Research & Technology Transfer

Alaska Department of Transportation & Public Facilities

Self-Evaluation and Readiness of Alaska DOT&PF on Deployment of Connected and Automated Vehicle (CAV) on Alaskan Roads

Prepared by:

Vinod Vasudevan, Ph.D., P.E., Associate Professor of Civil Engineering
Mohammad Heidari, Ph.D., Assistant Professor of Electrical Engineering
Joe Selmont, Director of Summer Engineering Academy

Date: October 13th, 2020

Prepared for:

Alaska Department of Transportation & Public Facilities
Statewide Research Office
3132 Channel Drive
Juneau, AK 99801-7898

Publication Number: FHWA-AK-RD-4000-190

REPORT DOCUMENTATION PAGE	Form approved OMB No.

1. AGENCY USE ONLY (LEAVE BLANK)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
FHWA-AK-RD-4000-190	January 7, 2020	Final - 2020

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Self-Evaluation and Readiness of Alaska DOT&PF on Deployment of Connected and Automated Vehicle (CAV) on Alaskan Roads	HFHWY000134
6. AUTHOR(S) Vinod Vasudevan, Ph.D., P.E., Associate Professor of Civil Engineering Mohammad Heidari, Ph.D., Assistant Professor of Electrical Engineering Joe Selmont, Director of Summer Engineering Academy	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) College of Engineering University of Alaska Anchorage 2900 Spirit Drive, Anchorage, AK 99508	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) State of Alaska, Alaska Dept. of Transportation and Public Facilities Research and Technology Transfer 3132 Channel Drive, Juneau, AK 99801-7898	10. SPONSORING/MONITORING AGENCY REPORT NUMBER FHWA-AK-RD-4000-190
11. SUPPLENMENTARY NOTES	
12a. DISTRIBUTION / AVAILABILITY STATEMENT No restrictions	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words):

The US Department of Transportation's (USDOT) TSMO/CAV Capability Maturity Model Framework published in 2017 provides a clear set of guidelines to DOTs across the country for assessing and advancing state and local transportation agencies' CAV and TSMO current capabilities. This report shares the results of a self-assessment of Alaska DOT&PF's capabilities across the USDOT's six prescribed dimensions related to CAV. This study has found that Alaska DOT&PF is at an early stage of CAV readiness. The TSMO/CAV CMM Framework defines readiness on a 4-level scale, and Alaska DOT&PF generally falls somewhere just below Level 1. Considering that no pilot projects have been initiated thus far, Alaska DOT&PF already has strengths in three of the six dimensions: 1) Collaboration; 2) Culture, Organization, and Staffing; and 3) Performance Measures. The agency is weaker in the three remaining dimensions: 1) Business Processes; 2) Systems and Technology: Back Office; and 3) Systems and Technology: Field. However, the very process of deploying a CAV pilot project and strategic planning effort would provide an opportunity to strengthen the agency's areas of weakness and develop much needed expertise in its staff to move the organization to the first level of CAV readiness in the TSMO/CAV CMM Framework.

14- KEYWORDS : CAV readiness, Alaska, Connected and Autonomous Vehicles, Preparedness, Assessment	15. NUMBER OF PAGES 90
	16. PRICE CODE N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	N/A

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document. The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this report only because they are considered essential to the objective of the document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Author's Disclaimer

Opinions and conclusions expressed or implied in the report are those of the author. They are not necessarily those of the Alaska DOT&PF or funding agencies.

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4		mm
ft	feet	0.3048		m
yd	yards	0.914		m
mi	Miles (statute)	1.61		km
		AREA		
in^2	square inches	645.2	millimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.4046	hectares	ha
		MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g
lb	Pounds (avdp)	0.454	kilograms	kg
T	Short tons (2000 lb)	0.907	megagrams	mg
		VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL
gal	Gallons (liq)	3.785	liters	liters
ft^3	cubic feet	0.0283	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	Miles (statute)	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
km^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.471	acres	ac
		MASS (weight)		
g	grams	0.0353	Ounces (avdp)	oz
kg	kilograms	2.205	Pounds (avdp)	lb
mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces (US)	fl oz
liters	liters	0.264	Gallons (liq)	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3

Note: Volumes greater than 1000 L shall be shown in m^3

TEMPERATURE (exact)

ºF	Fahrenheit temperature	5/9 (ºF-32)	Celsius temperature	ºC

ILLUMINATION

fc	Foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2

FORCE and PRESSURE or STRESS

lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

These factors conform to the requirement of FHWA Order 5190.1A *SI is the symbol for the International System of Measurements

TEMPERATURE (exact)

ºC	Celsius temperature	9/5 ºC+32	Fahrenheit temperature	ºF

ILLUMINATION

lx	lux	0.0929	foot-candles	fc
cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl

FORCE and PRESSURE or STRESS

N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi

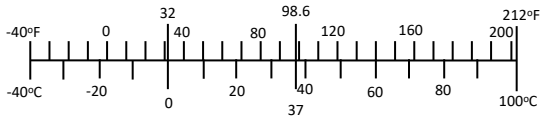

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

In the coming years, Connected and Autonomous Vehicle (CAV) technology is going to increasingly define the road infrastructure of the United States. With a relatively small number of road miles, Alaska is uniquely positioned to take advantage of CAV technology, despite challenges related to the state's cold climate, sparsely populated geography, and lack of communication technology in rural areas. However, in order to fully utilize CAV technology, the Alaska Department of Transportation and Public Facilities (DOT&PF) must first understand its current capabilities as they relate to CAV and, more broadly, to Transportation Systems Management and Operations (TSMO).

The United States Department of Transportation's (USDOT) TSMO/CAV Capability Maturity Model (CMM) Framework published in 2017 provides a clear set of guidelines to DOTs across the country for assessing and advancing state and local transportation agencies' CAV and TSMO current capabilities. The contents of this report fulfill the crucial first step of the TSMO/CAV CMM Framework by sharing the results of a self-assessment of Alaska DOT&PF's capabilities across the USDOT's six prescribed dimensions that are related to CAV and TSMO: 1) Business Processes, 2) Collaboration, 3) Culture, Organization, and Staffing, 4) Performance Measures, 5) Systems and Technology: Back Office, and 6) Systems and Technology: Field. The research team conducted six surveys, one for each of the dimensions, in which employees of Alaska DOT&PF and other individuals in the Alaska transportation community answered questions related to the agency's current CAV readiness. This report presents the results of the six surveys, multiple interviews with key staff and stakeholders, along with a literature review highlighting four transportation agencies' experiences and recommendations for Alaska DOT&PF moving CAV technology in Alaska forward.

The research team has found that Alaska DOT&PF is at an early stage of CAV readiness. The TSMO/CAV CMM Framework defines readiness on a 4-level scale, and Alaska DOT&PF generally falls somewhere just below Level 1. Considering that no pilot projects have been initiated thus far, Alaska DOT&PF already has strengths in three of the six dimensions: 1) Collaboration; 2) Culture, Organization, and Staffing; and 3) Performance Measures. The agency is weaker in the three remaining dimensions: 1) Business Processes; 2) Systems and Technology: Back Office; and 3) Systems and Technology: Field. However, the very process of deploying a CAV pilot project and strategic planning effort would provide an opportunity to strengthen the agency's areas of

weakness and develop much needed expertise in its staff to move the organization to the first level of CAV readiness in the TSMO/CAV CMM Framework.

INTRODUCTION

Connected and Autonomous Vehicle (CAV) technology is designed to increase safety and efficiency, and to reduce environmental impacts through situational awareness, improve personal mobility, enhance traveler services, reduce traffic incidents, and lower vehicle emissions. It is expected to take several years across the country and industry for this technology to become fully operational. Once deployed, CAV technology is expected to improve the efficiency of the transportation system by communicating real-time driving environment information to drivers. While considerable progress has been made in the area of communication systems, there are many challenges that must be addressed before CAV technology is fully deployed. The US Department of Transportation (USDOT) has been promoting the CAV program to improve the overall efficiency of the road network in the US. Since the road infrastructure is owned and operated by state and local agencies, they are considered the infrastructure owner-operators (IOOs). The IOO is responsible for deploying CAV infrastructure in its region. Some parts of CAV technology have been implemented in various states across the US over the last few years.

One major challenge in CAV implementation is the connectivity of all elements on the street. An efficient CAV system will capture, process, and disseminate the location and status of various traffic components, including vehicles, other road users, and roadside systems (including traffic signals) in real-time. This information will be used to provide the capability for vehicles to identify various threats, hazards, and delays on the roadway and provide drivers with alerts, warnings, and real-time information (USDOT, 2017). Various "connections," such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), infrastructure-to-vehicle (I2V), and vehicle-to-internet (V2N) play a critical role in an efficient CAV implementation. Among all the connections mentioned, IOO is directly responsible for V2I and I2V connections. In this report, V2I represents both V2I and I2V.

Traditionally, agencies use real-time data from sensors such as loop detectors, video detectors, Bluetooth sensors, and radar sensors to gather and disseminate traffic-related data. Although these sensors provide required data for the IOO to manage a system, they may not be effective in a CAV infrastructure in their current format. This is because these sensors are designed to provide macro-level traffic information, such as traffic flow rate, average speed, occupancy, or spot traffic information. In order to have an efficient CAV infrastructure, micro-level vehicle-by-vehicle trajectories are required on a regional level. Therefore, the existing sensor data do not meet

the requirement of CAV infrastructure. Hence, it is important to understand the preparedness of IOOs to adapt to CAV technology.

OBJECTIVE

The objective of this study was to conduct a self-assessment of the Alaska Department of Transportation and Public Facilities' (DOT&PF) readiness for CAV technology as an IOO. The assessment guidelines developed by the Federal Highway Administration (FHWA), US Department of Transportation (USDOT), are used in this project.

METHODOLOGY

This study involved two parts: 1) review of the state of practice, which was achieved via a thorough literature review; and 2) completing the self-evaluation, as per the methods outlined in the USDOT guidelines.

PART I: LITERATURE REVIEW

Various agencies, including DOTs, carried out self-assessment of CAV deployment preparedness. These include Oregon, Minnesota, Michigan, Pennsylvania, Texas, and Wyoming, among others. However, most of these studies were carried out before the USDOT guidelines were released in 2017. While these studies provided some insights, they were not very useful since this study aimed to closely follow the USDOT guidelines.

The MetroPlan Orlando (2019) CAV Readiness Study provides an evaluation of local existing capabilities of the MetroPlan Orlando and its partner agencies in adopting connected vehicle (CV) and automated vehicle (AV) technologies in the Central Florida area. CV-enabling roadway infrastructure, staffing proficiency, system and network capabilities, potential CAV testing locations, training plans for CAV awareness, and equity challenges were studied from the perspective of CAV readiness. The evaluation was based on interviews conducted either via phone or in person with a list of interviewed maintaining jurisdictions. The MetroPlan Orlando region and its partner agencies have shown interest in CAV technology with the implementation of two major pilot projects. The majority of the local jurisdictions in the MetroPlan Orlando area indicated their staff (or contractors) had established proficiency in signal or TSP device installation, maintenance, and repair; however, they lacked specific training in CAV applications, since much

of the next generation software, equipment, and technologies are new and evolving rapidly by the industry. The majority of jurisdictions in the MetroPlan Orlando region have fully implemented or are moving towards the use of fiber optic communication networks. Fiber optic networks could enable consistent communication and testing grounds for region-wide CAV deployment. It was observed that while the implementation of communications networks is often straight-forward, anticipating data storage and server needs for agencies is challenging, as many Central Florida agencies have partnered with vendors to store data on cloud servers instead of in-house. To facilitate partnerships and the advancement of near and mid-term CAV testing locations, and to collaborate on best practices in terms of equipment and software, it was recommended that a region-wide CAV consortium be created. The jurisdictions also believed that regional training is needed to ensure interoperability and consistency when deploying CAV systems. Equity was seen as a challenge in implementing CAV technologies across the MetroPlan area, particularly equity within the transportation sector in a vertical sense (agency-to-agency). For statewide jurisdictions, cross-regional collaboration was needed not only within the metropolitan areas of Orlando, but also in suburban and rural jurisdictions and roadway segments in the region.

The Pennsylvania Department of Transportation (PennDOT) commissioned a one-year project, Connected and Autonomous Vehicles 2040 Vision, with researchers at Carnegie Mellon University (CMU) to assess the implications of connected and autonomous vehicles on the management and operation of the state's surface transportation system (Henrickson et al., 2014). The report provides the impacts of connected and autonomous vehicles on design and investment decisions, communication devices investment, real-time data usage, existing infrastructure, workforce training needs, driver licensing, and freight flow. As a result of this research, it was understood that the implementation of CAV technology will produce a shift in the decision-making process regarding existing and planned transportation infrastructure. The Pennsylvania Department of Transportation wanted to understand how these new technologies will change their approach to designing, managing, and operating existing and planned transportation infrastructure. This research included eight tasks. Task 1 required the researchers to coordinate, conduct, and facilitate a workshop concerning the agency implications of connected and autonomous vehicles. The workshop consisted of a series of presentations by experts from the private and public sectors. Other tasks included understanding Impacts to Design and Investment Decisions, Impacts to Real-Time Data Usage, Impacts to Existing Infrastructure, Impacts to Workforce Training Needs,

Impacts to Driver Licensing, Impacts to Communication Devices Investments, and Impacts to Freight Flow. A variety of concerns and issues were discussed in the workshop; a few examples of which are as follows:

- Data need and capacity, who is going to produce useful information out of data, and who is going to process data?
- How to manage the difference between rural and city implementations (- no line painting in rural areas)
- Would overloading cellular system with broadcasting messages be a concern?
- How will insurance companies react?

The Report of the Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment in the State of Wisconsin provides a brief overview of CAV technology and provides a discussion of its potential impacts in the State of Wisconsin (WisDOT, 2018). The committee met over nine months and engaged industry groups, vehicle manufacturers, technology firms, state agencies, research groups, and Wisconsin businesses. It was understood that the ongoing deployment of CAVs has the potential to provide Wisconsin residents, visitors, and businesses with enhanced mobility, safer travel, and economic opportunities. It was noted that there are opportunities to build on emerging lessons learned from across the spectrum of connected and autonomous vehicle testing occurring worldwide. It was recommended to remove or modify Wisconsin laws that are barriers to the safe testing and deployment of connected and automated vehicles. The report sought to answer the following main questions:

- How will Wisconsin residents, businesses and state agencies respond to this rapidly changing technology?
- How can the state position itself to take advantage of the positive potential of connected and automated vehicles?
- Will self-driving cars require Wisconsin to update laws and upgrade infrastructure?

The researchers recommended that Wisconsin leverage its strong history of innovation and leadership in the technology and automotive industries, and its numerous advanced manufacturing businesses, research universities, and start-up businesses. The report also highlighted that continuing to invest in the technology and automotive industries, while removing barriers to testing and deployment, is a critical component in the path to realizing the advancement promised by CAV technology in Wisconsin.

In Michigan, Public Sector Consultants (PSC) and the Center for Automotive Research (CAR), with guidance from the Michigan Municipal League, produced a report on Planning for Connected and Automated Vehicles (PSC/CAR, 2017). The report recommended that the state must navigate the changing legal landscape. For example, law enforcement and other government entities may need to refine the legal mechanisms around the driver as the central actor in driving; e.g., how does law enforcement pull over a fully automated vehicle that has committed a traffic violation? The report also recommended that the role of transit agencies in protecting public benefits should be investigated. As CAV technology begins to overlap with shared modes of travel, public transit agencies will be critical to ensuring that the benefits of CAV technology are widely shared, and not just for those that can afford it. CAV technology was also perceived as requiring significant changes to the built environment. To prepare for these potential changes, the report recommended that local governments should begin to examine their zoning requirements, including a likely decrease in parking requirements, with higher penetration of CAV technology. To manage traffic congestion and flow, high-traffic development projects were recommended to consider expanding or adding curb space for pick-up and drop-off areas or possible space for automated vehicles to create a queue. To date, automated vehicle technologies have been developed to rely on pavement markings and signage to help the vehicles stay in their lane and navigate roadways. However, this is particularly an issue in Michigan, where poor markings are the result of limited road funding and weather challenges. The future direction of this technology was seen to have an impact on pavement marking policies and signage development and rehabilitation, both of which will cost road agencies more in maintenance. Therefore, the report recommended that road agencies track how vehicle developers and manufacturers are handling CAV lane-keeping technology. It was highlighted that government agencies at all levels should begin taking steps to incorporate CAV technology into planning documents. For example, metropolitan planning organizations should seek ways to incorporate the impact of self-driving cars into long-range transportation plans. Road agencies will need to update travel demand models and roadway design manuals, and must develop policies for data collection and sharing, including map creation and policies governing open data and data exchange. It was also recommended to consider communications infrastructure as transportation infrastructure. This includes identifying how agencies will ensure CAVs have timely, accurate information about construction, detours,

and other road hazards. It also includes monitoring the evolution of intersection design and signalization infrastructure.

California houses several CAV related projects. Most of them are carried out by various counties. For example, Contra Costa County won a major USDOT grant related to CAV deployment (CCTA, 2019). The county used these grants to initiate three major programs in their jurisdiction. These include:

1. A last mile connectivity option for an elderly community using shared autonomous vehicles,
2. An on-demand, wheel-chair accessible, autonomous vehicle shuttle service for people with special needs who do not have transportation, and
3. Preparation of a corridor for CAV by installing new and upgraded V2I and V2V technologies such as DSRC and 4G/5G communications.

The CAV pilots in Florida are under direct watch of Florida DOT (FDOT, 2020). They have a comprehensive CAV deployment program that addresses planning, design, and implementation. Some of the key projects include:

1. Vehicle-to-Everything (V2X) Data Platform: A data-oriented system that includes taking CAV data to make real-time and predictive decisions and assist stakeholders in the auto industry, research, traffic engineering, and in other areas.
2. I-10 Smart Road Ranger Project: A project in which Road-Side Units (RSU) and Road - Side Equipment (RSE) will be deployed along I-10, between 15 to 20 miles apart, from Jacksonville to Pensacola on existing infrastructure (DMS and CCTV structures/cabinets). These devices will use DSRC and Cloud Based technology to communicate with Road Ranger Operators and District personnel.
3. SR-710/Beeline Hwy FR Martin/PB CO Line to Old Dixie Hwy – CAV Freight: The scope of work includes deployment of a combination of Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) components required for freight vehicles and providing communication among freight vehicles.
4. Bike and Pedestrian Safety: Test and implement connected vehicle and pedestrian/bicyclist safety applications (active or passive) at 13 signalized intersections and 8 mid-block

crossings within the core of the University of Florida (UF) campus. The goal of this project is to reduce pedestrian and bicycle crashes and conflicts with vehicles and transit.

5. Lake Mary Boulevard CV Project: This project will deploy and test connected vehicle technology and applications, such as Red Light Violation Warning, Signal Phase and Timing, Forward Collision Warning, Target Classification (identifying other OBUs), and Traffic Incident Message, along seven signalized intersections.
6. Near Miss Identification Safety Systems (N-MISS): The goal of this project is to quickly demonstrate tangible safety and operational improvements at 26 intersections in the City of Lakeland.
7. Osceola County Connected Vehicle Signals: This project deploys Roadside Units (RSU) at two signalized intersections in Osceola County.
8. SR 434 Connected Vehicle Deployment: The purpose of this project is to implement CV technology and Signal Performance Metrics (SPM) in Seminole County. The project will deploy Roadside Units(RSU) and utilize Signal Phasing and Timing, Transit Signal Priority, and preemption applications along SR 434.
9. Incident Response Vehicle Pilot Project (Smart Work Zones): Equipping the District Six Incident Response Vehicle fleet in Miami-Dade County with 8 connected smart arrow board components and applying I2V communications to increase the safety and efficiency of the Regional transportation system.

Minnesota DOT has several ongoing CAV-related projects, including some that are nearly completed (MnDOT, 2020). These projects include:

1. Fiber Optic Feasibility Study: The Connected and Automated Innovative Design and Engagement Analysis (CAV IDEA): This project assesses where the state's fiber optic assets are currently located, and how public and private entities can work together to expand fiber during open road construction projects to meet the state's broadband expansion goals.
2. Smart Snelling: This public-private partnership pilot will deploy connected vehicle technology along Snelling Avenue and County Road B2 in Ramsey County.
3. LiDAR Research: This project is studying how reliable and durable LiDAR technology operates in snow, rain and dusty environments, all of which are common in Minnesota.

4. Highway 55 Connected Corridor: This Minneapolis corridor includes upgraded traffic signals that can send information to connected vehicles to advance basic safety messaging, signal priority, prevent cyber-attacks, and promote data security.
5. MnROAD: Minnesota has one of the nation's leading testing facilities with a 2.5-mile closed track, and a 3.5-mile closed segment of freeway to test connected and automated vehicle technology.

Overall, although the literature review did not offer references on the use of the USDOT guidelines, these studies discussing the readiness of various agencies help to provide an understanding of how US states are preparing for CAV technology.

PART II: USDOT GUIDELINES APPLIED TO ALASKA DOT&PF

The research team carried out a comprehensive assessment of Alaska DOT&PF and affected local agencies using guidelines provided by the USDOT. The USDOT guidelines, titled "Guidelines for Applying Capability Maturity Model Analysis to CAV Deployment" (USDOT, 2017), were used as the primary reference. It is important to note that USDOT does not currently mandate that all IOOs need to adopt V2I. Even the National Highway Traffic Safety Administration's proposed rules related to the requirements on passenger vehicles for V2V equipment do not presume the availability of road-side units (RSU) or V2I applications. This means that many basic CAV applications are not dependent on the IOOs' preparedness. However, it is important to assess the capabilities of the IOOs for CAV adaptability when the industry begins deploying the technologies.

The USDOT guidelines list a total of six dimensions of the Transportation Systems Management and Operations (TSMO)/Connected and Autonomous Vehicles (CAV) Capacity Maturity Model (CMM) Framework. Three (business processes, systems & technology, and performance measurement) are process-oriented, whereas the remaining three (culture, organization & staffing, and collaboration) are institutional. The USDOT guidelines define four different levels (levels 1 to 4) for each of these dimensions. In this document, Level 1 is defined as the basic level, labeled as "Performed," indicating that most of the CAV activities are ad hoc and outside the mainstream of other DOT activities. Level 4 is the best-case scenario in which TSMO/CAV is considered as a top priority of the DOT programs, with complete top-level

management support and full integration. Levels 2 and 3 fall between. This document illustrates details of these levels for the six dimensions of the TSMO/CAV CMM Framework. The entire methodology is divided into four major tasks, as follows:

Task 1: Interview

This task included a review of the infrastructure, systems, and types of readily available data collected by Alaska DOT&PF and other responding agencies, as well as identifying gaps. The research team contacted engineers to gather information on the prevailing standards and practices. The DOT&PF is divided into three regions as shown in Figure 1. Three officials with the DOT&PF (one for each of the agency's regions), including Mr. Val Rader (Central Region), Mr. Ethan Graetz (Northern Region), and Mr. Scott Vockeroth (Southcoast Region), provided input as technical advisors. The research team tried but was unable to interview MOA staff.

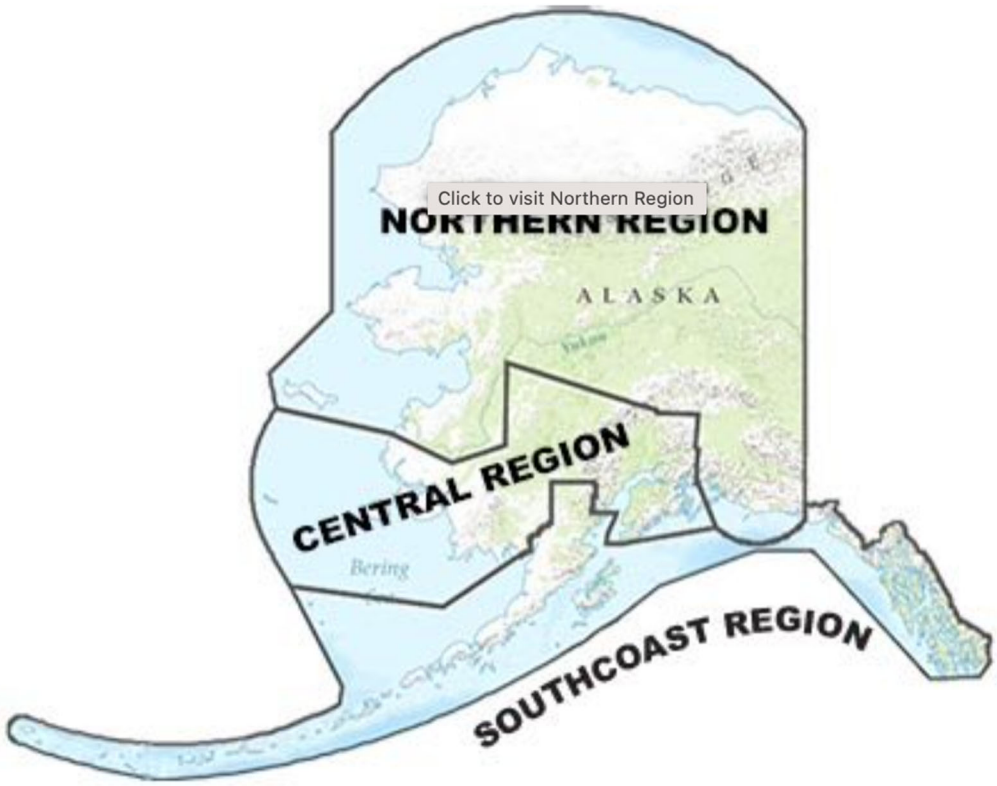

Figure 1: Alaska DOT& PF Regions (Source: http://dot.alaska.gov/regions-portal.shtml)

The Central Region includes the Municipality of Anchorage, Alaska's largest population community and the State's only Metropolitan Planning Organization as well as the Kenai

Peninsula and the Matanuska-Susitna Borough; combined this accounts for over half the state population. Northern Region includes Fairbanks and surrounding rural, isolated communities. Southcoast includes Juneau and multiple island/isolated communities. Comments from the technical advisers were used to understand the status of various relevant activities, both ongoing and completed in each region. Since one of the major challenges in CAV deployment is communication, most of the discussion was related to communication and challenges associated with procuring newer systems. For example, Mr. Rader was confident about the communication system in Central Region and he showed that the network, except for a few weak spots, are all built over capacity and he suggested that, for most CAV applications, communications will not be an issue. With reasonable funds, the weak communication spots could be enhanced. Mr. Rader also mentioned that adapting to a newer technology will not be a serious challenge, as Alaska DOT&PF has working experience with most of the major ITS vendors. This interview showcased the best scenario for preparedness among the regions and was used to get a basic understanding of the overall preparedness on CAV deployment and to finalize the surveys. However, it is important to note that the capabilities of the North Region and Southcost Region are quite different as these regions cover rural and isolated regions. However, it is believes that if any section is prepared for CAV deployment, the same process can be adopted by other regions (assuming availability of funds to carry out the same).

Task 2: Self- Evaluation

This was the main task of this project, and it consisted of the following steps.

1) Surveys: For this task, the USDOT's guidelines were used as the primary reference. As discussed before, the guidelines divide the TSMO/CAV CMM into six dimensions, and each dimension is accompanied with a list of questions for determining readiness. Based on information collected from Task 1, each of the six surveys were finalized. The final survey questionnaires are given in Appendix B.
2) Finalizing respondents: The respondents were mainly Alaska DOT&PF staff. Since the Alaska DOT&PF does not currently have a dedicated CAV program, finalizing the participants posed a challenge; the final list included several respondents who lacked functional knowledge of CAV technology. Since partnering agencies and professionals

working in the private sectors have a significant role in CAV deployment, participation from these groups was also solicited.

3) Data collection: The research team sent the surveys to select engineers, via Anna Bosin, within DOT&PF, in other public sector agencies and to private sector members of the Alaska Chapter of the Institute of Transportation Engineers and the Intelligent Transportation Society of Alaska. Data were collected in the months of June and July of 2020.
4) Data analysis: Lastly, the collected data were analyzed to assess Alaska DOT&PF's preparedness for CAV deployment.

The detailed data analysis is presented in Appendix C. Based on the results of the self-evaluation, it appears that Alaska DOT&PF has achieved Level 1 readiness in three dimensions of the TSMO/CAV CMM Framework: 1) Collaboration; 2) Culture, Organization, and Staffing; and 3) Performance Measures. However, the agency has weaknesses that must be addressed before achieving Level 1 readiness in the other three dimensions: 1) Business Processes; 2) Systems and Technology: Back Office; and 3) Systems and Technology: Field. For details, see Appendix C for an analysis of the primary survey results and Appendix D for an analysis of the survey's open-ended questions.

DISCUSSION & RECOMMENDATIONS

Based on the USDOT Guidelines, Level-1 capability is labelled as "Exploration." The overall descriptive details for Level 1 include:

- Organizational awareness of V2I and related issues,
- Concept of operations being formulated,
- V2I pilot being planned or implemented, and
- Limited expectations of benefits due to project scale.

The collected data show that, based on the self-assessment of its employees and collaborators as well as literature reviews and discussions with Outside DOTs, Alaska DOT&PF satisfies most of the requirements for Level 1. However, three dimensions need special attention:

1) Business Processes, 2) Systems & Technology: Back Office, and 3) Systems & Technology: Field.

The USDOT's TSMO/CAV CMM Framework suggests that agencies must meet the following requirements to be considered at Level 1 of the three dimensions that need additional work:

1. Business Processes: Agency is considering or conducting V2I pilot project(s) and developing plans for business processes.
2. Systems & Technology: Field: Agency has developed and deployed prototype V2I systems in field and at the TMC.
3. Systems & Technology: Back Office: Agency has developed and deployed prototype V2I systems in field and at the TMC.

The common recommendation in these three dimensions is a V2I pilot project. Once a customized pilot project is developed and deployed, the major concerns raised by the respondents will naturally be addressed. Additional actions are also recommended to strengthen the remaining three dimensions and prepare for Level 2 readiness. The below recommendations outline actions, policies, and projects that could be incorporated into a roadmap for Alaska DOT&PF's CAV readiness. Additional research may need to be completed during each step to stay current with the ever-changing technological advances and conduct proof-of-concept evaluations as the roadmap is enacted. Please see Appendix C for a detailed analysis of the survey results and a discussion of Alaska DOT&PF's specific areas of strength and weakness as they relate to the TSMO/CAV CMM Framework.

Actions to Achieve Level 1

CAV deployment is a long-term process. IOOs should aim to make progress steadily, so as to steadily reach higher levels of the TSMO/CAV CMM Framework. The USDOT Guidelines list actions to achieve Level 1 in Chapter 5. Table 1 summarizes this information. Completing a pilot project will help the Alaska DOT&PF to reach Level 1 without committing extraordinary resources.

Table 1: Actions to Get to Level 1: Exploration (Source USDOT, 2017

Business Process	Systems& Technology: Field	Systems& Technology: Back Office
Identify peer and national dialogue opportunities regarding policy, planning, technical, and legal issues.	Identify opportunities to participate in peer and national dialogue regarding technical specifications of field equipment.	Identify opportunities for participation in peer and national dialogue regarding technical specifications of back office systems.
Develop business case for TSMO regarding both public benefits and agency efficiency:	Develop deployment approach for pilot project foot print including right-of-way, structure, power, backhaul.	Identify impacts of pilot V2I operations on TMC legacy back-office systems.
Develop consensus regional policy and planning framework for V2I implementation:	Develop V2I pilot project use case, ConOps, system requirements, and architecture for field applications.	Review back-office data processing, storage, and interfacing tools and technologies.
Identify costs and resources for implementation of initial V2I applications.	Identify spectrum licensing need for pilot project.	Identify decision support system needs from pilot experiences.
Identify needs for ensuring privacy and security management.	Track progress of related vehicle programs including first-mile, last- mile transit, AV bus rapid transit, AV high occupancy toll/managed lanes, transportation network companies (TNCs).	Identify issues in cybersecurity and Personally-identifiable information (PII) protections in the V2I pilot data collection, storage, and use
Develop initial pilot system deployment concept including ConOps, architecture, and system requirements:	Identify cybersecurity issues in field device deployment plans.	

Table 1: Actions to Get to Level 1: Exploration (Source USDOT, 2017) (Continued)

Performance Measurement	Culture& Leadership, Organization and Staffing	Collaboration
Review agency performance measurement program and approach to meeting both MAP-21 and internal agency requirements regarding TSMO and V2I applications.	Identify staff champions for V2I.	Identify key participants in V2I applications—public and private.
Analyze pilot V2I applications role in providing both operational and asset management data based on probes.	Identify Connected Vehicle organizational structure issues:	Review ConOps associated with pilot V2I applications experience regarding roles and responsibilities.
Identify performance metrics, supporting data collection and analytics appropriate to measure effectiveness of start-up V2I applications.	Review core capacity KSAs needs for V2I specialty areas, such as systems engineering, data management, communication, software/hardware.	Review opportunities for multijurisdictional peer cooperation (including multistate) regarding all key aspects of V2I applications development.
Identify V2I pilot costs and impacts tracing system and collect data.	Create stakeholder/decision-maker outreach/communications plan to foster understanding of V2I business case within agency, policy-makers, and the public.	Identify opportunities to engage in dialogue with private-sector technology and service.
	Evaluated need for changes needed in agency in values and priorities and culture regarding fostering innovation and embracing technology.	

Potential Pilot Projects

The lack of pilot projects is a primary roadblock that is preventing Alaska DOT&PF from achieving Level 1 of all dimension of the TSMO/CAV CMM Framework. However, there are

several pilot projects for each dimension that could be undertaken by the agency that would offer the best evaluation opportunity. At this time, California, Florida, and Minnesota have all deployed major CAV programs. While a few other states have smaller programs that are still ongoing, the programs in these three states are best suited to serve as a model for other states.

Besides CA, FL and MN, other states have CAV-related pilots underway, however, most of them are similar to the ones listed above. As discussed in the previous section, Alaska DOT&PF has to carry out an appropriate pilot project to achieve Level 1 of the TSMO/CAV CMM Framework. While most of the pilots listed here are extensive, one common theme is with respect to deployment of a Road-Side Unit for CAV application. This is among the simplest and least cost prohibitive options for Alaska DOT&PF. A Road-Side Unit could enable the agency to conduct tests of proven or innovative ITS technologies using live data and real-time dissemination of this information to road users. Other low-cost options include testing of existing communication systems for CAV readiness, and enhancing the traveler information system with CAV-related components. There are, of course, many other options for piloting CAV technology in Alaska, but many require public private partnerships and a dynamic and open business plan since most of the CAV applications involve data sharing among the partners for efficient functioning.

REFERENCES

CCTA (2019), Contra Costa Transportation Authority, https://ccta.net/2019/09/17/contra-costa-transportation-authority-wins-7-5-million-usdot-grant-for-automated-driving-systems-pilot-program/

FDOT (2020), *The Florida Connected Vehicle Initiative*, https://www.fdot.gov/traffic/its/projects-deploy/cv/connected-vehicles.

Hendrickson C., Biehler A., Mashayekh Y. (2014), Connected and Autonomous Vehicles, 2040 Vision. Final Report, Carnegie Mellon University and Commonwealth of Pennsylvania Department of Transportation, https://traffic21.heinz.cmu.edu/wp-content/uploads/sites/23/2020-/02/Joint-Statewide-Connected-and-Autonomous-Vehicles-2040-Vision-Final-Report-smaller.pdf

Metroplan Orlando (2019), MetroPlan Orlando CAV Readiness Study, Task 2 Memorandum - Final Evaluation of Local Existing Capabilities, https://metroplanorlando.org/wp-content/uploads/MetroPlan-Task-2-Memo-FINAL-Updated-12.3.19.pdf

MnDOT (2020), Connected and Automated Vehicles, http://www.dot.state.mn.us/automated/-projects.html

PSC/CAR (2017), Planning for Connected and Automated Vehicles, Prepapred by Public Sector Consultants and Center for Automotive Research. https://www.cargroup.org/wp-content/uploads/2017/03/Planning-for-Connected-and-Automated-Vehicles-Report.pdf

USDOT (2017), *Guidelines for Applying Capability Maturity Model Analysis to CAV Deployment*, Report Number FHWA-JPO-18-629, Final Report.

WisDOT (2018), Report of the Governor's Steering Committee on Autonomous and Connected Vehicle Testing and Deployment, https://wisconsindot.gov/Documents/about-wisdot/who-we-are/comm-couns/av-final-report-062918.pdf

Appendix A: Questionnaires Used for Data Collection

Questionnaire for Business Process

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Business Process." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)Phone: (907) 306-2828 (Mobile)

Glossary of terms

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	We have developed the business case for TSMO.					
2	We have engaged in the national dialogue for TSMO.					
3	We understand the relationships between TSMO processes and V2I (or CAV) capabilities.					
4	We routinely apply the systems engineering process for development and procurement of high-technology systems.					
5	We have identified a communications strategy for public and internal benefits of business process standardization.					
6	We have identified a regional consensus framework for policy and planning for V2I (or CAV). (**OR)** We have we identified the right partners to develop such workflows.					
7	We have prioritized V2I (or CAV) applications for our agency.					
8	We have included V2I (or CAV) applications in agency planning documents.					
9	We have identified how regional processes and relationships among partner agencies will affect the implementation of business processes for V2I (or CAV) deployment.					
10	We have identified the costs and resources required for implementation of V2I (or CAV).					
11	We have identified the agency (or agencies) that will bear these costs and resources.					
12	We have outlined the requirements for security and privacy policies for V2I (or CAV) applications.					
13	We have identified scope and scale of the business processes related to a pilot deployment(s).					
14	We understand the opportunities to partner with other agencies.					
15	We have identified the ways that CAV deployment would impact land use codes.					
16	We realize that interoperability between vendors can be a challenge.					
17	We recognize that lower levels of CAV implementation will bring up some security concerns.					
18	As soon as experimentation and standards are developed, CAV technologies and infrastructure need to be quickly and holistically integrated into transportation systems and transit. CAV cannot be an add-on.					

19	In terms of Automated Vehicles (AV), there isn't as much focus on it since that will be tackled primarily by jurisdictions and vehicle manufacturers.					

20. From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV.

21. From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV.

22. List unique challenges that Alaska faces for CAV deployment.

23. List unique challenges that your agency faces for CAV deployment.

24. Do you have any other comments?

Questionnaire for Collaboration

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Collaboration." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)

Glossary of terms

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	There is a regional interest or established goals that will be achieved through CAV.					
2	Multiple agencies are interested in advancing CAV capabilities.					
3	We have identified potential roles and responsibilities for implementing or piloting CAV capabilities.					
4	There is a forum for partner agencies to collaborate, discuss, and obtain consensus on potential CAV applications.					
5	There are opportunities to leverage existing processes among agencies to initiate CAV capabilities (e.g., business processes, planning, procurement, system engineering, and operations).					
6	Some partner agencies have barriers to certain processes.					
7	If the response to the previous question was 4 or 5, please elaborate.					
8	There are regional processes that would need to be factored into piloting CAV capabilities (e.g., Transportation Improvement Plan, programming cycles, and flexibility to fund near-term improvements).					
9	There are partner agencies with staff who have skillsets that would align with CAV capabilities.					
10	If the response to the previous question was 4 or 5, please elaborate.					
11	The partner agency missions are aligned closely with regard to TSMO and CAV.					
12	There is consistent interest and leadership support among partner agencies.					
13	The private sector is involved in different TSMO initiatives.					
14	The police and fire departments have facilities and technologies in place that can support CAV deployment.					
15	If the response to the previous question was 4 or 5, please elaborate.					
16	We see CAV as an integral part of the Smart City plans that are being envisioned.					
17	There are barriers to engaging the private sector as part of a CAV pilot.					
18	If the response to the previous question was 4 or 5, please elaborate.					

19	We see data sharing with outside agencies and vendors as a security concern.					
20	If the response to the previous question was 4 or 5, please elaborate.					
21	We see interoperability on services/products by different service providers/vendors as a challenge.					
22	If the response to the previous question was 4 or 5, please elaborate.					

23. From your perspective, what are the advantages in the prevailing collaborative framework that will enable efficient/easy adaptation of CAV?

24. From your perspective, what are the limitations in the prevailing collaborative framework that will adversely affect the adaptation of CAV?

25. List unique collaborative challenges that Alaska faces for CAV deployment.

26. List unique collaborative challenges that your agency faces for CAV deployment.

27. Do you have any other comments?

Questionnaire for Culture, Organization, and Staffing

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Culture, Organization, and Staffing." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)

Glossary of terms

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	We have a champion for a CAV program.					
2	Is the champion in our organization? (Yes or No):					
3	Our organization embraces technology and innovation.					
4	There is a commitment from leadership to advance technology.					
5	Our organization takes tangible steps to promote a culture that embraces technology.					
6	Our staff has the skills required for operating and maintaining V2I (or CAV) infrastructure.					
7	We have technical expertise in ***systems engineering*** that can support V2I (or CAV).					
8	We have technical expertise in ***design*** that can support V2I (or CAV).					
9	We have technical expertise in ***deployment/integration*** that can support V2I (or CAV).					
10	We have technical expertise in ***data management*** that can support V2I (or CAV).					
11	We have technical expertise in ***operations*** that can support V2I (or CAV).					
12	We have technical expertise in ***maintenance*** that can support V2I (or CAV).					
13	We have technical expertise in ***analytics*** that can support V2I (or CAV).					
14	We have flexibility to acquire staff with required skill sets based on needs.					
15	We face issues in retention of skilled staff.					
16	We have mechanisms in place to address skill deficiencies (e.g., contracting/outsourcing, training).					
17	Training policies need to be revisited to better address the requirements for CAV deployment.					
18	We do not have operational or policy issues that would limit our ability to deploy V2I (or CAV).					
19	If your response to the previous question was 1 or 2, explain the limitations.					
20	We are active in national V2I (or CAV) and TSMO organizations (or activities) that enable us to learn about peer agency programs and experiences, national trends, and emerging technologies.					
21	There are no barriers to participating in these national activities.					

22	If your response to the previous question was 1 or 2, explain the limitations.					
23	Our agency welcomes testing opportunities on a small scale for evaluation of measures of effectiveness.					
24	We have flexible policies for task assignments, as determined by needs.					

25. From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV.

26. From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV.

27. List unique challenges that Alaska faces for CAV deployment.

28. List unique challenges that your agency faces for CAV deployment.

29. Do you have any other comments.

Questionnaire for Performance Measurement

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Performance Measurement." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)

Glossary of terms

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	We have reviewed the MAP-21 performance measurement requirements.					
2	We have identified how we will use existing TSMO systems to meet MAP-21 requirements.					
3	We have identified barriers to basic performance measurement requirements.					
4	If your response to question 3 was 1 or 2, explain what strategies can be followed to identify those barriers.					
5	We have identified how V2I (or CAV) data may supplement other TSMO performance measurement efforts.					
6	We have identified if/when V2I (or CAV) data collection may replace other data collection efforts.					
7	We have identified which V2I (or CAV) data could enhance certain TSMO performance measurement practices.					
8	We have identified which performance metrics will be used to measure V2I (or CAV) deployment performance.					
9	The identified performance metrics are feasible.					
10	We are taking a measured approach due to the evolution of devices and technologies.					

11. From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?

12. From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?

13. List unique challenges that Alaska faces for CAV deployment.

14. List unique challenges that your agency faces for CAV deployment.

15. Do you have any other comments?

Questionnaire for Systems and Technology: Back Office

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Systems and Technology: Back Office." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)

Glossary of terms

CMM: Capacity Maturity Model

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

PII: Personally Identifiable Information

RSU: Road-side Unit

TMC: Traffic Management Center

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	We have existing standards for common TSMO back office systems.					
2	If your response to the previous question was 1 or 2, We can develop standards for common TSMO back office systems.					
3	We have identified impacts of CAV operations on legacy systems in the TMC or other centers.					
4	We understand the role of data tools and technologies for processing, storing, and using CAV data.					
5	There are barriers or legacy requirements (OS, hardware, IT) that will impact selection of certain back office systems for CAV.					
6	If your response to the previous question was 4 or 5, elaborate					
7	We have articulated the need for decision support systems that may result from the outcomes of pilot deployments.					
8	We understand the issues with management of high-definition data from RSU.					
9	We understand the issues related to cybersecurity and PII protections of CAV pilot data collection, storage, and use.					
10	We understand how existing asset management systems might be utilized.					
11	We need new back-office systems for asset management.					
12	We understand what will be needed for back-office software maintenance.					
13	We have a preferred IT procurement strategy (IaaS, PaaS, DaaS, on-premise deployment, etc.).					
14	Data sharing with outside agencies may be an issue due to security concerns.					
15	We are proficient in efficiently processing data received from various sensors.					
16	We have identified spectrum licensing needs and procedures.					
17	CAV data can be easily integrated into our GIS database.					
18	We have identified how a CAV pilot can integrate with other related technology programs at our agency or at peer agencies.					

18. From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?

19. From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?

20. List unique challenges that Alaska faces for CAV deployment.

21. List unique challenges that your agency faces for CAV deployment.

22. Do you have any other comments?

Questionnaire for Systems and Technology: Field

The Alaska DOT&PF has contracted the University of Alaska Anchorage to conduct a self-assessment of the DOT&PF's preparedness as an infrastructure owner and operator (IOO) for connected and autonomous vehicle (CAV) technologies. The USDOT has developed guidelines for the assessment of IOOs, which serves as the framework for this project. The self-assessment is the first step for the DOT&PF to evaluate future infrastructure and maintenance investments necessary for CAV implementation. Your responses will help to identify preparedness shortfalls and to develop a road map for research activities for the DOT&PF and other local agencies.

The USDOT's Transportation Systems Management and Operations (TSMO) Capacity Maturity Model (CMM) framework includes six dimensions of preparedness: business processes, systems & technology (field), systems & technology (back office), performance measurement, culture/organization & staffing, and collaboration. While there may be some overlap among the questionnaires, each one addresses different aspects of the assessment.

This survey is on the dimension "Systems and Technology: Field." Please note that depending on your job responsibilities, you may be asked to respond to several questionnaires.

Thank you very much for your support. In case you have any questions, please contact Ms. Anna Bosin (anna.bosin@alaska.gov) or me.

Regards,

Vinod Vasudevan, Ph.D., P.E.
Associate Professor of Civil Engineering
University of Alaska Anchorage
Email: vvasudevan@alaska.edu
Phone: (907) 306-2828 (Mobile)

Glossary of terms

CAV: Connected and Autonomous Vehicles

IOO: Infrastructure Owner-Operator

TSMO: Transportation System Management and Operations

V2I: Vehicle-to-Infrastructure technologies

Please select your employer: ☐ DOT&PF ☐ Other Government Agency ☐ Private Sector

Professional title:

Please enter your professional experience (in years):

Please enter your experience in the current position (in years):

Select the appropriate response for the following statements.

(1: strongly disagree, 2: disagree, 3: neither disagree nor agree, 4: agree, 5: strongly agree)

No	Statements	Response				
		1	2	3	4	5
1	We have identified a deployment approach for a pilot project.					
2	We have legacy issues relevant to procurement of certain types of equipment.					
3	We have developed a pilot concept of operations and system requirements for field equipment for the pilot project.					
4	We have identified how the field equipment fits into our regional ITS architecture.					
5	Additional space is needed within the cabinets for new equipment.					
6	We have sufficient capacity in terms of communications network bandwidth for CAV applications.					
7	We have sufficient capacity in terms of computer servers and data storage.					
8	We have identified spectrum licensing needs and procedures.					
9	We have identified issues with cybersecurity of field equipment.					
10	Performance of CCTV cameras at intersections is satisfactory for potential CAV applications.					
11	Traffic signal controllers are intelligent or can be easily transitioned to intelligent traffic signal controllers.					
12	Existing Fiber Optic capacity is sufficient for CAV applications.					
13	Cloud computing is possible or will be possible in the near future for CAV applications.					
14	Real-time data collection and processing can be enabled for CAV application.					

15. From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?

16. From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?

17. List unique challenges that Alaska faces for CAV deployment.

18. List unique challenges that your agency faces for CAV deployment.

19. Do you have any other comments?

Appendix B: Summary of Key Responses of Survey Data Collected

Table B 1: Summary of Responses of Key Questions in "Business Process" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	We have developed the business case for TSMO.	1	5	19	6	3
2	We have engaged in the national dialogue for TSMO.	0	10	17	4	3
3	We understand the relationships between TSMO processes and V2I (or CAV) capabilities.	0	10	12	6	6
4	We routinely apply the systems engineering process for development and procurement of high-technology systems.	1	6	14	8	5
5	We have identified a communications strategy for public and internal benefits of business process standardization.	1	7	13	10	3
6	We have identified a regional consensus framework for policy and planning for V2I (or CAV). (OR) We have we identified the right partners to develop such workflows.	1	4	13	9	7
7	We have prioritized V2I (or CAV) applications for our agency.	1	2	14	6	11
8	We have included V2I (or CAV) applications in agency planning documents.	0	5	14	5	10
9	We have identified how regional processes and relationships among partner agencies will affect the implementation of business processes for V2I (or CAV) deployment.	0	2	14	7	11
10	We have identified the costs and resources required for implementation of V2I (or CAV).	0	5	10	7	12
11	We have identified the agency (or agencies) that will bear these costs and resources.	0	3	15	3	13
12	We have identified scope and scale of the business processes related to a pilot deployment(s).	0	3	15	4	12
13	We understand the opportunities to partner with other agencies.	2	10	15	4	3
14	We have identified the ways that CAV deployment would impact land use codes.	0	2	18	4	10
15	We realize that interoperability between vendors can be a challenge.	10	8	14	1	1
16	We recognize that lower levels of CAV implementation will bring up some security concerns.	8	9	14	2	1
17	As soon as experimentation and standards are developed, CAV technologies and infrastructure need to be quickly and holistically integrated into transportation systems and transit. CAV cannot be an add-on.	1	7	19	5	2
18	In terms of Automated Vehicles (AV), there isn‚Äôt as much focus on it since that will be tackled primarily by jurisdictions and vehicle manufacturers.	2	12	17	3	0

Table B 2: Summary of Responses of Key Questions in "Collaboration" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	There is a regional interest or established goals that will be achieved through CAV.	3	14	10	4	0
2	Multiple agencies are interested in advancing CAV capabilities.	4	14	10	2	1
3	We have identified potential roles and responsibilities for implementing or piloting CAV capabilities.	2	4	12	8	5
4	There is a forum for partner agencies to collaborate, discuss, and obtain consensus on potential CAV applications.	4	9	13	4	1
5	There are opportunities to leverage existing processes among agencies to initiate CAV capabilities (e.g., business processes, planning, procurement, system engineering, and operations).	3	12	12	4	0
6	Some partner agencies have barriers to certain processes.	2	8	21	0	0
7	There are regional processes that would need to be factored into piloting CAV capabilities (e.g., Transportation Improvement Plan, programming cycles, and flexibility to fund near-term improvements).	10	12	6	3	0
8	There are partner agencies with staff who have skillsets that would align with CAV capabilities.	0	9	19	2	1
9	The partner agency missions are aligned closely with regard to TSMO and CAV.	0	4	25	2	0
10	The private sector is involved in different TSMO initiatives.	1	8	16	6	0
11	The police and fire departments have facilities and technologies in place that can support CAV deployment.	1	4	21	1	4
12	We see CAV as an integral part of the Smart City plans that are being envisioned.	2	11	15	1	2
13	There are barriers to engaging the private sector as part of a CAV pilot.	0	14	14	2	1
14	We see interoperability on services/products by different service providers/vendors as a challenge.	6	4	17	3	1

Table B 3: Summary of Responses of Key Questions in "Culture, Organization & Staffing" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	We have a champion for a CAV program.	2	10	13	5	3
2	Is the champion in our organization?	0	0	0	0	0
3	Our organization embraces technology and innovation.	6	13	4	9	1
4	There is a commitment from leadership to advance technology.	5	11	6	10	1
5	Our organization takes tangible steps to promote a culture that embraces technology.	6	11	6	10	0
6	Our staff has the skills required for operating and maintaining V2I (or CAV) infrastructure.	2	5	13	11	2
7	We have technical expertise in systems engineering that can support V2I (or CAV).	2	4	14	9	4
8	We have technical expertise in design that can support V2I (or CAV).	1	7	14	9	2
9	We have technical expertise in deployment/integration that can support V2I (or CAV).	2	6	13	9	3
10	We have technical expertise in data management that can support V2I (or CAV).	3	9	12	8	1
11	We have technical expertise in operations that can support V2I (or CAV).	3	11	8	8	3
12	We have technical expertise in analytics that can support V2I (or CAV).	2	4	17	7	3
13	We have flexibility to acquire staff with required skill sets based on needs.	2	4	5	8	14
14	We face issues in retention of skilled staff.	16	9	7	1	0
15	We have mechanisms in place to address skill deficiencies (e.g., contracting/outsourcing, training).	4	13	10	4	1
16	Training policies need to be revisited to better address the requirements for CAV deployment.	8	13	10	1	0
17	We do not have operational or policy issues that would limit our ability to deploy V2I (or CAV).	1	4	23	3	1
18	We are active in national V2I (or CAV) and TSMO organizations (or activities) that enable us to learn about peer agency programs and experiences, national trends, and emerging technologies.	5	10	14	2	1
19	There are no barriers to participating in these national activities.	1	5	10	13	3
20	Our agency welcomes testing opportunities on a small scale for evaluation of measures of effectiveness.	3	15	11	3	0
21	We have flexible policies for task assignments, as determined by needs.	1	12	11	8	0

Table B 4: Summary of Responses of Key Questions in "Culture, Organization & Staffing" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	We have reviewed the MAP-21 performance measurement requirements.	5	10	13	2	2
2	We have identified how we will use existing TSMO systems to meet MAP-21 requirements.	1	6	17	2	6
3	We have identified barriers to basic performance measurement requirements.	0	8	19	3	2
4	Please elaborate what strategies can be followed to identify those barriers	0	0	0	0	0
5	We have identified how V2I (or CAV) data may supplement other TSMO performance measurement efforts.	0	1	21	4	6
6	We have identified if/when V2I (or CAV) data collection may replace other data collection efforts.	1	3	18	5	5
7	We have identified which V2I (or CAV) data could enhance certain TSMO performance measurement practices.	1	3	19	5	4
8	We have identified which performance metrics will be used to measure V2I (or CAV) deployment performance.	2	0	21	2	7
9	The identified performance metrics are feasible.	1	1	0	0	0
10	We are taking a measured approach due to the evolution of devices and technologies.	4	9	17	0	2

Table B 5: Summary of Responses of Key Questions in "Systems & Technology: Back Office" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	We have existing standards for common TSMO back office systems.	0	7	22	3	8
2	We can develop standards for common TSMO back office systems.	1	6	3	1	0
3	We have identified impacts of CAV operations on legacy systems in the TMC or other centers.	1	3	21	8	7
4	We understand the role of data tools and technologies for processing, storing, and using CAV data.	1	7	20	8	4
5	There are barriers or legacy requirements (OS, hardware, IT) that will impact selection of certain back office systems for CAV.	7	12	21	0	0
6	Please elaborate the barriers.	0	0	0	0	0
7	We have articulated the need for decision support systems that may result from the outcomes of pilot deployments.	2	1	25	9	3
8	We understand the issues with management of high-definition data from RSU.	0	9	18	10	3
9	We understand the issues related to cybersecurity and PII protections of CAV pilot data collection, storage, and use.	3	11	16	5	5
10	We understand how existing asset management systems might be utilized.	2	9	18	8	3
11	We need new back-office systems for asset management.	6	16	18	0	0
12	We have a preferred IT procurement strategy (IaaS, PaaS, DaaS, on-premise deployment, etc.).	1	5	27	4	3
13	Data sharing with outside agencies may be an issue due to security concerns.	12	7	17	3	1
14	We are proficient in efficiently processing data received from various sensors.	0	11	19	5	5
15	We have identified spectrum licensing needs and procedures.	0	1	25	6	8
16	CAV data can be easily integrated into our GIS database.	0	6	24	4	6
17	We have identified how a CAV pilot can integrate with other related technology programs at our agency or at peer agencies.	0	3	21	6	10

Table B 6: Summary of Responses of Key Questions in "Systems & Technology: Field" Dimension

Question No.	Question	Response				
		Strongly Agree	Somewhat Agree	Neither Agree or Disagree	Somewhat Disagree	Strongly Disagree
1	We have identified a deployment approach for a pilot project.	2	4	26	4	8
2	We have legacy issues relevant to procurement of certain types of equipment.	3	13	25	2	1
3	We have developed a pilot concept of operations and system requirements for field equipment for the pilot project.	0	5	28	3	8
4	We have identified how the field equipment fits into our regional ITS architecture.	0	9	24	7	4
5	Additional space is needed within the cabinets for new equipment.	4	12	25	2	1
6	We have sufficient capacity in terms of communications network bandwidth for CAV applications.	1	5	25	8	5
7	We have sufficient capacity in terms of computer servers and data storage.	1	2	22	12	7
8	We have identified spectrum licensing needs and procedures.	0	4	29	7	4
9	We have identified issues with cybersecurity of field equipment.	0	8	29	4	3
10	Performance of CCTV cameras at intersections is satisfactory for potential CAV applications.	0	7	27	6	4
11	Traffic signal controllers are intelligent or can be easily transitioned to intelligent traffic signal controllers.	3	7	26	5	2
12	Cloud computing is possible or will be possible in the near future for CAV applications.	5	5	26	5	2
13	Real-time data collection and processing can be enabled for CAV application.	2	7	25	6	3

xxxxxx

Appendix C: Detailed Analysis of Survey Results

As discussed in the report, this study considered six dimensions, the summaries for each survey are presented as subsections. Overall, the survey results demonstrate that Alaska DOT&PF is somewhere between Level 0 and Level 1 of the TSMO/CAV CMM Framework. However, it is important to note that many of the respondents appeared to be unfamiliar with TSMO processes and/or CAV technologies, which likely led many respondents to "Neither Agree nor Disagree" with many of the questions. Therefore, this analysis focuses on identifying areas of strength and weakness, based on a threshold of positive responses to each question. For all areas of strength, it should be possible to identify leaders within Alaska DOT&PF to manage the related TSMO/CAV processes. For areas of weakness, however, various actions will need to be undertaken to strengthen those areas. Some of these actions may include: training existing staff on TSMO/CAV processes and technologies; hiring staff who already possess that expertise; updating policies, procedures, and potentially laws to fit the different nature of CAV technologies; expanding communications technologies deeper into rural areas; and advocating for funding. For all dimensions, this report assesses the DOT&PF's preparedness to achieve Level 1.

Dimension 1: Business Processes

Based on the results from the Business Processes survey, it appears that Alaska DOT&PF is initially prepared for deployment of a CAV pilot program. While a majority of respondents were either unsure or doubted Alaska DOT&PF's business process capabilities as they relate to CAV, a substantial minority of respondents answered the survey questions positively. This supports the idea that, in general, Alaska DOT&PF could identify leaders within its ranks to perform the required actions based on the USDOT's Guidelines.

A total of 34 individuals responded to the Business Processes survey, with 27 from Alaska DOT&PF, 1 from another government agency, and 6 from the private sector. 19 of the respondents have offices in Anchorage, 7 in Juneau, 6 in Fairbanks, and 2 in other locations.

Table C **1** shows the spread of respondent experience, both in terms of years of total professional experience and years in their current position.

Table C 1- Years of Experience of Participants for "Business Processes" Survey

Number of Years	Total Professional Experience	Experience in Current Position
0 to 5	1	23
6 to 10	7	8
11 to 15	4	1
16 to 20	8	2
Over 20	14	0

The majority of respondents have a substantial amount of professional experience, with 26 respondents having worked for longer than a decade. The inverse is true of experience in their current position, with 31 respondents having worked in their current position for 10 years or less. This level of experience indicates that respondents generally had enough seniority and historical reference to answer the survey questions with the necessary degree of knowledge. A glance at the professional titles of respondents, which include several Officers, Chiefs, Directors, and Managers, further supports this.

The survey featured 19 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." For 18 of those questions, if a respondent agreed with the statement, then they were indicating that Alaska DOT&PF is prepared to deploy CAV technologies from the perspective of business processes, and if a respondent disagreed with the statement, then they were indicating that the Alaska DOT&PF is not prepared.

Table C 2 summarizes the responses to those 18 questions. The 19th question will be discussed separately.

A plurality of respondents answered "Neither Agree nor Disagree" to these statements (43.3 percent), with 36.2 percent either "Somewhat" or "Strongly" disagreeing and 20.4 percent either "Somewhat" or "Strongly" agreeing. However, respondents were nearly five times more likely to "Strongly Disagree" than they were to "Strongly Agree."

Table C 2 - Summary of Responses to First 18 Likert Scale Questions for “Business Processes” Survey

Response	Count
Strongly Agree	26
Somewhat Agree	99
Neither Agree nor Disagree	265
Somewhat Disagree	96
Strongly Disagree	126
Total	612

Partially disaggregating the data tells a similar story, as shown in Table C 3. For the two statements that related exclusively to TSMO—"We have developed the business case for TSMO” and “We have engaged in the national dialogue for TSMO”—the respondents were fairly evenly divided between agreeing and disagreeing. For the three statements that were more general in nature—“We routinely apply the systems engineering process for development and procurement of high technology systems,” “We have identified a communications strategy for public and internal benefits of business process standardization,” and “We realize that interoperability between vendors can be a challenge”— respondents were slightly more likely to agree than disagree. However, for the 13 statements that related explicitly to CAV, only 17.2 percent of respondents agreed with the statements, while 40.3 percent disagreed, and respondents were nearly 10 times more likely to “Strongly Disagree” than they were to “Strongly Agree.”

Table C 3 - Partially Disaggregated Survey Response Data for “Business Processes” Survey

Response	TSMO (2 Statements)	General (3 Statements)	CAV (13 Statements)	Total
Strongly Agree	1	12	13	26
Somewhat Agree	15	21	63	99
Neither…	36	41	188	265
Somewhat Disagree	10	19	67	96
Strongly Disagree	6	9	111	126
Total	68	102	442	612

However, these generally negative survey results do not necessarily negate the narrower areas of expertise and knowledge within Alaska DOT&PF and the wider community of transportation professionals. For most of these statements, it is possible that the negative results

could reflect poor communication or information sharing within Alaska DOT&PF, rather than a lack of capability. In Table C 4, the statements are divided between "Areas of Strength" and "Areas of Weakness" based on a threshold of 5 agree responses. In areas of strength, it should be possible to identify leaders within Alaska DOT&PF to guide those business processes forward. In areas of weakness, it may be necessary to provide additional training opportunities to develop

Table C 4 - Areas of Strength and Weakness for "Business Process" Survey

Areas of Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**
We have developed the business case for TSMO.	TSMO	6	9
We have engaged in the national dialogue for TSMO.	TSMO	10	7
We understand the relationships between TSMO processes and V2I (or CAV) capabilities.	CAV	10	12
We routinely apply the systems engineering process for development and procurement of high-technology systems.	General	7	13
We have identified a communications strategy for public and internal benefits of business process standardization.	General	8	13
We have identified a regional consensus framework for policy and planning for V2I (or CAV). (OR) We have identified the right partners to develop such workflows.	CAV	5	16
We have included V2I (or CAV) applications in agency planning documents.	CAV	5	15
We have identified the costs and resources required for implementation of V2I (or CAV).	CAV	5	19
We understand the opportunities to partner with other agencies.	CAV	12	7
We realize that interoperability between vendors can be a challenge.	General	18	2
We recognize that lower levels of CAV implementation will bring up some security concerns.	CAV	17	3
As soon as experimentation and standards are developed, CAV technologies and infrastructure need to be quickly and holistically integrated into transportation systems and transit. CAV cannot be an add-on.	CAV	8	7
Areas of Weakness			
We have prioritized V2I (or CAV) applications for our agency.	CAV	3	17
We have identified how regional processes and relationships among partner agencies will affect the implementation of business processes for V2I (or CAV) deployment.	CAV	2	18
We have identified the agency (or agencies) that will bear these costs and resources.	CAV	3	16
We have outlined the requirements for security and privacy policies for V2I (or CAV) applications.	CAV	1	18
We have identified scope and scale of the business processes related to a pilot deployment(s).	CAV	3	16
We have identified the ways that CAV deployment would impact land use codes.	CAV	2	14

leaders. These leaders may include senior level engineers, planners, fiscal officers who are in-charge of planning, programming, budgeting, and project development.

The 19th statement—"In terms of Automated Vehicles (AV), there isn't as much focus on it since that will be tackled primarily by jurisdictions and vehicle manufacturers"—is worded so that agreeing implies that the respondent believes that AV technology does not need to be a focus area for Alaska DOT&PF. 14 respondents agreed with this statement, versus 3 that disagreed and 17 that neither agreed nor disagreed. This indicates there is a general belief among Alaska's transportation professionals that there is no need for Alaska DOT&PF to pursue readiness for AV technologies. Arguably, this neither represents a strength nor a weakness.

In terms of the TSMO/CAV CMM Framework, the response data suggest that Alaska DOT&PF's current capability level for business processes is Level 0, but very close to Level 1 – Exploration. In some aspects, activities to support Level 2 – Initiated have already begun. Chapter 5 of the DOT's guidelines provides a variety of actions to move forward to Level 1 – Exploration, and beyond (P. 36-39).

Dimension 2: Collaboration

From the perspective of the Collaboration dimension of the TSMO/CAV CMM Framework, the results from the Collaboration survey seem to indicate that Alaska DOT&PF is initially prepared for CAV deployment. While respondents identified that several barriers and challenges impede the ability of Alaska DOT&PF to collaborate with itself and with other members of the Alaska transportation community, the results are largely favorable. It may be necessary to identify new avenues of collaboration or strengthen existing avenues, but the basic structure for collaboration appears to already exist.

In all, 31 individuals responded to the Collaboration survey, with 25 of the respondents employed by Alaska DOT&PF, 4 employed by private sector entities, and 2 employed by other government agencies. 15 of the respondents have offices based in Anchorage, 7 in Fairbanks, 6 in Juneau, and 3 in other locations. The respondents' experience in years, both in terms of total professional experience and experience in their current positions, is shown in Table C 5.

Table C 5 - Years of Experience for "Collaboration" Survey

Number of Years	Total Professional Experience	Experience in Current Position
0 to 5	1	19
6 to 10	6	7
11 to 15	4	2
16 to 20	6	2
Over 20	14	1

Over three-fourths of respondents have more than 10 years of total professional experience. The opposite is true, however, in terms of experience in their current position, with 26 of the 31 respondents having less than a decade of experience in their current role. This level of experience generally implies that the respondents have enough knowledge of Alaska's transportation community to understand the nature of collaboration between regional agencies. The makeup of respondent job titles also demonstrates that multiple layers of the organizational hierarchy are represented among the respondents. The mix of engineers, techs, and assistants along with directors, chiefs, and superintendents helps to ensure that top-down and bottom-up perspectives were captured. However, it is always possible that some individuals will have blind spots for collaboration initiatives that are occurring at higher or lower levels of the hierarchy, which could affect their answers.

The Collaboration survey had 16 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." 11 of these questions are worded so that agreement implies that the respondent feels positively about Alaska DOT&PF's collaboration capabilities. 4 other questions are worded so that agreement implies a negative understanding of Alaska DOT&PF's collaboration capabilities. These two subsets—positively-worded and negatively-worded questions—will be discussed separately. The final question is neither positive nor negative and will also be discussed separately. Table C 6 presents a summary of the responses to the 11 positively-worded questions.

Table C 6- Summary of Responses of 11 Positively-Worded Questions

Response	Count
Strongly Agree	20
Somewhat Agree	95
Neither Agree nor Disagree	169
Somewhat Disagree	42
Strongly Disagree	15
Total	341

A plurality of respondents neither agreed nor disagreed to the positively-worded questions (49.6 percent), while 33.7 percent of respondents either "Somewhat" or "Strongly" agreed and 16.7 percent of respondents either "Somewhat" or "Strongly" disagreed. Additionally, respondents were somewhat more likely to "Strongly Agree" than they were to "Strongly Disagree." These results provide evidence that Alaska DOT&PF's collaborative capabilities are sufficient for deployment of a CAV program. Table C 7 provides a summary of the responses to the 4 negatively-worded questions.

Table C 7- Summary of Responses to 4 Negatively-Worded Questions for "Collaboration" Survey

Response	**Count**
Strongly Agree	10
Somewhat Agree	32
Neither Agree nor Disagree	67
Somewhat Disagree	12
Strongly Disagree	3
Total	124

A majority of respondents neither agreed nor disagreed with the negatively-worded statements (54 percent), while 33.9 percent either "Somewhat" or "Strongly" agreed and 12.1 percent either "Somewhat" or "Strongly" disagreed. Respondent were also three times as likely to "Strongly Agree" than they were to "Strongly Disagree." These results contrast the responses to the positively-worded questions, but this may be due to the relatively soft language of these questions, i.e., the negatively-worded questions ask about "barriers," "concerns," and "challenges" in fairly broad terms.

Table C 8 divides the statements into areas of strength and weakness based on a threshold of 5 agree responses for positively-worded questions or 5 disagree responses for negatively-worded questions. With a minimum of 5 respondents who look favorably upon the Alaska DOT&PF's collaboration capabilities in relation to the posed statements, it should not prove overly difficult to identify leaders within the agency or the wider transportation community to help perform actions related to CAV deployment. Table C 8 also offers a categorization for each of the statements: "CAV" for statements directly related to CAV or "General" for statements that address Alaska DOT&PF's collaborative capabilities more broadly.

Table C 8 - Areas of Strength and Weakness for "Collaboration" Survey

Areas of Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**
There is a regional interest or established goals that will be achieved through CAV.	CAV	17	4
Multiple agencies are interested in advancing CAV capabilities.	CAV	18	3
We have identified potential roles and responsibilities for implementing or piloting CAV capabilities.	CAV	6	13
There is a forum for partner agencies to collaborate, discuss, and obtain consensus on potential CAV applications.	CAV	13	5
There are opportunities to leverage existing processes among agencies to initiate CAV capabilities (e.g., business processes, planning, procurement, system engineering, and operations).	CAV	15	4
There are partner agencies with staff who have skillsets that would align with CAV capabilities.	CAV	9	3
There is consistent interest and leadership support among partner agencies.	CAV	6	9
The private sector is involved in different TSMO initiatives.	General	9	6
The police and fire departments have facilities and technologies in place that can support CAV deployment.	CAV	5	5
We see CAV as an integral part of the Smart City plans that are being envisioned.	CAV	13	3
**We see data sharing with outside agencies and vendors as a security concern.	General	8	8
Areas of Weakness			
The partner agency missions are aligned closely with regard to TSMO and CAV.	CAV	4	2
**Some partner agencies have barriers to certain processes.	CAV	10	0
**There are barriers to engaging the private sector as part of a CAV pilot.	CAV	14	3
**We see interoperability on services/products by different service providers/vendors as a challenge.	General	10	4

NOTE: *The symbol ** indicates a negatively-worded question, i.e., agreeing with the statement implies a negative understanding of Alaska DOT&PF's capabilities.*

The final question—"There are regional processes that would need to be factored into piloting CAV capabilities (e.g., Transportation Improvement Plan, programming cycles, and flexibility to fund near-term improvements)"—is not worded so that agreement implies either a negative or positive understand of Alaska DOT&PF's capabilities. 22 respondents either "Strongly" or "Somewhat" agreed to the statement, 6 neither agreed nor disagreed, and 3 "Somewhat" disagreed.

The results from the Collaboration survey suggest that Alaska DOT&PF is likely at Level 1 – Exploration for this dimension of the TSMO/CAV CMM Framework. There are several action items in Chapter of the USDOT's Guidelines that Alaska DOT&PF should address as it aims to move to Level 2 of capacity maturity – Initiated (P. 64-67).

Dimension 3: Culture, Organization, and Staffing

The results from the Culture, Organization, and Staffing survey seem to signal that Alaska DOT&PF is prepared for CAV deployment from the perspective of this dimension. More respondents held favorable views than unfavorable views of Alaska DOT&PF's capabilities on this front, meaning that it should not be difficult to identify leaders to guide the Department through the culture, organization, and staffing actions in the DOT's Guidelines. While some areas, particularly those pertaining to staffing, underperformed compared to the survey results as a whole, the respondents generally seem to believe that Alaska DOT&PF has a culture that promotes organizational improvement, policies and procedures that allow for flexible decision-making, and a level of staff expertise that could meet the challenges of CAV deployment with some additional training, support, hiring, or outsourcing.

A total of 33 individuals responded to the Culture, Organization, and Staffing survey (though only 32 completed the survey), with all 33 employed at Alaska DOT&PF. 18 of the respondents have offices in Anchorage, 7 in Fairbanks, 5 in Juneau, and 3 in other locations. Table C 9 shows the spread of respondent experience, both in terms of years of total professional experience and years in their current position.

Table C 9 - Years of Experience for "Culture, Organization, and Staffing" Survey

Number of Years	Total Professional Experience	Experience in Current Position
0 to 5	1	23
6 to 10	8	7
11 to 15	2	1
16 to 20	4	1
Over 20	18	1

Most of the respondents appear to be well established in their careers, with 24 respondents having more than a decade of professional experience. Inversely, 30 of the respondents have served in their current position for less than a decade. This level of professional experience might imply

that the top of the organizational chart is overrepresented, which could prove problematic in a survey with culture as one of its focal points; however, the professional titles of the respondents demonstrate a representative mix, ranging from Administrative Assistants and Engineers to Directors and Chiefs.

The survey featured 21 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." For 19 of those questions, if a respondent agreed with the statement, then they were indicating a favorable understanding of Alaska DOT&PF's culture, organization, and/or staffing. Table C10 summarizes the responses to those 19 questions. The final 2 questions will be discussed separately.

Table C 10 - Summary of Responses to First 19 Likert Scale Questions for "Culture, Organization, and Staffing" Survey

Response	Count
Strongly Agree	52
Somewhat Agree	168
Neither Agree nor Disagree	213
Somewhat Disagree	142
Strongly Disagree	46
Total	621

With 35.4 percent, a narrow plurality of respondents either "Somewhat" or "Strongly" agreed to these statements, while 34.3 percent neither agreed nor disagreed and 30.3 percent either "Somewhat" or "Strongly" disagreed. Respondents were slightly more likely to "Strongly Agree" than they were to "Strongly Disagree."

Table C 11 shows the survey response data disaggregated into three categories: questions that pertain to culture, questions that pertain to organization (interpreted as policies and procedures), and questions that pertain to staffing. While the line between these three categories can be somewhat thin, and the three categories are inextricably linked—as changes in organization or staffing are bound to have changes on culture, and vice versa—it is nonetheless helpful to delineate the categories in order to observe areas of relative strength and weakness. For Culture, the category of greatest relative strength, the ratio of positive to negative responses is 1.95 to 1. For Organization, which is considerably weaker than culture but still presents a net positive, the ratio is 1.26 to 1. Staffing, meanwhile, is the only category that has a net negative with a ratio of

0.86 to 1. Staffing is also the only category in which respondents were more likely to "Strongly Disagree" than they were to "Strongly Agree."

Table C 11 - Partially Disaggregated Survey Response Data for "Culture, Organization, and Staffing" Survey

Response	Culture (5 Questions)	Organization (4 Questions)	Staffing (10 Questions)	Total
Strongly Agree	22	8	22	52
Somewhat Agree	60	31	77	168
Neither…	40	58	115	213
Somewhat Disagree	37	26	79	142
Strongly Disagree	5	5	36	46
Total	164	128	329	621

The 20th and 21st statements are worded so that agreement implies a negative understanding of Alaska DOT&PF's capabilities. For the first of these statements—"Training policies need to be revisited to better address the requirements for CAV deployment"—21 respondents either "Strongly" or "Somewhat" agreed, 10 respondents neither agreed nor disagreed, and 1 respondent "Somewhat" disagreed. For the second—"We face issues in retention of skilled staff"—25 respondents either "Strongly" or "Somewhat" agreed, 7 neither agreed nor disagreed, and 1 "Somewhat" disagreed. Both of these statements fall under the Staffing category, and the responses provide further evidence that Staffing is a relative weakness for Alaska DOT&PF.

Regardless of the relative weakness of the staffing category, these survey results are largely positive. It is clear that Alaska DOT&PF employees generally believe that the dimension of Culture, Organization, and Staffing is a strength of the agency. To this point, nearly every question passed the threshold of 5 positive responses that is used in the analysis of other dimensions to separate areas of strength from areas of weakness. It is perhaps more appropriate for this dimension to speak of areas of relative strength and weakness, as is shown in Table C 12. As opposed to the other dimensions, the division of relative strengths and weaknesses is based on whether a question had a ratio of agree to disagree responses of 1 or greater. The table also notes the category to which the question belongs. Technical expertise in various areas related to CAV deployment comprise most of the areas of relative weakness, implying that it may be necessary to hire on new staff who possess that expertise, contract out, or develop that expertise in the current staff of Alaska DOT&PF.

Table C 12 - Areas of Relative Strength and Weakness for "Culture, Organization & Staffing" Survey

Areas of Relative Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**
Our Agency welcomes testing opportunities on a small scale for evaluation of measures of effectiveness.	Culture	18	3
We have flexible policies for task assignments, as determined by needs.	Organization	13	8
We have mechanisms in place to address skill deficiencies (e.g., contracting/outsourcing, training).	Staffing	17	5
Our organization embraces technology and innovation.	Culture	19	10
There is a commitment from leadership to advance technology.	Culture	16	11
Our organization takes tangible steps to promote a culture that embraces technology.	Culture	17	10
We have technical expertise in data management that can support V2I (or CAV).	Staffing	12	9
We have technical expertise in operations that can support V2I (or CAV).	Staffing	14	11
We have technical expertise in maintenance that can support V2I (or CAV).	Staffing	15	9
We do not have operational or policy issues that would limit our ability to deploy V2I (or CAV).	Organization	5	4
We are active in national V2I (or CAV) and TSMO organizations (or activities) that enable us to learn about peer agency programs and experiences, national trends, and emerging technologies.	Organization	15	3
We have a champion for a CAV program.	Culture	12	8
Areas of Relative Weakness			
We have flexibility to acquire staff with required skill sets based on needs.	Staffing	6	22
Our staff has the skills required for operating and maintaining V2I (or CAV) infrastructure.	Staffing	7	13
We have technical expertise in systems engineering that can support V2I (or CAV).	Staffing	6	13
We have technical expertise in design that can support V2I (or CAV).	Staffing	8	11
We have technical expertise in deployment/integration that can support V2I (or CAV).	Staffing	8	12
We have technical expertise in analytics that can support V2I (or CAV).	Staffing	6	10
There are no barriers to participating in these national activities. [I.e., national V2I (or CAV) and TSMO organizations or activities.]	Organization	6	16
**Training policies need to be revisited to better address the requirements for CAV deployment.	Staffing	21	1
**We face issues in retention of skilled staff.	Staffing	25	1

NOTE: *The symbol ** indicates a negatively-worded question, i.e., agreeing with the statement implies a negative understanding of Alaska DOT&PF's capabilities.*

Based on the results from the Culture, Organization, and Staffing survey, Alaska DOT&PF is likely at Level 1 – Exploration of this dimension in the TSMO/CAV CMM Framework. Chapter

5 of the DOT's Guideline*s* lists a number of actions that Alaska DOT&PF can take to advance to Level 2 – Initiated (P. 58-61).

Dimension 4: Performance Measures

From the perspective of performance measures, it appears that Alaska DOT&PF is initially prepared for CAV deployment. While there are several weaknesses that Alaska DOT&PF needs to address, especially in relation to CAV capabilities, there is a generally positive view of the agency's overall performance measurement capabilities. It may be necessary to conduct training and develop new performance measurement processes related to CAV, but it seems possible to identify leaders to advance Alaska DOT&PF on this dimension of the TSMO/CAV CMM Framework.

The Performance Measures survey had a total of 32 respondents, with 31 of those respondents employed by Alaska DOT&PF and 1 respondent employed by another government agency. 14 of the respondents are based in Anchorage, another 14 are based in Juneau, and 4 are based in Fairbanks. Table C 13 displays the experience of respondents in years, both in terms of total professional experience and in terms of experience in their current position.

Table C 13 - Years of Experience for "Performance Measures" Survey

Number of Years	Total Professional Experience	Experience in Current Position
0 to 5	4	20
6 to 10	4	9
11 to 15	1	2
16 to 20	2	1
Over 20	21	0

A clear majority of respondents have more than a decade of total professional experience, with two-thirds of respondents having over 20 years of experience. Most respondents, though, have 10 years or less of experience in their current position. The professional titles of respondents show that Project Managers and Analyst/Programmers are thoroughly represented, and so too are higher-level administrators. The level of experience of respondents and the range of job duties, which seem to include both the production and consumption of performance measurement data, demonstrate that, in general, most respondents had an adequate degree of knowledge to answer the

questions. However, it is always possible that some respondents were unaware of Alaska DOT&PF's performance measures and related policies and processes.

The survey featured 9 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." All 9 questions were worded so that agreeing with the statement indicated that a respondent held favorable views of Alaska DOT&PF's performance measurement capabilities or related capabilities. However, one question was only asked to respondents who agreed to a specific previous statement, and this question will be discussed separately. Table C 14 presents a summary of the responses to the first 8 questions.

Table C 14 - Summary of Responses to First 8 Likert Scale Questions for "Performance Measures" Survey

Response	Count
Strongly Agree	14
Somewhat Agree	40
Neither Agree nor Disagree	145
Somewhat Disagree	23
Strongly Disagree	34
Total	256

A majority of respondents neither agreed nor disagreed with the statements (56.6 percent). The remaining responses are narrowly divided between agreeing and disagreeing, with 22.3 percent either "Somewhat" or "Strongly" disagreeing and 21.1 percent either "Somewhat" or "Strongly" agreeing. However, respondents were slightly more than twice as likely to "Strongly Disagree" than they were to "Strongly Agree."

By partially disaggregating the response data, as shown in Table C 15, it becomes clear that there is a divide between the respondents' belief in Alaska DOT&PF's performance measurement capabilities in general and the agency's performance measurement capabilities as they relate to CAV. For the questions that related generally to performance measures, the respondents were nearly twice as likely to agree with the statements than they were to disagree with them. However, when the questions referenced CAV, the opposite was true, with 24 respondents who either "Somewhat" or "Strongly" agreed versus 40 who either "Somewhat" or "Strongly" disagreed.

Table C 15 - Partially Disaggregated Response Data for "Performance Measures" Survey

Response	General	CAV	Total

Strongly Agree	6	8	14
Somewhat Agree	24	16	40
Neither…	49	96	145
Somewhat Disagree	7	16	23
Strongly Disagree	10	24	34
Total	96	160	256

These results demonstrate that Alaska DOT&PF's employees generally believe that the agency's performance measurement capabilities are adequate, but there is more work that needs to be done around CAV. This is also reflected when the statements are sorted into "Areas of Strength" and "Areas of Weakness," as shown in Table C 16. The division between areas is based on a threshold of 5 positive responses. With a minimum of 5 positive responses, it should not prove overly difficult to identify leaders within Alaska DOT&PF to advance the agency's capabilities. However, it may be necessary to provide additional training or perform other organizational development to improve Alaska DOT&PF's capabilities in areas of weakness.

Table C 16 - Areas of Strength and Weakness for "Performance Measures" Survey

Areas of Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**
We have reviewed the MAP-21 performance measurement requirements.	General	15	4
We have identified how we will use existing TSMO systems to meet MAP-21 requirements.	General	7	8
We have identified barriers to basic performance measurement requirements.	General	8	5
We are taking a measured approach due to the evolution of devices and technologies.	CAV	13	2
Weaknesses			
Statement	**Category**	**Positive Responses**	**Negative Responses**
We have identified how V2I (or CAV) data may supplement other TSMO performance measurement efforts.	CAV	1	10
We have identified if/when V2I (or CAV) data collection may replace other data collection efforts.	CAV	4	10
We have identified which v2I (or CAV) data could enhance certain TSMO performance measurement practices.	CAV	4	9
We have identified which performance metrics will be used to measure V2I (or CAV) deployment performance.	CAV	2	9

The 9th statement—"The identified performance metrics are feasible"—was only asked to respondents who answered positively to the statement, "We have identified which performance

metrics will be used to measure V2I (or CAV) deployment performance." Of the two respondents who answered this question, both agreed that the identified performance metrics are feasible. However, with so few responses to this question, these positive responses should be considered skeptically.

The results from this survey indicate that Alaska DOT&PF is likely at Level 1 – Exploration of the Performance Measures dimension in the TSMO/CAV CMM Framework. The DOT's *Guidelines* list several action items in Chapter 5 that could advance Alaska DOT&PF to Level 2 – Initiated (P. 53-56).

Dimension 5: Systems &Technology: Back Office

The Systems and Technology: Back Office dimension appears to be one of Alaska DOT&PF's weakest dimensions in the TSMO/CAV CMM Framework. Compared to most of the other surveys, a greater percentage of responses offered an unfavorable understanding of Alaska DOT&PF's capabilities. However, a substantial minority of respondents offered a favorable understanding and the survey results revealed a greater number of areas of strength than areas of weakness. It seems likely that Alaska DOT&PF is initially prepared for CAV deployment from the perspective of back office systems and technology, but the agency may need to conduct additional research and trainings, and acquire new systems or adapt existing systems to meet CAV needs.

There were 40 respondents to the Systems and Technology: Back Office survey, all 40 of whom are Alaska DOT&PF employees. 17 of the respondents work in Anchorage, 17 others work in Juneau, and 6 work in Fairbanks. The amount of respondents' experience, both in terms of total years as a professional and years in their current position, is displayed in Table C 17.

Table C 17 - Years of Experience for "Systems & Technology: Back Office" Survey

Number of Years	Total Professional Experience	Experience in Current Position
0 to 5	13	26
6 to 10	2	10
11 to 15	2	3
16 to 20	4	1
Over 20	19	0

Compared to most of the other surveys, the respondents to the Systems and Technology: Back Office survey tended to be earlier in their careers, with 15 of the 40 respondents having 10

years or less of total professional experience. However, the younger respondents are balanced by the 19 respondents who have more than 20 years of experience. In terms of their current position, a clear majority of respondents (36 out of 40) have a decade or less of experience. This skew toward less experienced professionals may be due to the prevalence of respondents who are most likely to use back office systems and technology as part of their daily jobs, such as analyst/programmers, engineering assistants, and engineers.

The survey had 17 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." 14 of those questions were worded so that agreement with the statement implied a favorable understanding of Alaska DOT&PF's capabilities on this dimension. However, one of the positively-worded questions was asked to only 11 participants. That question, along with the 3 remaining questions, will be discussed separately. Table C 18 offers a summary of the responses to the 13 positively-worded questions.

Table C 18 - Summary of Responses to 13 Positively-Worded Questions for "Systems & Technology: Back Office" Survey

Response	Count
Strongly Agree	10
Somewhat Agree	81
Neither Agree nor Disagree	277
Somewhat Disagree	85
Strongly Disagree	67
Total	520

With 53.3 percent, a slim majority of respondents neither agreed nor disagreed to the statements, while 29 percent either "Somewhat" or "Strongly" disagreed and 17.5 percent either "Somewhat" or "Strongly" agreed. Respondents were also nearly 7 times more likely to "Strongly Disagree" than they were to "Strongly Agree."

A similar story is told by partially disaggregating the results, as displayed in Table C 19. Respondents were more likely to agree with the statements categorized as "General" (20 percent) than they were to agree with statements pertaining directly to CAV (16.7 percent). Meanwhile, nearly 8 percent more of the respondents disagreed with statements related to CAV (31 percent) than disagreed to the general statements (23.3 percent). While this divide between the categories is smaller than the survey results on most of the other dimensions, it may still suggest that

respondents tend to hold more favorable views of Alaska DOT&PF's back office systems and technology in general than as those systems and technology relate to CAV.

Table C 19 – Partially Disaggregated Survey Response Data for "Systems & Technology: Back Office" Survey

Response	General (3 Questions)	CAV (10 Questions)	Total
Strongly Agree	1	9	10
Somewhat Agree	23	58	81
Neither…	68	209	277
Somewhat Disagree	12	73	85
Strongly Disagree	16	51	67
Total	120	400	520

The 14th positively-worded question—"We can develop standards for common TSMO back office systems"—was only asked to the 11 respondents who disagreed with the statement, "We have existing standards for common TSMO back office systems." Of those 11 respondents, 7 agreed, 3 neither agreed nor disagreed, and 1 disagreed. This means that 39 of the 40 respondents believe that Alaska DOT&PF either currently has common TSMO standards for back office systems or that it could develop those standards without much difficulty.

In addition to the 14 positively-worded questions, there were 3 negatively-worded questions. If a respondent agreed to these statements, then it implies an unfavorable understanding of Alaska DOT&PF's capabilities related to this dimension. Table C 20 summarizes the responses to the negatively-worded questions.

Table C 20 - Summary of Responses to 3 Negatively-Worded Questions for "Systems & Technology: Back Office" Survey

Response	Count
Strongly Agree	25
Somewhat Agree	35
Neither Agree nor Disagree	56
Somewhat Disagree	3
Strongly Disagree	1
Total	120

A narrow majority of respondents "Strongly" or "Somewhat" agreed (50 percent), while 46.7 percent neither agreed nor disagreed, and only 3.3 percent either "Strongly" or "Somewhat"

disagreed. These responses are substantially more unfavorable in their understanding of Alaska DOT&PF's capabilities, but that may be due to the framing of the questions.

Table C 21 divides the statements into areas of strength and weakness based on a threshold of 5 agree responses for positively-worded questions or 5 disagree responses for negatively-worded questions. With 5 or more favorable responses, Alaska DOT&PF should be able to identify leaders to guide the agency forward on that specific issue of the Systems and Technology: Back Office dimension.

Taken in total, the results from this survey seem to suggest that Alaska DOT&PF is currently at Level 1 – Exploration of the Systems and Technology: Back Office dimension. The DOT's Guidelines offer several important action items that can help move Alaska DOT&PF to Level 2 – Initiated (P. 47-50).

Dimension 6: Systems & Technology: Field

The survey results indicate that Alaska DOT&PF's capability as it relates to field systems and technology is among the weakest dimensions, along with business processes and back office systems and technology. While this dimension of the TSMO/CAV CMM Framework has several weaknesses, it nonetheless revealed a greater number of areas of strength than areas of weakness, and a substantial minority of respondents favorably viewed the Alaska DOT&PF's capabilities. The Systems and Technology: Field survey results suggest that Alaska DOT&PF is initially prepared for CAV deployment, though the agency may need to update some aspects of its field technology and related processes to satisfy requirements to achieve Level 1 capacity maturity.

A total of 44 individuals responded to the survey, though only 43 completed it, with 40 of the respondents employed by Alaska DOT&PF and 4 employed by private sector firms. 25 of the respondents work in Anchorage, 11 work in Juneau, 7 work in Fairbanks, and 1 works in another location. Table C 22 displays the respondents' experience in years, both in terms of total professional experience and experience in their current positions. 30 of the 44 respondents have more than a decade of total professional experience. However, 40 of the 44 respondents have been in their current position for 10 years or less. In general, this implies that the respondents have

Table C 21- Areas of Strength and Weakness for "Systems & Technology: Back Office" Survey

Areas of Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**

We have existing standards for common TSMO back office systems.	General	7	11
*We can develop standards for common TSMO back office systems.	General	7	1
We have a preferred IT procurement strategy (IaaS, PaaS, DaaS, on-premise deployment, etc.).	General	6	7
We are proficient in efficiently processing data received from various sensors.	General	11	10
We understand the role of data tools and technologies for processing, storing, and using CAV data.	CAV	8	12
We understand the issues with management of high-definition data from RSU.	CAV	9	13
We understand the issues related to cybersecurity and PII protections of CAV pilot data collection, storage, and use.	CAV	14	10
We understand how existing asset management systems might be utilized.	CAV	11	11
CAV data can be easily integrated into our GIS database.	CAV	6	10
We understand what will be needed for back-office software maintenance.	CAV	8	11
Areas of Weakness			
We have identified impacts of CAV operations on legacy systems in the TMC or other centers.	CAV	4	15
We have articulated the need for decision support systems that may result from the outcomes of pilot deployments.	CAV	3	12
We have identified spectrum licensing needs and procedures.	CAV	1	14
We have identified how a CAV pilot can integrate with other related technology programs at our agency or peer agencies	CAV	3	16
**We need new back-office systems for asset management.	CAV	22	0
**Data sharing with outside agencies may be an issue due to security concerns.	General	19	4
**There are barriers or legacy requirements (OS, hardware, IT) that will impact selection of certain back-office systems for CAV.	CAV	19	0

NOTE: *The symbol * indicates the question with only 11 responses and the symbol ** indicates a negatively-worded question, i.e., agreeing with the statement implies a negative understanding of Alaska DOT&PF's capabilities.*

enough knowledge of Alaska DOT&PF and the broader transportation community to accurately answer the questions. Based on the respondents' job titles, it appears that the respondents skew toward early-career professionals, with fewer than 10 job titles from the ranks of superintendents, managers, chiefs, etc., and a prevalence of titles like engineering assistant, engineer, and technician.

Table C 22 - Years of Experience for "Systems & Technology: Field" Survey

Number of Years	Total Professional Experience	Experience in Current Position

0 to 5	8	31
6 to 10	6	9
11 to 15	10	3
16 to 20	5	1
Over 20	15	0

The Systems and Technology: Field survey had 14 questions (posed as statements) in which the answers ranged on a 5-point Likert scale from "Strongly Disagree" to "Strongly Agree." For 11 of those questions, agreeing with the statement implies that the respondent holds a favorable view of Alaska DOT&PF's capabilities on this dimension. These 11 positively-worded questions and the final 3 questions will be discussed separately. A summary of the responses to the first 11 questions is shown in Table C 23.

Table C 23 - Summary of Responses to 11 Positively-Worded Questions for "Systems & Technology: Field" Survey

Response	Count
Strongly Agree	15
Somewhat Agree	61
Neither Agree nor Disagree	285
Somewhat Disagree	68
Strongly Disagree	51
Total	480

Most respondents neither agreed nor disagreed with these statements (59.4 percent), while 24.8 percent either "Somewhat" or "Strongly" disagreed versus 15.8 percent that either "Somewhat" or "Strongly" agreed. Respondents were also more than three times more likely to "Strongly Disagree" than they were to "Strongly Agree."

When this data is partially disaggregated, as shown in Table C 24, a different response pattern emerges than in most of the other surveys. For the two questions categorized as "General," 13.6 percent of respondents agreed to the statements versus 34.1 percent who disagreed. Meanwhile, for the nine questions that pertained more directly to CAV field systems and technology, a smaller percentage of respondents disagreed (22.7 percent) and a larger percentage of respondents agreed (16.3 percent).

Table C 24 - Partially Disaggregated Response Data for "Systems & Technology: Field" Survey

Response	General (2 Questions)	CAV (9 Questions)	Total (11 Questions)
Strongly Agree	1	14	15
Somewhat Agree	11	50	61

Neither…	46	239	285
Somewhat Disagree	19	49	68
Strongly Disagree	11	40	51
Total	88	392	480

Three questions were not included in the analysis of positively-worded questions. These three questions are negatively-worded, meaning that agreement with a statement implies that the respondent holds an unfavorable view of Alaska DOT&PF's field systems and technology capabilities. A summary of the responses to these questions is presented in Table C 25.

Table C 25 - Summary of Responses of 3 Negatively-Worded Questions

Response	Count
Strongly Agree	7
Somewhat Agree	33
Neither Agree nor Disagree	79
Somewhat Disagree	8
Strongly Disagree	5
Total	132

Most respondents neither agreed nor disagreed to the statements (59.8 percent), while 30.3 percent either "Somewhat" or "Strongly" agreed and 9.8 percent either "Somewhat" or "Strongly" disagreed. These responses demonstrate a somewhat more unfavorable understanding of Alaska DOT&PF's capabilities in this dimension, but not substantially so.

All of the statements are divided into areas of strength and weakness based on a threshold of 5 agree response for positively-worded questions or 5 disagree responses for negatively-worded questions, as shown in Table C 26.

Table C 26 - Areas of Strength and Weakness for "Systems & Technology: Field" Survey

Areas of Strength			
Statement	**Category**	**Agree Responses**	**Disagree Responses**
We have identified a deployment approach for a pilot project.	CAV	6	12

We have developed a pilot concept of operations and system requirements for field equipment for the pilot project.	CAV	5	11
We have sufficient capacity in terms of communications network bandwidth for CAV applications.	CAV	6	13
Performance of CCTV cameras at intersections is satisfactory for potential CAV applications.	CAV	7	10
Traffic signal controllers are intelligent or can be easily transitioned to intelligent traffic signal controllers.	CAV	10	7
Cloud computing is possible or will be possible in the near future for CAV applications.	CAV	10	7
Real-time data collection and processing can be enabled for CAV application.	CAV	9	9
Existing Fiber Optic capacity is sufficient for CAV applications.	CAV	7	9
We have identified how the field equipment fits into our ITS architecture.	General	9	11
**We have identified issues with cybersecurity of field equipment.	CAV	8	7
Areas of Weakness			
We have identified spectrum licensing needs and procedures.	CAV	4	11
We have sufficient capacity in terms of computer servers and data storage.	General	3	19
**We have legacy issues relevant to procurement of certain types of equipment.	General	16	3
**Additional space is needed within the cabinets for new equipment.	General	16	3

NOTE: *The symbol ** indicates a negatively-worded question, i.e., agreeing with the statement implies a negative understanding of Alaska DOT&PF's capabilities.*

The results of the Systems and Technology: Field survey suggest that Alaska DOT&PF's current capability level for this dimension is Level 0, but close to Level 1 – Exploration. There are a variety of action items in the DOT's Guidelines that can be accomplished to move Alaska DOT&PF to Level 1 – Exploration and beyond (P. 42-44).

Appendix D: Detailed Analysis of Open-Ended Questions

Each of the surveys has open-ended questions, allowing respondents to provide more detailed information and opinions regarding Alaska DOT&PF's capabilities across the six dimensions of the TSMO/CAV CMM Framework. All the surveys include at least these five questions (or variations of these five questions):

- "From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"
- "From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?"
- "List unique challenges that Alaska faces for CAV deployment."
- "List unique challenges that your agency faces for CAV deployment."
- "Do you have any other comments?"

However, some of the surveys feature additional open-ended questions beyond these five. All of the responses are discussed in the six following subsections

Business Processes

The Business Processes survey features five open-ended questions. The first of these questions is:

- "From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"

A total of 16 respondents offered useable answers to this question, and their answers largely fall into one of three groups. The first group of responses focuses on the expertise, motivation, and adaptability of Alaska's transportation workforce (5 responses). One representative response from this group suggests that "highly skilled and motivated transportation infrastructure planning, design, and construction professionals" would enable efficient/easy adaptation of CAV. The second group of responses focuses on the available knowledge that has been gained via CAV implementation projects from outside of Alaska (3 responses). One respondent suggests that other states' past successes and failures "will save us time and money as we can learn from [them]." The third group of responses focuses on the ability of Alaska DOT&PF and/or the private sector to quickly make decisions (3 responses). Other unique responses included the role of the University of Alaska as a research/testing partner, the availability of funding, and various attributes of Alaska's geography and population.

The second open-ended question in the Business Processes survey is:

- "From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?"

A total of 18 respondents offered useable answers to this question, and their answers tend to fall into one of four groups, with some overlap for certain respondents. The first group of responses consists of concerns about funding (9 responses). It should be noted that funding was usually considered alongside other concerns. The second group of responses suggests that a lack of specific expertise in CAV technologies is a hindrance (5 responses). The third group of responses points to Alaska's sparsely populated geography and harsh climate as challenges (5 responses). The final group of responses identifies leadership and direction, with one respondent suggesting that Alaska DOT&PF "Does not have an internal champion who is taking this on as their sole duty" (3 responses).

The third and fourth open-ended questions are:

- "List unique challenges that Alaska faces for CAV deployment."
- "List unique challenges that your agency faces for CAV deployment."

There were 20 useable responses to the third question, with most responses listing weather/climate (10 responses) and/or the sparsely populated geography (9 responses). Other respondents suggested funding and technology shortfalls may be unique challenges. The fourth question had 14 useable responses, and the respondents believe that Alaska DOT&PF's unique challenges include funding (8 responses), staffing (2 responses), and Alaska's political landscape (2 response).

The final open-ended question in the Business Processes survey is:

- "Do you have any other comments?"

Only 2 respondents offered useable answers to this question. The first respondent suggested that security and privacy "will always be an issue… [but] they will not be impediments to implementation." Further, this respondent suggested that standards should be built "on the latest technology," otherwise they may become unstable. The second respondent does not believe that it would be "appropriate" for Alaska to be among the first states to implement new technologies.

Collaboration

There are 11 open-ended questions in the Collaboration survey. In addition to the 5 standard questions, there are 6 questions that were asked to respondents who "Somewhat" or "Strongly" agreed to various statements. These 6 questions ask respondents to "elaborate upon" their previous answers. The first question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "Some partner agencies have barriers to certain processes."

Of the 7 who elaborated upon their answer, 6 provided useable responses. Those responses fall into 3 overlapping groups: funding (3 responses), processes (3 responses), and technology (3 responses).

The second question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "There are partner agencies with staff who have skillsets that would align with CAV capabilities."

Of the 6 who elaborated upon their answer, the first 3 offered a general sense of other Alaska agencies possessing CAV skillsets, though they could not provide details. The other 3 pointed to the Municipality of Anchorage's staff who are responsible for overseeing the city's traffic signal system.

The third question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "The police and fire departments have facilities and technologies in place that can support CAV deployment."

Of the 4 who elaborated upon this question, 2 offered useable responses. They both pointed to Opticom/connected intersections.

The fourth question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "There are barriers to engaging the private sector as part of a CAV pilot."

Of the 13 who elaborated upon this question, 11 provided useable responses that can be categorized into 5 groups: laws/regulations (4 responses), privacy/security concerns (3 responses), the need for financial incentives (2 responses), physical safety concerns (2 responses), and agency territoriality (2 responses). One response is worth quoting in full:

> "I'm in the private sector and I don't know anything about DOT's plans for CAV pilot. What will they do in-house? What will they need help with? If we can understand DOT's high-level plans, or intentions for a CAV pilot in advance, then we'll have time to develop our own strategies for aligning our staff skills to the state's needs. The current barrier is that we're blind on the matter."

The fifth question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "We see data sharing with outside agencies and vendors as a security concern."

There were 5 responses to this question, all of which were useable. The general sense of the responses is best summed up by this individual response:

> "As with any system collecting data, privacy and security of that data is paramount. Data needs to be only used for its intended purpose and collected anonymous to avoid any bias. Any security issues will reduce trust in the system and could potentially slow down the acceptance of CAV."

The final question that respondents were asked to elaborate upon is whether they agreed with this statement:

- "We see interoperability on services/products by different service providers/vendors as a challenge."

Of the 7 responses to this question, 6 were useable. Each of the responses offered the same general message, and this individual response is representative of the group:

> "Each manufacturer adheres to the standards, but add[s] desirable features unique to themselves in their capabilities or ease of implementation. The standards do not evolve as fast [as] capabilities and so are not useful in creating a true 'plug and play' environment that is vendor agnostic. We get 'locked in'

and become dependent upon our vendors, awaiting their implementations of new features and standards."

The remaining 5 open-ended questions in the Collaboration survey are the standard questions that were included in all 6 surveys. However, the wording in the Collaboration survey varied slightly. The first of these questions is:

- "From your perspective, what are the advantages in the prevailing collaborative framework that will enable efficient/easy adaptation of CAV?"

There were 11 useable answers to this question, with the answers generally falling into one of three groups. The first group of responses questions whether a collaborative framework actually exists (3 responses). The second group focuses on open lines of communication as an advantage (4 responses). The final group of responses points to shared standards, technologies, and/or processes (3 responses).

The second of these questions is:

- "From your perspective, what are the limitations in the prevailing collaborative framework that will adversely affect the adaptation of CAV?"

The 9 useable responses to this question fall primarily into one of two groups. The first group of responses suggests that shared decision-making and stakeholder inclusion in decision-making can be a concern (7 responses). The second group offers funding as an issue (2 responses)

The third and fourth questions are:

- "List unique collaborative challenges that Alaska faces for CAV deployment."
- "List unique collaborative challenges that your agency faces for CAV deployment."

The third question had 15 useable answers. The responses can fit into four groups. The first group focuses on the difficulties of communication and coordination across such a large state (6 responses). The second group points to technology and infrastructure challenges, particularly in rural areas (6 responses). With some overlap with the previous groups, the third group focuses on Alaska's harsh climate (4 responses). The final group, which also overlaps with the other groups, is concerned about funding (2 responses). For the fourth question, there were 9 useable responses that fell into three partially overlapping groups: funding (5 responses), communication and

coordination across agencies (3 responses), and issues related to Alaska's infrastructure (3 responses).

The final question in the Collaboration survey is:

- "Do you have any other comments?"

There was only one response to this question. The respondent discussed the difficulty of implementing autonomous vehicles in Alaska due to the frequent illegibility of road markings during the winter due to snow/ice and during the spring due to wear.

Culture, Organization, & Staffing

The survey on Culture, Organization, and Staffing has seven open-ended questions. In addition to the five standard questions, there are two questions that ask respondents to "Elaborate upon" their previous answer if they either "Somewhat" or "Strongly" disagreed with the previous statement. The first question respondents were asked to elaborate upon is whether they disagreed with the following statement:

- "We do not have operational or policy issues that would limit our ability to deploy V2I (or CAV)."

There were 2 useable responses to this question. Both respondents addressed operational issues, both pointing to funding specifically. One of the respondents also suggested that lack of staff expertise is an issue, while the other suggested that Alaska's long winters present an operational problem.

The second question respondents were asked to elaborate upon is whether they disagreed with the following statement:

- "There are no barriers to participating in these national activities."

13 respondents provided useable answers to this question, with 11 of them suggesting that travel restrictions and/or lack of funding were barriers. The other 2 responses suggest that "winter weather events" and "Staff time availability" are barriers.

The first of the standard questions in the Culture, Organization, and Staffing survey is:

- "From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"

There were 12 useable answers to this question. Most of the responses fit into two categories: as one respondent phrased it, "Inspired and motivated staff" (4 responses); and a relatively small amount of infrastructure (3 responses). Other responses included access to federal funding, the current move toward cloud implementations, and open lines of communication across the state.

The second question is:

- "From your perspective, what are the limitations that your agency has that will adversely affect adaptation of CAV?"

16 respondents offered useable answers to this question. Most of the responses fell into these two overlapping groups: funding (9 responses) and lack of technical expertise (4 responses). Other respondents also discussed outdated infrastructure, outdated regulations, and small traffic volumes.

The third and fourth standard questions in the Culture, Organization, and Staffing survey are:

- "List unique challenges that Alaska faces for CAV deployment."
- "List unique challenges that your agency faces for CAV deployment."

The third question had 18 useable responses that fell primarily into three overlapping groups: Alaska's winter weather (9 responses), Alaska's sparsely populated geography (8 responses), and a lack of communications infrastructure (8 responses). The fourth question had 14 useable responses. The majority of responses fit into two groups: lack of technical expertise (8 responses) and funding (7 responses).

The final question in this survey is:

- "Do you have any other comments?"

Performance Measures

The survey on Performance Measures has six open-ended questions. Apart from the five standard questions present in each of the surveys, there is one question that is a follow-up for those who

"Somewhat" or "Strongly" disagreed with the following statement: "We have identified barriers to basic performance measurement requirements." The follow-up question is:

- "Please elaborate what strategies can be followed to identify those barriers."

There were three useable responses to this question. The first respondent seems to suggest that the city of Fairbanks is not suitable for implementing performance measures due to its small traffic flow and the unpredictability of weather events. The second respondent points to a pilot project in Hi Resolution Signal Performance Measures in Wasilla, noting that there may be a need to identify additional funding. The final respondent is worth quoting in full:

> "Identify and empower staff with sufficient resources to fully understand MAP-21 performance measures, evaluate current systems (both existing and prospective), and […] create a plan for identifying and overcoming barriers. Without dedicated staff and management support, progress toward meeting performance measures will be stymied in a partial effort.
>
> "Too little management commitment and support will result in a staff with good intentions, but without the decision-making capacity to allocate funds and resources to ensure the job is accomplished."

The second question in the Performance Measures survey is:

- "From your perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"

10 respondents offered useable answers to this question, which can be generally divided into three groups. The first group focuses on Alaska DOT&PF's ability to model its CAV implementation on other states' plans (3 responses). The second group points to Alaska DOT&PF's staff and/or leadership (3 responses). The final group discussed various aspects of CAV technology (3 responses).

The third question is:

- "From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?"

There were 12 useable responses to this question. The responses tended to fit into one or more of the following groups: lack of funding (8 responses), lack of suitable technology/infrastructure (6

responses), and inadequate staffing levels and/or expertise (4 responses). One response is worth quoting in full:

> "Our Agency is organized to build projects and maintain existing infrastructure. That could be a good attribute, if it could be re-made to operate a highly integrated and complex electronic traffic control system across a very large area. Away [from] urban centers, most roads are small and remote, often with insufficient communication.
>
> "If that purpose is re-imagined to develop Traffic Control Centers the way other states have, to install hardwired communication along all state highways, or invest in satellite communications to support the more distant communications needs, it might be done."

The fourth and fifth questions in the Performance Measures survey are:

- "List unique challenges that Alaska faces for CAV deployment."
- "List unique challenges that your agency faces for CAV deployment."

The fourth question had 13 useable responses, which fell into one or more of the following groups: Alaska's weather and climate (11 responses), Alaska's sparsely populated geography (8 responses), and lack of funding (3 responses). The fifth question had 8 useable responses, which can be categorized into one or more of the following groups: issues relating to Alaska's geography (4 responses), staffing concerns (3 responses), lack of funding (2 responses), issues relating to Alaska's driving population (2 responses).

The final question in this survey is:

- "Do you have any other comments?"

There were 5 useable responses to this question. One respondent suggested that the private sector should take lead on CAV technologies, including development, deployment, and maintenance of related infrastructure. One respondent suggested that autonomous vehicles should be issued specialty license plates. One respondent said, "We are and will continue to be 10 years behind most of the rest of the States." Similarly, another respondent pointed out that Alaska has "more needs […] than ability to take on new performance features", suggesting that it is already difficult to adequately maintain basic infrastructure needs, such as plowing. The final respondent believes

that predominantly rural states like Alaska are inherently a low priority for autonomous vehicle implementation.

Systems and Technology: Back Office

The Systems and Technology: Back Office survey has six open-ended questions. The first question was asked only to those who "Somewhat" or "Strongly" agreed to this statement: "There are barriers or legacy requirements (OS, hardware, IT) that will impact selection of certain back office systems for CAV." The question is:

- "Please elaborate the barriers."

The first question had 13 responses, with three primary groups of answers. The first group suggests that the processes and policies of Alaska's centralized Office of Information Technology is a major barrier, with one respondent noting that "State IT… is notoriously non-responsive to DOT&PF unique needs for systems, software, and support" (6 responses). The second group points to a current lack of equipment and/or funding to procure equipment (5 responses). The third group believes that a lack of staff expertise is a barrier (3 responses).

The second question in the Systems and Technology: Back Office survey is:

- "From our perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"

10 respondents provided useable answers to this question, and those answers can be broadly categorized into two groups. The first group of responses mention various aspects of Alaska's infrastructure and/or currently available technologies (6 responses). The other group points to Alaska DOT&PF's staff and/or internal processes (4 responses). One respondent suggested that Alaska's DOT&PF's advantages include, "openness to participate in pilot studies, new technologies. Willing to work with other agencies for coordinated effort. Existing working group on topic established with stakeholders."

This survey's third question is:

- "From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?"

There were 14 useable responses to this question, with the responses forming into three groups with substantial overlap. The groups of responses are a lack of staff expertise (5 responses), funding (4 responses), and infrastructure/technology (4 responses). One respondent answered at length:

> "Infrastructure (physically on the ground and electronically), acquisition and maintenance of right of way and network systems, enforcement, safety, security, adequacy and stability of network, appropriate technology for our topography and remote nature, demand, and available providers for equipped vehicles and the network they will use. Relocation may also be a concern in the future."

The fourth and fifth questions in the Systems and Technology: Back Office survey are:

- "List unique challenges that Alaska faces for CAV deployment."
- "List unique challenges that your agency faces for CAV deployment."

The fourth question had 14 useable responses, with groups of answers focused on Alaska's climate (8 responses) and sparsely populated geography (5 responses). The fifth question had 9 useable responses. The answers can be divided into three overlapping groups: technology/infrastructure (4 responses), funding (4 responses), and staffing (3 responses).

The final question in this survey is:

- "Do you have any other comments?"

There were 3 useable responses. The first respondent suggests that Alaska will remain "10 years behind everyone else." The second and third offer more substantial answers. The second suggests that obtaining equipment is less problematic than hiring, training, and retaining the personnel to run the equipment, due largely to grants from the Federal Highway Administration. The final respondent is worth quoting in full:

> "We are engaged in several pilot project that will integrate into our existing systems. We are not sure how other agencies will be able to use this data. We build according to the ITS Architecture, so if the information is needed it can be shared. Our experience has been that in theory other agencies can use our data and systems, but no other agency has found the use of our data to be the best use

of their limited resources. So, with respect to agency integration, I would say that funding for their end is a major impediment to the use and integration of our systems and data."

Systems and Technology: Field

The Systems and Technology: Field survey has five open-ended questions. The first of these questions is:

- "From our perspective, what are the advantages that your agency has that will enable efficient/easy adaptation of CAV?"

This question had 8 useable responses, which generally fall into one of three groups. Respondents in the first group identify "enthusiastic [and] capable" staff (2 responses). The second group of responses is focused on the availability of funding, with one respondent specifically identifying Alaska, the Federal Highway Administration, and Department of Transportation as potential funders (2 responses). The final group suggests that Alaska DOT&PF has no advantages (2 responses). Two final respondents suggested that being geographically isolated and the growth of surveying are both advantages.

The second open-ended question related to field systems and technology is:

- "From your perspective, what are the limitations that your agency has that will adversely affect the adaptation of CAV?"

A total of 13 respondents provided useable answers to this question. The answers fall primarily into one of two groups. Respondents in the first group are concerned about the readiness of Alaska DOT&PF's technology and related processes (9 responses). This group can be broken down into sub-groups, with several respondents concerned about the lack of technology along the road system (fiber optic cables, cell towers, etc.) and other respondents concerned about data processing and storage. One respondent frankly suggested, "We are a dinosaur." The second group of responses, which includes some overlap with the first, suggests that funding is an adverse limitation on CAV deployment (5 responses).

The third and fourth open-ended questions are:

- "List unique challenges that Alaska faces for CAV deployment."

- "List unique challenges that your agency faces for CAV deployment."

The third question had 14 useable responses, with most respondents suggesting that either weather/climate (9 responses) or sparsely populated geography (7 responses)—or both—are among Alaska's unique challenges. The fourth question has 12 useable responses. For this question, most respondents believe that Alaska DOT&PF's unique challenges include a lack of staff capacity and/or expertise (6 responses) or funding (5 responses).

The final question in the Systems and Technology: Field survey is:

- "Do you have any other comments?"

Only 2 responses to this question were useable, though it is of note that 9 respondents suggested that their knowledge base was not adequate to respond to this survey. Of the 2 useable responses, one respondent suggested that "capacity" is a "moving target" and, as such, it's difficult to determine CAV readiness without a better understanding of the resources needed. The second response is worth quoting in full:

> "We are engaged in cloud based pilot projects for Signal Timing and Phase (SPaT) information to 2 private traveler information services. We have pilot projects for cloud-based Automated Signal Performance Measures (SPM) and cloud based Adaptive Signal Technology (which will evolve into signal timing based on V2I information as that becomes a viable). We are working with a private company that uses an app for vehicle detection and integrates it into our signal system detection capabilities. It has a proof of concept pilot in Arizona now, and expects to be able to deploy field devices next year. The[y] are using 4G cellular communications from devices within vehicles to supplement our existing detection.
>
> "Our networks are appropriate for today's traffic and there is a clear path forward as more bandwidth is needed. Lack of fiber is not expected to be a constraint, just a cost element. 5G is a likely substitute technology. Because lack of fiber and funding are an even greater challenge for most other agencies, nationwide, solutions are being developed that can be phased in (such as the SPM and ASC)

and detection. Otherwise manufacturers of our devices will not have a large enough market to justify the investments necessary to build the devices and software necessary to automate our systems. Econolite's approach is an example of this implementation strategy. We are among the earliest 5% (guess) of agencies nationwide to adopt this approach."