The CITI project – An update on Australia's first deployment of Cooperative Intelligent Transport Systems targeting heavy vehicle safety

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Abstract

Cooperative Intelligent Transport Systems (CITS) is the term generally used to describe a form of Intelligent Transport Systems in which information is shared amongst vehicles or between vehicles and roadside infrastructure such as traffic signals. This has the potential to greatly improve road safety, improve network efficiency and reduce greenhouse gases.

The Cooperative Intelligent Transport Initiative (CITI) pilot will be the first semipermanent CITS field test bed site in Australia. The Objective of the CITI project is to construct a 42 km connected freight corridor test facility in the Illawarra Region of NSW south of Sydney. This will be one of the first large scale test facilities dedicated to Heavy Vehicles in the world.

The first stage of the project will fit in-vehicle dedicated short range communication (DSRC) transceivers in up to 60 trucks that regularly travel the planned route. In addition, three signalised intersections are being equipped with DSRC roadside units which will communicate with the trial vehicles. A 40 km/h truck and bus speed zone warning system is also planned for installation at the top of Mt Ousley to alert drivers about to descend the very steep (up to 12 percent downhill gradient) south bound section of the road.

This paper will provide an update on the progress of the CITI project and examine issues including project planning, equipment licensing, human machine interface development, data management and participant recruitment.

Introduction

Creating test beds and trialling new emerging technologies can be a challenging exercise. Emerging technologies are likely to be in a state of flux. How the technology works may challenge existing models, regulations and laws. What makes it new and different can present new and different problems. While some risks can be identified and resolved early, other risks take time to resolve, and others may arise as the technology evolves. In such projects, clear core aims and a flexible project management style is often warranted. Multiple project paths may be developed to provide alternatives should one fail. This paper describes how such an approach has been used for the CITI project by presenting some of those risks and how they were managed.

Background

The Cooperative Intelligent Transport Initiative (CITI) is a project being conducted by Transport for NSW (TfNSW) in partnership with NICTA and the Federal Government's Heavy Vehicle Safety Productivity Program under the Nation Building Program. The project is run and operated out of TfNSW. NICTA is providing significant technical expertise and a project manager who is embedded in TfNSW. The Federal Government is providing a significant funding contribution. The first stage of the project aims to install Cooperative Intelligent Transport System (CITS) devices in

[1] NICTA is funded by the Australian Government through the Department of Communications and the Australian Research Council through the ICT Centre of Excellence Program.

up to 60 heavy vehicles, at 3 signalised intersections and at the top of Mt Ousley near Wollongong, NSW.

What are Cooperative Intelligent Transport Systems?

Intelligent Transport Systems (ITS) is a term used to describe a vast array of technologies that use computing devices associated with vehicles. The technologies range from in-vehicle navigation, electronic tolling and speed cameras to more advanced systems such as live data, parking guidance or weather information. Cooperative Intelligent Transport Systems (CITS) is the term generally used to describe a form of Intelligent Transport System in which information is communicated and shared amongst vehicles or between vehicles and roadside infrastructure such as traffic signals. An example of a common simple CITS application is in electronic toll collection where a vehicle mounted toll tag is detected by a road operator who in turn charges the owner of the vehicle for travelling on a section of road. More recently, complex generalised CITS systems are being developed that enable vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication to occur as peers that are part of a broad network. In these networks, there are no central computers or processors. Network participants communicate with each other as peers. These systems use radio technology known as Dedicated Short Range Communications (DSRC)[2], working in a similar way to computer WiFi networks. Currently both the U.S. Department of Transport and European standards groups are refining standards that enable V2V and V2I communication. With this technology, various applications are possible, and significantly the initial applications are focusing on vehicle safety.

DSRC and its applications

At the heart of DSRC is a communication network that is designed to be suitable for communication between vehicles and between vehicles and infrastructure. Rather than providing a solution for a specific problem like electronic tolling, this network is a form of infrastructure on which applications can be built. Whilst the nature of the infrastructure lends itself to a variety of applications, the primary motivator for deploying DSRC is road safety. Therefore, at the core is a design that has a focus on road safety. Initial applications being delivered on DSRC platforms worldwide include alerts for potential forward as well as side collisions and curve speed warnings. For example, vehicles with DSRC devices are broadcasting their position, speed and direction (among other parameters) up to 10 times per second. When they receive those messages from other vehicles, calculations can be made to determine if that other vehicle poses a collision threat. Even threats that cannot be seen by the driver can result in an alert for the driver.

In addition to safety, it is expected that DSRC will provide a platform for applications in the areas of driver information, network management, environmental and network efficiency, routing, incident detection, vehicle management and driver assistance technology. No doubt many more applications will emerge as the technology is explored. Furthermore, older communication technology such as electronic tolling could migrate to this more flexible technology. In the future DSRC may even be a technology that assists autonomous vehicles. A more detailed discussion is available in Wall (2013).

The CITI project

The CITI project is a test bed for DSRC technology in the Illawarra region of NSW. In Stage 1, the project aims to trial this technology in heavy vehicles operating out of Port Kembla and has a focus on safety applications.

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[2] In this paper, we use DSRC to refer specifically to V2V and V2I systems such as the Wireless Access in Vehicular Environments (WAVE) as stated in various standards including IEEE 802.11p, IEEE 1609, SAE J2735 or the equivalent European standards for CALM M5.

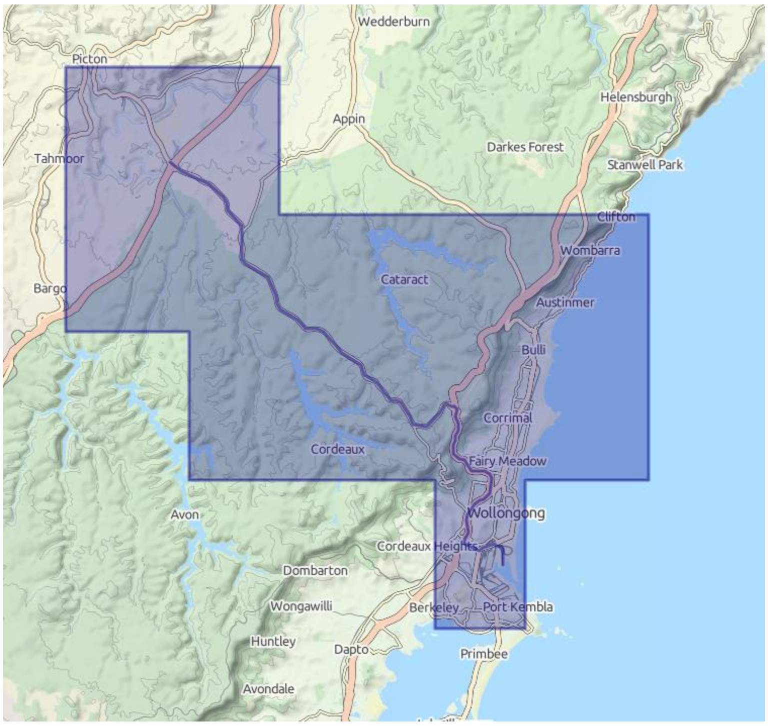

Figure 1: CITI Focus Route and Area

Location

The CITI project is focusing on a 42 km length of road that connects the Hume Highway in Sydney's South West to the port of Port Kembla situated two kilometres south of the Wollongong Central Business District. Due to the variety of routes often used by heavy vehicles using Port Kembla, the project is also enabling a broader area for the trial of DSRC. Figure 1[3] shows a map of the focus route and area.

Having recently undergone a major expansion, Port Kembla has seen a diversification of its trade base to include general and break bulk cargoes, containers and motor vehicle imports. Mt Ousley Road is a busy road carrying an increasing number of heavy vehicles that form a significant part of the traffic using that road.

Picton Rd, connecting Mt Ousley to the Hume Highway, has recently had significant physical works completed. Prior to those works, heavy vehicles were involved in a majority of fatal road crashes recorded on the focus route for the three year period up to 30 September 2011.

A number of factors make the focus route and trial area ideal for a DSRC test bed. The route covers a range of environments, including urban, mountains and isolated rural areas. A high concentration of heavy vehicles with regular trips and a common focus point of Port Kembla give a unique opportunity to focus on heavy vehicles with a higher chance of interaction.

CITI Stage 1

Project Planning

Research projects with defined deliverables can be difficult to plan and execute when the research is instrumental to delivery. Technology projects are known to suffer time and cost blow-outs. Emerging technology projects with evolving standards and untested processes have to deal with change. The CITI project has elements of all these. At the heart of the first stage is the aim to do

[3] Cartography by OpenStreetMap contributors. Retrieved 1 August 2014. See http://www.openstreetmap.org/copyright

research into DSRC for safety applications by trialling, collecting data and assessing. DSRC is not only technology, but a new emerging technology that is evolving as more experience is gained from trials.

For the CITI project, project planning has been a continual process of managing and modifying the project details while maintaining the overall aim. Potential risks have been identified and where possible, mitigated. Mitigation often involved multiple options, each with a flow on effect to other aspects of the project. Unlike projects with mature technology, one linear plan was not sufficient. Any number of risks could have caused such a plan to fail. By planning with multiple options and maintaining flexibility, potential risk events can be avoided. A number of these risks are discussed further in this paper.

At the heart of the CITI project plan was the aim to equip 30 heavy vehicles, at least one signalised intersection and some roadside warning infrastructure with DSRC units. A number of key tasks were identified. These were radio licensing, device procurement, participant enrolment, infrastructure development, and data collection.

Ultimately as the project progressed and a number of potential costly issues were resolved, the first stage has been expanded with the aim to equip up to 60 heavy vehicles, three signalised intersections, one roadside warning site, and two data collection locations. Some of those issues are discussed in the rest of this paper.

Radio licensing

DSRC standards require devices to operate on specific channels in the 5.9GHz channels of the radio frequency spectrum. In Australia, this part of the spectrum is under embargo, specifically reserved for CITS applications. It was determined early on that the CITI project had a strong preference to operate on this standard frequency. This holds a number of advantages, including consistency with standards, commonality with trials overseas, and a degree of assurance that the frequency band should be clear, largely unused, and unlikely to suffer from interference external to the trial.

However in early planning it became clear that determining a precise radio licence model for the trial was going to be problematic. Current legislation provides models for various styles of radio networks. DSRC is an emerging technology that is based on peer devices and largely mobile in nature. Current licence models do not have this kind of network in mind. The most similar style of radio network in use in Australia is a computer Wi-Fi network. Even still, a Wi-Fi network requires a Wireless Access Point and so are not true peers. Wi-Fi networks are licensed under a class licence, a licence determined for open use subject to specific conditions, allowing anyone to set up a Wireless network. The current class licence for Wi-Fi does not cover the frequencies for DSRC and introduction of new class licences are done for national reasons. This model of licensing was not suitable for the CITI trial.

A number of other options were explored with the Australian Communication and Media Authority (ACMA). Some of those options involved significant additional infrastructure for the project. Some styles of licence were very expensive. The uncertainty posed by the requirement for a licence to operate at 5.9GHz not only required ongoing discussion with the ACMA, but the development of alternative plans. Without certainty or an alternative plan, starting a procurement process was risky.

We developed two options. The first was to continue pursuing a licence for 5.9GHz. This option would only become certain at the time we held a licence. A backup option was developed to use frequencies in 5.8GHz that can be used under the Low Interference Potential Devices (LIPD) class licence. Both options held risks. The uncertainty of securing a licence for 5.9GHz was due to finding an appropriate licence type at an affordable price. Using the 5.8GHz part of the spectrum compromised our aims to use current standards and presented a risk of encountering interference from other users of devices operating under the LIPD class licence.

Ultimately this issue was resolved with Transport for NSW securing an affordable licence for the appropriate channels at 5.9GHz from the ACMA in January 2014.

Standards – US or Europe?

Both the United States of America and Europe have been developing standards for DSRC. While the low level communication hardware is similar, the choice of radio channels and the format of information are different. A number of competing factors weighed on our choice. The standards from the USA were more formed and in use in similar trials. European standards lagged and trials have been more ad-hoc. However Australia imports far more vehicles designed for the European market. Other factors also hint at Australia ultimately adopting European standards.

Rather than choose one standard that was locked in stone, the CITI project has sought to keep both options open. By seeking DSRC devices that are able to be changed over through deploying new software, the option remains to change standards at a future date. The devices ultimately sourced for the trial have been delivered with the US standard installed. This standard has been used in other trials and suppliers have significant experience with it. However if a time arises where it is determined that European standards would be more suitable, the CITI test bed has the option to swap over.

Specifying and Procuring Devices

Procuring devices provided some challenges. The dollar value of the proposed purchase meant a tender process was deemed most suitable. Two major issues were identified. The first was the nature of the market for sourcing the proposed devices. As the devices are based on emerging technology, they are not off the shelf. Only a handful of suppliers worldwide manufacture suitable devices. Additionally, it was discovered that not all suppliers were easily contacted or willing to supply to Australia. The combination of the nature of the technology, a small number of suppliers and conducting the trial in Australia resulted in a restricted market for securing devices. The second issue was that of specifying the devices. If the specification were too tight, some of the few suppliers may be ruled out. If the specification were too loose, unsuitable proposals may be received.

The tender process used was a Request for Proposal (RFP). This process allows potential suppliers to propose a solution to the RFP. It is a little less strict than a request for tender. The RFP provided a number of mandatory requirements regarding standards and equipment, and a number of other preferences of varying degrees of importance. The RFP indirectly relied on work previously done in US trials and resulted in proposals that drew heavily from those US trials.

The RFP attracted only a few responses and resulted in a contract awarded to Cohda Wireless Pty Ltd, the only Australian developer of DSRC devices.

Human Machine Interface (HMI) development

After acquiring early model devices, the CITI project team considered the effectiveness of the Human Machine Interface (HMI). Previous experience with similar equipment had identified HMI issues to be important but the team had no expertise in assessing the HMI.

The CITI project engaged Monash University Accident Research Centre (MUARC) to do a literature survey of HMI research for in-vehicle devices with interfaces similar to those of the CITI devices. They were also asked to develop guidelines for developing or assessing an HMI on these types of devices. MUARC produced a comprehensive report (Young & Lenné, 2013a) that exceeded expectations. The clear guidelines have proved invaluable in assessing and designing the CITI device HMI.

Further, MUARC was asked to provide an independent assessment of the current proposed HMI against their guidelines (Young & Lenné, 2013b). That assessment resulted in some additional improvements to the HMI which are currently being implemented.

Portable Infrastructure

One of the Project's aims was to deliver roadside equipment that broadcast warnings. Sites and possible installations were considered. However, proposed works in one location, lack of access to power, and a realisation that performance of devices could be effected by location resulted in a plan to deploy portable trailer based road side devices. The trailers required telescopic masts for the radio devices, had to provide power, and be robust. Trailers used in the mining industry were identified as meeting these requirements.

These trailers provide flexibility in deploying road side devices. This enables us to try different locations as we assess performance. As they are self powered, sites are not restricted to locations with power. A trailer will be deployed to one road side location at the top of Mt Ousley for providing truck speed zone and weather information. Two other trailers will be deployed for data collection.

Planning for Data Management

With up to 60 vehicles each transmitting 10 messages a second, logging those and any received messages results in data rates that are large. Collecting and storing that data required serious planning. Current estimates suggest that data could be as much as 64Gb per week over the entire installation, spread across the devices deployed in each vehicle.

A number of technical issues are present in this problem. The amount of the data rules out network based solutions such as 3G or 4G mobile both on speed and cost. The need to collect data and store it temporarily at a roadside location presents technical issues, especially in considering temperature requirements. The requirement to manually collect data requires a solution that is safe for workers.

Software is currently being developed to enable each device to upload their logs to collection points placed within the port. The collection points will consist of a road side trailer equipped to receive and store the logs. Due to the amount of data, that data will be retrieved manually by staff and returned to the Wollongong office for secure storage.

Participant Recruitment

A number of heavy vehicle operators have been approached to participate in the trial. All have been happy to participate. At present, Transport for NSW has sorted through the legal relationship for participants who are operators of a fleet of vehicles with drivers who are employees. This kind of participant presents few issues and allows one relationship over a number of vehicles and drivers. In this kind of arrangement, the participant manages the drivers and vehicles. Transport for NSW has a relationship with the vehicle owner and operator directly and indirectly with the drivers. The data collected by Transport for NSW does not identify drivers or the particular vehicle.

To date, five operators each offering between 10 and 15 vehicles each have agreed in principle to participating in the trial. At the time of writing, negotiations with one company on a deed have been finalised and the other four are considering the proposed deed.

Current Progress

Stage 1 of the CITI Project is progressing well for delivery by the end of 2014. At the time of writing, devices had been procured, participants were signing or considering deeds, and plans were in place for deploying roadside infrastructure. A significant amount of work remains in finalising the HMI, producing documentation, driver training and device installation. However it is expected this work will be completed between the time of writing and presentation of this paper.

Conclusion

Developing a test bed for an emerging technology is a time consuming and intensive process requiring flexible project management and strong technical understanding of the technology. Successful management needed to be focused on the big aims while maintaining options on how to deliver those aims. Stage 1 of the CITI project has managed to navigate some significant issues while keeping true to the aims of developing a DSRC test bed. The project team is looking forward to the completion of Stage 1, of having equipped vehicles on the road and trialling the technology, and moving on to expansion of the trial in the future.

References

IEEE (2010a). Draft Standard for Information Technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 6: Wireless Access in Vehicular Environments. IEEE P802.11p/D11.0.

IEEE (2010b). IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services. *IEEE Standard 1609.3-2010.*

Young, K., & Lenné, M. (2013a) *Cooperative Intelligent Transport Systems (CITS): Targeted Literature Review and Human Machine Interface Guidelines Development*, Unpublished manuscript, Monash University Accident Research Centre

Young, K., & Lenné, M. (2013b) *Cooperative Intelligent Transport Systems (CITS): HMI Assessment of Proposed Warnings and Messages*, Unpublished manuscript, Monash University Accident Research Centre

Wall, J. P. (2013). The CITI Project: Building Australia's first Cooperative Intelligent Transport System test facility for safety applications, *Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference*, Brisbane, Queensland