunity to leverage cultural and language commonalities with collaborators in Latin America to advance their pursuit of research and education in the U.S. This will offer an advantage to not only the Hispanic populations throughout the U.S., but will cement collaborative relationships throughout the Western Hemisphere. To ensure the greatest possible participation, the Hispanic Association of Colleges and Universities (HACU) is acting as research lead in establishing these connections to the proposed activities. See section D.3.6. for more information.

D.2.2.3. LILA Enhances Infrastructure for Research and Education

Just as high-speed networking has been a catalyst for improved research and education in the U.S., it will also be throughout the Western Hemisphere. The bar will effectively be raised for all, rewarding the U.S. for its collaboration with its neighbors. Examples of U.S. science benefits are shown in Section D.3.

D.2.2.4. Results Disseminated Broadly to Enhance Technological and Scientific Understanding

Our dissemination plan will get information into the hands of the communities that can best use them. We will work through our participants to reach communities of interest. The approach planned is detailed in section D.10.

D.2.2.5. Benefits to Society

This proposal will also generate Pan-American goodwill. The Central and South American region is underserved compared to NSF investments in network resources for Asia and Europe, even though important instruments required by US researchers are located in this region. This has led to confusion and a sense of abandonment from both U.S. researchers and our Americas' colleagues. The Central and South America region, as indicated in the letters of support, have rallied around this proposal. The pledged level of funding from Brazil, at over $5 Million, represents the importance placed on relationships with the U.S.

D.2.3 Rationale of WHREN and LILA

WHREN is an elegant solution to a challenging problem. It provides a sensible, scalable, flexible governance model for equal participation in research and education networking throughout the Western Hemisphere. The model is open and allows for creative network designs at all layers. More detail on the governance model can be found in Section D.5.1.

The LILA connections as a whole offer a high-speed international peering network throughout the Western Hemisphere. This allows the U.S. to contribute to and leverage Western Hemisphere network initiatives in a way that has previously been impossible. Our underlying vision creates a framework that grows with interregional science and education needs. While LILA serves to link inter-regional networks, specific domains that wish to provision dedicated or committed bandwidth have both the benefit of LILA infrastructure and the WHREN management organization.

D.2.4 Ability and Capabilities of Proposing Team to Operate and Maintain Network Services

As the historic incumbents for providing U.S. to Latin American connectivity, with little or no NSF support[3], FIU and CENIC have demonstrated unmatched expertise in operating and maintaining network services. No one else in the U.S. has the experience in the unique Latin American telecom market that CENIC and FIU do. More information is in Section D.5 and D.6.

D.2.5 Quality of Engineering and Implementation Plan

CENIC and FIU have led the US in both regional and international network infrastructure since the new millennium. The plans detailed in section D.4 and D.6 continues this tradition of excellence.

D.3. US Science Applications in Western Hemisphere

US e-Scientists and engineers require high performance networks in a rational global international architecture. At the same time, the education community realizes that higher education is becoming globalized. High-performance networks are key to effective natural global education linkages[5]. In this section, we discuss US research requirements that will use the proposed links. We also discuss the education opportunities that will be catalyzed through a partnership with the Hispanic Association of Colleges and Universities (HACU). The researchers listed have committed to participate on the WHREN research advisory committee (see D.5.1)

D.3.1. High Energy Physics: DØ Experiment at Fermilab

Project Overview: The DØ High Energy Particle Physics Experiment at Fermilab's Tevatron will record several petabytes of data over the next five years in pursuing the goals of understanding nature and searching for the origin of mass. Computing resources required to analyze these data far exceed capabilities of any one laboratory or university. In addition, the widely scattered geographical distribution of DØ collaborators poses further serious difficulties for optimal use of human and computing resources. DØ Southern Analysis Region (DØSAR) consists of eleven universities in the Southern US, Brazil, Mexico and India, as part of the DØ experiment's effort to utilize grid technology for the expeditious analysis of data. The total computing resource in DØSAR is on the order of one Teraflop. In order to take full advantage of the grid in simulation data production and transmission, actual data reprocessing and data analyses must sift through multiple petabytes of data without much delay. It is critical to have sufficiently large bandwidths to move data through the grid across the network in order to fully utilize the available one Teraflop of computer resources at DØSAR. Just for DØ data re-processing, an aggregated bandwidth of 280 Mbps is needed. This need will be increased by about a factor of two when other tasks such as moving reduced data set for detailed analyses and the simulated data within the grid are incorporated. The needs will increase as the total available resources within the grid increases in the near future for the DØ experiment

How the research of DØ will be enhanced by WHREN and LILA:

In this regard, the network connection through WHREN will allow DØSAR-Grid to efficiently transfer data to and from the University of São Paulo, Brazil, to other institutions within the grid. The bandwidths proposed in WHREN will lay down the foundation for close collaboration and efficient operation of an international computing grid for a presently running High Energy Physics experiment and will facilitate advancement in grid computing technology and in understanding nature, as well as engaging many high-level human resources.
WHREN Research Advisory Committee member(s): Jaehoon Yu, University of Texas, Letter of Support Attached, Senior Personnel responsible for D0 participation in WHREN.

D.3.2 High Energy Physics: Large Hadron Collider (LHC)

Project Overview: The multi-TeV energy scales needed to advance the study of the nature of matter and its most basic interactions and to search for new particles and forces, has led to unprecedented challenges in petabyte data access and analysis. The Large Hadron Collider (LHC) program at CERN in Geneva encompasses four major experiments searching for the Higgs particles thought to be responsible for mass, as well as the states of matter and violation of symmetries that existed in the early moments of the universe. The US is a major player in the two largest of these experiments, ATLAS and CMS, with approximately 400 US physicists and engineers (20% of the total) involved in each one.

How the research of LHC will be enhanced by WHREN and LILA:
The CERN/LHC program is a large, but not atypical, example of a collaboration-driven project. The US has expended significant resources in this research area. The principal experimental devices are located in Europe with major US contributions, and the Computational Data Grids under development will be worldwide. Nevertheless, the program asks questions on such a grand scale that more than 5,000 individual researchers (in four large collaborations) are involved in working with various aspects of the problem. The Parallel and Distributed Processing Group of the Federal University of Rio Grande du Sul, in collaboration with its physics research staff, is an important player in the development of the Grid processing and data handling techniques necessary for the success of the LHC. Participating universities in Brazil include:

UERJ Universidade do Estado do Rio de Janeiro[6]	UFRGS Universidade Federal do Rio Grande do Sul
UFRJ Universidade Federal do Rio de Janeiro	CBPF Centro Brasileiro de Pesquisas Físicas
UNESP Universidade Estadual Paulista (S.Paulo)	USP Universidade de São Paulo
UFBA Universidade Federal da Bahia	UNICAMP Universidade de Campinas

The improved connectivity to Brazilian HEP will directly benefit US science research in this area by improving collaborative analysis, add needed subject matter expertise and uphold pedagogical improvements in the areas of science, math, and global cooperation.
WHREN Research Advisory Committee member(s): Harvey Newman, California Institute of Technology, Paul Avery, University of Florida, Sergio Novaes, University of São Paulo, Letter of Support Attached, Senior Personnel responsible for LHC participation in WHREN.

D.3.3. Astronomy: Ground-based Optical/IR Astronomy

From an astronomer's perspective, many of the most scientifically interesting celestial objects are only properly viewed from south of the Equator. The Andes of northern Chile comprise one of the best locations for such observations in the Southern Hemisphere, due to its combination of proximity to the very dry Atacama Desert and favorable prevailing winds.

Thus, it is no surprise that four major US observatories have established a significant collection of world-class telescope facilities based in Chile's Fourth Region in the coastal city of La Serena. Three of these US facilities are the Gemini Observatory's southern telescope and the Southern Observatory for Astrophysical Research (SOAR) on Cerro Pachón, and the Cerro Tololo Interamerican Observatory's (CTIO) suite of telescopes. These NSF-funded programs are managed by the Association of Universities for Research in Astronomy (AURA).
In addition, the Observatories of the Carnegie Institution of Washington (OCIW, also known as CARSO) are host to four additional telescopes on Cerro Las Campanas. In all, there are 14 La-Serena-based US-operated telescopes in operation or nearing completion. One must also look to the near future to get a more complete picture of US astronomy requirements in Chile. There are two major NSF-funded optical/IR initiatives that may have additional profound effects on US interests: The first is the Large-aperture Synoptic Survey Telescope (LSST), often called the Dark Matter Telescope. With the camera detector having over 2-billion pixels, LSST will amass 130 TB of data in five years. One of the two most likely sites for LSST is in northern Chile. The second major program is the Thirty Meter Telescope (TMT) that is now looming on the horizon for the US and possible European (and other) partners.

This monster will most likely be located in either in northern Chile or Hawaii. Its connectivity requirements are difficult to estimate, but they will be huge by current standards.

How the research of Optical/IR Astronomy will be enhanced by WHREN and LILA:

Modern astronomy requires a wide range of network applications to cost-effectively operate. Over the next five years, many ground-based optical/infrared observatories, such as Gemini South, SOAR, CTIO, and Las Campanas, will each require peak network rates approaching 100 Mbps to accommodate normal operations.

The future of existing telescopes is in the rapidly developing detector technology used in the instruments that actually sense and analyze the collected light. The Moore's Law for the number of pixels has persistently shown a one-year doubling time, as has been the case in other microelectronic technologies. As one would expect, this is tracked very well by the one-year doubling time of accumulated astronomy data that must be moved from telescope to archives to the research end users. Gemini, for example, has instruments today that are technically capable of producing as many as 3 TB/yr. However, instruments already planned for 2010 are technically capable of producing upwards of 36 TB/yr. The development of the WHREN high-speed backbone, with progressively staged steps of higher bandwidth over time, will ensure the continued viability of existing US programs as their facilities realize the potential of new instrumentation. Accommodating the possible arrival of future programs, like LSST and TMT (and ALMA in the radio world), will require the presence of an extensible, expandable backbone infrastructure in the near term, as the framework for even greater needs a few years from now.

WHREN Research Advisory Committee member(s): James Kennedy, Associate Director and CIO for Gemini AURA and Chris Smith, Associate Astronomer with Tenure, NOAO/CTIO, La Serena, Chile and Manager of NOAO Data Products Program South, NOAO/CTIO, Letters of Support attached, Senior Personnel responsible for optical/IR telescope participation in WHREN.

D.3.4. Astronomy: Radio Astronomy

Very Long Baseline Interferometry (VLBI) is a radio astronomy technique that allows multiple radio telescopes distributed around the world to be combined into a single coherent virtual instrument that is equivalent in size to the physical separation between these instruments. VLBI is the highest precision technique available for global tectonic plate measurements (mm over thousands of miles), and it provides the highest spatial and time resolution of the Earth's motion in space as well as the only technique that can calibrate the Global Positioning System satellites within a fundamental celestial reference frame. In recent years, the use of high-speed research and education networks has been used to transfer data between well connected sites at rates approaching 1 Gbps[7]. This practice has come to be known as **Electronic-VLBI (e-VLBI)** offers many advantages over traditional VLBI including: rapid processing turnaround, bandwidth growth potential for higher sensitivity, real-time diagnostics, and increased reliability through the elimination of complex recording equipment. WHREN will provide the broadband connectivity necessary to enable radio telescopes in Brazil, Chile and Mexico to participate fully in e-VLBI and will allow them to leverage the benefits of e-VLBI.

e-VLBI sites include:

1. Radio-Observatorio Espacial do Nordeste - ROEN (Northeastern Space Radio Observatory), in Brazil.

2. The Atacama Large Millimeter Array (ALMA) is an international astronomy facility located in Llano de Chanjnantor in Chile. The use of ALMA for e-VLBI iprojected for the end of 2007 will be a valuable addition to the international VLBI community.

3. Transportable Integrated Geodetic Observatory (TIGO) in Chile is an active participant in International VLBI Service experiments. This year, TIGO began its first e-VLBI experiments. These are currently low bandwidth experiments due to the limitations of their international connectivity. However, with connectivity to backbone infrastructure such as that proposed by WHREN, TIGO will be able to rapidly increase its use of e-VLBI to the level where it can support regular production level transfers.

4. The Large Millimeter Telescope (LMT) is a 50-meter, millimeter-wave telescope to be located in Puebla, Mexico. It is being designed to operate primarily at wavelengths of 1-4 mm with construction expected to be completed in 2004.

Currently, well connected VLBI antennas are connected at rates of between 34 Mbps to 1 Gbps. Through operational experience with production level e-VLBI experiments we have found that 50 Mbps sustained throughput provides sufficient bandwidth to enable VLBI antennas to support e-VLBI in the near future. Over the next 5 years, this will ramp up to 1-2 Gbps per station as the bandwidth of VLBI experiments continues to increase.

Benefits to the Research Community from WHREN

One of the key hurdles to be overcome in order to fully realize the potential of e-VLBI is station network connectivity. Many stations that participate in VLBI are not well connected and continue to ship magnetic media as part of their day-to-day operations. WHREN will provide the foundation that will enable antennas in Brazil, Chile and Mexico to become well connected to high-speed international research and educations networks. This connectivity will facilitate the use of e-VLBI in the support of "production" level research experiments and will help to realize the full potential of e-VLBI. The use of e-VLBI will significantly help to improve the efficiency of observations through the use of real-time diagnostics, and will help to enable new science through the use of new capabilities. In addition, by facilitating the connection of these telescopes to high-speed international research and education networks, WHREN will greatly help to increase international collaborative science.
Research Leader(s) for proposal Dr. David Lapsley, MIT Haystack Observatory Research Engineer, has agreed to act as coordinator for the proposal and is listed as senior personnel with letter of support attached.

D.3.5. OptIPuter

Project Overview: The OptIPuter, so named for its use of Optical networking, Internet Protocol, computer storage, processing and visualization technologies, is an envisioned infrastructure that will tightly couple computational resources over parallel optical networks using the IP communication mechanism.
How the research of the OptIPuter will be enhanced by WHREN and LILA:
The OpIPputer project is developing LambdaGrid middleware, control place software, and scaleable visualization systems driven by the needs of scientists. The WHREN will allow for effective utilization and testing of these advances through out the Western Hemisphere. The LILA connections will allow for collaborative optical research with El Centro de Investigacion Cientifica y de Educación Superior de Ensenada (CICESE), expanding the reach of collaborations with Mexico from CAL-(IT)^2.
Research Leader(s) for proposal: Dr. Larry Smarr, San Diego State University, has a Letter of Support attached.

D.3.6. Earth Sciences

The LILA circuits and WHREN will greatly enable practical applications for applied science like Earth Systems, seismic response, weather and volcano prediction, El Nino and La Nina, ozone hole problems and environmental science. The ability to do research from the northern latitudes of Canada through the equatorial region to the deep southern latitudes enables scientists to study seasons, migration patterns, ocean temperature and atmospheric conditions in profound ways that the national and regional networks of today do not allow. Most scientists focused on the Earth study regions, which may seem large in the historical context of running around sampling in that region, but which now can be studied on a massive scale with the advent of sensor networks and near real-time analysis, visualization and computation. With the ability to begin to see relationships, such as the one between volcanism and active seismicity that connect dynamic processes below the surface and out of physical sight, science can spread its wings in observation and relational analysis given the integration of sensors, satellite imagery, ground observations, and hemispheric collaboration. For more details, see support letter from Eric Frost in Supplementary Documents section.
Benefits to the Research Community from WHREN: Connecting north to south provides a richness of Earth data that east to west cannot provide. East to west is generally in the northern hemisphere and most Earth conditions are similar in terms of season, atmosphere, solar influx, astronomical viewpoint, etc. Connecting north to south covers the range of what can be observed from the Earth, especially in terms of physical conditions such as seasons, ozone and other atmospheric conditions related to the poles, and oceanographic currents. The WHREN proposal will greatly encourage scientists in many Earth (land, ocean, atmosphere, remote sensing, modeling, decision making) specialties to begin doing more integrated and difficult science because it is possible to both get the real data in real time and to work with real people with real network tools that actually provide collaboration capabilities.
Research Leader(s) for proposal: Dr. Eric Frost, San Diego State University, has a letter of support in the Supplementary Documents section.

D.3.7. Western Hemisphere Education Opportunities

The US has a large quantity of Hispanic Serving Institutions (HSIs) which retain strong ties with the Spanish-speaking neighbors in the south. Our links can be further leveraged to enable education throughout the region through a partnership with the Hispanic Association of Colleges and Universities (HACU).

HSIs worldwide realize that globalization of higher education is vital to their survival. Via HACU, globalization is being realized. Through the proposed links, US Hispanic students can take advantage of the natural linkages between US and Latin America for the new education opportunities. Today, HACU represents more than 350 colleges and universities committed to Hispanic higher education success in the U.S., Puerto Rico, Latin America and Spain. Although HACU's member institutions in the U. S. represent less than 7% of all higher education institutions nationwide, together they are home to more than two-thirds of all Hispanic college students. HACU is the only national educational association that represents Hispanic-Serving Institutions (HSIs).

Our nation's economic and social success rests on the level of skills and knowledge attained by Hispanics, now the nation's largest minority population. Education, indisputably, is the key. HACU is committed to Hispanic success in education, from kindergarten through graduate school and into the work force of tomorrow. Everyone has a stake in HACU's crucial goals: to promote the development of member colleges and universities; to improve access to and the quality of postsecondary educational opportunities for Hispanic students; and to meet the needs of business, industry and government through the development and sharing of resources, information and expertise.
HACU's membership includes:

- 180 Hispanic-Serving Institutions (HSI) –non-profit, accredited college, university or district/system in the U.S. or Puerto Rico, where total Hispanic enrollment constitutes a minimum of 25% of the total enrollment
- 95 Associate Member Institutions – non-profit, accredited college, university or district/system in the U.S. or Puerto Rico, where total Hispanic enrollment constitutes at least 10 percent of the total enrollment or a minimum of 1,000 Hispanic students enrolled.
- 38 Partner Institutions **-** non-profit, accredited, degree-granting college, university or district/system in the U.S. or Puerto Rico where total Hispanic enrollment constitutes less than 10% of the total enrollment[1] and less than 1,000 Hispanic students are enrolled.
- 29 International Member Institutions in Argentina, Brazil, Chile, Mexico, Nicaragua, and Paraguay.

How the work of HACU will be enhanced by WHREN and LILA:
HACU will use the LILA and WHREN to develop new education programs made possible by high-speed, reliable network connections between the member institutions, and the broader educational community.
WHREN Research Advisory Committee member(s):
HACU's Office of Information Technology Initiatives (OITI) provides technological assistance to member and partner higher education institutions to enhance their capacity in information technology. OITI promotes, educates, assists and facilitates the use of information technology for teaching, learning, research and administration at member institutions through cutting-edge partnerships and initiatives. Alex Ramirez, OITI's Executive Director, will work with the proposers to develop a plan to leverage the proposed links to benefit HACU member institutions and their students.

D.4. Network Topology, Architecture and System Design

The consortium is forming a network collaborative that complements the Western Hemisphere's evolving regional networking activities with an infrastructure that interconnects North America (US, Mexico and Canada) to emerging aggregation-peering points in South America. The regional networking activities track the emergence of four areas of evolution:

1. RedCLARA, a regional backbone network in Latin America built through a development activity between the European Union and the Cooperación Latino-Americana de Redes Avanzadas (CLARA[8]);
2. Community-owned and managed fiber-optic facilities in the US that have led to the development of regional optical networks and the National Lambda Rail[9] (NLR) to serve the future needs of the US research and education community in the US and worldwide;
3. Canada's leadership in customer-empowered optical networking with the CA*net4 network[10];
4. The increasing availability of wide-bandwidth international circuits interconnecting the US and Canada to Europe and Asia.

The consortium will bridge these emerging network infrastructures with today's production-level R&E networks (e.g., Internet2's Abilene) and with existing and emerging optical exchanges in the North and in the South -- forming a transparent and rational network for the Western Hemisphere that will interconnect with peer networks in Europe and in the Asia-Pacific region.

The overall network topology consists of (1) locations in the Western Hemisphere where international exchanges interconnect R&E networks: Miami, Los Angeles, Seattle, Chicago and New York (North America), with São Paulo, Santiago, Tijuana (Latin America); and (2) consortium member network resources for shared and scheduled use: Pacific Wave, CA*net4, Abilene, RedCLARA, ANSP (see Figure 1 above). The advantages of this topology are:

- Multiple rings provide redundant paths both regionally and inter-regionally

- Ease of configuration and connection allow growth to other countries/regions as needed
- Growth paths for the 3 funded links
- Solid, cooperative network management so even the weakest links will be well supported
- Diverse routes over Internet2's Abilene and NLR providing high-availability production and experimental network services

We are requesting funding for three connections. Together with FIU's STM-1 link from Santiago to São Paulo, they complete a ring between the US and South America and Mexico. The first link starts in Miami, US and lands in São Paulo, Brazil. The second link runs from Santiago, Chile up through Tijuana, Mexico. The ring completes with a cross-border fiber connection between Mexico and California. The details about each proposed connection is described below.

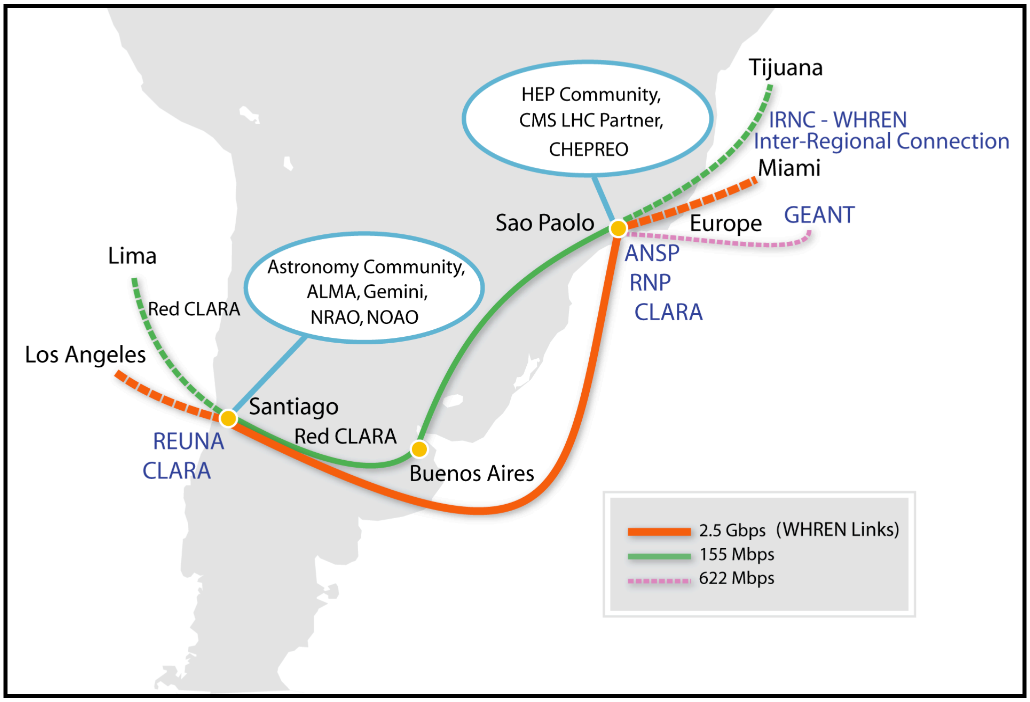


Figure 2 Emerging International Aggregation and Peering

D.4.2 South America's Regional Research Network -- CLARA

Planned to start in June 2004, the ALICE (América Latina InterConectada con Europa) project is developing an IP research network infrastructure within the Latin American region that connects to Europe[11]. DANTE[12] is the coordinating partner of ALICE. The ALICE IP research network, called RedCLARA, will initially interconnect the NRENs of Argentina, Brazil, Chile, Peru and Mexico using STM-1 private-line circuits to form a ring topology (see Figure 1 above). The RedCLARA backbone will connect to Europe's GEANT pan-European research network from São Paulo.

One of the goals of the RedCLARA regional backbone is to keep intra-regional traffic within the region (local), as opposed to transiting to the US, then back to Latin America. RedCLARA will also provide an infrastructure to aggregate the region's R&E traffic destined for other regions. These emerging aggregation points will facilitate peering relationships between international R&E networks, communities of interest and promote the establishment of national and regional distributed exchange points. Figure 2 highlights the aggregation and peering that will emerge in São Paulo and Santiago.

The facility in Santiago, Chile, where the REUNA PoP is located will be the site of the proposed Santiago-Tijuana Pacific link, where the following international R&E resources will be located:

(1) Points of Presence (PoPs) for CLARA and REUNA (Chile's NREN); and
(2) The emerging meet point for the R&E networks of the astronomy communities in Chile.

The cross-border connection between Tijuana and San Diego will provide a terrestrial connection to the CLARA regional backbone from the US using dark fiber. Dark fiber offers the maximum capacity and the greatest economy of scale for the development of next-generation R&E networks. This dark fiber connection between San Diego and Tijuana, then on to Los Angeles, would significantly increase the network infrastructure capability between the US and Mexico, interconnect the CLARA backbone to the North America R&E community, providing the R&E networks of Latin America inter-regional connectivity to the R&E networks in the Asia-Pacific region, and a diverse path across CANARIE to the R&E networks in the pan-European region.

D.4.3. System Design

There is an increasing need for the Central and South American regional research networks to connect to the US in order to enable US investigators and their international peers to actively engage in e-Science projects featuring unique regional characteristics. A network design that interconnects the regional networks in a flexible, scalable way will need to be able to support end-to-end service provisioning across the WHREN member networks and beyond.

We are proposing an open system design model, a strategic partnership with our links and distributed peering exchange providers, variable link configurations, and customized researcher support. Note that no funding is being requested for network equipment, only circuits. Consortium members, including participating vendors, will provide link-terminating equipment.

D.4.3.1 Open Model for Investment in System Design

If particular research groups are interested in dedicated bandwidth on the LILA topology, they are invited to participate in WHREN to provision it.

An example might be the Gemini Observatory in Chile. While our proposed links provide the Gemini with general-purpose network connectivity, Gemini has two options for pursuing 'committed' bandwidth for use during observations. Through the consortium, they can propose, as a research group, for a specific network configuration (such as a guarantee of 150 Mbps from Chile to Chicago). The consortium will analyze the available resources and try to support the Gemini project's committed network resource need. If existing resources are not available Gemini can invest to augment the links with an additional 155Mbps from Chile to Tijuana. Gemini now has a guarantee of that amount available for a price significantly lower than through a separate procurement, and the opportunity to work with the consortium to burst beyond that. Whenever Gemini is not using the committed bandwidth, the general-purpose research and education users of the links benefit from the increase in bandwidth paid for by Gemini. Gemini and NOAO have expressed their interest in the attached letter of support.

D.4.3.3 Link Configuration

The proposed links aim to provide a hybrid of scheduled temporary use and permanent use network services to support discipline-specific and general-purpose high performance computing and networking services over wide geographical distances. As such, links will be configured for (1) permanent-shared to support international production traffic; (2) permanent-dedicated use to support high-performance discipline- or application-specific Community of Interest traffic; or (3) scheduled use to support temporary deterministic application traffic.

We will work with consortium members to test TCP congestion protocols for high-speed long-latency networks, such as FAST TCP[13], to optimize link performance and congestion control. We also plan to deploy bandwidth-provisioning protocols, such as the User-Controlled Light Path (UCLP)[14] technology, on our links. This allows for the dynamic provisioning of bandwidth to satisfy user Quality of Service needs. We will facilitate the incorporation of advanced transport protocols, e.g., FAST TCP, in the high performance applications, such as high-speed data transfer and real-time high-fidelity collaboration, by utilizing networking mechanisms such as Active Queue Management (AQM).

The proposed network will be able to support a number of services to end users, examples including:

1. High-speed data transfer. Supported by UCLP, and FAST TCP;
2. Real-time collaboration. Supported by UCLP, and the Virtual Rooms VideoConferencing System (VRVS)[15];
3. Real-time high throughput visualization for VLBI. Supported by UCLP and/or UDP.

The services to the end users will be enabled by: (1) dynamically provisioned end-to-end lightpaths for individual sessions that support efficient resource utilization and QoS guarantees; and (2) shared resource access with high performance transport protocols designed to adapt to the high bandwidth delays produced by the long-latency network environment (e.g., FAST TCP).

IPv6, IPv4 and Multicast will be supported using layer-3 routing protocols, such as RIP, OSPF, IS-IS, BGP, IP multicast, natively.

D.4.3.4 Customized Researcher Support

We will offer multiple levels of QoS services to the research applications. We can provide best effort through layer2/3 VLAN/routed-packet services. For applications with specific QoS requirements, we can incorporate dynamic resource provisioning and associated resource usage monitoring, traffic accounting, etc. These QoS mechanisms include packet classification, traffic policing, differentiated service supports, active queue management, as well as layer-1 lightpath dynamic provisioning.

To determine how to satisfy a user's QoS request, we need to assess the resource usage in the network, and make necessary resource reservation at various points of the network. This requires a comprehensive end-to-end monitoring mechanism able to provide precision real-time and historic information about the health of the software (applications, middleware and operating systems) and hardware (hosts and network) operations, including, but not limited to, data analysis tools for event analysis and visualization of traffic exchanged with the peering networks, point-to-point bandwidth availability, packet loss rates, end-to-end delay statistics, etc.

The MonALISA[16] system, a distributed cluster and network-monitoring framework, allows for JINI/WSDL-based monitoring service discovery and provisioning. We will deploy MonALISA and other end-to-end monitoring systems in the proposed network to facilitate the service provisioning and resource management, as defined and requested by the NSF, or WHREN.

D.5. Organization Description

D.5.1 WHREN Governance Plan

Our consortia of organizations from across North and South America have come together to develop and operate a distributed exchange model for international peering and shared network infrastructure that will foster collaborative research and advance education throughout the Western Hemisphere.

The primary responsibilities of the consortium's Governing Board will be to collectively oversee the assignment and management of lightpaths, and the development of a flexible distributed operational structure to support the scheduling and provisioning of lightpaths based on user service level requirements. The Governing Board will establish assignment and management decisions based on the advice and counsel of the Research Advisory Committee (RAC) and the Engineering Committee (EC).

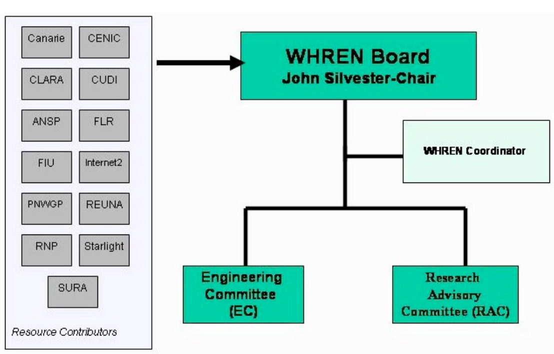


Figure 3 WHREN Governance Model

CANARIE—Bill St. Arnaud	CENIC—John Silvester
CLARA—Nelson Simões	CUDI—Carlos Casasus
ANSP—Luis Lopez	FIU—Julio Ibarra
Internet2—Heather Boyles	NLR – Tom West
Pacific Wave—Ron Johnson	REUNA—Florencio Utreras
RNP—Nelson Simões	StarLight—Tom DeFanti
SURA—Gary Crane	

Table 2 WHREN Participants

The Governing Board will be comprised of representatives of organizations who provide network resources to the consortium. The initial board will include representatives from:

John Silvester serves as the founding chair. Representatives of similar groups providing connectivity between the Americas and the Pan-Pacific and Europe will be invited to participate on the Governing Board to ensure worldwide connectivity.

The Governing Board will assign lightpaths to their network management organizations who will then attach routers, optical switches, etc. to the prescribed facilities. Typical network management organizations may be

CLARA, REUNA, AMPATH, CENIC, CUDI, Internet2, CANARIE, etc. Eventually, as we move to discipline specific networks, specific lightpaths may be managed by consortium of researchers, for example, biodiversity research users. The links funded through this proposal will go into the pool and be allocated using the same process as for other consortium allocations.

The Research Advisory Committee (RAC) will be comprised of representatives from various research communities (high energy physics astronomy, geology and seismology, etc.) who are conducting collaborative research activities requiring Western Hemisphere networking resources. The RAC will provide input and advice to the Board on program and network needs and requirements of the board research community. The governing board is now determining the RAC chair. Once appointed, the chair will take on the role of fleshing out the membership of this group.

The WHREN Engineering Committee (EC) will be comprised of engineering managers from the various networks that comprise WHREN. The EC will ensure the implementation of new protocols and the ongoing operation of the distributed optical exchange and its interoperability with peer international networks.

The WHREN will act as an ongoing, virtual cooperative. The cooperative will have an open call for proposals of new use, and will act as an open vehicle to discuss planned network interconnections and developments. Much like the Joint Engineering Team (JET) in the U.S., this will be accomplished though regularly scheduled telephone conferences managed by the WHREN coordinator. Email follow-ups and agendas will support week-to-week tracking of activities. Annual meetings will be scheduled with simultaneous events of interest (such as Internet2 meetings) to reduce unnecessary travel. Participants will fund logistics expenses. No funds are requested of the NSF for these meetings.

D.5.2 WHREN and LILA Project Management Organization

The WHREN PI will coordinate the geographically distributed team. The PI is responsible for all NSF reports and the performance of the activities funded. The PI will direct the LILA Project Manager, Network Engineer Coordinator and the Research Coordinator. The Co Lead (WHREN Chair) will work to ensure the effectiveness of the WHREN governance board, by engaging participants and facilitating the activities. The chair will work with the WHREN Project Coordinator (see figure 3) to ensure effective dissemination of governing committee activities. The WHREN chair will work with similar organizations globally to ensure effective inter-networking. The LILA Project Manager will oversee the planning and provisioning of the connections in concert with the Engineer Coordinator, and ensure their availability and reliability. The LILA Project Manager will work with the circuit vendor to manage the deployment of new technologies on the cable system, and to establish new pricing models.

The WHREN Project Coordinator will ensure a consistent and organized method to the operations of the WHREN Governance Board. This will be achieved through regular electronic correspondence and active coordination of topics to be addressed by the Governance Board.

The Research Coordinator will work with the Senior Personnel and letter of support documented researchers and educators attached to this proposal. The coordinator will ensure that the proposed science and education applications are well supported. The coordinator will also work through other communities of scientist and educators to disseminate the opportunities supported through the proposal.

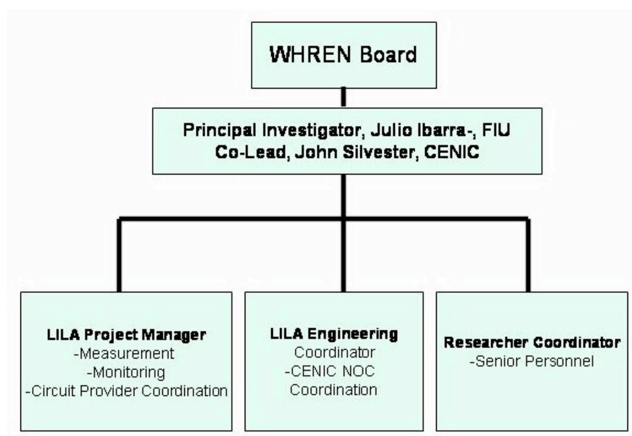


Figure 4 Project Management

D.5.3 Principal Investigators and Key Personnel

Julio Ibarra, FIU, as the PI, will leverage four years of large project management and operational experience in the procurement, provisioning, and support of circuits in Latin America. As the PI of AMPATH, he has extensive experience working with the R&E community of Latin America. He will provide overall leadership and planning for the LILA project team and participate on the WHREN governance committee. He will coordinate people and resources across the western hemisphere for the successful implementation and operation of the LILA project.

John Silvester, USC and Chair of the CENIC Board will act as co-Lead for this project and PI for the CENIC subaward. As proposed Chair of WHREN, he will ensure effective communication and collaboration between the broader governance team and the LILA project team. He will also provide overall leadership for the CENIC sub-award. He has extensive experience in network infrastructure governance as chair of CENIC for 5 years, member of Internet2 NPPAC, member of NLR Board, and member of the IEEAF Board of Directors. His research background in high-speed networks and traffic analysis will also benefit the project.

Heidi Alvarez, FIU, will be the Research Coordinator and work with the applications communities to ensure effective utilization of the network resources. Responsibilities include working with science groups to document their utilization of the network, and forecast future demand. She will coordinate application specific key personnel. As the present Co-PI of AMPATH and Co-PI of CHEPREO, she brings extensive experience working with diverse groups of science and research communities using advanced R&E cyberinfrastructure.

Chip Cox, FIU, will be the LILA Project Manager and be responsible for day-to-day operations of the LILA infrastructure. As the current COO of AMPATH, he has experience in the engineering and provisioning of network connections in Latin America, and project management expertise as a previous NSF program director. His responsibilities include coordinating network operations, deployment, and upgrades, ensuring availability of network resources, coordinating technology transfer, and developing new pricing models for LILA. Cox will also be responsible for coordinating quarterly and annual reports of WHREN activities for NSF and external review.

Susan Estrada, CENIC, will act as WHREN Project Coordinator and facilitate the activities of the WHREN. Responsibilities include organizing request for configurations from user groups, coordinating the activities of the committee, publishing the proceedings, and education outreach with HACU.

David Reese, CENIC, will lead LILA engineering management and work as part of the team ensuring the availability and reliability of the network segments. He will manage network personnel.

D.6. Operations, Monitoring and Quality Assurance Plan

The CENIC will provide coordination for both engineering services and call center functions for the LILA circuits as the LILA NOC. Coordinating with other WHREN participations, these services will include:

- Monitoring and fault isolation
- Problem resolution and service assurance
- Targeted performance measurements
- Inter-NOC coordination and orchestration
- Future engineering design of WHREN

The operational, engineering and experimental support services for the LILA will be provided by geographically distributed groups of NOC service centers and network engineers from each of the participating member organizations, coordinated by CENIC. The emergence of the NLR in the US has motivated the transition from a traditionally centralized NOC services model to a distributed model that would be more effective and efficient in monitoring and managing optical resources and supporting the experimental services component.

D.6.2. Monitoring and Quality Assurance Plan

The LILA NOC will actively monitor the requested links to identify faults, trends that lead to potential failures, trap threshold-exceeding performance measures, then communicate and coordinate incidents through notification and escalation processes to network engineers, service providers, equipment vendors and management.

The LILA NOC will coordinate the processes involving problem resolution. Problems will be tracked and reported on deterministic intervals until fully resolved. The LILA NOC will coordinate with network engineers to reroute traffic, in the event of link failure or performance degradation, while the link is being restored into service. Collaboration tools, such as multipoint video conferencing and electronic whiteboards, will be utilized for coordinating and enhancing problem resolution processes.

D.6.2.1. Link Allocation and Management

Links will be allocated for permanent-shared use to support international production traffic, permanent-dedicated use to support high-performance discipline- or application-specific Community of Interest traffic, as well as scheduled use to support temporary deterministic application traffic. This multi-allocation of multi-service links for a distributed international exchange will involve the implementation of processes (new or enhanced) for resource allocation, tracking and reporting. Link allocation processes must be developed to support scheduled link allocations in a coordinated fashion. Link management processes must provide coordinated management of the distributed network infrastructure, involving multiple engineers and possibly users along the link path. The WHREN Executive

Council and the Research Advisory Council will have oversight on the processes and procedures for link allocation and management.

D.6.2.2. End-to-End Service Level Monitoring

LILA will be used by communities of interest who will plan to provide services with various levels of QoS guarantees, as required by applications. The achievable performance offerings range from best effort, differentiated services, to dynamically provisioned light paths. This caters to the multiple communities supported by WHREN, from regional low-to-medium bandwidth collaboration, to long-distance, high-bandwidth data transfer and real-time visualization applications.

We extend participation and collaboration to groups who are developing tools for end-to-end performance monitoring. We have received endorsements from several groups, listed in the table below, who are interested in collaborating and participating in the active and passive monitoring of the proposed links.

Unit of Analysis	Tool	Participants
Optical Link Performance	MonALISA[16]	FIU, Caltech
End-to-end link performance	NLANR AMP[17]	FIU, NLANR
	E2E pIPES[18]	Internet2
	Web100 Tools	Web100[19]
User Application Characteristics	NetFlow[20], NLANR PMA[17]	FIU
Grid application and performance characteristics	MonALISA, Grid3 Monitoring Tools[21]	IVDGL and Grid3 community
	NetLogger[22]	Lawrence Berkeley National Laboratory

Table 3 End-to-End Monitoring Resources

As user communities span across large geographical and national boundaries and operate over various regional/international networks, there is a strong need for unified approach to monitoring, security, and other middleware related services, such as AAA and dynamic bandwidth provisioning. As a result, the approach is to conform to the standards-based tools, such as those who adhere to Global Grid Forum standards. As examples, we adhere to a JAVA JINI/WSDL based monitoring framework in MonALISA. We also plan to respond to the emerging web service-based AAA and resource provisioning technologies, such as UCLP and GMPLS.

D.7. Use of International Links

D.7.1 AUP

Regional and national networks and other classes of networks that connect to the WHREN are likely to have an Acceptable Use Policy defined that describes the proper usage of network resources. The aim of an AUP should be the responsible use of R&E networks. With the goal of interconnecting international, regional and national R&E networks and exchange points, the consortium has no AUP on its peering points or links.

D.7.2 Peering Policies

The WHREN must adopt a set of routing policies that will be established by its member community in compliance with member AUPs. At a minimum, routing policies must take into consideration minimum path latency, route diversity, and symmetric routing in the operation of production R&E network services.

Research and education networks peer with each other to reduce the inter-domain path latency that is induced by transit networks. The popularity of Ethernet as an exchange point peering fabric allows R&E networks to create private point-to-point networks using 802.1q VLANs by which bilateral peering relationships can be established. Optical switches are becoming more common to support peering at layer 1. Layer 1 peering has increasingly become more important for the exchange of data, because of the security features it offers[23]. The ability to create private tunnels through physical layer lightpaths is extremely important for the exchange of information to the e-Science research and education community. As WHREN is an international collaboration, there is a need for confidentiality and privacy regarding the transmission of data between countries. As a result, WHREN will only use standards-based technologies, protocols and polices on a production-grade distributed exchange peering fabric. However, there is much work pursuing in the development of inter-domain routing protocols. WHREN's experimental infrastructure would support by groups developing inter-domain protocols to advance the practice of inter-domain routing and peering across a distributed exchange optical fabric.

D.8 Results from Prior NSF Support

Julio Ibarra: (ANI-0123388): **AMPATH Workshop to Identify Areas of Scientific Collaboration between the US and the AMPATH Service Area**, **April 15-17, 2001** Report. (ANI-0220176): **First AMPATH International Conference, Valdivia, Chile, April 12, 2002** Report. (ANI-0215434). **STI - AMPATH Collaborative Research and Education Operational and Functional Support, PI for AMPATH** (ANI-0231844) funded September 12, 2002, ongoing. PI for (ANI-6188654) **AMPATH Workshop, Miami, January, 2003: Fostering Collaboration and Next Generation Infrastructure.** The workshop results can be found at www.ampath.fiu.edu and show a robust agenda, informative presentations, and a very well rounded participant list.

Heidi Alvarez: (ANI-0123388): **AMPATH Workshop to Identify Areas of Scientific Collaboration between the US and the AMPATH Service Area, April 15-17, 2001** (ANI-0220176): **First AMPATH International Conference, Valdivia, Chile, April 12, 2002** (ANI-0215434) **AMPATH StarLight Rio Grid Workshop, held February 7-8, 2002** Newman and Alvarez worked with RNP Brazil to test COJAC application for HEP visualization. **STI - AMPATH Collaborative Research and Education Operational and Functional Support**, Co-PI for AMPATH (ANI-0231844) funded September 12, 2002, ongoing. Co-PI for (ANI-6188654) **AMPATH Workshop, Miami, January, 2003: Fostering Collaboration and Next Generation Infrastructure.** Results are available now at www.ampath.fiu.edu **. Inter-Regional Grid-Enabled Center for High Energy Physics Research and Educational Outreach at FIU (CHEPREO)** Co-PI Award #0312038 was made on 09/29/03 and the first report was accepted March, 2004. Results to date are available at www.chepreo.org.

D.9 Dissemination of Results

Web documentation, journal articles, and conference presentations and demonstrations will be used to disseminate information about the WHREN project. More specifically, we will make our architecture designs and non-proprietary industrial partner information easily accessible, and will provide a repository of network monitoring results. We will also provide PPT slides, videodiscs and other promotional material to collaborators to give presentations at conferences, government briefings, workshops, etc. In addition to educating our peers, our proposed education and outreach activities will enable us to bring advanced technology into the HACU and beyond classrooms, inspiring next-generation scientists and technologists. The WHREN governance committee meetings will be open, and the activities published by all appropriate means.

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Larry Smarr (Chair)
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