Program Progress Performance Report for University Transportation Centers
SOLARIS INSTITUTE

Safety and Operations of Large-Area Rural/Urban Intermodal Systems Institute

Submitted to:
U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology (OST-R)

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Report Term: Semi-annual

Program Director:
Dr. Zong Tian
SOLARIS Director
zongt@unr.edu
(775)-784-1232

Submitting Official:
Same as above

Recipient Organization:
University of Nevada, Reno
Mail Stop 258
Reno, NV 89557

Recipient Account Number:
1320-117-13SU

Signature of Submitting Official:

____________________________________
1. Accomplishments

1.1 What are the major goals and objectives of the program?
The major goals and objectives of the program as outlined in the proposal include the following categories.

Research
SOLARIS’s research is focused on safety in addition to other U.S. DOT strategic areas. The three main research areas involve: 1) Traffic Safety Data Management and Crash Mitigation; 2) Technologies for Safe Traffic Operations and Managements; and 3) Safe and Sustainable Infrastructure. SOLARIS will conduct applied research in all of these areas to produce methodologies and tools that can be implemented to tackle long-standing and emerging transportation issues. The expected outcomes of each research topic are listed below:

Traffic Safety Data Management and Crash Mitigation
- Improved quality of safety data through better data collection and inventory
- Implementation of scientifically sound crash data analysis methodologies and software tools
- Reduction of injury and fatal crashes in both rural and urban areas
- Maximization of the rate of return for all safety project investments

Technologies for Safe Traffic Operations and Management
- Congestion mitigation to reduce travelers’ frustration and to promote safe driving
- Reduction in air pollution and noise to promote livable communities
- Efficient freight movement to improve the regional and national economy

Sustainable and Safe Transportation Infrastructure
- Improved safety, mobility, and environment for tribal lands and rural towns
- Innovative materials that will prolong the life of pavements and bridges
• Expanding and integrating advanced traffic modeling technologies into infrastructure risk analysis under earthquake and other disastrous events

*Rigorous Project Selection Process*
To aid in the project selection process, SOLARIS organized a Technical Advisory Committee composed of professionals from public and private agencies. The Technical Advisory Committee is responsible for reviewing, ranking, and recommending research projects.

*Leadership*
SOLARIS is composed of several nationally and internationally known transportation programs and academic leaders. The resources from the five institutions composing the consortium make SOLARIS a highly qualified team that can significantly contribute to the advancement of transportation research. Four ways in which SOLARIS will measure the effectiveness of its leadership include studying innovative ideas that strengthen long-term vision and goals; delivering new models and tools that are readily implementable into practice, disseminating research through journal publications and conference presentations; participating in academic and professional organizations. The leadership group includes Center Director Zong Tian, Center Coordinator Erika Hutton, and Associate Directors Pitu Mirchandani from Arizona State University and Rafiqul Tarefder from the University of New Mexico.

*Education and Workforce Development*
Education and workforce development are important to the success of SOLARIS. The universities in the consortium currently have both undergraduate and graduate programs that focus on transportation. SOLARIS plans to enhance these transportation programs by providing course material in sustainability and mobility for large sparse rural-urban regions. Another educational and workforce development goal for SOLARIS is to hold workshops, conferences, and continuing education courses in order to educate the public, industry, and academic communities. Summer camps, internships, and fellowships will also be conducted in order to attract a new generation of professionals to transportation.

*Technology Transfer*
SOLARIS has established a plan in order to provide technology transfer. This plan includes the publication of reports, peer-reviewed journals, and conference papers; showcases; seminars; webinars; and international cooperation and collaboration. UNR hosts visiting scholars to present at seminars for transportation professionals and students. PhD and Master candidates are also
presenting at seminars every week at UNR. In addition, links to principal investigators presenting research through webinars is posted on the website.

**Collaboration**

SOLARIS has outlined the framework by which collaboration within the consortium, public agencies, educational and professional organizations, and industry and other private companies will be developed. This collaboration framework aims at providing collaborative brainstorming, research, decision making, and activities related to education and technology transfer. The following list provides detailed information about the different collaborative categories.

**Collaboration within the Consortium**

Some of the collaborative efforts involving the five institutions of SOLARIS include the sharing of transportation courses via interactive classrooms and distance learning technologies. This will provide students with a broad set of transportation-related courses, which no single university would be able to offer. SOLARIS has created collaborative committees in which faculty members from different institutions serve as graduate committee members. In addition, collaborative research between the institutions will best use institutional resources and expertise on delivering high quality research products.

**Collaboration with Public Agencies**

The different institutions composing SOLARIS have a strong collaborative effort with many transportation agencies. These agencies include the USDOT; the Departments of Transportation from Arizona, Nevada, and New Mexico; the Regional Transportation Commission (RTC) of Washoe County; the RTC of Southern Nevada; Maricopa County Department of Transportation, Maricopa Association of Governments, Cities of Phoenix, Tucson, and Tempe in Arizona; and the City of Las Vegas.

**Collaboration with Educational and Professional Organizations**

Outreach activities for K-12 schools and tribal colleges will focus on recruiting students that are interested in transportation research and education. The faculty members of the consortium are active in various professional organizations such as ASCE, ITE, TRB, APTA, INFORMS, and ITS America. In addition, the faculty members have or are currently serving as committee chairs in some of these organizations.
Collaboration with Industry and Private Companies

Partnerships with industry, industry-related organizations, and private companies are encouraged by SOLARIS in order to develop, promote and support transportation research and education. These types of collaboration efforts will effectively promote technology transfer activities.

1.2 What was accomplished under these goals?

Research

Quarterly progress reports are still being required to confirm projects are on schedule with a sufficient completion rate. The reports are now designed to fulfill the needs of matching organizations as well as the UTC program’s requirements.

Projects from the original grant dates have been completed and awaiting final report submissions. The total number of completed projects is now 38. Only two projects remain, which were granted the extension period to May 30, 2019.

Leadership

Center Coordinator Erika Hutton and Associate Directors Pitu Mirchandani (ASU) and Rafiqul Tarefder (UNM) continue their roles at SOLARIS. Dr. Nader Ghafoori continues serving as the UNLV Coordinator.

Center Director Zong Tian is a member of the planning committees for two major international conferences: International Symposium on Enhancing Highway Performance and World Conference on Transportation Society (WCTRS). Dr. Tian continues his role as Technical Area Manager (TAM) for overseeing Area C of the WCTRS, which includes four Special Interest Groups covering traffic operations, traffic safety, highway capacity and design, and intelligent transportation systems.

Education and Workforce Development

The 3rd Civil/Transportation Engineering Summer Camp at UNR took place in July 2018. Almost 30 high school students attended the week-long camp which consisted of lectures and hands-on activities in transportation, bridges and water treatment. The camp also included field trips to the Verdi Water Treatment Facility and the Reno-Stead Airport Project.
Technology Transfer
The center has been conducting weekly seminars. In these seminars, guest speakers and graduate students present their current research activities. Guest speakers are scheduled once a month, if possible, during the semester. The upcoming seminar schedule and past presentations are posted on the SOLARIS website.

A workshop was hosted at UNR and Lake Tahoe in May for university faculty and professional engineers who are interested in traffic signal control. Critical issues and cutting-edge technology applications were a major part of the 3-day workshop, which also included overview of signal control basics, hands-on signal timing plan development, site visits, timing verifications, and practical-oriented research topics in signal control.

Collaboration
The collaboration efforts SOLARIS has been part of during this reporting period include the following:

- Collaborate with Trans-Intelligence on continuing outreach and technology transfer activities by offering agencies case demos of the TranSync tool.
- Collaborate with Econolite Inc., one of the major signal controller manufacturers in the U.S., to develop the PASS system for research and education.
- Collaborate with Beijing University of Technology to jointly develop the PASS system.
- Collaborate with University of Arizona to assist City of Tucson on performance-driven signal timing approaches and applications.
- Collaborate with Connected Signals, LLC. to use real-time signal status data for improving arterial signal operations.

Collaboration within the Consortium
No new activities for this period.

Collaboration with Public Agencies
The Nevada Department of Transportation Board continues to match projects to be conducted by consortium members within Nevada, including the University of Nevada, Reno, the University of Nevada, Las Vegas, and the Desert Research Institute.
UNR researchers continue to work with the RTCs in both Washoe County and Las Vegas to address imminent transportation issues and improve transportation system efficiency, such as implementing new signal timing for arterial streets. One new area of research is application of LiDAR technologies in traffic safety and traffic operations. Additional funding has been provided by NDOT and RTC on this cutting-edge research.

UNR and University of Arizona are collaborating on pursuing research projects to improve signal coordination for both Arizona and Nevada.

Dr. Tian from UNR and Dr. Wu from UA continue to work on two projects, sponsored by the City of Tucson and Nevada DOT. Additional funding and agreements are in process with City of Phoenix, AZ.

Dr. Tian is collaborating with RTC in Southern Nevada by providing technical support and training on signal timing. A new contract was awarded for using the TranSync tool for improving existing traffic signal timing practices. UNR researchers also helped develop a software to automatically score and rank corridor performance using GPS data generated from paratransit vehicles. The corridors are then selected for the re-timing project.

Collaboration with Educational and Professional Organizations
UNR successfully collaborated with Beijing University of Technology, China to jointly develop a realistic signal system simulation system called PASS (Physical Arterial Signal Simulation) that connects micro-simulation, real NEMA controllers, and physical small-size intersections and cars, which will be used for education and research purposes. This is the first-ever system that has been developed and has been fully set up and functioning after shipment of the physical model from China. PASS is anticipated to provide close-to-real signal control systems where students can learn the process of designing, implementing, and evaluating signal control in a lab environment.

Collaboration with Industry and Private Companies
The Center for Advanced Transportation Education and Research (CATER) at UNR has established an advanced traffic signal control lab with partial sponsorship from Econolite Inc. Econolite has donated their Centracs control software for research purposes. UNR has also been collaborating with Trans-Intelligence, LLC to advance the TranSync software. Trans-Intelligence provided $15,000 to support UNR’s effort.
Alon Asphalt USA, Ergon Asphalt Co. and Western Emulsions continued to supply engineered emulsions for the conduct of laboratory experiments and provide technical input on field applications and construction techniques. The research team also worked with local agencies such as Carson City Public Works and Douglas County Public Works to collect materials from ongoing pavement construction projects.

Dr. Sanders of UNR collaborated with various companies to gain information on various sealers. These include Sika, Prosoco, Advanced Chemical Tech, BASF, ChemMasters, Echem, Transportation Industries, Five Star and KwikBond.

Additional collaborations may be found in Table 2 under Section 3.2.

1.3 What opportunities for training and professional development has the program provided?
The weekly seminars are open to the general public, particularly to local and state transportation agencies and graduate students. Training workshops were hosted to promote traffic signal timing and coordination practices and invited industry and academia professionals.

1.4 How have the results been disseminated?
- Thirty-two final reports have been completed and sent to the various agencies as required by the grant.
- Several presentations and publications have been made based on the research.
- Test beds have been set up in both Reno and Las Vegas to use LiDAR for pedestrian detection
- Two training sessions are being set up for training Caltrans traffic signal engineers on using TranSync for signal re-timing projects.
- UNR is helping City of Tucson to implement flashing-yellow-arrow to improve signal coordination.

1.5 What do you plan to do during the next reporting period to accomplish the goals and objectives?
The following tasks are planned in order to accomplish the goals and objectives of SOLARIS.

- Stay updated on final funded projects and their progress.
- Update SOLARIS website and RiP as necessary.
- Attend TRB meeting in January
• Continue fostering professional relationships for Distinguished Lecturer seminar series.
• Start grant close-out and final deliverables

2. Products

2.1 Publications, conference papers, and presentations

LiDAR research at UNR continues to make marked progress with two related papers presented at conferences. “An Automatic Procedure for Vehicle Tracking with a Roadside LiDAR Sensor” by Jianqing Wu was selected as a winner and presented at the 2018 ITE Joint Western and Texas District Meeting as well as the ITE International and Midwestern/Great Lakes District Meeting. In addition, “Vehicle Pedestrian Near-Crash Identification with Roadside LiDAR Data” was also awarded and presented at the 58th Annual Intermountain Section Meeting.

Dr. Tian made a presentation at the COTA annual conference in Beijing to introduce the PASS system.

Ph.D candidate Aobo Wang made a presentation titled “Monitoring Signal System Performance using Broadcasted Traffic Signal Status Data” at the Fall Transportation Conference in Las Vegas. This is a collaboration with Connected Signals LLC.

2.2 Website(s) or other internet site(s)

The SOLARIS website is located at http://www.unr.edu/solaris. This website is used to disseminate any information related to the program. It is updated monthly, or as needed.

2.3 Technologies or techniques

The TranSync tool continues to be promoted to agencies to improve the current practice on signal timing and coordination. Field demos were provided to the following agencies: Kansas City in Missouri and Orange County, CA.
Dr. Hao Xu at UNR has been testing LiDAR technology on signal control and safety under the connected vehicle environment. LiDAR sensors have been installed at two intersections in Reno, and two intersections in Las Vegas. More implementations are being planned in Reno with support from the Regional Transportation Commission of Washoe County.

UNR continues to work with NDOT on implementing SafetyAnalyst software for traffic safety data management and analysis.

UNR has initiated a research project with the Nevada Department of Transportation on “Developing a Quality of Signal Timing Performance Index”. The research will refine the methodology developed earlier by UNR researchers. It is anticipated that the outcome of the research will provide a needed guideline for agencies across the country to assess the quality of signal timing based on vehicle trajectory data, either collected through traditional floating car techniques or future connected and autonomous vehicles.

2.4 Inventions, patent applications, and/or licenses
Nothing to report for this period.

2.5 Other products
Nothing to report for this period.

3. Participants & Collaborating Organizations

3.1 Who has worked on the program?
The members of SOLARIS include the University of Nevada, Reno (UNR); the University of Nevada, Las Vegas (UNLV); Arizona State University (ASU); the University of New Mexico (UNM); and the Desert Research Institute (DRI). Table 1 lists the individuals who have worked on the program during this reporting period.
### Table 1: SOLARIS Staff Working on the Program

<table>
<thead>
<tr>
<th>Name</th>
<th>Zong Tian</th>
<th>Pitu B. Mirchandani</th>
<th>Rafiqul A. Tarefder</th>
<th>Nader Ghafoori</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program/Project Role</td>
<td>Program Director</td>
<td>Associate Director at ASU</td>
<td>Associate Director at UNM</td>
<td>UNLV Coordinator</td>
</tr>
<tr>
<td>Number of hours worked during the reporting period</td>
<td>180</td>
<td>100</td>
<td>80</td>
<td>40</td>
</tr>
</tbody>
</table>

**Contribution to Program/Project**

- **Zong Tian**: Oversees overall operations of the program. Responsible for coordinating with stakeholders and developing and implementing the SOLARIS Strategic Plan.
- **Pitu B. Mirchandani**: Serves as liaison between SOLARIS and ASU.
- **Rafiqul A. Tarefder**: Serves as liaison between SOLARIS and UNM.
- **Nader Ghafoori**: Serves as liaison between SOLARIS and UNLV.

### Funding Support

<table>
<thead>
<tr>
<th></th>
<th>UNR</th>
<th>ASU</th>
<th>UNM</th>
<th>UNLV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collaborated with individual in foreign country</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td><strong>Country(ies) of foreign collaborator</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Traveled to foreign country (for center related business)</strong></td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td><strong>If traveled to foreign country(ies), duration of stay</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### 3.2 What organizations have been involved as partners?

Table 2 lists the organizations that have partnerships with SOLARIS and Table 3 lists the members of the Technical Advisory Committee.
<table>
<thead>
<tr>
<th>Organization Name</th>
<th>Location of Organization</th>
<th>Partners Contribution to Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevada Department of Transportation</td>
<td>Nevada</td>
<td>Financial Support: X</td>
</tr>
<tr>
<td>Regional Transportation Commission of Washoe County</td>
<td>Nevada</td>
<td>In-kind support: X</td>
</tr>
<tr>
<td>Regional Transportation Commission of Southern Nevada</td>
<td>Nevada</td>
<td>Facilities: X</td>
</tr>
<tr>
<td>Las Vegas Global Economic Alliance</td>
<td>Nevada</td>
<td>Collaborative Research: X</td>
</tr>
<tr>
<td>New Mexico Department of Transportation</td>
<td>New Mexico</td>
<td>Personal Exchanges: X</td>
</tr>
<tr>
<td>Maricopa Association of Governments</td>
<td>Arizona</td>
<td></td>
</tr>
<tr>
<td>Arizona Department of Transportation</td>
<td>Arizona</td>
<td></td>
</tr>
<tr>
<td>California Department of Transportation</td>
<td>California</td>
<td></td>
</tr>
<tr>
<td>Econolite Control Products Inc.</td>
<td>California</td>
<td>X</td>
</tr>
<tr>
<td>City of Carson City</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>Douglas County</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>Trans-Intelligence, LLC</td>
<td>Texas</td>
<td>X</td>
</tr>
<tr>
<td>Texas Tech University</td>
<td>Texas</td>
<td>X</td>
</tr>
<tr>
<td>Nevada Highway Patrol</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>HollyFrontier Refining and Marketing</td>
<td>Arizona</td>
<td>X</td>
</tr>
<tr>
<td>Alon Asphalt USA</td>
<td>California</td>
<td>X</td>
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<tr>
<td>Ergon Asphalt Co</td>
<td>Mississippi</td>
<td>X</td>
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<tr>
<td>Western Emulsions</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>City of Las Vegas</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>Nevada Cement Company</td>
<td>Nevada</td>
<td>X</td>
</tr>
<tr>
<td>New Mexico State University</td>
<td>New Mexico</td>
<td>X</td>
</tr>
<tr>
<td>USDA, Jornada Experimental Range</td>
<td>New Mexico</td>
<td>X</td>
</tr>
<tr>
<td>Bureau of Land Management</td>
<td>New Mexico</td>
<td>X</td>
</tr>
<tr>
<td>National Resource Conservation Service</td>
<td>New Mexico</td>
<td>X</td>
</tr>
</tbody>
</table>
### Table 3: Technical Advisory Committee Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Expertise</th>
<th>Position/Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nevada</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracy Larkin (Chair)</td>
<td>Operations, Design</td>
<td>Deputy Director, NDOT</td>
</tr>
<tr>
<td>Mike Fuess</td>
<td>Traffic Operations</td>
<td>Assistant District Engineering, District 2, NDOT</td>
</tr>
<tr>
<td>Ken Mammen</td>
<td>Safety</td>
<td>Chief Safety Engineer, NDOT Planning</td>
</tr>
<tr>
<td>Steve Merrill</td>
<td>Design/GIS</td>
<td>Chief Engineer, Location Division, NDOT</td>
</tr>
<tr>
<td>Troy Martin</td>
<td>Structure</td>
<td>Engineer, Bridge Division, NDOT</td>
</tr>
<tr>
<td>Nathan Morian</td>
<td>Pavement</td>
<td>Engineer, Materials Division, NDOT</td>
</tr>
<tr>
<td>Randy Travis</td>
<td>Traffic Information/Planning</td>
<td>Chief, Traffic Information, NDOT</td>
</tr>
<tr>
<td>Manju Kumar</td>
<td>Operations, Planning</td>
<td>Research Coordinator, NDOT</td>
</tr>
<tr>
<td>Jim Poston</td>
<td>ITS/Operations</td>
<td>Engineer, RTC of Washoe County</td>
</tr>
<tr>
<td>Scott Gibson</td>
<td>Pavement</td>
<td>Engineer, RTC of Washoe County</td>
</tr>
<tr>
<td>Brian Hoeft</td>
<td>Traffic Operations</td>
<td>Director of FAST, RTC Southern Nevada</td>
</tr>
<tr>
<td>Raymond Hess</td>
<td>Transportation Planning</td>
<td>Manager, Planning Division, RTC Southern Nevada</td>
</tr>
<tr>
<td>Sondra Rosenberg</td>
<td>Transportation Planning</td>
<td>Assistant Director of Planning, NDOT</td>
</tr>
<tr>
<td><strong>New Mexico</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mohammad Moabed</td>
<td>Pavement/Traffic</td>
<td>Former District 2 Engineer, NMDOT</td>
</tr>
<tr>
<td>Parveez Anwar</td>
<td>Pavement Materials</td>
<td>Engineer, NMDOT</td>
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<tr>
<td><strong>Arizona</strong></td>
<td></td>
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<tr>
<td>Sarath Joshua</td>
<td>ITS/Safety</td>
<td>Program Manager, Maricopa Association of Governments</td>
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<tr>
<td>Scott E. Nodes</td>
<td>Traffic/Design</td>
<td>Arizona DOT</td>
</tr>
<tr>
<td><strong>Academia (External)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robert Bertini</td>
<td>ITS/Traffic</td>
<td>Professor, Portland State University</td>
</tr>
</tbody>
</table>
3.3 Have other collaborators or contacts been involved?
UNR is teaming up with KOA, a consulting company in southern California, to introduce TranSync into the signal timing practice in that region. A similar project is pursued with City of Ontario. UNR has worked with Missouri S&T University to introduce the TranSync tool to Kansas City in improving their signal timing practices. A case study was conducted in an arterial and major improvements have been shown with the new optimized results. In addition, Clackamas County in Oregon is in the process of acquiring the TranSync tool after a presentation in April at the Regional Transport quarterly meeting.

4. Impact

4.1 What is the impact on the development of the principal discipline(s) of the program?
Transportation Engineering at UNR has drawn more attention within the college and community due to the various activities that have been created under the grant. Not only do events like the summer camp and distinguished seminar series contribute to this attention, but most notably, so do the activities in technology transfer and research. Particularly, TranSync is now being used in over 20 jurisdictions, including the official adoption by Caltrans as their signal timing tool. Additionally, UNR’s LiDAR research is attracting attention throughout the country and China. UNR had been in negotiation with DiDi, a major rideshare company in China, to use LiDAR for vehicle detection and arterial operations. Velodyn, the largest LiDAR manufacturer, has offered UNR researchers product support to explore potential large-scale deployment of LiDAR for connected vehicle applications.

4.2 What is the impact on other disciplines?
Nothing to Report.

4.3 What is the impact on the development of transportation workforce development?
Exchange of information has been made possible through Distinguished Lecturer Seminars, which include professional and academic entities, held at the University of Nevada, Reno. In addition, workshops and demo presentations at other jurisdictions have furthered the awareness and adoption of the TranSync tool as well as advanced signal timing practices.
4.4 What is the impact on physical, institutional, and information resources at the university or other partner institutions?
Most importantly, research in the signal control area has attracted interests from various agencies, which could become potential sponsors in the future.

4.5 What is the impact on technology transfer?
Technology transfer has been a crucial point in establishing the success of advanced research. Presentations have been made at international and regional conferences which have focused primarily on TranSync and LiDAR to improve practices and advance tools for research. The signal timing tools have also been tested in agencies across the country to improve the efficiency of developing signal timing plans. Our proposed signal timing methodology can have major impacts nationwide on the way we do signal coordination, such as developing timing plans without traditional manual turning movement counts. LiDAR is an emerging technology that can have the potential of providing much more accurate and continuous detection of all modes of traffic: vehicles, pedestrians, and bicycles. With possible future widespread deployments, it could drive the price down significantly, thus making it possible to replace other conventional detection technologies.

4.6 What is the impact on society beyond science and technology?
The development and implementation of tools such as TranSync and PASS assist current and future engineers in providing society with optimized signal timing situations. Improvements done with these tools can provide significant reduction in travel time and user costs as well as hazardous emissions, improving air quality. So far, each of our signal timing projects has produced emission reductions up to 25 tons annually. In addition, the efficiency of these tools and first-of-its-kind features assist in improving the quality of life for society and protection of natural resources.

5. Changes/Problems

5.1 Changes in approach and reasons for change
Nothing to Report
5.2  Actual or anticipated problems or delays and actions or plans to resolve them
Nothing to Report

5.3  Changes that have a significant impact on expenditures
No significant impact is perceived.

5.4  Significant change in use or care of animals, human subjects, and/or biohazards
Nothing to Report

5.5  Changes of primary performance site location from that originally proposed
Nothing to Report

5.6  Additional information regarding products and impacts
Nothing to Report

6.  Special Reporting Requirements
The University of Nevada, Reno’s Office of Sponsored Projects will submit Federal Financial Reports as needed.