COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS

LEVEL CROSSING SAFETY

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Advanced INFORMATION & COMMUNICATIONS TECHNOLOGIES used to enhance safety, improve mobility, support commerce, and help sustain the environment

Addressing multi-modal

- Transport Safety
- Transport Productivity
- Travel Reliability
- Health & Safety
- Environmental Performance
- Informed Travel Choices
- Social Equity
- Network Operation & Resilience
- etc.

What is Cooperative Intelligent Transport Systems?
COOPERATIVE MOBILITY CONCEPT

- Anticipating by communication
  - Efficient use of roads during heavy traffic
  - Information on road conditions and traffic flow
  - Information on behaviour of other road users

- Supported by cooperative technology
  - Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication
  - Real-time personal warning and advising
CO-OPERATIVE INTELLIGENT TRANSPORT SYSTEMS TO IMPROVE SAFETY AT LEVEL CROSSINGS
### Level Crossing Collisions in Australia (2000 – 2009)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Public road</th>
<th></th>
<th>Private road</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Active control</td>
<td>Passive control</td>
<td>Active control</td>
<td>Passive control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of collisions</td>
<td>356</td>
<td>248</td>
<td>27</td>
<td>64</td>
<td></td>
<td>695</td>
</tr>
<tr>
<td>Number of people fatally injured</td>
<td>58</td>
<td>35</td>
<td>0</td>
<td>4</td>
<td></td>
<td>97</td>
</tr>
</tbody>
</table>

- Over 70 fatalities (1997 – 2002)

Source: ITSR
NEED FOR A COMPREHENSIVE SOLUTION

- Causes include
  - lack of awareness of an on-coming train
  - unintended road user error
  - driver behaviour and other human factors

- Aust. Government Recommendations
  - **State Government (Dec 2008)**
    - Adopt new developing technologies such as ITS
    - Govt. to coordinate support to develop, trial and adopt ITS
    - Trial, promote/encourage use of ITS at rail-road interface
  - **Federal Government (June 2009)**
    - Gov. to support ITS research to speed the implementation
    - Research into feasibility of cut-in warning systems

Lismore 2006: Tipper truck/Freight train collision (est. cost upwards of $13.5 million)

Ban Springs 2006: Trailer road train/Passenger train collision (cause driver behaviour and large heavy road vehicles start/stop time)
Vehicle safety research is shifting its focus towards crash avoidance and collision mitigation.

Traditional sensors, like radars, have the following limitations:
- Limited range (sense immediate vehicles)
- Limited Field of View (FOV)
- Expensive

Cooperative Intelligent Transport Systems using wireless comm. (DSRC) for vehicle safety, mobility and commercial apps.

“360 Degrees Driver Situation Awareness” using wireless comm.
Vehicle-to-Vehicle Communications
Vehicle-to-Infrastructure Communications
Human-Machine Interface (human factors)

Safety
- Intersection collision avoidance
- Cooperative collision warning
- Traffic signal interface

Mobility
- Traffic congestion management
- Traffic signal control and management
- Incident management

Consumer & Commercial
- Electronic payment
- Fleet management
**Safety**
- Intersection collision avoidance
- **Cooperative collision warning**
- Traffic signal interface

**Mobility**
- Traffic Congestion Management
- Incident Management
- in-vehicle signage/messaging
- Traffic signal control & management

**Consumer & Commercial**
- Electronic payment
- Fleet management
- Information transfer

**Technology: DSRC**
- Vehicle-to-Vehicle (V2V)
- Vehicle-to-Infrastructure (V2I)
- Multi-hop

**Human Factors/Behavior**
CONCEPT OF THE SAFETY SOLUTION

Intelligent Transport Systems using 5.9 GHz DSRC Technology

Scenario: Vehicle approaching a level crossing
ESSE Framework (Linux 2.6.18 - Centos, x86_64 Architecture)

HPC Messaging Library
Open MPI (with InfiniBand Support and Gigabit Ethernet)

Parallel Computing Cluster

Simulation/Scene Builder Setup
“Drag Drop” Entity Selection (Vehicle/Driver/Map)
Configurable Parameters
Visualisation/Animation
Design of Experiments (DoE)

Simulator Elements
XML Configuration Parser
Routing/Congestion Algorithms
Global Positioning System (GPS)
Mechanical Solver (Vehicles)
Behavioral Models (Drivers)
Following Model (Vehicles)
DSRC PHY/MAC
DSRC Context Perception
HMI Messaging

ESSE Framework
(Linux 2.6.18 - Centos, x86_64 Architecture)

Hardware Platform

Extensible Configuration Files
- Scene (Map)
- Vehicle Characteristics
- Driver Characteristics
- HMI Messages
- DSRC Radio (PHY)
- DSRC MAC
- GPS etc.

Simulation/Simulator Configuration

Simulator Software

Exchange Information
Traced Statistics
Configuration Data
SIMULATION PLATFORM

Simulation/Scene Setup Toolbox
Simulation Object Panel
Simulation Object Configuration
Train Model
Level Crossing Signal Model
DSRC Range Circle
DSRC Equipped Vehicle
Destination/Path Markers

Vehicle Configuration

Vehicle Properties
- start_time: 4
- is_path_finder: true
- is_dsrc_on: true
- num_dsrc_units: 1
- initial_speed: 2
- model: PM
- mass_module: 6000.00
- mass_load: 2000.00
- service_braking: 1.2
- max_power: 500000
- rpm: 6000
- wheel_radius: 0.34
- gear_ratios: 3.6;3.0;2.4;1.8;1.2;0.5
- gear_speeds: 20;30;40;70;90;120
- differential_gear: 4
- engine_brake: 3.85
**SYSTEM IMPLEMENTATION**

**DSRC Functionality**
- CCH Operation (max higher power for RSU and Train)
- T2V and T2I-I2V for train messaging
- V2V BSM send on sync (network performance)

**Mapping & Context Perception**
- Auto-positioning and map interpolation
- Context perception for Head/Tail detection and trajectory estimation (V2V/V2I)
- Intelligent remote dead-reckoning
- Crossing safety detection

**Warning algorithm**
- Train critical position detection
- Intersection collision time calculation
- Extended NHTSA Collision Avoidance algorithm

**System Software**
- Logging events and packet information
- System error auto-detection and recovery functions
Staged intelligent warnings (direct path)
- First warning: presence of train on current path
- Higher levels: triggered through algorithm calculations (NHTSA + presentation time, reaction time, safety margins)
- Combination of audio and video to produce perceptual cascading effect
- Volume of sound and intrusiveness of visual alert increase with level of urgency

Staged intelligent warnings (in-direct path)
- Higher level audio-visual alerts are only triggered as driver enters a direct path to the level crossing
- All alerts extinguish as soon as vehicle has cleared the crossing or is heading away from crossing
FIELD TRIAL SITE
HIGHETT (METROPOLITAN MELBOURNE)

- LOS NLOS radio propagation in city area
- Heavy channel congestion and interference
- Radio fading and path loss in high-building area
- Level-crossing warning threshold in city area
- Complex indirect path operations
- Heavy-traffic and complex road driving habits
- Driving habits at highly controlled crossing
DIRECT APPROACH

Perpendicular Approach
## Factors Affecting Connectivity at Trial Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Street</th>
<th>&gt; 90%</th>
<th>50%</th>
<th>&lt; 10%</th>
<th>Building Density</th>
<th>Terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dingee</td>
<td>Dingee Rd</td>
<td>0-200m</td>
<td>700m</td>
<td>&gt;1050m</td>
<td>Low</td>
<td>Flat</td>
</tr>
<tr>
<td></td>
<td>Queen St</td>
<td>0-250m</td>
<td>1050m</td>
<td>&gt;1700m</td>
<td>Low</td>
<td>Flat</td>
</tr>
<tr>
<td></td>
<td>King St</td>
<td>0-200m</td>
<td>600m</td>
<td>&gt;700m</td>
<td>Low</td>
<td>Flat</td>
</tr>
<tr>
<td>Highett</td>
<td>Highett Rd (West)</td>
<td>0-210m</td>
<td>380m</td>
<td>&gt;410m</td>
<td>Medium</td>
<td>Lower than RSU</td>
</tr>
<tr>
<td></td>
<td>Highett Rd (East)</td>
<td>0-100m</td>
<td>150m</td>
<td>&gt;220m</td>
<td>High</td>
<td>Flat</td>
</tr>
<tr>
<td></td>
<td>Railway Parade</td>
<td>0-110m</td>
<td>130m</td>
<td>&gt;170m</td>
<td>Medium</td>
<td>Flat</td>
</tr>
<tr>
<td></td>
<td>Graham Rd</td>
<td>0-220m</td>
<td>320m</td>
<td>NA</td>
<td>Medium</td>
<td>Flat</td>
</tr>
<tr>
<td>Cheltenham</td>
<td>Park Rd (West)</td>
<td>0-130m</td>
<td>180m</td>
<td>&gt;240m</td>
<td>Medium</td>
<td>Much Higher than RSU</td>
</tr>
<tr>
<td></td>
<td>Park Rd (East)</td>
<td>0-360m</td>
<td>NA</td>
<td>NA</td>
<td>High</td>
<td>Flat</td>
</tr>
</tbody>
</table>

- Connectivity at **urban sites** (Highett and Cheltenham) is significantly different from that of the **rural site** (Dingee).
- **LOS** quality is clearly the **primary factor** that affects the connectivity.
- **Building density** and **terrain** also notably affect the connectivity.
**Participant self-reports of Startled**

- **Percentage (%):**
  - Rural trial: Blue bars
  - Urban trial 1: Red bars
  - Urban trial 2: Brown bars
  - Generic trial: Green bars

- **Driver Responses:**
  - Startled: Bars showing percentage for each trial type.
  - Not Startled: Bars showing percentage for each trial type.

**Participant self-reports of Distraction**

- **Percentage (%):**
  - Rural trial: Blue bars
  - Urban trial 1: Red bars
  - Urban trial 2: Brown bars
  - Generic trial: Green bars

- **Driver Responses:**
  - Distracted: Bars showing percentage for each trial type.
  - Not Distracted: Bars showing percentage for each trial type.
LARGE SCALE DEPLOYMENT TRIAL

- Two trials sites in remote Townsville, Queensland: Manton Quarry Road, Calcium and GroMac Quarry Access Road, Broughton
- Trial period: 6 months 2013/2014
- Freight trains and heavy vehicles
TRAM NETWORK

- Ongoing interest in improving safety record and reduction of tram-to-tram and tram-to-road vehicles/pedestrian collisions

- Commercial & safety benefits
  - Reduce accident rates and tram repair costs of franchise:
    - Reduced tram to tram accidents
    - Reduced tram to road vehicle accidents as the road fleet commences utilising the DSRC capability
    - Reduced tram to pedestrian accidents

- Operational applications
  - Speed restrictions, forced stops, other
TRAM SAFETY POSSIBLE TRIAL SCENARIO
BOURKE - SPENCER STREET

- Possible Trial sites
  - Bourke-Spencer
  - Swanston-Flinders

- Collision Avoidance
  - Tram-to-Tram
  - Tram-to-Vehicle
  - Tram-to-Pedestrian
  - Speed restrictions
  - etc.

- Modelling
  - Environment
  - Trams
  - Communication Channel
  - T2T, T2V, T2I, etc
  - HMI

- HMI – Safety messaging

Warning: Safe headway distance is 15 meters.
DEMONSTRATION AND LAUNCH VIDEO
Thank you

Centre for Technology Infusion

“Bringing ideas to Life”

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