Smarter Highways through Active Traffic Management

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Kittelson & Associates, Inc.
Transportation Engineering/Planning

My Role

- Manager of Network and Performance at Transport and Main Roads at the state level (“think Central Office”) since July
- Responsible for policy, guidelines, research and development, and the delivery of STREAMS enhancements
- Team of electrical, systems, and traffic engineers
- Smarter Roads program has been ongoing for many years – the Concept of Operations was finalized in 2008
- Kittelson has been involved in the delivery side (“think District Office”) since 2008

How it works in Queensland

- Smarter Highways are achieved through STREAMS - a traffic management system that has traditionally operated Queensland's signals.
- STREAMS analyzes real-time field data triggering a range of responses including:
  - Ramp metering
  - Reduced speed for high flow interception
  - Reduced speed into the back of a queue
  - Reduced speed for weather events
  - Incident lane and ramp control
  - Communicating travel times

Data Inputs

- Flow, occupancy and speed of traffic is collected at detectors spaced approximately every 500 meters
- Wind, rain and visibility is collected at weather detectors
- Closed Circuit Television (CCTV) and webcams feed the traffic management centers to confirm events and assist in recovery.
- Emergency phones placed at regular intervals for driver safety and assistance.

The Smarter Signs

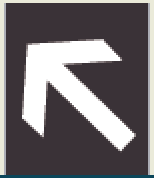
Variable speed signs

A flashing red circle indicates the speed limit has changed – drivers should smoothly adjust to the new speed. This lane is open to traffic.

Lane control

A flashing red cross indicates the lane is closing – leave the lane as soon as it is safe to do so.

A solid red cross indicates the lane is closed – do not travel in this lane.



A white arrow indicates that drivers should follow the direction of the arrow and exit the motorway using the nearest exit.

Source – Transport and Main Roads

The Smarter Signs

Ramp signaling

Traffic lights on motorway on-ramps enable safer merges and effectively manage traffic flow onto the motorway.

Blank signs

If the electronic signs are blank, drivers should comply with traditional speed limit signs displayed permanently beside the motorway.

Travel time

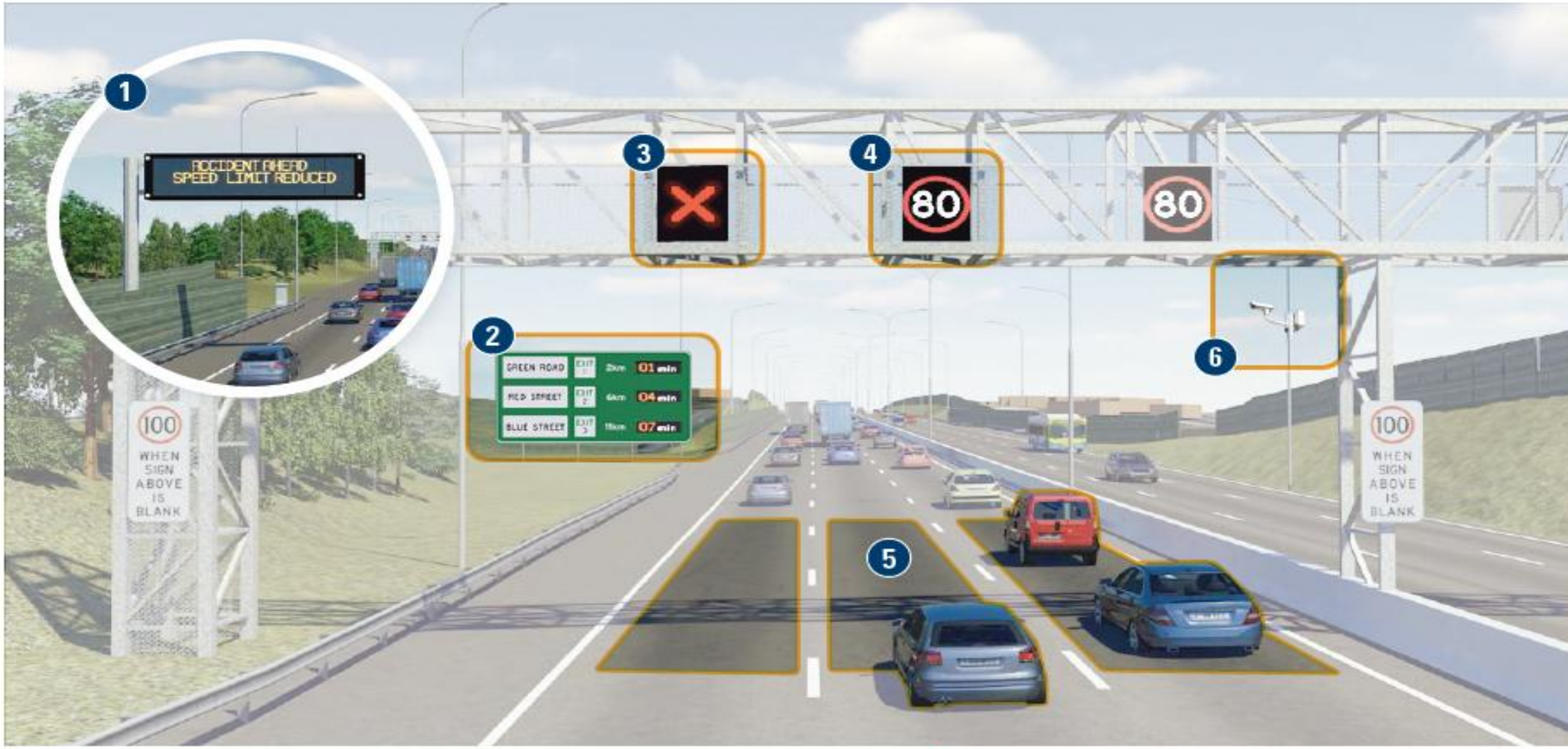
Travel Time signs will feature an additional LED panel, providing accurate travel time information to destinations and popular road exits. These signs will be accompanied by electronic message signs.

Electronic message signs

Electronic Message Signs provide real-time advice about expected travel times, warnings, alerts or information about changing road conditions.

Source – Transport and Main Roads

Gantry Mounted Sign Example



The technology behind Smarter Motorways

1. Electronic Message Sign
2. Travel Time Sign
3. Lane Control Sign
4. Variable Speed Limit Sign
5. Detectors in the road surface to monitor traffic flow
6. CCTV camera

Source – Transport and Main Roads

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Queensland's Smarter Roads

- Over the next 10 years, more than 250 km of motorways will be upgraded.

Source – Transport and Main Roads

2010		VSL	LC	RS	TT
M5 Centenary Motorway	Darra – Springfield.	✓	✓	x	x
Clem 7		✓	✓	x	x
2011					
M7 Ipswich Motorway	Goodna – Darra	✓	✓	x	x
M3 Pacific Motorway	Greenslopes – Underwood	x	x	✓	x
Houghton Highway	Ted Smout Memorial Bridge	✓	✓	x	x
M5 Western Freeway	Sumner – Richlands	✓	✓	x	x
M1 Gateway otorway	Eight Mile Plains – Nudgee	✓	✓	x	x
M1 Bruce Highway	Caboolture – Strathpine	✓	x	x	x
2012					
M1 Bruce Highway	Carseldine – Caboolture	x	x	x	✓
M3 Pacific Motorway	Beenleigh – Gaven	x	x	x	✓
M2 Ipswich Motorway	Dinmore – Goodna	✓	✓	✓	x
M5 Centenary Highway	Toowong – Sumner	✓	x	x	x
Airport Link		✓	✓	x	✓

RS = Ramp Signaling
VSL – Variable Speed Limits
LC – Lane Control
TT – Travel Time

Did you know?

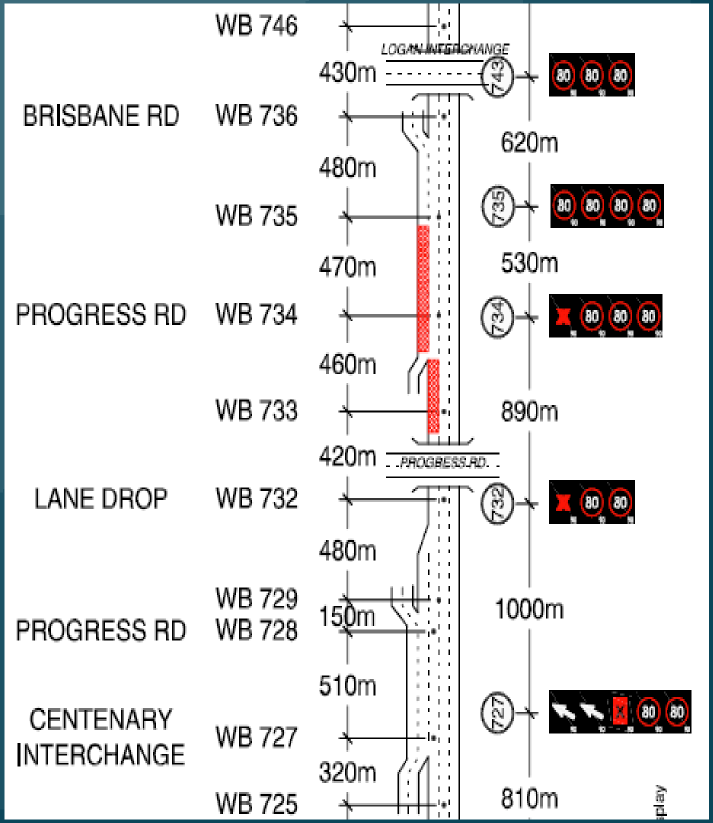
- Melbourne (VICROADS) have Ramp Metering and VSL. Following the installation:
  - Crashes reduced by 30% on the M1 in Melbourne
  - Average travel speeds increased by 25.9% from 48.9 km to 66 km/h in peak hour traffic on the M1 in Melbourne.
  - On-ramp throughput increased by 9% in peak hour traffic

What is the status of Queensland's Program

- Automated ramp-signaling active
- Manual Lane-Use Management (LUMS) active
- VMS signs in use (No travel time)
- OTHERS –
  - VSL – High-flow algorithms in STREAMS but not approved
  - Queue detection and projection, and enhanced VMS under development within STREAMS
  - Automated enforcement under development in conjunction with the Queensland Police Services and within STREAMS

LUMS in Work zones

- Kittelson assessed Lane Use Management for a work zone:
  - 95% of traffic merges prior to a solid “X” over the lane
  - Delta speeds by lane improved
  - Speed compliance similar to pre-conditions
- Traffic control too long using gantry
- “IF BLANK” sign not located appropriately for work zone access
- Guidelines drafted for work zone to TMC communication & procedures



ITS Spacing and Placement

- Lack of understanding within the delivery teams of how to optimize spacing and placement
- Civil/electrical consultants are preparing plans without traffic engineering support
- Traffic and Road Use Manual (TRUM) includes limited spacing and placement guidance

Reference	ITS	Description
TRUM 2.18	VSL Spacing, Placement	500-1200m; Ave 750m, 200-400m downstream of on-ramp
TRUM 2.9	VMS Spacing, Placement	Ave 3000m, 900-1200m upstream of the off-ramp
TRUM 5.5	Detector Spacing	500m
TRUM 2.18	VMS – VSL Spacing	200m upstream or downstream of VSL
TRUM 2.18	Static Signs near VSL	150m+ upstream or 300m+ downstream of VSL

ITS Spacing and Placement

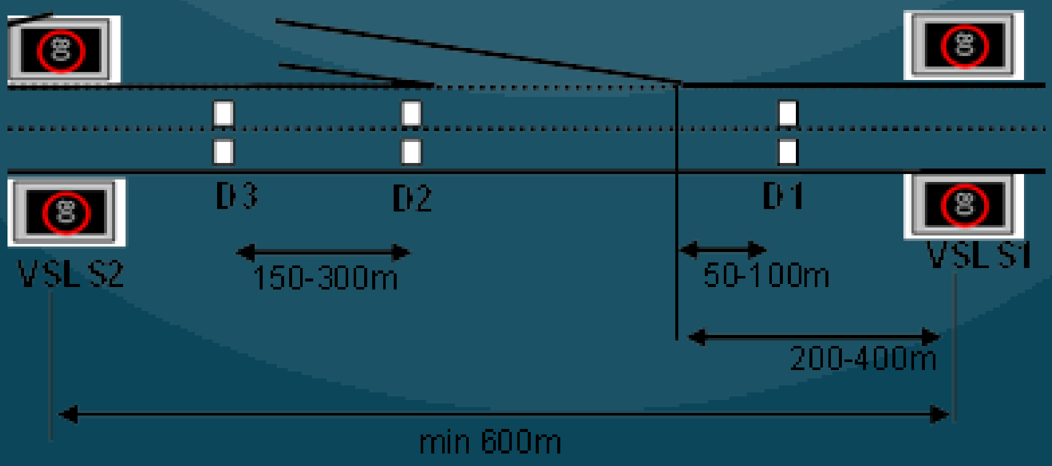
- STREAM algorithms are reliant on detector site data placed at key locations:
  - EVMS: between off-ramps;
  - High Flow - upstream & downstream of the bottlenecks;
  - Queue Detection and Protection - upstream of the bottlenecks;
  - Ramp Signalling: downstream of the on-ramp merge taper.
- VSL is based on downstream detector data, and should ideally have two detectors for data verification and redundancy.

ITS Spacing and Placement

- Interim placement guidance developed for pole mounted VSL (which does not allow for any co-location with other ITS)
  - Step 1: Traffic Analysis (locate existing and future bottleneck fronts)
  - Step 2: Locate Detector / VSL per the guidelines for:
    - Type I Bottlenecks (Merge)
    - Type II Bottlenecks (Geometric and Lane Drop)
    - Type III Bottlenecks (Weave)
    - Arterial Queue Spillover (Diverge)
    - High Crash Locations
  - Step 3: Locate Basic Section Detector / VSL (Repeaters)
  - Step 4 - 6: Locate EVMS, CCTV, Static Sign Placement
- The process is iterative - 2nd and 3rd passes needed to consider civil and electrical requirements, and the optimisation of placement with the opposite direction of travel

ITS Spacing and Placement

- Example of placement guidelines at an on-ramp
  - VSLS 1 – Resets speeds beyond bottleneck front
  - VSLS 2 – Controls speeds at merge
  - D1 – Flow discharge data for ramp-metering and high-flow
  - D2 and D3 – Queue detection and confirmation



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Data Health

- Algorithms rely on one minute data – Poor data could trigger or release algorithms
- Healthy detectors have events that can skew the data:
  - Speeds – one to two spikes in a given lane of 0 to 250 km/hr – Ave +/-5km/hr
  - Occupancy – spikes in data that results in significant minute occupancy error
  - Volume – most robust to error (+/- a couple of vehicles does not greatly impact the count)
  - Smoothing of minute data currently results in residual impacts for several future minutes

Data Health

- Healthy data observations:
  - Nortec and Excel detectors rely on one detector at the site for occupancy
  - Sensys use both detectors to confirm the reasonableness of the occupancy measure
- Unhealthy detectors:
  - STREAMS is slow at failing a detector – 15+ minutes
- Main Roads currently examining methods to reduce data issues including relationship and back-checks

Current Research Efforts - CARRSQ

- The regions want to co-locate all ITS at each gantry because:
  - Road space is limited
  - Gantries are expensive
  - Electrical and civil works can be consolidated
- How do we plan to test co-location?
  - Test Environment: CARRSQ (QUT) car simulator
  - 60 participates
  - A range of highway co-location options
  - Observation of lane and speed compliance, lane changing behavior, eye movements, task completion, and some verbal questions

Current Research Efforts - CARRSQ

- What does co-location look like (loosely….)?
- Why is co-location a concern – mix of regulatory and non-regulatory signs with driver comprehension.

- Still investigating two OR three levels of sign given the directional signage needs, gantry support, sight line.
- Other countries use much small VMS signs and can support two levels.

Some Next Steps – Algorithm Optimization

- Acceleration needs from the ramp-meter stop bar is difficult to achieve on the existing on-ramps without slower mainline speeds.
- Ramp metering algorithm is triggered at a critical occupancy (slower speeds) BUT can force ramp metering at slave ramps with free-flow mainline conditions.
- VSL and ramp-metering algorithms currently do not speak in STREAMS.
- Main Roads to investigate functionality.

Thank you

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