Specific ITS Applications:
Transit Signal Priority, Advanced Transit Traveler Information Systems, and Connected Vehicle Systems

Brendon Hemily
<brendon.hemily@sympatico.ca>

Agenda

- **Transit Signal Priority (TSP)**
  - Experience
  - Lessons Learned
- **Transit Traveler Information Systems (TTIS)**
  - Traditional
  - State of the Practice
  - State of the Art
  - Cutting Edge
  - Issues
  - Recommendations
- **The Future**
  - **Connected Vehicle Systems (IntelliDrive)**

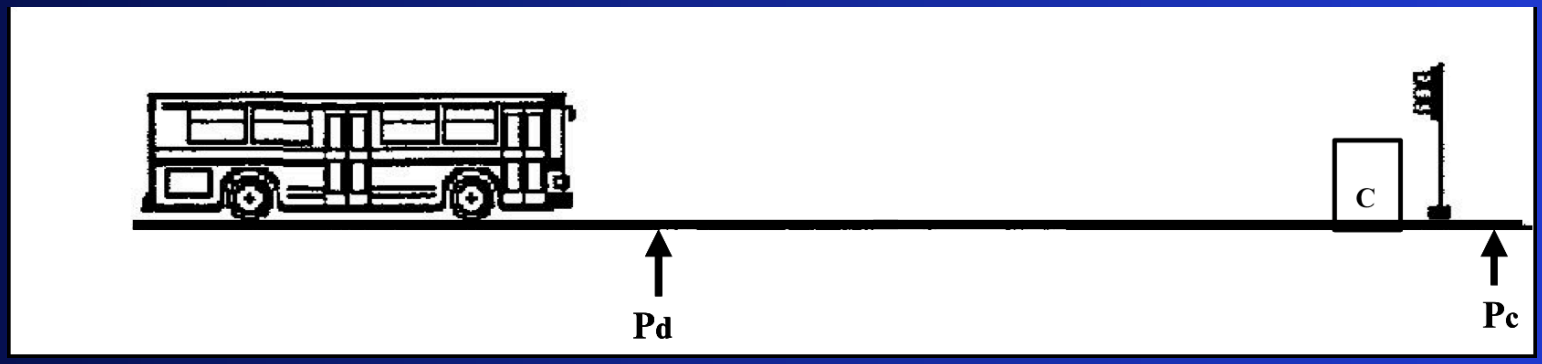
A. What is TSP?

(Based on NTCIP 1211)

Priority: The preferential treatment of one vehicle class (such as a transit vehicle, emergency service vehicle or a commercial fleet vehicle) over another vehicle class at a signalized intersection without causing the traffic signal controllers to drop from coordinated operations.

Priority ≠ Pr-emption

Simplified Representation of TSP

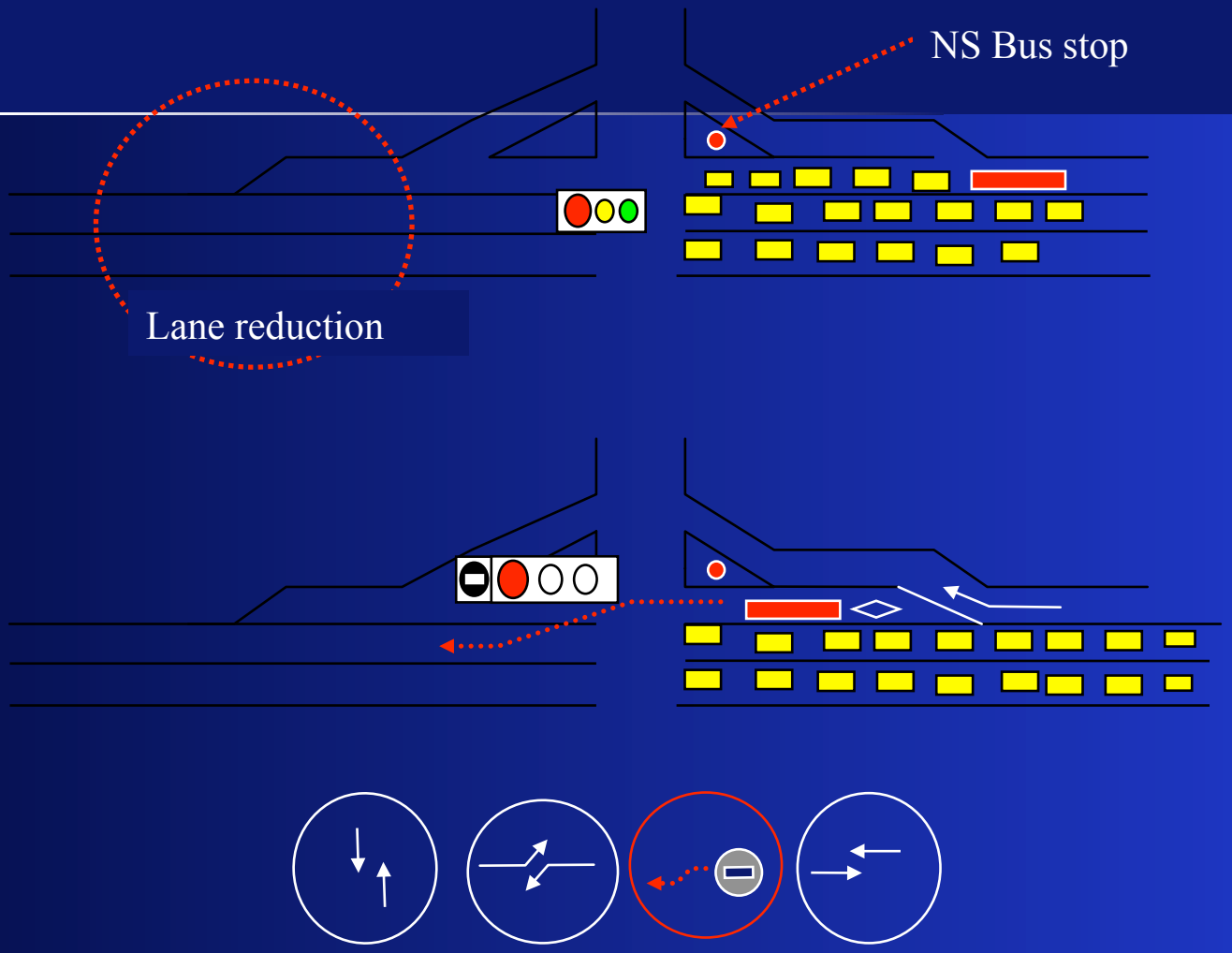


TSP Control Strategies

- Passive Priority
- Active Priority
  - Green extension
  - Red truncation
  - Actuated transit phase insertion
    - Exclusive left-turn, queue jump
  - Phase rotation

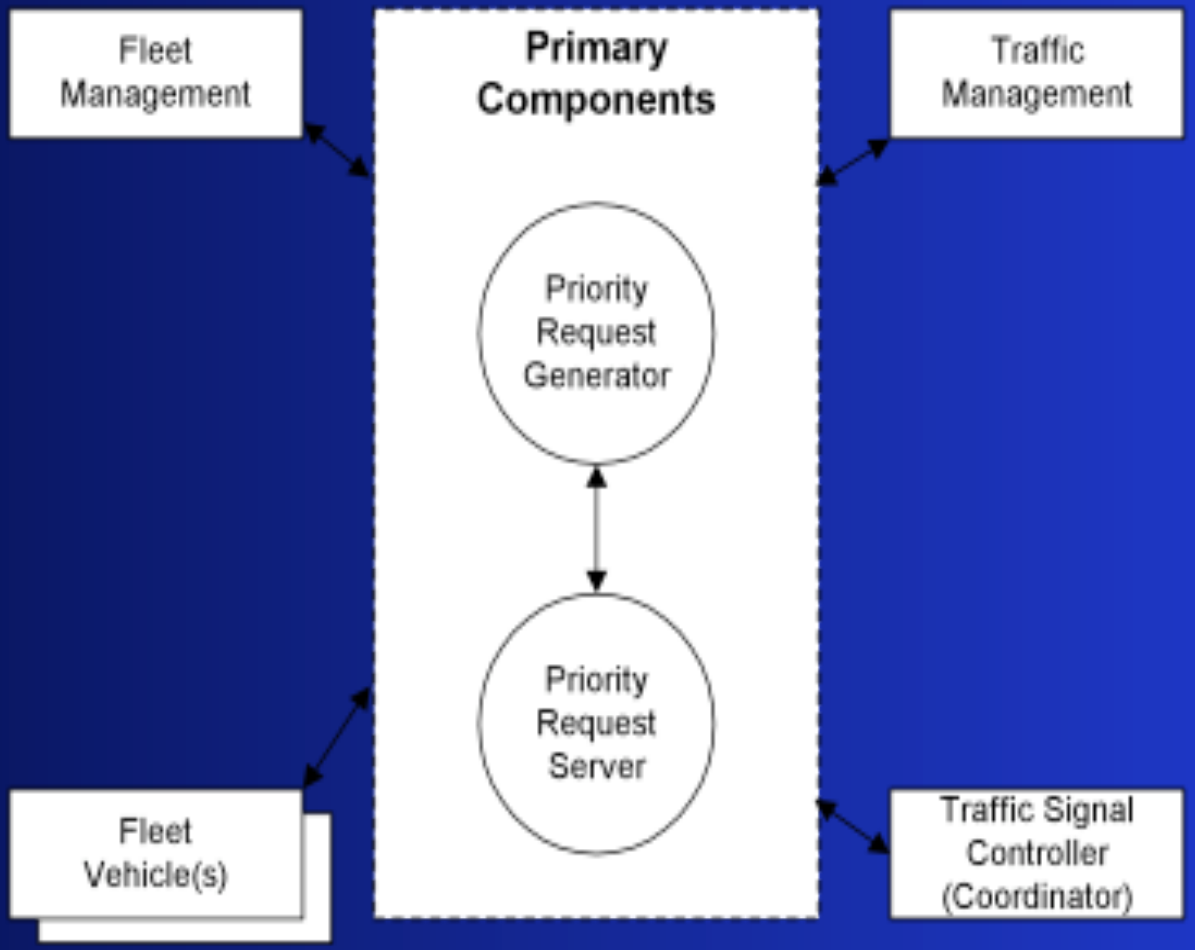
Note: Relatively little “adaptive control” in North America

Queue Jump with Signal Priority and Bus Lane

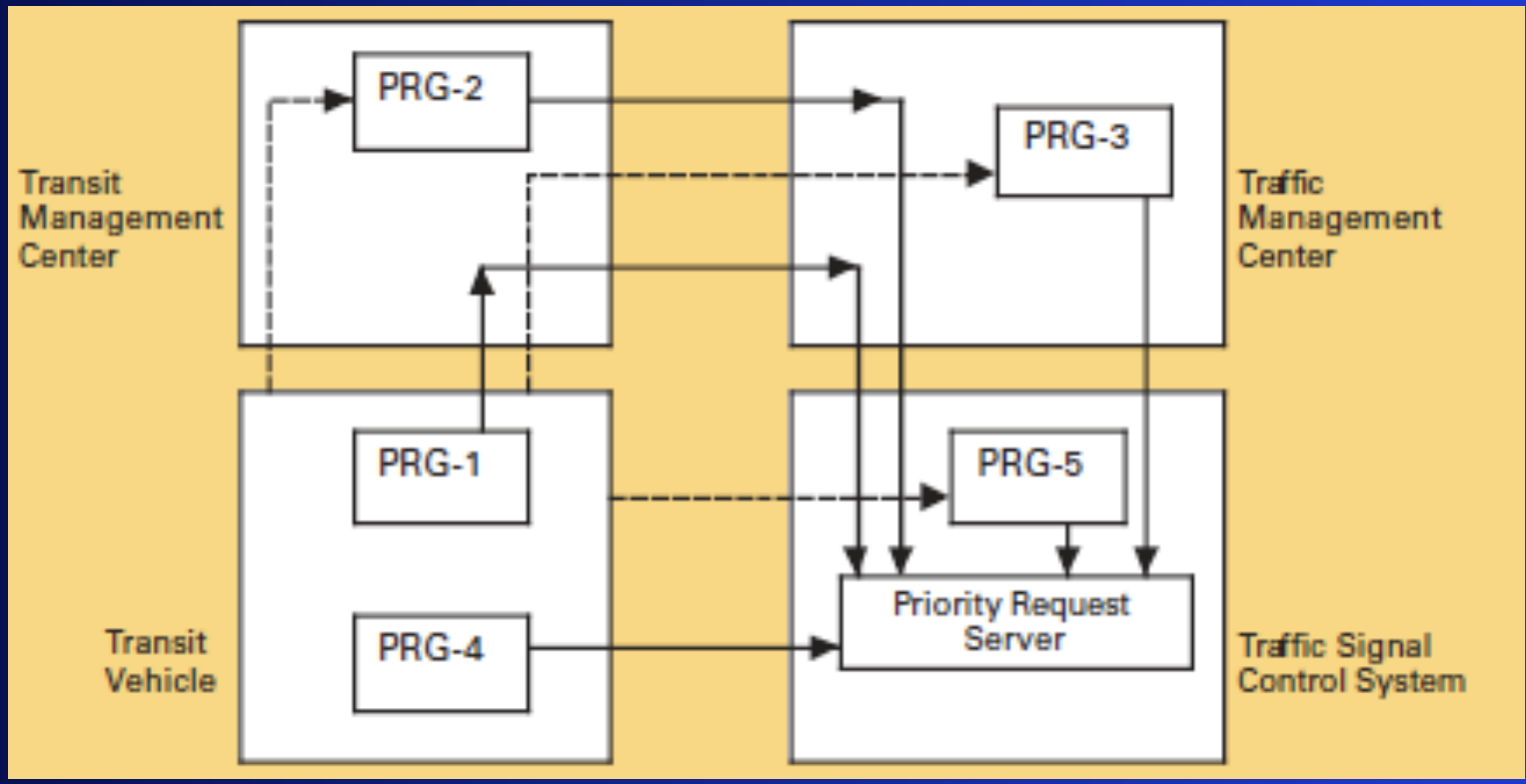


TSP Architecture Elements

(Based on NTCIP 1211, TCIP)



TSP Main System and Components



Bus Rapid Transit and Signal Priority

- **BRT Major Initiative in North America**
  - **Combines the quality of rail transit (speed, reliability) with the flexibility of buses**
  - **Signal Priority is a Major Component**
  - **TSP Benefits are significant**

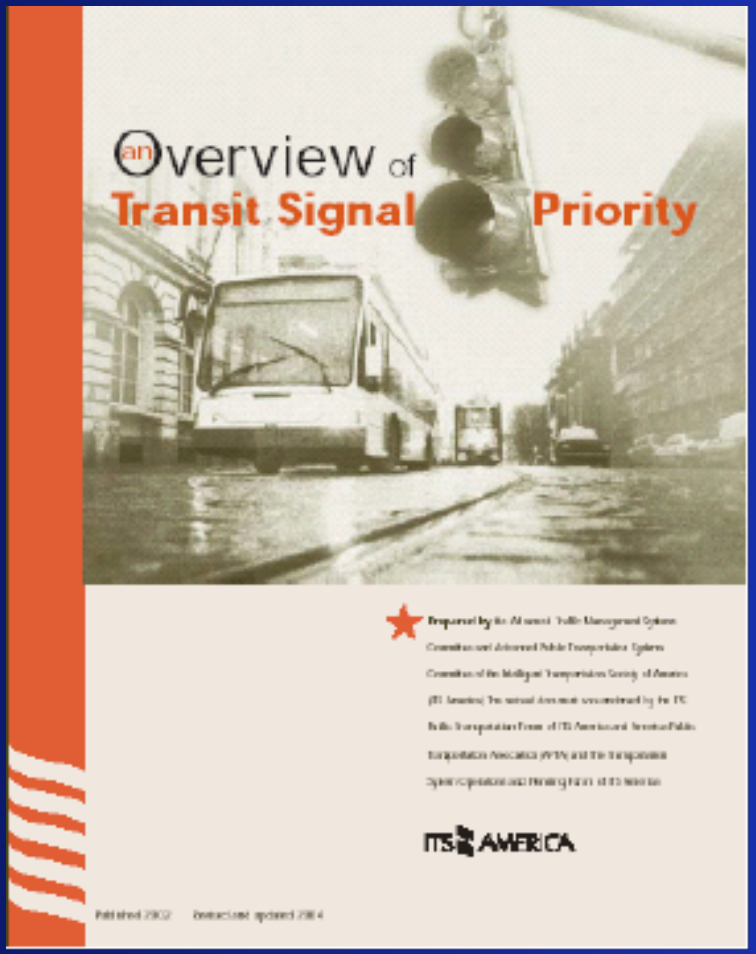
Early TSP Implementers

- Toronto - TTC
- Chicago – Pace
- Pierce Transit
- Seattle – King County
- Portland – Tri-Met

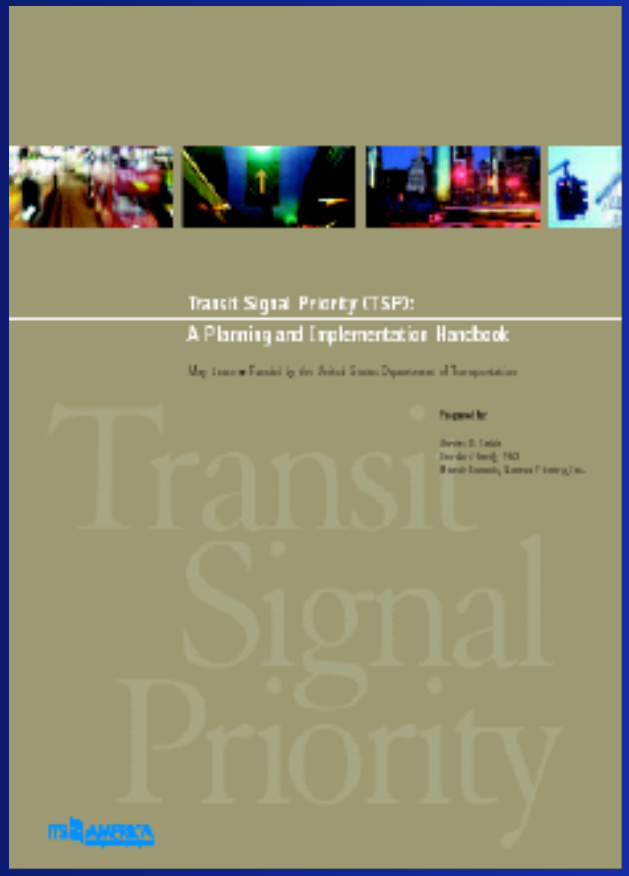
BRT Systems:

- Los Angeles Metro Rapid
- Vancouver – B-Line
- York Region – Viva
- Grand River Transit - iXpress

Overview of Transit Signal Priority



Transit Signal Priority: A Planning and Implementation Handbook



Key Lessons Learned

- ***TSP can produce significant benefits***
  - **Reduced intersection delay (20 - 40%)**
  - **Total travel time savings (5 - 8%)**
  - **Reduced travel time variability and improved transit service reliability**
  - **Sometimes, even a win-win solution for all traffic**
- ***No significant negative impacts***

Key Lessons Learned

- ***Lack of monitoring data and performance measurement methodologies***

- ***Many complex choices***
  - **detection,**
  - **communications,**
  - **control strategies, "conditionality"**
  - **integration with other systems (EMS, ITS)**
  - **integration with BRT, physical priority**
  - **worked out through *Concept of Operations***

A Systems Engineering Approach
and "Key Questions" at Each Step

- Project Planning
  - (Concept of Operations)
- Project Design
- Project Implementation
- Operations and Maintenance
- Evaluation, Verification, Validation

Concept of Operations (ConOps)
(What will TSP do?)

- Centralized versus distributed control
- Integration with EMS pre-emption (Yes/No)
- Priority Request Generator (PRG) conditionality requirement (Yes / No)
  - Basis of conditionality (type of service, schedule adherence, headway management etc.)
- Active Priority strategy choices
- TSP Control Strategy Parameters (by intersection)
  - Amounts of time, insertion points, rules for PRG/PRS), different levels of “low” priority
- Detection distance capability
- Check-in / Check-out mechanisms
- Traffic control system conditions
  - Coordination, Windows in cycles, Recovery process
- Data to be collected

Keys to Success

- Early Stakeholder Involvement
- Good Communication
- A Champion
- Demonstration / Pilot Project to Test TSP and Build Trust
- Convincing Evidence
- Momentum
- Standardization of equipment

And .....

Conclusions from Metrolinx / York Region Workshop

- Cooperation: “Not if, but when and how much…”
- Performance measurement
- Technological developments - earlier detection and more continuous monitoring of buses along corridor
  - IntelliDrive^{SM}
- More sophisticated TSP strategies that take advantage of earlier detection and more continuous vehicle monitoring
- Use of TCIP and NTCIP Standards

B. Transit Traveler Information Systems (TTIS)

- Traditional Means of Transit Traveler Information
  - Static information materials and print media, such as schedules, maps, brochures, bulletins, and advisories
  - Operators
  - Customer service call centers
  - Automated Interactive Voice-Response (IVR) telephone systems
  - Pathfinding at stops / stations/ pedestrian access
- Intelligent Transportation Systems (ITS) and Real-Time Information Systems
  - Displays at bus stops (scheduled arrivals / real-time ETA)
  - Monitors at terminals
  - Next stop information on-board vehicles (AVA)

TTIS State of the Practice

- Web-based Applications
  - Transit agency trip planning systems (typically commercial)
  - Google Transit trip planning
    - Requires export / translation into GTFS
  - E Alerts (especially in rail systems)
- Smart Phone Applications
  - Schedule information, GIS-based applications
  - Scraped data
  - Provision of GTFS data
  - Policies for applications developers
- 511 Systems and Transit
  - Provincial / Federal TIS initiatives

TTIS State of the Art

- Social Media
  - Facebook
  - Twitter
- Real-Time Information
  - Requires accurate AVL: stand alone or Transit ITS
  - ETA via multiple media (including texting)
- Transit Agency Sponsorship of Open-Source Traveler Information Software Development
  - Proactive partnerships with applications developers

    Tri-Met, BART, CTA, Mass DOT, NY MTA
  - OpenTripPlanner (Multi-modal)

TTIS Cutting Edge

- Special Mobile Applications for Customers with Special Needs
  - Path finding for visually impaired
  - “Buddy” system for persons with cognitive disabilities
- “Augmented Reality” and Implementation in Custom Smartphone Applications
  - Combine compass, visual recognition, other tools
- Peer-to-Peer, On-Line, Real-Time Exchange by and between Transit Passengers
  - Social interaction
  - Loyalty

Issues: Resource Constraints

- Lack of understanding that TTIS entails significant resources (distortion caused by popular portrayal of Web 2.0)
- Overall financial constraints / general lack of financial resources
- Difficulty in Securing Operating (as opposed to Capital) Funding
- Lack of board / management recognition of it as a strategic resource for transit
- General lack of IT resources

Issues Related to TTIS Strategy Development

- Lack of focus on market research, and lack of surveys to inform strategy
- Sensitivity to the Digital Divide

  (Smart Apps don't replace traditional means for all customers)
- Use of social media and strategy
- The debate about controlled versus open data

Issues: Data Availability and Technical Challenges

- Implications of being locked into commercial, proprietary systems and contracts
- Lack of use of open standards for ITS / transit traveler information systems (e.g. TCIP)
- Difficulty in adapting legacy systems to new uses – for example, transit traveler information systems

Challenges Related to Specific Information Delivery Mechanisms

- Labor-intensiveness of E-alerts composition and maintenance
- Cost of SMS message transmission
- Targeted deployment trends for real-time information displays at stops

Recommendations for Transit Systems

- Develop an Informed TTIS Strategy
  - Conduct necessary market research on transit traveler information systems (TTIS)
  - Sensitivity to digital divide
  - Develop a multi-format TTIS strategy, consistent with Technology strategy
  - Clarify role/structure for social media and E-alerts as part of overall TTIS strategy
- Acquire Sufficient Resources (Financial and IT)
  - Build and support sufficient information technology (IT) resources
  - Ensure sufficient operating as well as capital funding for TTIS initiatives
- Develop a Data Strategy: Interoperability, Open Source, and Open Government
  - Eliminate constraints on use of data and interfaces of commercial software
  - Adopt open-source and intelligent transportation systems (ITS) standards
  - Adopt and benefit from “open government” approach to public data

Critical Need for Research

- Research Needed to Develop Transit Agency strategy
  - Use of TTIS: Who? How? When? Why?
  - TTIS and Travel Behaviour?
  - Impact on Ridership?
- Basis for Transportation System Policy Decisions
  - Multi-Modal Trip Planning / Travel Behaviour and Climate Change Implications

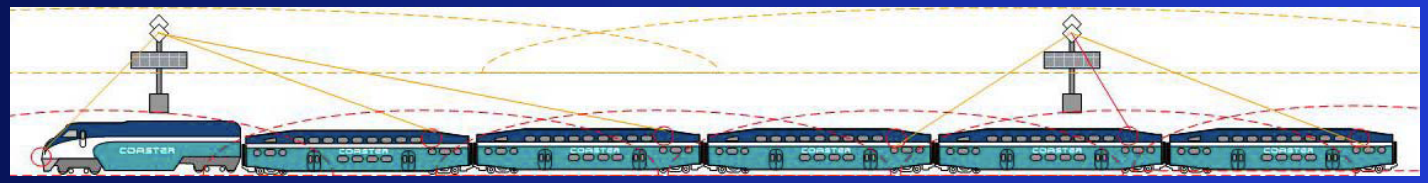
- Role for Senior Governments!
- Work with academics
- Where TTIS exists: monitoring / analyzing TTIS use patterns
- Sharing of market research data and experience with TTIS

C. Future Directions for ITS

- **Real-time traveler information**
- **Real-time digital video (on demand)**
- **Business Intelligence**
- **More Effective Use of TSP** (performance monitoring, strategies)
- **New Transit ITS applications**
  - Decision support systems (real-time control)
  - General public demand-responsive systems (FlexBus)
- **AFC paradigm shift**
  - Contactless credit card, Payment by cell phone
- **Multi-modal integration**
  - Multi-modal trip planning
  - Centre to Centre (C2C)
- **Wireless communications and mesh networks**
  - Wi-Fi, WiMAX, DSRC

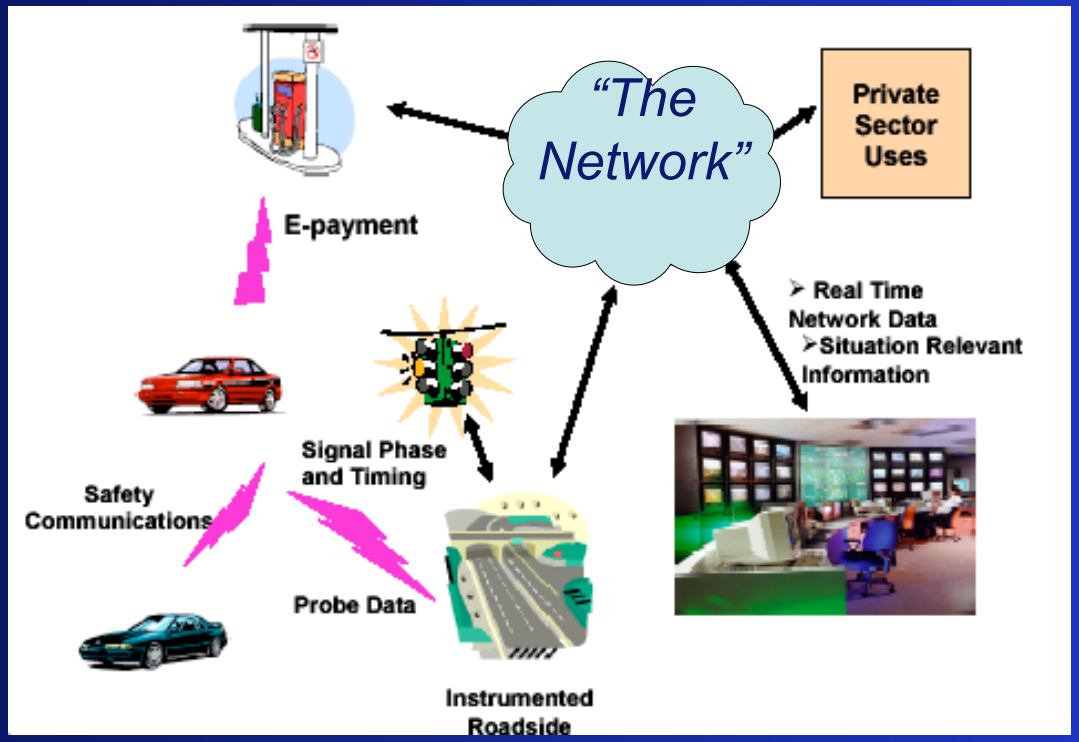
Rail Transit ITS

- **Train location (AVL) and schedule monitoring**
- **Real-time passenger information**
  - Pre-trip – departures, alerts (Web, Mobile Devices)
  - Terminals and platforms (LED, LCD, PDS)
- **On-Board public internet access**
- **Security (On-board / station intrusion)**
- **Wireless on-board emergency communications** (VOIP)
- **Real-time video monitoring**
- **Grade crossing safety**



Coaster - Design of Train/Mesh Node Communication

IntelliDrive℠ / Connected Vehicle Environment



Opportunities / Issues for Transit ?

What is IntelliDrive℠?

- IntelliDrive℠ is a suite of technologies and applications that use wireless communications to provide connectivity:
  - Among vehicles of all types
  - Between vehicles and roadway infrastructure
  - Among vehicles, infrastructure and wireless consumer devicesTo Improve Safety, Mobility and Environment
- FCC Allocated Spectrum at 5.9 GHz for Transportation Safety (known as DSRC)

Advantages of IntelliDrive℠

- **Increased broadband data communications**
  - Dedicated Short Range Communications – DSRC
  - 4G, other?
- **Continuous monitoring of vehicles**
- **All types of vehicles and fleets, infrastructure and wireless consumer devices, including the after-market**
- **Sharing / fusion of data: Synergy!**
  - Probe data to monitor travel speeds / traffic volumes
  - Micro-climate data from vehicle sensors

US DOT's Perspective on IntelliDrive℠ Deployment

- **Safety applications** (assumed through DSRC)
  - V2V and V2I using DSRC
  - Aggressively pursue V2V: "Here I am !" (HIA) messages
  - NHTSA Regulatory Decision in 2013 whether to mandate DSRC!
  - Leverage vehicle capability for V2I spot safety
  - Note: DSRC is non-existent in transit industry
- **Non-safety (mobility, environment)**
  - Leverage existing data sources & communications; include DSRC as it becomes available
  - Support development of key applications for public agencies using current data sources and evolving probe data from IntelliDrive
  - Shared Data Environement

IntelliDrive^{SM}-type Transit Applications In Operation / Under Development

- **TSP Using Wireless Communications**
- **King County's RapidRide ITS Concept**
- **Smart Parking Systems for Transit Park and Ride**
- **SafeTrip-21 Demonstration**
- **Integrated Corridor Management**
- **Smart Devices in Transit Applications**
  - Remote Infrared Audible Signage Model Accessibility Program
  - Travel Assistant Device (TAD) system
  - Bluetooth-enabled devices for specialized transit customers
- **North County Transit District's COASTER Wireless Mesh Security Communications Network**

IntelliDrive℠ benefits most likely to interest transit systems

- **Safety Applications (V2V, V2I, Pedestrians)**
- **Refinements in performance for important applications through earlier detection and continuous monitoring:**
  - TSP
  - On-board / wayside traveler information,
- **More frequent communications and data transfers along IntelliDrive℠-equipped corridors**
  - CAD/AVL: Supplement the system-wide data radio with additional bandwidth for more frequent location polling on BRT corridors.
  - AFC: support stand-alone off-board fare equipment
  - Security video could be streamed to the control center during an emergency incident along equipped corridors
- **New applications that may be created / enhanced:**
  - Smart parking
  - Use of smart devices for more personalized traveler information
  - Applications for persons with special needs

Potential Transit-Related Dynamic Mobility Applications

- Transit Signal Priority
- Connection Protection
- Integrated Multi-modal Electronic Payment
- Smart Park & Ride System
- Dynamic Transit Dispatching

Some Challenges

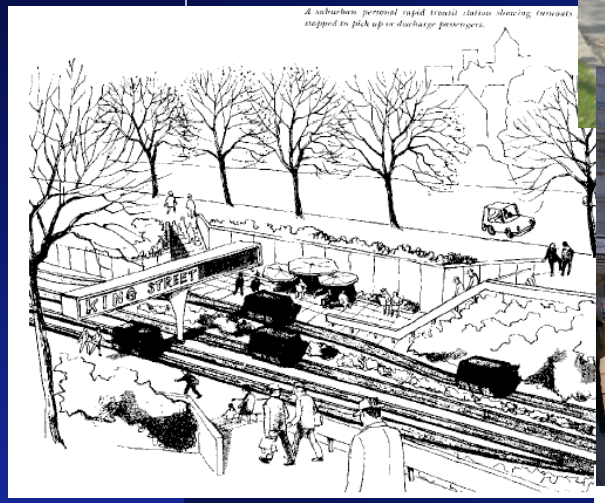
- Well established Transit ITS architecture
- Integration of voice and data communications
  - Voice typically through private radio
  - Data through cellular communications
- Capital vs. Operating cost:
  - Private radio: Capital cost-intensive
  - Cellular: Operating cost-intensive
- Reliability of system and ability to function under emergency conditions
- Corridor-based approach: Seamless integration of corridor system with rest of network
- Integration of DSRC-based safety warnings in device and sensory-saturated environment of bus operator work station

Conclusions

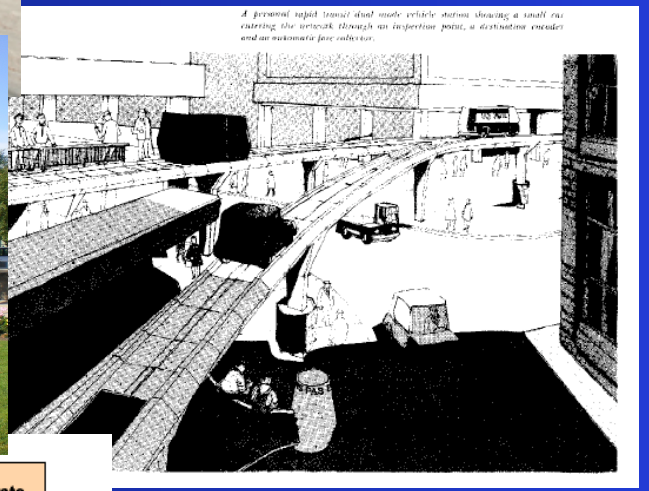
- Exciting period
- Growing investment in Transit ITS
- Increasingly strategic role played by technology in transit
- Need to better understand transit's potential involvement in Connected Vehicle Systems

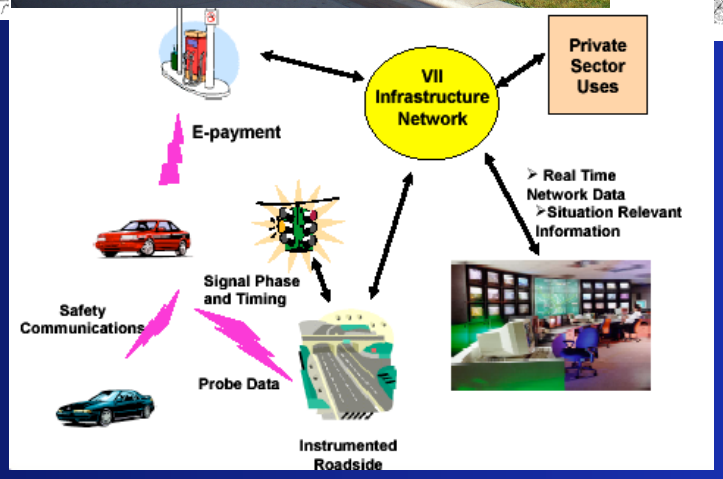
THANK YOU!


WOODWARD


KING STREET


CITY HALL
CITY HALL
THE ROYAL BANK OF CANADA




VII Infrastructure Network
Private Sector Uses
E-payment
Real Time Network Data
Situation Relevant Information
Signal Phase and Timing
Safety Communications
Probe Data
Instrumented Roadside