Study Objectives

• “Independent and objective analysis”

• “Describe performance on various segments of the corridor that represent segments used by typical drivers, and describe where the corridor is working, and where it is not working”

• What evidence (i.e. performance measures) can be obtained from the data about the effectiveness of the ETL corridor during its pilot phase?
Washington state statute RCW 47.56.880 lists several general performance measures for the I-405 ETL facility. Of these, three measures are of primary interest to this study:

- Whether the express toll lanes generate sufficient revenue to pay for all I-405 express toll lane-related operating costs;
- Whether the express toll lanes maintain speeds of 45 miles per hour (mph) at least 90 percent of the time during peak periods; and
- Whether the average traffic speed changed in the general purpose lanes.
Key Findings

- Financial Performance Measure Met.

- ETL Speed Performance Measure Not Met.
  This study finds that on average the amount of time in peak period where ETL speed is above the 45 mph statutory goal is 85 percent in the northbound direction and 78 percent in the southbound direction (Jan 2017 – Jun 2017). However, ETLs and corridor are carrying significantly more traffic.

- GPL Speeds Showed No Significant Change.
Study Process

• Six month study (began June, 2017)

• Extensive work with staff workgroup (staff from JTC, Legislature, OFM, WSDOT, Transportation Commission)

• Data transfer from WSDOT completed in August, 2017

• Developed **database and computer programs** specifically for this study
Facility Timeline

- Constructions started
- Construction: Fall 2012 to 3rd-27 2015
- Tolling scheme changed to weekdays only
- ETL opened to traffic
- Construction: Aug 2016 to Apr 2017
- Shoulder-lane opened to northbound traffic
Approach to Data Analysis

- Three potential sources of data:
  - WSDOT loop detectors
  - ETL toll transaction data
  - HERE/INRIX cell-phone derived data

- Data source characteristics:
  - Availability
  - Content: traffic volume, seed, density, travel time
  - Resolution
Double Loop Detector Data

- Source: WSDOT
- Speed and volume per lane
- Every 0.5 miles
- Every 20 seconds
- January 2014 to June 2017
- Nearly 13M records per month
ETL Transaction Data

- Source: WSDOT
- ETL *volume and travel time*
- By origin/destination, January, 2016 – June, 2017
- Per segment, every minute
- Vehicle location & time at ETL gantries (10 NB and 11 SB)
- Trip types: HOV, AVI, IMG
- More than 4M records per month

*ETL Transaction data tells us which trips are more common and the volume they comprise in each segment of the corridor*
HERE & INRIX Data

- Derived from use of proprietary smart phone navigation apps
- Tracks aggregate travel time
- Every 5 minutes
- For cars and trucks
- Nearly 300K records per month

- Not used for analysis in this study
  - No lane information
  - No distinction between GPL and ETL
  - No volume information
Available WSDOT Data

What can be obtained from Loop Detector & ETL Transaction data?

• Volume:
  - Both on GPL and ETL
  - Both before and after

• Speed:
  - Both on GPL and ETL
  - Both before and after

• Travel Time:
  - Both on GPL and ETL
  - Both before and after

• Widely accepted/being used
• High volume/amount
• High resolution
• Comprehensive (complete info)
Data Analysis Methodology

• We developed *database systems* and *computer programs* to undertake our analysis in this study.

• We calculated traffic measures on *ETL and GPL* separately and independently.

• We calculated volume, speed and travel time:
  – In peak and off peak periods
  – For every month
## Data Summary & Comparison

<table>
<thead>
<tr>
<th>Data set</th>
<th>Loop Detector Data</th>
<th>ETL Transaction Data</th>
<th>HERE Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contents</td>
<td>Speed and volume, date, time, milepost and lane information</td>
<td>Transaction date, time, locations, toll amount, etc.</td>
<td>Estimated segment travel times</td>
</tr>
<tr>
<td>Sample rate</td>
<td>20 seconds, every 0.5 miles</td>
<td>Real time at 21 gantries</td>
<td>5 minutes, 0.5-0.8 miles</td>
</tr>
<tr>
<td>Advantages</td>
<td>Provides both volume and speed info; High resolution data; Provides lane usage info; Provides good coverage along the corridor</td>
<td>Tracks trips on ETL, so complete trip info; Provides accurate travel time info; Provides accurate volume info</td>
<td>Estimated travel times for different types of vehicles</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Reported speeds are local, need processing for travel time</td>
<td>Lacks info on GPL and HOV lanes before ETL</td>
<td>No volume information; No distinction between ETL and GPL; No lane usage info; Small sample size; Potentially biased travel times</td>
</tr>
<tr>
<td># of records*</td>
<td>13 million / month</td>
<td>4 million / month</td>
<td>300,000 / month</td>
</tr>
</tbody>
</table>

* # of records does not necessarily mean the number of sampled vehicles.
Effect of opening the ETL in September, 2015

- Improvement in NB ETL peak-period travel times
- Little change in NB ETL off-peak or GPL peak-period travel time
- NB GPL travel times do not show noticeable changes after opening of ETL
- Travel time variation in the segments between NE 85th St to NE 160th St and between SR 520 to ST 522 (high travel time variability indicates lower reliability)
Effect of opening the ETL in September, 2015

- Travel times on all segments of the ETL are lower and more reliable compared with travel time on the HOV lanes before opening the ETL
- Noticeable but less dramatic improvement in SB ETL off-peak travel time
- Improvement in ETL peak-period travel times in all depicted common-trip segments
- No sustained change in GPL travel times
Average daily VMT increased throughout the corridor

- In the SB single ETL section, VMT increased on both GPL and ETL
- In the SB double ETL, VMT increased on both GPL and ETL
- In the NB single ETL section, VMT increased on both GPL and ETL
- In the NB double ETL section, VMT increased on both GPL and ETL
Average daily VMT increased throughout the corridor

- The corridor carries more vehicles after ETL opening
- Along with better travel times, this indicates a better-performing corridor
- For comparison, the average Washington State VMT increased in 2014 by 1.7%; in 2015 by 3.6%; and in 2016 by 2.7%

<table>
<thead>
<tr>
<th></th>
<th>GPL</th>
<th>HOV/ETL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northbound</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan-Jun 2015</td>
<td>924,600</td>
<td>144,342</td>
<td>1,068,942</td>
</tr>
<tr>
<td>Jan-Jun 2017</td>
<td>936,339</td>
<td>229,857</td>
<td>1,166,195</td>
</tr>
<tr>
<td>Percent Change</td>
<td>1.3%</td>
<td>59.2%</td>
<td>9.1%</td>
</tr>
<tr>
<td><strong>Southbound</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan-Jun 2015</td>
<td>983,689</td>
<td>137,213</td>
<td>1,120,903</td>
</tr>
<tr>
<td>Jan-Jun 2017</td>
<td>1,067,442</td>
<td>266,858</td>
<td>1,334,299</td>
</tr>
<tr>
<td>Percent Increase</td>
<td>8.5%</td>
<td>94.5%</td>
<td>19.0%</td>
</tr>
</tbody>
</table>
ETL volume in peak period increased more than its capacity increase

<table>
<thead>
<tr>
<th>Direction</th>
<th>Section</th>
<th>Lane Type</th>
<th>Jan'15-Jun'15 Avg</th>
<th>Jan'17-Jun'17 Avg</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>Single</td>
<td>GPL</td>
<td>102,903</td>
<td>105,754</td>
<td>2.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HOV/ETL</td>
<td>25,441</td>
<td>36,451</td>
<td>43.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>128,344</td>
<td>142,205</td>
<td>10.8%</td>
</tr>
<tr>
<td></td>
<td>Double</td>
<td>GPL</td>
<td>133,248</td>
<td>128,228</td>
<td>-3.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HOV/ETL</td>
<td>32,039</td>
<td>79,584</td>
<td>148.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>165,287</td>
<td>207,812</td>
<td>25.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total NB</td>
<td>293,632</td>
<td>350,017</td>
<td>19.2%</td>
</tr>
<tr>
<td>SB</td>
<td>Single</td>
<td>GPL</td>
<td>86,252</td>
<td>104,724</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HOV/ETL</td>
<td>20,972</td>
<td>29,588</td>
<td>41.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>107,224</td>
<td>134,312</td>
<td>25.3%</td>
</tr>
<tr>
<td></td>
<td>Double</td>
<td>GPL</td>
<td>147,249</td>
<td>150,812</td>
<td>2.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HOV/ETL</td>
<td>21,855</td>
<td>74,987</td>
<td>243.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>169,104</td>
<td>225,799</td>
<td>33.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total SB</td>
<td>276,328</td>
<td>360,111</td>
<td>30.3%</td>
</tr>
</tbody>
</table>
ETL & GPL Speed Profiles

We analyzed monthly lane type speed throughout the corridor, by time of day. This led us to our conclusions about the percent of time the ETL was above 45 mph.

<table>
<thead>
<tr>
<th>Northbound, % ETL above 45 mph</th>
<th>85%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound, % ETL above 45 mph</td>
<td>78%</td>
</tr>
</tbody>
</table>
This is a **key finding** in our study: the maximum toll in the ETL during peak hours is too low to keep traffic flowing at or above 45 mph 90% of the time.

In peak hours, drivers entering the ETL “lock in” a toll rate that doesn’t always reflect building traffic volume. Drivers paid as much as $4 less than what was required to keep traffic flowing, based on the traffic in the corridor at the end of their trip.
Maximum toll rate reached too frequently to keep the ETL moving at 45 mph 90% of the time

In a well-functioning corridor, the maximum toll is paid only rarely.

That’s because the toll should increase to the point where drivers choose not to enter the toll lane – thus ensuring the free-flow of traffic in the ETL.
ETL Facility Breakdown

THE PROBLEM: ETL speeds falling short of 45 mph threshold + facility breaking down too often.

THE CAUSE: Toll rates not responding fast enough to volume changes + motorists allowed to lock in toll rates not reflective of actual conditions.

Lighter traffic volume at start  | Express Toll Lane (ETL) | Heavier traffic volume at end

When vehicle enters ETL, the price is appropriate for current level of traffic several miles downstream.

When this vehicle reaches a low capacity point several miles down the road it will contribute to a flow breakdown and generate recurrent congestion.
Corridor Performance Findings

1. ETL speed performance measure not met
2. Speed improved after transforming HOV lane to ETL
3. ETL facility increasing corridor throughput
4. GPL Speeds showed no significant change
5. ETL toll rates max out during 15 percent of peak period
6. Tolling algorithm is not optimally responsive and toll rate is too low as traffic volume builds
Many factors are impacting the GPL speeds:

- Opening of the 1.8-mile northbound shoulder lane
- Recent changes in striping, signage and merge lanes
- Population growth in the area
- Change in carpool rules from 2+ HOV to 3+ HOV

Relative impact of multiple variables on corridor performance cannot be measured without the use of more sophisticated traffic modeling.
Recommendations

Top Tier Short-Term Recommendations
- Impact achievable in short term
- Best hope to reduce current congestion & improve corridor performance

Second Tier Short-Term Recommendations
- Impact achievable in short term
- Would reduce current congestion & improve corridor performance

Long-term Recommendations
- Require a longer period of time to implement
- Would reduce current congestion & improve corridor performance
Recommendations

Top Tier Short-Term Recommendations

1. Improve ETL speed through a more responsive dynamic toll algorithm

2. Improve ETL speed through segmented corridor tolling
Second Tier Short-Term Recommendations

3. Move toward an “open access” ETL facility to smooth lane transfer

4. Increase maximum toll rate to reduce ETL breakdown

5. Adjust AM peak period times to increase ETL speed
Recommendations

Long-Term Recommendations

6. Extend second full ETL in each direction to improve ETL speed and capacity

7. Add capacity to ensure lane continuity and ease bottlenecks

8. Increase transit options to improve throughput and speed
Recommended Future Studies

• Analyze corridor travel demand patterns by origin-destination and alternative routes and propose a pricing algorithm with prices varying by entrance ramp location.

• Conduct field tests of different price ranges and price change increments to determine Value of Time (VOT) and price elasticities.

• Develop a traffic simulation model to experiment with different pricing algorithms and to optimize pricing algorithm parameters.
The I-405 ETL facility is meeting statutory performance measure related to financial sustainability, but not the performance measure related to average ETL speeds.

• Due in part to overall traffic volume growth and a toll rate algorithm and pricing not adequately responsive to rapidly-increasing traffic volume during peak periods

As time passes and conditions change, even the most sophisticated ETL facilities require regular adjustments.

• Recommendations should be considered part of the natural evolution of the corridor, not criticisms of work that has been done in the past.
• Implementation of recommendations should improve I-405 ETL performance and increase throughput and efficiency
Questions?

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akhani@umn.edu
612-624-4411
Volume

• Lane-by-lane volume
• Every 20 sec
• Example:
  – SB peak period in the week of Jan 20, 2016
Speed

- Lane-by-lane speed
- Every 20 sec
- Example:
  - SB peak hours in the week of Jan 20, 2016
Lane-by-lane VMT changes

We analyzed VMT changes lane-by-lane throughout the corridor and generated graphs like this example

**Northbound**

- VMT on ETL1 is almost comparable to the previous HOV lane while ETL2 carries additional traffic. Overall, the ETLS carry greater traffic volume than HOV lane

- In the single ETL section, VMT changes on GPL are not significant. However, high VMT in the ETL indicates that the higher VMT in the single-lane section is primarily served by the ETL

**Southbound**

- VMT on ETL1 is almost comparable to the previous HOV lane while ETL2 carries additional traffic, so overall the ETL carries more traffic than the HOV lane

- VMT changes in the SB single ETL section are not significant
Southbound peak traffic starts later than the defined peak period.
ETL tolling data shows slow-downs by time and location

- Traffic slows significantly between 4:20 PM and 5:40 PM at SR 522
- …and between 4:35 PM and 5:15 PM at NE 116th

*Travel time ratio:*

*Example: NB peak hours in April 2017*
ETL tolling data shows volume and paid toll by time and location

Example: NB peak hours in April 2017