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PUBLIC INTEREST COMMENT

THE DEPARTMENT OF TRANSPORTATION'S PROPOSED VEHICLE-TO-VEHICLE TECHNOLOGY MANDATE IS UNPRECEDENTED AND HASTY

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"Connected cars" that use mobile connections to transmit and receive wireless data is a growing market. American automakers offered emergency services like OnStar for years and in recent years added wireless infotainment connections like 4G LTE and WiFi access. The next era in connected cars could be vehicle-to-vehicle (V2V) and vehicle-to-infrastructure technologies. V2V may someday alert drivers to potential collisions that are not visible to existing sensor-based technologies.[1] In December 2016 the National Highway Traffic Safety Administration (NHTSA) proposed to mandate a particular V2V technology standard—dedicated short-range communications (DSRC)—for all new light vehicles.[2] NHTSA, an agency within the US Department of Transportation (DOT), boasts that this is "the first proposed mandate of V2V technology worldwide."[3] Mandating an experimental technology like DSRC

1. GAO, Intelligent Transportation Systems: Vehicle-to-Vehicle Technologies 5, GAO-14-13, November 2013.
2. US DOT, Federal Motor Vehicle Safety Standards; V2V Communications, Notice of Proposed Rulemaking, National Highway Traffic Safety Administration, Dkt. No. NHTSA-2016-0126, 82 Fed. Reg. 3854 (January 12, 2017), https://www.gpo.gov/fdsys/pkg/FR-2017-01-12/pdf/2016-31059.pdf.
3. US DOT, NHTSA Issues Notice of Proposed Rulemaking and Research Report on Vehicle-to-Vehicle Communications 1, Fact Sheet (December 13, 2016).

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V2V is premature. The technology has not been proven economic or safe, and there should be no device mandate for light vehicles at this time.

While foresight is admirable, a device mandate for a wireless technology still in development is unprecedented. Connected cars are "just another mobile device"[4] and would benefit from the competitive pressures seen in other mobile device markets. The Federal Communications Commission (FCC), the nation's primary wireless device regulator, generally avoids stringent device mandates because top-down control locks in technology long beyond its usefulness. Crucially, the FCC allows mobile device companies to develop their own standards and interoperability requirements.

The DOT acknowledges that "estimating the potential costs and benefits of V2V [is] quite difficult" because V2V "improve[s] safety only indirectly."[5] The indirect safety benefits, plus the long timeline before net benefits arise, plus the unreasonably optimistic predictions of market-ready units should counsel caution. The agency's estimate[6] that cumulative benefits will match cumulative costs in 2030 should be viewed skeptically.

At this early stage in V2V development, it is unclear whether DSRC will ever be a safe technology or whether V2V is the best way to improve auto safety. There is a significant likelihood that DSRC will be eclipsed by competing technologies, like lidar, radar, and cameras. Cellular technology may displace DSRC as a V2V technology. As ITS America has said about a parallel FCC proceeding, there is "significant regulatory uncertainty that is threatening to derail the progress that DSRC is making toward nationwide deployment."[7]

Given the various regulatory uncertainties and DSRC's technical drawbacks, it is far too early to mandate this technology for light vehicles. In this comment, I first describe DSRC's government-directed development and slow progress. I then raise the strong possibility that other technologies will prove superior to DSRC if the market is permitted to develop, and I go on to describe DSRC's severe reliability problems. Finally, I point out that firms can develop device interoperability without an interoperability mandate.

DSRC V2V TECHNOLOGY IS RIGIDLY PRESCRIBED AND UPDATES WILL BE SLOW AND COSTLY

It's concerning to hear that NHTSA is considering prescriptive technology mandates in the fast-moving area of connected car technology. Innovation at the speed of government, it turns out, isn't very speedy at all. Congress created the intelligent transportation system

4. Carolyn Duffy Marsan, Networks drive car of the future, 22 Network World 1, 72 (2005). SAS, The Connected Vehicle: Big Data, Big Opportunities 5 (2016), http://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/connected-vehicle-107832.pdf.
5. 82 Fed. Reg. 3854, 3858 (January 12, 2017).
6. NHTSA estimates that the breakeven year—when cumulative benefits exceed the cumulative costs—will be about 2030. 82 Fed. Reg. 3854, 3858 (January 12, 2017).
7. Comments of ITS America, In the Matter of Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Infrastructure Devices in the 5 GHz Band, ET Dkt. No. 13-49, p. i (May 28, 2013), http://itsamerica.org/wp-content/uploads/2016/09/FINAL-ITS-America-Comments-5-GHz-NPRM.pdf.

(ITS) program, which is administered by the DOT, in 1991.[8] V2V communications is the first step towards a national ITS. The DOT has not wavered from its commitment in the 1990s to develop ITS infrastructure via "a top-down, systematic process"[9] where, the Department says, "each component of the system" is prescribed by regulators.[10] The notice of proposed rulemaking (NPRM) uses the language of markets, and it states that the mandate permits a "market-based approach to application development."[11] A closer analysis reveals, however, a very limited ability to innovate upon the DSRC platform.

DSRC is a government-designed technology from top to bottom, which injects paralyzing rigidity into the system. The Federal Highway Administration considered putting DSRC in the 5.9 GHz band starting about 1996.[12] After public consultation, the FCC set aside 75 MHz of radio spectrum in the 5.9 GHz band for ITS uses in 1999[13] based on a scant 19 comments and reply comments from outside parties.[14] In 1999 and 2004, the FCC codified DSRC transmission standards,[15] transmit power,[16] emission mask requirements,[17] priority framework,[18]

8. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 6 (rel. Feb. 10, 2004).
9. US DOT, National ITS Program Plan: Synopsis 21, First Edition (March 1995), http://ntl.bts.gov/lib/jpodocs/repts_pr/3845.pdf.
10. US DOT, National ITS Program Plan: Synopsis 20, First Edition (March 1995), http://ntl.bts.gov/lib/jpodocs/repts_pr/3845.pdf. "An architecture is open if its documentation is in the public domain. An open architecture encourages competition among multiple vendors. with their success determined by capability, cost, and innovation. Supporting information in a 'closed' architecture usually is proprietary and consequently does not encourage competition among suppliers."
11. 82 Fed. Reg. 3858 (January 12, 2017).
12. Spectrum Requirements for Dedicated Short Range Communications (DSRC): Public Safety and Commercial Applications 84, ARINC, July 1996, http://ntl.bts.gov/lib/jpodocs/repts_te/3943.pdf.
13. In the Matter of Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order (rel. October 22, 1999). The spectrum is 5850 MHz to 5925 MHz.
14. In the Matter of Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, para 1.4 (rel. October 22, 1999).
15. See Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.580-5.925 GHz Band (5.9 GHz Band), WT Docket No. 01-90, Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, FCC 03-324, 19 FCC Rcd 2458 (2004). An outside standards organization adopted the DSRC standard in 2003. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 19 (rel. Feb. 10, 2004). In 2004, the FCC required all DSRC units abide by those standards. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 19 (rel. Feb. 10, 2004). Two years later, the FCC updated channel designations and power limits after parties petitioned for changes. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, Memorandum and Order, WT Dkt. No. 01-90 (rel. July 26, 2006).
16. In the Matter of Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, para 1.24 (rel. October 22, 1999).
17. In the Matter of Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, para 1.25 (rel. October 22, 1999).
18. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 31 (rel. Feb. 10, 2004).

antenna height,[19] and equipment certification procedures.[20] For DSRC V2V devices, the FCC and NHTSA have prescribed or have proposed to prescribe[21]

- access technology (IEEE 802.11p),[22]
- spectrum channels (10 MHz),[23]
- spectrum bands (5.9 GHz),
- throughput (6 Mbps),[24] and
- communications technology (DSRC).

Even the DSRC device makers were hand-selected by DOT officials and subsidized.[25]

The need to comply with the requirements from two federal agencies and satisfy multiple private and public organizations has contributed to DSRC's slow progress. The DOT started testing road safety technologies around 2000.[26] Nevertheless, only a few firms created DSRC prototypes, and these tended to be small firms. Before 2014, there was still little improvement, little commercial interest in DSRC devices, and the DOT "took a lead role in the device development process."[27]

Contrast the slow progress of DSRC with cellular standards. The FCC codified DSRC standards over a decade ago, and DSRC—still in the experimental phase—seems destined for the stasis associated with other FCC-mandated technology standards, like broadcast TV, which lasted largely unchanged for over 60 years.[28] Cellular standards, on the other hand, the FCC leaves to market actors. Cellular standards have improved significantly since 2000 and have substantial market penetration, despite a lack of device mandates.

In the broader mobile communications market, access technology (WiMax, 4G LTE), spectrum channels (5 MHz pairs, 20 MHz pairs), spectrum bands (700 MHz, 1800 MHz) and

19. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 39 (rel. Feb. 10, 2004).
20. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 44 (rel. Feb. 10, 2004).
21. 82 Fed. Reg. 3854, 3857 (January 12, 2017).
22. 82 Fed. Reg. 3854, 3893 (January 12, 2017).
23. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 27 (rel. Feb. 10, 2004).
24. 82 Fed. Reg. 3854, 3886 (January 12, 2017).
25. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 51, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf; Comments of ITS America, In the Matter of Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Infrastructure Devices in the 5 GHz Band, ET Dkt. No. 13-49, p. 21 (May 28, 2013), http://itsamerica.org/wp-content/uploads/2016/09/FINAL-ITS-America-Comments-5-GHz-NPRM.pdf.
26. Paul Kirby, FCC Adopts Regulations For Highway Communications, 70 Telecomm. Reports 1, 24 (2004).
27. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 50, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf.
28. The FCC established the National Television System Committee in 1940. The first NTSC standards were created in 1941, and most broadcasters, after FCC pressure, had moved to digital standards by 2009. See Stuart Minor Benjamin, The Logic of Scarcity: Idle Spectrum as a First Amendment Violation, 52 DUKE L.J. 1, 18 n.57 (2003).

communications technology (CDMA2000 1xRTT, VoLTE) change regularly in response to consumer demands, industry standards, and input availability and prices.

The competitive churn and consumer benefits are noticeable. Around 1990, AMPS, a first-generation cell phone standard, was the dominant US cell phone standard. But since then, AMPS was replaced by D-AMPS, GSM, CDMA2000, WiMax, and then 4G LTE technologies. The competition generated by cellular technologies has induced hundreds of billions of dollars in investment and consumer spending.[29] This is a remarkable contrast to DSRC, which, despite the full support of the US government and the nominal support of dozens of auto and device companies, has generated marginal commercial interest.

Private companies see slow progress in many technical areas, and V2V technology poses unique technical issues. But private companies are subject to competitive pressures and consumer demands. A dead-end technology in the private sector is eventually shelved, and resources shift to promising (profitable) new developments. With government-mandated technology adoption, however, there are no competitive pressures and regulators are spending taxpayer money. As FCC's history shows—in obsolete technology standards like NTSC broadcast standards, FireWire,[30] and CableCard[31]—dead-end consumer technology that is mandated by government can live on, zombielike, for years or decades after the market has moved on.

OTHER TECHNOLOGIES WILL LIKELY OVERTAKE NHTSA'S MANDATED DEVICES

Prior predictions of DSRC deployment have been unreasonably optimistic. DSRC has failed to gain commercial traction, and the DOT appears to believe a mandate will save the federal government's sunk costs into DSRC. After assigning free spectrum for DSRC and codifying technology standards in 2004, the FCC believed there would be "rapid development and deployment of DSRC equipment."[32] In January 2004, DOT officials told reporters they expected DSRC to be commercially available sometime in 2005.[33] Yet, 12 years later, the DOT is still waiting for DSRC deployment.

The rapid development of cellular-based technologies poses the biggest competitive threat to DSRC. ITS proponents envisioned 32 different DSRC user services when DSRC spectrum

29. From 2003 to 2013, wireless carriers invested over $300 billion into networks and devices. Coleman Bazelon & Guilia McHenry, Mobile Broadband Spectrum: A Vital Resource for the U.S. Economy 4-5 n.5, CTIA (May 11, 2015), http://www.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf.
30. Todd Spangler, FCC Douses FireWire Requirement for Set-Tops With IP, Multichannel News, June 21, 2010, http://www.multichannel.com/news/news/fcc-douses-firewire-requirement-set-tops-ip/378067.
31. Nate Anderson, FCC admits CableCARD a failure, vows to try something else, Ars Technica, December 4, 2009, https://arstechnica.com/tech-policy/2009/12/fcc-admits-cablecard-a-failure-vows-to-try-something-else/.
32. FCC, In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band, WT Dkt. No. 01-90, para 20 (rel. Feb. 10, 2004).
33. Paul Kirby, FCC Adopts Regulations For Highway Communications, 70 Telecomm. Reports 1, 24 (2004) ("The agency said it had been working cooperatively with the auto industry in hopes of making the technology commercially available by 2005.")

was set aside in 1999.[34] However, while ITS firms and the DOT have slowly developed DSRC, a robust wireless ecosystem of cellular technology, devices, and applications developed. Many of those 32 services have already been "solved" by non-DSRC technologies, including "map and music data updates," video uploads, parking lot payment, rollover warning, "driver's daily log," and "enhanced route planning and guidance."[35] The DSRC V2V mandate is intended to provide drivers imminent collision warnings, but competing technologies like radar and lidar are already in the market. Automatic braking systems have been around for years, and research from the Insurance Institute for Highway Safety suggests that such systems are preventing more rear-end accidents than warning systems[36] like the one NHTSA contemplates for its mandate.

Other technologies are improving fast and may prove superior to DSRC if the connected car market is permitted to develop. 3GPP, the global cellular standards body, for instance, released its initial V2X (vehicle to anything) standard in September 2016.[37] In fact, as technology publications have reported, China is likely to use a cellular-based system, and Europe may follow.[38] DSRC may prove to be a viable technology in other countries eventually, but it appears unlikely that, for instance, Japan or South Korea will mandate DSRC.[39]

DSRC IS NOT SAFE AND RELIABLE TODAY AND MAY FAIL TO BE ROADWORTHY

The V2V network NHTSA is proposing to mandate is a mesh network, which means nodes communicate directly and without an intervening network. While mesh networks generated substantial academic interest circa 2000 when DSRC was developed, they have proven to be notoriously complicated and expensive to deploy. To my knowledge, aside from small experiments, there are no real-time communication mesh networks in existence. Perhaps predictably, researchers have found DSRC V2V units are subject to the reliability and resource management problems associated[40] with mobile mesh networks.

34. In the Matter of Amendment of Part 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, para 1.10 (rel. October 22, 1999).

35. See 5.9 GHz Dedicated Short Range Communication (DSRC) Overview 29, http://rsl.ece.ubc.ca/archive/DSRC_Tutorial_06-10-021.pdf.

36. Crashes Avoided: Front crash prevention slashes police-reported rear-end crashes, Status Report Vol. 51, January 28, 2016, http://www.iihs.org/iihs/news/desktopnews/crashes-avoided-front-crash-prevention-slashes-police-reported-rear-end-crashes.

37. Dino Flore, Initial Cellular V2X standard completed, 3GPP, September 26, 2016, http://www.3gpp.org/news-events/3gpp-news/1798-v2x_r14.

38. Junko Yoshida, V2X Radio War Still Smoldering in China, Europe, EE Times, October 25, 2016, http://www.eetimes.com/document.asp?doc_id=1330670.

39. Junko Yoshida, V2X Radio War Still Smoldering in China, Europe, EE Times, October 25, 2016, http://www.eetimes.com/document.asp?doc_id=1330670.

40. As one researcher put it: "Even in static environments with all nodes stationary, mesh network topologies remain dynamic due to variations in RF propagation and atmospheric attenuation. With mobile nodes, a mesh network's constantly shifting topology dictates the need for dynamic routing allocation, resource management, and quality of service management—all of which must be precisely choreographed to ensure optimum performance and reliability." Jason Melby, Mesh Networks: The Next Generation of Wireless Communications 103, Proceedings of the International Symposium on Advanced Radio Technologies, NTIA SP-04-409 (March 2004).

It's important to allow the nascent connected car, V2V, and vehicle sensor markets to develop. DSRC is not safe and reliable today and has severe technical deficiencies that may or may not be remedied. The following draws from several researchers and engineers but especially from a Booz Allen Hamilton report produced for NHTSA in May 2016,[41] referred to heretofore as the "Booz Allen Report."

DSRC Uses Legacy Technology That Is Ill-Suited for Vehicle-to-Vehicle Communications

The DOT proposes to mandate DSRC, which incorporates the IEEE 802.11p communications standard.[42] Some of DSRC's reliability problems stem from IEEE 802.11 technology, which is also used in WiFi devices. The IEEE 802.11 standard was not designed for moving vehicles, and technology choices that are appropriate for home WiFi might not be appropriate for millions of moving vehicles. Researchers noted in a recent Institute of Electrical and Electronics Engineers journal article about DSRC's technical challenges that

> the typical use cases of IEEE 802.11 standards are sparse nomadic deployment with stationary channels. Consequently, existing commercial IEEE 802.11 chipsets are naturally optimized for best performance in such an environment. However, vehicular communications can happen among highly mobile vehicles, with multipath fading channel, and often in densely populated environments.[43]

Further, different radio frequency bands have different transmission propagation characteristics. It's not clear that the 5.9 GHz band, assigned by the FCC in 1999 for DSRC, is optimized for V2V communications. Namely, as the DOT has acknowledged, non-line-of-sight transmissions suffer in the 5.9 GHz band.[44]

Researchers have raised concerns for years about the reliability of DSRC transmissions under congested circumstances[45] because DSRC has a relatively long range (at least 300 meters) but relatively narrow communications channels (10 MHz). NHTSA boasts of DSRC's range relative to competing systems,[46] but extended range comes with downsides. With larger range,

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41. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
42. 82 Fed. Reg. 3854, 3893 (January 12, 2017).
43. Xinzhou Wu et al., Vehicular Communications Using DSRC: Challenges, Enhancements, and Evolution, 31 IEEE J. Selected Areas in Comm. Supp. 399, 399 (2013).
44. "For optimal performance, it requires uninterrupted line-of-sight between the transmitter and receiver." US DOT, FHWA Vehicle-to-Infrastructure Deployment Guidance and Products 27, Rep. No. FHWA-HOP-15-015 (December 30, 2016), http://www.its.dot.gov/research_archives/safety/pdf/V2I_DeploymentGuidance12-30-2016.pdf.
45. "The current version of DSRC MAC is contention-based and thereby does not support efficient and reliable broadcast services. Specifically, the poor performance of the DSRC MAC in supporting safety applications is mainly due to the high collision probability of the broadcasted packets." Ning Lu et al., Connected Vehicles: Solutions and Challenges 5 (2014), https://ece.uwaterloo.ca/~n7lu/jrnl_14_IoTJ_LCZSM.pdf.
46. 82 Fed. Reg. 3854, 3855 (January 12, 2017) ("V2V also offers an operational range of 300 meters or farther between vehicles, nearly double the detection distance afforded by some current and near-term vehicle-resident systems.").

contention between vehicle device transmissions increases, and as researchers have found with DSRC simulations, larger ranges reduce the probability of channel access significantly.[47]

In short, DSRC reliably plummets when many units are transmitting at the same time. The decision to have 10 MHz channelization for DSRC was chosen at an early stage in DSRC development.[48] This decision was made because DSRC device makers could use existing, circa 2000, Wi-Fi chipsets.[49] While this might have made sense 15 years ago, as Booz Allen[50] and others[51] have noted, 10 MHz channels underutilize the capability of current wideband technology. Namely, with 10 MHz channels, "channel congestion is a serious issue" and in dense traffic, "the occurrence of message losses" owing to congestion is "highly likely."[52]

Booz Allen assessed how well DSRC units worked in a report for NHTSA.[53] Their assessment is not encouraging. The Booz Allen Report goes on to note that the existing DSRC standards are "an inefficient use of the DSRC band" when used for V2V.[54] This inefficiency means that even modest traffic can cause network congestion. "With perfect Carrier Sense Multiple Access (CSMA) performance," Booz Allen researchers said, "the system can support at most 204 vehicles transmitting BSMs at 10 Hz."[55]

Another potential impediment to V2V effectiveness is how device updates are accomplished. DSRC units, like all mobile devices, will require periodic updates. The problem with a V2V-only network like the one NHTSA is proposing is that it doesn't have a pervasive, intervening network that can push updates.[56] This flaw may be why the DOT's original DSRC plan was to

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47. Shahzad A. Malik et al., Performance Evaluation of IEEE 802.11p MAC Protocol for VANETs, 4 Australian Journal of Basic and Applied Sciences 4089, 4097 (2010).
48. Xinzhou Wu et al., Vehicular Communications Using DSRC: Challenges, Enhancements, and Evolution, 31 IEEE J. Selected Areas in Comm. Supp. 399, 405 (2013).
49. "The 5.9 GHz DSRC spectrum is divided into seven 10 MHz bands. A main motivation behind such channelization is the ability to utilize the market penetration of existing Wi-Fi chipsets that operate over 20MHz channels. The original chips can be run 'half-clocked' to achieve a 10 MHz bandwidth and be made more suitable for the highly mobile and frequency selective vehicular channels." Xinzhou Wu, Vehicular Communications Using DSRC: Challenges, Enhancements, and Evolution, 31 IEEE J. Selected Areas in Comm. Supp. 399, 403 (2013).
50. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 41, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
51. Xinzhou Wu, Vehicular Communications Using DSRC: Challenges, Enhancements, and Evolution, 31 IEEE J. Selected Areas in Comm. Supp. 399, 403 (2013).
52. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 41, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
53. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 107, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
54. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 42, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
55. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 41, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
56. Xinzhou Wu et al., Vehicular Communications Using DSRC: Challenges, Enhancements, and Evolution, 31 IEEE J. Selected Areas in Comm. Supp. 399, 405-06 (2013).

deploy V2I networks first and V2V technology later.[57] It is unclear to this researcher why the DOT's model changed over the years. It is premature to mandate DSRC V2V when it is unclear if updates can be effectively pushed to V2V units.

The Safety Pilot Model Deployment Reveals That DSRC Is Not a Reliable Anti-Collision Technology and May Never Be Safe for Mass Use

NHTSA grossly overstates DSRC's roadworthiness and underplays the serious upgrades needed before DSRC V2V devices are reliable and safe. For instance, NHTSA states that "DSRC is the only mature communication option that meets" the necessary requirements for collision avoidance[58] and that it is effective at preventing potential crashes.[59]

NHTSA points to real-world testing of DSRC in the Safety Pilot Model Deployment (SPMD),[60] which purportedly "demonstrated the readiness of DSRC-based connected vehicle safety applications for nationwide deployment."[61] NHTSA says that the SPMD showed that DSRC V2V devices "have proven effective in mitigating or preventing potential crashes" and need only "additional refinement."[62]

The truth is that the SPMD revealed serious problems with DSRC and had limited value in showing safety. The SPMD field tests were delayed, lasted only a few weeks, and were beset by technical problems.[63] As NHTSA states in the NPRM, the deployment analysis was limited: it assessed "*whether* the prototypes and the system worked, but not necessarily *how well* they worked."[64] The DOT noted that "every DSRC device deployed had to be recalled at least once during the SPMD to identify and correct issues."[65] False alerts were a particular problem.[66]

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57. US DOT, Notice of Ex Parte Presentation 9, WT Dkt. No. 01-90 and ET Dkt. No. 98-94, November 17, 2010, https://ecfsapi.fcc.gov/file/7020920834.pdf.
58. 82 Fed. Reg. 3854, 3864 (January 12, 2017).
59. 82 Fed. Reg. 3854, 3864 (January 12, 2017).
60. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 2, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf. "Overall, the Safety Pilot Program was a major success and has led the USDOT to initiate rulemaking that would propose to create a new Federal Motor Vehicle Safety Standard (FMVSS) to require V2V communication capability for all light vehicles and to create minimum performance requirements for V2V devices and messages."
61. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 2, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf.
62. 82 Fed. Reg. 3854, 3867 (January 12, 2017).
63. "There were a number of gaps in the device requirements that impacted the Test Conductor's ability to monitor and maintain the devices throughout the Model Deployment." US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 52-54, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf.
64. 82 Fed. Reg. 3854, 3867 (January 12, 2017).
65. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 55, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf.
66. US DOT, Safety Pilot Model Deployment: Lessons Learned and Recommendations for Future Connected Vehicle Activities 73, FHWA-JPO-16-363, Final Report (September 2015) http://ntl.bts.gov/lib/59000/59300/59361/FHWA-JPO-16-363.pdf.

The Booz Allen analysts found that the DOT's 2014 Safety Pilot Model Deployment offered "relatively few vehicle interactions and *no known identified situations where vehicles were on collision courses and the system properly warned the driver*, or where vehicles were on a near miss course and the system accidentally warned the driver."[67] With no known situations testing collision avoidance, the analysts used DSRC device parameters to simulate collision situations.

They identified "significant issues with the accuracy requirements on the data in the BSM [basic safety message]."[68] The researchers found that "if the BSM data is only accurate to within the error tolerances stated for the Safety Pilot program, *the system will be able to reliably predict collisions only about 35% of the time*."[69] The current error tolerances for DSRC V2V units, they added, "will fail to provide the desired levels of intended and reliable safety benefits."[70]

Alarmingly, in simulations DSRC units misclassified vehicle interaction (i.e., a collision or miss) 72 percent of the time five seconds away from impact.[71] The report noted that "the chance of a misclassification [of a collision or near miss] occurring, even at 1 second prior to collision, is concerning."[72] Error rates improve as vehicles approach each other, but even one second before a sure collision, DSRC devices had only an 80 percent rate of detecting the collision.[73] Since drivers need three or more seconds to respond to a collision warning, the researchers concluded the error rate "draws into question the safety integrity of the system."[74]

The authors stated that "much tighter tolerances . . . are needed in order to assure data sent from vehicles can be used to reliably predict imminent collisions and generate driver warnings

67. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 107, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf (emphasis added).
68. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 5, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
69. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 5, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
70. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 5, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
71. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 100, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
72. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 102, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
73. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 100, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
74. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 100, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.

or other mitigation actions."[75] These improvements, the team says frankly, "may be challenging to achieve."[76] The researchers concluded:

> If the objective is that the system must not miss more than 5% of actual collisions, the resulting BSM parameter accuracy requirements will need to be much tighter. If the objective is 99.999% (0.001% classification failure) reliability, then the system is probably not viable.[77]

Before mandating a specific V2V technology for light vehicles, NHTSA should first determine an acceptable collision rate. Without such, the agency may be mandating a technology that will never have acceptable reliability.

The agency proposes to require "that a message packet error rate (PER) is less than 10%."[78] It is not clear that DSRC units satisfy this proposed standard. The Booz Allen analysis revealed significant signal degradation when dozens of DSRC units are in close proximity.[79] They estimated that if 256 devices were in a 100 x 100 meter area, packet error rates would exceed 45 percent.[80] Since heavy traffic of DSRC-connected cars would mean 400 to 600 vehicles within range of a DSRC device,[81] the mandated device specifications may be inadequately safe.

DEVICES CAN INTEROPERATE WITHOUT A MANDATE

NHTSA asserts that "without government intervention," V2V communications will not be standardized and interoperable.[82] Scholars have found that the public sector is ill-suited to determine what specific technology will be the best option for the future, especially where complex information technologies are involved.[83]

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75. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 172, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
76. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 172, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
77. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 102, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
78. 82 Fed. Reg. 3854, 3884 (January 12, 2017).
79. The researchers assume 6 Mbps channels, NHTSA's proposed throughput. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 41, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf. ("It is well understood that at this data rate [6 Mbps] channel congestion is a serious issue.")
80. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 81, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
81. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 41, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
82. 82 Fed. Reg. 3854, 3856 (January 12, 2017).
83. John Palfrey & Urs Gasser, Interop: The Promise and Perils of Highly Interconnected Systems 175 (2012). See also Adam Thierer, What is "Optimal Interoperability"? A Review of Palfrey & Gasser's "Interop," Technology Liberation Front, June 11, 2012, https://techliberation.com/2012/06/11/what-is-%E2%80%9Coptimal-interoperability%E2%80%9D-a-review-of-palfrey-gasser%E2%80%99s-%E2%80%9Cinterop%E2%80%9D/.

Mandating that other technologies have interoperability with DSRC, as NHTSA proposes,[84] adds to the complexity. This may cause firms to shy away from wireless communications technologies. "Interoperable" means many things when it comes to DSRC V2V, and certification testing alone will take time—perhaps years—to develop and operationalize.[85] Further, DSRC's design-by-committee framework requires compromises between powerful tech, auto, and government interests that likely sacrifices speed, performance, or both.

The existing communications market reveals that interoperability arises without a government device mandate. Market processes do create reliable and interoperable networks. Cellular phones, for instance, absent regulatory mandates, have both interoperable elements (SMS messaging, VoLTE) and non-interoperable elements (IP messaging, CDMA versus GSM, operating systems, app stores).

Interoperability for critical services can be quite rapid even without a mandate. Tens of thousands of computer networks connecting billions of devices, for instance, interoperate and exchange IP traffic without a mandate to interoperate. Firms interoperate because interoperability increases the value of a platform. Verizon introduced VoLTE, an inter-carrier voice communications technology, to subscribers in 2014. By early 2017, most Verizon voice traffic was transmitted via VoLTE.[86] This is a remarkable example of a company developing an important application (voice) that interoperates across networks and across millions of devices.

NHTSA also proposes requiring non-DSRC technologies not merely to interoperate with DSRC technology when sending BSMs, but to have very similar technological characteristics.[87] In effect, NHTSA is mandating DSRC-like requirements for non-DSRC V2V wireless technology. These constraints are limiting, particularly the proposed requirement that non-DSRC technologies have a minimum 300-meter range.[88] Since this extensive range increases the chance for congestion, this requirement biases future technologies to low-throughput information. No one can be certain, ex ante, that the high-range, low-throughput applications NHTSA de facto requires will be more useful and lifesaving than low-range, high-throughput applications, or some other mix of capabilities.

CONCLUSION

DSRC V2V technology is far from roadworthy. Any technology "so good it must be mandated" warrants extreme skepticism. Many of DSRC's technical elements were mandated over a decade ago and underutilize current wireless technology. Researchers have pointed out that

84. NPRM, p. 10.
85. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 138, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf ("Development of standardized certification processes is a sophisticated and challenging endeavor that could face many issues and require legal, policy, technical, and institutional decisions from a variety of perspectives.").
86. Verizon Public Policy, "Verizon welcomes new 'Cellular Service Reform' rules," Press Release (March 23, 2017), http://www.verizon.com/about/news/verizon-welcomes-new-cellular-service-reform-rules.
87. 82 Fed. Reg. 3854, 3896-97 (January 12, 2017).
88. 82 Fed. Reg. 3854, 3896 (January 12, 2017).

DSRC has many technical drawbacks and is unreliable. The Booz Allen Report concluded in 2016, a few months before the NPRM:

> Ideally, these technical issues would be resolved before finalizing requirements, but given the NHTSA rule-making timeline, it may not be possible for complete solutions to be included in the first rule.[89]

Modifying the DSRC standards would bring operational benefits, especially regarding congestion, but would require yet another lengthy FCC rulemaking.[90] Connected car and sensing technology is advancing rapidly. Given the dynamic marketplace, any connected car device mandate would not only be unprecedented, at this point in DSRC development, it would be dangerously hasty. The agency should halt this NPRM, resolve DSRC's many technical issues, and allow the connected car market to develop before proceeding.

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89. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 107, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.
90. Ed Adams et al., Development of DSRC Device and Communication System Performance Measures: Recommendations for DSRC OBE Performance and Security Requirements 42 n.4, Rep. No. FHWA-JPO-17-483 (May 22, 2016), http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf.