WTI Systems Engineering and Integration of Transportation Technology Program (SEITTP) Concept Document

by

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and

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1. OVERVIEW

The objective of this study is to determine the feasibility of creating a Systems Engineering and Integration of Transportation Technology Program (SEITTP) within the Western Transportation Institute at Montana State University. The proposed program will be dedicated to defining, developing, promoting and applying an integrated and interdisciplinary approach in all aspects of complex and innovative transportation technologies including specification, design, training, integration, deployment, operation, maintenance, and evaluation.

This document, the concept document, is the compilation of information gathered from MSU COE faculty, WTI staff, and a subcontractor, Shel Leader. Initial text was taken from presentations and drafts created by Steve Albert. Feedback was provided by the people mentioned above, to assist in defining a clear, agreed-upon concept of the potential program. One changes of particular note was changing the name from "Center" to "Program". There was expressed uncertainty regarding the relationship of this proposed entity with WTI. Calling it a program within WTI clarifies that issue. Other comments were made asking if the focus would be rural or general (rural and urban), or if there would be a national or regional focus. Tentatively, these have been addressed by recognizing a potential focus on both rural and urban transportation with a national target market. Note though that the statement of need is still phrased in the context of rural transportation, which is WTI's area of expertise. Market research done in the business plan should provide further guidance in these areas.

The next step is the production of a business plan. This document outlines and details many of the capabilities potentially available to this program, and lists a number of scenarios in which the program might operate. These scenarios are diverse, spanning the identified focus areas of Education, Research and Application. Further information is provided regarding potential stakeholders, competitors, funding sources, etc.

The business plan will be produced by a subcontractor, Shel Leader, using this document as a basis of information and as the definition of the program concept.

It should be noted that this document, as a compilation of numerous contributor's comments, is not intended or ready for publication. It is an internal document.

2. STATEMENT OF NEED

In rural and small urban areas, highway transportation presents a broad spectrum of challenges: isolated roads, limited communications coverage, challenging terrain, extreme weather, inadequate public transportation, and conflicts with the environment. Advanced technology has proven beneficial in dealing with these challenges. However, rural and small urban areas are also particularly susceptible to technical problems related to inadequate systems engineering and integration due to a shortage of personnel having experience with advanced technologies and systems engineering processes. Establishing a program will allow us to better address these issues in rural and small urban areas nationwide. The program will help to attract high quality engineering and scientific staff to Montana State University, and will create a strong research, education and support infrastructure of direct benefit to organizations that face these challenges.

3. MISSION STATEMENT

The mission of the Systems Engineering and Integration of Transportation Technology Program (SEITTP) is to develop, promote and apply interdisciplinary skills and services necessary to implement best management practices and solutions for the integration of advanced transportation technologies within rural and small urban settings.

4. EXECUTIVE SUMMARY

Development and deployment of advanced transportation technologies is, of necessity, a multidisciplinary process requiring the application of advanced skills in civil engineering, computer science, electrical and computer engineering, industrial engineering, mechanical engineering, human factors engineering, and sciences such as ecology, chemistry, and economics. Currently, the transportation industry has a severe shortage of personnel who have the knowledge and experience to bring these disciplines together into effective teams and solutions, particularly in rural and small urban settings. There is also a lack of knowledge about best management practices for integrating the products of these disciplines.

Development and deployment of advanced transportation technology is a process of seven interdependent steps: (1) identify the need for a technological solution to a problem, (2) research the underlying technical questions about the operational principles of the technology, (3) engineer to convert the underlying principles of the technology into practice, (4) deploy the technology into the transportation infrastructure, (5) operate and maintain the technology, (6) evaluate the technology, and (7) decommission the technology when its useful life is completed. Systems engineering and integration link these steps together as a structured engineering process. This process is often neglected due to lack of resources such as funding, time, manpower, and expertise necessary to bring together an effective, multidisciplinary team.

To address this problem, the Western Transportation Institute at Montana State University-Bozeman proposes to leverage its existing status and expertise to form a Systems Engineering and Integration of Transportation Technology Program (SEITTP). This program will bring together a multidisciplinary team of engineers, scientists and students from a broad range of university departments to address the education, research, and application issues of systems engineering and integration in relation to advanced transportation technology.

WTI is the largest national Research and Special Programs Administration University Transportation Center focused on rural transportation. A cooperative transportation research effort between the California Department of Transportation, Nebraska Department of Roads, Montana Department of Transportation, and Montana State University-Bozeman, WTI has an ongoing $8 million annual budget and a portfolio involving 35 states and six countries. WTI has an expanding emphasis on rural public transit, advanced transportation technologies, winter mobility, transportation infrastructure, and vehicle/wildlife interactions.

WTI, through the SEITTP and in conjunction with the Montana State University College of Engineering, will provide education, research and application support for systems engineering and integration to client organizations by:

- providing workforce development and continuing education opportunities in systems engineering and integration for transportation professionals. It will promote systems engineering and integration training as part of the undergraduate and graduate

engineering curriculum, and will provide students with the opportunity to apply what they've learned in the classroom to "real-world" problems.

- providing multidisciplinary transportation-related research and development opportunities for engineering and science faculty, staff and students, and will use and promote WTI, COE and other MSU labs and facilities for systems integration efforts. It will use technology transfer and the publishing of research results to promote the application of transportation-related research in systems engineering and integration.
- supporting the development of emerging transportation technologies, and assisting to evaluate and implement state-of-the-art technology, evaluating existing conceptual design products under actual use conditions, and developing and providing best management practices for integration of these technologies.

5. FOCUS AREAS

5.1. Education

The program will provide workforce development and continuing education opportunities in systems engineering and integration for transportation professionals. It will promote systems engineering and integration training as part of the undergraduate and graduate engineering curriculum, and will provide students with the opportunity to apply what they've learned in the classroom to "real-world" problems.

5.2. Research

The program will provide multidisciplinary transportation-related research and development opportunities for engineering and science faculty, staff and students, and will use and promote WTI, COE and other MSU labs and facilities for systems integration efforts. It will use technology transfer and the publishing of research results to promote the application of transportation-related research in systems engineering and integration.

5.3. Application

The program will support the development of emerging transportation technologies, and assisting to evaluate and implement state-of-the-art technology, evaluating existing conceptual design products under actual use conditions, and developing and providing best management practices for integration of these technologies.

6. POTENTIAL USAGE SCENARIOS

WTI staff and a subcontractor, Shel Leader, suggested a number of potential usage scenarios for the proposed program. These scenarios span the focus groups – education, research and application – and are somewhat open-ended at this point. Several address specific (potential) projects, others suggest possible project sources, and others are more generic in nature. There are also two that specifically address separate potential education programs that would dovetail nicely with the proposed SEITTP, but would require extensive involvement and management from COE faculty.

There are certainly many other potential usage scenarios for the program.

6.1. Gallatin Canyon – Hwy 191

6.1.1. Focus Areas:

All

6.1.2. Stakeholders:

MDT, Gallatin County, EMS Agencies

6.1.3. Problem Description:

Highway 191 is a high use roadway that has a large number of associated incidents/fatalities. It is a prime candidate for study, and would be a valuable "test-bed" for technologies such as wireless and satellite communications, sensors, animal detection systems, dynamic message signs, and cameras at key locations.

This project would dovetail with current WTI research, specifically the TRAIL project, Redding Responder, RADS test-bed, and the Bozeman Pass project.

6.1.4. Services:

The center would participate in developing and evaluating various technologies for use in the canyon. The canyon provides communications challenges that might benefit from Richard Wolff's expertise in the area of Telecommunications. Computer Science, Civil, Electrical, Mechanical, and Industrial Engineering could all provide solutions for powering systems, relaying, displaying, and analyzing data, etc. If cameras were to be used, there would be a need for image processing and compression/analysis.

6.1.5. Funding Mechanism:

unspecified

6.2. Knowledge Management

6.2.1. Focus Areas:

All

6.2.2. Stakeholders:

Systems Engineering & SEITTP as service provider

WTI, DOTs, or Transit organizations as end users

6.2.3. Problem Description:

For any complicated projects such as transportation projects, the knowledge every expert has is quite different, ranging from the highly quantitative knowledge (e.g., mathematics and physics) to the qualitative knowledge (e.g., social sciences, human factors, and management). The first challenge is to establish a systematic procedure/method to identify, create, and store the knowledge (quantitative and qualitative) from numerous projects that have been completed by WTI/DOT in the past. The next challenge is to manage the developed knowledge system, which the future projects can put to good use.

6.2.4. Services:

This knowledge management system will be able to help determine the efficient mechanism for connecting people by studying the routings, movements, and interactions of knowledge, so that the right people can be assigned to the right tasks for successful project team and engineering management.

6.2.5. Funding Mechanism:

First stage: UTC funding is needed to establish the basic framework, using WTI as a showcase organization.

Second stage: With preliminary results from the WTI case study, NSF funding can be pursued to enrich and improve the knowledge management system.

Third stage: With a system tested for WTI, funding from state DOTs, transportation pooled fund (TPF), the National Cooperative Highway Research Program (NCHRP), or Transit Cooperative Research Program (TCRP) could be pursued to extend its application to other organizations.

6.3. Systems Engineering and Integration Database for Transportation

6.3.1. Focus Areas:

All

6.3.2. Stakeholders:

All possible program stakeholders would benefit.

6.3.3. Problem Description:

The SEITTP could facilitate the development and maintenance of a database of system integration procedures and methodologies. Systems Integrators often create unique solutions for every problem encountered. However, individual elements of the solution likely come from previous experience. Documenting, cataloguing, and making solutions available would help to reduce overall costs associated with solving new or similar problems. Information could be categorized by general topics such as: “Weatherproof connectors used for RS232 Communication Link”, “Mounting Brackets for High wind Conditions”, “Embedded Applets for Control of Detectors”, etc. A small fee could be charged to help cover the cost of operating and maintaining the database.

6.3.4. Services:

The database would be made available to students, researchers and practitioners, disseminating lessons learned and best management practices for the purposes of education, research and application. The center would create and manage the database and assist users (help desk) with research services.

6.3.5. Funding Mechanism:

A fee could be charged to help cover the cost of operating and maintaining the database. There could be “pay-as-you-go” fees and subscription services. There could potentially be donations from database software companies or from technical foundations seeking to encourage compilation of information databases.

6.4. Customized systems engineering support for projects

6.4.1. Focus Areas:

All

6.4.2. Stakeholders:

SEITTP as service provider

WTI, DOTs, or Transit organizations as end users

6.4.3. Problem Description:

Transportation projects involve various stakeholders and end users, and the products of these projects may interact with legacy systems or other infrastructure. Systems engineering methodologies should be adopted to make sure that the delivered product/service meets the needs of end users and fits well into the existing architecture. For instance, in the planning stage, stakeholders and their roles should be identified, system requirements should be investigated, and integration with legacy systems should be considered.

Traditional systems engineering methodologies were designed for multi-million dollar projects and are not necessarily applicable to small projects often encountered in rural transportation environment. It is a challenge to determine what degree of systems engineering should be adapted to a project to take advantage of its strength without compromising the budget/schedule of the project.

6.4.4. Services:

The Program can provide systems engineering support customized to meet the needs of specific projects by:

- Gathering and analyzing system requirements
- Documenting concepts of operations
- Facilitating risk management
- Facilitating configuration management
- using other systems engineering tools, as applicable

6.4.5. Funding Mechanism:

With a customizable system tested for WTI projects, funding from state DOTs, transportation pooled fund (TPF), the National Cooperative Highway Research Program (NCHRP), or Transit Cooperative Research Program (TCRP) could be pursued to extend its application to other organizations.

6.5. Systems engineering training for transportation professionals

6.5.1. Focus Areas:

All

6.5.2. Stakeholders:

SEITTP as service provider

WTI, DOTs, or Transit organizations as end users

6.5.3. Problem Description:

Transportation projects involve various stakeholders and end users, and the products of these projects may interact with legacy systems or other infrastructure. Systems engineering methodologies should be adopted to make sure that the delivered product/service meets the needs of end users and fits well into the existing architecture. For instance, in the planning stage, stakeholders and their roles should be identified, system requirements should be investigated, and integration with legacy systems should be considered.

6.5.4. Services:

The Program can help the user to:

- understand the principles of systems engineering
- understand the manner in which the National ITS Architecture and system standards support the systems engineering process
- understand the principles of systems integration

6.5.5. Funding Mechanism:

Funding from state DOTs and transit organizations could be pursued.

6.6. Greater Yellowstone Tour District

6.6.1. Focus Areas:

All

6.6.2. Stakeholders:

Yellowstone and Grand Teton National Parks; Gallatin County, Park County, and other regional counties; START Transit (Jackson); Bozeman, West Yellowstone, Idaho Falls, Cody; Private transportation providers; INEEL; GYT Clean Cities Coalition; Yellowstone Business Partnership; visitors; local commuters; seniors and people with disabilities.

6.6.3. Problem Description:

A diverse group of public and private interests have succeeded in developing a modernized vehicle, the New Yellow Bus, aimed at providing exciting new transportation choices in our national parks and gateway communities in all seasons. The next step in taking advantage of the potential of this bus to provide new economic opportunities to the communities surrounding the parks is to study and plan a network of these vehicles in and around Yellowstone and Grand Teton National Parks.

The vision is to share resources and opportunities through a Greater Yellowstone Tour District that will coordinate across three states and two national parks, a region roughly the size of Connecticut. This tour district will encompass the issues of transportation, energy use, Intelligent Transportation Systems, and winter use of the parks. The New Yellow Bus vehicles will be owned or run by private tour companies, public transportation districts, parks, senior and disabled transportation providers, or other organizations that serve the Greater Yellowstone economy. The tour district will be in place to share these vehicles and services across the different members and to provide information to the travelers in a cohesive manner. Other opportunities for cooperation, coordination, or consolidation will be included as groups of stakeholders identify and agree to them.

A key component of the implementation of this new Tour District is the evaluation and planning of what is available, what is needed, where it is needed, and what will be provided.

6.6.4. Services:

- Regional workshops
- Stakeholder needs assessment
- Logistical design of routes, vehicle distribution, maintenance capabilities, etc.
- Define ITS needs
- Define ITS requirements
- Evaluate effectiveness of ITS solutions
- Develop applications if they are not commercially available

- Evaluate effectiveness of the tour district including changes in travel behavior and economic impact
- Investigate impact and issues from the political science perspective
- Document the process used to develop the tour district and share with other regions with shared characteristics
- Incorporate some of these efforts into senior design courses, masters thesis, and other educational opportunities.

6.6.5. Funding Mechanism:

Congressional designation of funds; non-profit foundations

6.7. Alabama Voting Rights Transportation System

6.7.1. Focus Areas:

Research, Application

6.7.2. Stakeholders:

Alabama DOT, Selma Voting Rights Trail (NPS), City of Selma, City of Montgomery, visitors; local commuters; seniors and people with disabilities

6.7.3. Problem Description:

For greater economic return on investment, the New Yellow Bus has been designed to meet the needs of the National Park Service and community transportation. Its use in the Greater Yellowstone region should be replicable in other federal lands applications in rural areas. To test this theory, funding is being requested for implementation along the newly designated Selma Voting Rights trail in Alabama. The region is looking for 3-4 vehicles, transit ITS, and funding to identify coordination opportunities with nearby planned and existing public transit systems.

A key component of the implementation is the evaluation and planning of what is available, what is needed, where it is needed, and what will be provided.

6.7.4. Services:

- Logistical design of routes, vehicle distribution, maintenance capabilities, etc.
- Define ITS needs
- Define ITS requirements
- Evaluate effectiveness of ITS solutions
- Develop applications if they are not commercially available
- Evaluate effectiveness of the tour district including changes in travel behavior and economic impact
- Investigate impact and issues from the political science perspective
- Document the process used to develop the tour district and share with other regions with shared characteristics
- Incorporate some of these efforts into senior design courses, masters thesis, and other educational opportunities.

6.7.5. Funding Mechanism:

Congressional designation of funds; non-profit foundations

6.8. Hardware Testing, Evaluation and System Integration Solutions for Manufacturers

6.8.1. Focus Areas:

Research, Application

6.8.2. Stakeholders:

Manufacturers/Distributors/Value-Added-Resellers/System Integrators

- Funding
- Engineering Support

Departments of Transportation (Would be given general information about product type, but not specific name of manufacturer or actual hardware)

- Oversight
- Review of Testing Procedures
- Review of Test Results

Montana State University

- Department support as required for specific products

6.8.3. Project Description:

Manufacturers want products tested to determine suitability for use in traffic and freeway management situations. Often products must function under severe circumstances which include: significant road vibration (such as location on an elevated structure); severe weather conditions; dust and corrosion; minimal power and telecommunication service availability.

They must account for:

- hardware testing to certify compliance with specific standards. For this purpose, standards would be transportation related. Compliance certification would be for specific products and situations.
- integration their equipment into legacy systems.
- integration their equipment into new systems.
- proof of compliance with project specifications.

6.8.4. Services:

SEITTP would provide evaluation and testing services to hardware and software manufacturers. Manufacturers would pay a nominal fee for the testing of products to determine if they meet stated specifications and to receive recommendations for changes. SEITTP would provide test beds to determine and recommend best management practices, and would look at potential

systems integration problems. SEITTP could also conduct customer surveys of customers to determine the need for product enhancements.

SEITTP could provide:

- laboratory testing of products.
- controlled “real-world” scenario testing in field conditions and simulated actual use conditions.
- investigation of legacy systems to determine product suitability, with recommended integration procedures.
- investigation of new system requirements to determine best procedures for integration of specific hardware.
- comparison of manufacturer products with project specifications to certify compliance.

6.8.5. Funding Mechanism:

All services described in this scenario would be funded by the party/s making the request. Budgetary estimates would be provided with progress payments when specific elements of the testing are completed.

6.9. Hardware and Software Testing, Evaluation and System Integration Solutions for Departments of Transportation

6.9.1. Focus Areas:

Application

6.9.2. Stakeholders:

Departments of Transportation

- Oversight
- Review of Testing Procedures
- Review of Test Results

Montana State University

- Department support as required for specific products

6.9.3. Problem Description:

Departments of Transportation need products tested to determine suitability for use in traffic and freeway management situations. Often products must function under severe circumstances which include: significant road vibration (such as location on an elevated structure); severe weather conditions; dust and corrosion; minimal power and telecommunication service availability.

They must account for

- hardware and software testing to certify compliance with specific standards. For this purpose, standards would be transportation related. Compliance certification would be for specific products and situations.
- integration of new hardware and software into a legacy systems.

6.9.4. Services:

SEITTP could provide:

- product testing.
- controlled “real-world” scenario testing in field conditions and simulated actual use conditions.
- investigations of legacy systems to determine product suitability, with recommended integration procedures.
- investigations of new system requirements to determine best procedures for integration of specific hardware.
- comparison of manufacturer products with project specifications to certify compliance.

6.9.5. Funding Mechanism:

All services described in this scenario would be funded by the entities making the request. Budgetary estimates would be provided with progress payments when specific elements of the testing are completed. Some funding may be provided via “ear mark” in State and Federal programs.

6.10. California Narrows Project

6.10.1. Focus Areas:

Research

6.10.2. Stakeholders:

Caltrans

- Develop problem statement
- Provide funding
- Provide real-world test location

Hardware Manufacturers

- Provide hardware and software for testing
- Provide engineering and technical support

Montana State University

- Department support as required for development
- WTI Staff provide traffic and transportation engineering support

6.10.3. Problem Description:

Caltrans needs a system to detect over width vehicles attempting to use section of roadway that cannot support over width vehicles. WTI staff would like to test several systems, each representing a different technology solution.

6.10.4. Services:

SEITTP could provide:

- Gain understanding of individual system requirements for installation, communication and power.
- Determine potential system conflicts when installed for side-by-side comparison.
- Create test procedures to measure individual system performance
- Create test methodology for comparing system results.
- Make recommendations for best installation practices.
- Support WTI staff with deployment of selected system at Caltrans location.
- Support WTI staff with final evaluations.

6.10.5. Funding Mechanism:

- Caltrans provides funds for overall test
- Vendors provide “in-kind” support and hardware/software for testing.

6.11. Integrative Graduate Education and Research Traineeship (IGERT)

6.11.1. Focus Areas:

Education

6.11.2. Stakeholders:

Faculty and graduate students at MSU's College of Engineering and other center affiliated academic departments.

Participating faculty would foster collaborative research initiatives that transcend disciplinary boundaries and are centered on transportation systems engineering and integration. PhD level graduate students would actively be recruited to participate in this research. Interdisciplinary curriculum development would provide a cohesive focus for the graduate program (a certificate could be offered, for example, in transportation systems integration. In addition to related research work, certificate requirements could include coursework on systems engineering, ITS, and transportation systems integration. A program of industry or government traineeships would add additional benefit to students and cohesion to the program as well).

6.11.3. Project Description:

The SEITTP aims to improve deficiencies noted in the current transportation workforce with respect to advanced technologies, to increase the transportation research capabilities of MSU by attracting high quality engineering and scientific staff to the university, to solve systems integration issues related to advanced transportation technologies, and to advance the state of the art. An integrated, research-based interdisciplinary graduate training program centered on the integration of cutting edge advanced transportation technologies would promote these objectives. Interdisciplinary research activities, theme-based graduate course offerings, and industry and government traineeships would form the backbone of the program. Recruitment and retention strategies would be developed to ensure that the program graduated a diverse pool of PhD students in science and engineering with expertise relevant to both academic and non-academic careers in the transportation field.

6.11.4. Services:

Research efforts would be pursued under select focus areas to address existing issues with advanced transportation technologies and to advance the state of the practice. Career placement of graduates with integrated research and professional experience and skills would address deficiencies in the current transportation workforce. Industry research needs with respect to advanced transportation technologies could be addressed through sponsored research through the integration center.

6.11.5. Funding Mechanism:

- NSF funding through the Integrative Graduate Education and Research Traineeship (IGERT) program would cover student stipends, recruitment expenses, administrative costs, and some faculty buy-out time for program-related curriculum development and teaching.

- Industry and government sponsorship would cover research costs for select projects.

6.12. Engineering Research Center (ERC)

6.12.1. Focus Areas:

Education and Research

6.12.2. Stakeholders:

Faculty and students at MSU's College of Engineering and other center affiliated academic departments.

Participating faculty would foster collaborative research initiatives that transcend disciplinary boundaries and are centered on transportation systems integration. Research initiatives would specifically focus on industrial and government partners' needs in the realm of real-world transportation technologies. Graduate and undergraduate students would actively be recruited to participate in this research. Research initiatives and innovations developed in the ERC would be translated to the classroom at MSU and to university partners' and K-12 classrooms through coordinated outreach efforts.

6.12.3. Project Description:

The SEITTP aims to improve deficiencies noted in the current transportation workforce with respect to advanced technologies, to increase the transportation research capabilities of MSU by attracting high quality engineering and scientific staff to the university, to solve systems integration issues related to advanced transportation technologies, and to advance the state of the art. The establishment of a NSF Engineering Research Center (ERC) would provide funds to adequately staff and equip such a center. In addition, the prestige of an ERC would facilitate faculty and research staff hires, graduate student recruitment, and success rates in obtaining sponsored research contracts from industrial and government partners on a national basis. Increased research opportunities for faculty and graduate students from various engineering departments would expand the interdisciplinary expertise available to the center. Research and education initiatives centered on the integration of cutting edge advanced transportation technologies would promote workforce development in this field while addressing the needs of the ERC's industrial and government partners.

6.12.4. Services:

Research efforts would be pursued under select content areas to address existing issues with advanced transportation technologies and to advance the state of the practice. Career placement of graduates with integrated research and professional experience and skills would address deficiencies in the current transportation workforce. Industry research needs with respect to advanced transportation technologies could be addressed through sponsored research through the ERC.

6.12.5. Funding Mechanism:

- NSF funding through the Engineering Research Center (ERC) program would cover administrative salaries, outreach efforts, experimental equipment and laboratory space.

- Industrial partners would pay membership fees to the Center and would form a technical advisory board to ensure that successful technology transfer strategies were practiced.
- Industrial and government partners would sponsor specific projects based on their research needs.

6.13. Other suggested potential scenarios from staff:

- Application of systems engineering process to rural ITS projects
- Paratransit operations and routing studies, using Galavan (Big Sky Transit and Bobcat Transit???) as a testing ground
- Evaluate rural transit ITS applications
- Courses or seminars in systems engineering for rural ITS aimed at affiliated MSU members, MSU students, or continuing education
- Assist local agencies (cities, counties, transit agencies, state non-DOT departments, tribal entities, parks) in developing RFP's, requirements, concepts of operations, evaluations, etc.
- Turning the pavement temperature thermal model into a product that is useful to end users
- Bozeman Pass testbed for weather and winter mobility issues – instrumentation, plows w/ GPS, etc.
- Montana Transportation Management Center staffed by MSU students

Comments from Susan Gallagher, WTI Education Coordinator, Regarding the Connection Between the Program and the IGERT and ERC Programs:

I looked over the ERC RFP. I think it fits very nicely with the SEITTP goals and objectives and should be pursued. One thing to note, this will require significant faculty participation as LEADS on the project (i.e. the PI and Center Director, Deputy Director, and Education Program Director must be tenure-track faculty members according to the NSF requirements).

Thanks for forwarding the emails and materials to me related to the SEITTP concept refinement. Attached are some ideas regarding concept development for the Integration Center. I have included IGERT and the ERC as possible scenarios under potential usage. After giving this considerable thought, I believe it is premature to try to submit a proposal for the IGERT at this time. Instead, I suggest that both the IGERT and ERC need to be one aspect of the concept development and feasibility study that is being undertaken currently. Both require extensive commitments from faculty for graduate student recruitment and mentorship, program management and development, and curriculum development and change. In fact, we will need to identify a core group of faculty to serve as PIs for either or both of these programs should we decide to proceed with proposals for them. We will need to hash out what this means to WTI in

terms of playing a key role in the organization and administration of these programs as we will need to give up some measure of control. In addition, both IGERT and ERC programs require the development of (and commitments from) industrial partnerships. Until we have a more specific concept for the center hashed out and have taken a complete inventory of potential partners, stakeholders, faculty participants, facilities and equipment, etc. through the feasibility study, it will not be clear how the IGERT or ERC programs can be integrated into the plan. I would like to suggest that we work together more closely over the coming months so that each step in the concept development process and feasibility study includes a clarification of corresponding educational goals and objectives. In particular, it would be good to be able to add education-related questions to any materials sent to faculty for feedback and comment. Please let me know if this idea is compatible with your planned course of action regarding the Center.

7. INTERNAL CAPABILITIES

7.1. WTI Staff

There are a number of WTI staff who have been identified for involvement with the potential program. Certainly all WTI staff could play a role in and/or benefit from the program. In addition to research staff, WTI has a capable and diverse support staff providing services such as accounting, technical writing and editing, graphic design and publication. WTI senior management has extensive management and research experience in transportation and transportation research. WTI research staff has expertise and education ranging from Civil Engineering to Computer Science to Wildlife Biology to Human Factors. WTI is currently in the process of adding a researcher to provide support in systems engineering. In addition, WTI has staff experienced in training of undergraduate and graduation students as well as professionals in continuing education and workforce development.

Several staff members provided background information that may be of relevance to the center, some in greater detail than others. Some are listed in name only, and further information can be gathered regarding their capabilities later.

- Steve Albert, WTI Director
- Mike Kelly, WTI Research Director, PhD, Human Factors
- John Taylor, WTI Deputy Director
- Doug Galarus – M.S. Computer Science, M.A.T. Mathematics – extensive experience in software and systems development, IT management, technical writing and training, education, operations research, systems analysis and software/systems engineering.
- Suzanne Lassacher, M.S. Computer Science, Driving Simulator Sys Admin and Programmer, WTI systems administrator
- Xianming Shi – PhD in Chemistry, Master's in Industrial and Management Engineering; trained in Systems Analysis, Decision Support, Operations Research, Quality Insurance; interactions between materials and the environment; has taken training in Applied Systems Engineering for Advanced Transportation Projects. systems engineering, interactions between materials and the environment
- Lisa – transportation systems engineering; coordinate between end users and people unfamiliar with transportation field. before WTI, 5 years experience working with multi-discipline team on developing advanced transportation management systems, developing designs for installing field devices (CCTV, CMS, ramp metering, traffic detectors), traveler information kiosks, applications for both cities and transit systems. Designed user interfaces; upgraded the design of an expert system for assisting operators in incident management. Rural transit applications. 511. RWIS. Understand state of the practice in weather applications. Conversational understanding of databases (Oracle, mySQL, Access, queries, scipts, database design, data dictionaries, backups, etc.), programming, UI design, etc.
- Susan Gallagher, WTI Education Coordinator

- Jaime Eidswick – MDT, traveler info, 511, message sets, beginning to learn about NTCIP and other systems engineering related stuff.
- Chris Strong – architecture, evaluation, safety
- Pat McGowan – ITS evaluation, some architecture, transportation engineering algorithms
- Research associates, other WTI engineers, researchers and student fellows and interns, coordinator for student recruitment/retention and education initiatives, administrative support (accounting, communications, graphics, computer support).

7.2. WTI Facilities and Equipment

WTI has an ever-growing list of facilities and equipment. Some of these items are "owned" by WTI, while others are shared with other organizations such as COE. The following listed items are either current or anticipated items. Greater detail is given for some. Additional detail can be gathered, if necessary.

7.2.1. Student Support:

Graduate student offices (13 spaces), undergraduate computer lab (10 computers), transportation simulation software packages (Tait Computer Lab) [computer and work space support for students working on interdisciplinary transportation research. WTI student space is available on a first-come-first serve basis. Tait computer lab is available to CE students unless classes scheduled there. Not currently available summer to students but could possibly make arrangements with CE if needed].

7.2.2. Driving Simulator:

The Driving Simulator allows testing of driver performance and behavior in the safety of a controlled laboratory environment. Collection of data related to driving hazards and unsafe conditions is dangerous and time consuming if done on actual highways or test tracks. Because of the changing nature of environmental conditions and traffic, it is impossible to maintain the full control of driving scenarios necessary for experimental precision. This can be accomplished safely and easily in a simulation laboratory designed to collect detailed measures of driver performance during high fidelity, realistic driving scenarios.

Exploratory research on new traffic engineering practices and devices often cannot be performed in real world traffic scenarios. A research simulator would allow testing and development of prototype and notional systems before they can be fielded. The laboratory would economically support research in safety, control theory, psychology, driver fatigue, alcohol and OTC drugs effects, and other topics that are difficult to study in low fidelity laboratory simulations or on the real roadways.

The DriveSafety DS500C Vection simulator features five visual channels providing approximately 140-degrees of view plus rear-view mirror. The visual simulation allows the driver to drive through scenarios including roadways, buildings, traffic signs and signals, other vehicles, trees, rain, snow, fog, and even animals in the roadway. Auditory displays provide a realistic sound environment. A driving cab contains the driver seat and all fully functional displays and controls. An automated performance measurement system collects a broad range of data on the driver's control inputs and performance. An operator station allows the researcher to program and control the research scenarios.

The simulator utilizes high-resolution textured graphics (800 x 600 pixels) on each of five visual display channels arranged in a semicircle around the front of a cab that is actually a quarter of a Saturn sedan. The visual displays run efficiently in real-time – maintaining a 60Hz update rate with a 48 msec latency. All roadways and traffic control devices are geometrically correct and modeled to highway design standards. The simulator can replicate up to 256 autonomous ambient vehicles to create traffic for the simulated environment. The autonomous vehicles obey all traffic laws and traffic signs. It is also possible to script specific behaviors for the ambient vehicles to create traffic conflicts.

The simulator is the only one of its kind in the Pacific Northwest. The cost of such a high fidelity driving simulator at MSU would be leveraged into funding for multidisciplinary research grants from Federal and state transportation and research agencies. It would serve as a laboratory supporting faculty, undergraduate, and graduate student research projects from numerous departments across the campus.

Some specific research areas that have been suggested by WTI staff that could yield funding include the following:

- Driver distraction (e.g., with mobile phones) as a major cause of accidents.
- Driver understanding of dynamic messaging systems.
- Aging related deficits in driving performance.
- Winter driving performance and weather warning systems.
- Computer-based systems to assist driving performance.

- Driver behavior and safety in the rural versus urban environment.
- Driver behavior when encountering obstacles such as large animals.

7.2.3. Mobile laboratory infrastructure

7.2.4. Includes data acquisition, weather station, GPS handheld instruments, 4KW A/C Power, 4WD, full mechanics tool inventory, other unique equipment and systems; Resources – ME Instrumentation Lab, inventory of sensors & data acquisition equipment.

7.2.5. Transportation, Research, Applications, and Instrumentation Laboratory (TRAIL):

The Western Transportation Institute's Transportation Research, Applications and Instrumentation Laboratory (TRAIL) will demonstrate and evaluate various data acquisition, control systems, information delivery, and management systems in a small urban and rural environment.

The goal is to establish a travel corridor for 19th Street in Bozeman that promotes a safe and efficient traveling environment for its users. The diverse nature and increasing traffic volumes of 19th Street qualifies it as an appropriate candidate for the initial phase of this project. Traffic volumes on 19th have currently exceeded projected expectations and continue to increase. High traffic volume promotes safety and delay concerns. Given the increased development along the 19th Street corridor, we expect an even greater increase in traffic volume, congestion, and incidents over time. Deployment of traffic, weather, and road condition sensors will allow WTI to obtain real-time and summary data describing travel conditions. The Groundhog sensors will collect data on roadway conditions (pavement wet/dry), the amount of anti-icing agent present on the roadway, and vehicle information consisting of speed, volume, and classification. Data is collected in five minute intervals. These data will be communicated wirelessly to the TRAIL data management center for processing and archiving. Methods of communicating real-time travel conditions to motorists will be explored.

Data collected by the laboratory would be used for the development of incident response plans, signal timing schemes, and special events traffic coordination. Data could be used as a reference point for future expansion and development plans along the roadway. The transportation research, applications and instrumentation laboratory would be a test bed for a variety of new human factors, weather, pavement, animal detection, and traffic technologies.

**More detail/information can be added on actual technology along with pics.

7.2.6. Facility: The Lewistown Cold Region Test-bed

The Cold Region and Rural Transportation Research, Maintenance and Operations Test-bed in Lewistown, Montana would create the opportunity to perform high quality research and testing on surface transportation issues facing rural and cold regions. The test-bed would create an opportunity to "pool" resources from different partners (private, state, country) to answer both basic and applied research questions that withstand rigorous peer review to meet the credibility needs of various stakeholders and audiences. The research conducted in Lewistown would create the opportunity to develop a national and international Maintenance Research Center of Excellence to address surface transportation maintenance issues and even beyond maintenance as well. The Test-bed can be used by the Systems Engineering and SEITTP to test the interaction of different ITS systems and to experiment the integration of various systems. The Lewiston Cold Region Test-bed has been proposed to the Congress and is likely to be funded this year. After construction, it will be available for use in year 2006 or so.

7.3. COE Faculty

COE faculty has expressed great interest in the SEITTP. They have participated in several meetings regarding it, and approximately 10 faculty members provided extensive feedback regarding the concept of the program and their potential contributions to it.

Note that some provided greater detail than others regarding their experience and interests. Further detail could be gathered where necessary.

- Robert Marley (COE) – Dean
- Robb Larson (ME) – MSME, BSME, Registered PE, 8 years Aerospace Industry Engineering Design & Project Engineering, 12 years teaching upper division Mechanical Engineering coursework, 5 years WTI affiliated faculty; Meachanical Engineering Instrumentation courses, Meachanical Engineering Design courses, ME Computer applications, CAD instructor, Project Design supervisor; Composite materials impact testing, reverse engineering of Diesel Locomotive Engine components, Snow Avalanche characteristics & instrumentation, Transportation system sensors & instrumentations, consulting engineer since 1990 – various product design, analysis, manufacturing support, instrumentation, and expert witness tasks; WTI Affiliated Faculty since 1999 – projects include ODOT ITS planning, MDT Weather Decisions Support Tool, WTI Mobile Laboratory design/construction/implementation/management, MDT Video Traffic Detection contract in work; Resources – Mobile laboratory infrastructure including data acquisition, weather station, GPS handheld instruments, 4KW A/C Power, 4WD, full mechanics tool inventory, other unique equipment and systems; Resources – ME Instrumentation Lab, inventory of sensors & data acquisition equipment.
- Ruhul Amin (ME): Expertise is numerical modeling. Also has background in experimental heat transfer. Mentioned College computing facilities that he uses for work.
- Mike Cole (IE): math modeling & optimization (linear, integer, etc.); simulation (discrete event); background in transportation modeling (freight flows, facility location, fleet management, etc)
- Richard Wolf (ECE) – Gilhousen Telecommunications Chair: expertise and experience in wireless and wired communications systems and information technologies, with applications to telematics.
- Michael Oudshoorn (CS) – Head – involvement most likely to be through the supervision of students working on projects. Can see some of the projects being used in senior design projects and individual problems. Equipment – students could use computers in CS labs is work is purely computational. Suspects that they would need access to equipment for which integration is to be performed. CS does not have extra space to devote to such projects though.
- Don Boyd (I&ME) – could participate on a limited basis. Recently published a text which introduces the first major change in systems analysis and modeling since Jay Forrester introduced systems dynamics more than 40 years ago. Once served as a Professor and Director of the Industrial & Management Engineering Graduate Program at

MSU – Bozeman, Dr. Boyd instructed in the following areas: Systems Analysis and Dynamic Systems Modeling, Expert Systems, Statistical Applications and Simulation, Operations Research. Dr. Boyd is the author of a recent published book titled "Systems Analysis and Modeling: A Macro-to-Micro Approach with Multidisciplinary Applications" (Academic Press, October 2000). The book presents a fresh, new approach to systems analysis and modeling with a systems science flavor that stimulates systems thinking. After introducing systems modeling principles, the ensuing wide selection of examples aptly illustrate that anything which changes over time can be modeled as a system. Each example begins with a knowledge base that displays relevant information obtained from systems analysis. The diversity of examples clearly establishes a new protocol for synthesizing systems models. As a retired professor at MSU, Dr. Boyd may be able to provide his expertise to the Center on an as-needed basis.

- Shi-Jie (Gary) Chen (I&ME) – proposes development of knowledge management system for transportation . Serving as an Assistant Professor in the Department of Mechanical and Industrial Engineering, Montana State University (Aug. 2001 - present), Dr. Chen's research focuses on the following areas: Concurrent Engineering and Management, Team Management, Computer Simulation, Project Management. Dr. Chen's expertise in knowledge management, group technology, and project management will be a great asset to the Center. As a tenure-track professor at MSU, Dr. Chen may be able to provide his expertise to the Center in the summer time or on other basis.
- Aleksandra Vinogradov (ME) – suggests integration of her Advanced Materials Lab. Can provide details on test equipment.
- Ahmed Al-Kaisy (CE)
- Jim Peterson (ECE) – Head
- Vic Cundy (M&IE)
- Gary Harkin (CS)
- John Paxton (CS)
- Binhai Zhu (CS)
- Ed Adams (CE)
- Steve Perkins (CE)
- Jerry Stephens (CE)
- Denbigh Starkey (CS)
- Ray Babcock (CS)
- Brett Gunnink (CE)
- Bill Jameson (EE – retired)

7.4. COE Departments

COE departments who have expressed interest in the proposed program include the following:

- Civil Engineering
- Computer Science
- Mechanical and Industrial Engineering (Mechanical Engineering, Industrial and Management Engineering) – optimization, simulation, scheduling, human factors
- Electrical and Computer Engineering

Most of the Engineering departments including Mechanical Engineering have senior design projects or "capstone" experience classes at the undergraduate level that are in constant need of real-world problems to investigate. Within the past few years, the concept of multidisciplinary projects has been embraced by the COE, and several departments (ME, EE, Chem E) are actively participating in the multi-D projects. These project courses provide an ideal opportunity for supervised engineering progress on various projects such as those that can be envisioned through the center. It would be wise for WTI personnel to become familiar with curriculum issues, scheduling, project selection guidelines etc. to be able to utilize this source of (almost free) engineering and ingenuity.

7.5. COE Labs and other Entities

COE has a variable of formal and informal labs. Labs from other departments or university-affiliated organizations may also be available, and several are listed below.

- Telecommunications Lab (ECE)
- Image Processing (CS)
- Artificial Intelligence (CS)
- Cold Regions Lab (CE)
- The Transportation Lab – under development (CE)
- Materials Testing Lab
- Geotechnical Lab
- Gilhousen Telecommunications Program: facilities to model, simulate, prototype, test and evaluate communications networks and their applications
- College Computing Facilities – used by various faculty for numerical modeling, etc.
- Advanced Materials Lab – Alexandra Vinogradov
- ME Instrumentation Lab, inventory of sensors & data acquisition equipment.
- IE linear/integer optimization software (AMPL, OPL, CPLEX); Math Analysis (Matlab)

7.6. MSU (Other Colleges, Departments and Resources)

As with all Universities, a variety of knowledge and expertise is available through numerous departments and programs. Those specifically mentioned by WTI staff members include:

- LRES (Land Resources and Environmental Sciences)
- GIAC (Geographic Information and Analysis Center)
- Political Science Department.

7.7. Affiliated Entities (Example: Tech Ranch)

There are a variety of university-affiliated entities that could be potential partners or could offer or use services for the proposed program. One example is "TechRanch." TechRanch is a business incubator that opened in 2001 to help Montana entrepreneurs develop high-technology businesses that can compete in global markets. TechRanch could, for instance, assist in turning technologies developed through the program into businesses.

8. EXTERNAL CAPABILITIES

There are certainly a virtually limitless number of outside entities who could be partners in or could provide or derive services from the program. These include public and private entities. Several listed by WTI staff include:

- INEEL Test Track – They have roads that employees use where they can move people from one roadway to another.
- GYRITS projects – ongoing research about the effectiveness of this activity and the equipment that was installed.
- Steering Committee members for GYRTWIS or other past project stakeholders, consultants, etc.
- Possible institutional collaborators and available facilities include Japanese researchers and facilities at the Nagaoka Institute of Snow and Ice Studies (NISIS) and the Institute of Low Temperature Science Hokkaido University (ILTS) and those at the Swiss Federal Institute for Snow and Avalanche Research (SLF). These entities have already signed a collaboration agreement with WTI and the MSU Civil Engineering Department to use available resources for snow, avalanche, and severe weather research most effectively. Collaborative student exchanges between these institutions may also be possible.
- Industrial partnerships (several have been mentioned in the past)
- Federal laboratories
- State DOTs

9. ADDITIONAL (NEEDED) CAPABILITIES/INFRASTRUCTURE

The subcontractor, Shel Leader, listed the following commentary and items in reference to additional capabilities that would be useful to the program:

Each system integration problem could require a different set of capabilities. The center will have to evaluate each request for support, and determine its ability to handle the problem with internal capabilities, and which will have to be acquired. This will have an impact on the pricing of an individual project. In general the SI Center will be available to accomplish the following:

- Evaluate hardware
- Evaluate software
- Solve specific integration problems.

The three items above were defined under usage scenarios, and would generally require the greatest amount of additional resources, not resident at the University.

Some projects will be designed to evaluate equipment, others to evaluate software, and still others will evaluate both. Each request for support will be presented in the form of a project. The center (under the direction of WTI and the COE) will have some set of testing equipment, tools, spare parts, technical library, and qualified personnel available on opening day. There will also be a protocol established for using additional University facilities and personnel. But, there will always be a need for "outside" resources. Some of these resources will include:

1. Access to standards organizations and their library of documents
2. Personnel with specialized skill sets, knowledge and experience
3. Test equipment
4. Assorted spare parts, cables, connectors, etc.

The following sections will define the four items listed above.

- **Access to standards organizations and their library of documents - Description**
  - A primary consideration to providing a solution for integration problems is the adherence to standards. Most standards allow for some variance while still being compliant. Often, manufacturers will publicize the fact that their products meet a specific standard.
  - A large part of the need for systems integration is generated by the requirement to combine several diverse hardware items into a single system. Each manufacturer stipulates that their product meets the required specifications, but the products may not, in fact, work together without some modification, or adaptation. The staff would need to have access to the specification in order to determine what variances are permitted.
  - RS232 connectors are a case in point. The standard was produced and published by the IEEE (Institute of Electrical and Electronic Engineers) and the EIA (Electronic Industries Association). The standards are identical. A problem arises in the fact that RS232 connectors and cables can be provided in any number of physical formats. Field personnel have been required to create special cable and connector arrangements in order to mate one device to another via an RS232 connection. A systems integrator would normally check for inconsistencies before items are sent to the field for installation.

- **Access to standards organizations and their library of documents – Availability & Acquisition**
  - The University probably subscribes to many standards organization libraries. Make certain that the SI Program personnel are able to access the information.
  - Additional research and information resources can be purchased as needed to fulfill project requirements.
- **Personnel with specialized skill sets, knowledge and experience - Description**
  - The SI program will need to seek out personnel with special skill sets that may be called on from time-to-time to support specific project requirements.
  - Such skill sets may include knowledge of various construction techniques, system implementation techniques, specific knowledge of a specific product or product type. The project manager will have to evaluate the need for personnel, and determine if there is "in-house" expertise or a need to outsource for services.
- **Personnel with specialized skill sets, knowledge and experience – Availability & Acquisition**
  - A list of available personnel with necessary knowledge and skill sets must be developed.
  - Open-ended contracts can be developed with funding applied on a project by project basis.
- **Test equipment - Description**
  - The type of test equipment required will depend upon specific SI problems to be solved.
  - All test equipment will need to be properly stored and maintained. Periodic accuracy checks will be required to assure compliance. This will be especially important if the SI Center does testing for specification compliance.
  - Any University personnel using the equipment will need to be trained on its proper use and care.
- **Test equipment - Availability & Acquisition**
  - Standard testing equipment such as volt meters, continuity testers, connector testers, BERT (bit error rate tester) etc should be purchased at start up.
  - Complex test equipment, such as OTDR (optical time domain Reflectometer), multifunction Oscilloscopes, etc, can be rented for a specific project. Based on use trends, the more expensive and complex equipment can be acquired as needed.
  - Specific needs for large quantities of test equipment can also be met through rental.
  - The University could also lease equipment for a brief period (3 years) and then trade in for a newer version.
- **Assorted spare parts, cables, connectors, etc. – Description**
  - This is basically the same as the test equipment scenario.
  - A certain level of spare parts will be needed on opening day. Additional items can be acquired as projects dictate.
  - Careful records must be kept to assure that spare parts are available.
- **Assorted spare parts, cables, connectors, etc. – Availability & Acquisition**
  - Keep a list of suppliers
  - Have open contracts available to minimize purchasing problems.

- Buy in bulk using the University's leverage with suppliers.

10. POTENTIAL STAKEHOLDERS

The subcontractor, Shel Leader, identified the following stakeholders for the prospective program.

Stakeholders:

1. Montana State University
    - A general stakeholder providing facilities to house the SI Center
    - Member of the core team providing policy and general council
    - Client using the educational and research capabilities of the SI Center
2. College of Engineering
    - A general stakeholder providing faculty and research staff
    - Member of the core team helping to develop policy and creating core curriculum for the educational function of the SI Center.
    - A client using the center to meet objectives of research requirements for their clients
3. WTI
    - A general stakeholder responsible for day-to-day operation of the center, marketing its capabilities to prospective clients, and providing overall management and staff.
    - Member of the core team responsible for overall program development and securing state and federal funding for research grants.
4. State DOTs
    - State DOT members of the governing council for WTI would be considered as general stakeholders.
    - Most State DOTs would be clients providing funding on a “pay-as-you-go” basis for SI/SE work on Traffic and Freeway Management systems. As indicated in the usage scenarios, DOTs would use the center to solve integration problems associated with the deployment of technology based systems. The center could also be used to review RFP specifications, and responses to the same.
5. FHWA
    - A general stakeholder because they would have an interest in the successful operation of such a center.
    - A client because they would most likely be asked to provide funding for the general operation of the center, and also providing contracts to do specific work.
6. Hardware and Software Manufacturers
    - A general stakeholder because they would have an interest in the successful operation of such a center. You may want to have a manufacturer on the board or governing council of the SI Center. A company like Boeing, a big contributor to the University, and a potential client.
    - A client using the services of the SI/SE center. The ITS/Telematics industry has spawned a number of small to medium size businesses that lack resources to fully fund their own product testing and integration services. The center could be used as an “outsourced resource”. Large companies such as General Motors could use the center to perform specific research for new products. Software companies such as Computer Associates might use the center to develop database program designed to specifically support the transportation industry.

11. POTENTIAL COMPETITORS

The subcontractor, Shel Leader, identified two potential competitor categories, educational institutions and commercial enterprise. It should be noted that other entities such as government research centers might also be considered competitors. Other UTCs might be considered competitors as well. They are listed at the end of this section. Other non-UTC competitors to WTI have been researched and documented, but are not included in this document.

From Shel:

There are two categories of competitors:

1. Educational Institutions
2. Commercial Enterprise

11.1. Educational Institutions

Most Universities – especially engineering schools – provide basic systems research for clients on a fee for service or grant funded basis. Many of these schools have transportation programs where faculty and students work on projects that help to either further research on a specific topic, or in fact provide practical solutions to a problem. A by-product of this is a systems integration process for the specific problem. Additional research may provide a list of educational institutions actively engaged in systems integration work under a fully developed program.

A general WWW search – using "Educational Institutions Systems Integration", as a general search term did not provide a list of educational institutions actively involved in systems integration work. However, the search did provide a significant list of commercial companies.

Several examples of educational institutions involved in SI type work:

- Princeton University has a "Program in Transportation" under the direction of Professor Alain L. Kornhauser. The program is listed with the following description: "The Program in Transportation is an interdisciplinary program offered jointly by the School of Engineering and Applied Science (Operations Research and Financial Engineering) and the Woodrow Wilson School of Public and International Affairs. Faculty members and students from other departments also participate. The interdisciplinary nature of transportation problems is emphasized throughout. In addition to work in their own discipline, all students participate in a common core of courses and workshops dealing with the technological, economic, and social aspects of transportation. Methodological research in network analysis, stochastic systems, large-scale optimization and interactive computer graphics focused on intelligent transportation systems is an area of emphasis for engineering majors." http://www.princeton.edu/pr/catalog/gsa/03/377.htm
- The University of New Hampshire has a Research Computing Center with an "Interoperability Laboratory". The University provides the following description: "A part of the University of New Hampshire's Research Computing Center, the InterOperability Laboratory (IOL) has the dual mission to foster interoperability within the data communications industry and to provide students with a detailed education in data communications technologies. These two mission goals have been combined in a unique partnership between academia and industry where the first goal is actually the mechanism

for achieving the second goal, while the second goal fulfills the first. By bringing together parties working on a standard technologies the IOL helps to improve the state of interoperability within the industry. By employing students to develop the test suites, tools, scripts, and to perform the testing, the IOL provides them with a detailed, hands-on apprenticeship. For over fifteen years, the IOL has been successfully fulfilling both missions and has expanded to include activities that go beyond its core mission goals, but that increase the opportunities for students and provide necessary technical assistance to the industry." http://www.iol.unh.edu/general/. The University is working on a research project to develop an intelligent police vehicle. The project is known as "Project 54". This could be considered as an exercise in systems integration. More information is available at: http://www.ceps.unh.edu/news/releases/car54800.html

11.2. Commercial Enterprise

There are a large number of commercial entities that do systems integration work. 99% of the work is project oriented. Each client requests a solution for a specific problem. The size of companies involved in this business varies from small independent contractors to multi-billion dollar corporations. These commercial enterprises would compete for general systems integration business. They would not normally be involved in the research and development aspect that would be a part of SEITTPmission.

Examples of companies doing this type of work include:

- ITS/Communications – the contractor preparing this report
- Siemens ITS – a United States Subsidiary of Siemens specializing in work for the Transportation and Traffic Industry.
- IBM
- Boeing

11.3. University Transportation Centers and Related Centers

Center_Name:	Western Transportation Insitute
University:	Montana State University
Research_Area	rural transportation
Focus_Areas	wildlife, rural its, public transit, materials, weather/winter mobility
Center_Name:	Unversity Transportation Center
University:	Assumption College
Research_Area	Transportation and environmental studies
Focus_Areas	Transportation and environmental education for the 21st century
Center_Name:	University Transportation Research Center
University:	City College of New York
Research_Area	Regional Transportation
Focus_Areas	Planning and management of regional transportation systems
Center_Name:	National ITS Implementation Research Center

University: George Mason University
Research_Area Transportation Systems
Focus_Areas Deployment of of intelligent transportation systems

Center_Name: Midwest Transportation Consortium
University: Iowa State University
Research_Area Transportation Asset Management
Focus_Areas Benefits of winter maintenance, roadway alignments

Center_Name: Appalachian Transportation Institute
University: Marshall University
Research_Area Trans. and Economic Development in Mtn. Regions
Focus_Areas County trans. Studies and inventories, wildlife, impact of mountains

Center_Name: MIT Center for Transportation and Logistics
University: Massachusetts Institute of Technology
Research_Area Strategic Management of Transportation Systems
Focus_Areas alleviate congestion, surface transportation, institutional innovations

Center_Name: National Transportation Center
University: Morgan State University
Research_Area Transportation: A key to Human and Economic Devel.
Focus_Areas urban transportation problems

Center_Name: National Center for Trans. and Industrial Product
University: New Jersey Institute of Technology
Research_Area Productivity Increases Through Trans. Improvements
Focus_Areas public transit, logistics, provisions of transportation functions

Center_Name: Urban Transit Institute
University: North Carolina A&T State University
Research_Area Urban Transit Performance in Small and Rural Areas
Focus_Areas crash risk reduction, crisis management, traffic control

Center_Name: Center for Transportation and the Environment`
University: North Carolina State University
Research_Area Transportation and the Environment
Focus_Areas wildlife ecology, public transit

Center_Name: Mountain-Plains Consortium
University: North Dakota State University
Research_Area Rural and Intermodal Transportation
Focus_Areas rural transit, environmental impacts, recreational travel, low volume roads

Center_Name: Infrastucture Technology Institute
University: Northwestern University

Research_Area Infrastructure Technology
Focus_Areas remote monitoring technology, structural stability, bridges and dams

Center_Name: MAUTC
University: Pennsylvania State University
Research_Area Advanced Technologies in Trans. Operations & Manag
Focus_Areas bus transit, accident/risk management, pavement maintenance

Center_Name: Institute for Safe, Quiet and Durable Highways
University: Purdue University
Research_Area Safe, Quiet, and Durable Highways
Focus_Areas highway based transit systems, pavement and material design, traffic

Center_Name: Center for Advanced Infrastructure and Transport.
University: Rutgers University
Research_Area Advanced Trans. Infrastructure
Focus_Areas pavement materials, infrastructure, its

Center_Name: Mineta Transportation Institute
University: San Jose State University
Research_Area Policy Guidance of Trans. Management
Focus_Areas transportation and land use, analysis of pre- and post-construction

Center_Name: James E. Clyburn UTC
University: South Carolina State University
Research_Area Professional Capacity Building in Transportation
Focus_Areas public transit, accident prevention, its, designing fuel cells

Center_Name: Southwest Region UTC
University: Texas A&M University
Research_Area Transportation Solutions
Focus_Areas transit, highway, multimodal, economic growth and trade, mobility

Center_Name: UTC for Alabama
University: University of Alabama
Research_Area Management and Safety of Trans. Systems
Focus_Areas rural transit, safety computer programs, crash studies, bridges, work zones

Center_Name: Mack-Blackwell Transportation Center
University: University of Arkansas
Research_Area Rural Transportation
Focus_Areas physical infrastructure, trans. Education, construction, design, materials

Center_Name: Unversity of California Trans. Center
University: University of California-Berkeley
Research_Area Transportation Systems Analysis and Policy

Focus_Areas	urban planning, engineering economics, transportation systems
Center_Name:	Center for Advanced Transportation Systems Simulat
University:	University of Central Florida
Research_Area	Advanced Transportation Systems Simulation
Focus_Areas	planning, traffic operation, environmental analysis
Center_Name:	NCIT
University:	University of Denver and Mississippi State U.
Research_Area	Intermodal Transportation
Focus_Areas	intermodal traffic, traffic systems, intercity travel
Center_Name:	National Institute for Advanced Trans. Tech
University:	University of Idaho
Research_Area	Advanced Transportation Technology
Focus_Areas	Alternative fuels and engines, transportation software, lightweight vehicles
Center_Name:	Transportation Research Institute
University:	University of Michigan
Research_Area	Commericial Highway Trans.
Focus_Areas	statistical analysis, safety and efficiency of motor cars
Center_Name:	Center for Transportation Studies
University:	University of Minnesota
Research_Area	Human-Centered Trans. Technology
Focus_Areas	rural safety, ramp metering, cold weather operations, GPS technologies
Center_Name:	Unversity Tranportation Center
University:	University of Missouri, Rolla
Research_Area	Advanced Materials and Non-destructive testing Tec
Focus_Areas	shear-wave velocities, strut failure investigation, bridge rehab.
Center_Name:	Mid-America Transportation Center
University:	University of Nebraska, Lincoln
Research_Area	Design and Operations of Trans. Facilities
Focus_Areas	truck parking, rural highways, intersections, MwSWZDI
Center_Name:	URI Transportation Center
University:	University of Rhode Island
Research_Area	Surface Intermodal Trans. Systems
Focus_Areas	surface transportation, intermodal systems, environmental prtotection
Center_Name:	National Center for Metrpolitan Trans. Research
University:	Unversity of Southern Cal. And Cal. SU. Long beach
Research_Area	Metropolitan Transportation
Focus_Areas	highway capacity, freight routing, public transit, traffic simulation

Center_Name:	Center for Urban Transportation Research
University:	University of South Florida
Research_Area	Transit and Alternative Forms of Urban Trans.
Focus_Areas	transit buses, prototype transit materials, repair times of public transit

Center_Name:	Center for Tranportation Research
University:	University of Tennessee
Research_Area	Transportation Safety
Focus_Areas	crash predictions models, trans. And emergency services

Center_Name:	Transportation Northwest Regional Center-TransNow
University:	University of Washington
Research_Area	Transportation Operations and Planning
Focus_Areas	transportation operations and planning, infrastructure systems

Center_Name:	Midwest Regional Unversity Transportation Center
University:	University of Wisconsin-Madison
Research_Area	Optimization of Trans. Investment and Operations
Focus_Areas	systhesis of data, freight corridor study, systems management

Center_Name:	CUNY Insititute for Transportation Systems
University:	City University of New York
Research_Area	Transportation Engineering
Focus_Areas	planning, systems management, physical design

Center_Name:	School of Civil and Environmental Engineering
University:	Cornell Unveresity
Research_Area	Civil Infrastructure, Environment
Focus_Areas	Systems and management, design and contruction

Center_Name:	Georgia Transportation Institute
University:	Georgia Institute of Technology
Research_Area	Transportation Research and Education
Focus_Areas	environmental issues, transportation infrastucture, traffic operations

Center_Name:	Civil Engineering
University:	Kansas State University
Research_Area	Civil Engineering
Focus_Areas	environmental, hydraulics, geotechnology, pavement research

Center_Name:	Oklahoma Transportation Center
University:	Oklahoma State Unversity
Research_Area	Transportation and Telecommunications solutions
Focus_Areas	advanced materials and pavements, ITS, public trans., energy and

Center_Name:	Transportation Research Institute
University:	Oregon State Unversity
Research_Area	Infrastructure and Transportation
Focus_Areas	intel life cycle, nighttime flaggers, cold weather roads, wave and currents

Center_Name:	Transportation Research Institute
University:	Polytechnic Unversity
Research_Area	Transportation Research
Focus_Areas	travel demand management, pavement management, construction materials

Center_Name:	Department of Civil Engineering
University:	Rensselaer Polytechnic Institute
Research_Area	computational mechanics
Focus_Areas	predictions of earthquakes, electrified roadways, snowloads on stuctures

Center_Name:	Department of Civil and Environmental Engineering
University:	Tennessee Technological Unversity
Research_Area	Transportation Studies
Focus_Areas	enviroment, mechanics, structures, transportation, water resources

Center_Name:	Institute of Transportation Studies
University:	University of California, Davis
Research_Area	impacts of tranportation
Focus_Areas	travel behavior, environmental vehicle technology, environmental impacts

Center_Name:	Institute of Transportation Studies
University:	University of California, Irvine
Research_Area	solutions to contemporary trans. Problems
Focus_Areas	activity systems analysis, ITS, freight and logistics

Center_Name:	Institute of Transportation Studies
University:	University of California, Los Angeles
Research_Area	Transportation Research
Focus_Areas	informal travel mode, transit dependence, urban parkways

Center_Name:	Transportation Research Center
University:	University of Florida
Research_Area	Transportation Research
Focus_Areas	traffic modeling, intersection design, highway service

Center_Name:	Urban Transportation Center
University:	University of Illinois at Chicago
Research_Area	Urban transportation
Focus_Areas	ground level ozone, freight corridors, environmental justice

Center_Name:	Kentucky Transportation Center
University:	University of Kentucky
Research_Area	kentucky transportation
Focus_Areas	pavement resurfacing, traffic crashes, effects of warning signs

Center_Name:	Department of Civil and Environmental Engineering
University:	University of Louisville
Research_Area	Infrastucture Research
Focus_Areas	rapid void detection, earthquake hazard, elastomer degradation

Center_Name:	University of Massachusetts Transportation Center
University:	University of Massachusetts
Research_Area	Transportation Research
Focus_Areas	traffic safety, bay state roads, regional traveler info

Center_Name:	Department of Civil Engineering
University:	University of Memphis
Research_Area	civil engineering
Focus_Areas	bridge and highway design, water water treatment

Center_Name:	Department of Civil and Environmental Engineering
University:	University of Missouri, Columbia
Research_Area	transportation engineering
Focus_Areas	river ports, management systems, railroad crossings, ITS

Center_Name:	Center for Transportation Studies
University:	University of Missouri, St. Louis
Research_Area	transportation studies
Focus_Areas	taxicab curb design, airport ground transportation, technology transfer

Center_Name:	Transportation Research Center
University:	University of Nevada, las Vegas
Research_Area	transportation research, outreach activities
Focus_Areas	pedestrian safety, internet mapping, high crash locations

Center_Name:	Department of City and Regional Planning
University:	Univesity of North Carolina, Chapel Hill
Research_Area	regional planning
Focus_Areas	urban studies, water resources, natural resources, environmental planning

Center_Name:	Department of Electrical and Systems Engineering
University:	University of Pennsylvania
Research_Area	Modeling and design of complex systems
Focus_Areas	sensing and imaging, signal processing, urban transportation, networking

Center_Name:	Center for Transportation Research
University:	University of Texas at Austin
Research_Area	transportation Research
Focus_Areas	asphalt technology, contruction mobility, emissions testing, traffic safety

Center_Name:	Center for Transportation Studies
University:	University or Virginia
Research_Area	Transportation Research
Focus_Areas	ITS, truck flow, accident reduction, information technology, rail transit

Center_Name:	Vanderbuilt Eng. Center for Trans. Operations
University:	Vanderbuilt University
Research_Area	Trans. Research, education and Outreach
Focus_Areas	fleet management and tracking, spatial databases, highway traffic volumes

Center_Name:	Virginia Tech Transportation Institute
University:	Virginia Polytechnic Institute and State U.
Research_Area	Transportation Technologies
Focus_Areas	pavement research, ITS, Smart Road

Center_Name:	Department of Civil and Environmental Engineering
University:	Wayne State University
Research_Area	Applied Transportation Research
Focus_Areas	handicap access on buses, crash data processing, computer modeling

Center_Name:	Harley O. Staggers National Trans. Center
University:	West Virginia University
Research_Area	Transportation Research
Focus_Areas	pavement modeling and design, transportation planning, aviations

Center_Name:	
University:	University Of Southern Mississippi
Research_Area	
Focus_Areas	

Center_Name:

University: Texas Southern Mississippi

Research_Area

Focus_Areas

12. POTENTIAL FUNDING SOURCES

The subcontractor, Shel Leader, provided the following ideas regarding funding:

Funding sources can be divided into the following categories:

- Government
  - Appropriation
  - Projects
  - Subscriptions
- Alumni
  - Faculty Chair
  - Scholarships
  - Specific Research Grants
  - Matching Funds
- Private Industry (Corporate)
  - Grants
  - Projects
  - Subscriptions

The listed categories can be further defined as startup, short and long term:

- Startup
  - Government can, based on the submitted business plan provide a 3 to 5 year "get-started" appropriation. This would be equal to a decreasing percentage of the required operating budget designed to move the program toward self sufficiency. Example: The program requires an annual budget of $3 million per year to provide for the total cost of operations, plus $500 thousand for tools, computers, books, etc for startup. FHWA, could provide a sliding scale appropriation of 70% year one; 60% year two; 40% year three; 20% year four; 10% year five.
  - Alumni could contribute to the "tools" budget
  - Corporate donations could also be used to supplement the first year budget.
- Short Term
  - The state governments (on the WTI governing council could provide additional appropriations to help make up short falls in year one and two, with a larger percentage contributed in years three through five.
  - Alumni – continued contributions, plus scholarships and Faculty Chair to support the educational aims of the program.
  - Corporate contributions could be made in the form of subscriptions to news letters, database access, and random calls for information and support. Possible "seat" on an executive council, etc.
  - Corporate funding via actual project work.
- Long Term
  - FHWA and state and local governments will contract for project work.
  - Corporations will contract for project work
  - All categories of customers will subscribe to database access, newsletters via e-mail, and special web site access.
  - Sales of technical books and publications via the University bookstore, and Amazon

- Continued support from Alumni contribution funds.
- Sales of specialized software trouble shooting tools

Conclusions:

There are a number of potential sources of income; however, we must recognize that the primary revenue stream should come from project work. That is, if the primary objective of the SI program is to solve system integration problems, that is where most of the revenue should come from.

I am assuming that Alumni contributions and University general funds would be used to support the educational aspects. “Profits” from SI Program activities would be used to support growth and marketing as well as educational programs.