TOWARDS INTELLIGENT LEVEL CROSSINGS

Abstract
This paper reviews the current status of the development of new technology Cooperative Intelligent Transport Systems (C-ITS) – Dedicated Short Range Communications (DSRC) - motor vehicle anti-collision applications, in the global motor vehicle manufacturing industry and raises the potential for the global rail industry, firstly to “interface” to that technology, and secondly, for that interface to then provide the quantum-leap “towards intelligent level crossings”.

Key Words Cooperative Intelligent Transport Systems (C-ITS), Connected Vehicles, Dedicated Short Range Communications (DSRC), Intelligent Grade Crossing (IGC), Intelligent Level Crossing (ILX), La Trobe University – Centre for Technology Infusion (CIT), national Cooperative Research Centre for Advanced Automotive Research (AutoCRC), Public Transport Victoria (PTV), Rail Level Crossing (RLX), SAFESPOT – European Union (EU), SMARTWAY - Japan, US Department of Transportation (DOT) – Research and Innovative Technology Administration (RITA), US DOT Intelligent Transport Systems (ITS) – Joint Program Office (JPO), US DOT - Federal Railroad Administration (FRA), vehicle to vehicle (V2V), vehicle to infrastructure (V2I), vehicle to consumer devices (V2D),
Introduction

There are some very exciting new technology “connected vehicle” developments (as they are known in the United States), or “cooperative intelligent transport system” (C-ITS)\(^1\) developments (as they are known in the European Union and Australia), currently taking place in the global motor vehicle manufacturing and road safety industries. None of which have anything to do with level crossing safety; yet...they actually have EVERYTHING to do with level crossing safety.

With apologies to the US NASA 1969 manned lunar landings, these new cooperative ITS\(^2\) technologies are considered “one small step for man, but one giant leap towards Intelligent Level Crossings\(^3\)."

United States (US) – Department of Transportation (DOT) – Research & Innovative Technology Administration (RITA) – Joint Program Office (JPO)

The following concept incorporates the adoption of new technology vehicle-to-vehicle (V2V)\(^4\), vehicle-to-infrastructure (V2I)\(^5\), & vehicle to consumer devices (V2D)\(^6\), level crossing safety management applications (app’s), as a “first step” towards intelligent

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\(^{1}\) The Austroads Cooperative ITS Strategic Plan - Publication No: AP-R 413-12 contains a very good definition of Connected Vehicles and/or C-ITS. Austroads C-ITS Strategic Plan

\(^{2}\) See “What is ITS” on the US DOT RITA JPO web site: US DOT ITS

\(^{3}\) See US DOT FRA web site for a description of intelligent grade crossings: IGC

\(^{4}\) See US DOT RITA JPO web site for a research overview of: V2V

\(^{5}\) See US DOT RITA JPO web site for a research overview of: V2I

\(^{6}\) See Smart-Traveller web site for definitions of: V2D as well as definitions of V2V & V2I
level crossings.

If as expected, the global motor-vehicle manufacturing industry implements this anti-collision technology in the next year or so, it will be an absolute “no-brainer” for the rail industry not to develop level crossing safety interface applications.

Which is exactly why we are developing those interfaces in Victoria - Australia now, rather than wait until the motor vehicle industry makes that final decision and then have to spend possibly up to three years developing our level crossing application interfaces. After which we would then have to go cap-in-hand to the motor vehicle manufacturers to seek to have our level crossing interface applications adopted into all new motor vehicles.

We are planning that when the global motor vehicle C-ITS Dedicated Short Range Communications (DSRC) manufacturing decision is made, (likely in a year or two) the rail industry can immediately raise its hand to indicate that “we are also ready”; so please incorporate our level crossing safety applications into all new vehicles.

The question then arises, how quickly will the global rail transport industry adopt these new technology applications, and how quickly will they then extend the application of that technology to the ultimate objective of developing intelligent level crossings?

The Global motor vehicle manufacturers, together with the US DOT, European Union, and Japanese road safety regulators, have been collaborating for over a decade on technical standards for new technology V2V and V2I motor vehicle, anti-collision, C-ITS. This has recently been complemented by research programs that support connectivity amongst vehicles, infrastructure, and “consumer devices” (V2D), to deliver even more safety mobility benefits.

**Cooperative ITS (C-ITS) US, EU & Japan Collaboration**

You can find out more about these cooperative ITS collaborations at the following web sites;

- John H Volpe NTS Centre ITS News
- SAFESPOT Project - EU
- SMARTWAY Project - Japan

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7 Wikipedia definition of DSRC
**Dedicated Short Range Communications (DSRC)**

Dedicated Short Range Communications (DSRC) has emerged from a number of options as the primary global communications standard for future *connected vehicle* research\(^8\), and for ITS systems for motor vehicle industry connected vehicle applications, and appears to be the key foundation upon which these future ITS applications will be built.

However, the “short range” component of DSRC may yet prove to be unsuitable for the global rail industry for high speed train applications in particular (160+KPH), and other DSRC compatible “on-board” train communications may have to be applied. (It is possible to extend the short range nature of DSRC by installing additional repeater base stations, but the feasibility of this requires further research and trials).

**AusDSRC Cluster**

In Australia the AusDSRC Cluster\(^9\) was formed in 2008. Its role is to seek and achieve the allocation of the 5.9GHz radio frequency spectrum for DSRC and act as a catalyst for ITS applications demanding secure, wireless broadband capability.

DSRC-based ITS is being adopted around the world as a means to:

- Save lives lost to traffic accidents
- Reduce the economic impacts of traffic accidents and congestion
- Reduce the global warming impact of congestion.

**US DOT Video Clips**

The US DOT have excellent video clips in their RITA video library at ITS Videos\(^10\), including; “A New Generation of Driver Assistance”\(^11\) and “Vehicle to Vehicle Communication”\(^12\) (N.B. they are large files and may take a couple of minutes to load). The video clips demonstrate various V2V anti-collision applications.

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\(^8\) [US DOT Connected Vehicles](https://www.dot.gov/connectedvehicles)  
\(^9\) [Aus DSRC Cluster Web Site](https://ausdsrc.com)  
\(^10\) [US DOT JPO ITS Videos](https://www.dot.gov/itsvideos)  
\(^11\) [US DOT DSRC Video](https://www.dot.gov/dsrcvideo)  
\(^12\) [US DOT V2V Video](https://www.dot.gov/v2vvideo)
The global rail industry is currently in the middle of a transition from “Analogue” to “Digital” communications and in my view has not yet gained a full appreciation of the potential immense benefits flowing from this new telecommunications technology and in particular from C-ITS DSRC safety applications.

From a rail industry perspective it is important to remember that this new technology is not being developed by the rail industry and that current predictions are that it may start appearing in all new motor vehicles manufactured from around 2015, following decisions in the US and the EU in the next year or so.

In any event, the global rail industry simply needs to develop level crossing safety applications that interface to the new motor vehicle anti-collision technology and in Melbourne - Australia, we are currently liaising with our road authority colleagues along those lines.

**Daimler C2X 120 Vehicle Trial – Stuttgart 6 August 2012**

Daimler\(^{13}\) have been trialling V2V communications since early 2006. On 6 August 2012 they announced (then) one of the world’s largest C2X communications trial.

**US DOT DSRC – Pilot Study – Ann Arbor Michigan 21 August 2012**

On 21 August 2012 the US DOT announced the largest ever road test of crash avoidance technology in a 12 month 3000 vehicle trial\(^{14}\) of DSRC in Ann Arbor - Michigan.

**ITS World Congress Vienna October 2012**

At the ITS World Congress in Vienna in October 2012 the European Commission and US DOT presented a joint paper entitled “International Deployment of Cooperative Intelligent Transportation Systems – Bilateral Efforts of the European Commission and United States Department of Transportation\(^{15}\)”.

The opening message in the paper states; “The United States Department of Transportation Intelligent Transportation System (ITS) Joint Program Office and the European Commission Directorate General for Communication Networks, Content and Technology, have been working together on mutual ITS challenges and

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13 [Daimler Web Site C2X Trial](#)
15 [Vienna 2012 US EU Bilateral Paper](#)
opportunities related to connected vehicles as they are known in the United States, or cooperative ITS, as it is known in the European Union (EU). Our goals for this collaboration are to increase the value of our regions’ research by creating a joint framework for field operational tests and evaluation tools; collaborate on cooperative vehicle safety, mobility, and sustainability application research projects; and internationally harmonize cooperative ITS standards to support cooperative ITS.”

In the paper summary it states that; “Cooperative systems have the potential to deliver significant safety, mobility, and environmental benefits. Through a system of vehicles in constant communication with each other and roadside equipment, we have the ability to transform transportation as we know it and reduce its impact on our global society. The EU and U.S. are joining together to fully explore the promise of such a cooperative system.

The partnership increases the value of each region’s research by creating a joint framework for FOTs and evaluation tools, collaborating on cooperative system safety applications research projects, and working to internationally harmonize cooperative system standards.

Going forward, the EU and U.S. bilateral efforts will continue to focus on international standards harmonization as a key outcome of our collaborative work. As a global industry, it is critical to reduce barriers to multiregional standardization and achieve broad agreement on harmonization that can benefit both the traveling public and the ITS and motor vehicle industries. Harmonization facilitates interoperability between products and systems, which can benefit transportation management agencies, vehicle manufacturers, equipment vendors, and others. We will also build on our respective agreements with Japan to foster collaboration on international standards harmonization, probe data usage, and evaluation.

In addition, the Safety and Sustainability Applications Working Groups will identify critical technical issues, and the Driver Distraction and HMI Working Group will continue to gain knowledge in safe HMI design. We also anticipate that by sharing the results of each region’s individual demonstrations (such as the U.S. Connected Vehicle Safety Pilot and the EU C2C-CC demonstration at the 2012 World Congress); we will maximize our overall knowledge and research. Ultimately, our goal is that our bilateral efforts will accelerate the deployment of cooperative vehicle systems worldwide.
NEXT STEPS

Going forward, the EU-U.S. Working Groups plan to complete the following steps toward their bilateral effort to foster the deployment of cooperative vehicle systems:

- **Safety Applications Working Group** -- Hold a meeting in early 2013 in the Detroit area, enabling C2CCC members to tour the U.S. Connected Vehicle Safety Pilot Model Deployment and to continue face-to-face discussions for advancing work on the technical agenda items

- **Sustainability Applications Working Group** -- Choose a Spat-related application for joint research, develop the application's concept of operations, and work with the Standards Harmonization Working Group to define an environmental message set for the application and develop a joint data set for the environmental Spat application.

- **Standards Harmonization Working Group** -- Harmonize a broader and richer set of V2V and V2I messages that can be used to support safety, mobility, and sustainability applications

- **Assessment Tools Working Group** -- Focus on defining the Cross-Project Database Interrogation approach, including using this approach on specific databases

- **Driver Distraction and HMI Working Group** -- Shift focus to safe HMI design of automotive ITS applications

- **Glossary Working Group** -- Update the current version of the glossary during 2013

For over 125 years the automotive industry has been a catalyst for innovation, new technology and economic growth. In the new millennium the social, political, cultural, environmental, and economic pressures from massive global road tolls, congestion, and global warming, are speeding up the pace of innovation, and new technology is allowing the industry to once again be on the cusp of revolutionary change.

That change has the potential to reshape the way we interact with vehicles, infrastructure and mobility devices and indeed the future design of our cities, roads, and transport systems, including both road and pedestrian users of level crossings.
PTV, AutoCRC, La Trobe, QUT – ITS To Improve Safety At RLX

In 2009 in a world first for the rail industry the Victorian Department of Transport (since restructured and now Public Transport Victoria16 (PTV) ) was awarded a research grant from the national Cooperative Research Centre for Advanced Automotive Research17 (AutoCRC). The DOT then entered into a partnership with - La Trobe University18 – Centre for Technology Infusion (CTI), Queensland University of Technology (QUT) and others, to develop railway level crossing safety management interfaces to the motor vehicle anti-collision new technology, in a project entitled ‘ITS To Improve Safety At Road Rail Crossings’.19 This involves a 3 Year - 100 vehicle trial of Dedicated Short Range Communications (DSRC) and has grown into a $5.5 M project with $1M cash from the AutoCRC/La Trobe CTI & QUT and $1.25 M cash from DOT/PTV20.

GLXS 2010 – Tokyo October 2010

A paper “Intelligent Transport System to Improve Safety at Road-Rail Crossings21” Professor Jugdutt (Jack) SINGH - La Trobe University, Terry SPICER - DOT, was presented at the 11th World Level Crossing Safety Symposium, in Tokyo – Japan, in October 2010. This paper contains details of the above project.

GLXS 2012 – London October 2012 - Update

The paper was recently updated as “Intelligent Transport Systems: Level crossing safety visionary solution22.” Aniruddha DESAI, Professor Jugdutt (Jack) SINGH- La Trobe University and Peter NELSON-FURNELL - PTV, delivered at (Session 5) of the 12th Global Level Crossing & Trespass Symposium in London 7 – 12 October 2012. More information about the Project and the 100 vehicle DSRC trials, at two metropolitan and one regional Victorian location is also available on the PTV23 web

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16 PTV RLX DSRC
17 AutoCRC
18 La Trobe CTI RLX ITS
19 La Trobe ITS to Improve Safety
20 La Trobe Saving Lives at RLX
23 PTV RLX DSRC
It also helps if you think about the DSRC Technology as being simply in the same context as a ‘Smart Phone', which is only successful through its APPLICATIONS (apps).

The following is a list of “potential" rail level crossing safety management applications, which only scratches the surface in identifying many other potential rail safety applications available using this technology.

1. road level crossing app.
2. pedestrian level crossing app.
3. train to train app.
4. train to track gang warning app.
5. train to tram app
6. tram to tram app.
7. tram to vehicle app.

Low cost RLX safety warning system

One very obvious benefit from this new technology will be the provision of a “low-cost-level-crossing-warning-device", in that motorists will be able to be warned about the train/s approaching the level crossing which they are about to encounter, even if they cannot yet see the crossing, and even if it is a passively controlled crossing in a remote location

Intelligent Level Crossings (ILX)/Intelligent Grade Crossings (IGC)

So, why advocate that all of the above, is just “one giant leap" towards intelligent level crossings?

In very simple terms, ILX is a marriage between next generation Train Control & Signalling ITS systems with Smart Road Traffic ITS Warning Systems, as well as with interoperability between road/rail control centres.

Once all of the above is in place, and with V2V, V2I, & V2D, linked to in-vehicle audio and visual human factors researched DSRC systems, we will be able to very accurately predict when a train or trains will arrive at a level crossing, and get the human response we are looking for from the technology.
The ITS will look at the road traffic activities at each level crossing several minutes before the train/s are due, and interfacing with the smart road traffic ITS warning system, will clear any immediate road congestion using the road traffic light system, with the objective of minimising the time that the train warning system needs to operate to allow the train/s to pass, also minimising inconvenience to road and pedestrian users.

All of which is captured on the in-vehicle communications screen, smart phone, or roadside variable message signs, which will advise you of exactly how long the delay will be, or may even allow you to decide to take an alternative route, as you approach an intersection that leads to a level crossing.

As indicated in the introduction to this paper the US DOT FRA web site contains a very good description of ILX or IGC$^{24}$ as it is known in the US;

“Intelligent Grade Crossings” (IGC) are those locations where ITS for roadways come together with Intelligent Railroad Systems, and in particular, Positive Train Control (PTC) systems. PTC systems, unlike traditional railroad signal systems, provide continuous information on train location and speed. FRA, working with the ITS Joint Program Office, intends to sponsor Intelligent Grade Crossing projects on railroad corridors in Michigan, Illinois, and Alaska where FRA-sponsored communication-based PTC systems are being implemented and demonstrated.

Coordination will take place with the State highway departments so that these grade crossing projects are integrated with other projects that are underway.

For example, warning to motor vehicles of oncoming trains, as well as advice on alternate routes to avoid blocked crossings, would be transmitted through the standardized ITS dedicated short-range communications system and displayed on standardized in-vehicle information displays and roadside variable-message signs.”

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$^{24}$ US DOT FRA IGC Description
So When Is All Of This Going To Happen?

**US DOT ITS Strategic Research Plan 2010 - 2014**

In the US DOT ITS Strategic Research Plan there is a section headed;

**“ITS Rail Exploratory Initiative ...**

... is a research effort designed to explore whether Connected Vehicle offers increased safety benefits within the rail environment. The research will also determine the requirements for rail-based communications and ITS technologies. The vision for the ITS Rail Exploratory Initiative research is to improve rail safety and lower operational costs through real-time data exchange and ITS applications.

**Research Plan**

The objective of this exploratory research initiative is to determine whether V2V or V2I Connected Vehicle application can offer potential safety benefits for commuter, freight, or heavy rail. The research will also focus on the feasibility of developing applications.

Currently, Connected Vehicle safety applications address the automobile platform and use DSRC. This research will investigate if DSRC is appropriate for rail-to-rail, rail-to-infrastructure, or rail-to-automobile communications. Additionally, this research will assess if existing rail communications or other modes of communication (Cellular, Wi-Fi, WiMAX, etc.) can be used for rail safety applications.

The research questions will focus on the current communication capabilities used within the rail environment, and how these technologies might interface with DSRC communications. Rail cars, including locomotives, have different architectures than automobiles, potentially adding greater complexity to Connected Vehicle rail applications. In particular, the institutional and policy issues will need to be assessed, as the business, policy, and jurisdictional models employed within the rail industry differ significantly from other transportation industries.

If the V2V and V2I safety applications for heavy rail and other rail modes are feasible, the benefits to travellers are immense and include lives saved through improved safety.
safety and lower repair costs for the infrastructure and rail vehicles.

Areas that will be assessed for their viability to implement Connected Vehicle communications technologies and safety applications include the following:

- Positive train control (PTC) for freight and commuter rail
- Communication-based train control (CBTC) on commuter, heavy rail, and light rail
- Grade crossing and blocked crossing for commuter rails
- Vehicle and track surveillance (Right-of-Way or intrusion detection) on commuter, heavy rail, and light rail.

The research will be led by the FTA and involve a partnership with the FRA, transit experts, and stakeholders. The research will investigate the development and adoption of standards for data interoperability and communication between rail vehicles, rail to light vehicles, and rail to infrastructure. It will develop one or more business models that support sustainability and industry innovation, and it will investigate national policy and regulations. Finally, the research will identify target markets or locations for potential application demonstrations which will be determined after the feasibility research is successfully completed.”

It is my hope that once the global vehicle manufacturers in collaboration with the global transport agencies covered in this paper implement the technologies indicated above, we in Australia can contribute our rail safety and level crossing safety management experience to the future development of technology leading towards intelligent level crossings.

Terry Spicer
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