The Cost in Fatalities, Injuries and Crashes Associated with Waiting to Deploy Vehicle-to-Vehicle Communication

James R. Sayer, Carol A. C. Flannagan, Andrew J. Leslie
University of Michigan Transportation Research Institute
Ann Arbor, Michigan, USA 48109-2150

Today, the auto industry is ready to deploy vehicle-to-vehicle (V2V) communication-based safety systems employing proven technology and well-developed standards. In fact, the readiness entails more than just V2V, but potentially vehicle-to-everything (V2X) communication, where everything (X) can include communication with other vehicles, the roadway infrastructure, and vulnerable road users.

The incumbent communications technology, dedicated short range communication (DSRC), was adopted by the Federal Communications Commission on December 17, 2003 establishing licensing and service rules for DSRC service in Intelligent Transportation Systems (ITS) in the 5.850-5.925 GHz band (5.9 GHz band). "The DSRC Service involves vehicle-to-vehicle and vehicle-to-infrastructure communications, helping to protect the safety of the traveling public. It can save lives by warning drivers of an impending dangerous condition or event in time to take corrective or evasive actions."[1] This communication technology directly connects devices and has been developed over the course of the last 15 years[2], resulting in several important international standards to ensure interoperability (i.e., the ability of equipment used on different vehicles and the infrastructure to operate in conjunction with each other).

Recently, within the industry there exists an ongoing debate between DSRC and another competing wireless communication technology for V2V communication. The emerging second technology C-V2X, uses cellular technology and is capable of both directly communicating between devices and utilizing a cellular network similar to cellular networks used for mobile phones. Standards for deploying C-V2X are only now being initiated. As a result, there will be a delay in deploying C-V2X regardless of the technical readiness. Development of DSRC standards like IEEE 1609.x have required multiple revisions. Each one of these revisions has been based on real-world testing, additional research, and development.

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[1] Dedicated Short Range Communications (DSRC) Service. https://www.fcc.gov/wireless/bureau-divisions/mobility-division/dedicated-short-range-communications-dsrc-service Accessed on November 27, 2017.

[2] Third Annual Report of the Crash Avoidance Metrics Partnership, April 2003 - March 2004 https://ntlrepository.blob.core.windows.net/lib/29000/29500/29503/CAMP-IVIThirdAnnualReport.pdf. Accessed on November 27, 2017.

Where the difference in the two communication technologies exists is in their readiness for actual deployment in motor vehicles and the nation's infrastructure, not just in the state of C-V2X standards development. Currently, there exists a draft Federal Motor Vehicle Safety Standard, FMVSS 150, that would mandate the deployment of DSRC in all new vehicles sold by a yet to be determined start date or schedule. FMVSS 150 was developed based on more than 12 years of development in addition to extensive real-world testing and evaluation by automotive manufacturers and suppliers world-wide. There is no similar FMVSS for C-V2X, no spectrum allocation for C-V2X, nor has there been the equivalent amount of testing or development of C-V2X. As such, while DSRC is technically ready for deployment today, C-V2X would need a yet-unknown amount of additional time to develop, test, propose standards, and develop proposed rulemaking. This additional time is the focus of this paper, specifically examining the number of crashes that could be avoided by deploying DSRC now, as opposed to waiting for C-V2X. The actual amount of time that would be necessary to bring C-V2X up to the level of technical readiness and broad acceptance such that it could be mandated is completely unknown. However, the following analysis makes what are some fairly generous assumptions of three, five, or seven years of additional delay in order for C-V2X to reach the equivalent state of readiness for mandate.

The purpose of this white paper is not to assess the strength or weaknesses of either DSRC or C-V2X technology. Rather it is to investigate and quantify the lost opportunities to prevent light-vehicle crashes by waiting for the development and implementation of C-V2X as opposed to mandating DSRC now in the form of FMVSS 150. The focus on V2V crashes, as opposed to all crashes, is based on significant levels of uncertainty associated with the deployment of infrastructure-based hardware and/or small-cell networks that would be required for either DSRC or C-V2X technologies to address many of the single-vehicle crash types.

Assumptions and Calculations

The following were assumed to be constant between a DSRC or C-V2X mandate:

- Penetration rate – the rate of either technology to be introduced into the vehicle fleet, assuming that any USDOT mandate would only stipulate installation in new vehicles sold. This value is held constant at 4.5% of the total vehicle fleet being new vehicles each year over the span of the time frame to reach full, or virtually full, deployment across the fleet of vehicles operating in the U.S. While retrofitting is possible with either technology, neither is seen as having an advantage over the other in terms of the rate older vehicles could be retrofitted.
- Effectiveness models – the rate at which either system is effective in mitigating V2V crashes. Because any near-term deployment of V2V technology would rely to some degree on the vehicle operator to respond appropriately, and because there will be cases where neither technology is completely effective, the rate of which either technology would gain effectiveness will vary. Two levels of effectiveness

are assumed, 25% and 75%. Note that effectiveness represents the ability of V2V communication to address any crash involving two or more vehicles equipped with the communication technology and associated applications. The rate of effectiveness will change over time with improvements and until the vehicles that are equipped reaches the maximum level of penetration. The conservative effectiveness model assumes it will take 13 years to reach 75% effectiveness, whereas a more aggressive model assumes only seven years in order to become 75% effective. Both models assume a minimum effectiveness of 25% to start.

- Years to reach maximum penetration – the number of years it would take to reach the maximum levels of penetration of either technology, recognizing that there will always be some percentage of the vehicle fleet made up of older vehicles which will never be equipped. The duration to reach maximum penetration is held constant at 15 years.
- Light-vehicle crashes per year – this is based on recent 2011 U.S. DOT crash statistics[3], and assumes in all cases that there are 5,400,000 light-vehicle crashes a year. It also assumes that 68% of all light-vehicle crashes involve two or more vehicles. Therefore, even with 100% penetration and 100% effectiveness, the maximum number of light-vehicle crashes that could be addressed by V2V in this analysis is 68% of 5,400,000, or 3,672,000, crashes annually.
- Injuries and fatality data for light-vehicle crashes is also based on the 2011 U.S. DOT crash statistics. Based on the 2011 data, the injury per crash rate is 0.4153 of and a fatality per crash rate is 0.0061. The analysis assumes that injury and fatality distributions are the same among prevented crashes as in the population at large.

The following assumption is varied:

- Years delayed to deployment (i.e., mandate) – this is the time difference between when DSRC could be mandated and deployed (assuming calendar year 2019) and when C-V2X could be deployed. Three values representing the potential delay between deploying DSRC in 2019 and C-V2X in some subsequent year are calculated. These are three, five and seven years, and represent the ability to deploy C-V2X in the years 2022, 2024, and 2026 respectively. This assumes that C-V2X reaches the same level of current readiness (LOR) of DSRC, which is assumed to be 9.

[3] Traffic Safety Facts 2011: A Compilation of Motor Vehicles Crash Data from the Fatality Analysis Reporting System and the General Estimates System. National Highway Traffic Safety Administration. DOT HS 811 754. https://crashstats.nhtsa.dot.gov/Api/Public/Publication/811754 Accessed on February 14, 2018.

Lost Opportunity to Prevent Two-Vehicle Crashes

Again, the focus of this analysis to assess the lost opportunity to prevent two-vehicle crashes by delaying the deployment of a wireless V2V communication technology. The analysis assumes that DSRC, based on its level of readiness, could be deployed as early as calendar year 2019, whereas C-V2X would require additional time to reach the same level of readiness (three, five or seven additional years). The number of crashes not prevented are cumulative, in other words over the assumed 15-year time frame it would take for either technology to reach its maximum penetration there is a cumulative effect of waiting to initiate deployment of any V2V technology.

The annual and cumulative number of crashes that could be prevented by deploying DSRC in 2019, and not waiting three years until C-V2X has reached the same level of readiness are shown in Table 1. Depending on the level of effectiveness that includes variability in how long the systems take to become 75% effective, the cumulative number of crashes that could have been prevented, the lost opportunity cost, ranges from 7,374,065 to 8,115,790 light vehicle crashes. Longer delays in deploying a vehicle-to-vehicle communication system being five (CY 2024) and seven (CY 2026) years, result in even great lost opportunity. A delay of five years results in the cumulative number of light vehicle crashes that could have been prevented ranging from 12,572,647 to 13,611,907, and a seven-year delay results in 17,927,859 to 19,119,862 light vehicle crashes that could have been prevented. Figure 1 illustrates the cumulative effect on crashes not prevented by delaying the deployment of a V2V wireless communication system by three years for the most aggressive assumptions of system effectiveness (e.g., 75% effectiveness is achieved in seven years).

Lost Opportunity to Prevent Injuries and Fatalities

Of the two-vehicle crashes that are not prevented by delaying the deployment of DSRC-based V2V, there is also lost opportunity to prevent injuries and fatalities associated with these same crashes. The annual and cumulative number of injuries and fatalities that could be prevented by deploying DSRC in 2019, and not waiting three years until C-V2X has reached the same level of readiness are shown in Table 2. Depending on the level of effectiveness that includes variability in how long the systems take to become 75% effective, the cumulative number of injuries and fatalities due to light-vehicle crashes that could have been prevented by deploying DSRC, the lost opportunity cost, ranges from 2,788,922 to 3,052,040 injuries and 40,717 to 44,558 fatalities. Longer delays in deploying a V2V communication system being five (CY 2024) and seven (CY 2026) years, result in even great lost opportunity. A five-year delay results in the cumulative number of light vehicle crashes that could have been prevented ranging from 4,764,264 to 5,143,901 injuries and 69,556 to 75,098 fatalities. A seven-year delay results in 6,804,197 to 7,243,115 injuries and 99,338 to 105,746 fatalities due to two light-vehicle crashes that could have been prevented by deploying DSRC in 2019. Figure 2 illustrates the cumulative effect on injuries, and Figure 3 fatalities, not prevented by delaying the deployment of a V2V wireless communication system by three years for the most aggressive assumptions of system effectiveness (e.g., 75% effectiveness is achieved in seven years).

Summary

This paper illustrates the negative consequences of delaying the deployment of DSRC, and reinforces the need for the U.S. DOT to finalize FMVSS 150. By deploying DSRC-based V2V communication systems in 2019, millions of light-vehicle crashes could be prevented as compared to waiting even three additional years to deploy C-V2X. More importantly are the millions of injuries and tens of thousands of lives that could be saved by deploying DSRC in 2019 - instead of waiting three, or more, years for C-V2X to reach a level of readiness comparable to DSRC. Given current crash, injury and fatality rates, the cumulative lost opportunity of not mandating DSRC now represents roughly one full year's worth of fatalities, injuries and crashes that occur on U.S. roadways that could otherwise be prevented. These analyses clearly illustrate the negative consequences of waiting for the potential of a different technical communications solution. If, as a society, we keep waiting for something better to come along, we will always be in a waiting mode – and hence nothing will get deployed. But in the meantime, there are crashes, injuries and fatalities that can be prevented.

Finally, it is important to note that DSRC and C-V2X are not mutually exclusive, but in fact could be very complimentary. The deployment of DSRC does not mean that C-V2X cannot be integrated into an overall V2X strategy at a later date, in which case C-V2X and DSRC could provide redundancy for safety critical V2X systems.

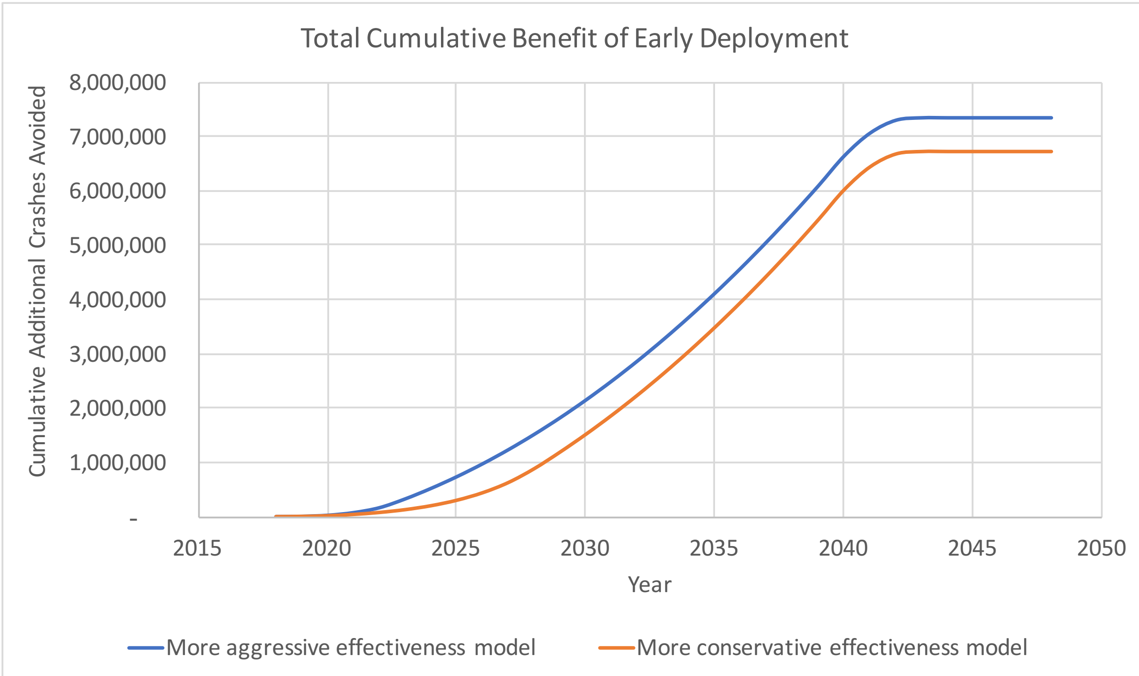

Figure 1. The cumulative benefit to crashes prevented by deploying a DSRC-based V2V wireless communication system in 2019, as opposed to waiting three years for a C-V2V alternative.

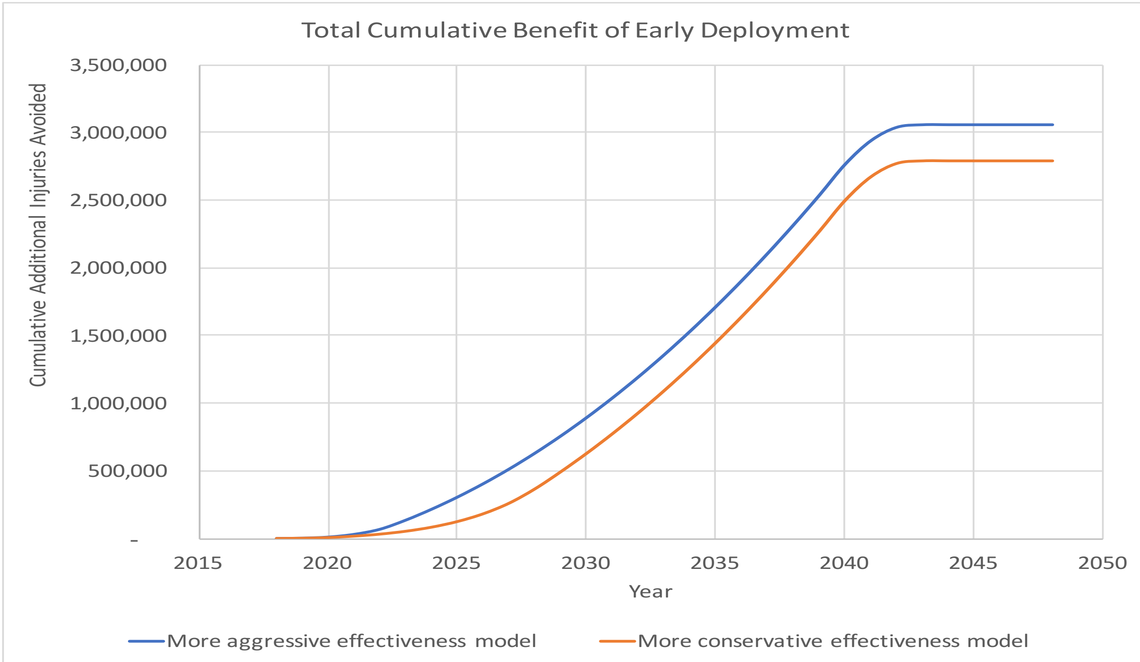

Figure 2. The cumulative benefit to injuries prevented by deploying a DSRC-based V2V wireless communication system in 2019, as opposed to waiting three years for a C-V2V alternative.

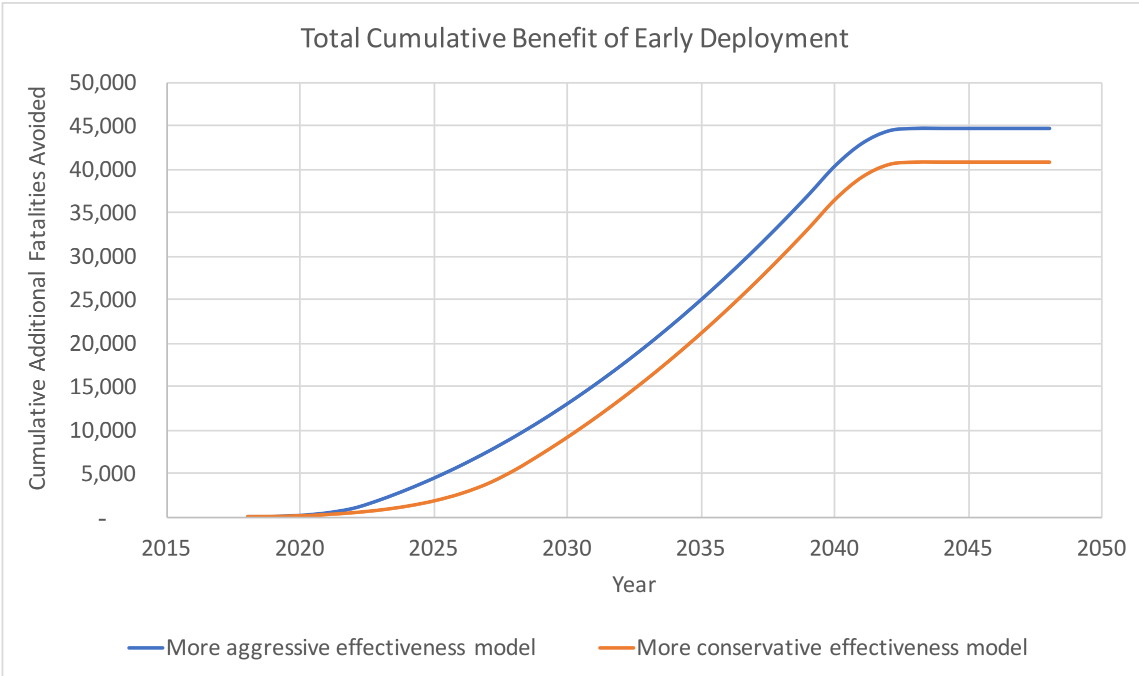

Figure 3. The cumulative benefit to fatalities prevented by deploying a DSRC-based V2V wireless communication system in 2019, as opposed to waiting three years for a C-V2V alternative.

Table 1. Number of crashes that could be prevented by deploying DSRC in 2019 verses waiting three years to deploy C-V2X.

Deployment Year	Annual Difference in Vehicles Crashes - Conservative Estimate	Annual Difference in Vehicles Crashes - Aggressive Estimate	Cumulative Crashes - Conservative Estimate	Cumulative Crashes - Aggressive Estimate
-	-	-	-	-
2019	4,339	5,461	4,339	5,461
2020	11,968	18,959	16,307	24,420
2021	24,528	48,902	40,835	73,321
2022	35,942	90,188	76,777	163,510
2023	51,488	162,608	128,265	326,118
2024	72,508	193,695	200,773	519,814
2025	100,756	216,003	301,530	735,816
2026	138,516	238,310	440,046	974,126
2027	188,759	260,618	628,804	1,234,744
2028	255,340	282,925	884,144	1,517,669
2029	305,232	305,232	1,189,377	1,822,901
2030	327,540	327,540	1,516,916	2,150,441
2031	349,847	349,847	1,866,764	2,500,288
2032	372,155	372,155	2,238,918	2,872,442
2033	394,462	394,462	2,633,380	3,266,904
2034	416,769	416,769	3,050,149	3,683,674
2035	439,077	439,077	3,489,226	4,122,750
2036	461,384	461,384	3,950,610	4,584,134
2037	483,692	483,692	4,434,302	5,067,826
2038	505,999	505,999	4,940,300	5,573,825
2039	528,306	528,306	5,468,607	6,102,131
2040	550,614	550,614	6,019,220	6,652,745
2041	417,960	417,960	6,437,180	7,070,705
2042	234,422	234,422	6,671,603	7,305,127
2043	43,448	43,448	6,715,051	7,348,575
2044	4,339	5,461	6,715,051	7,348,575

Table 2. Number of injuries and fatalities prevented by deploying DSRC in 2019 verses waiting three years to deploy C-V2X.

Deployment Year	Cumulative Injuries - Conservative Estimate	Cumulative Injuries - Aggressive Estimate	Cumulative Fatalities - Conservative Estimate	Cumulative Fatalities - Aggressive Estimate
-	-	-	-	-
2019	1,802	2,268	26	33
2020	6,773	10,142	99	148
2021	16,960	30,452	248	445
2022	31,887	67,910	466	991
2023	53,271	135,445	778	1,977
2024	83,386	215,891	1,217	3,152
2025	125,232	305,602	1,828	4,462
2026	182,762	404,578	2,668	5,907
2027	261,158	512,819	3,813	7,487
2028	367,206	630,324	5,361	9,202
2029	493,977	757,095	7,212	11,053
2030	630,012	893,130	9,198	13,039
2031	775,312	1,038,430	11,319	15,161
2032	929,877	1,192,994	13,576	17,417
2033	1,093,706	1,356,824	15,968	19,809
2034	1,266,800	1,529,918	18,495	22,336
2035	1,449,160	1,712,277	21,157	24,998
2036	1,640,784	1,903,901	23,955	27,796
2037	1,841,672	2,104,790	26,887	30,729
2038	2,051,826	2,314,944	29,956	33,797
2039	2,271,244	2,534,362	33,159	37,000
2040	2,499,927	2,763,045	36,498	40,339
2041	2,673,516	2,936,634	39,032	42,873
2042	2,770,877	3,033,995	40,453	44,295
2043	2,788,922	3,052,040	40,717	44,558
2044	2,788,922	3,052,040	40,717	44,558