



ROADMAP TO VEHICLE CONNECTIVITY



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EXECUTIVE SUMMARY

Manufacturers, technology providers, and national and regional governments have invested billions of dollars in connected and autonomous vehicle research, pilots and demonstrations. Underlying the potential success for these important life-saving technologies is the need for communications infrastructure and interoperability. The questions invariably remain: what communications technology best serves the most? Who will build the infrastructure on which it will operate? Who will pay for it? Building that infrastructure will, in large measure, be the responsibility of the private sector pursuing communications business opportunities. The building of the necessary communications infrastructure is reminiscent of the “chicken and egg” metaphor, which in our opinion requires that the specifications for Connected Vehicles (CVs) and Autonomous Vehicles (AVs) come first. As a result, the recommendations in this report focus on how to establish a clear path forward for CVs and AVs. Based on these findings, we believe that the necessary infrastructure will fall into place.

This report was funded by Crown Castle, the nation’s largest provider of communications infrastructure, in an effort to consider and support the needs of carriers, vehicle manufacturers and local governments as they prepare to meet the infrastructure, regulatory, and security requirements of the connected and autonomous vehicles ecosystem. The views, opinions, and recommendations expressed herein are exclusively those of the authors and do not necessarily reflect those of Crown Castle.

The authors of this report completed an exhaustive review of currently available material and interviewed more than 50 individuals from organizations representing a cross section the transportation and technology spectrum. The list of organizations interviewed is provided in Appendix A. While interviewees did not necessarily answer all questions, we believe that the responses we received are representative of the industry.

KEY FINDINGS

- 1. As the Telecommunications Industry Builds Out its 5G Network, it Should Consider the Needs of Connected Vehicles.** The transition from 4G to 5G will require increased network densification. Many estimate that 5G will require approximately five times the number of small cells that are currently deployed. The 5G build-out provides an excellent opportunity for collaboration. As the network providers build out their networks, they should work with local governments to incorporate connected vehicle infrastructure needs into their plans. Doing so could result in access to fiber or siting locations and potentially reduce the overall cost of building out both carrier and operator infrastructure.

2. **The Automotive, Technology and Telecommunications Industries Support a Federally Led Connected Vehicle Program to Save Lives, Time and Money.** We interviewed representatives from all segments of the industry and found uniform support for a federally led connected vehicle program. While there is skepticism that meaningful deployment would occur in a timely manner, interviewees agreed that if the technology were available and ubiquitous, the automotive industry would take advantage of it and it would have significant safety benefits.
3. **While the Automotive and Technology Industries are Divided on the Need for Vehicle Connectivity in Autonomous Vehicles, Most Agree That if it is Available, They Will Use it.** Most automobile manufacturers and tier one providers that we interviewed believe that autonomous vehicles will require vehicle connectivity, at a minimum for redundant safety purposes. Many technology companies that we interviewed are designing systems that do not require vehicle connectivity, largely because they do not want to rely on systems or data they do not own. All agree, however, that if vehicle connectivity were available and reliable, they would take advantage of it.
4. **U.S. DOT Should Continue to Support the Build-Out of Connected Vehicle Infrastructure to Expedite the Deployment of Connected Vehicles.** U.S. DOT has seeded the connected vehicle market with the Safety Model Deployment Program, Connected Vehicle Pilots, and its overall support of multiple pilots and demonstrations around the country. This support, along with other programs such as the AASHTO SPaT challenge, has resulted in over 2,000 intersections being outfitted with connected vehicle radios. This increased deployment has encouraged the automotive industry to allocate resources toward connected vehicle technology and innovation. Continued funding of local infrastructure deployment will spur rapid adoption of connected vehicle technology and result in immediate safety benefits.
5. **The Data Collection, Transfer, Analysis and Storage Needs of Connected and Autonomous Vehicles Will be Significant.** We know that the 2,800 connected vehicles in the Safety Model Pilot Deployment utilized more than 60% of the city of Ann Arbor’s fiber capacity; 1,000 connected vehicles in the New York City Pilot produced 250 terabytes of data in 18 months; and that former Intel CEO Brian Krzanich estimated that autonomous vehicles would produce 4,000 gigabytes of data a day by 2020. Even if most data transfers are only conducted once per day, there will still be the need for a robust communications infrastructure that can transfer significant volumes of data wirelessly, process at the edge, and have adequate fiber backhaul to the cloud.
6. **Much of the Industry is Technologically Agnostic Regarding DSRC and C-V2X.** Our research indicates that there is a strong sentiment that a single technology be agreed upon, whether DSRC or C-V2X. From an industry standpoint, those interviewed see very little difference between the two technologies.

RECOMMENDATIONS

We have divided our recommendations between connected and autonomous vehicles, although a number of the recommendations apply to both.

Connected Vehicles

U.S. DOT has concluded that the deployment of connected vehicle technology can reduce non-impaired crashes by more than 80%. This is greater than any previous automotive safety technology. As such, the industry should do its best to install this technology in vehicles and on the roadside as soon as possible. To facilitate this, the authors recommend:

- **The Federal Communications Commission Should Preserve the 5.9 Ghz Spectrum for Connected Vehicles.** In 1999, the FCC set aside the 5.9 Ghz ITS spectrum for the connected vehicle program to promote safety and save lives. We are finally seeing deployment of DSRC by many transportation agencies and manufacturers. We are also seeing many companies testing C-V2X, a competing technology, on the 5.9 Ghz spectrum. As such, we are on the cusp of finally seeing the promised safety benefits of connected vehicles and now is not the time to open the spectrum to non-licensed users or to sharing without a guarantee that there would not be interference.
- **U.S. DOT Should Mandate the Deployment of Vehicle to Vehicle (V2V) Connectivity to Enhance Safety, Minimize Market Confusion, and Reduce Costs.** In 2017, U.S. DOT issued a Notice of Proposed Rulemaking that would require connected vehicle technology in new model vehicles sold after 2023. Our respondents voiced strong support for a government mandate to insure consistent and widespread adoption of this life saving technology.
- **U.S. DOT Should Drive the Industry to a Single V2V Technology.** The Notice of Proposed Rulemaking on connected vehicle technology focused on DSRC but opened the door to competing technologies. While our respondents tended to prefer one technology over another, they uniformly believed that a single technology is preferable to competing technologies and that the costs and complexity of operating multiple interoperable systems outweighed its flexibility.
- **U.S. DOT Should Financially Support the Deployment of Vehicle to Everything (V2X) Technology.** Over the past decade, U.S. DOT has funded research and pilots of connected vehicle technology. These investments have seeded the market for connected vehicles. Continued support of local government deployment of connected vehicle technology will expedite the deployment of this life-saving technology.
- **Operators Should Upgrade Their Traffic Signal Technology with Connected Vehicle Technology.** As state and local governments upgrade their infrastructure, they should upgrade to the most current technology that includes connected vehicle radios. They should also look to their carrier partners to avoid unnecessary duplication of hardware and fiber deployment.

Autonomous Vehicles

U.S. DOT has also concluded that more than 94% of traffic accidents are the result of human error. If we reduce the human factor in the equation, we can dramatically reduce or eliminate crashes. While this technology holds great promise, it is still under development. The following recommendations are intended to support the development of this technology and its roll-out.

- **U.S. DOT Should Require That AVs Are Connected.** All respondents of our survey agreed that if connected vehicle technology were available and reliable that they would use it. If U.S. DOT mandates connected vehicle technology, it should include autonomous vehicles in this mandate to ensure the greatest level of safety possible.
- **Congress Should Expand Federal Funding for Autonomous Vehicle Research.** In 2018, Congress provided an additional \$100M for autonomous vehicle research. These funds will continue essential research. Additional research needs exist that will not likely be addressed uniformly or comprehensively by the private sector such as privacy, liability, ethics, artificial intelligence, rural access, data ownership, etc.
- **Congress Should Pass Legislation to Clarify Federal and State Authorities and Responsibilities in the Autonomous Vehicle Space.** Both houses of Congress have passed legislation that seeks to clarify the roles and responsibilities of federal and state governments. Congress should pass a consensus bill and then continue to monitor the deployment of AVs to ensure that no confusion remains with respect to federal and state roles and responsibilities.
- **Autonomous Vehicle Stakeholders Should Promote and Participate in the Development of International Standards.** International standards will be key for global deployment of these life-saving technologies. The various stakeholders should engage in the standards process to ensure that their company is not disadvantaged by the standards process and that the U.S. industry is not placed at a competitive disadvantage vis-à-vis other regions developing autonomous vehicles or the infrastructure to support them.
- **U.S. DOT Should Facilitate Greater Collaboration Among the Parties.** One of the most common complaints voiced by our respondents was the lack of collaboration among the parties. There continues to be stove-piped conversations within communities rather than across them. Specifically, the need to bring the technology community and local governments into the discussion was highlighted.
- **Manufacturers Should Support Campaigns to Educate the Public About Autonomous Vehicles.** There are regular articles about waning enthusiasm and trust of autonomous vehicles. These articles generally refer to a lack of understanding of autonomous vehicle technology by the public. Waymo recognized this and recently launched a public education campaign with a number of partners in Arizona. Additional public education will result in less suspicion and a higher adoption rate.