THE SECOND STRATEGIC HIGHWAY RESEARCH PROGRAM PRODUCT IMPLEMENTATION AND TESTING IN MARYLAND: ESTABLISHING MONITORING PROGRAMS FOR MOBILITY AND TRAVEL TIME RELIABILITY

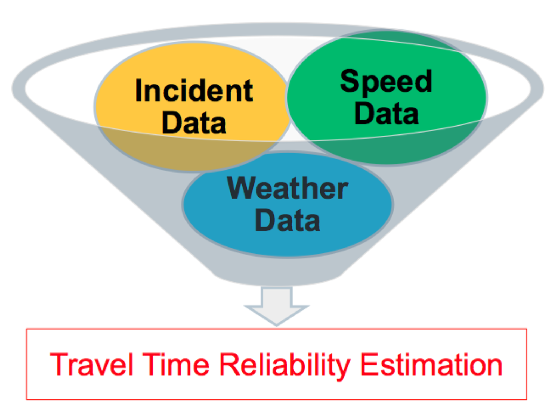
Golnush Masghati Amoli, Yeming Hao, Kaveh Farokhi Sadabadi, Thomas H. Jacobs
Center for Advanced Transportation Technology, University of Maryland, College Park, MD 20742, USA

Abstract

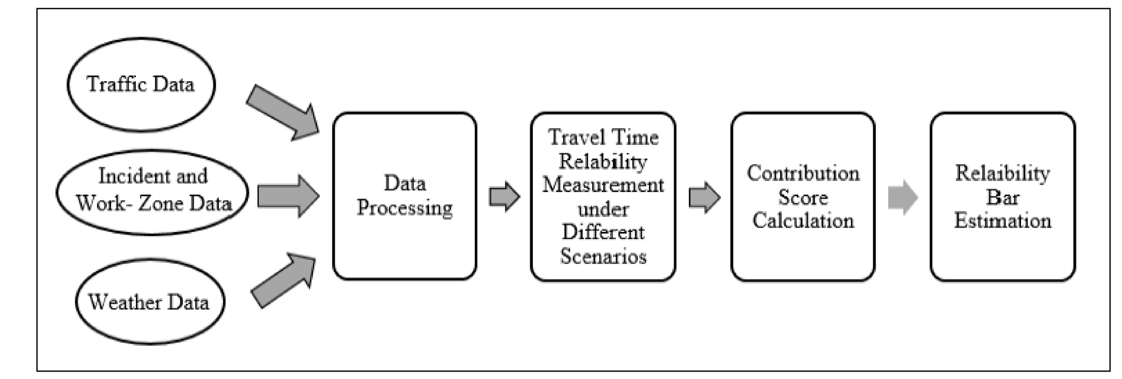
This study aims to develop an efficient algorithm to measure travel time reliability along a corridor, using real-world data, under different congestion, incident, and weather operating conditions. Three types of incidents are studied: crash, disabled-vehicle, and work-zone. The only weather condition evaluated is precipitation. The developed algorithm is a variation of the Travel Time Reliability Monitoring System (TTRMS) developed within the Second Strategic Highway Research Program (SHRP 2), project L02. It employs a new approach to generate a more diverse set of corridor travel time reliability scenarios and produces Cumulative Density Function (CDF) of travel times under each scenario. It also estimates a contribution score for each single congestion, incident, and weather operating condition, which quantifies the extent of their contribution to the travel time reliability performance of the corridor. The scores are then used to provide reliability bars aimed at decomposing the reliability in corridor travel times into its top three contributors. The developed algorithm was applied to a number of sub-corridors along I-95 corridor in Maryland for the calendar year 2015. Crashes were seen to be the number one contributor to travel time reliability in 75% of the sub-corridors. The results revealed that, on average, crash, precipitation and disabled-vehicle contributed respectively 43%, 34%, and 23% to the travel time reliability along the north-bound sub-corridors. On the south-bound sub-corridors, crash and precipitation constituted, on average, 34% and 25% of travel time reliability and the rest was distributed uniformly among disabled-vehicle, work-zone and high congestion.

Introduction

- This study is sponsored by **Maryland State Highway Administration (MD-SHA).**
- It introduces a variation of the **Travel Time Reliability Monitoring System (TTRMS)** developed within the **Second Strategic Highway Research Program (SHRP 2), project L02.** The developed algorithm is capable of evaluating **travel time reliability** under a comprehensive set **of weather, incident and congestion scenarios**.
- **Real world incident, speed and weather data** are used to determine the **CDF of travel times under different weather, incident and congestion scenarios** and a newly defined **score** is introduced that **measures the contribution of different weather, incident and congestion operating condition to travel time reliability**.
- The operating conditions evaluated in this study are:
  - Incidents
    - ❑ **Crash**
    - ❑ **Disabled Vehicle**
    - ❑ **Work-Zone**
  - Congestion
    - ❑ **Uncongested**
    - ❑ **Low Congestion**
    - ❑ **Moderate Congestion**
    - ❑ **High Congestion**
  - Weather
    - ❑ **Precipitation**
- Significance of Study:
  - ❑ Use of **real world data** for evaluating travel time reliability.
  - ❑ Development of a **new algorithm** capable of identifying the **Distribution of Travel Time under a comprehensive set of weather, incident, and congestion scenarios**
  - ❑ Development of a **newly defined Score** aimed at **quantifying the contribution of different weather, incident and congestion operating condition to travel time reliability**.
  - ❑ Development of **Reliability Bars** aimed at **decomposing variability in travel time to its root causes.**



Methodology



- **Data Processing:**
  - ❑ **Traffic Data:** For each TMC along a corridor of interest, VPP speed data were accessed and downloaded with a resolution of one minute, resulting in 525,600 records for one calendar year and interpolation techniques were used to deal with missing values.
  - ❑ **Incident Data:** Incidents were matched to TMCs based on their recorded latitude and longitude. The date, time, and duration of the incidents was used to tag the VPP speed data for each TMC with the corresponding events occurred at the time of recordings.
  - ❑ **Weather Data:** Weather data for each TMC was downloaded from weather stations' historical databases based on TMC zip codes. If historical weather data was missed for any of the weather stations for a period of time, the weather data from adjacent station was used.
- **Travel Time Estimation:**

$$TT^t_{corridor} = TT^t_{TMC1} + TT^t_{TMC2} + \dots + TT^t_{TMCn}$$

where, $TT^t_{corridor}$ = travel time along the corridor at time t

TT^t_{TMCi} = *travel time of TMC$_i$ at time t*

- **Scenario Generation:**
  - ❑ **K-means clustering** technique was used to generate scenarios.
  - ❑ Scenarios were generated as a combination of **six operating conditions**:
    - **Congestion, Crash, Disabled Vehicle, Work Zone, Precipitation,** and **None** (representing the normal condition)
  - ❑ **Congestion** itself was subdivided to **four categories** based on the **normalized semi-variance of travel rate.**

$$\bar{\sigma}^t_i = (S_{FFS}/S^t_i - 1)$$

where, $\bar{\sigma}^t_i$ = normalized semi-variance of travel rate along corridor i at time t

S_{FFS} = Free Flow Speed

S^t_i = Speed along the corridor i at time t

Thresholds Used to Define Congestion Levels

Normalized Semi-Variance of Travel Rate	Congestion Level	Speed Level (mph)
<0.21	Uncongested	>60
0.21-0.31	Low Congestion	55 - 60
0.31-0.53	Moderately Congested	45-55
>0.53	Highly Congested	<45

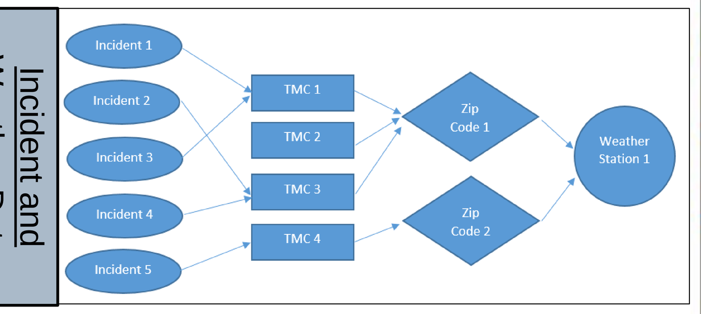
- **Contribution Score Calculation**

$$S_i = \frac{\text{No. of highly unreliable scenarios with event i}}{\text{Total No. of highly unreliable scenarios}} \times \text{Weighted Avg. of PTI of scenarios with event}$$

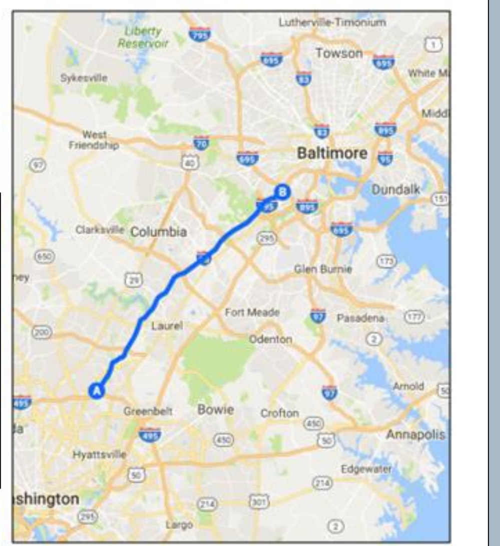
- **Reliability Bar Estimation**
  - ❑ **Estimated scores** were used to generate reliability bars to decompose the reliability in corridor travel time into its **top three sources** among the studied operating conditions.

Data

- **Traffic Data** was accessed and downloaded from **RITIS Vehicle Probe Project (VPP) database** for the list of **TMCs along I-95 corridor** for the **year 2014 and 2015.**
- **Incident Data** was accessed and downloaded from **RITIS incident database** for the **years 2014 and 2015** along **I-95 corridor** and contained information on:
  - ❑ Type of the incident: **Crash, disabled vehicle, and work zone,**
  - ❑ The location of the incident (**latitude and longitude**), and
  - ❑ Date, time and **duration of the incident.**
- The **historical weather data** was accessed from **Weather Underground website** for the **years 2014 and 2015** along **I-95 corridor** and contained information on weather condition such as **temperature, wind speed, and precipitation.**

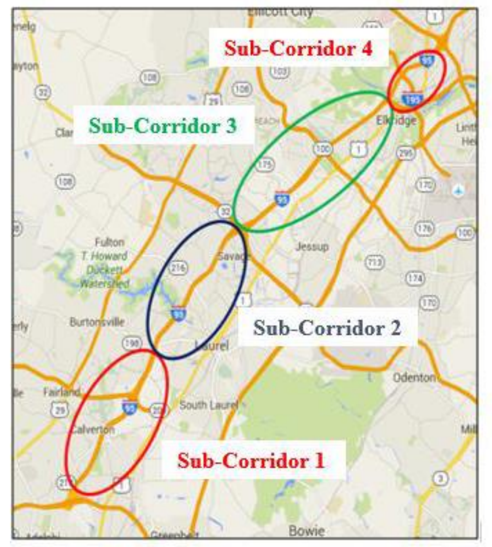


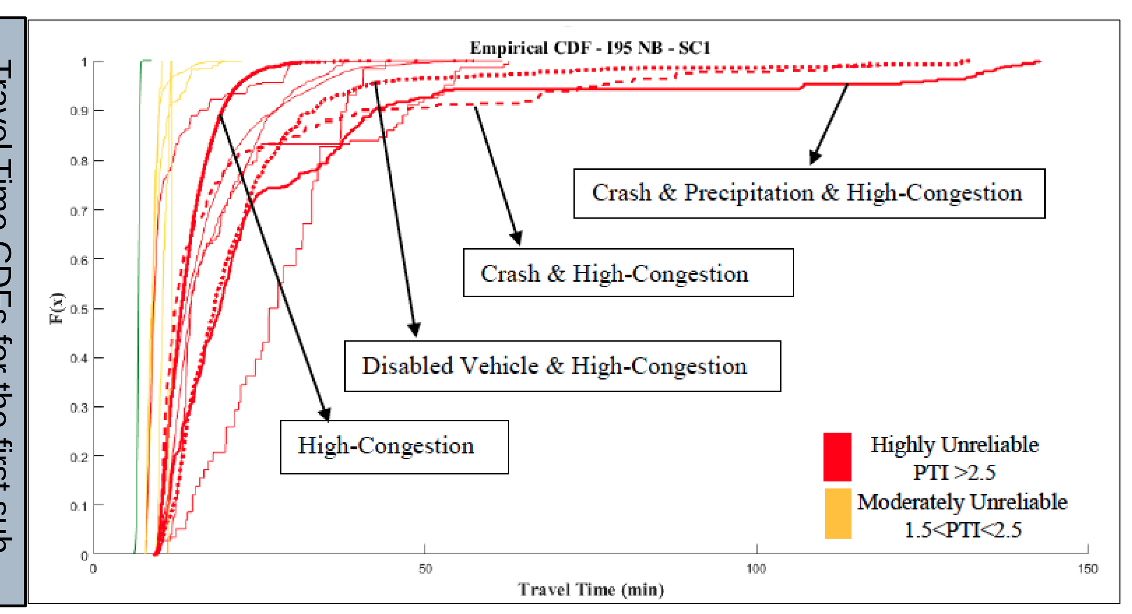
Incident and Weather Data Matching Process



Case Study

- Due to inconsistency in the geometry and demand over different segments of the corridor, the corridor was further divided into a number of sub-corridors defined **between significant access points to major residential and commercial areas** such that the **roadway geometry, weather condition** and **AADTs** are **homogeneous** along each sub-corridor:
- **Sub-corridor 1:** Between **I-495** and **MD-198 (Laurel)** with the length of **5 miles**
- **Sub-corridor 2:** Between **MD-198** and **MD-32 (Columbia)** with the length of **5 miles**
- **Sub-corridor 3:** Between **MD-32** and **I-895 (Baltimore-Washington International Thurgood Marshall (BWI) airport)** with the length of **6 miles**
- **Sub-corridor 4:** Between **I-895** to **I-695** with the length of **2.6 miles**





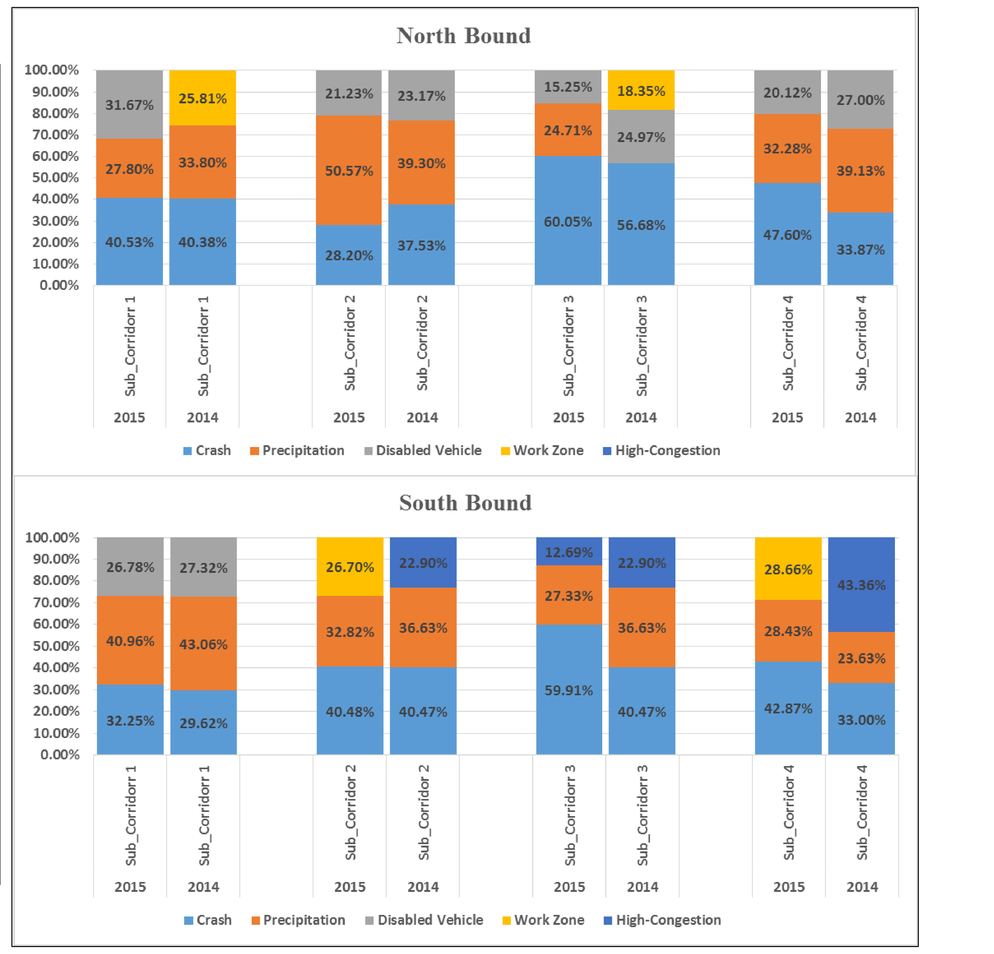
Travel Time CDFs for the first sub-corridor of I-95 NB / Year 2015

Result

Contribution Scores / Year 2015

			North-Bound			South-Bound		
			Score	Frequency (mins)	Rank	Score	Frequency (mins)	Rank
Sub-Corridor 1	From I-495 to MD-198	High-Congestion	0.36	16893	-	0.51	20176	-
		Crash	3.02	1721	1	1.8	1483	2
		Precipitation	2.07	5088	3	2.29	6670	1
		Disabled Vehicle	2.36	583	2	1.5	593	3
		Work Zone	1.46	1897	-	0.46	625	-
Sub-Corridor 2	From MD-198 to MD-32	High-Congestion	0.43	14549	-	0.52	4099	-
		Crash	1.12	1627	2	1.83	578	1
		Precipitation	2.00	8528	1	1.48	3824	2
		Disabled Vehicle	0.84	631	3	1.12	172	-
		Work Zone	0.67	562	-	1.2	212	3
Sub-Corridor 3	From MD-32 to I-895	High-Congestion	0.38	18199	-	0.66	12153	3
		Crash	3.85	1307	1	3.12	644	1
		Precipitation	1.59	7144	2	1.42	5382	2
		Disabled Vehicle	0.98	139	3	-	-	-
		Work Zone	0.49	1133	-	0.36	318	-
Sub-Corridor 4	From I-895 to I-695	High-Congestion	0.55	5095	-	0.56	11770	-
		Crash	3.06	559	1	3.03	1468	1
		Precipitation	2.08	2195	2	2.01	4808	3
		Disabled Vehicle	1.3	118	3	0.96	356	-
		Work Zone	0.66	103	-	2.03	3076	2

Reliability Bars / Years 2014 & 2015



Conclusion

- In overall, the developed algorithm provided a platform for the end users to find answers to the below questions:
  - ❑ What is the CDF of travel times in the system under different combinations of congestion, incident and weather operating conditions?
  - ❑ How to rank the contributors of travel time reliability in terms of the extent of their contribution?
  - ❑ What are the top three contributors to travel time reliability along a corridor over different time periods?
  - ❑ How effective are operational improvement actions in reducing the contribution of top three travel time reliability contributors resulting in more reliable travel times?

Contact Information

Golnush Masghati Amoli
Graduate Research Assistant

University of Maryland
College Park, MD 20742

Email:
golnush@umd.edu

www.PosterPresentations.com