COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS

LEVEL CROSSING SAFETY VISIONARY PROJECT

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MOTIVATION

- Majority of human population live in cities – urbanisation
- More than 60 metropolitan with population > 5million
  - Many will be driving cars, and the products they consume will be arriving in trucks – making gridlock the norm.
- What might the future hold?
  - Transportation infrastructure and management approaches can't handle the world's traffic.
  - In Australia, the latest estimates put the cost of time spent sitting in traffic at $11.1 billion annually
  - In USA ~2.8b gallons of gas wasted sitting in traffic costing ~$83b

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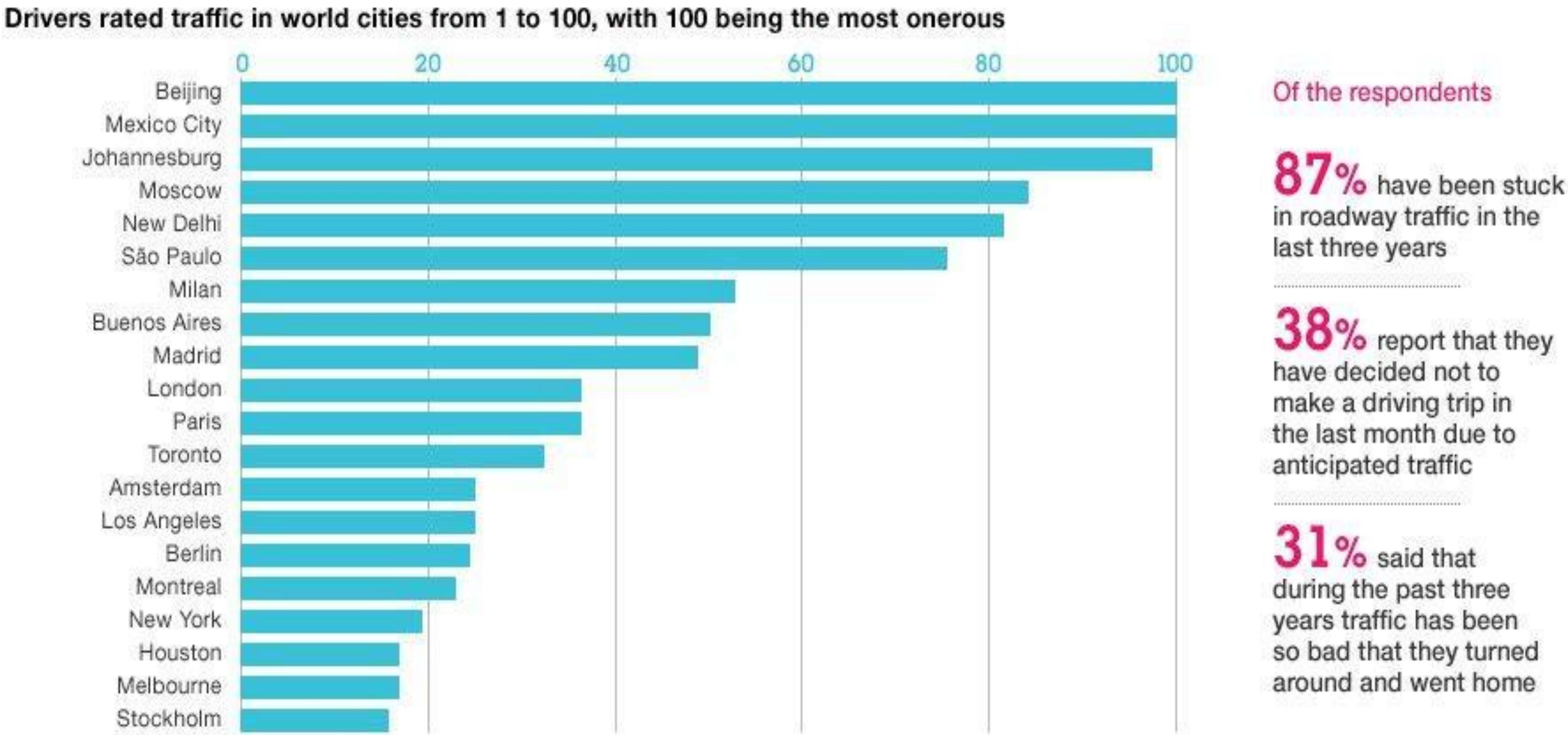
MOTIVATION

- **Traffic congestion is a major cause of lost productivity**
  - In Australia avoidable productivity cost of congestion of $9.4b in 2005 rising to $20.4b in 2020
- **Traffic congestion is a major cause of pollution**.
  - Land transport pollution accounts for around 13% of Australian Green House Gas emissions (National Greenhouse Accounts).
- **Safety**
  - In Australia - annual national road toll is around 1,300 deaths and 32,500 serious injuries.
  - Approximately 40,000 people are killed each year and ~1.7 million with critical injuries in Europe
  - Annual cost related to traffic accidents total roughly US$1 trillion

EMOTIONAL & ECONOMIC TOLL OF COMMUTING



- Beijing, Mexico City, Moscow, New Delhi – very high economic & emotional toll than most of the Western world cities

Source: IBM

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What Can We Do?

- **Public transport**: extension and improvement of public transport networks, parking space management, city logistics, low-speed zones, etc.
- **Traffic management:** integrated computer based control systems, traffic safety
- **Zero emission vehicles:** electrical vehicles
- **Air quality and noise pollution:** Usage of traffic management solutions in connection with air monitoring networks to improve air quality and noise abatement
- **Logistics:** Application of ICT solutions to freight traffic to reduce pollution and congestion, optimize delivery times and limit transport costs
- **Urban planning:** Monitoring of flows and planning of building and activities (e.g. malls, public buildings, etc.) in order to prevent congestion, reduce traffic and facilitate the use of public transport
- **Smart Grids:** Connection between energy networks and transport networks to ensure availability of alternate fuels, pollution control, etc.
- **Communication Tools:** innovative communication tools to improve ridership on public transport, traffic, etc.

WAY FORWARD

Better use of existing Road capacity

“Cooperative Intelligent Transport Systems”

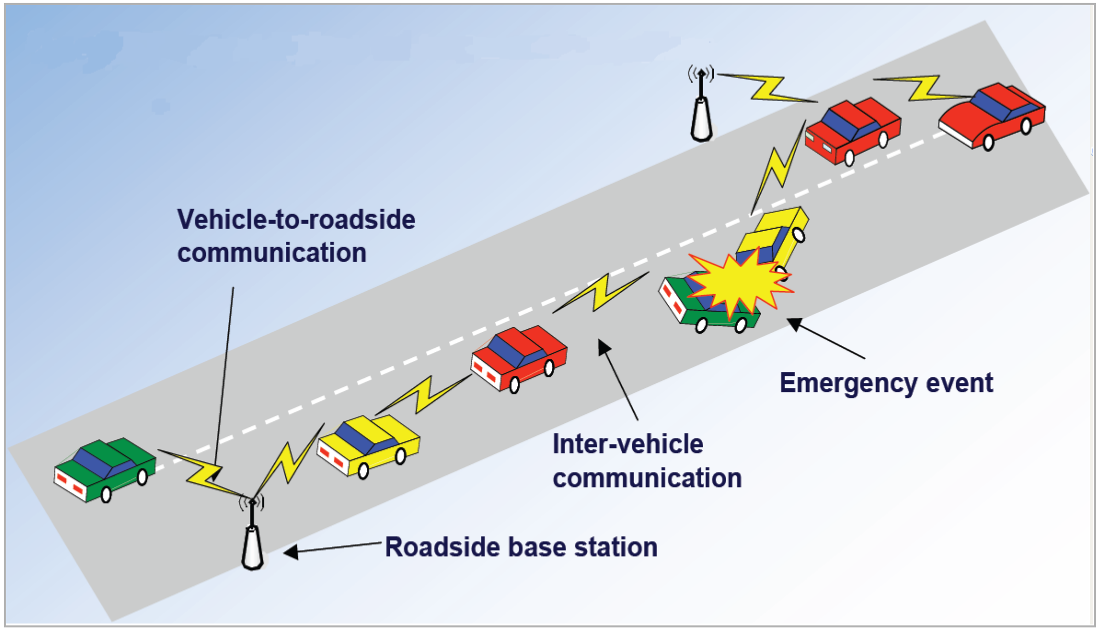
COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS

What is Cooperative Intelligent Transport Systems?

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.



COOPERATIVE MOBILITY CONCEPT

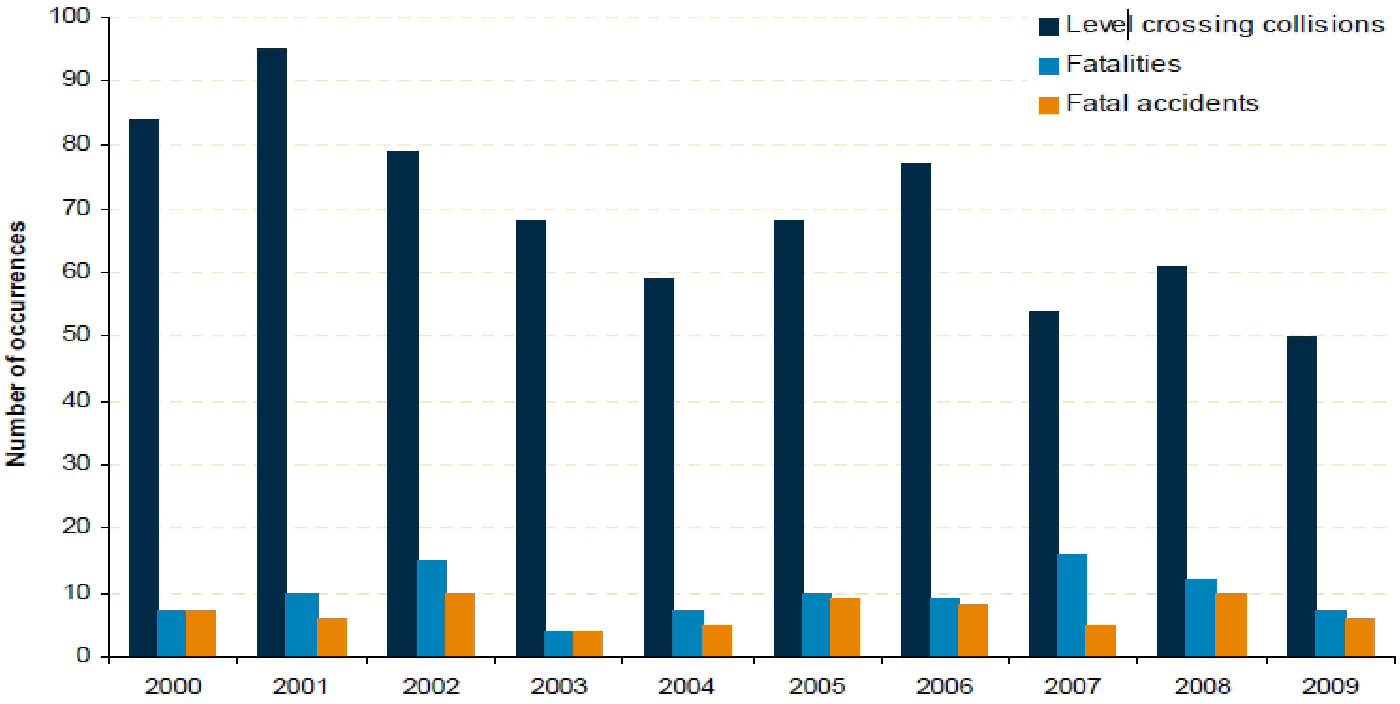
- Anticipating by communication
  - Efficient use of roads during heavy traffic
  - Information on road conditions and traffic flow
  - Information on behaviour of other road users
- Supported by cooperative technology
  - Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication
  - Real-time personal warning and advising

CO-OPERATIVE INTELLIGENT TRANSPORT SYSTEMS TO IMPROVE SAFETY AT LEVEL CROSSINGS

LEVEL CROSSING COLLISIONS IN AUSTRALIA (2000 – 2009)

Statistic	Public road		Private road		Total
	Active control	Passive control	Active control	Passive control	
Number of collisions	356	248	27	64	695
Number of people fatally injured	58	35	0	4	97

- **Over 70 fatalities (1997 – 2002)**



Source: ITSR

DEATH AND INJURY BY CATEGORY EUROPE (2011)

	Number of persons											
	Killed				Seriously Injured				Total			
	Passengers	Employees	Other	Total	Passengers	Employees	Other	Total	Passengers	Employees	Other	Total
Collisions	9	3	3	15	33	11	5	49	42	14	8	64
Derailments	2	2	0	4	43	2	0	45	45	4	0	49
Accidents involving level-crossings	6	0	311	317	24	14	291	329	30	14	602	646
Accidents to persons caused by rolling stock in motion	22	25	856	903	123	36	453	612	145	61	1 309	1 515
Fires in rolling stock	0	0	0	0	0	0	0	0	0	0	0	0
Others	0	1	2	3	6	20	22	48	6	21	24	51
Total	39	31	1 172	1 242	229	83	771	1 083	268	114	1 943	2 325

Source: Eurostat

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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)

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TECHNOLOGY:
DEDICATED SHORT RANGE COMMUNICATION (DSRC)

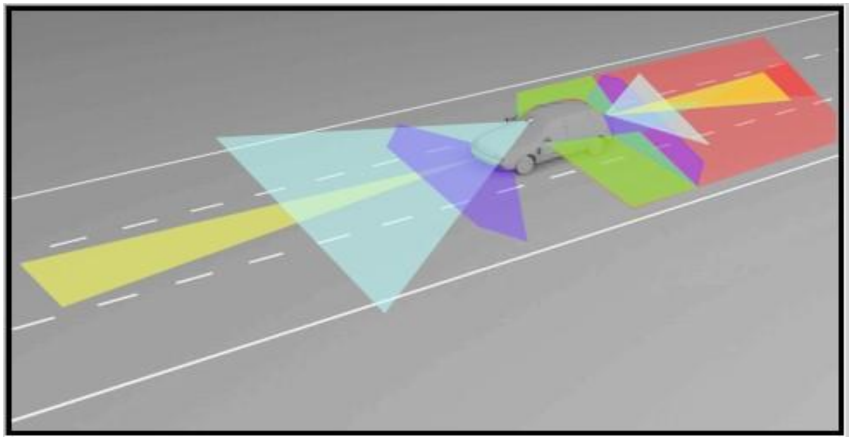
- Vehicle safety research is shifting its focus towards crash avoidance and collision mitigation

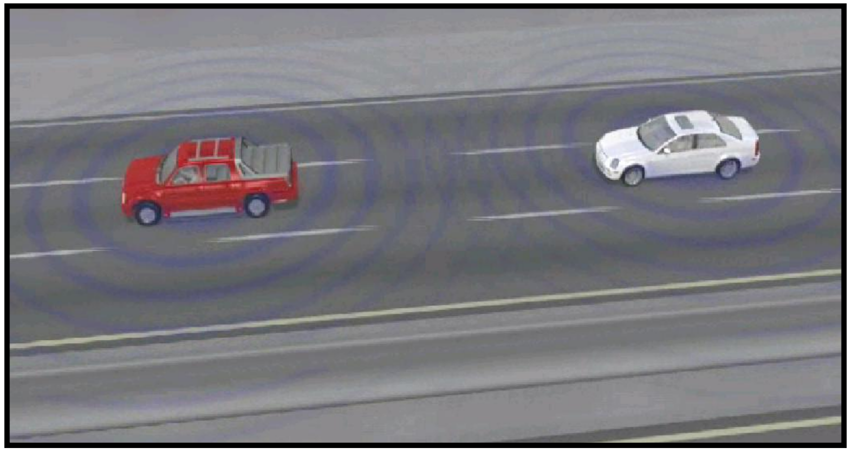
- Traditional sensors, like radars, have the following limitations:
  - Limited range (sense immediate vehicles)
  - Limited Field of View (FOV)
  - Expensive

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

"360 Degrees Driver Situation Awareness" using wireless comm.

TRADITIONAL SENSORS





COOPERATIVE COLLISION WARNING (CCW)

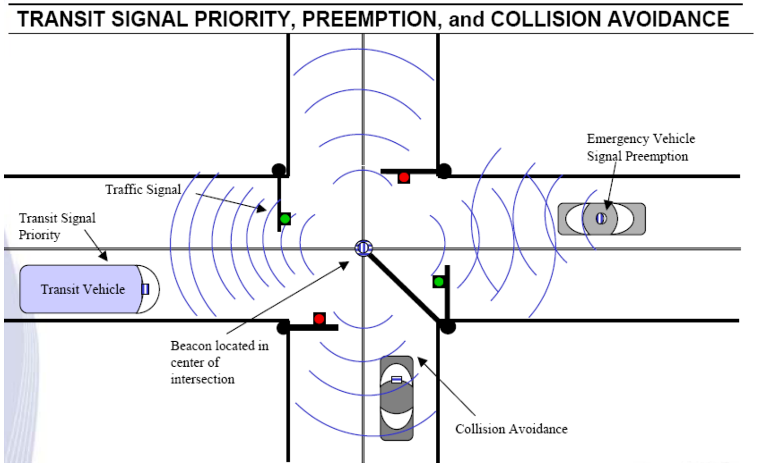
WHY DSRC ?

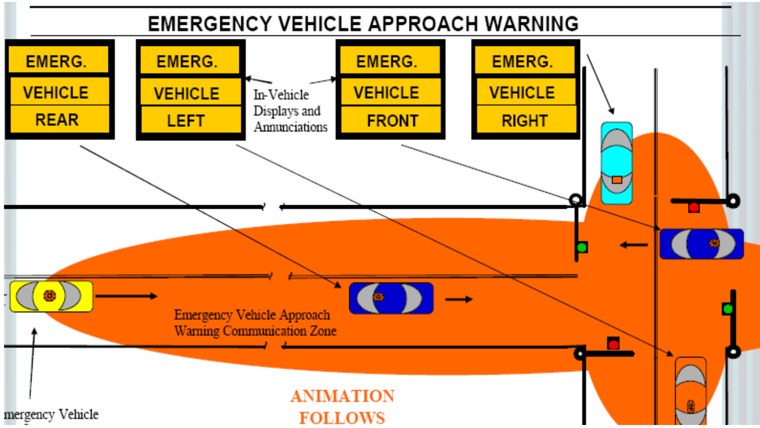
- International standard for wireless vehicular communication at 5.8/5.9 GHz
- Licensed band operation
- 7 channels (10 MHz each) for supporting safety and non-safety applications
- Outdoor high-speed vehicle applications
- Cooperative safety system
  - Passive ⇨ active
  - Reactive ⇨ preventative

COOPERATIVE INTELLIGENT TRANSPORT SYSTEMS

- 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





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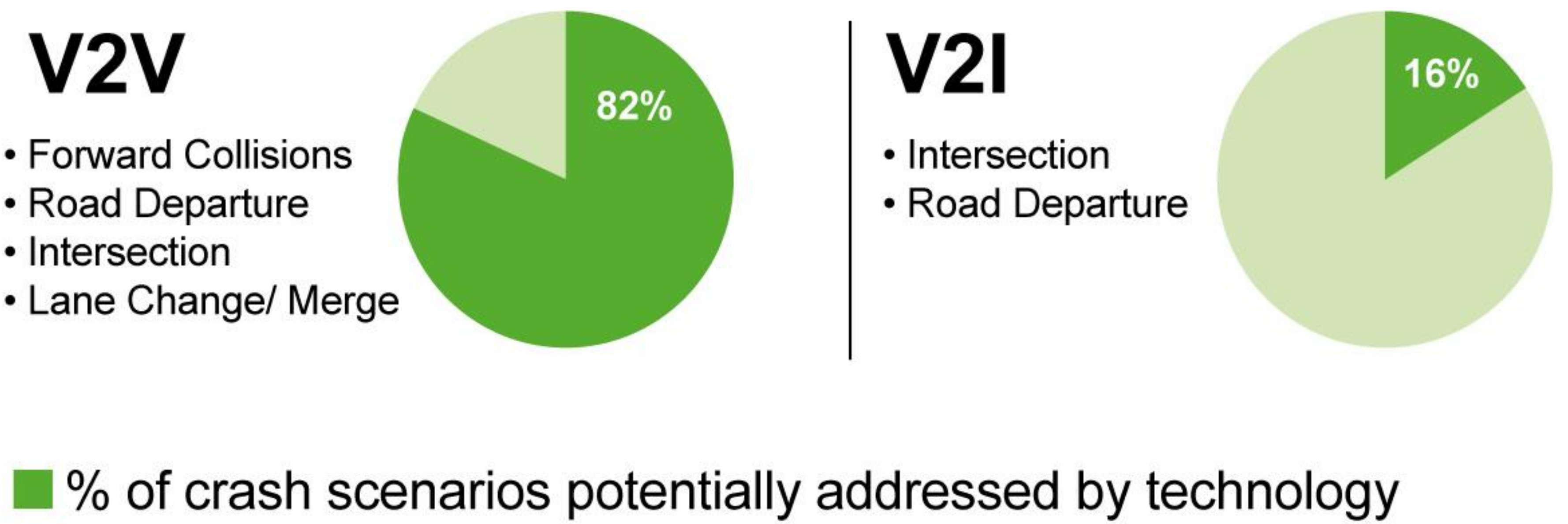
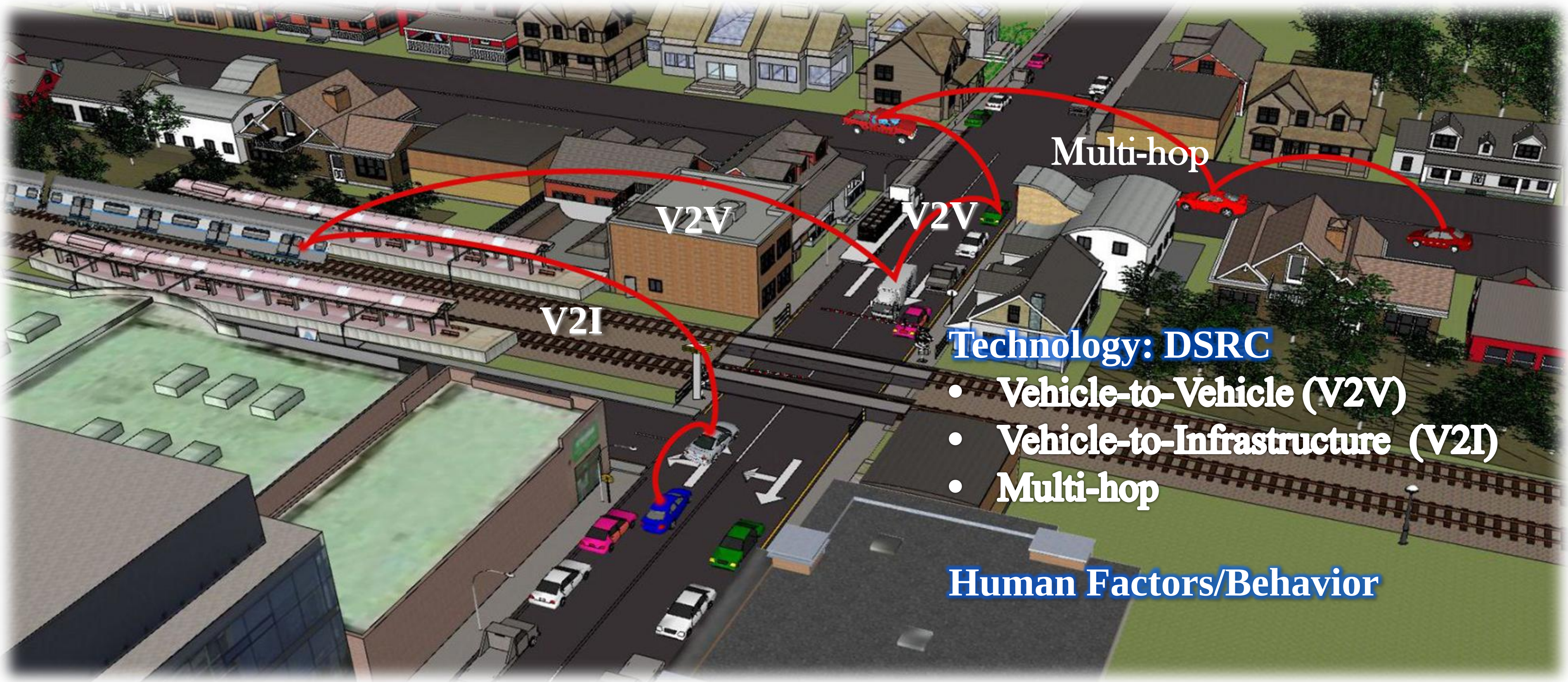
SAFETY APPLICATIONS

- Ability of V2V and V2I to address crash scenarios involving non-impaired drivers



(NHTSA Assessment)

SOLUTION



- **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

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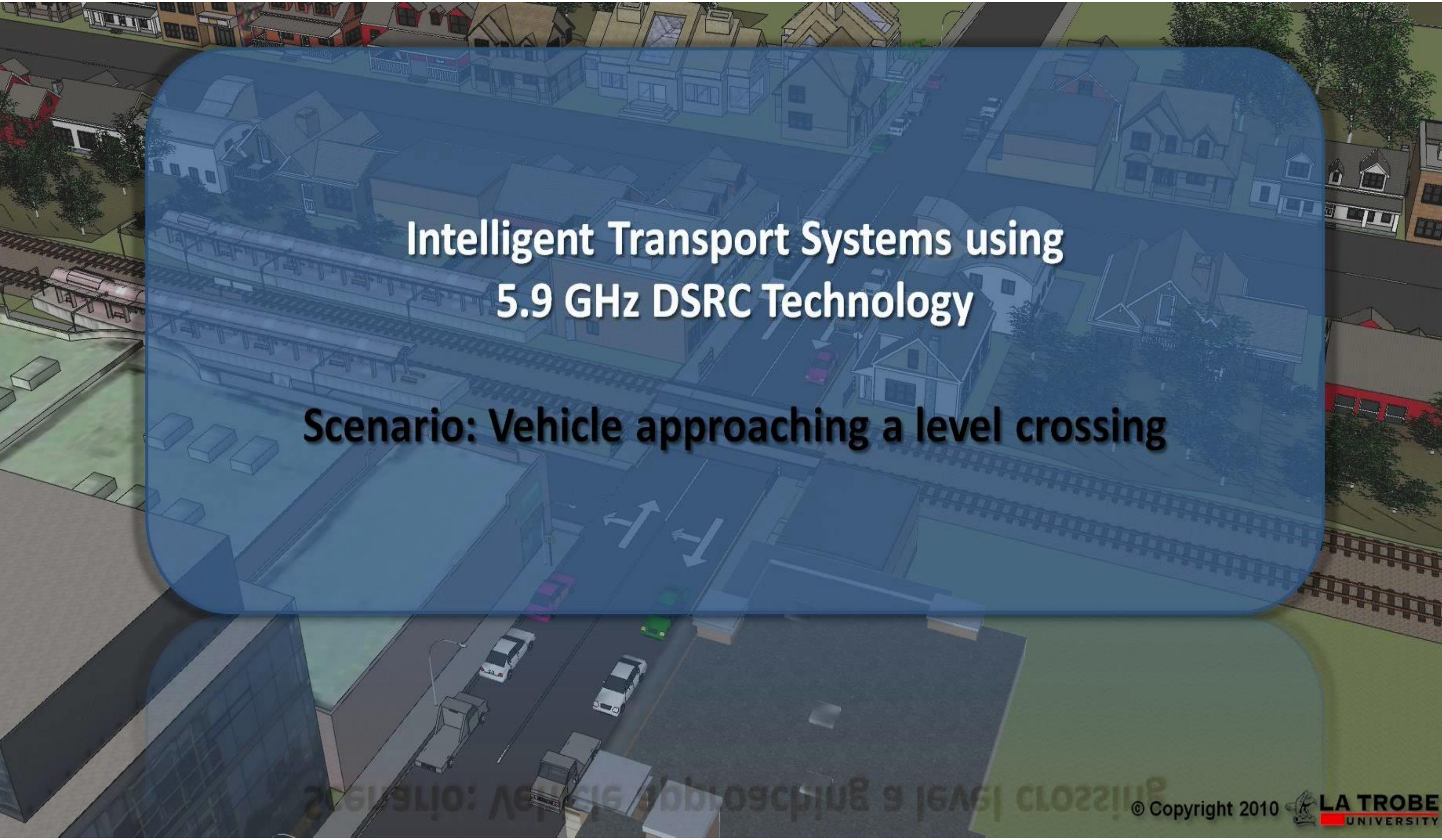
Concept of the Safety Solution



PARTNERS

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Victoria

PUBLIC TRANSPORT VICTORIA PT>

AutoCRC
Smarter Safer Cleaner

V/Line

METRO

同濟大學
TONGJI UNIVERSITY

清華大學

QUT

EST
VIDERE QUAM ESSE

VPAC

CohdaWireless
Mobile Broadband

PROJECT SCOPE

Phase 1

Development of Scalable Simulation Platform for Level Crossings

- Specialised ITS Simulation platform for Rail-road crossings
- Development/Implementation of scalable simulation models
- Empirical analysis of typical interactions between rail and road traffic

Phase 2

Development of the ITS Demonstrator System

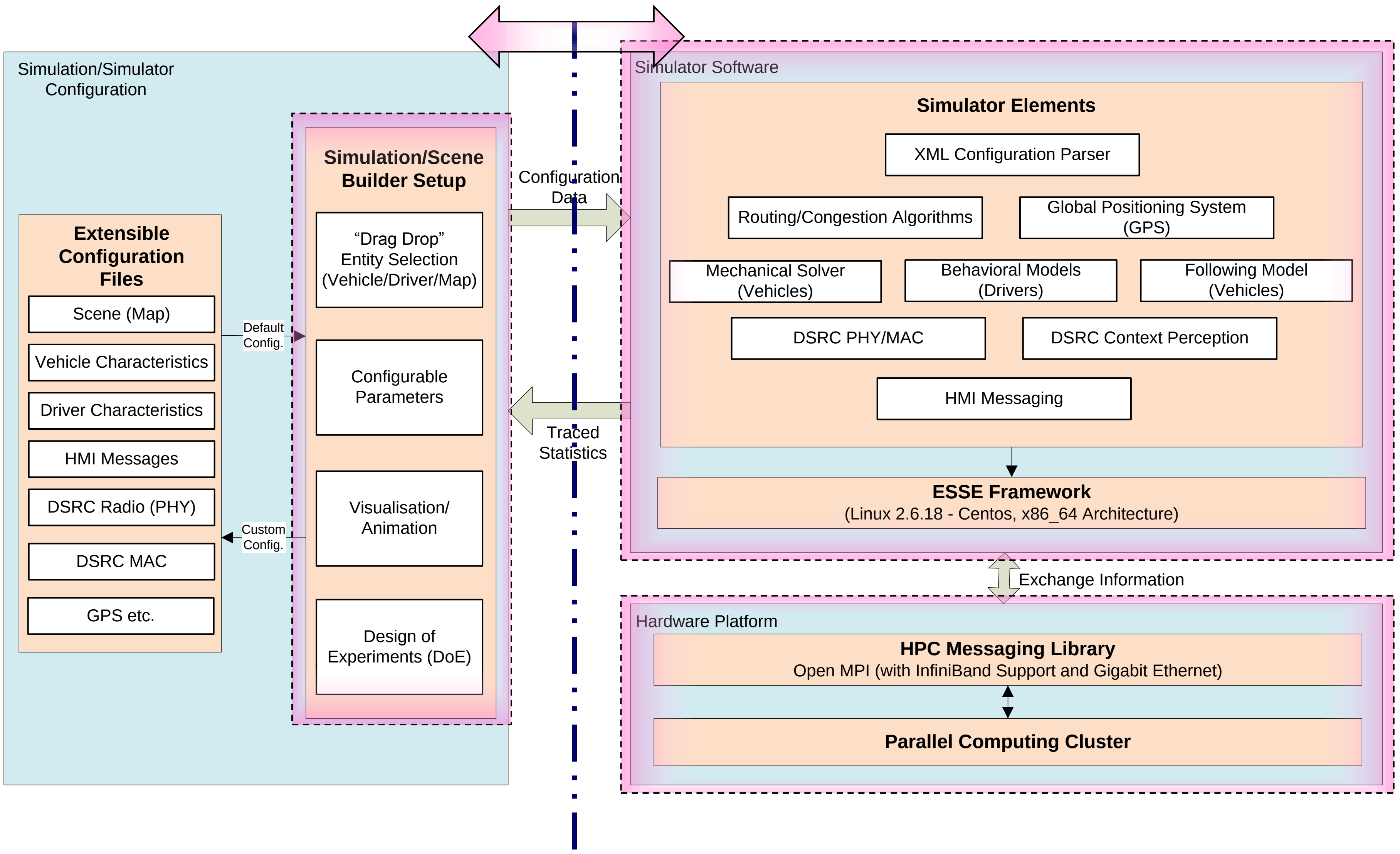
- Implementation of new algorithms for safety
- Implementation and tuning of new scalable HMI interfaces
- Testing, validation and optimisation before field trial

Phase 3

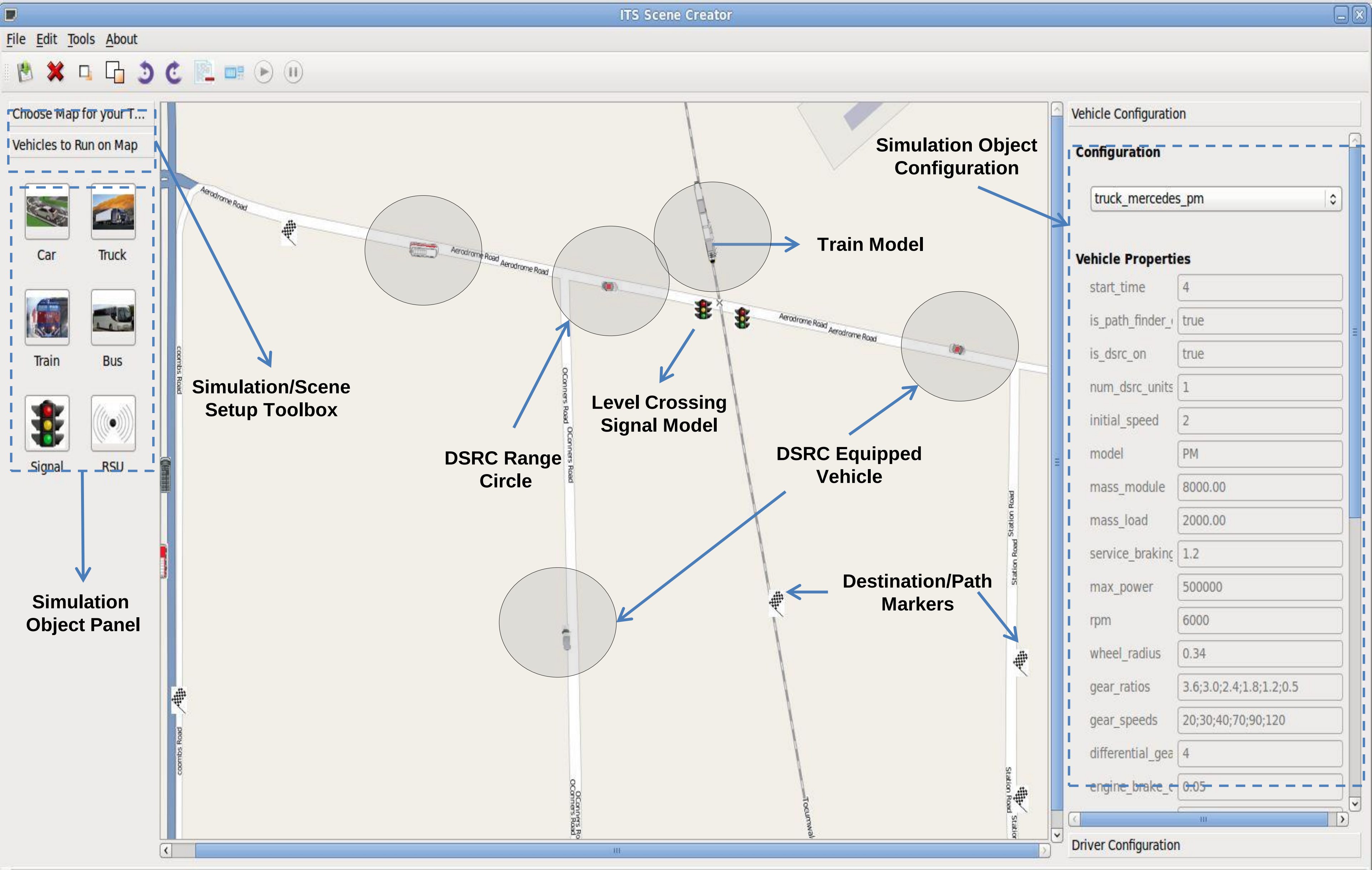
Field Trial

- Field trial with 100+ vehicles
- Installation in trains, trucks, cars and at rail-road crossings
- Data collection and analysis - refining algorithms/implementations

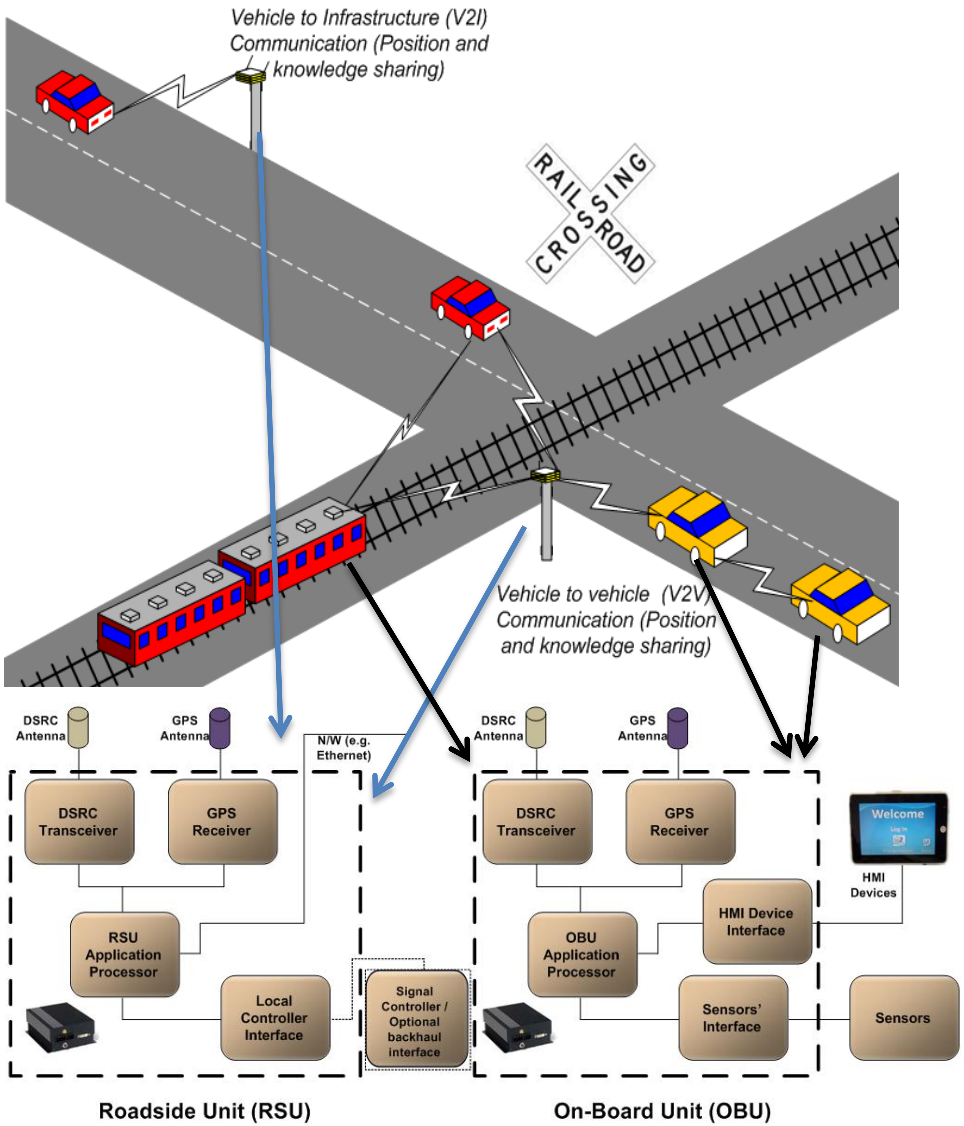
SIMULATION PLATFORM ARCHITECTURE



SIMULATION PLATFORM



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

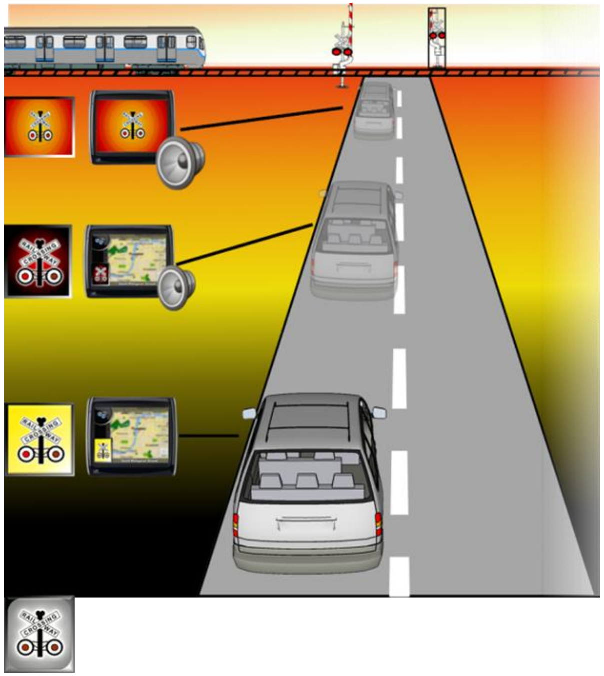
Warning algorithm

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

System Software

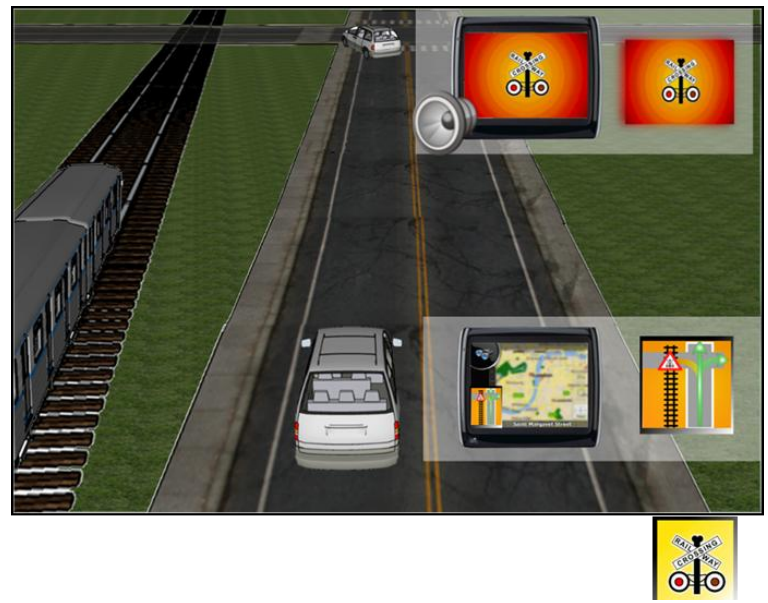
- Logging events and packet information
- System error auto-detection and recovery functions

SAFETY MESSAGING ALGORITHM AND HMI



- **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

- **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



FIELD TRIALS SCENARIOS

Orchestrated Scenarios (with different approach speeds where applicable)	Rural (7 vehicles)	Urban 1 (70 vehicles)	Urban 2 (30 vehicles)
1. Mass vehicles stationary/moving		70	
2. Road vehicles approach perpendicular to crossing	X (40-100 km/h)	X (30-60 km/h)	X (30-60 km/h)
3. Road vehicles approach parallel to crossing	X (40-100 km/h)	X (30-50 km/h)	X (30-50 km/h)
4. Road vehicles turn away from crossing (from direct or indirect approach)	X	X	X
5. Road vehicles turn in towards crossing	X	X	X
<u>Special Scenarios</u>			
- Hard deceleration on high urgency alert			X
- Obtuse approach (V2V)	X		

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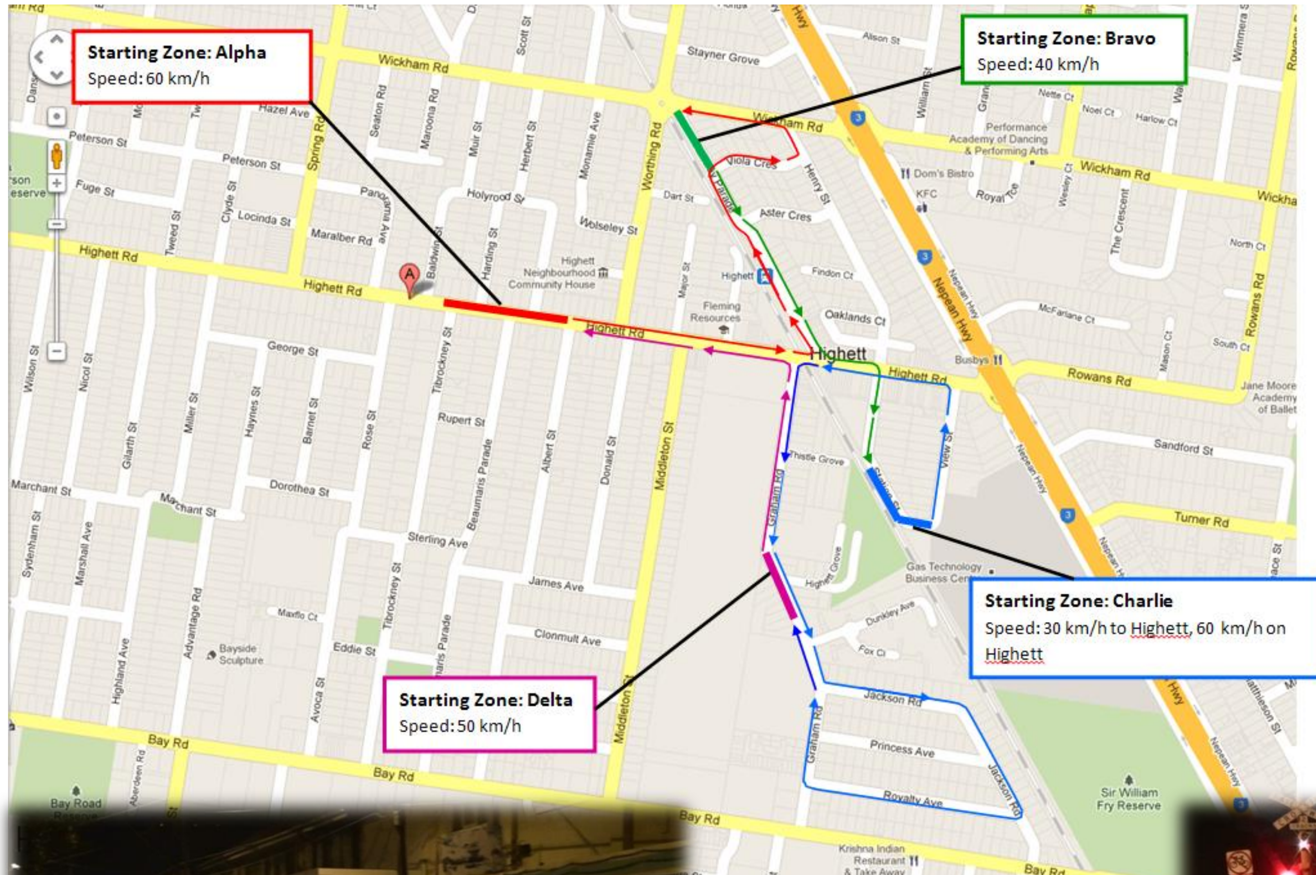
FIELD TRIAL SITE
HIGHETT (METROPOLITAN MELBOURNE)



- 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

FIELD TRIALS
RESULTS AND DATA ANALYSIS - HIGHETT

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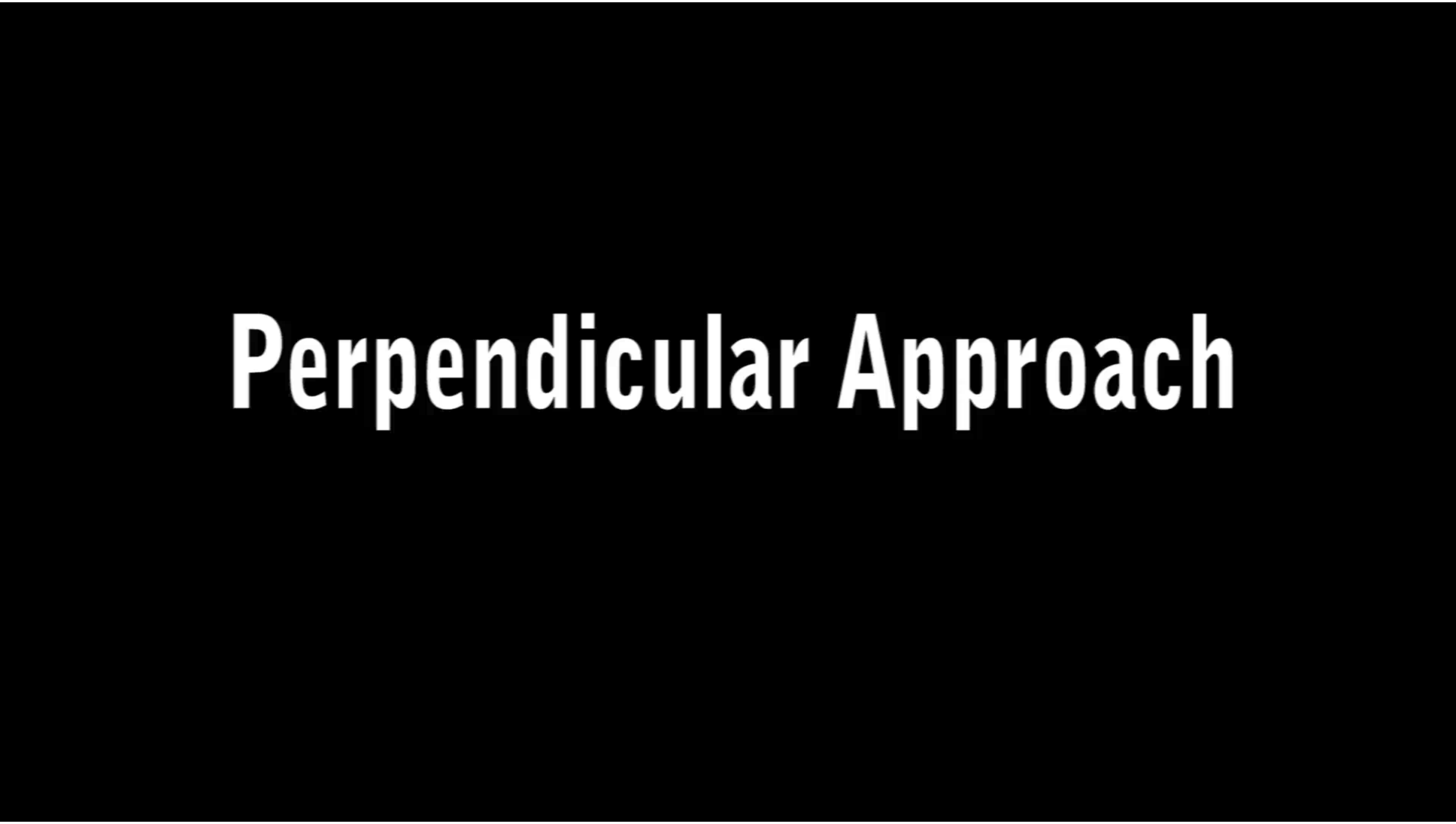
DIRECT APPROACH



HIGHETT SHOWING LOS QUALITY AND CONNECTIVITY

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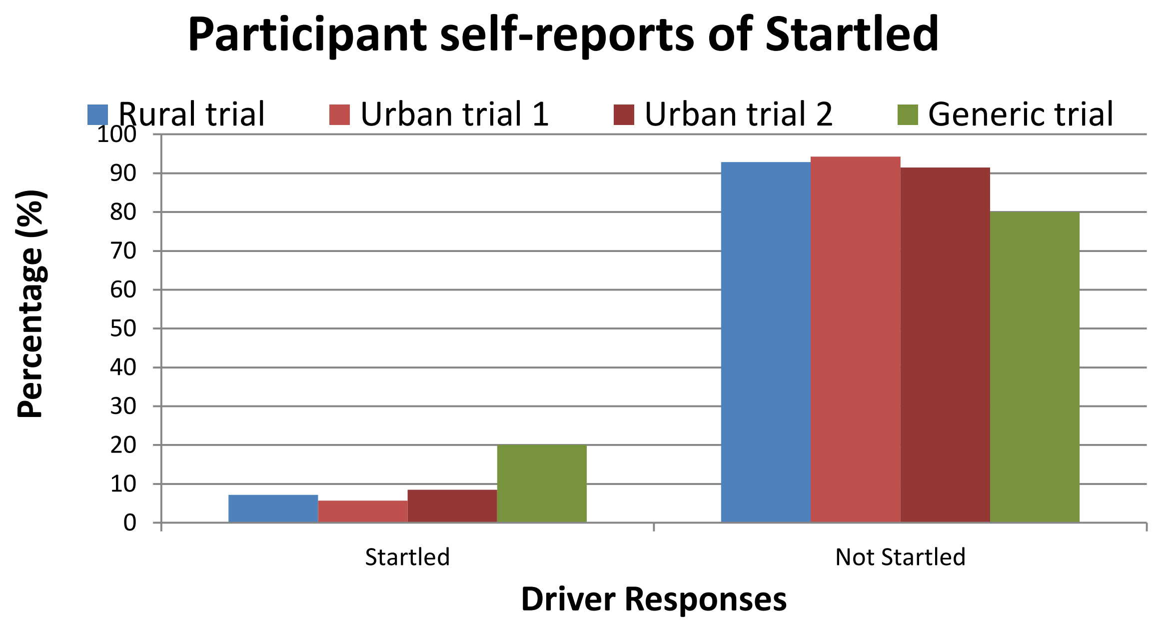
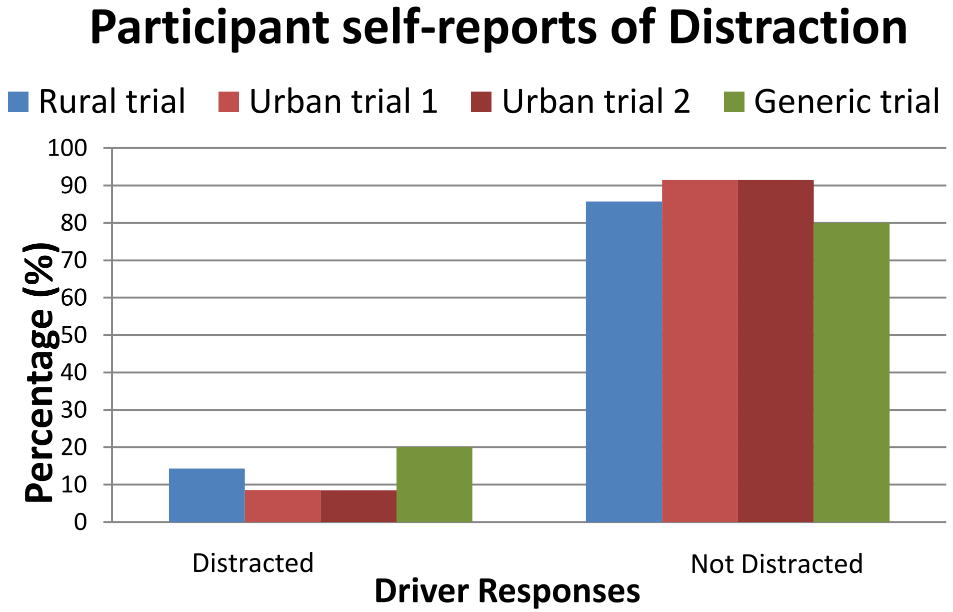
FACTORS AFFECTING CONNECTIVITY AT TRIAL SITES

		Distance to Level Crossing for connectivity levels				
Site	**Street**	**> 90%**	**50%**	**< 10%**	**Building Density**	**Terrain**
Dingee	Dingee Rd	0-200m	700m	> 1050m	Low	Flat
	Queen St	0-250m	1050m	> 1700m	Low	Flat
	King St	0-200m	600m	> 700m	Low	Flat
Highett	Highett Rd (West)	0-210m	380m	> 410m	Medium	Lower than RSU
	Highett Rd (East)	0-100m	150m	> 220m	High	Flat
	Railway Parade	0-110m	130m	> 170m	Medium	Flat
	Graham Rd	0-220m	320m	NA	Medium	Flat
Cheltenham	Park Rd (West)	0-130m	180m	> 240m	Medium	Much Higher than RSU
	Park Rd (East)	0-360m	NA	NA	High	Flat

- 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.

DRIVER FEEDBACK





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ROAD MAP AND COMMERCIALIZATION

Research

Victorian Trial

Queensland Large Scale Deployment Trial

"Smart City Test Bed" Shanghai, China

TRAM NETWORK

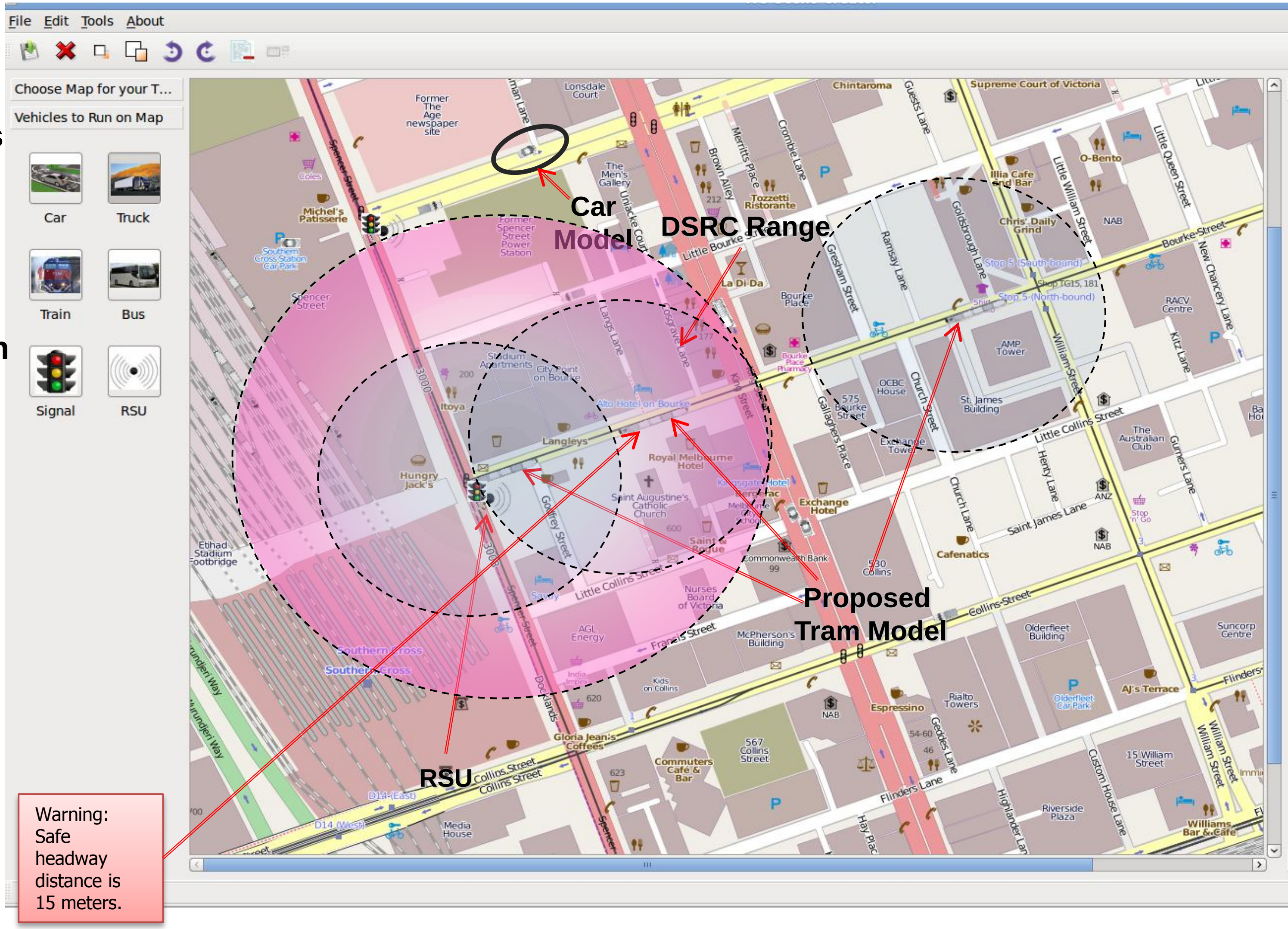
- Ongoing interest in improving safety record and reduction of tram-to-tram and tram-to-road vehicles/pedestrian collisions

- 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

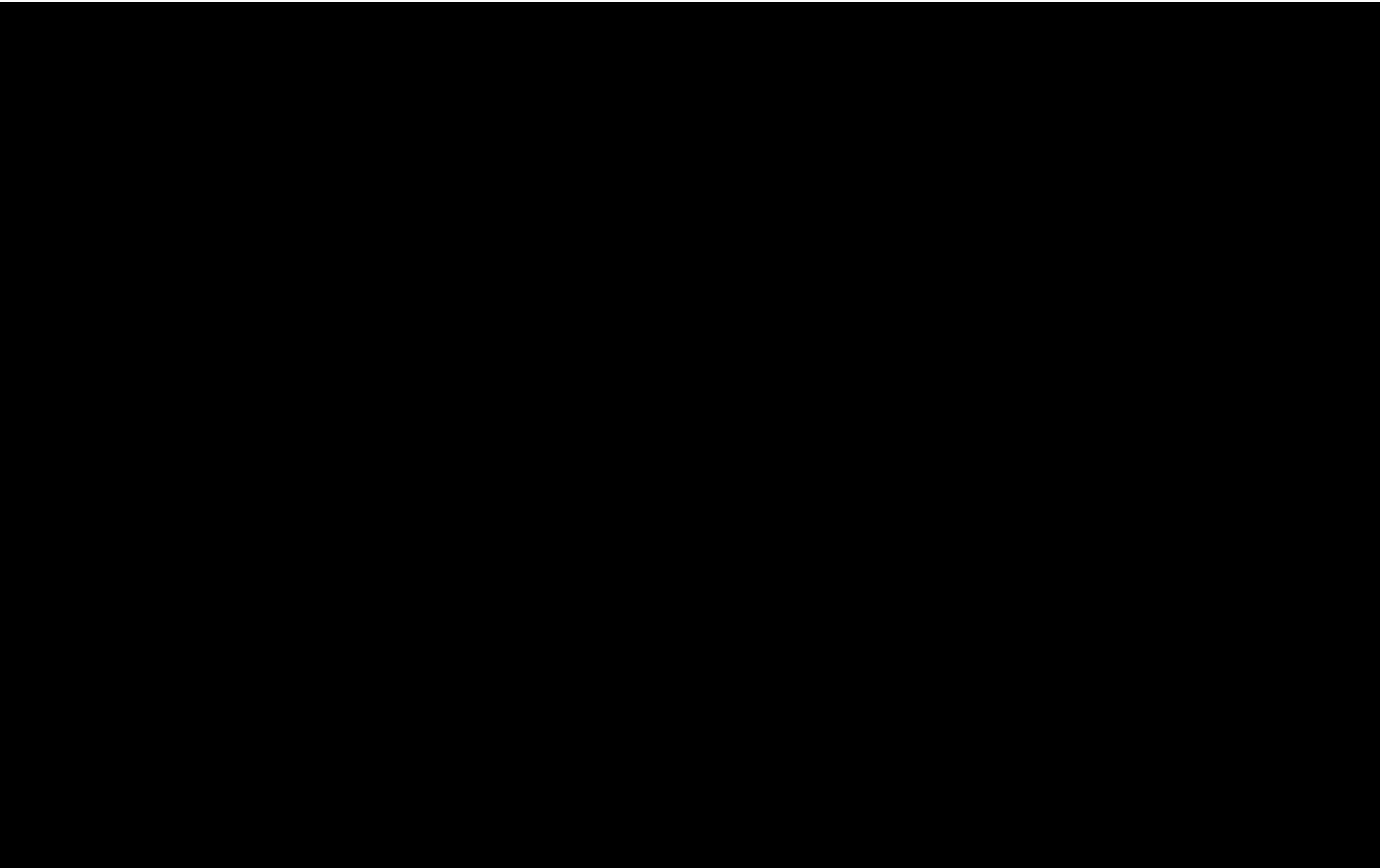
- Operational applications
  - Speed restrictions, forced stops, other

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



Demonstration and Launch Video



Thank you

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