AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): California Department of Transportation

2. Name and Title: Aaron Chamberlin, Division of Constriction Senior Innovation Engineer; Chris Thornton, Office of Land Surveys Chief of New Technology Systems; Mark Counts, Office of Land Surveys Chief of Surveying Systems.

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Innovation Description (10 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

Caltrans Real Time Global Navigation Satellite Systems Network (CRTGN) Expansion and use for Automated Machine Guidance (AMG) inspection using Global Navigation Satellite Systems (GNSS)

4. Please describe the innovation.

Caltrans CRTGN is robust statewide GNSS network that provides real-time differential corrections to GNSS equipment, which can be utilized to support projects. With the expansion of the CRTGN during construction projects has enabled Caltrans to streamline support for Surveys, Construction, Asset Management and Maintenance. This innovation has been a primary driver of the successful implementation of Automated Machine Guidance (AMG) efforts statewide. This innovation is allowing the department to rapidly and efficiently move into the digital construction environment with less staff training. Staff can be trained to utilize the system rapidly and efficiently to reduce staking intervals, enabling concurrent asset location collection, roadway inspection, and modernizes existing workflows.

5. What is the existing baseline practice that the innovation intends to replace/improve?

This innovation streamlines the process for roadway inspection, which historically has been completed with conventional surveying methods. Traditional earthwork inspection involved the use of hand levels, laser levels, distance wheels, and stringlines to verify line and grade from survey stakes. Inspectors equipped with cross sections and/or slope stake notes were required to inspect horizontal and vertical tolerance compliance, station by station. These workflows for grade verification of large new alignments could take weeks depending on project complexities such as, site conditions, traffic volumes, project size, and tasks requiring multiple staff working together. Often the contractors were slowed down by this process, which adds to the overall duration of a project and potential claims filed.

6. What problems associated with the baseline practice does the innovation propose to solve?

This innovation replaces and streamlines antiquated inspection methods by leveraging state of the art GNSS technology. The use of 3D alignments and surfaces streamlines this process. 3D design models are loaded into field data collectors and are then used to verify line and grade utilizing GNSS equipment referenced to the CRTGN network. GNSS equipment significantly improves the roadway inspection process and reduces the number of staff required to complete the work. GNSS equipment can be connected to the CRTGN within seconds through a simple cellular service, substantially reducing setup time and requiring less GNSS equipment. In some instances, Unmanned Aircraft Systems (UAS) can be used to verify earthwork quantities using the CRTGN network, which further reduces inspection times. This innovation has improved cost, reduced time, and has enhanced project safety. Over 50 projects have been completed to date, by leveraging state of the art GNSS technology, yielding a capital outlay support savings in excess of $5 million dollars. This innovation is a key to successfully implement the Department's AMG and Building Information Modeling (BIM) for Infrastructure vision.

7. Briefly describe the history of its development.

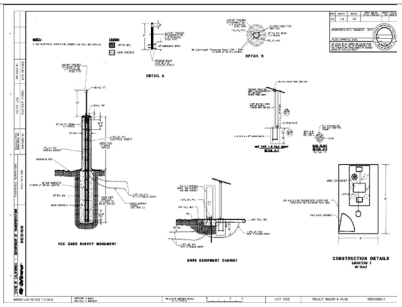
Caltrans first began to implement pilot projects for AMG in March of 2016, with additional pilots in following years. Obstacles were identified in the pilot projects which included the lack of an independent check while using contractor models and leased equipment. Inefficiencies and errors associated with daily setup and takedown of GNSS equipment was also encountered. In April of 2018, the first permanent

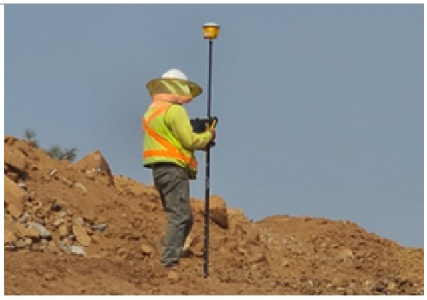
Real Time Network (RTN) station was constructed for a Caltrans project that enabled a continuous GNSS connection to be received for both the contractor's GNSS equipment and state owned GNSS equipment.

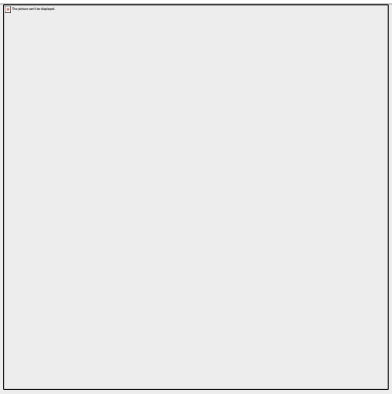
8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

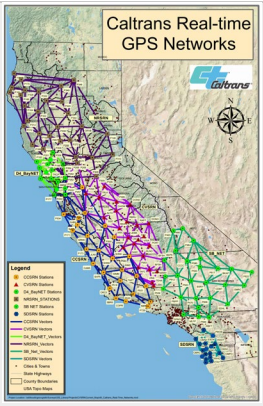
- Automated Machine Guidance (AMG) Training Guide
- Automated Machine Guidance (AMG) Specifications
- Division of Research, Innovation & System Information analysis on Real Time Networks
- Plans and Specifications for Caltrans Real Time Global Navigation Satellite Systems Network (CRTGN)

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.









State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☐ Prototype has been piloted successfully in an operational environment

☐ Technology has been deployed multiple times in an operational environment

☒ Technology is ready for full-scale implementation

To date, 10 new RTN stations have been completed as of September 2021 in various locations throughout California, adding to the 198 existing stations or partner stations connected to the network. Over 45 GNSS receivers have been deployed for AMG inspection with an additional 50 receivers on order. Caltrans hopes to equip staff with hundreds of receivers in the coming years.

10. What additional development is necessary to enable implementation of the innovation for routine use?

Funding for equipment, software, support budgets, and permanent staffing is needed to continue the expansion of the CRTGN. This innovation is considered a critical technology for the implementation of BIM for Infrastructure for the Caltrans Division of Construction and the Office of Land Surveys.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☒ Yes ☐ No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
Oregon DOT	Chris Pucci	(503) 302-5474	Christopher.PUCCI@odot.state.or.us
Ohio DOT	Kolton Wilson	(614)-752-634	Kolton.Wilson@dot.ohio.gov
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Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice.

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

This innovation has improved efficiencies, processes and quality assurance for both Caltrans, Department of Water Resources, Local Agencies and Transportation Authorities. With the implementation of BIM for Infrastructure, it will provide the critical survey grade accuracy needed to solve issues such as underground utility conflicts, asset collection, and asset management. Access to the CRTGN has been shared with other state agencies and local governments, meeting their geospatial needs. The CRTGN provides any entity connected to the network, to collect centimeter grade accuracy data, without the use of line of sight surveying equipment. Leveraging this technology can be utilized to support Asset Managers, Maintenance, and can replace paper as-builts.

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	Inspection and surveying task durations are shortened, reducing exposure to traffic and heavy equipment for our field staff conducting surveying and inspection work. The CRTGN also provides data streams that can be utilized by UAS systems, limiting field staff exposure. Earthwork projects have been surveyed and verified by UAS without the need for inspectors to be on the ground near heavy equipment or traffic.
Improved Quality	Model based inspection has led to more detailed inspection and improved accuracy, which leads to higher quality and less rework. Collection of assets while they are being installed, feeding our statewide utility database, reducing future utility conflicts.
Organizational Efficiency	Caltrans has realized over $5 Million in capital support savings, documented on 40 projects utilizing AMG. This innovation has improved the workflow efficiencies associated with surveying and construction inspection. Caltrans will be implementing mandatory AMG

	specifications for all earthwork projects in early 2022. In addition to savings documented by these projects, contract duration has decreased by an average of 2%, which equates to less delay for the public.

Provide any additional description, if necessary:

Click or tap here to enter text.

14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

This innovation is being looked at as essential technology supporting the transition to BIM for Infrastructure. It will be a critical element to support asset management, maintenance, environmental, and local partners/private industry. This innovation can also be leveraged by autonomous vehicles, UAS, and augmented reality/virtual reality.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☒	Gaining executive leadership support	Leadership must be educated in the importance of the technology and prioritize the up-front capital costs for equipment and training.
☒	Communicating benefits	Leadership, internal staff, Information Technology (IT) managers and external partners must be educated on the cost savings and return on investment. Safety, efficiency, and quality are key elements.
☒	Overcoming funding constraints	Leadership must buy-in to the innovation and break down organizational barriers. Finance departments must be educated to the advantages and support the investment. IT departments must assist in the data connectivity, costs of the system and other support needs.
☒	Acquiring in-house capabilities	IT constraints may exist within organizations. Leadership may be required to break down barriers.
☐	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	NA
☐	Resolving conflicts with existing national/state regulations and standards	NA

☒	Other challenges	Field staff training and buy in are required for successful use of the system. New CRTGN stations may require additional Right-of-Way.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: Average costs of a single CRTGN station are $50,000 each. On larger projects, the efficiencies gained by the system exceed the costs of the system within nine to twelve months and reoccurring station maintenance cost.

Level of Effort: CRTGN stations can be physically constructed in as few as three business days with conventional tools and equipment.

Time: Total time involved including the procurement of equipment and parts can be completed in under six weeks.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

Detailed parts lists for the installations have been developed, along with detailed specifications and plan sheets. Electrical contractors familiar with Caltrans electrical work had no difficulties in the procurement of components and construction of CRTGN stations. Caltrans staff configure the software and connect the stations to the centralized server. Staff are then trained on the use of GNSS equipment in Just-In-Time (JIT) trainings that take a few hours.