

## MEMORANDUM

TO: Greg Monaco  
NSF Project Director

FROM: Janet Poley  
Principal Investigator  
Advanced Internet Satellite Extension Project

DATE: May 24, 2002

SUBJECT: GPRA Report - AISEP Major Results and Findings

---

(see [www.adec.edu](http://www.adec.edu) - NSF project for additional documents related to this project)

### I. PROJECT OVERVIEW

The Advanced Internet Satellite Extension Project represents a projected three-year \$4,039,173 NSF core project investment and a projected \$1.5 million match from ADEC, Tachyon, OARNet and ADEC member institutions. It also includes two REU supplements totaling \$60,000 for 10 undergraduate students and an \$80,000 supplement for a Chinese Advanced Networking Symposium. Dr. Janet Poley is Principal Investigator and President of the American Distance Education Consortium, ADEC, (includes more than 60 state universities and land-grant colleges - 18 HBCUs and 34 Tribal Colleges). ADEC headquarters is located at the University of Nebraska-Lincoln where Dan Cotton, Director of Communication Information and Technology and Dale Finkelson, Network Engineer serve as co-PIs. Co-PIs at the University of Maryland are Don Riley, CIO of the University of Maryland System and Valorie McAlpin, Associate Dean of the College of Agriculture and Life Sciences responsible for Communication, Information and Technology. ADEC is a non-profit organization, 12 years old, and includes local, state, national and international partnerships. It reaches into nearly every county in the United States through its Extension system. Kevin Gamble, ADEC CIO, and Ray Kimsey, ADEC software engineer, reside at North Carolina State University. ADEC is an affiliate of Internet2 and cooperates with a number of advanced networking partners in conducting research and development focused on digital inclusion in rural/remote/underserved areas of the country as well as minority serving institutions.

Lead Institutions for AISEP include:

- University of Nebraska-Lincoln
- University of Maryland-College Park
- University of Illinois
- North Carolina State University
- North Carolina A&T State University
- Washington State University

AISEP's Private Sector Partner is Tachyon, Inc. with headquarters in San Diego, California.

A. The Project **Goal** is to:

Bring advanced networking applications to geographically remote campuses and learning centers for purposes of research, teaching and extension.

B. The Project **Outcomes** will be to:

1. enable unreachable campuses, remote learning centers, extension offices to share in advanced networking research and applications; and
2. create access for the research university community to scientific, cultural and human resources otherwise inaccessible.

C. The Project **Objectives** are to:

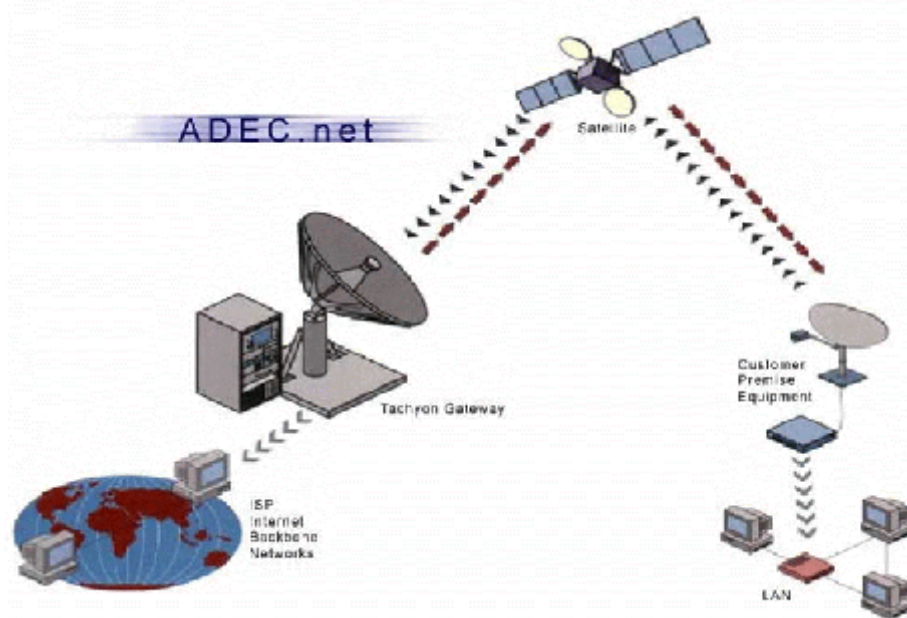
1. explore the use of satellites to deliver Internet services to determine compatibility of satellite technology with advanced networking (such as Internet2) services and applications.
2. explore deployment and integration of distance education applications, including collaborative applications at rural, remote institutions and extension learning centers.

D. **Specific Research Objectives** related to these objectives are to:

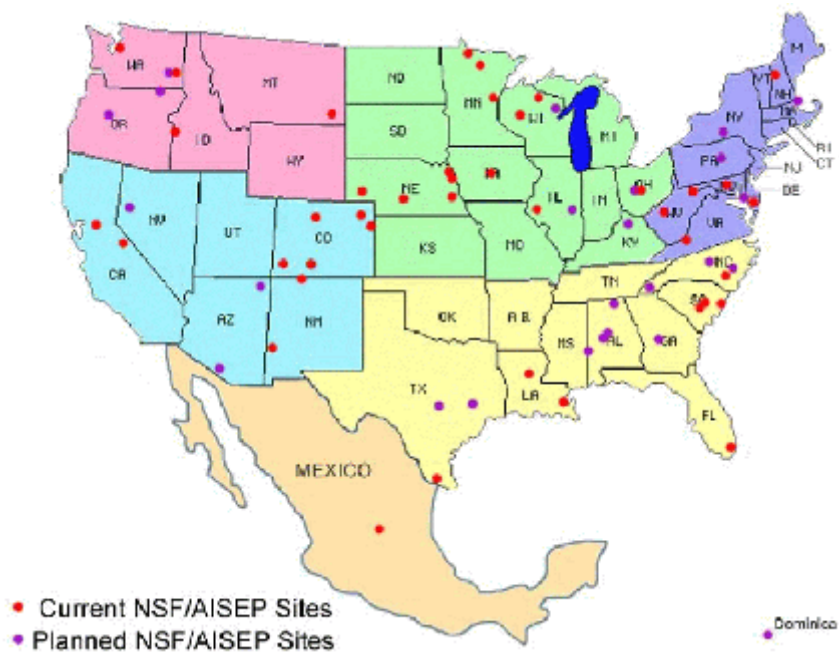
1. establish standards for acceptable application based Internet for remote locations.
2. understand how to establish, build and support a satellite based IP network
3. connect Tachyon satellite gateway to the Network Access Point (NAP) at the San Diego Super Computer Center - both commodity Internet and Internet2

4. provide and test Customer Premise Equipment (CPEs) to ADEC member institutions (70 sites)
5. investigate Quality of Service (QOS)
6. determine requirements to support this type of network
7. determine parameters for a sustainable business model.

E. **The ADECnet configuration is pictured below:**



F. **The Current and Planned NSF/AISEP sites (total of 70 in the core project) are shown below.**



## **G. Challenges for Advanced Hybrid Networking**

A major challenge for Advanced Networking is to be able to assure adequate bandwidth, appropriate network devices, efficient protocols and useful applications to serve the needs of scientists, educators and learners anywhere, anytime affordably. Big pipes alone are not in and of themselves the answer. This is a systemic problem with engineering challenges, as well as economic, social, organizational, control and security aspects to the research problem to be addressed.

## **H. AISEP Discovering Fundamental Hybrid Networking Principles**

The AISEP project has discovered important underlying principles related to hybrid networking over satellite links and is also defining concepts and generating knowledge fundamental to studying the systemic challenges inherent in next generation hybrid networking. Advanced networking over satellite has particular obstacles to overcome, including low bandwidth for the back channel and high latency making standard SNMP IP monitoring difficult and use of certain protocols difficult. Hybrid networking is defined backwards from the end user, rather than forward from the large pipe provider. The scientist, educator or learner will use fiber, satellites, wires and radio technology to carry signals in combination with software and a variety of devices for data collection, communication, teaching and learning, visualization, decision making, language preservation, etc. Hybrid networking research involves questioning underlying assumptions related to interoperability, compatibility, scalability, affordability and utility of existing networks and devices. Research and development issues involve testing and measuring performance under different conditions and with different devices. Ultimately, availability, appropriateness to use and cost become the defining factors from the consumer perspective.

A fundamental underlying principle of the AISEP project is that it is theoretically and conceptually possible to network "the edges" including tribal colleges and reservations, scientists conducting research in remote biological field stations and distance learners in the rural/remote areas of the country. It is also possible to include new immigrants - for example, the growing Hispanic population coming from Mexico and Latin American, as well as serving the rural "Black Belt" small farmers of the south. Understanding how to accomplish this task as economically as possible is in the national interest from a business and security perspective. This project is defining concepts and generating knowledge necessary to mapping advanced hybrid networking systems.

The AISEP project has already made progress toward developing solutions designed to optimize multi-vendor, multi-protocol, hybrid networking, while reducing costs and increasing use through application testing and increased understanding of media attributes and requirements for educational effectiveness and remote scientific research study.

## II. OUTCOMES AND ACCOMPLISHMENTS

### A. Research Area: Engineering to Need Using Hybrid Networks

1. The AISEP co-PIs and partners addressed the question of how to **reduce the number of inquiries and responses** as well as the need to query all sites within 2.5 minutes to maintain a "safety" margin for back-end monitoring. AISEP tested the use of PDU Stuffing - SNMP getback which puts all queries and responses in a single PDU. Using this technique, performance was improved and query/response execution time was cut to 1/3 of the time required for standard SNMP get request cycle - i.e. only two packets need to be sent with this discovery replacing eight.
2. AISEP succeeded in developing the knowledge and principles necessary to **establish ADECnet** resulting in the first-time connection of a satellite network to both Internet2 and the commodity Internet (**never done before and not trivial**). This TCP/IP based hybrid network currently includes 50 local nodes (AISEP will be adding at least 20 addition sites under the core project in the coming year), local connectivity over VSAT technology (Tachyon CPEs) including Local Area Networking of various types - wired and wireless.

Logical Layer Diagram –

[http://www.adec.edu/nsf/Adec\\_Router\\_Logical.gif](http://www.adec.edu/nsf/Adec_Router_Logical.gif)

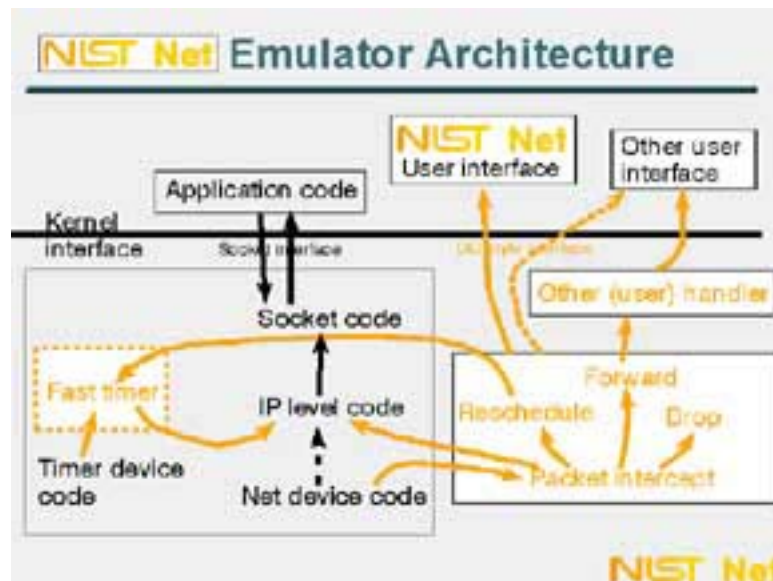
Physical Layer Diagram

[http://www.adec.edu/nsf/Adec\\_Router\\_Physical.gif](http://www.adec.edu/nsf/Adec_Router_Physical.gif)

AISEP's private sector partner, Tachyon, is focused on supporting the integration of network applications including H.323, multicast, transportable Internet and class based queuing. They also provide detailed traffic statistics to the project.

The end users for the local sites include Tribal Colleges/Indian Reservations, as well as Historically Black Colleges and Universities, Hispanic Serving Institutions and Learning Centers, Youth Serving Sites including four under the Power-Up Program and other rural/remote learning centers. A computer list of sites can be found on the ADEC webpage.

As stated in the objectives - establishment of ADECnet in a short timeframe is a significant accomplishment (this type of network has never been established before) and required considerable collaboration across multiple entities not used to working together: ADEC, Internet2, ITEC, Tachyon, ARIN, Tribal Colleges, Tribal Councils, Historically Black Colleges and Universities, Hispanic Serving Institutions, land-grant university learning centers and local Extension offices, local communities, housing centers, schools, inner city youth centers and camps. The establishment of the network has resulted in new applied knowledge within ADECnet about advanced networking and the institutional structures associated with it - for example, ARIN and the assignment of addresses. A key finding is that human trust and development of real, sustainable communities of interest and place are essential in order to be able to effectively study the problem of “Engineering to Need.” In addition to financial capital and business processes, human capital and the processes of community bonding and bridging must be understood, and the next phase of AISEP work will focus more deeply upon the factors related to learning, conduct of science, cultural factors and media attributes important to defined outcomes.



Development of an appropriate network performance measurement and monitoring system is in testing. Monitor specifications include Immunix 7.0 (migrating to Mandrake 8) Perl 5.6.0, Net-SNMP, Ploticus 1.43 and Apache.

3. **Network emulation** and its application to the ADECnet was tested and compared with simulation. Simulation has some advantages: quick, cheap, easy to assemble, can do large scale tests given adequate

computing resources, and tests are controlled and reproducible. But simulation requires redoing code, simulated implementation may differ considerably from real ones and poorly represent real conditions.

4. The Network Emulation was used to understand **H.323 performance bounds** in order to better understand the H.323 application and Network interaction, as well as whether **H.323 is a suitable candidate for DiffServ**. A simple procedure was tested under a variety of conditions: point-to-point, MCU, Cascaded MCUs, Isolated Latency, Loss and Jitter.

Results of the testing showed that users may find latency annoying, but it does not break the protocol. Some loss can be tolerated but **H.323 is very jitter intolerant**, particularly in a cascaded MCU scenario (**this is a breakthrough - new finding**).

Any End-to-End solution has scalability problems in the sense that in packet switched networks, the *solution vector is more than the number of hops and delays, etc. - it is also a function of the topology*. Research is continuing focused on the principle that It Is Necessary to Engineer to Need.

In summary, the H.323 test over satellite included:

#### Variables

- Tachyon Network (satellite IP, asynchronous, bandwidth settings, dedicated versus non-dedicated service)
- Polycom Units (Dialing Speeds)
- Internet1, Internet2
- Point to Point, Multi-Point
- Data Flow: Uplink>downlink, downlink>uplink
- Network traffic noise
- H.323
- MCU

#### Observations

- Data rate
- Frame rate
- Packet loss
- Pixellation
- Latency
- Jitter

The tests were conducted at 2 Mb/256K non-dedicated and 2 mb/512 non-dedicated in order to identify optimum Polycom speed per Tachyon

bandwidth service. The test is being repeated with Internet2. Preliminary results show that it works with some fluctuations in quality and some packet loss. (The next aspect of the project will further determine for H.323 as well as multicast whether these differences make a difference in education as well as in a variety of remote research projects in the remote sensing area). Certain optimum speeds for the Polycom units were identified. Next round testing will be over Internet2, multipoint and varying media treatment assumptions to determine the most important attributes.

A masters thesis resulted in part of this work.

([http://www.adec.edu/nsf/PrasadCalyam\\_MS\\_Thesis.pdf](http://www.adec.edu/nsf/PrasadCalyam_MS_Thesis.pdf))

5. AISEP tested a **hybrid approach to video conferencing** using the Megaconference III sponsored by ITEC-Ohio as an opportunity. PI Poley created a test using Polycom units, H.323 and broadcast videoconferencing/television assumptions, working with UNL engineers in developing an unconventional engineering scheme to see if the program quality could be improved in this environment.

ADECnet Schematic for Hybrid Videoconferencing

(<http://www.adec.edu/nsf/CITSchematic.pdf>)

Interest has been low in developing low-cost IP based videoconferencing over hybrid networks due to quality issues. Poor quality audio is a particularly off-putting issue.

The results of this test were very positive (major improvement over any other aspect of Megaconference III) and the approach has resulted in substantial cost savings and new ways of doing business over videoconferencing rather than traveling for face-to-face sessions at the University of Nebraska. It has also increased the use of the Great Plains Network MCU. This is an example of why research teams with different research interests and backgrounds is essential to advancing the field in terms of "out of the box thinking."

## 6. **Tests in Progress**

### a. **Transportable/Fly-Away**

AISEP is configuring and testing **transportable CPEs** with the goals being:

- inexpensive to build and operate

- off-the-shelf parts for easy duplication
- easy to operate by one person with one day training
- small and light
- reliable and adaptable to diverse field conditions
- easily modified

Three units with differing characteristics will be operated under different test conditions by Ohio State/OARnet; Prairie View A&M University and Washington State University.

Tachyon also has a **fly away unit** we will test able to be carried through an airport. ADEC would like to expand the transportable research and development to completely mobile for land and water, but will not be able to under current project funding.

Applications include:

- distance education in underconnected locations/rural areas and inner cities.
- demonstration/ evaluations for future fixed locations such as biological field stations.
- linking field research to campus computers and laboratories and collaborators worldwide
- linking field instruction and demonstrations to campus classrooms.
- linking field activities to remote databases, eg via PDAs
- linking special events, conferences, fairs, disasters
- remote monitoring of various types

(<http://www.vide.net/resources/conferences/spr2002/presentations.shtml>)

**b. Multicast**

Development of a better understanding of use of multicast in a hybrid network and solution of the problems involved have large potential for improved affordable educational delivery possibilities into rural and remote areas. If interoperability with I2 can be achieved a much wider audience for education programs and products in currently underserved areas.

Experimentation is beginning with the IP Multicast protocols. IP/MC can be delivered to the San Diego gateway in a number of different ways including I2 and this content can be delivered to receivers at variable data rates. ADECnet anticipates that I2 will be a primary delivery vehicle for delivering most of the data streams to the gateway and the content can be delivered in reliable

or unreliable formats - both of which will be tested. At present Tachyon is using DVMRP (Distance Vector Multicast Routing Protocol) dense mode while I2 uses PIM (Protocol Independent Multicast) sparse mode for IP/MC transport. Interoperability at the router is being investigated and the IP/MC testing will begin with Iowa State University serving as the source of the stream delivering to the received at OARnet. Multicast testing will include authorization issues, issues involved in the delivery of content to hybrid receivers and terrestrial I2 and I2 terminals, origination sites for streams, real-time delivery and delivery to cache. Initially RealPlayer is being used for the tests with anticipation that specialized IP/MC products will be used in the more advanced testing.

## 7. **Educational Effectiveness Research**

A blue ribbon panel was selected to oversee site selection and develop strategies for educational effectiveness research. Dr. Cornelia Flora, Charles Curtiss Professor and Director of the North Central Regional Center for Rural Development, Iowa State University serves as the senior social science researcher and is responsible for all aspects of the human subjects research. She and the Center are responsible for baseline data collection at the local sites, as well as analysis of this data on a county basis. When integrated with the performance and measurement testing done at OARnet, AISEP will be able to analyze and characterize traffic from all local sites. The Pew Foundation is cooperating with AISEP and providing all of their raw data from earlier Internet studies for use in this aspect of the project. Three subteams are responsible for:

- a. Media Attributes Research (Dan Cotton, University of Nebraska-Lincoln).

Media Attribute Analysis comes from Connie Dillon and Pat Smith's work published in the Journal of Distance Education in 1999. It provides a framework for studying Delivery System Features, Attributes and Instructional Potential. For example, Bandwidth provides realism and has instructional potential for concrete verses abstract symbols and complex versus simple visuals. One Way/Two Way interactivity and feedback have instructional potential related to Overt/Covert response, active engagement and adaptation to learners. Synchronous and asynchronous delivery are different in terms of immediacy of interaction and instructionally can be studied with respect to pacing responsiveness. Finally, the interface and its branching attribute offers different options for learner control and navigation.

- b. Community Learning Centers with a Youth Orientation-constructivist versus structured curriculum and variable cultural conditions (Valorie McAlpin, University of Maryland-College Park and Lodis Rhodes, University of Texas-Austin),
- c. Distance Education for Adult Learners via the internet including culture, barriers and motivation (Chere Gibson, University of Wisconsin-Madison, Randy Ross, NW Indian Center)

## 8. **Outreach and Dissemination**

The AISEP Project is broadly engaging more than 50 state universities and land colleges in implementation, as well as reaching down into local communities. The AISEP Project team is conducting training, outreach and dissemination as discoveries are made. The following is an indicative list of presentations and publications generating from the project to date. The ADEC website ([www.adec.edu](http://www.adec.edu) - mirrored at [adec.unl.edu](http://adec.unl.edu)) includes many of the documents from the AISEP project in addition to those mentioned here and in this report.

### Dissemination:

- EDUCAUSE Annual Meeting (October 2000, October 2001)
- Great Plains Network (November 2000, April 2001)
- EPSCoR State Regional & National Meetings
  - Las Vegas (December 2000)
  - West Virginia (February 2001)
  - Washington D.C. (April 2001)
  - Puerto Rico (April 2001)
- 1890 Administrators Meetings D.C. and Atlanta (2001)
- All ADEC Meeting (March 2001)
- Chinese American National Symposium (March 2001)
- NIT 2001- Beijing China (May 2001)
- Internet2 Joint Tech (June 2001, January 2002)
- ACE/NETC Annual Conference (July 2001)
- 17<sup>th</sup> Annual Distance Teaching and Learning Conference (August 2001)
- ADEC Engineering Meeting (September 2001)
- UNC Distance Teaching Conference (September 2001)
- Organization of Biological Field Stations Annual Conference (September 2001)
- USDA Faculty Exchange Russia – Moscow, Russia (October 2001) Windows on the Future ITEC-Ohio (November 2001)
- Texas A&M Annual Conference (January 2002)
- National Learning Infrastructure Initiative (NLII) (January 2002)

- Alabama Rural Networking Conference (February 2002)
- ITEC/ADEC/I2 Joint Meeting (April 2002)
- SURA/ViDe Annual Digital Video Workshop (March 2001)
- SURA/ViDe Annual Digital Video Workshop (April 2002)
- National Extension Technology Conference - 3 Presentations (May 2002)

9. **Breadth of Involvement and REU's Involvement**

The AISEP project is conservatively engaging 500 participants in its research development and educational activities. Some of the important education occurring is within the two REU supplements received and utilized. These opportunities are focused on bringing women and minorities into the exciting science and technology challenges of the program. The 10 AISEP REUs work/worked on site in the field on Indian reservations, with rural/remote site problem solving data collection and analysis. REU students are mentored and develop written reports on their work. AISEP provides REU visibility through ADEC's heavily traveled website. REUs interact with graduate students working on the project as well.

10. **Chinese Advanced Networking Symposium**

The supplement for supporting the Chinese Advanced Networking Symposium with the University of Maryland as lead institution was successfully completed as planned in March 2001. The grant supported pre-symposium and post-symposium follow-up consultation between U.S. advanced networking and applications experts and Chinese experts resulting in greater understanding of work ongoing in China including plans and progress. Another symposium is scheduled in Shanghai in August.

III. **CONCLUSION: IMPORTANT IMPACTS FROM THIS PROJECT**

Beyond large I2 institutions, many others are envisioned as providers in the hybrid network of the future. Next stage research will involve increasing the capacity from the edges of the network to fully participate as educational program providers in important areas. From the foundation in hybrid networking being built in this project, the potential will be created to increase capacity at the edges of the network to engage in educational programs coming from "anywhere", as well as decide in an informed manner to what degree they want to provide programming, function as field research sites and become fully engaged in an increasingly rich, robust and inclusive research and education network of the future. The technology is necessary but not sufficient. A systems understanding that includes the people, cultures, economics, social structures and business realities is essential to stimulating involvement of institutions and communities

currently isolated in participatory research. For example, Tuskegee University, an ADEC member and participant in this project, has an outstanding nutrition research program with an emphasis on implications for Africans and African Americans. Development of this type of program to scale could have important impact at Tuskegee, across the nation and around the world. The speakers of native American languages for the most part exist at the edges of the network in very rural/remote areas of the nation. The technological research being conducted in this project can assist researchers on campuses to study and record the language while remaining non-remote, more importantly, the study of disappearing languages can be cast in a larger framework within the network. This can profoundly impact its saving.

ADEC has the capacity to quickly scale outcomes to larger numbers of partners to aggregate resources and design, develop and educate across boundaries. In many important respects, the problem AISEP is addressing is very similar to the problem addressed 150 years ago as the first of these land-grant universities were being creating: "taking the university to the people". Since that time, we have also come to understand that "the people - their issues, realities and gifts can make large contributions to research and learning". We have far to go to really understand concepts we talk about like "interaction", "visualization", "sequencing", "collaboration", "telework", "cross-cultural communication" as they apply to teaching/learning and research. Also, the recognition that further marginalization of rural and remote areas of this nation may not be in the best interest of those in cities and suburbs. There are important and strategic environmental and natural resources in the less populated areas upon which quality of life for all could increasingly depend. Isolation can beget further isolation and marginalization ultimately results in dysfunctions and ramifications far beyond the local boundaries. This principal is as true in isolated inner cities as it is in geographically rural and remote areas of the country.

Dr. Robert Kahn, one of the fathers of the Internet, was quoted in the Washington Post on May 22 as saying: "There are a lot of people who think the Internet happened in the '90s. Actually, its history is far more extensive. By the same token, present-day AOL does not begin to define the almost boundless future of the medium. All great inventions take years to be explored and appreciated. The age of technology has only just begun."

Interestingly he noted that one general principle learned to date: If you had a good business the Internet made it better. He followed that by saying: one of the biggest failures of the Internet to date is the untapped potential of education. He states that almost no progress has been made in this area. AISEP hypothesizes, just as Kahn does, that it is essential to involve the educators, not just the engineers and technologists as resources to advancing "network based research in the public interest." This project is a major element in making research based progress in shaping advanced networking to the inherent challenges in teaching and learning.

"This material is based upon work supported by the National Science Foundation under Grant No. 0073240. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation."