**Connected Vehicle Concepts**

**Connected Vehicle Equivalents to Detector Data**
- The trajectory view contains all the relevant information.
- Arrival times measured by a setback detector.
- Phase times measured by the local controller.

**Sampling Methodology Overview**

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**Using Connected Vehicle Equivalents to Detector Data**
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**Impact of Volume on Accuracy of Subset Profiles at Different Values of Market Penetration P**
- Statistical significance (P-value) of Kolsmogorov-Smirnov Tests are shown.
  - p = 50%
  - p = 33%
  - p = 25%
  - p = 12.5%
  - p = 10%

**Methodology Overview**
- Complete data from measured arrivals was subsampled to develop example Connected Vehicle data for different market penetrations.
- Impact of sample period investigated:
  - T = 15 minutes used for "online" optimization.
  - T = 3 hours used for "offline" optimization.
- 100 different iterations carried out for each market penetration level and sample period.
- Performance of sampled distributions for offset optimization compared by using the resulting settings into the complete-data model.

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**OFFSET-PERFORMANCE CURVES FOR DIFFERENT MARKET PENETRATIONS**

**Offline Optimization**
- T = 3 Hours
- Curves are very similar even for p = 1%
- Opportunity at low levels of market penetration

**Online Optimization**
- T = 15 Minutes
- Curves are very similar for p = 10%
- The p = 1% curve is not very accurate
- Opportunity at moderate levels of market penetration

**Extended Offline Optimization**
- T = 9 Hours (3 Hours over Three Days)
- Curves are very similar even for p = 0.1%
- Opportunity at very low levels of market penetration

**SENSITIVITY OF OFFSET OPTIMIZATION OUTCOMES TO MARKET PENETRATION RATE**

**Offline Optimization**
- T = 3 Hours
- All solutions were better than existing offsets at p = 5%
- Over 75% of solutions were better than existing offsets at p = 1%
- Not viable beneath p = 1%

**Online Optimization**
- T = 15 Minutes
- All solutions were better than existing offsets at p = 50%
- Over 75% of solutions better than existing offsets at p = 10% and p = 5%
- Not viable beneath p = 5%

**EXAMPLE REAL-WORLD CONNECTED VEHICLE TRAJECTORY DATA**

**Southbound, SR 37, Fishers, IN**
- p = 0.8%

**Northbound, SR 37, Fishers, IN**
- p = 0.6%

**OVERVIEW OF RESULTS**
- Solution quality varied with market penetration as expected.
- Opportunities for detector-free offset optimization exist at relatively low levels of market penetration:
  - For "online" optimization (T = 15 min), p = 5% may be viable
  - For "offline" optimization (T = 3 hr), p = 1% may be viable
  - Layering multiple days of data might make even lower rates viable
- Some example real-world data shown in poster. The equivalent level of penetration is approximately 0.6–0.8%.
- Primary barrier to implementation will likely be time synchronization between data sets.