Leveraging Connected and Automated Vehicle (CAV) Technology Initiatives to Advance Safety and Mobility

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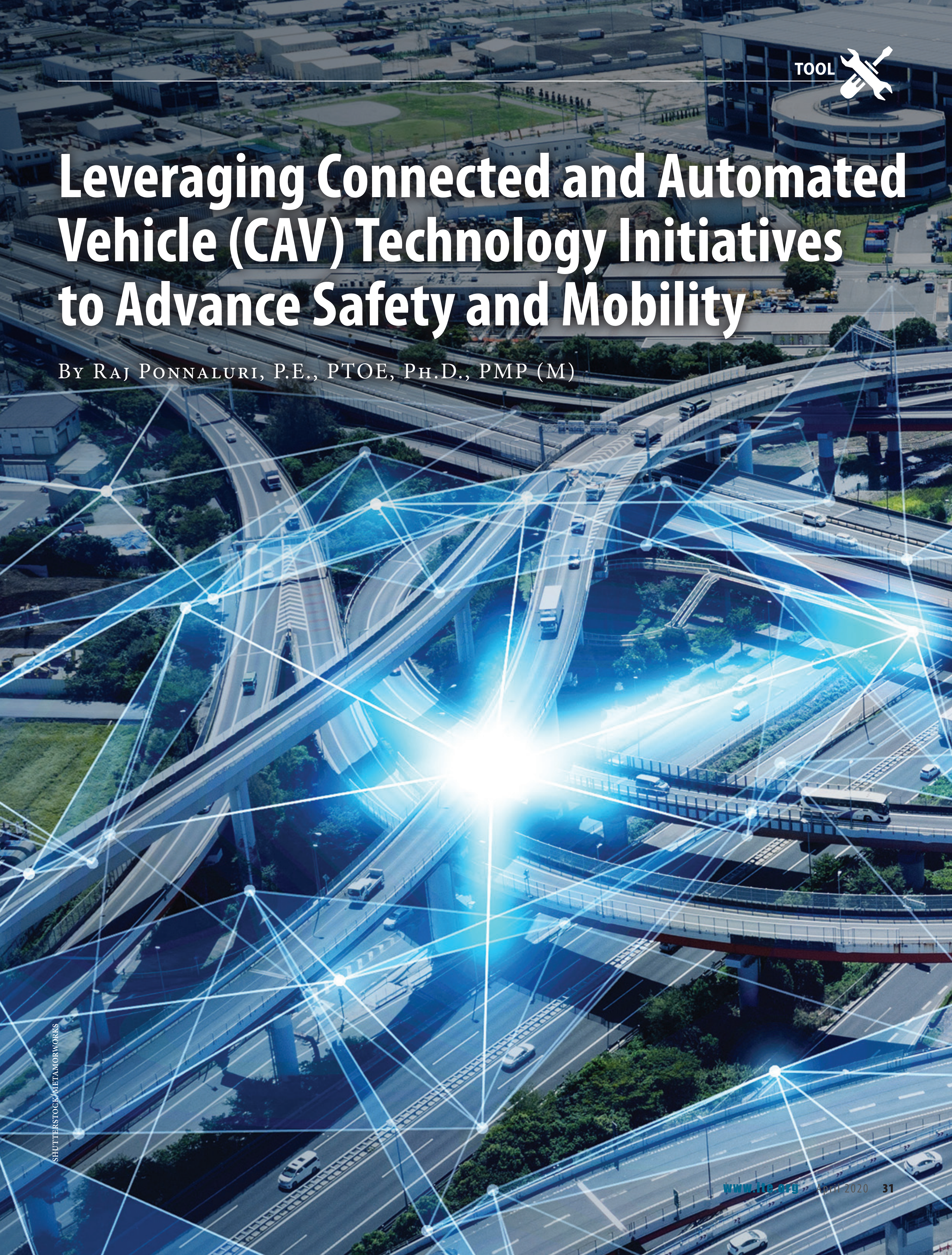

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As a part of its mandate to serve its membership, ITE is advancing knowledge, providing guidance, and instilling the spirit of workforce development in all aspects of transportation technology advancements. As part of ITE's Connected and Automated Vehicle (CAV) Institute Initiative, a joint Steering Committee on CAV was formed. Some of the objectives of this CAV Steering Committee include: advocating for the policy and governance elements; providing guidance on technology deployments; documenting the lessons learned; discussing topics of interest to the practitioners; and speaking for the membership on policy, education, outreach, national standards, rule-making, and more.

The ITE CAV Steering Committee's activities are aimed at stakeholders such as the following:

- The Federal Highway Administration (FHWA);
- Infrastructure Owner Operators (IOO) such as the state Departments of Transportation (DOTs), local agencies, and Metropolitan Planning Organizations (MPOs);
- The transportation consulting industry;
- Technology equipment vendors and industry partners including auto manufacturers often referred to as Original Equipment Manufacturers (OEMs);
- Academia and researchers; and
- Standards development organizations such as the Society of Automotive Engineers (SAE) and the Institute of Electrical and Electronics Engineers (IEEE).

The ITE CAV Steering Committee includes members from all core ITE Technical Councils, as well as members who serve on other significant national groups such as the American Association of State Highway and Transportation Officials (AASHTO), Transportation Research Board (TRB), ITS America, National Operations Center of Excellence (NOCoE), and the National Electrical Manufacturers Association (NEMA); while also coordinating with international entities such as the ERTICO, ITS Asia-Pacific, AustRoads, etc., as necessary.

This white paper synthesizes topics of immediate relevance to the ITE membership and the transportation community at large. It is timely because several IOOs are deploying CAV programs with synergistic projects, or are considering emerging technologies with the primary objective of significantly reducing traffic crashes and improving mobility for all road users. These safety and mobility benefits are to be gained during both recurring and non-recurring congestion, on freeways and arterials, in urban and rural areas, within the United States and around the world.

Emerging technologies within the transportation context, and an understanding of good project management practices and innovative procurement methods, are essential for implementing CAV programs. Strategic planning should also recognize user needs, avoiding technology deployments just because they are "cool." A typical project management lifecycle requires systematic and systems level planning, but with a goal to quickly deploy projects to immediately realizing the benefit of current technologies. Practitioners experience challenges with seeking funding to deploy CAV projects, especially because estimating benefit-to-cost ratios or return on investment is difficult. This is partly because few methodologies exist to quantify the safety and mobility benefits of these emerging technologies.

AASHTO and USDOT are credited with their milestone announcements on the Signal Phasing and Timing (SPaT) Challenge and the USDOT Joint Program Office (JPO) connected vehicle (CV) Pilot projects, which have both radically transformed emerging technologies deployments and the active utilization of the 5.9 GHz safety spectrum.

Intelligent Transportation Systems

Traditional traffic engineering has been in development for several decades before the advent of the Intelligent Vehicle Highway Systems (IVHS) during the 1990s, which led to the creation of a well-defined, actively discussed, and comprehensively collaborated intelligent transportation systems (ITS) framework. Today, practically every transportation entity, public or private, includes ITS, and leverages ITS technologies with real-time traffic data monitoring capabilities. IOOs also include statewide and Regional Transportation Management Centers (RTMCs) whose primary purpose is to collect, analyze, maintain, and disseminate data and information with the express intent to serve the safety and mobility needs of all road users in real-time. While CAV may be considered nascent, emerging technologies have always evolved. The difference is that ITS systems are now being fully utilized, thereby providing a significant impetus to the CAV programs.

The emphasis of TSMO strategies has recently advanced the discussion on the emerging transportation technologies even further, as TSMO mainstreams ITS by extending it from the systems and policy planning stage through project development and environment (PD&E), design, construction, operations, and maintenance. However, the need for developing a sustainable funding program is less discussed but equally important, helping formulate, identify, and prioritize funding availability. When juxtaposed with the ITS maintenance and operations funding allocations, programs become institutionalized and lead to sustainable initiatives that can last beyond the *pilot phase* of any project. ITS used to be typically associated with only the freeway systems. The more recent significant advancements with traffic signal systems, arterial network, and multimodalism have expanded the role of ITS to include the active management of arterial corridors, integrated corridor management (ICM), transit signal priority (TSP), and freight signal priority (FSP). The fiber network of the ITS systems is the key component to enable technology platforms and is thus an important element of CAV deployments, especially when large volumes of disparate data need to be transmitted to a central system through a back haul. Even though the typical CAV equipment such as the road side units (RSU) and on-board units (OBUs) can be distinguished from the standard ITS equipment such as dynamic message signs (DMSs), closed-circuit televisions (CCTVs), highway advisory radios (HARs), etc., at some point in the future the CAV equipment will be treated on par with ITS infrastructure.

ITS systems provide ground truthing in real-time, and are at the forefront in collecting data and information by utilizing the ITS detectors in the field, the microwave vehicle detection systems (MVDS), CCTVs, radar systems, and many other sensors. Even though standards are being developed for the CAV devices and associated data structures, the existence of adopted standards for ITS infrastructure help to jump-start any CAV program. For instance, the 511 programs in various states collect information that is disseminated to the general public and can be readily integrated into a potential vehicle-to-everything (V2X) data platform (vehicular technology that allows a car to communicate with other cars and infrastructure around it) as is being pioneered at a few agencies.

RTMCs are an important component of ITS systems and will play a crucial role in realizing the full benefits of CAV deployments, which in turn depend on strong ITS networks. Any CAV program should be seen as being integral to ITS systems at the agency, and therefore the need for CAV to reside within the traffic engineering and operations divisions which is also where the operations-led TSMO and ITS programs are housed. TSMO and ITS focus on freeway and arterial operations, including traffic incident management, managed lanes, commercial vehicle operations, and the traditional traffic engineering practices. Thus, CAV stands to gain from institutionalization, infrastructure readiness, innovation, implementation, and ingenuity perspective.

Institutionalization

An empirical review of the transportation practice, particularly at public agencies and even more so within the operations divisions, shows the significant role played by individuals who—over time—may have developed rigorous programs. These *champions* pioneer concepts of immediate importance to the agency and the stakeholders with a goal directly or indirectly linked to safety and mobility of the transportation network. Over time, the efforts of such individual champions develop into solutions-oriented approaches with seemingly streamlined programs yet with visible gaps in intra-departmental collaboration and inter-departmental coordination. Such gaps provide an indication and are symptomatic of program individualization. Over time, this forms silos and creates barriers for interested stakeholders to enter and support such systems.

Agency leadership should recognize individualization and implement preventive practices such as the development of a second-layer leadership to address the silo effect, failing which the organization could remain dependent on the *champion*. These individuals are also often the technical experts who take up the role of administrators and managers, an aspect that could either spur or stifle innovation. Such champions fully embrace technology, provide space for stakeholders, invite the industry, encourage research, develop a strong vision, seek and obtain funding, set the program in motion, develop and implement projects, achieve the organizational objectives, monitor progress, and develop performance-oriented systems.

On the other hand, a skeptical individual may impede exploring the utility of emerging technologies, let alone implement the same to address the safety and mobility concerns. Such professionals in managerial roles cause a ripple effect by impacting the entire divisions, departments, and organizations, in at least three aspects:

Safety and Mobility. Not adopting the transportation technologies is counterproductive especially when successful deployments by other entities do in fact yield quantifiable reductions in traffic crashes and congestion.

Opportunity Costs. Not adopting the transportation technologies could set the organization behind both in time and innovation. The organization may face significant challenges in the future with higher costs and a need for significant infrastructure upgrades.

Workforce Development. The new and incoming professional staff are not only interested in but are also able to incorporate technological advancements into their day-to-day job functions. Not adopting the transportation technologies could discourage the younger workforce from proposing any innovative ideas and over a period of time, the organization could lose competitiveness and residual capabilities.

Forward-thinking leaders keenly observe their organizations top-down and bottom-up, identify the champions, provide them the necessary resources and support, encourage ideation and technology adoption spurred by these champions, innovate with the industry recognized by the champions, and begin institutionalizing such thought leadership.

Institutionalization, just as with individualization, has its own set of strengths and weaknesses. In particular, this leads to sustainability and building strong technology organizations, which last beyond the tenures of the leaders and the said champions. Technology adoption, especially with many IOOs seeking to leverage it for the safety and mobility gains, needs to continue un-impeded, for which a long-term perspective is essential. Institutionalization, as opposed to individualization, is about the only way to provide confidence to the industry for partaking in discussions to consider advancements, adopt technologies, conceptualize programs, and deploy projects to fulfill the organization's vision, mission, and objectives. It is worth observing that good institutions in fact emerge from established champions.

Innovative Portfolio Development

Capturing the vision of an organization and translating its mission into an implementable portfolio of programs and projects, with a feasible work breakdown structure that incorporates transportation technologies, is essential to developing sustainable safety- and mobility-centric CAV programs. Several organizations, IOOs for example, have embarked on developing strategic plans for their TSMO programs. Pivotal to success are garnering financial support; mainstreaming the programs across disciplines and divisions internal and external to the organization; and designing, developing, and deploying TSMO and ITS initiatives. Organizations may repeat this process to launch their emerging technology portfolio of CAV programs and projects. Entities that have already been participating in the AASHTO SPaT challenge, deploying the USDOT JPO pilot projects, and implementing their respective state and local funded projects have all developed ingenious ways that are specific to their respective organizations. In Florida, USA for instance, the SPaT-only deployment in Tallahassee was followed by the Gainesville SPaT project which included other CAV applications such as motorist-to-pedestrian communication, passenger collision warning, emergency vehicle preemption, etc. This was followed by incorporating RSUs with both dedicated short range communications (DSRC) (an open-source protocol for wireless communications) and cellular-vehicle-to-everything (C-V2X) (which uses cellular connectivity to facilitate communication to and from vehicles) capabilities in Pinellas County, FL. Ingenuity could extend in several directions including technical elements and process orientation. While the DSRC alongside C-V2X communication modes were considered in the Pinellas County SPaT project, the Gainesville experience showed that innovative procurement approaches should be explored despite the legacy procurement protocols at public agencies.

Engaging with the transportation industry is a crucial factor for a successful implementation of CAV applications. IOOs exist to serve the people and all road users, and are therefore intimately familiar with the functional needs of any technology system. Industry, on the other hand, develops commercial solutions and contributes the technical know-how and the intellectual capital with equipment and sensor capabilities to realize the safety and mobility goals of the public entities. Therefore, the emerging technology portfolio development strategies should consider several stakeholders including the industry and the research community to fully capitalize the public-private process, program, and project partnerships with *connectivity*; yet, such *connectivity* among infrastructure, vehicles, and all modes should remain seamless because the real required outcome is the reduction in traffic crashes, relief in traffic congestion, promoting commerce, and improving the environment.

Development of the vision, mission, and objectives by the agency leadership followed by program development by the senior executives and a well-defined array of projects by technical experts eventually leads to a structured project management implementation framework. While several standard approaches exist, the 10 knowledge areas and the five process groups proposed by the Project Management Institute (PMI) in the Project Management Body of Knowledge (PMBOK) can help the practitioner to conceptualize CAV initiatives from concept to concrete. Given that the shelf-life of technology in the modern era is extremely short, and new market players emerge or purge all the time, the project management lifecycle should be *agile*. The project manager should strive to expedite the development and delivery of the CAV program goals while striking a balance between resources, budget, time, and any other considerations. Both *systems engineering* and *agile* approaches can help achieve this. Ingenious portfolio development should also account for the leadership to be keenly aware of the challenges faced by the CAV program staff and projects but also field implementation initiatives. Implementation effort requires a full-scale understanding of the interdisciplinary functions within an organization such as:

- The need to evaluate if the proposed CAV program is consistent with the organizational policy;
- The need to determine if the proposed CAV program matches the system-level objectives of the IOO;
- The possibility of including all possible technology alternatives within the PD&E studies;
- The availability of guidelines, specifications, and standards during the design phase;
- The potential to supplement construction contracts with emerging technologies in Smart Work Zones (SWZ), etc.;
- The in-depth profile of benefits to be gained from CAV applications in traffic operations;
- The utility of advancements such as autonomous truck mounted attenuators (ATMA) with routine maintenance or construction activities, etc.

Conclusion

The ITE CAV Steering Committee is aggressively working to support the ITE membership by serving as a knowledge center on all CAV aspects including policy formulation, planning consideration, implementation readiness, deployment challenges, education and outreach strategies, and lessons learned from ongoing efforts. The Steering Committee thanks ITE leadership for providing a forum to discuss the topics of interest and to develop guidance on institutionalization, innovation, infrastructure-readiness, and implementation of CAV programs. **itej**

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