Pooled Fund Study: Work Zone Analytics

Background & Impact

For the past 3 years, Purdue University and the Indiana Department of transportation have been monitoring congestion and hard braking data across all 2600 miles of Indiana Interstates using connected vehicle data. Figure 1 illustrates one such report for I-465 that shows the impact of the 2021 construction activities on congestion.

However, hard braking data has been found to be even more insightful and is a modern day surrogate for looking for skid marks on the road (Figure 2). For example, if one looks at hard braking connected vehicle data shown in Figure 3, one can see the horizontal line of hard braking at approximately MM 154.4, the same location as the Figure 2 photo that shows the entry into the work zone and the skid marks. Furthermore, one can visualize the impact of a crash that occurred in the work zone at approximately 11:00 a.m., and the subsequent queue that extended approximately 5.5 miles. One can also see numerous hard braking at the back of the queue as free flow traffic approached the queued traffic and suddenly slowed.

Figure 4 provides a crisp example of how these hard braking can be used to identify specific locations along a road that should be looked at further by comparing the before construction (Figure 4a) with the connected vehicle hard braking data during construction (Figure 4b).

Figure 5 and Figure 6 provide similar examples of specific work zone locations highlighted by a change in hard-braking activity which were then mapped using drone imagery to identify contributing factors the cause of the hard-braking.

Research Need

These reports have evolved over the past 3 years in Indiana and there is a need to develop a multi-state consensus on the most effective reports. This will provide a framework to formalize the reporting models, data reduction processes and decision making process so these techniques can be scaled to other states so they can pro-actively identify emerging safety concerns in their work zones, conduct effective after action reviews of past work zones, and ultimately identify best practices for future work zones that minimize congestion, hard braking and ultimately crashes.

Research Tasks

1. Meet with panel members to review work zone analytic reports that can be produced with existing data was well as formulate prioritized list of desirable modifications/additions to those reports. Developing a shared vision among multiple states will facilitate scaling this data and stimulate engagement with the connected vehicle data providers. For example, hard braking is useful, but there may be some opportunities to adjust or provide variable hard braking thresholds.
2. Identify commercial probe data sets that are available and procure probe data for each participating state. Data will include passenger car trajectories and passenger car hard braking, and commercial truck trajectories. There are also emerging data sets
    a. From trucks that provide hard braking and lateral deviation.
    b. From passenger cars that provide lateral deviation and lane marking quality.
3. Perform penetration analysis of connected vehicle data to understand how it varies by state. There is broad interest in ensuring that the connected vehicle data is representative and has sufficient penetration to provide accurate performance measures.
4. Prepare weekly work zone safety and mobility analytics report that can be distributed to the panel. This report will include congestion, queueing and hard braking.
5. Conduct monthly webinars with participating states to review their reports, highlight emerging locations of safety and mobility concerns, and compare and contrast emerging best practices.

6. Hard braking thresholds (currently 2.67 m/s^2) have historically been defined by vehicle OEM's and have been shown to correlate reasonably well . An important part of this task will be coordinating with connected vehicle vendors to obtain and/or derive alternative hard braking thresholds to develop an industry consensus if the 2.67 m/s^2 is a recommended threshold or if other instantaneous or short term hard braking data would provide better insights on work zone operations and risks. This task will include both 2023 data as well as historical data to ensure a large data sample.
7. Convene in person panel meeting of participating states and key stakeholders to review the lessons learned and feedback obtained during Task 4, 5 and 6 to obtain consensus on final recommended data items to collect and the reporting format.
8. Prepare final report that summarizes research and has a recommended implementation plan for states to deploy weekly work zone analytics.

Funding Request

- $30,000 /yr per participating state for 3 years.
- 6 states (Total Budget $540,000)

Proposed Start Date
July 1, 2023

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References

1. Desai, J., Li, H., Mathew, J.K. et al. Correlating Hard-Braking Activity with Crash Occurrences on Interstate Construction Projects in Indiana. J. Big Data Anal. Transp. 3, 27–41 (2021). https://doi.org/10.1007/s42421-020-00024-x
2. Mathew, J.K., J.C. Desai, R.S. Sakhare, W. Kim, H. Li, and D.M. Bullock, "Big Data Applications for Managing Roadways," ITE Journal, Institute of Transportation Engineers, February 2021. https://www.nxtbook.com/ygsreprints/ITE/ite-journal-february-2021/index.php#/p/28
3. Hunter, M., Mathew, J.K., Li, H. and Bullock, D.M. "Estimation of Connected Vehicle Penetration on US Roads in Indiana, Ohio, and Pennsylvania." Journal of Transportation Technologies, 11, 597-610. (2021) https://doi.org/10.4236/jtts.2021.114037
4. Sakhare, R., Desai, J., Mathew, J., McGregor, J. and Bullock, D. (2021) "Evaluation of the Impact of Presence Lighting and Digital Speed Limit Trailers on Interstate Speeds in Indiana Work Zones," Journal of Transportation Technologies, 11, 157-167. https://doi.org/10.4236/jtts.2021.112010

5. Mathew, J.K., Desai, J., Li, H. and Bullock, D.M. "Using Anonymous Connected Vehicle Data to Evaluate Impact of Speed Feedback Displays, Speed Limit Signs and Roadway Features on Interstate Work Zones Speeds." Journal of Transportation Technologies, 11, 545-560. (2021) https://doi.org/10.4236/jtts.2021.114034
6. Sakhare, R.S.; Desai, J.; Li, H.; Kachler, M.A.; Bullock, D.M. Methodology for Monitoring Work Zones Traffic Operations Using Connected Vehicle Data. Safety 2022, 8, 41. https://doi.org/10.3390/safety8020041

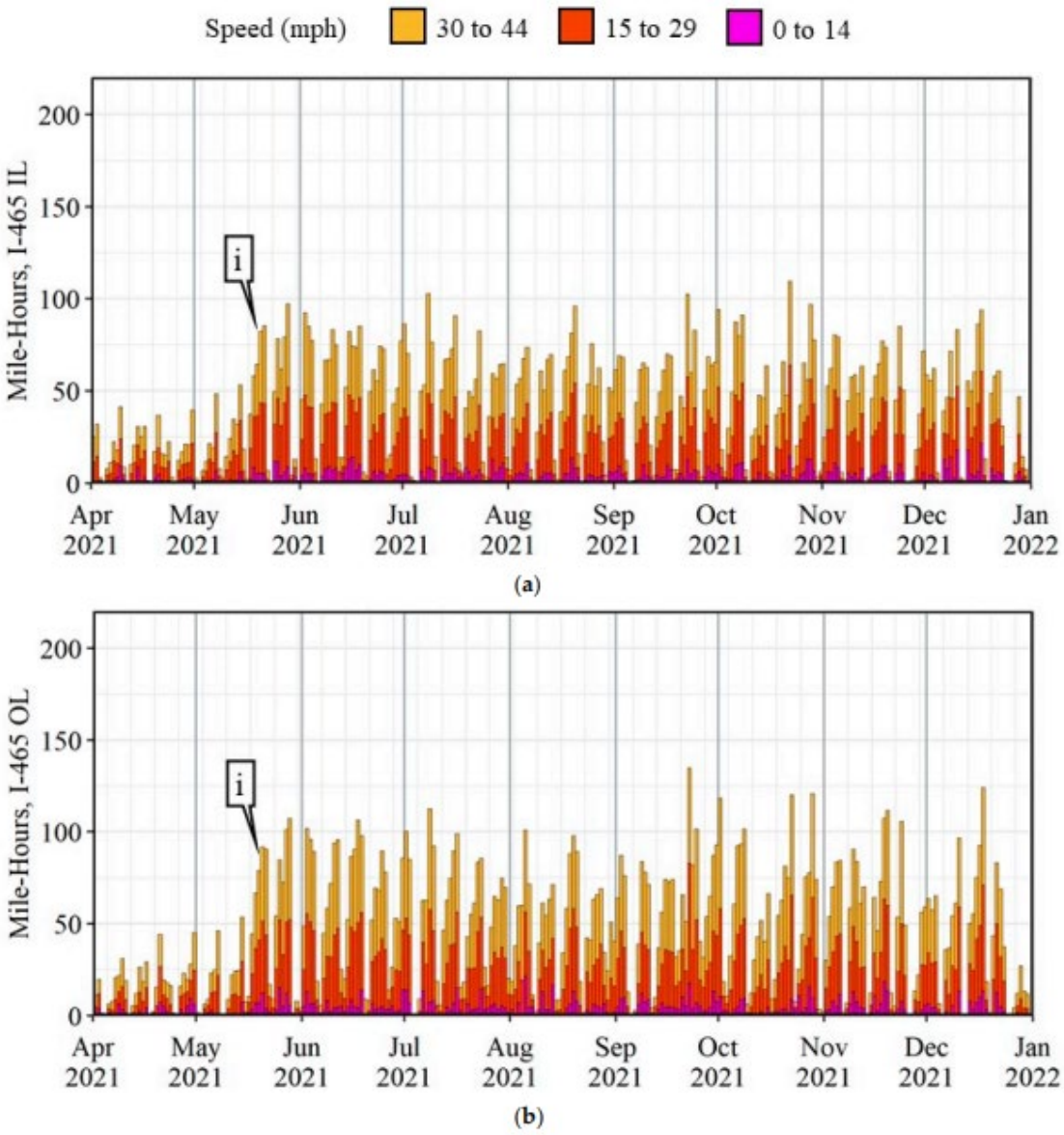

Figure 1: Congestion on the inner loop (a) and outer loop (b) of I-465 by speed bin.

Figure 2: Example skid mark (s) on NB I 65 at MM 154.4.

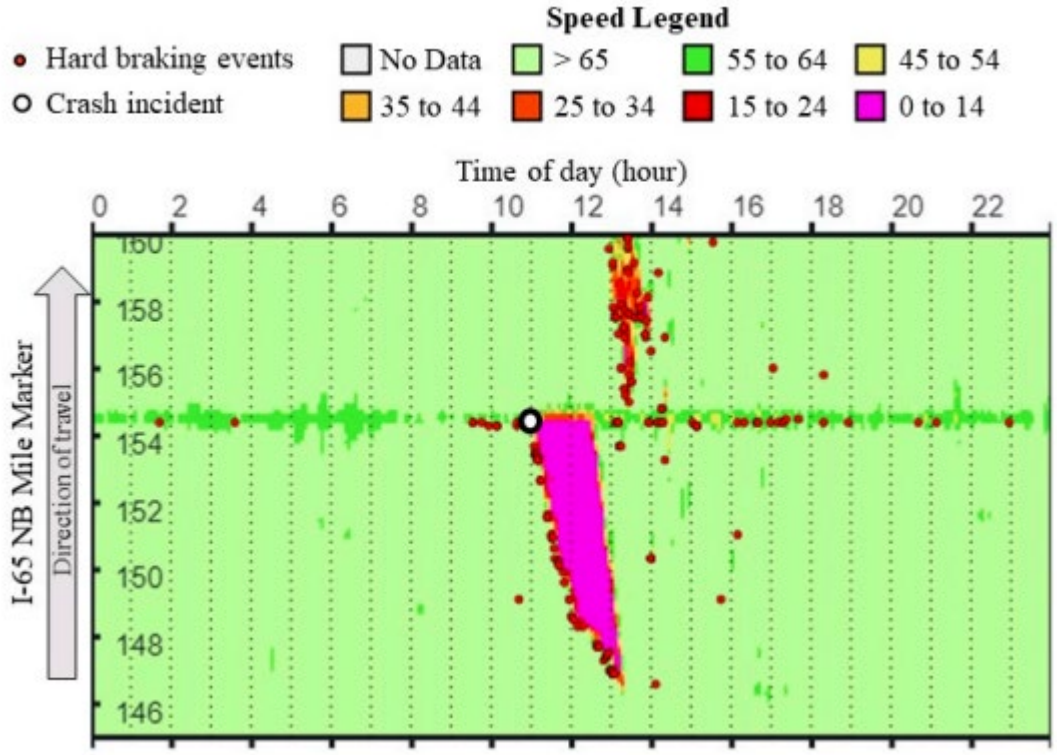

Figure 3: Plot of connected vehicle speeds and hard braking by mile marker (vertical axis) and time of day (horizontal axis)

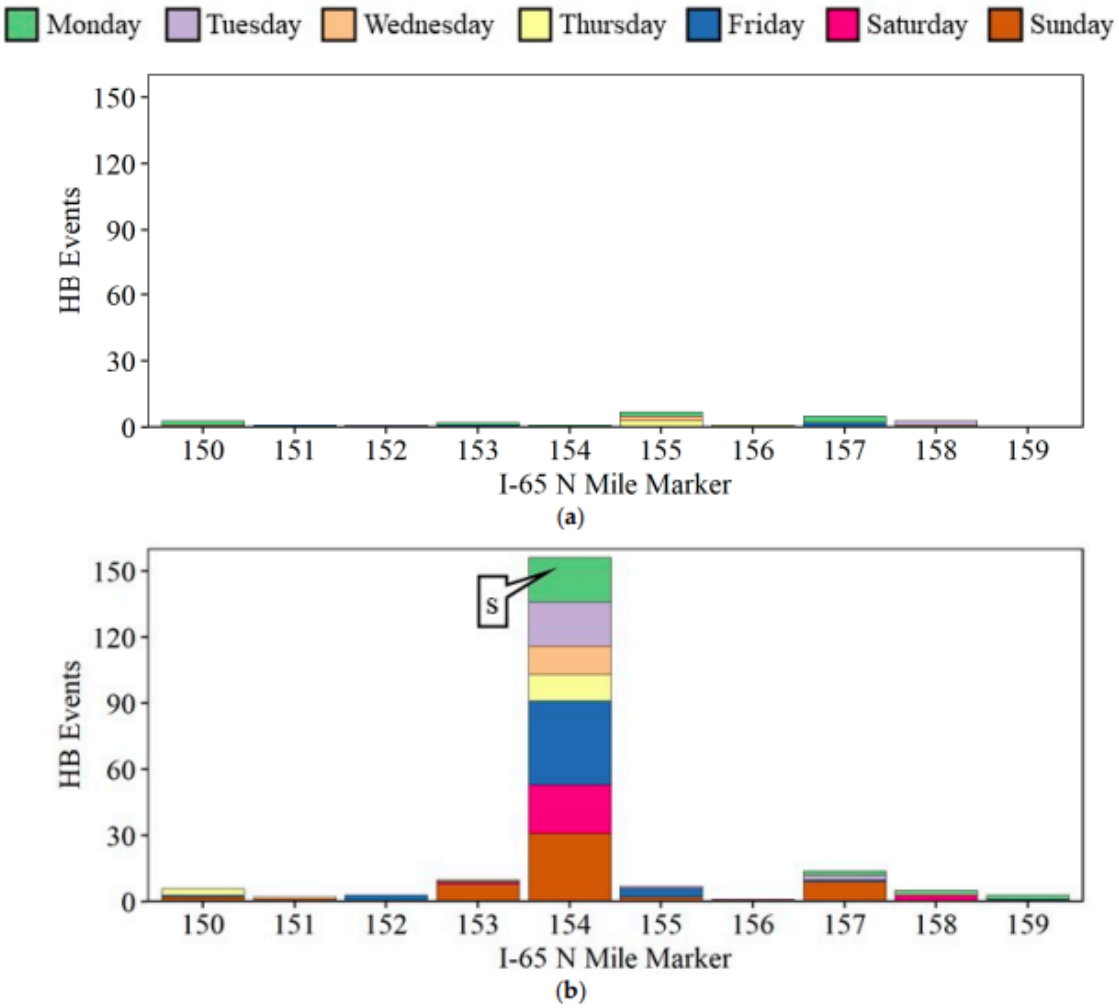

Figure 4: Plot of hard braking by mile marker on I-65 before construction (a) and during construction work zone (b)