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16. ABSTRACT
This report summarizes support and training for the Mountain Pass Road Opening (MPRO) Systems for the 2022 pass opening season. This implementation effort was supported and performed under Task 4010, "Research Implementation Accelerator: Workshops and Seed Funding Program." The effort included preparation of the MPRO systems for the pass opening season, provisioning of Satellite-Based Augmentation Service (SBAS) for the position and heading sensors, training of Maintenance personnel, and final demonstrations at the four maintenance yards. Based on this implementation effort, the eight MPRO systems are now successfully deployed, and Caltrans has the ability to train additional operators, prepare the systems each year, and make full use of the systems to guide their pass opening efforts.

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Implementation Support for Mountain Pass Road Opening (MPRO) Systems

Kin Yen, Vic Reveles, and Ty Lasky

Report Number: CA22-4010
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California Department of Transportation

Division of Research, Innovation and System Information

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List of Acronyms and Abbreviations

Acronym	Definition
AHMCT	Advanced Highway Maintenance and Construction Technology Research Center
Caltrans	California Department of Transportation
DOT	Department of Transportation
DRISI	Caltrans Division of Research, Innovation and System Information
ESN	Electronic Serial Number
GNSS	Global Navigation Satellite System
MPRO	Mountain Pass Road Opening
SBAS	Satellite-Based Augmentation Service
SR	State Route

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Mountain Pass Road Opening (MPRO) Implementation Support

The MPRO system was officially deployed to Caltrans in April 2021. Based upon discussions with Maintenance and the Division of Research, Innovation and System Information (DRISI), the current project was developed to provide support for one additional year of system preparation, training, demonstration, and support, all for the 2022 pass opening season. This report summarizes this implementation effort, which occurred within Task 4010, "Research Implementation Accelerator: Workshops and Seed Funding Program." Detailed discussion of the MPRO system and its development and testing is provided in prior research [1], including lessons learned, user instructions, and system setup.

Objective

The objective of this research effort was to provide support for Caltrans use of MPRO systems in April, 2022 road opening operation. The primary goal was final transition of all preparation and training for use of MPRO to Caltrans staff.

Summary of Effort

The Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center worked closely with Maintenance and DRISI throughout this effort. AHMCT prepared the systems in accordance with the instructions provided in prior research [1]. ***The key preparation task was procurement of the Satellite-Based Augmentation Service (SBAS), which provides the differential corrections needed by the MPRO system to achieve 10-cm-level accuracy.*** The SBAS service must be procured and provisioned every season (year). Budget must be available to procure the service, and Caltrans must retain the expertise to provision the SBAS for each MPRO system in the future. For the current effort, AHMCT procured service for one month for each system used. The provisioning steps are documented in prior research [1]. The specific service to be used is Atlas H10 SBAS differential correction service. In 2022, this service costs $180 per month per system, or $485 per quarter per system. The service must be tied to an individual Hemisphere Vector V500 GNSS (Global Navigation Satellite System) receiver by way of the receiver electronic serial number (ESN). The services may be pre-paid, and the dealer will provide the activation code(s) upon the start day of the road opening. The V500 GNSS receiver ESNs are provided in a table in Appendix A.

AHMCT worked with DRISI and Maintenance to arrange a date for training and demonstration at each of the maintenance yards. The final dates are provided in Table 1, including the State Route (SR). Snow build-up at Tioga Pass

did not justify installing and testing the MPRO system in April 2022, so the system was demonstrated on an AHMCT research vehicle for this site.

Table 1: Training and demonstration dates for the four maintenance yards

Maintenance Yard	SR	Pass	Date
Woodfords	4	Ebbetts (East of Ebbetts Peak)	April 4, 2022
Sonora Junction	108	Sonora (East of the summit)	April 5, 2022
Lee Vining	120	Tioga	April 6, 2022
Camp Connell	4	Ebbetts (West of Ebbetts Peak)	April 8, 2022

The remaining figures illustrate MPRO use and demonstration at the four deployment sites. The training was successful at each of the yards, and Caltrans Maintenance staff were prepared to use the MPRO system in their pass opening operation. The snow build-up once again was not sufficient to illustrate the benefits of the system (see Table 2 for snowfall information provided by Caltrans). However, Caltrans Maintenance received the needed information and training to prepare the systems and train new operators in future seasons. As such, the MPRO system is now fully deployed into regular Caltrans operations. AHMCT remains available for support questions should they arise.

Table 2: Partial snow build-up record

Maintenance Yard	Normal snowfall	20/21 snowfall	21/22 snowfall	20/21 % normal	21/22 % normal
Groveland	70"	48"		69%	
Long Barn	203"	94"		46%	
Caples Lake	346.5"	203.5"	251"	59%	72%
Camp Connell	320"	188"		59%	

Key seasonal MPRO preparation includes the following steps:

- Check for equipment availability/readiness
- Confirm cabling and power are already installed on the equipment
- Check the serial number of the Vector V500 GNSS receiver for each system

- Purchase Atlas H10 SBAS differential correction service, for either one or three months, for each system (in 2022, $180/month or $485/quarter per system)
- Provision SBAS service on corresponding MPRO systems on site following instructions from previous report [1]
- Test systems in on site, and train operators
- Deploy MPRO in field as lead vehicle

Figure 1: The pass opening challenge and the end goal

Figure 2: MPRO Hemisphere V500 Vector GNSS sensor mounted on top of a loader using magnetic mount

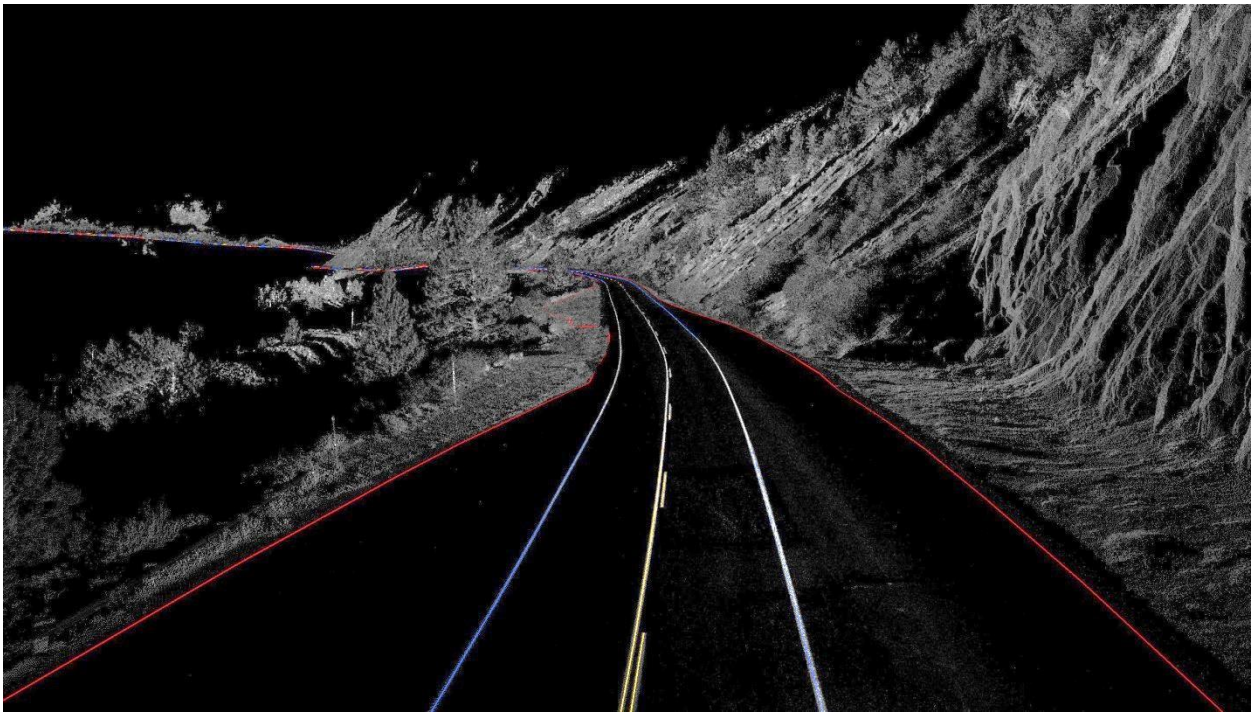

Figure 3: Example MPRO base map for SR120, overlaid on top of the MTLS point cloud and derived using MTLS

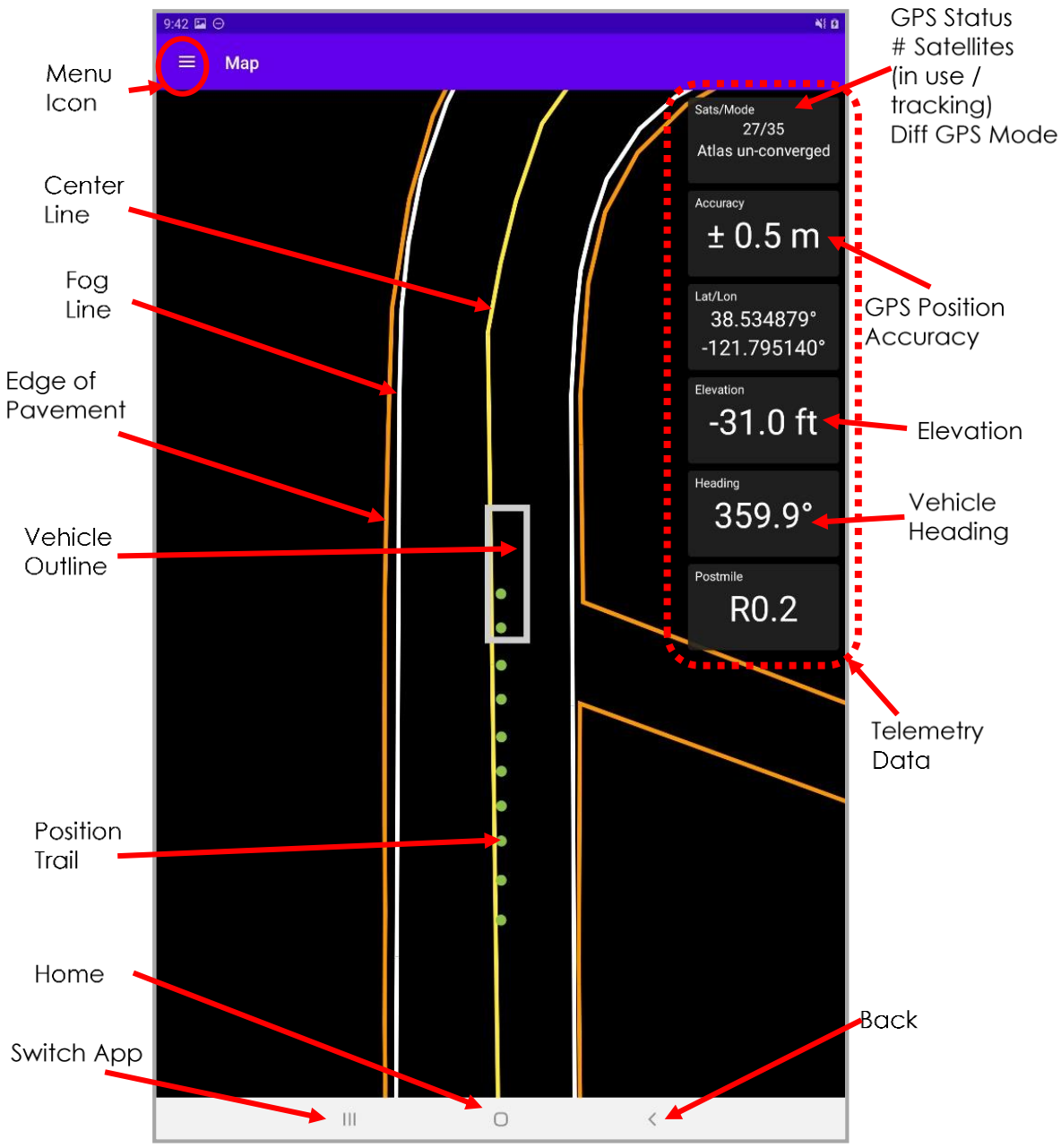

Figure 4: The MPRO HMI on an Android tablet

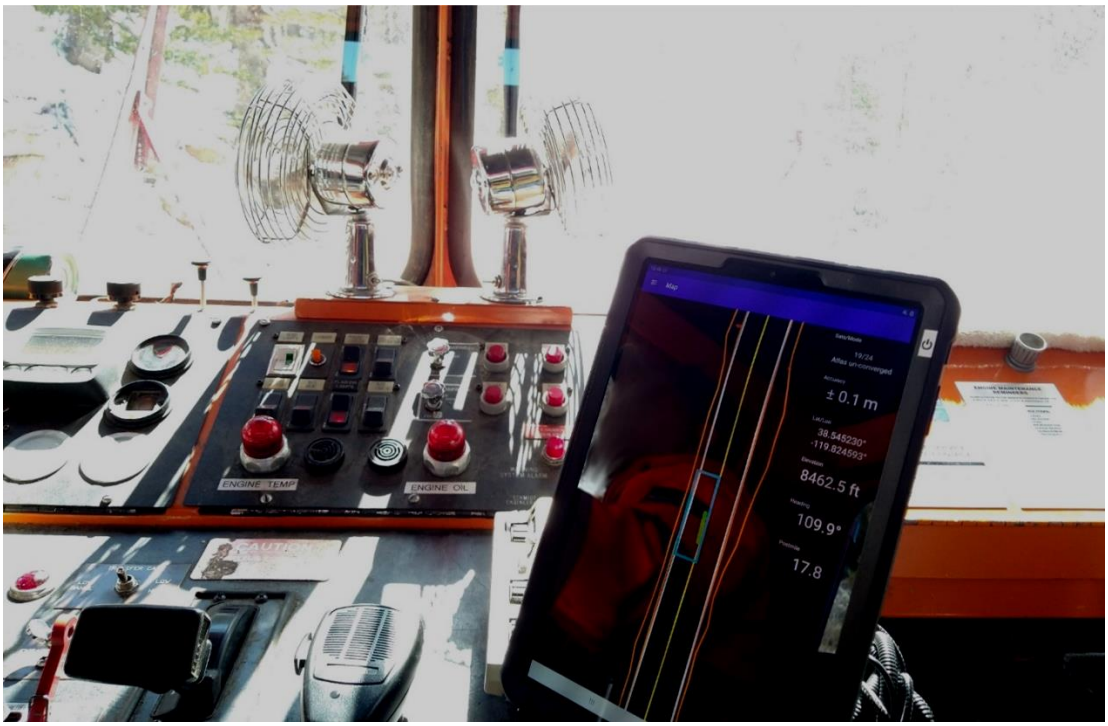

Figure 5: Updated MPRO system installed in rotary snow blower. This clearly illustrates the greatly improved sunlight readable capability of the final system.

Figure 6: Updated MPRO system installed in front-end loader. This clearly illustrates the greatly improved sunlight readable capability of the final system.

Figure 7: MPRO tablet installation on another front-end loader. The image was taken inside the shop building, hence the GNSS position is not available.

Figure 8: MPRO system during demonstration on a front-end loader on SR108. As noted, snow build-up was not significant in 2022.

Figure 9: MPRO field testing on SR4 with a blower in a GPS-challenged area (tall trees)

Future work

Depending on the snow accumulation on the mountain pass, Caltrans sometimes rents a snowcat for road opening. In general, the snowcat will get on top of the deep snow and push snow down to the snow blower. The snow blower then ejects the snow to the road side. The snowcat make and model varies. However, the PistenBully 400 snowcat, as shown in Figure 10, is often used. The snowcat would benefit from the MPRO system. In previous research [1], images and measurements were taken to support future design of removable mounts for the MPRO system for potential deployment on snowcat.

The snowcat has a 1" handlebar mounted at the rear and near the top of the cab (see Figure 11). This is suitable for a clamp-on mount for the V500 GNSS receiver. In addition, there is a 12-VDC outlet (see Figure 12) for MPRO system power. The large dashboard has a flat area (see Figure 12) for a tablet RAM mount. The GNSS power and data cable could be routed through the passenger side sliding window to the V500 GNSS receiver.

Figure 10: Example snowcat (PistenBully 400) rented for road opening (SR4 east of Ebbetts summit)

Figure 11: The PistenBully 400 1" handlebar (highlighted in yellow) near the top of the cab is suitable for the GNSS mount

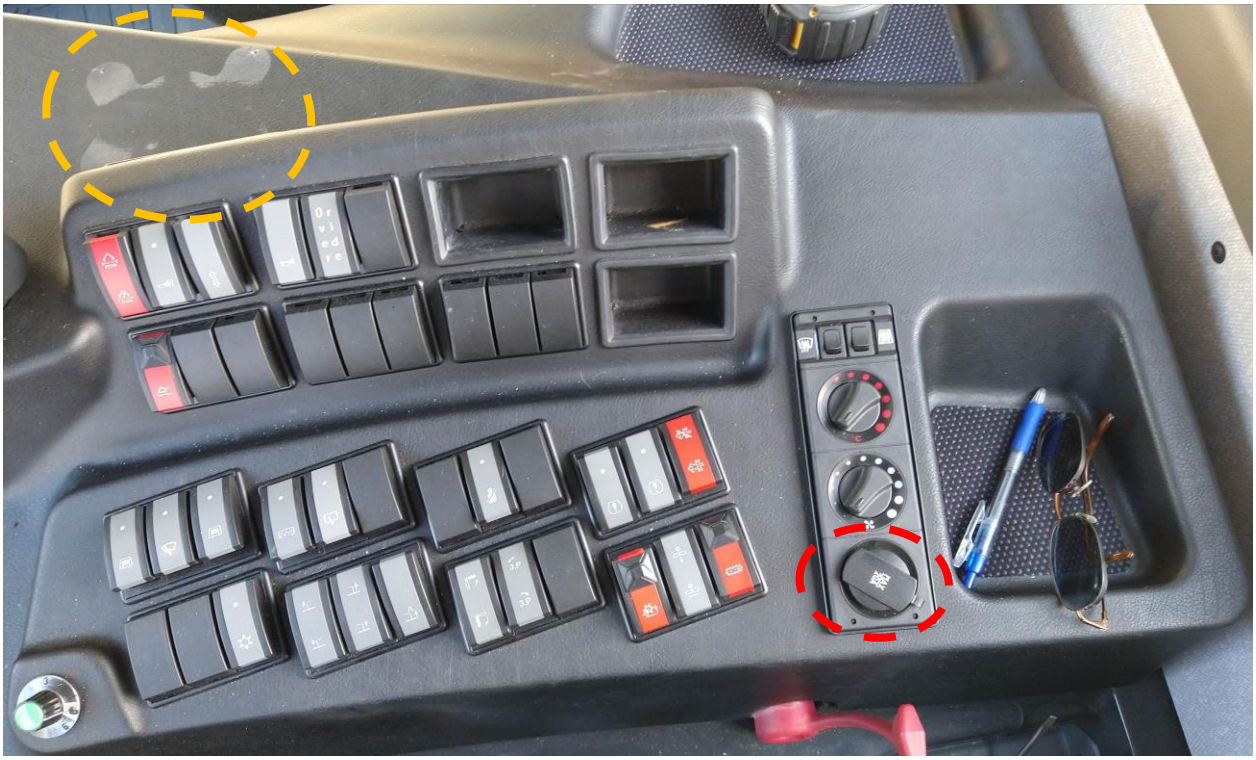

Figure 12: PistenBully 400 dashboard (right side of the driver seat). Table mount location is highlighted in yellow, and 12-VDC power outlet location is highlighted in red.

References

[1] K. Yen, S. Donecker, T. Swanston, and T. Lasky, "Mountain Pass Road Opening (MPRO) Implementation and Training," AHMCT Research Center, UCD-ARR-21-11-30-01, 2021.

Appendix A: Equipment Information

Table A-1: Hemisphere V500 GNSS receiver ESN

ESN	Caltrans Equipment #	Location
19501916	7002194	Woodfords Yard
19501907	Not Deployed	
19501970	1717510	Camp Connell Yard
19501936	AHMCT Truck	For Demo & Training
19501912	7011160	Sonora Junction Yard
19500895	Spare	
19501949	Not Deployed	
19501934	Not Deployed	
19501948	Not Deployed	

Note: Snow build-up at Tioga Pass did not justify installing and testing the MPRO system in April 2022. The system was demonstrated on an AHMCT research vehicle for this site.

Table A-2: List of Caltrans snow removal equipment pre-wired for MPRO systems

Caltrans District	Caltrans Equipment #	Equipment Description	Location
9	1717507	Blower	Lee Vining Yard
9	1715183	Blower	Lee Vining Yard
9	1717437	Blower	Sonora Junction Yard
9	7011160	Front-end Loader	Sonora Junction Yard
10	1715411	Blower	Cabbage Patch
10	1717510	Blower	Cabbage Patch
10	7002194	Volvo Front-end Loader	Woodfords Yard
10	7002345	Volvo Front-end Loader	Woodfords Yard