

# Understanding the Traffic Flow Evolution after Network Disruption

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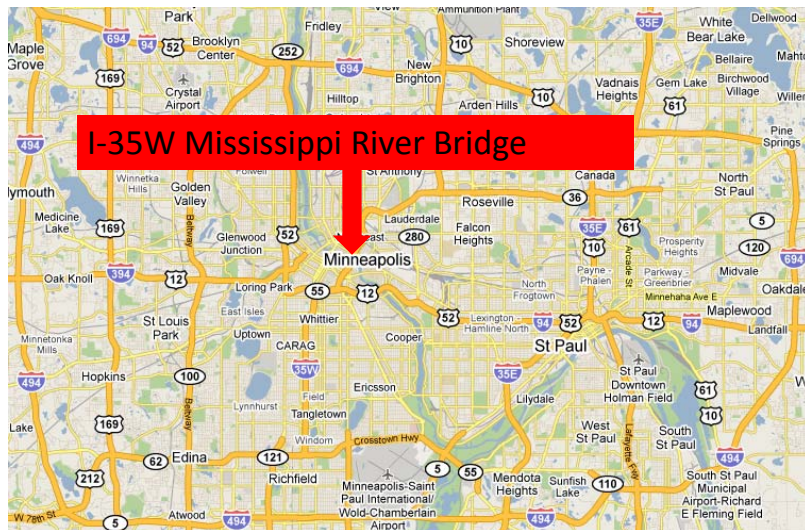


## The Fall and Rise of the I-35W Bridge

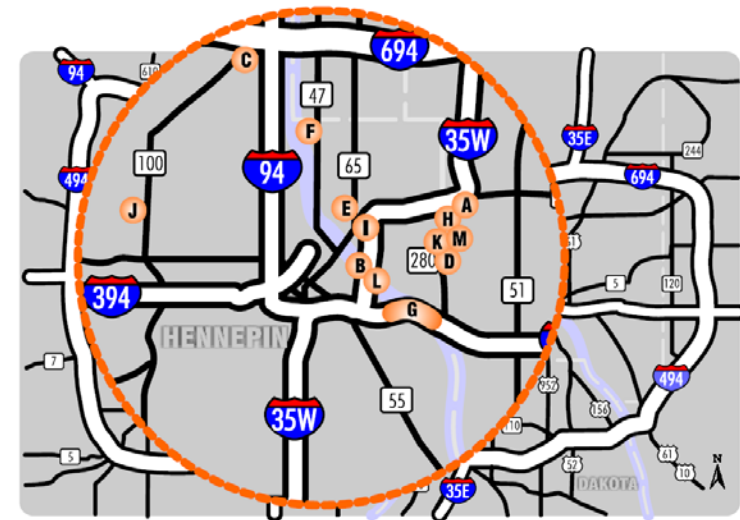
Source:  
[www.dot.state.mn.us](http://www.dot.state.mn.us)



## Google Map of the Twin Cities



## Mn/DOT Traffic Restoration Projects



## Research Questions

- How should transportation agencies optimize their resources in response to the network disruption?
- How do traffic patterns evolve from a network disruption?
  - After bridge collapse
  - After bridge reopening
- MnDOT economists estimated that, without the I-35 Bridge, the public lost \$400k everyday in terms of economic productivity.



## Empirical Observations

### Data Sources:

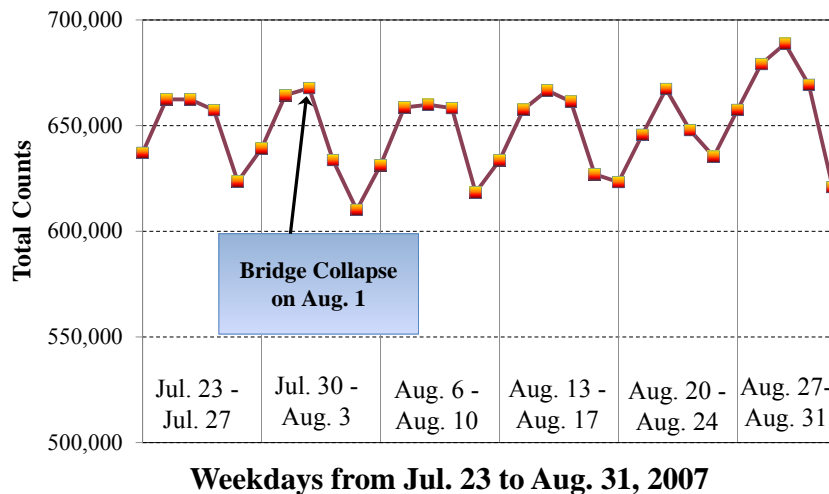
1. Freeway Loop Detector Data
2. Travel Behavior Survey Data
  - Questionnaire
  - GPS Trajectories

### References:

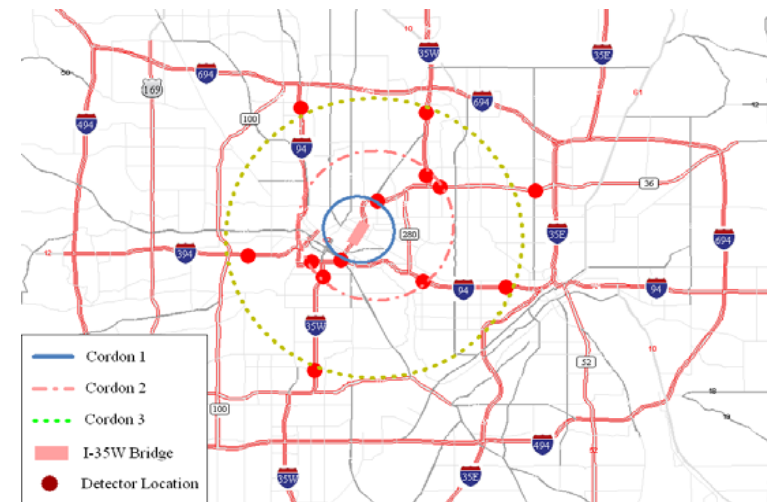
1. Zhu, S., Levinson, D., Liu, H., Harder, K. (2011) The Traffic and Behavioral Effects of the I-35W Mississippi River Bridge Collapse, *Transportation Research Part A*, 44, 771-784.
2. Guo, X. and Liu, H. (2011) Bounded Rationality and irreversible network changes, *Transportation Research Part B*, 45(10), 1606-1618.
3. He, X. and Liu, H. (2012) Modeling the day-to-day traffic evolution process after an unexpected network disruption, *Transportation Research Part B*, 46(1), 50-71



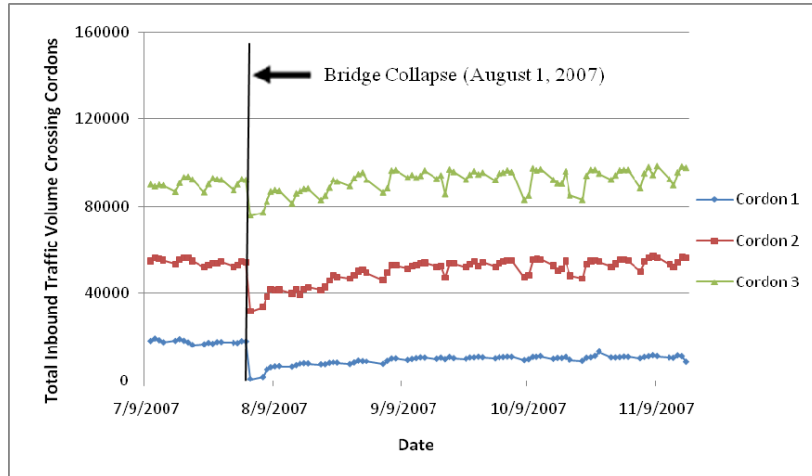
## Freeway Travel Demand (AM Peak)



## Three Cordons

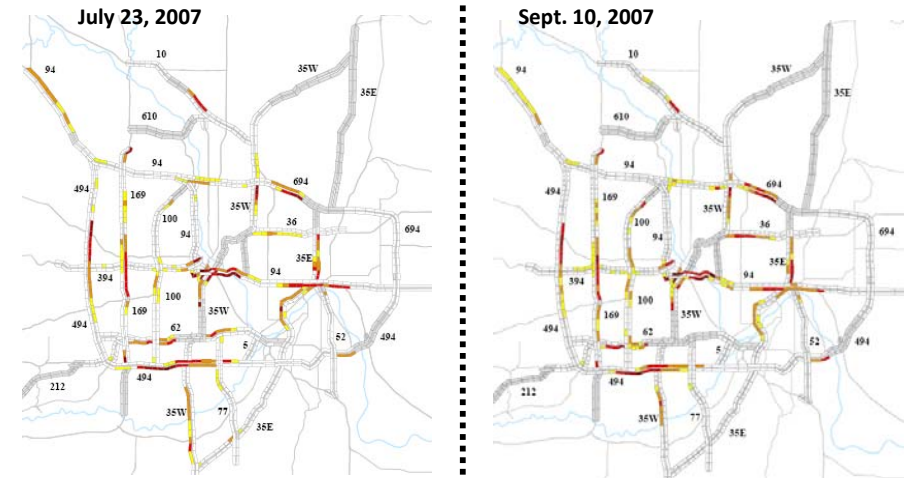


## Inbound Cordon Volumes (6-9AM)



## Morning Congestion Impacts

6:00 to 9:00 a.m. – Relatively Unchanged



Source: MnDOT RTMC



## Findings from Bridge Collapse Survey

- Handed out 860 surveys, and received 148 responses (Mid-Sept, 2007)
- 56 respondents changed routes after bridge collapse
  - 14 of them were NOT regular I-35W Bridge users
    - Changed their daily routes on Aug. 2<sup>nd</sup>, 2007 because of **anticipated congestion**



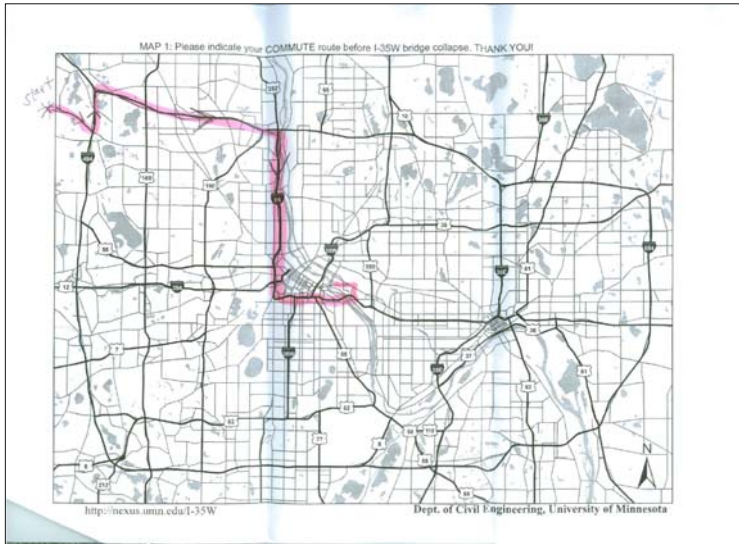
## Random Driver (Survey Results)

Survey of Travel Behavioral Consequences of I-35W Bridge Collapse  
Please complete the table, indicating the choice best describing your MORNING COMMUTE trip in the following time periods and draw your route(s) on the attached maps.

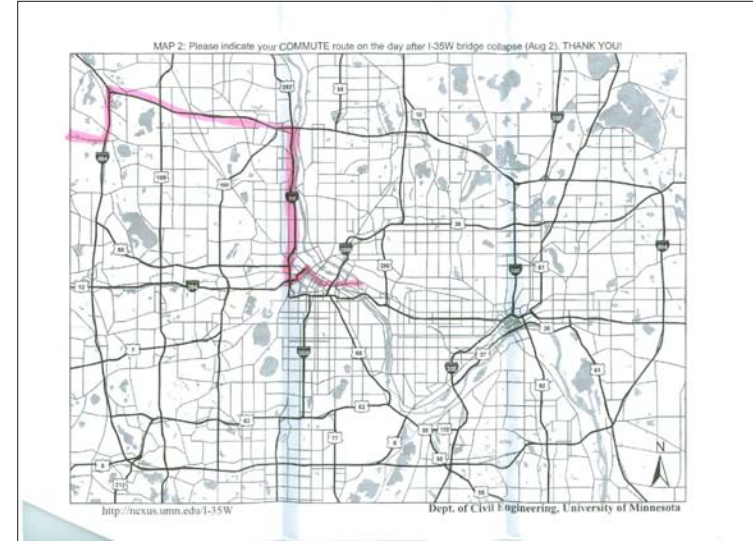
|   | Before I-35W Bridge Collapse | After Bridge Collapse August 2nd | Following Weeks | Current Status |
|---|------------------------------|----------------------------------|-----------------|----------------|
| Departure Times:<br>(Typical time leaving home, to the nearest minute)  | 6:45 AM                      | 6:20 AM                          | 6:45 AM         | 6:45 AM        |
| Arrival times:<br>(Typical time arriving at work, to the nearest minute)  | 7:20 AM                      | 7:15 AM                          | 7:25 AM         | 7:20 AM        |
| Travel Mode:<br>(Please indicate the primary mode of travel):<br>a) Drive alone b) Car/poolcar<br>c) Bus/Light rail d) Bicycle<br>e) Walk<br>f) Other (Please specify)  | a                            | a                                | a               | a              |
| Route Choice:<br>(Please draw your routes on the attached maps. If you take bus or LRT, please indicate the route and on and off stops.)  | ✓                            | ✓                                | ✓               | ✓              |
| Travel Information Resources:<br>(Which sources of information help you make travel decisions)<br>a) Experience b) Call 511<br>c) Website d) TV<br>e) Radio f) Co-workers<br>g) Neighbors h) Family<br>i) Others (Please specify) | a, d, e, f                   | a, d, e                          | a, d, e         | a, d, e        |
| Motivation for Changes in Travel Choices:<br>a) To reduce travel time<br>b) Road or ramp closed<br>c) Others (Please specify)   | a                            | a                                | a               | a              |



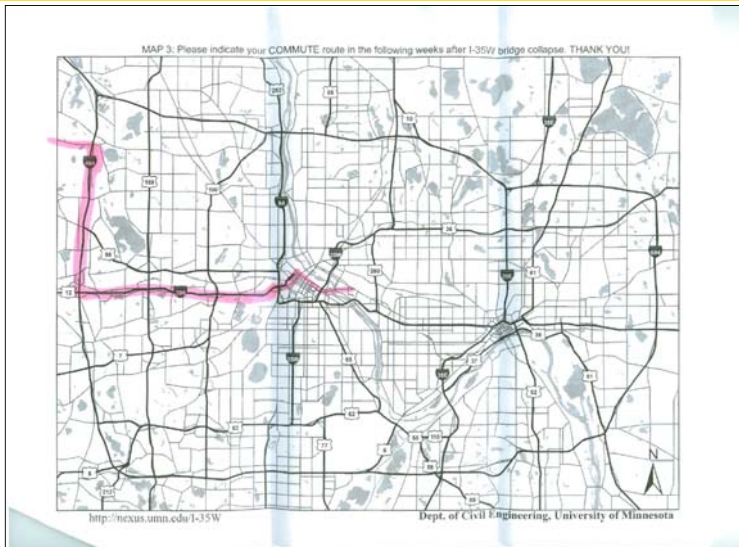
## Random Driver (Before Collapse)



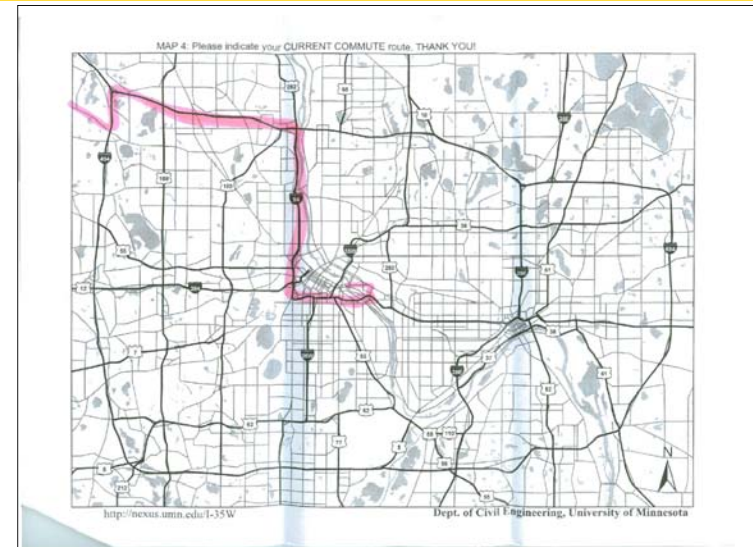
## Same Driver (August 2<sup>nd</sup>)



## Same Driver (Weeks after Collapse)



## Same Driver (Mid-Sept. 2007)

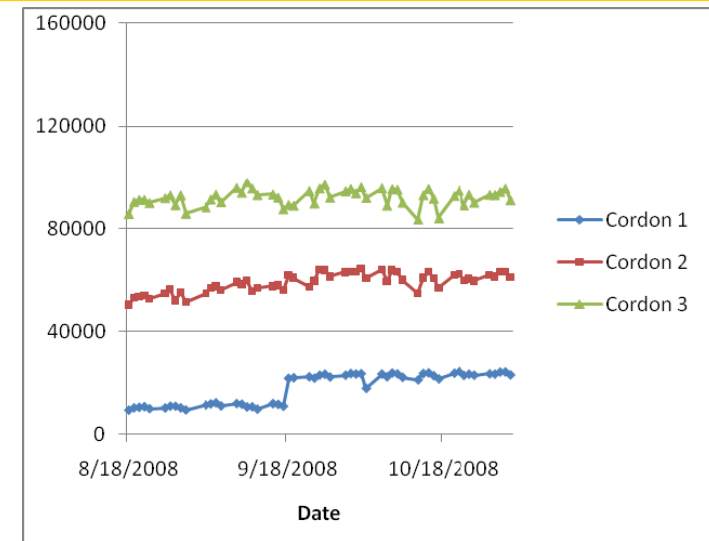


## Observations on “Recovery” Pattern

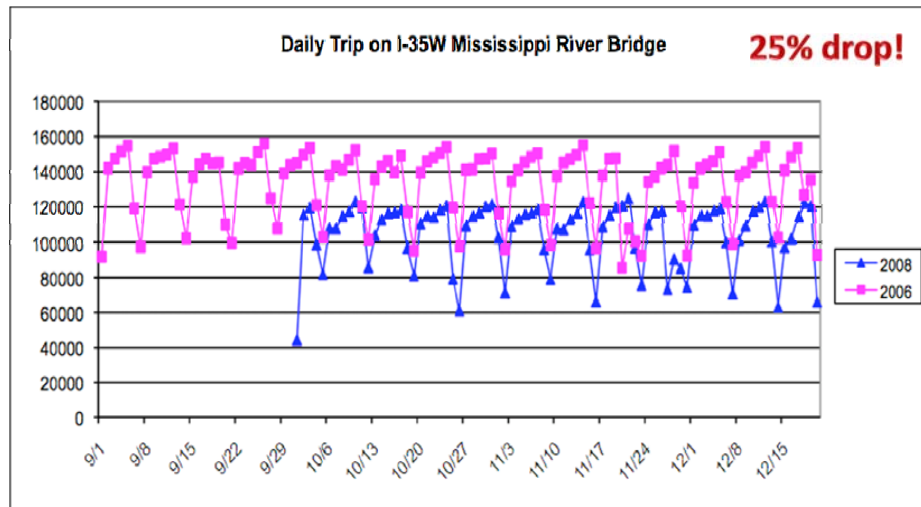
- Traffic “shock” is observed close to bridge site
- Travelers avoid the area because of the anticipation of traffic congestion
- Travelers learn and adjust their routes during the transition time
- In long-term (aside from cordon at bridge), traffic recovers to pre-collapse levels



## Inbound Cordon Volumes (6-9AM)



## Irreversible Network Disruption



## Findings from Bridge Reopening Survey

- Handed out 840 surveys, and received 137 responses (Mid-October 2008)
- 26 respondents changed routes after bridge reopening
- 3 respondents, who were regular I-35W Bridge, did not use it as commute route after new bridge reopened because **they are satisfied with their current routes**



# Random Driver (Survey Results)

## Survey of Travel Behavior Impacts of I-35W Bridge Reopening

Please complete the table, indicating the choice best describing your **MORNING COMMUTE** trip in the following time periods, and draw your route(s) on the attached maps.

|   | Before Bridge Collapse<br>(e.g., in July 2007) | Before Bridge Reopening<br>(e.g., Sept 17th, 2008) | After Bridge Reopening<br>(September 18th, 2008) | Following Weeks<br>(Sept. 19th to Oct. 23th) | Current Status               |
|---|--|--|--|--|------------------------------|
| <b>Departure Time:</b><br>(Typical departure time from home, to the nearest minute)   | 8:40   | 8:35   | 8:35   | 8:40   | 8:40                         |
| <b>Arrival Time:</b><br>(Typical arrival time at work, to the nearest minute)   | 9:05   | 9:05   | 8:55   | 9:10   | 9:00                         |
| <b>Travel Mode:</b><br>(The primary mode of travel)<br>a) Drive alone<br>b) Carpool driver<br>c) Carpool passenger<br>d) Bus/Light rail<br>e) Bicycle<br>f) Walk<br>g) Other (Please specify) | A  |  |  |  |                              |
| <b>Route Choice:</b><br>(Please draw your routes on the attached maps.)<br><i>If you did not change route, please draw your route on at least one map.</i>                                    | Please mark line(s) on MAP 1                   | Please mark line(s) on MAP 2                       | Please mark line(s) on MAP 3                     | Please mark line(s) on MAP 4                 | Please mark line(s) on MAP 5 |
| <b>Route Familiarity:</b><br>(How familiar are you with the routes you used)  | 1 2 3 4 5 6 7                                  | 1 2 3 4 5 6 7                                      | 1 2 3 4 5 6 7                                    | 1 2 3 4 5 6 7                                | 1 2 3 4 5 6 7                |
| <b>Motivation for Changes in Travel Choices:</b><br>Why did you change your route(s)? Please specify.   |  |  |  |  |                              |



# Random Driver (Before Collapse)

MAP 1: Please indicate your commute route BEFORE the I-35W Bridge COLLAPSE. THANK YOU!



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# Same Driver (Before Reopening)

MAP 2: Please indicate your commute route BEFORE the I-35W Bridge REOPENING. THANK YOU!



Dept. of Civil Engineering, University of Minnesota



# Same Driver (on Sept. 18)

MAP 3: Please indicate your commute route ON THE DAY of the I-35W Bridge REOPENING (September 18). THANK YOU!



Dept. of Civil Engineering, University of Minnesota



## Same Driver (Weeks after Reopening)



## Summary of Empirical Observations

- Traffic Recovery Patterns are **Different** for Unexpected Closure and Expected Reopening
  - Unexpected Closure
    - Sudden Drop and Gradual Recovery
  - Reopening from A Closure
    - Seemingly immediate recovery and stabilization
    - Irreversible network flow change



## Behavioral Explanations

- Unexpected Closure
  - Travelers avoid the area because of the anticipation of traffic congestion
  - Prediction of future traffic condition needs to be included in the model
- Reopening from a closure
  - Travelers are reluctant to change routes if the benefit is small
  - Travelers are not perfectly rational. Bounded rationality is behaviorally appealing.



## GPS Trajectory of a Traveler

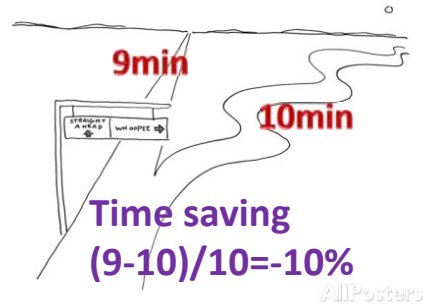


## Indifference Band

$\epsilon$ : deviation from the minimum cost



$\epsilon=10\%$



## Reasons for Bounded Rationality

1. Driving habit
2. Cognitive limit

“Satisfactory” ✓

“Optimal” ✗



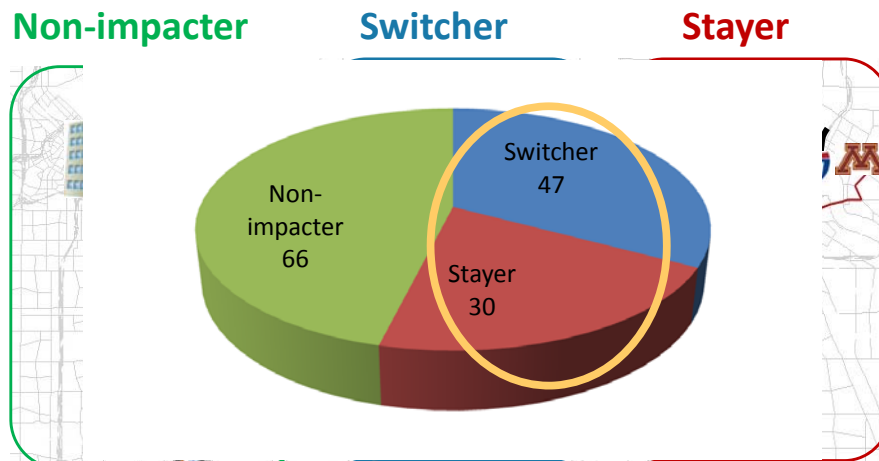
\*Source: huffingtonpost

143 commuters morning trips

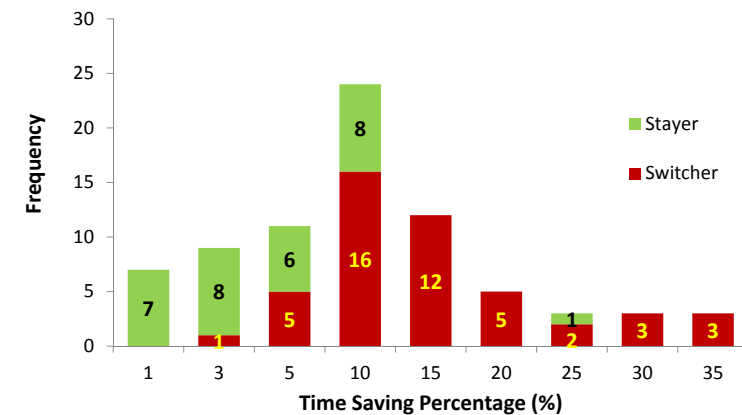
☐ Before: 2 or 3 weeks before

☐ After: 1 or 2 months after

\*Source: Zhu (2010)



## Value of Indifference Band





## Conclusions

- Empirical observations shows that drivers can adapt to a disrupted network rather quickly.
  - No bridge, no problem.
- Driver adaptability and predictability, as well as bounded rationality, should be included in driver behavior modeling.
- More studies are needed for disrupted transportation network
  - Multimodal impacts
  - Congested networks



## THANK YOU!

### Contact Information:

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