Using Probe Data to Analyze Local and Regional Impact of I-85 Bridge Collapse in Atlanta

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Some background

> On March 30, 2017 a bridge on I-85 north of Atlanta collapsed from an intense fire, closing all five lanes of highway in each direction for 45 days

> This presentation goes into a deep-dive of how to analyze roadway network performance before, during and after the collapse

Photo by CNN

Data retrieval for deep-dive analyses

> Using the Massive Data Downloader, gathered data for:
>> – **Before collapse**
>> (Feb 13, 2017 to March 29, 2017)
>> – **During reconstruction**
>> (March 30, 2017 to May 13, 2017)
>> – **After reopening**
>> (May 14, 2017 to June 27, 2017)

> And to investigate seasonal travel effects:
>> – Corresponding time period in previous year
>> (Feb 13, 2016 to June 27, 2016)

> Data size:
>> – Approximately 14 GB; more than 228 million records.
>> – Detours and main routes were constructed by merging TMC codes.
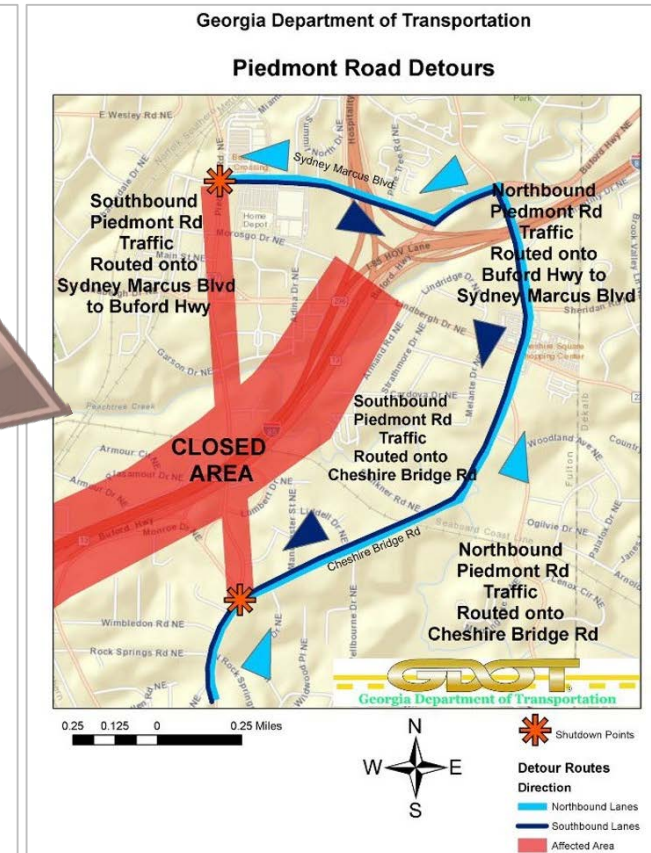
Local and regional analysis

> The impact of road closure on the local travel corridor near the collapse site, as well as changes in the regional traffic patterns were studied.

> **Local analysis:**
  – used congestion scan and bottleneck ranking tools in RITIS

> **Regional analysis:**
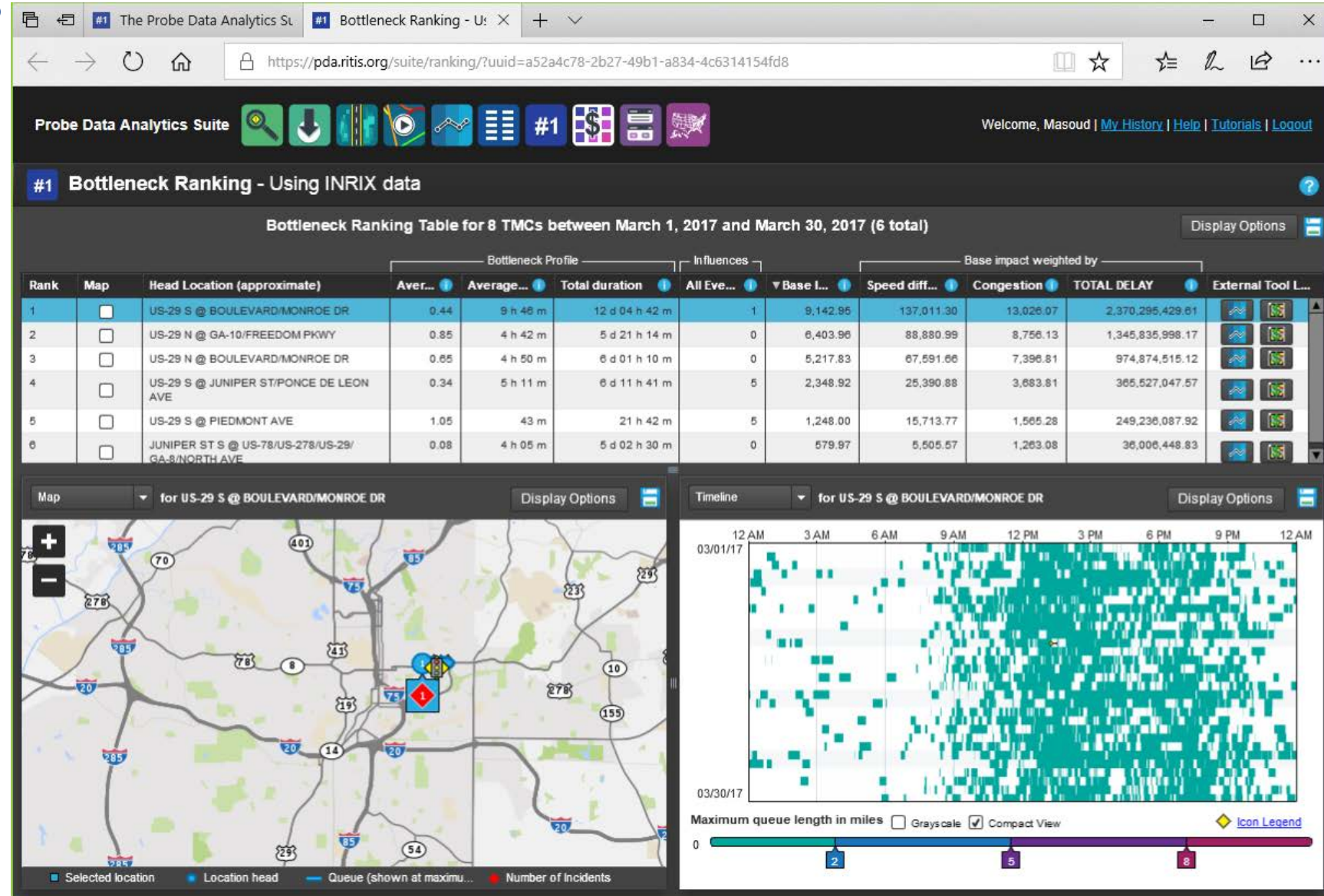 – developed python scripts to create performance measures

Regional Detours

I-85 DETOURS
Atlanta Travel Advisory: I-85 is closed between I-75 and SR 400.
Motorists are advised to use I-75, I-285 and I-20 until further notice.

400

75

85

SR 400 SOUTHBOUND:
EXIT AT
SIDNEY MARCUS BLVD.
OR TAKE I-85 NORTH

285   285

I-85 CLOSED BOTH DIRECTIONS
FROM I-75 TO SR 400

I-85 NORTHBOUND HOV LANE CLOSED

75
85
20   20

I-85 NORTHBOUND
DIVERTED TO BUFORD-
SPRING CONNECTOR
FOR LOCAL TRAVEL ONLY

UPDATED 4-1-2017   **ATLANTA**   GDOT
Georgia Department of Transportation

Local Detours

Georgia Department of Transportation
Piedmont Road Detours

Southbound
Piedmont Rd
Traffic
Routed onto
Sydney Marcus Blvd
to Buford Hwy

Northbound
Piedmont Rd
Traffic
Routed onto
Buford Hwy to
Sydney Marcus Blvd

Southbound
Piedmont Rd
Traffic
Routed onto
Cheshire Bridge Rd

CLOSED
AREA

Northbound
Piedmont Rd
Traffic
Routed onto
Cheshire Bridge Rd

0.25   0.125   0   0.25 Miles

GDOT
Georgia Department of Transportation

Shutdown Points

Detour Routes
Direction
— Northbound Lanes
— Southbound Lanes
Affected Area

Bottleneck Ranking

Bottleneck Ranking
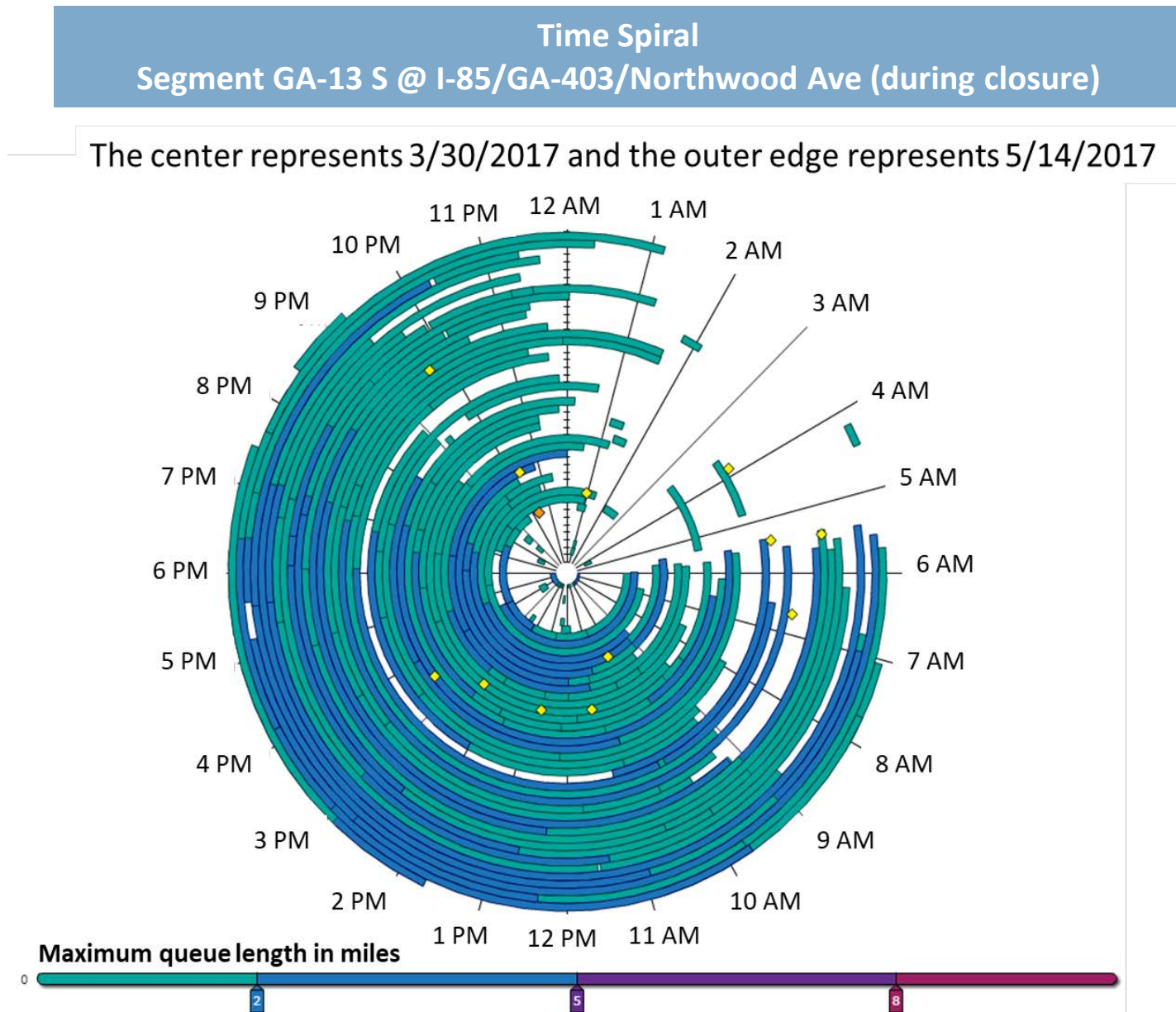
> This tool were used to find the location and intensity of bottlenecks "before", "during" and "after" the collapse

> Bottleneck Ranking was also used for the three corresponding time periods in the year prior to the event.

	Bottleneck Locations with Increased Impact Only During Closure								
RANK	Location	Direction	LENGTH (Mile)	2017			2016		
				BEFORE	DURING	AFTER	BEFORE	DURING	AFTER
1	GA-13 @ I-85/GA-403/NORTHWOOD AVE	SB	0.24	55499	410317	26363	39232	43541	32275
2	GA-42 @ US-78/US-23/US-278/US-29/GA-8	SB	1.36	36945	408120	20165	28288	32775	23603
3	US-29 @ DECATUR RD	NB	1.00	93123	297372	0	0	55797	0
4	US-23 @ GA-154/MEMORIAL DR	SB	0.98	18301	131578	7400	4836	0	5765
5	US-19 @ 17TH ST	SB	0.26	38847	129764	3815	29829	26429	17536
6	US-29S @ PIEDMONT AVE	SB	0.64	23251	94745	0	742	1643	16387
7	US-19N @ GA-236/LINDBERGH DR	NB	1.2	34180	80473	8683	11132	13639	18770
8	I-85 @ GA-13/EB EXIT 86	NB	0.24	2247	76890	1137	1007	1677	1635
9	I-85S @ GA-400/EB EXIT 87	SB	0.37	246	49770	291	102	652	1149
10	GA-400 @ SIDNEY MARCUS BLVD/EXIT 1	SB	0.39	423	33611	1750	200	276	767

GA-13, ranked 1st , experienced an Impact increase of **639%** during the bridge closure compared to the 'before' period, and was **1456%** higher than 'after' bridge reopening. This segment has observed more frequent, more intense, and lengthier congestion episodes compared to the locations with lower values.
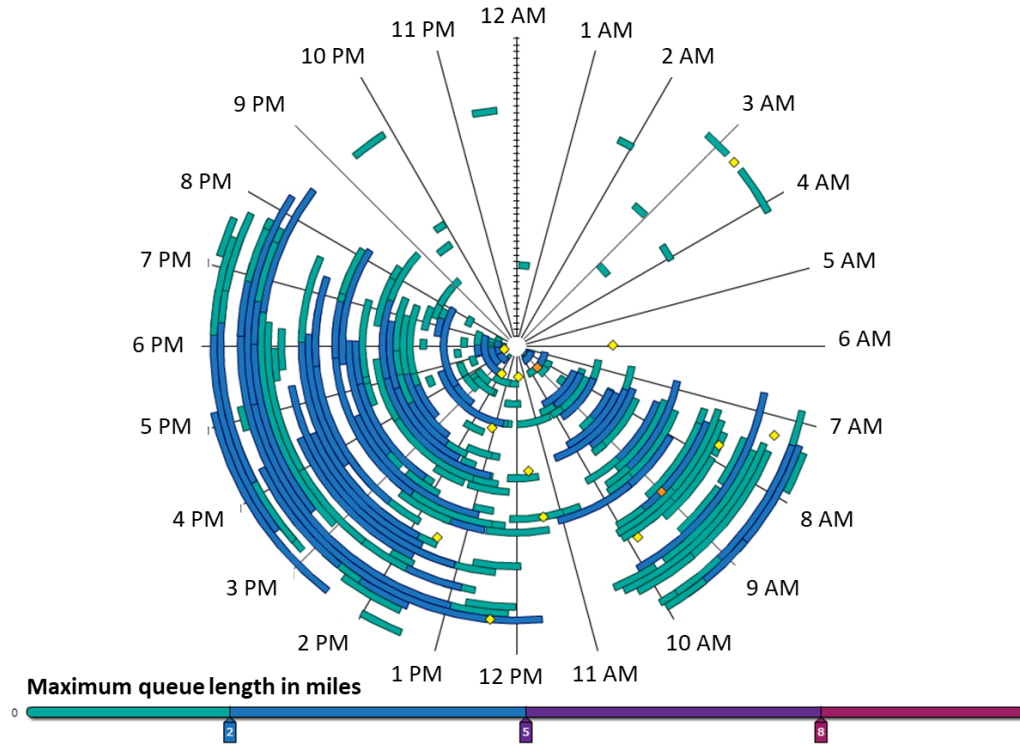
Time Spiral graphs

- The Time Spiral shows bottlenecks and events occurring at a selected location.

- These graphics help to clearly show changes in bottlenecks temporally, spatially and in intensity of the local and regional study areas.

- The Time Spiral for the top location during closure shows that the segment has been consistently congested from morning till evening almost everyday, with higher queue lengths in afternoon peak.
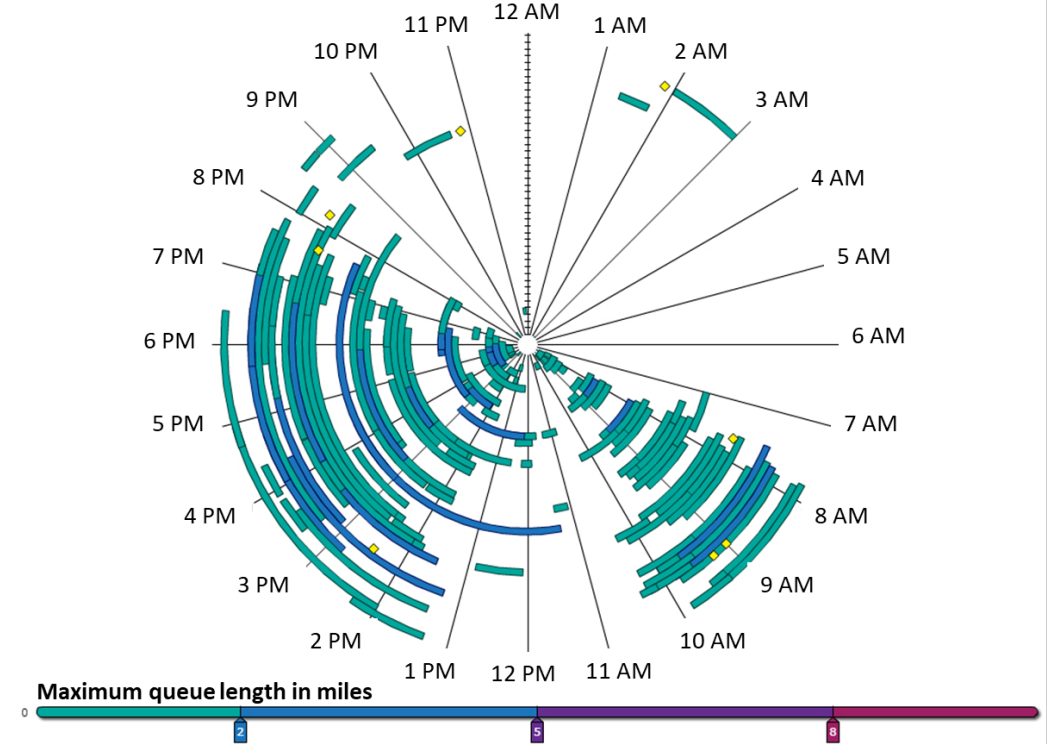

Time Spiral
Segment GA-13 S @ I-85/GA-403/Northwood Ave (during closure)

The center represents 3/30/2017 and the outer edge represents 5/14/2017

Maximum queue length in miles

Time Spiral graph comparison example

Spiral congestion graph of segment GA-13 S @ I-85/GA-403/Northwood

The center represents 2/13/2017 and the outer edge represents 3/30/2017

The center represents 5/14/2017 and the outer edge represents 6/28/2017

Before Collapse

After Opening

> Time Spiral graphs show some congestion relief after opening, partially due to seasonal travel changes as reflected in the analysis of data in the year prior to the event.

Bottleneck Ranking

> Going beyond the obvious analysis of the I-85 closure, the data can also be used to discover less conspicuous impacts to the local road network.

				2017			2016		
Bottleneck Locations with Increased Impact Only During Closure									
RANK	Location	**Direction**	**LENGTH (Mile)**	BEFORE	DURING	AFTER	BEFORE	DURING	AFTER
1	GA-13 @ I-85/GA-403/NORTHWOOD AVE	SB	0.24	55499	410317	26363	39232	43541	32275
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Comparing changes in 'before' and 'after' impact on this segment shows that after opening, congestion on this segment has not significantly increased relative to similar periods in 2016. This may be due to the change in drivers' route choice behavior where some shifted to the alternative route (GA-13) 'during' the closure and experienced better travel time, and kept using that route even after bridge opening.

Travel Time Index (TTI)

> Travel time reliability analysis was used for measuring uncertainty associated with speed volatility caused by congestion

> The open portion of I-85 has remained uncongested for **outbound traffic**, both in the morning and evening peak hours

> Conversely, it has been severely and heavily congested for the **inbound traffic** during morning and evening peaks, respectively


Congestion Level Comparisons (I-85 road closure period)
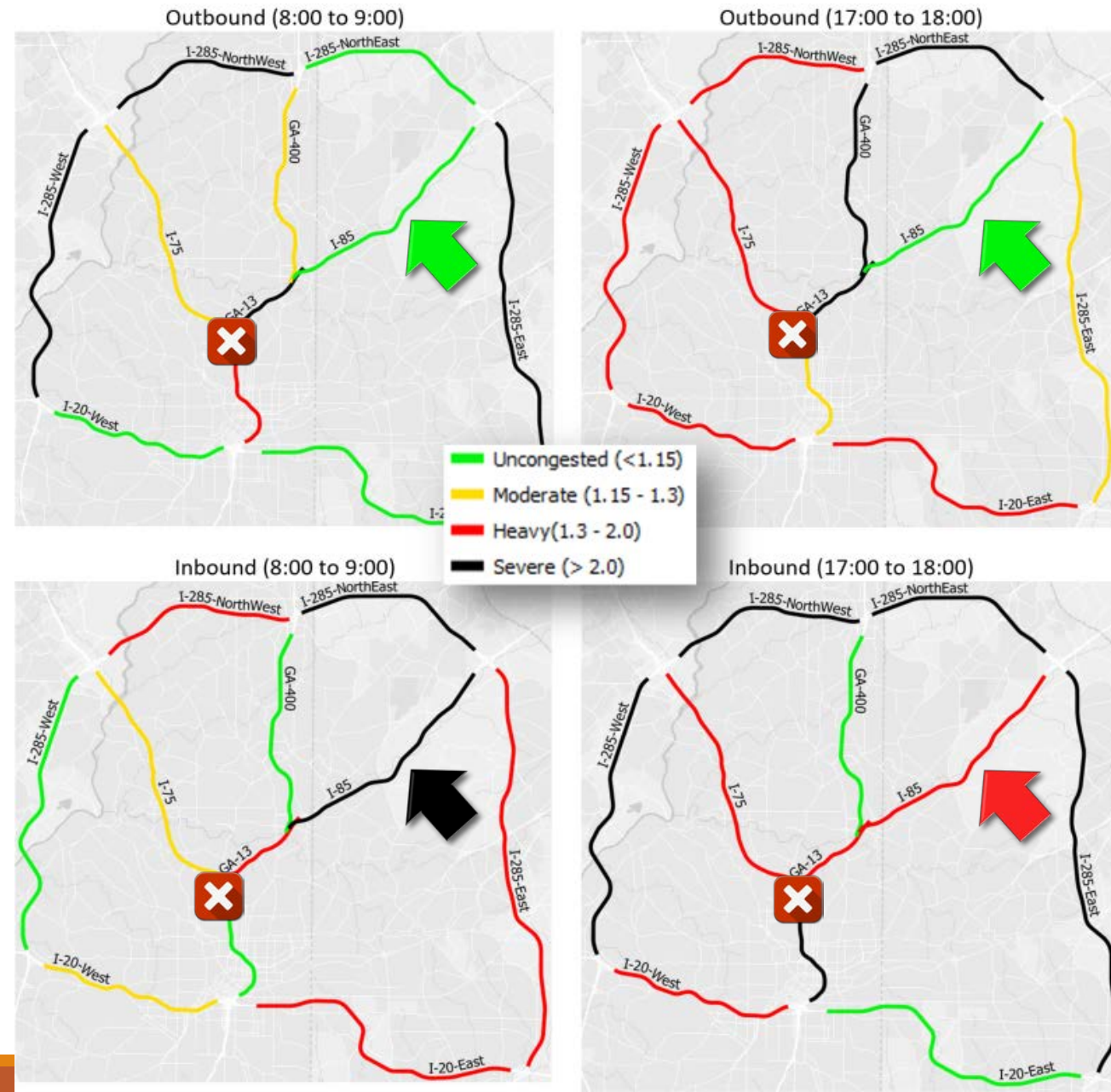
Travel Time Index (TTI)

> Congestion on GA-13, which is a parallel road next to the I-85 bridge collapse location, has become severely congested during the reconstruction period

> Congestion on GA-13 northbound for evening peak is much worse compared to the morning peak

> This is compatible with the bottleneck location analysis results discussed earlier, in which the 0.24 mile segment of GA-13 was ranked 1st


Congestion Level Comparisons (Before, During, After the Collapse)
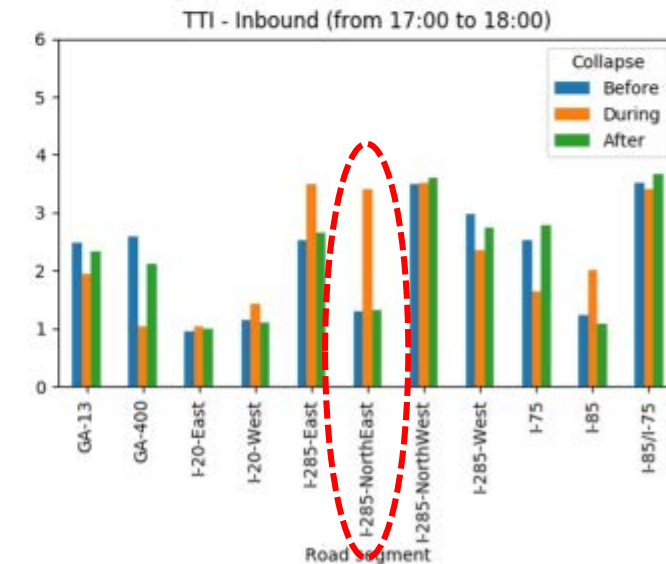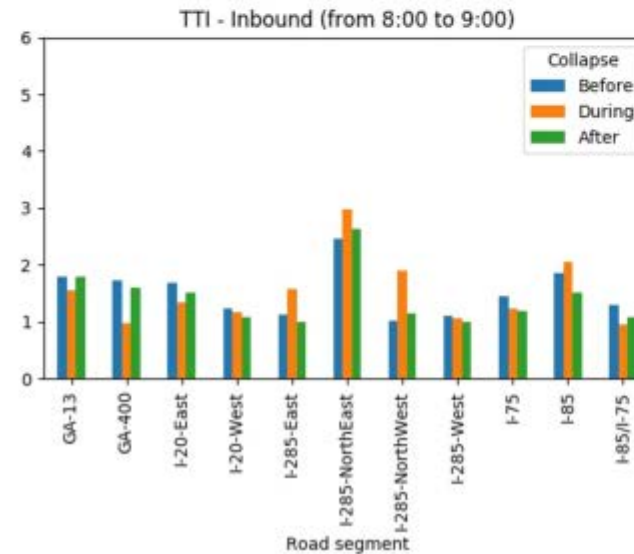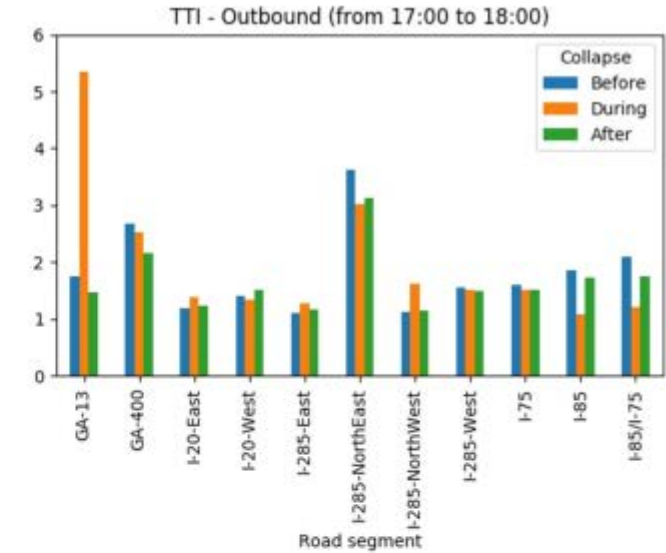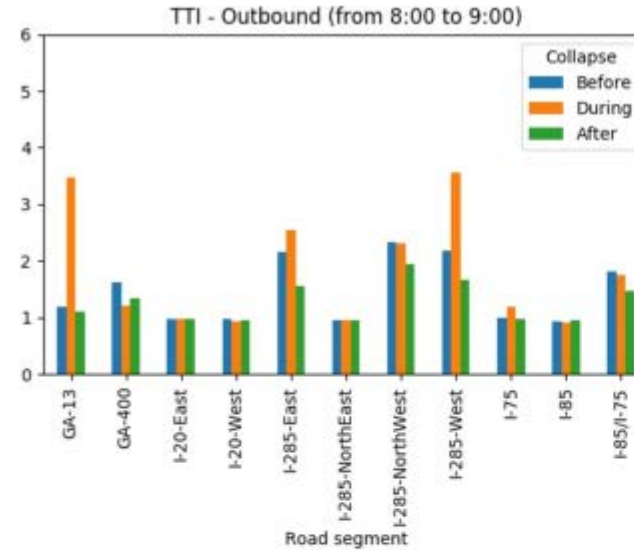
Travel Time Index (TTI)

> Similar calculations were performed based on the data for the year prior to the bridge collapse, and on the exact time periods

> GA-13 congestion levels in the year before the bridge closure have been much lower compared to the I-85 bridge closure time in 2017

> Majority of the segments in the study area, show increased TTI during the event when compared to the same interval in the year before


AM/PM Peak Hour Comparisons (Mar 30th – May 13th)
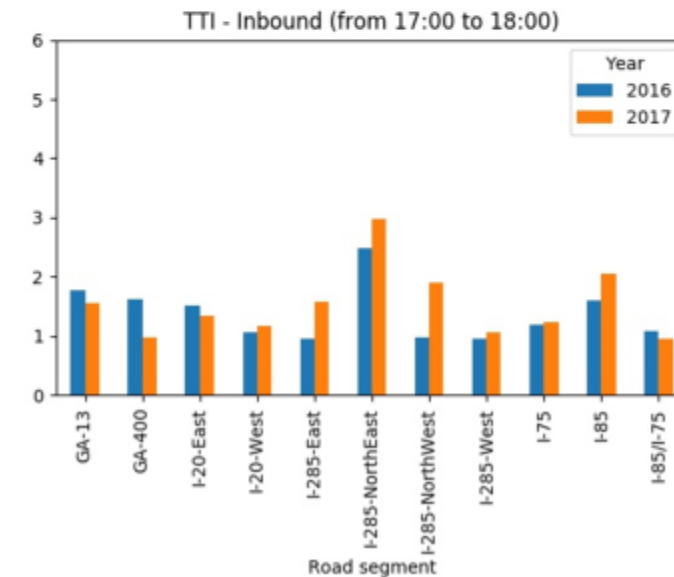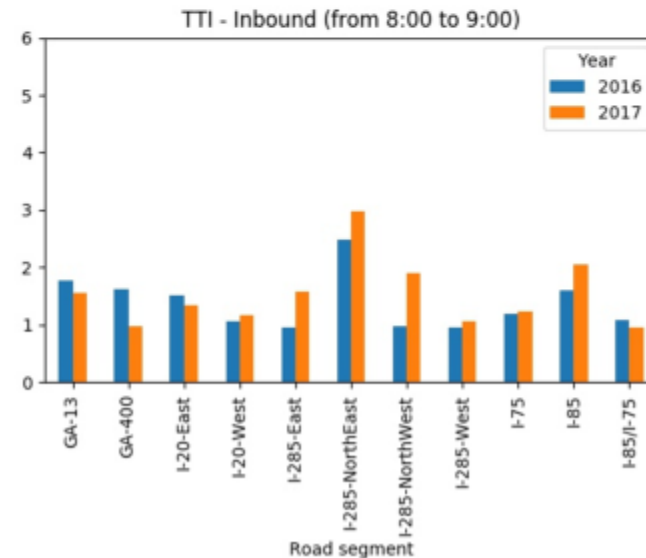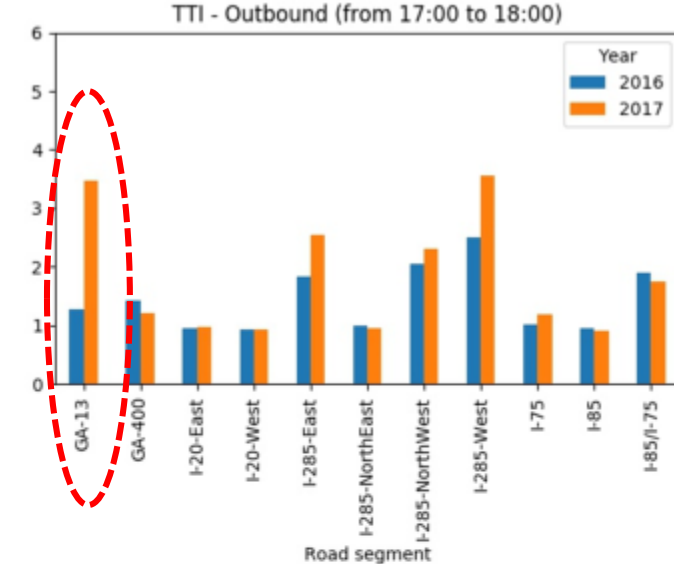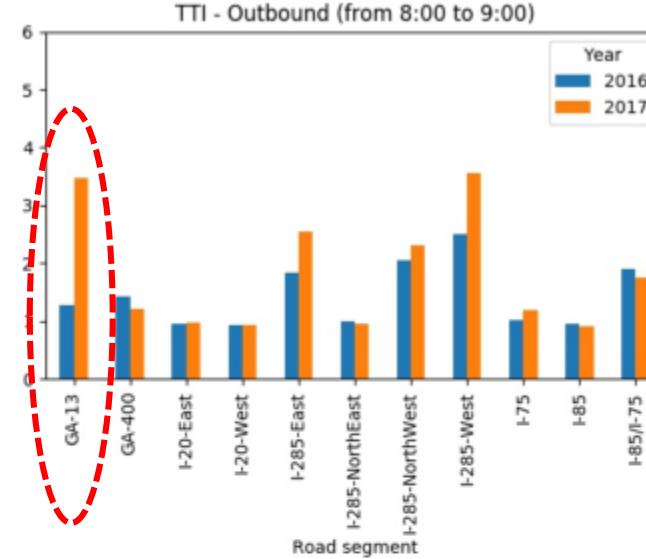
Weekly Travel Time Index (TTI)

> This graph selectively shows four routes that exhibited more fluctuation in their congestion level

> Congestion levels on these road has risen with the start of I-85 road closure (March 30, 2017) and has dropped after reopening (May 13, 2017)

> Changes on GA-13 and I-285-West has been more significant

TTI for outbound direction (from 8:00 to 9:00)
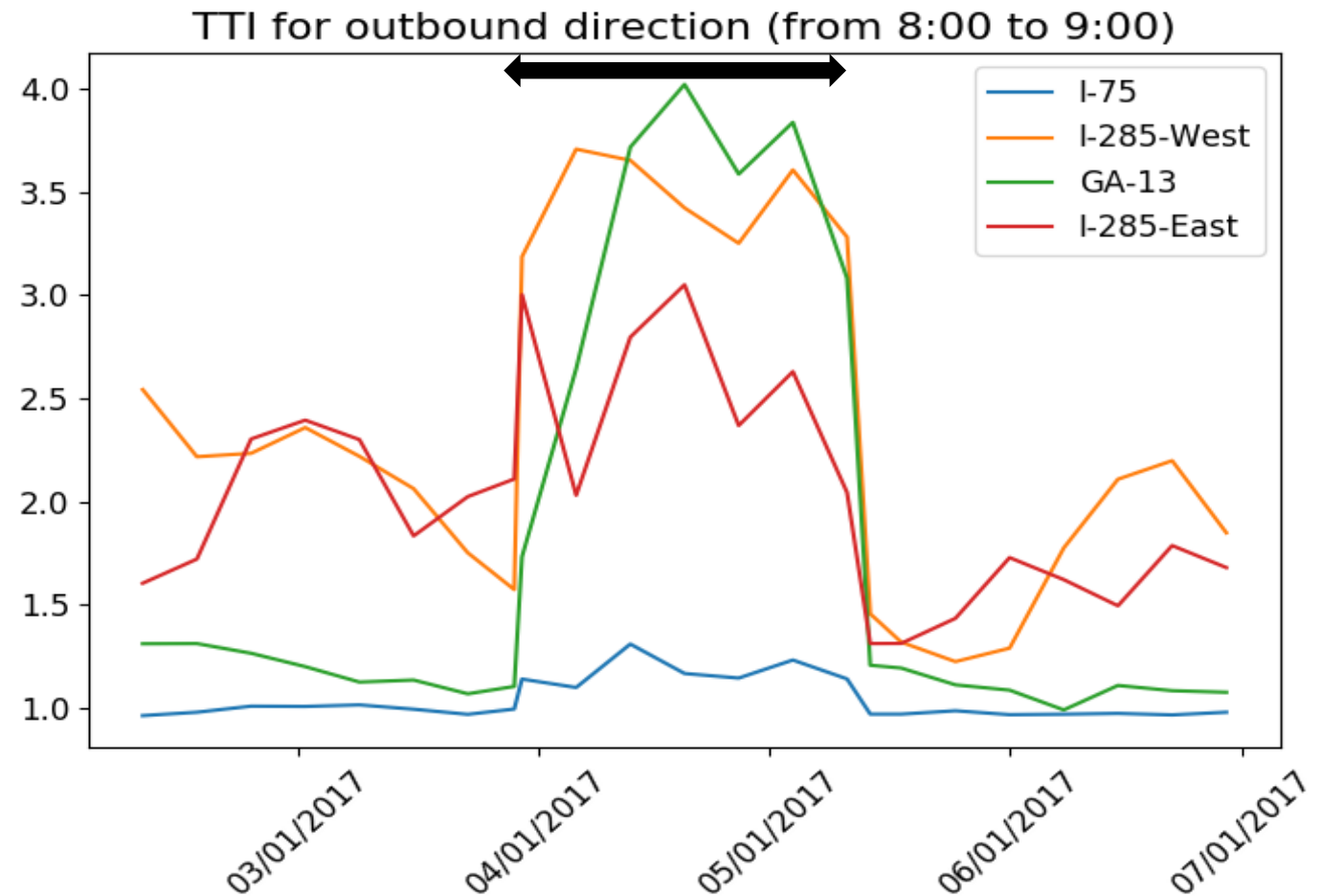
Comparative Congestion Index

> In order to track the overall changes in congestion in one snapshot, an index was developed to indicate the relative value of TTI during the road closure, compared to average TTI before and after the bridge collapse period:

$$Comparative\ Congestion\ Index\ (CCI) = \frac{TTI\ during}{0.5 * (TTI\ before + TTI\ after)}$$

> Comparative Congestion Index (CCI) was calculated for all roads in both inbound and outbound directions, and five index value ranges were chosen to form five categories, each marked by a color-coding:

    ■ **Less Congestion** (<0.85)
    ■ **No change** (0.85 – 1.15)
    ■ **Mildly increased congestion** (1.15 – 1.50)
    ■ **Moderately increased congestion** (1.50 – 2.50)
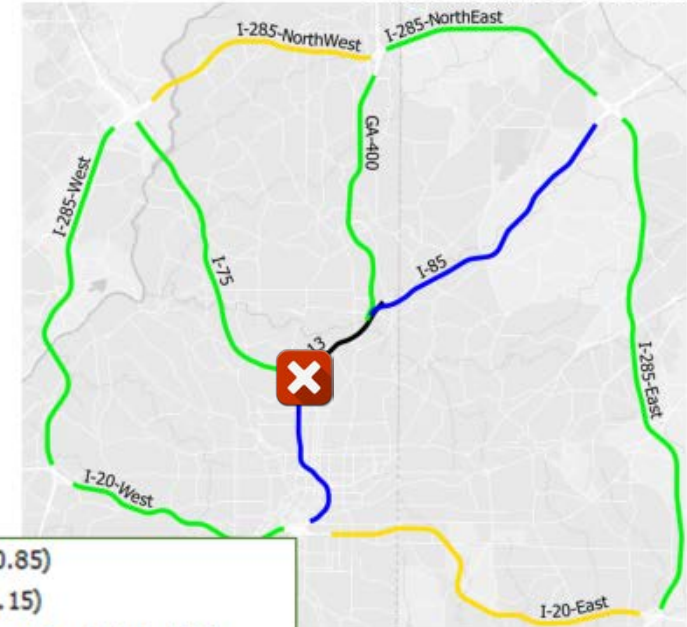   ■ **Severely increased congestion** (>2.50)

Comparative Congestion Index

> Overall, it seems that the system has been more resilient to the bridge closure shock in **inbound** travel direction.
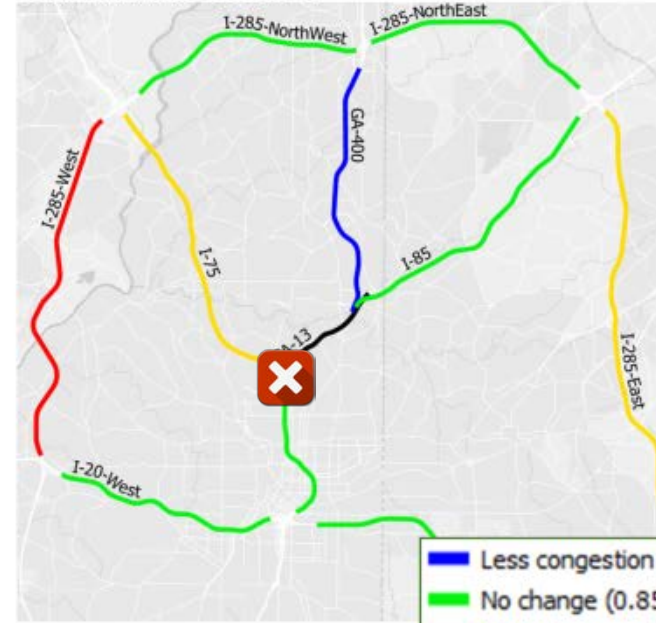
Resiliency by numbers
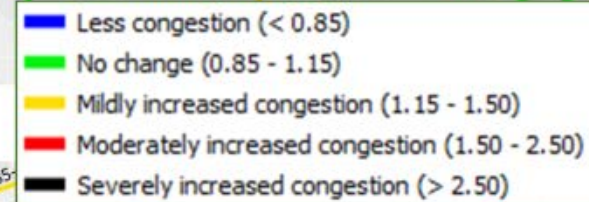
> Relative change (expressed by CCI) in both TTI and PTI for outbound direction during the bridge closure, is higher compared to the inbound direction

> Also, standard deviation, range, median and quartile values of the TTI, PTI and CCI indicate that changes in travel time reliability and excessive delays are less significant in inbound direction

> The numbers suggest that **inbound traffic during the collapse event has been distributed more evenly both spatial and temporal among detours** compared to the outbound traffic

Time	Measurement	TTI				PTI			
		Before	During	After	CCI	Before	During	After	CCI
OUTBOUND	**MEAN**	**1.64**	**1.89**	**1.46**	**1.25**	**1.91**	**2.24**	**1.71**	**1.26**
	Standard Deviation	0.68	1.12	0.50	0.68	0.83	1.40	0.66	0.66
	Minimum	0.92	0.91	0.94	0.60	0.97	0.97	0.97	0.56
	25%	1.10	1.19	1.11	0.97	1.22	1.38	1.34	0.95
	50 % (Median)	1.57	1.44	1.46	1.02	1.83	1.65	1.69	1.01
	75%	2.03	2.47	1.63	1.19	2.45	2.94	1.94	1.28
	Maximum	3.63	5.34	3.13	3.33	4.21	6.40	3.80	3.16
INBOUND	**MEAN**	**1.88**	**1.91**	**1.81**	**1.11**	**2.22**	**2.25**	**2.15**	**1.12**
	Standard Deviation	0.81	0.90	0.86	0.48	0.99	1.10	1.07	0.54
	Minimum	0.95	0.95	0.98	0.44	1.00	1.01	1.04	0.38
	25%	1.23	1.18	1.09	0.83	1.42	1.32	1.27	0.77
	50 % (Median)	1.70	1.60	1.51	1.00	1.96	1.84	1.76	0.98
	75%	2.51	2.27	2.56	1.26	2.94	2.99	3.09	1.34
	Maximum	3.51	3.51	3.67	2.63	4.24	4.17	4.45	2.63
ALL DIRECTIONS	**MEAN**	**1.76**	**1.90**	**1.63**	**1.18**	**2.07**	**2.25**	**1.93**	**1.19**
	Standard Deviation	0.75	1.00	0.72	0.59	0.92	1.25	0.91	0.60
	Minimum	0.92	0.91	0.94	0.44	0.97	0.97	0.97	0.38
	25%	1.14	1.18	1.09	0.89	1.30	1.34	1.27	0.90
	50 % (Median)	1.60	1.53	1.48	1.00	1.86	1.77	1.74	1.00
	75%	2.21	2.39	1.83	1.23	2.72	3.02	2.40	1.32
	Maximum	3.63	5.34	3.67	3.33	4.24	6.40	4.45	3.16

Overall TTI and PTI Summary for Inbound/Outbound Travel Directions

Conclusions

✓ Changes in congestion levels, bottleneck locations, and mobility performance measures are successfully captured and reflected by probe data

✓ Analytics tools can be effectively used for tracking changes in the bottlenecks in the aftermath of major road closures

✓ Large scale travel time reliability analysis is shown to be an effective approach for measuring and quantifying changes in regional mobility patterns

✓ Visualizing the results on GIS and color coding maps based on predefined threshold values helps in communicating the findings to the decision makes, planners and interested citizens

✓ Since TTI, PTI and CCI do not have dimensions, this method can be used to compare resiliency and adoptability of a network to shocks caused by a major event, with other networks.

Thanks!

For more information, please contact:

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