Evaluating HOT lanes using an enhanced traffic simulation tool

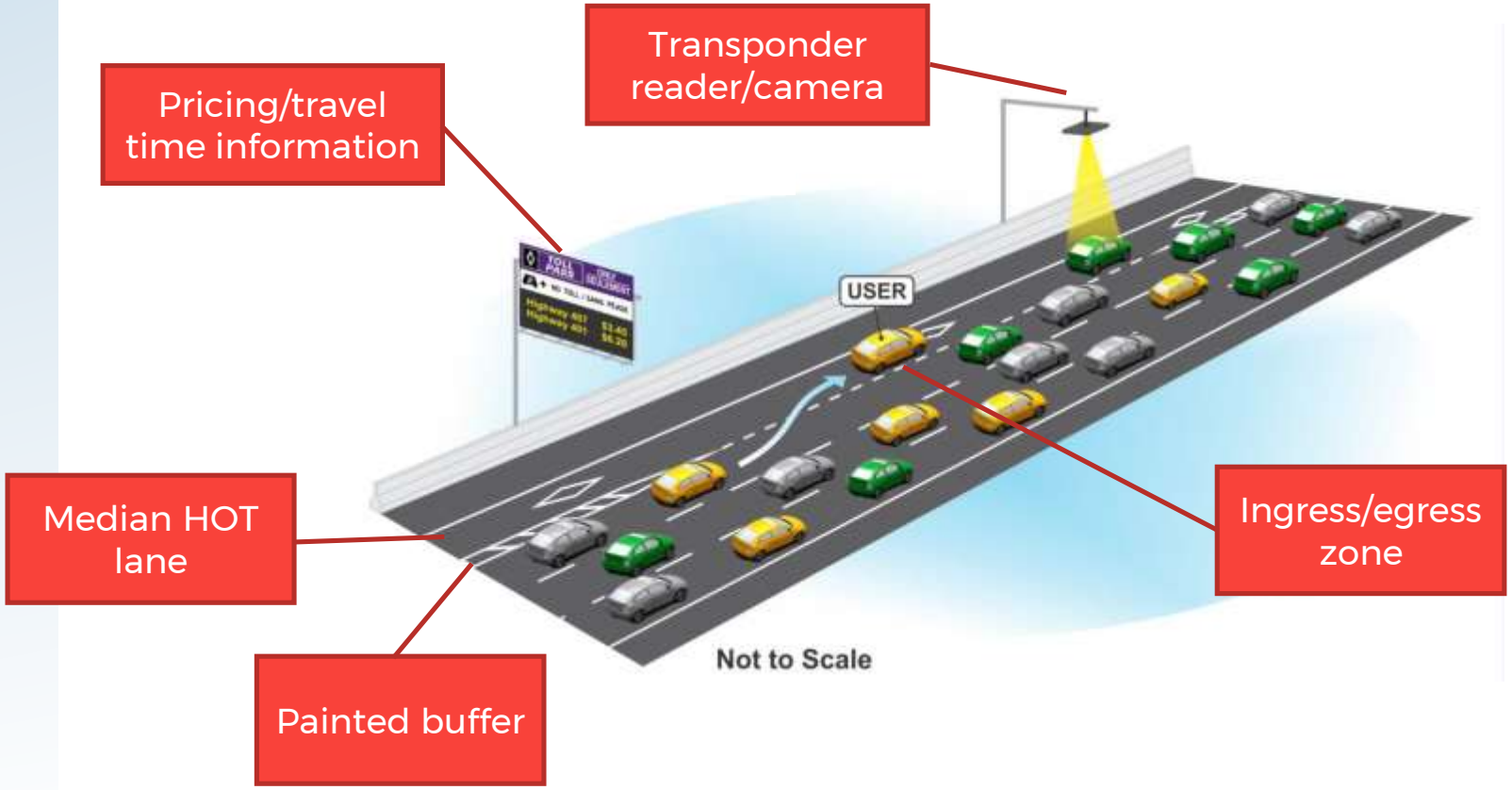
Goran Nikolic P.Eng. – Head, Traffic Planning, Ministry of Transportation of Ontario
Rob Pringle P.Eng. – Senior Project Manager, WSP

topics

1. **Background – HOT lanes and dynamic pricing**
2. Wanted – a tool to evaluate dynamically-priced HOT lanes
3. A traffic simulation framework for the evaluation of dynamically-priced HOT lanes
4. Additional functionality for on-line operation
5. Ongoing enhancements
6. Applications

What is a HOT lane (High-Occupancy/Toll lane)?

— A HOT lane is an HOV (High-Occupancy Vehicle) lane that single-occupant vehicles can use in return for payment of a toll



Why HOT lanes?

- HOV lanes are not typically fully utilized over their length
- Converting to HOT lanes allows excess capacity to be “sold”

What is dynamic pricing?

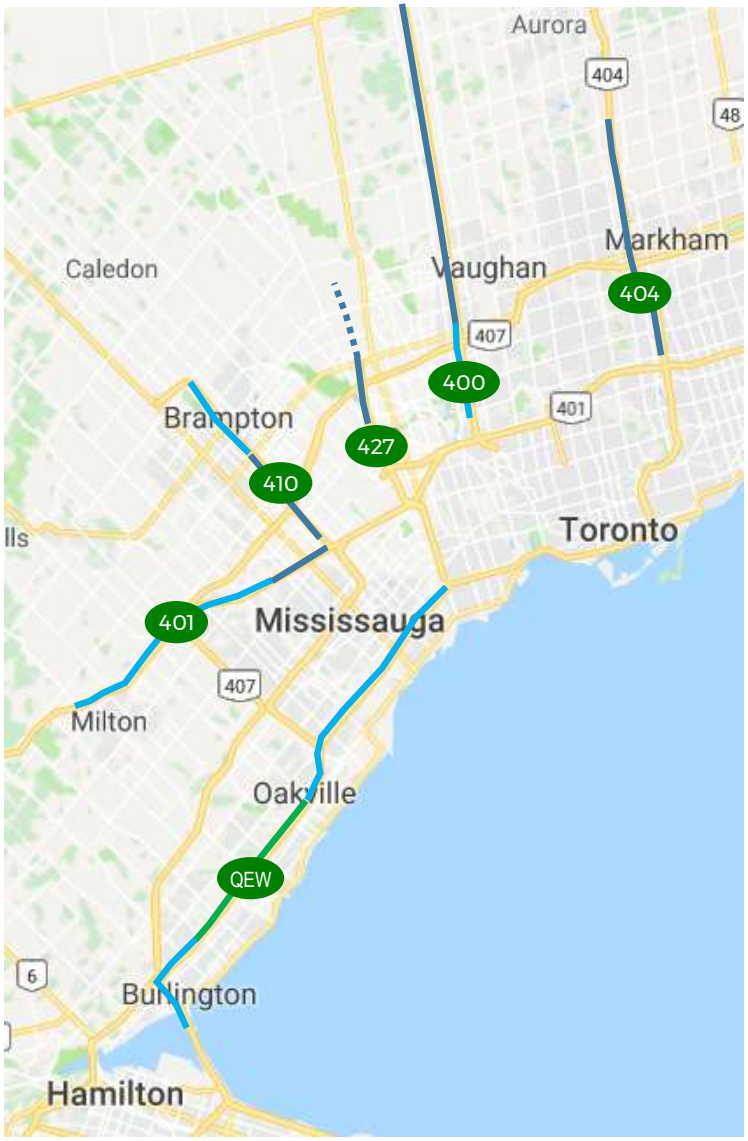
- Tolls are adjusted dynamically (typically every 5 minutes), in response to changing real-time traffic demand and performance
- Tolls are set to maintain a specified performance level in the HOT lane

Typical dynamic pricing objective:

- Maintain a pre-determined target speed in the HOT lane 90% of the time in the peak direction during the peak hour (US examples typically use 70 km/h)
- Maximize utilization of the HOT lane subject to maintenance of the target speed
- 70 km/h approximately consistent with 1,700 veh/h

Ontario context

- A 2-4 year HOTL Pilot Project was implemented in 2016 using the existing HOV lanes on the Queen Elizabeth Way between Guelph Line and Trafalgar Road. This pilot project is not dynamically priced – uses monthly permits
- MTO has announced that dynamically-priced HOTLs will be operational on Highway 427 by 2021
- Feasibility and business-case assessment of HOTLs on Highways 400, 401, 404, 410, QEW is underway

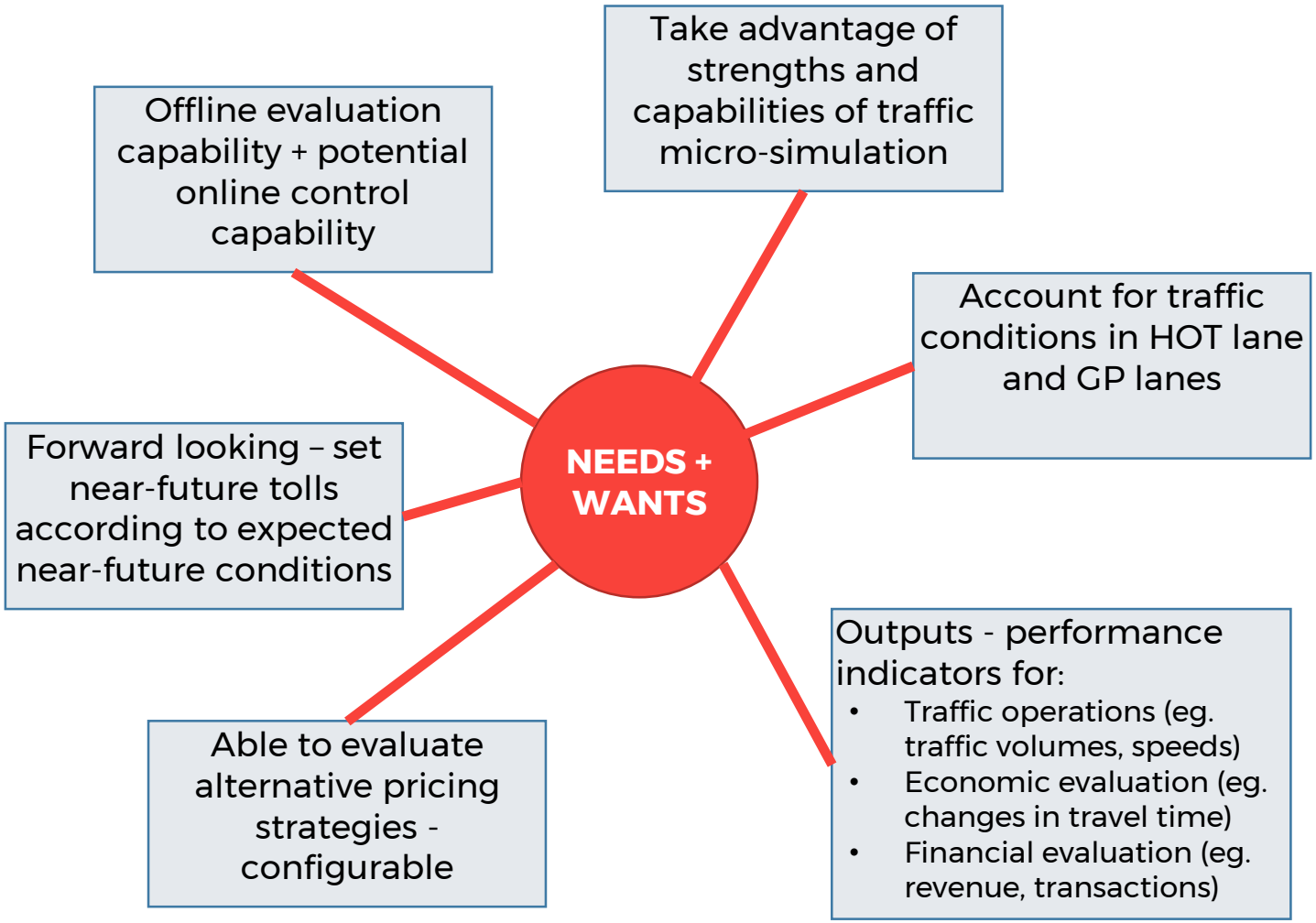


1. Background – HOT lanes and dynamic pricing
2. **Wanted – a tool to evaluate HOT lanes**
3. A traffic simulation framework for the evaluation of dynamically-priced HOT lanes
4. Additional functionality for on-line operation
5. Ongoing enhancements
6. Applications

Wanted – a tool to evaluate HOT lanes

— MTO wanted to assess HOT lanes but there was no known simulation tool available at the time (2013) that would enable evaluation of the performance and traffic implications of a dynamically-priced HOTL at the microscopic level

TOOL NEEDED (DEVELOPED AND TESTED) FOR SCENARIO EVALUATION WITHIN 6 MONTHS!!!

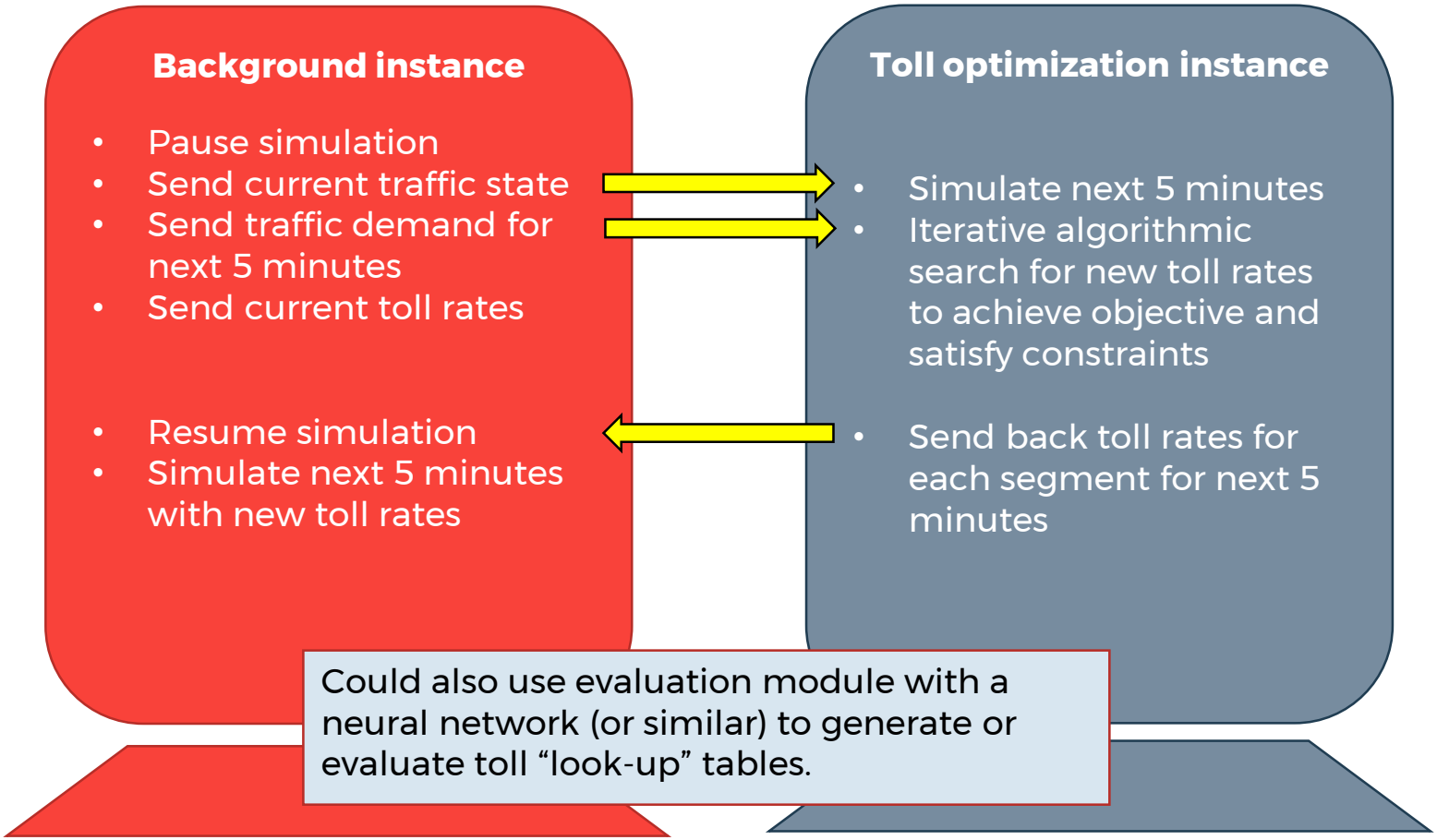

Take advantage of strengths and capabilities of traffic micro-simulation
Offline evaluation capability + potential online control capability
Account for traffic conditions in HOT lane and GP lanes
NEEDS + WANTS
Forward looking – set near-future tolls according to expected near-future conditions
Able to evaluate alternative pricing strategies - configurable
Outputs - performance indicators for:
• Traffic operations (eg. traffic volumes, speeds)
• Economic evaluation (eg. changes in travel time)
• Financial evaluation (eg. revenue, transactions)

1. Background – HOT lanes and dynamic pricing
2. Identifying a need
3. **A traffic simulation framework for the evaluation of dynamically-priced HOT lanes**
4. Additional functionality for on-line operation
5. Ongoing enhancements
6. Applications

Concept of operation – offline evaluation mode

— Two parallel and interacting simulation instances (Aimsun)

— at each 5-minute toll update interval……



Toll optimization algorithm

Objective:

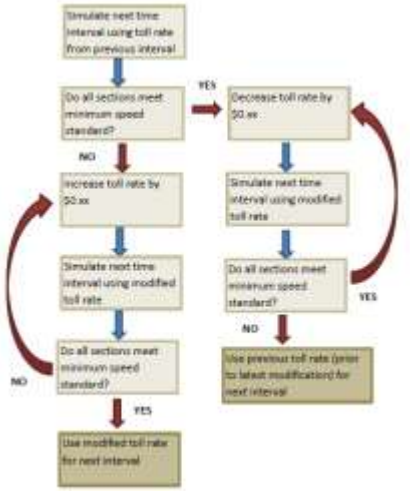
— to achieve a speed as close to (but above) target speed (70 km/h in this case) – assume this will optimize utilization

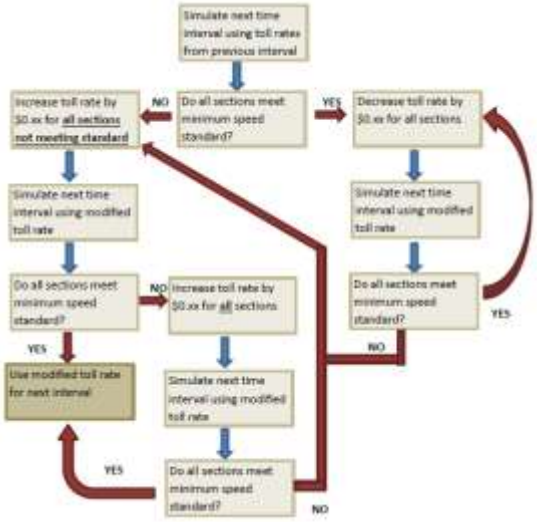
Iterative search process:

— Simulate next 5 minutes with current toll rates

— Increase or decrease toll rate for each segment (and/or designated upstream segments) in successive iterations until objective met or maximum allowable change in toll rate reached

— Pre-set parameters include:
  — *Target speed*
  — *Maximum change in toll rate per interval*
  — *Cap on toll rate (if desired)*
  — *Minimum toll rate*





Some process parameters

Drivers' willingness to pay:

— *Assigned stochastically from distribution based on stated-preference survey*

Scope of toll rate "lock-in" for individual drivers:

— *Segment, zone (group of segments), or entire HOTL*

Scope of driver decision-making:

— *For next segment, rest of zone, or rest of trip (individually or either/or)*

Vehicle class eligibility to use HOTL and toll fraction:

For example:

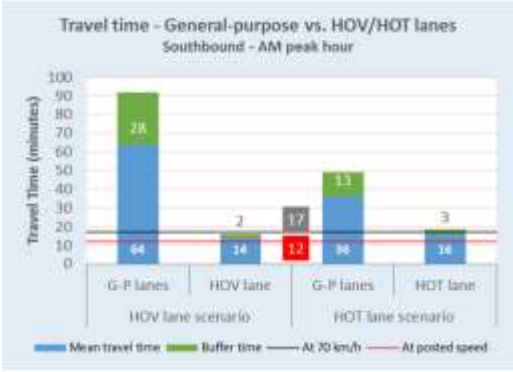
— *charge HOV2 (a discounted rate)*

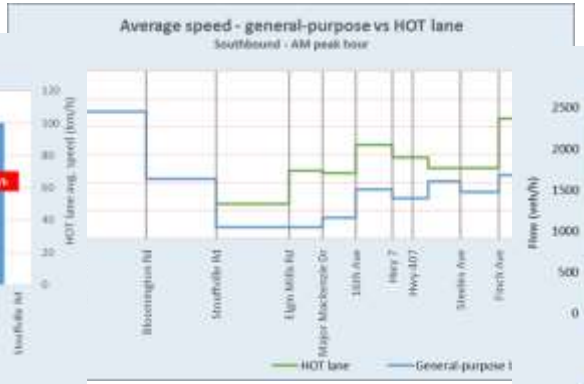
— *allow trucks to use HOTL but charge 2x auto rate*

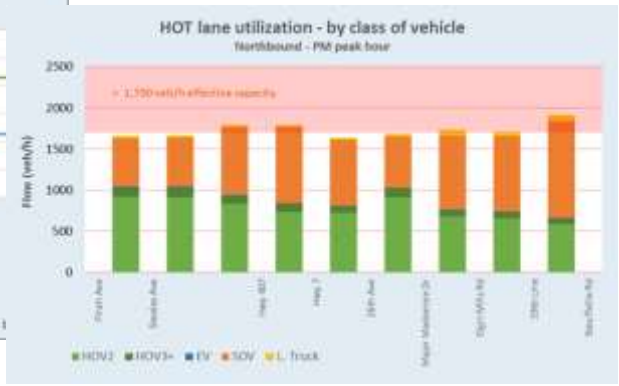
Outputs

Traffic performance measures:

- “Typical” traffic simulation outputs
- Compliance with speed target
- Travel time and reliability



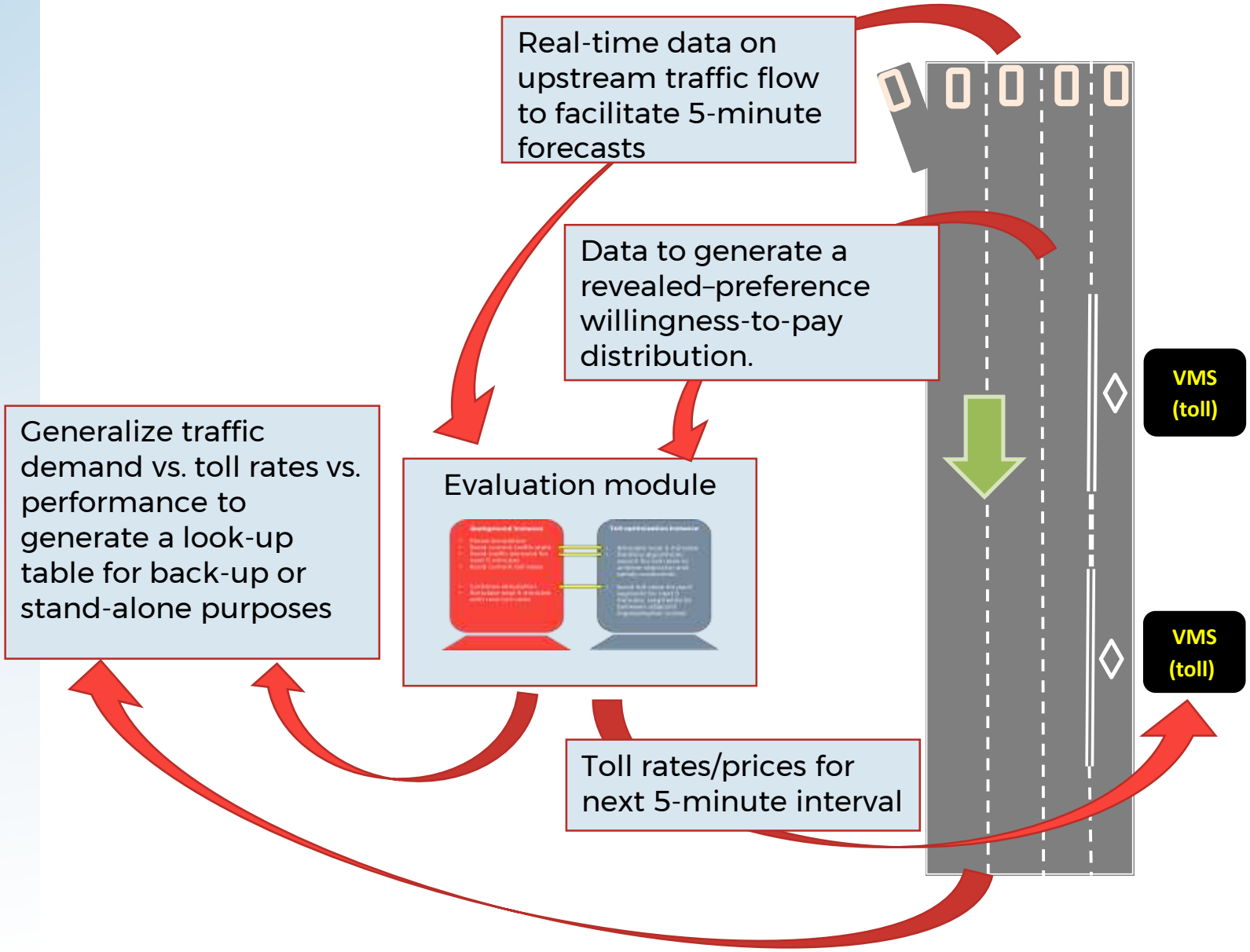




Measures to support economic and financial analysis:

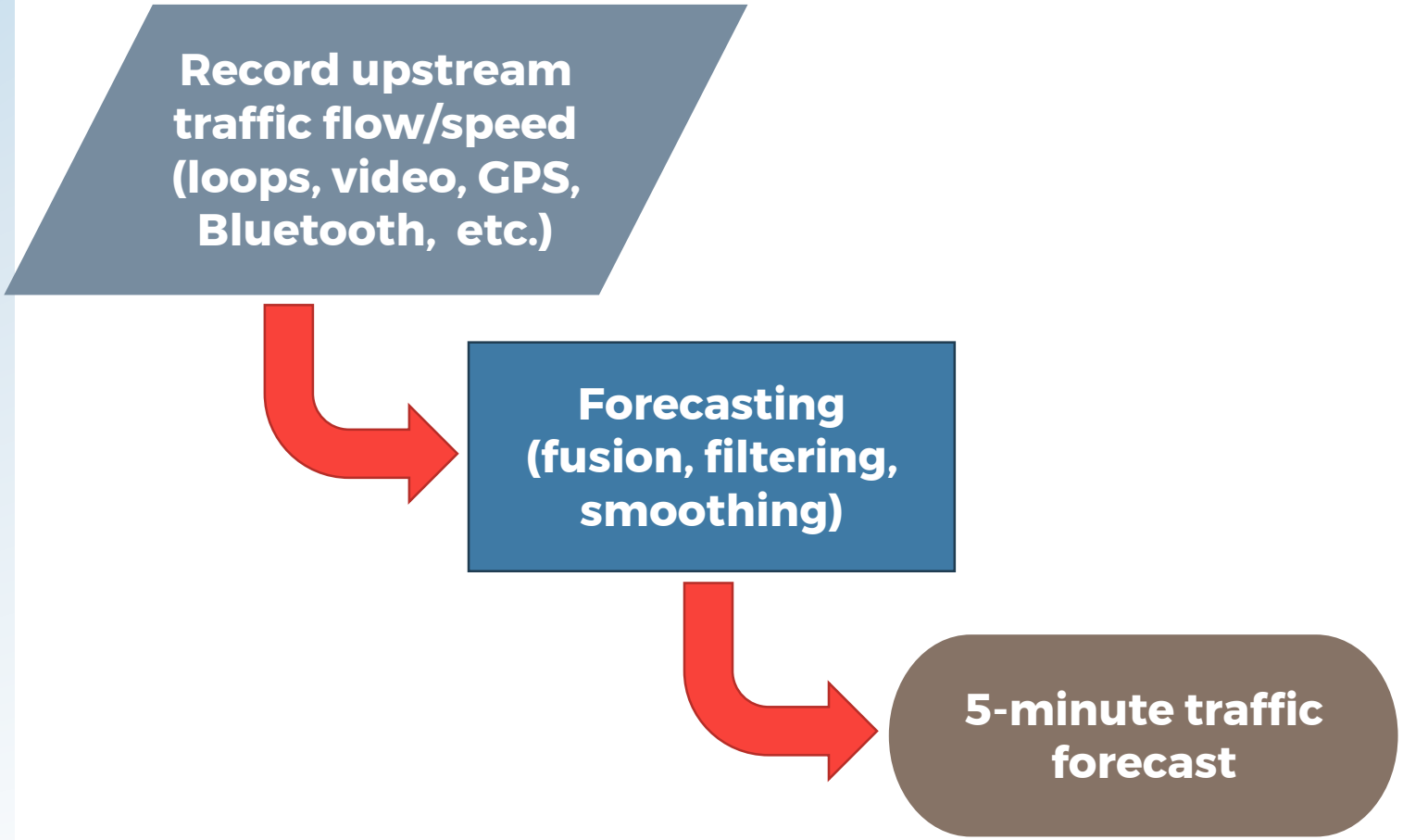
- Toll rates, revenue
- Throughput (veh-km), travel-time savings (veh-h)
- Transactions (for estimation of back-office costs)
- Vehicle trajectory files - input to SSAM and cost model for collision cost analysis

Conceptual framework – online operation mode

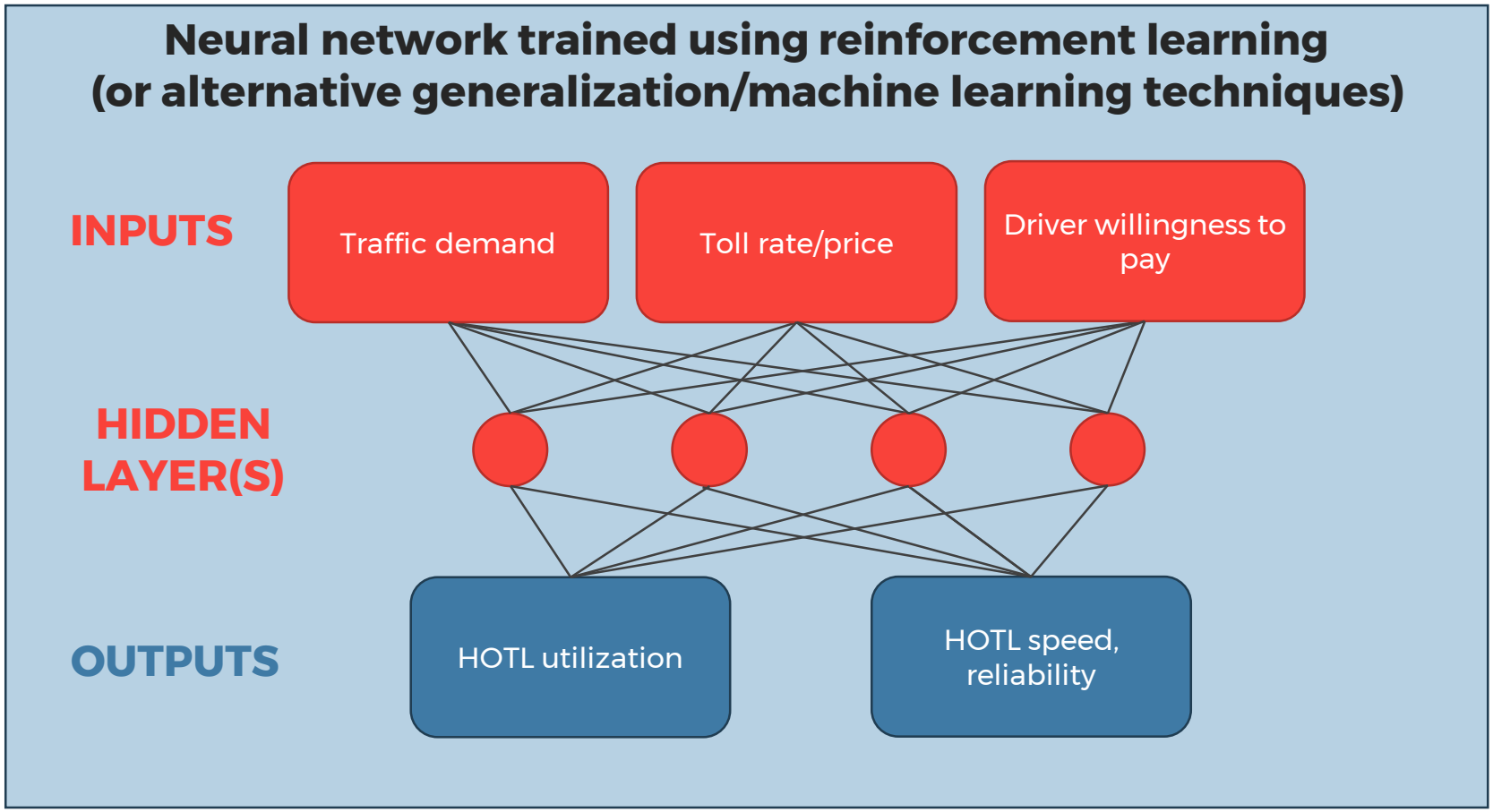


1. Background – HOT lanes and dynamic pricing
2. Identifying a need
3. A traffic simulation framework for the evaluation of dynamically-priced HOT lanes
4. **Additional functionality for on-line operation**
5. Ongoing enhancements
6. Applications

Short-term (5-minute) traffic forecasts:



Generalizing observations to produce a "look-up" table:



— The trained neural network can be used as a stand-alone look-up table to choose toll rates based on traffic conditions

(eg. if on-line system is down or in lieu of an on-line system)

Updating driver willingness-to-pay information:

— Gradually update stated-preference data obtained from prior surveys with revealed-preference data based on actual observations

— Periodically update the willingness-to-pay distribution

Updating simulation model calibration:

— Periodically check simulation model against recorded data and refine calibration as necessary

1. Background – HOT lanes and dynamic pricing
2. Identifying a need
3. A traffic simulation framework for the evaluation of dynamically-priced HOT lanes
4. Additional functionality for on-line operation
5. **Ongoing enhancements**
6. Applications

Dynamic pricing enhancements

- Pricing strategy options have been added:
  - *Zone-based pricing – various options*
  - *Skewing of pricing to reflect downstream conditions*
  - *Permit-based pricing*

- Potential future pricing strategy options:
  - *Ability to work from a time-based schedule*
  - *Ability to work from a look-up table referenced to traffic conditions*

Modelling enhancements (examples)

- Implemented improved recording of travel-time through ingress-egress zones:
- Looking at ability to model alternative configurations for ingress/egress zones:
  - *eg. speed-change lanes, separate ingress and egress zones*
- Looking at benefits of:
  - *Reducing decision-making interval to 1 or 2.5 minutes to avoid driver decisions becoming stale in light of changing traffic conditions*
  - *Time-slicing matrices to 15 minutes (instead of 1 hour) to minimize abrupt changes in traffic demand*
- Improve driver ability to perceive situation and change mind about using HOTL if congestion has developed at ingress/egress zones due to high demand

1. Background – HOT lanes and dynamic pricing
2. Wanted – a tool to evaluate dynamically-priced HOT lanes
3. A traffic simulation framework for the evaluation of dynamically-priced HOT lanes
4. Additional functionality for on-line operation
5. Ongoing enhancements
6. **Applications**

Applications

Evaluation of permit-based HOTL Pilot Project for the QEW

— Provide inputs to decisions on maximum number of permits to sell, price

— In conjunction with ongoing monitoring, provide input to changes in number of permits issued

5-corridor HOTL feasibility/business-case assessment

— Assess traffic performance feasibility/issues

— Provide inputs to economic/financial analyses

Highway 427 HOTL planning

— Assess traffic performance issues

— Potentially use to evaluate/support dynamic pricing algorithms proposed for implementation

Thank you!

wsp.com