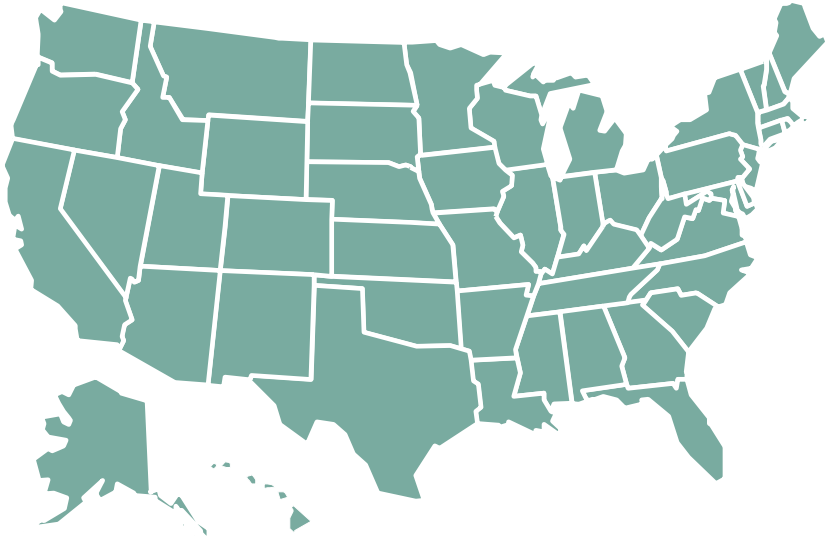
NCHRP 08-99/TRB Report 824, 2016

Methodology for Estimating the Value of Travel Time Reliability for Truck Freight System Users

NCHRP is a State-Driven Program

- Sponsored by individual state DOTs who
  - Suggest research of national interest
  - Serve on oversight panels that guide the research.



- Administered by TRB in cooperation with the Federal Highway Administration.

Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, syntheses
- Can be applied in planning, design, construction, operations, maintenance, safety, environment

Additional NCHRP Publications Available on this Topic

- NCFRP Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investments
- NCFRP Report 22: Applying Benefit-Cost Analysis to Freight Project Selection: Lessons From the Corps of Engineers
- NCFRP Report 38 (Pre-Publication Draft) Guide for Conducting Benefit-Cost Analysis of Multimodal, Multijurisdictional Freight Corridor Investments
- NCHRP Project Panel 07-24: Methodology for Estimating the Value of Travel-Time Reliability for Truck Freight System Users – Phase 2

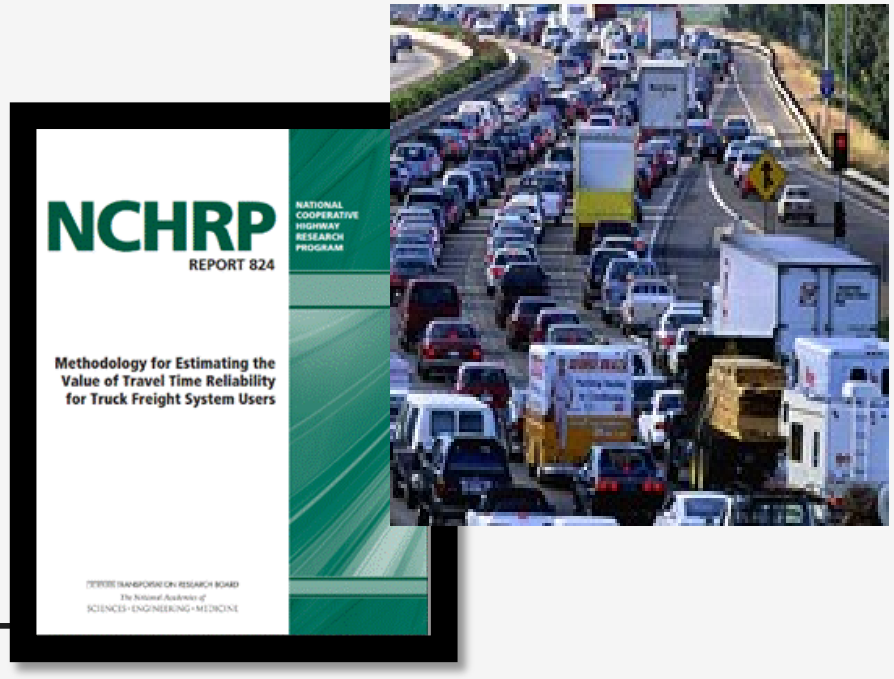
You can learn more about these publications by visiting www.trb.org

Today's Speakers

- *Ira Hirschman, Ph.D., Principal Economist, WSP | Parsons Brinckerhoff – U.S. Advisory Services*
- *Anne Strauss – Wieder, Director, Freight Planning- North Jersey Transportation Planning Authority*
- *Sebastian Guerrero, WSP | Parsons Brinckerhoff, – the state of truck freight reliability valuation research, overview and preview of NCHRP 07-24*
- *Joe Bryan, WSP | Parsons Brinckerhoff, Principal Freight Practice Manager, U.S. Advisory Services*
- *Barry Padilla, Senior Economist, CA Department of Transportation (Caltrans) – Moderator*

TRB Webinar, February 15, 2017

- NCHRP Project 08-99/TRB Report 824 Methodology for Estimating the Value of Travel Time Reliability for Truck Freight System Users
- Study Summary



Ira Hirschman, Ph.D., Principal Investigator
WSP | Parsons Brinckerhoff

1. **Study Purpose, Study Elements/Outcomes**
2. **Definitions of Reliability**
3. **Survey Research**
4. **Concept Framework for the Truck Freight Reliability Valuation Model**
5. **Model Details**
6. **Case Study Demonstrations**
7. **Model Limitations and the Next Study Phase**

Where to Find it?

- TRB Report 824
  - http://www.trb.org/Publications/Blurbs/174297.aspx
  - Includes Excel based Truck Freight Reliability Valuation Model together with User's Guide
  - Study completed Sept. 2016

Study Purpose, *Study Elements/Outcomes*

- *Develop and demonstrate a methodology to estimate the value of travel time reliability to truck freight system users*
  - Improve understanding of how shippers and trucking service providers respond to unreliability and to mitigate the risk.
  - Develop a survey research based hypothesis or framework for how shippers and truckers perceive and react to risk:
    - statistical analysis using structured Stated Preference or Revealed Preference analysis was not considered for this round of the research
  - Estimate the economic costs of unreliability based on the informed hypotheses of shipper and trucker strategies obtained from the surveys
  - Derive a methodology and associated model of economic costs/benefits, useful in planning applications and to provide a tool for Benefit Cost practitioners to incorporate reliability.
- *NCHRP 08-99 was considered a first round of analysis with possibility of follow up research through NCHRP*

Study Purpose, Study Elements/Outcomes

- Survey of the reliability literature/definitions of reliability
- In-depth program of survey research, including on-line surveys and industry interviews, to improve understanding of trucker and shipper behavior in response to travel time uncertainty.
- Develop the economic valuation framework
- Develop an Excel based modeling tool, the Truck Freight Reliability Valuation Model.
- Demonstrate the methodology through case studies.
- Identify gaps in the research and suggest future research extensions

Measures of Reliability

- Literature review revealed a range of types of measures:
  - Dispersion based, e.g.
    - Standard deviation, Coefficient of dispersion, Interquartile range
    - Travel time index, Buffer time index
  - Schedule based
    - On-time performance - shipments must arrive at the dock or destination within a given time window with a given level of certainty
  - Hybrid: Standard deviation of actual arrivals versus scheduled arrivals

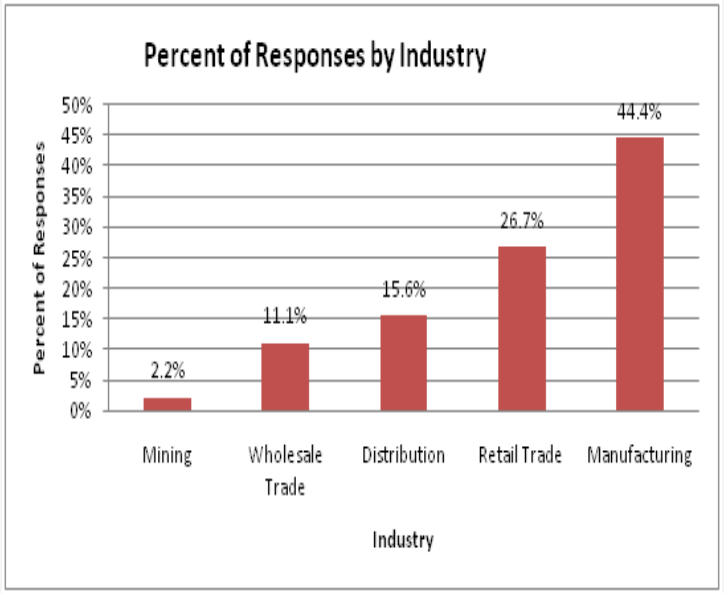
Survey Research – Overall Effort

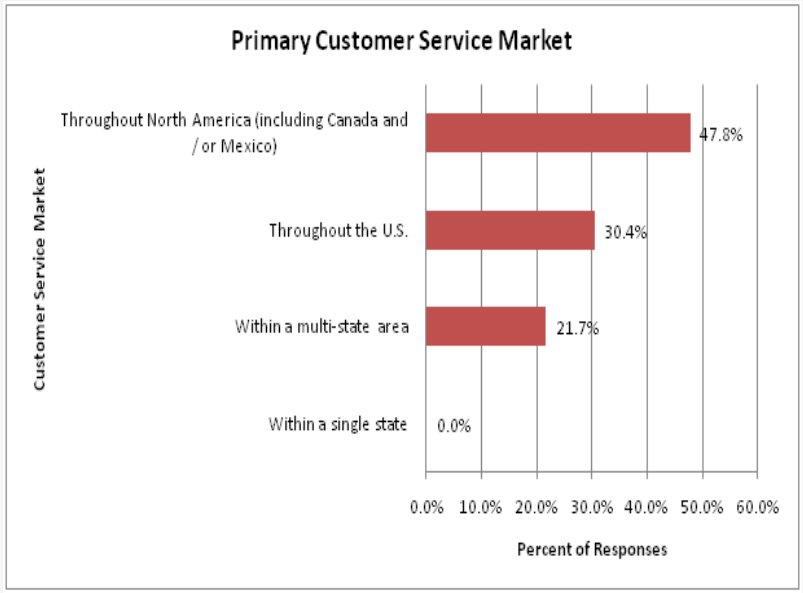
- Survey research comprised three different efforts:
  - an *initial* online survey of shippers and truck transportation service providers;
  - *in depth interviews* of shippers and transportation service providers;
  - *a shorter but more focused follow-up on line survey*, which narrowed on the most common response to unreliable conditions—adding buffer time to truck schedules.

Survey Research - Initial On Line Survey Sample Characteristics

- 7000 surveys sent, 169 returned complete
- Response rate nearly 3% as measured by the number of responses compared to all people asked to respond.
- A better indicator of response compares the number of responses versus the number companies in the survey. A little more than 3 people per company were invited to respond to ensure coverage.
- The response rate as measured by companies participating in the survey is just under 10%.

Initial On Line Survey – Shippers





Initial On Line Survey – Shippers

Causes of Unreliability – Top Five Reasons

- Delays on truck routes
- Truck driver availability
- Truck availability
- Hours of service rules
- Length of travel time

Reasons for Delays	Significance Weighted Score
Delays on Truck Routes	3.71
Truck Driver Availability	3.32
Truck Availability	3.25
Hours of Service Rules	3.22
Length of Travel Time	3.08
Trucking Costs	2.84
Weather	2.78
Delays at Receiving Facility	2.75
Delays at Load/Unload Facilities	2.71
Real-Time Cargo and Truck Tracking	2.62
Vehicle Breakdowns	2.58
Consistent Travel Times for Ocean	2.36
Consistent Travel Times for Rail	2.35
Availability of Real-Time Traffice Information	2.35
Consistent Gate Times at Terminals	2.21
Delivery Appointment System Issues	2.16
Consistent Travel Times for Air	1.73
Availability of Truck Parking	1.73
Toll Costs	1.59
Driver Unable to Find Location	1.41

Significance weightings in this and subsequent similar tables were based on a 1 to 5 survey response rating with 5 being the highest and most significant score.

Initial On Line Survey – Shippers

Mitigation Strategies

- Route planning is most commonly employed response to inconsistent travel time and excess delay in deliveries. Route planning includes adding buffer time (scheduling), varying routes in advance, and real time route tracking and response
- Second and third most frequently cited actions were to add more trucks and equipment to routes, and to employ driver teams. These are costly strategies.

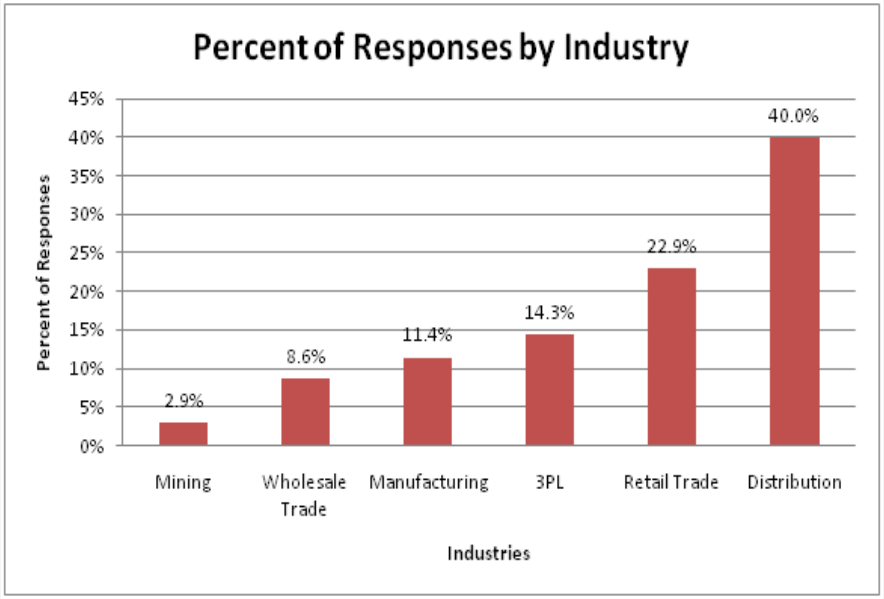
Short-Term	Permanent
Route planning	Route planning
Use of driver teams	Adding more trucks
Adding more trucks	Real-time truck tracking
Use of alternative transportation modes	Outsource/Rebid trucking
Outsource/Rebid trucking	Use of driver teams
Real-time truck tracking	Use of alternative transportation mode

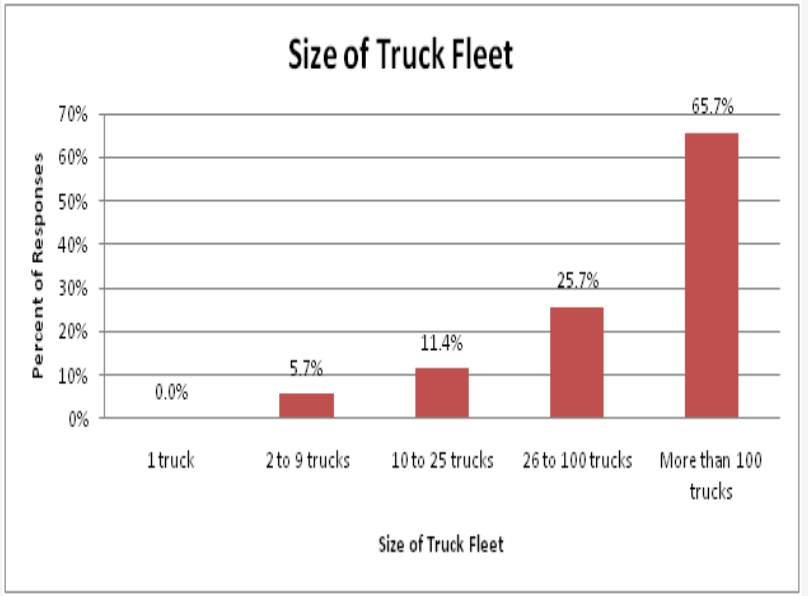
Initial On Line Survey – Shippers

Mitigation Strategies

- Most surprising and significant finding: increased buffer *inventory* was *rarely* cited as a strategy to respond to unreliability.
- Above has important implications for valuation:
  - BCAs typically include carrying cost of increased inventory when there are delays. *This result suggests doing otherwise.*
  - Possible interpretation:
    - supply chain managers expect the transportation system to perform to the inventory plan by any means necessary - which in many cases amount to mitigating risk by adding cost.
    - *inventory* (not time) buffers are reserved for other risks (e.g. demand fluctuation and supplier failure).

Initial On Line Survey – Service Providers





Initial On Line Survey – Service Providers

Causes of Unreliability – Top Five Reasons

- Truck driver availability
- Truck availability
- Hours of service rules
- Trucking costs
- Delays at load/unload facilities

Reasons for Delays	Significance Weighted Score
Truck Driver Availability	4.10
Truck Availability	4.03
Hours of Service Rules	3.87
Trucking Costs	3.86
Delays at Load/Unload Facilities	3.81
Delays on Truck Routes	3.71
Real-Time Cargo and Truck Tracking	3.52
Delays at Receiving Facility	3.47
Availability of Real-Time Traffic Information	3.47
Delivery Appointment System Issues	3.47
Weather	3.23
Vehicle Breakdowns	3.16
Length of Travel Time	3.08
Consistent Gate Times at Terminals	2.84
Toll Costs	2.82
Driver Unable to Find Location	2.77
Consistent Travel Times for Air	2.46
Consistent Travel Times for Rail	2.40
Availability of Truck Parking	2.34
Consistent Travel Times for Ocean	2.18

Initial On Line Survey – Service Providers

Mitigation Strategies

- Similar to shippers
- Exception is outsourcing, which is cited frequently. A way to transfer risk to others – including owner operators.

Short-Term	Permanent
Route planning	Route planning
Outsource trucking	Adding more trucks
Adding more trucks	Real-time truck tracking
Use of alternative transportation modes	Specialized pricing for congested areas
Real-time truck tracking	Use of driver teams
Specialized pricing for congested areas	Outsource trucking
Use of driver teams	Change location of distribution centers and warehouses

Interviews

- **Transportation Providers** (may also operate private fleets for shippers):
  - Best Transportation
  - Con-Way
  - Halls Fast Freight,
  - New England Motor Freight
  - NFI
  - Schneider
- **Shippers**:
  - Fiat Chrysler
  - H-E-B
  - Macy’s
  - MillerCoors,
  - Whirlpool

Supplementary Follow Up On-Line Survey

- Information Gaps from Initial Round of Surveys and Interviews
  - buffer time reveals the value of increased unreliability/improved reliability
  - not sufficiently clear picture of how shippers and truckers buffer schedules
- Follow up On Line Surveys to Fill the Information Gaps
- Focused on Buffer Time

Follow Up Survey Sample Characteristics

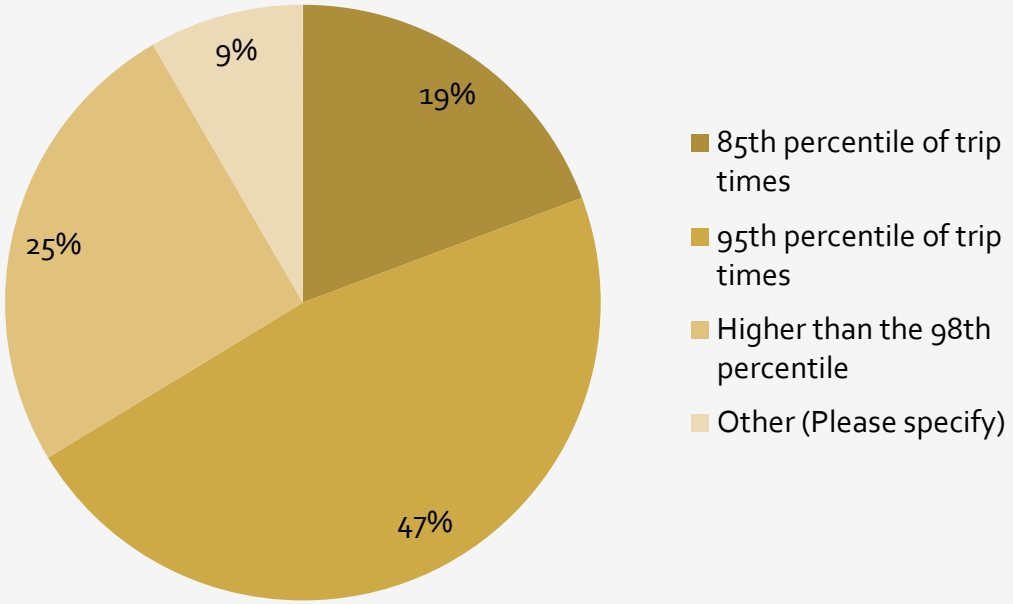
- Received 84 completed responses to this survey.
- Equates to approximately a 9% response rate based on the companies we sent the survey to.
- The number of responses represent significant enough numbers of responses to provide meaningful results.

Follow Up Survey Data

Other Responses	# of Responses
48 hours	
3 days	
Same City 24 hours, cross City 48 hours.	
Within 30 minutes of the scheduled delivery apt	3
Within 1 hour	2
5 days	
Within 1 hour plus or minus	
Varies based on destination as we ship TL from one central facility nationally.	
Delivering the shipment during a customer's typical 8 hour receiving window on the date promised based on either a customer specified date or our standard promise of same day shipping (subject to carrier availabilty and time of order placement) with a delivery date based on the carriers current published transit time	
Varies widely	
Customer generally require delivery on the due date and are sometimes tolerant to delays after the scheduled time.	
We ship UPS ground so depends upon what part of the country its destination is...usually 2 day delivery and 3-5 for further zones.	

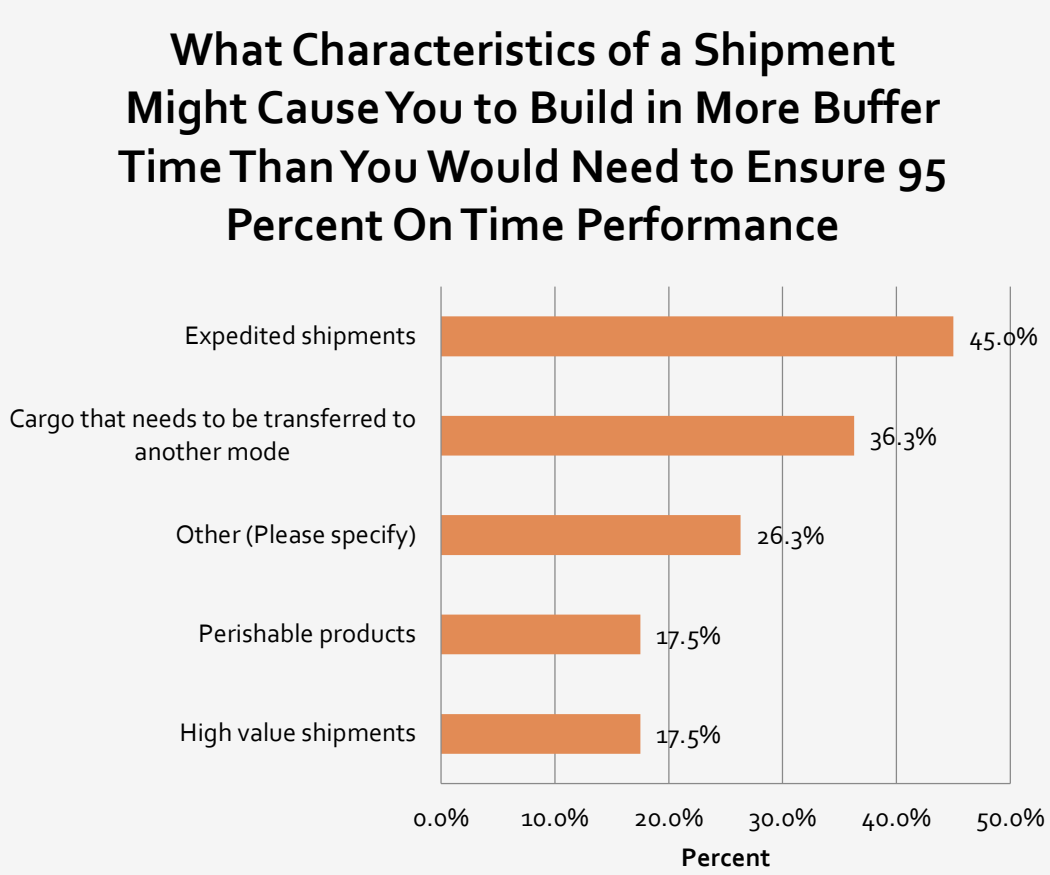
Follow Up Survey Data

How Much Buffer Time Do You Build Into Your Dispatch Schedules



Other Responses
50th percentile
On Truck Load, we typically add 25%-30% time for buffer compared to quoted time for the lane
Buffer' time is not built into our schedules
90th
We build enough drive time into the trip, to be at 95th%, however, we are delayed by customer releases that would put us below this %.
We do not decide.

Follow Up Survey Data



Other Responses
Job Site Crew waiting to unload
Delivery to sight where a crew is waiting for arrival of truck
Geographic - residental vs. commercial
General weekly shipments
Tighter delivery windows.
Home Delivery
Shipments that need to make connections between various modes of transport (ie: ocean to rail to truck).
Time slots at delivery location
Shipments routed through geographical areas prone to poor weather. Anything through the mountains
Job site deliveries where cranes and workers are waiting for product.
Residential deliveries with light assembly.
We may expedite on certain loads but would never implement enough buffer to get to the 95th percentile.
Returns to D/C's. We are a regional carrier and b/c of our tight l/h we run our own trucks to control our results.
Crane's booked by customer
Shippers typically want the maximum time to pull the product, so they limit the buffer on dedicated lanes.
Heavy equipment - especially loads requiring permits.
Potential running out of stock.
Just in time demand shipments, specifically also taking into consideration inventory levels and supply pricing
Customer requirements and our committment
EIther destination or inbound receipt of the product before shipping out.
Multi stop loads.

Concept Framework for Truck Freight Reliability Valuation Model

- Estimates the additional costs incurred by truck users under various degrees of travel time uncertainty
- Considers alternative strategies to “buffer” against delay where travel times are uncertain and potential delays above the mean are substantial and entail significant risk and cost.
- Uses buffer time index as the primary metric of travel time variability
  - Buffer time values are easier to obtain or derive than most other measures, and can be related directly to on time delivery performance - reflects how supply chain managers think about delay uncertainty
- Takes into account penalties for late arrival or dock clearance; direct transport costs of delay; fixed costs of buffering, penalties for late arrival, and commodity value and time sensitivity

Truck Freight Reliability Valuation Model - Model Logic and Structure

- The definition of travel time reliability used in the model is on-time performance of trucks to their delivery destination.
- Economic costs will be much greater when 95 percent of all trips arrive up to one hour later than scheduled delivery times, compared with say when 95 percent of all trips arrive up to 15 minutes late.
- For a given level of travel uncertainty, the model estimates, first, the expected cost of a hypothetical case in which shippers are assumed to *accept* the risk of late delivery and absorb (or pass on) the additional costs of delay. This value is then compared to the costs incurred when shippers *build in buffer time* and effectively limit the chances of late deliveries to the most infrequent outlier cases.
- When the costs of buffering are greater than the expected cost *without* buffering, a residual economic value is implied. That value may be viewed as an additional unreliability cost premium that is not accounted for by direct transport costs, dock penalties, and assumed cargo related “late to point of delivery” costs.

Truck Freight Reliability Valuation Model - Model Logic and Structure

Costs Included in the Model

- ***Directly Variable Truck Transportation Cost***—This is the variable cost per hour of operating and maintaining the truck. The American Transportation Research Institute (ATRI) publishes updated estimates of the operational costs of trucking each year
- ***On-Dock Penalties***—Our surveys showed that in close to 70 percent of cases, customers and in some cases truck service providers stipulate penalties for late delivery. The interviews further highlighted this practice in trucking, and indicated on-dock penalties ranging from a few hundred dollars for delivering outside the stipulated time window to $500 per truckload.
- ***Cargo Related Supply Chain Cost***—This bundle of costs is most similar to the "Inventory Cost" category often cited in freight cost. At the margin, these costs cover a number of specific supply chain attributes, such as cost of capital incurred from delays in getting intermediate inputs to production facilities, opportunity cost of delayed final sales, administration and management, insurance, product spoilage, reduced production efficiencies, etc.

- Each of these costs are expressed as "expected values", based on the trip time distributions implied by Buffer Index values or derived directly from disaggregate travel time data. Expected values reflect the central tendency of the assumed travel time distribution *above* the median trip time value for a log normal distribution.

Truck Freight Reliability Valuation Model - Model Logic and Structure

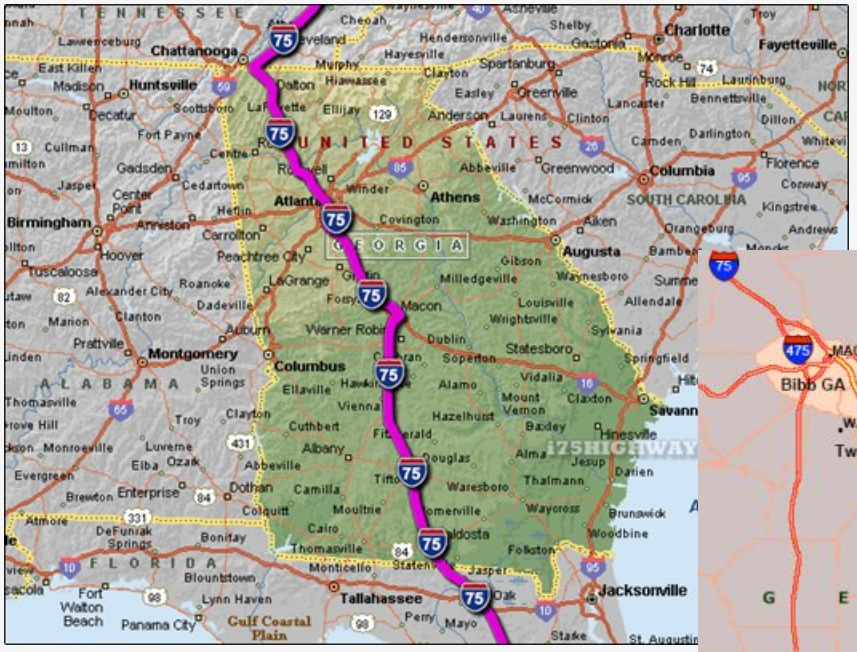
Reliability-Cost Relationships, example:

Medium trip distance, high value added (high buffer, high time value of cargo)							
95th percentile travel time / avg. travel time	95th pct. Buffer index value	95th pctl. hours above mean	expected value of unreliability cost per trip without mitigation (per loaded trip)	expected value of unreliability - cost per loaded trip with buffer mitigation	implied residual economic cost per loaded trip	expected reliability cost per expected delay hour	RELIABILITY RATIO - expected cost per delay hour as pct of direct hourly cost
1.1	0.1	1	$ 34.74	$ 85.22	$ 50.48	$ 177.68	277.6%
1.2	0.2	2	$ 80.88	$ 172.59	$ 91.71	$ 181.74	284.0%
1.3	0.3	3	$ 133.26	$ 262.18	$ 128.92	$ 185.74	290.2%
1.4	0.4	4	$ 180.99	$ 353.72	$ 172.73	$ 189.50	296.1%
1.5	0.5	5	$ 224.17	$ 446.99	$ 222.82	$ 193.03	301.6%
1.6	0.6	6	$ 264.12	$ 541.83	$ 277.71	$ 196.34	306.8%
1.7	0.7	7	$ 301.84	$ 638.18	$ 336.34	$ 199.48	311.7%
1.8	0.8	8	$ 337.96	$ 735.98	$ 398.02	$ 202.47	316.4%
1.9	0.9	9	$ 372.91	$ 835.18	$ 462.27	$ 205.33	320.8%
2	1	10	$ 406.95	$ 935.73	$ 528.78	$ 208.07	325.1%

Trip Parameters	
trip length	500 miles
avg. speed	50 mph
buffer for mitigation	98th pctl.
dock penalty	$250
cargo supply chain cost per hour	$ 80.00
dock delivery window for penalty incursion	2 hours

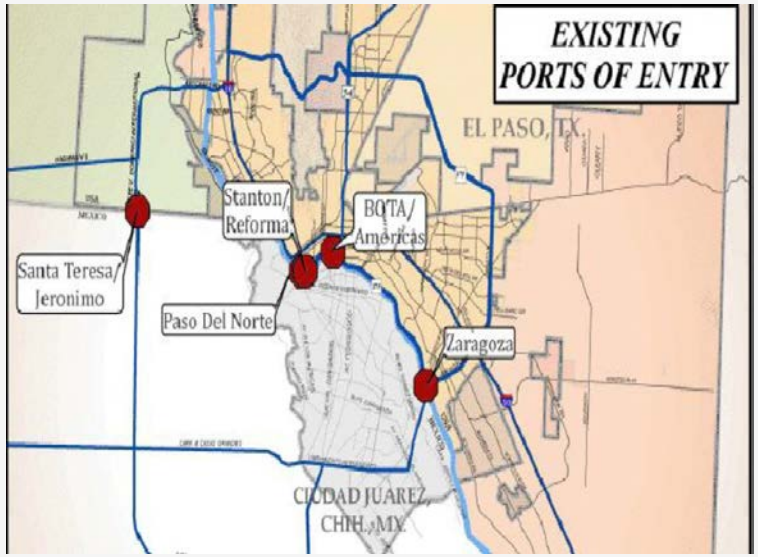
Model Demonstration Phase

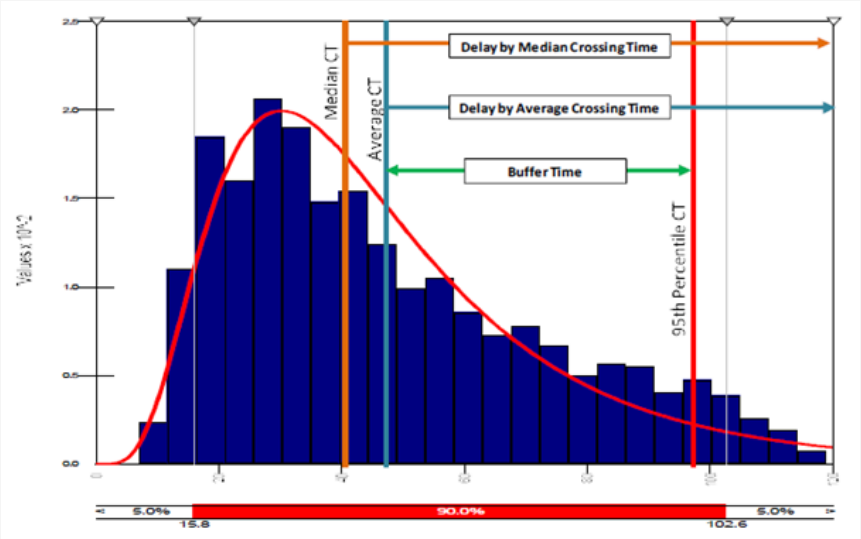
Case Study # 1—Georgia I-75/I-16 Corridor (GDOT)



Model Demonstration Phase

Case Study # 2—El Paso Ports of Entry (TUTTI)





Model Demonstration Phase

Case Study # 1—Georgia I-75/I-16 Corridor – Inputs

Georgia I-75/I-16Corridor										
Low Reliability Segments	**NB**					**SB**				
	# hours per day peak variability	Avg. Buffer Index for variable time period	segment distance	median speed across segment	AADTT during peak buffer period	# hours per day peak variability	Avg. Buffer Index for variable time period	segment distance	median speed across segment	AADTT during peak buffer period
I-75										
I-75 Miles 217-231	10	1.125	14	58	2500	7	1.2	14	50	2500
I-75 Miles 243-251	11	1.5	8	40	2500	14	1.4	8	35	2500
I-75 Miles 257-275	6	1.7	18	35	2500	4	1.2	18	45	2500
Corridor Segment Total			**40.000**		**2500**			**40.000**		**2500**
I-16										
I-16 Miles 141-166 (end 2 miles)		1.5	2	50	1250		1.5	2	50	1250
Corridor Segment Total			**2.000**		**1250**			**2.000**		**1250**

Variable Truck O&M Costs (per truck hour)	$64
Commodity Tier	High
Commodity Supply Chain Cost per truck hour	$80
Late Delivery Penalty—per truck delivery	$250
Built in Buffer (percentile)	0.98

Case Study # 1—Georgia I-75/I-16 Corridor – Illustrative Results

Georgia I-75/I-16Corridor	NB		SB		Total, both directions
	Per trip	Annual	Per trip	Annual	
Unreliable Corridor/Segments					
I-75					
I-75 Miles 217-231	$ 2.58	$ 1,934,434	4.83	$ 2,602,684	$ 4,537,118
I-75 Miles 243-251	$ 8.91	$ 6,682,501	8.06	$ 6,046,960	$ 12,729,461
I-75 Miles 257-275	$ 32.70	$ 24,527,093	6.90	$ 5,174,999	$ 29,702,092
Corridor Segment Total		$ 33,144,028		$ 13,824,643	$ 46,968,671
I-16					
I-16 Miles 141-166 (end 2 miles)	1.78	$ 668,250	1.78	668250	$ 1,336,500
Corridor Segment Total		$ 668,250		668250	
Full Composite Corridor Total		$ 33,812,278		$ 14,492,893	**$ 48,305,171**

Next Step

NCHRP 07-24

About to commence!

The End

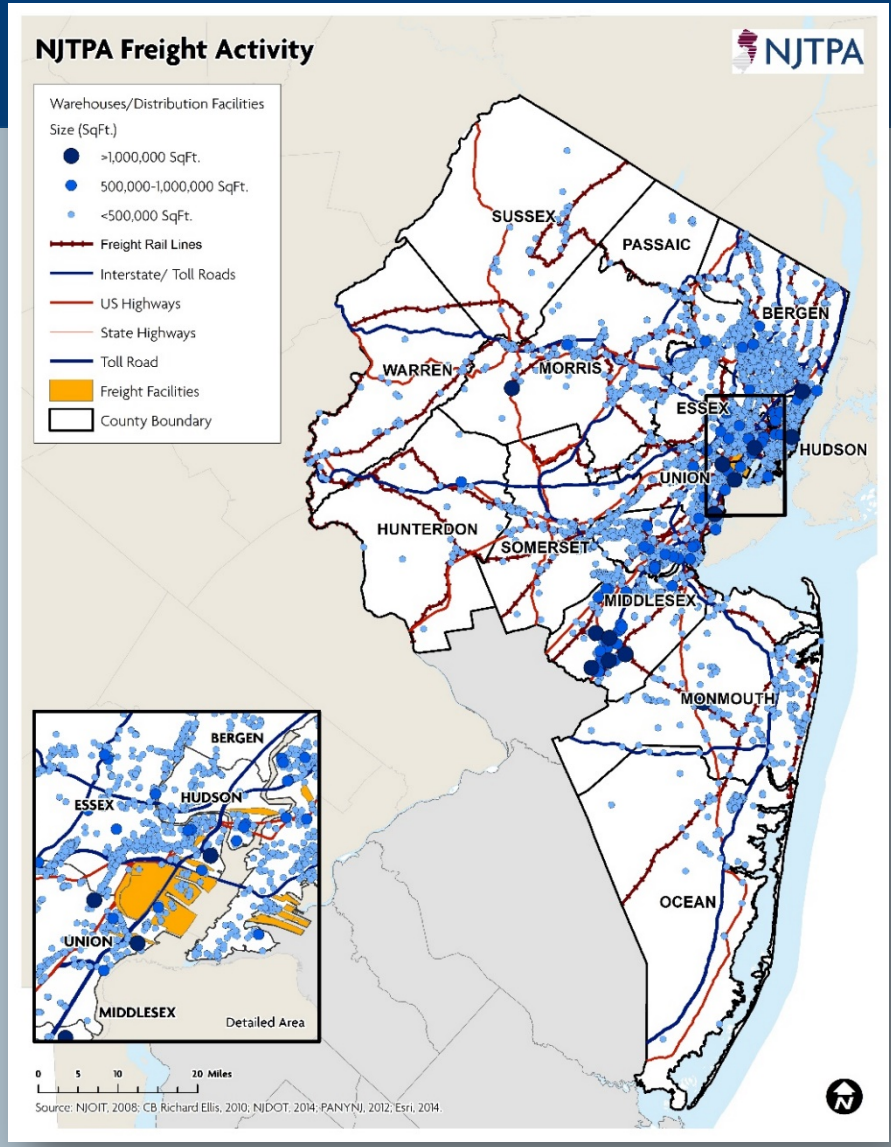
Findings from Shipper and Transportation Provider Interviews

2017 TRB/NCHRP 824:
The Economic Costs of Unreliability in Freight and Truck Travel Time

Anne Strauss-Wieder
Director, Freight Planning
North Jersey Transportation Planning Authority

New Jersey is a Key Distribution Platform

- 809 million square feet of industrial space in the NJTPA area
- Largest port on the East Coast – 6.4 million TEUs in 2015
- Robust rail freight network – 2 Class Is, Conrail, shortlines
- Extensive roadway network
- Newark Liberty International Airport – 10th largest in the US



Examples of NJTPA Freight Initiatives

- NJTPA's Freight Initiatives Committee
- Subregion outreach and field visits
- Inventory & Assessment of Waterborne Resources
- Freight Rail Industrial Opportunity (FRIO) Corridors Program
- Pilot Freight Concept Development Program

What Keeps Supply Chain Professionals Up at Night?

- Managing the challenges of a rapidly evolving retail environment
  - Compressed delivery times
  - Expanding delivery location options
- Guaranteeing temperature controlled supply chains for pharmaceutical and food products

PLAN 2045
Connecting North Jersey
NJTPA REGIONAL TRANSPORTATION PLAN

Randall Park Mall
Source: http://news.yahoo.com/photos/abandoned-mall-that-was-once-the-largest-in-the-world-1421355579-slideshow/

What Keeps Supply Chain Professionals Up at Night?

- Identifying and undertaking the actions and investments needed to enable all aspects of the freight system to operate 24/7
  - Bunching and pinch points
  - Local ordinances that restrict hours of operation
- Ensuring on-time delivery
  - Resolving unpredictable truck travel and turn times

Source: WSJ

Organizations Interviewed

- Transportation Providers
  - Best Transportation
  - Con-Way (XPO Logistics)
  - Halls Fast Freight
  - New England Motor Freight
  - NFI
  - Schneider
- Shippers
  - Fiat Chrysler
  - H-E-B
  - Macy's
  - Miller Coors
  - Whirlpool

Categorizing Inconsistent Truck Travel Times

- By Supply Chain Segment
  - Pick up
  - Drop off
  - In-transit
- By Delivery Schedule
  - Static/consistent delivery schedules
  - Dynamic/as-needed replenishment
- By Operational Considerations
  - Customer interactions
  - Traffic management considerations
  - Trucking company management

Source: http://blog.linelogic.com/blog/2013/06/05/wall-mount-crowd-control-for-warehouse-safety-osha-compliance/

Interview Findings – Causes

- Pick up locations
- Drop off locations
- During move/in-transit
- Within trucking operations

Interview Findings – Causes at Pick Up Locations

- Products are not ready for loading
  - Delays in production processes
  - Obtaining loads at intermodal yards, including waterborne, air cargo, and rail terminals
- Weather conditions affecting connecting modes
- Delays arriving at the pick up location
- Availability of chassis and labor
- Software issues at pick up location
- Loading times exceed 2 hours provided by carrier

Interview Findings – Causes at Drop Off Locations

- Truck docks not available
- Excessive times to unload trucks
- Missing the scheduled appointment window

Interview Findings – Causes During Transit

- Congestion on roadways, bridges, and toll plazas
- Construction on roadways and bridges
- Weather conditions
- Border crossing inspections and equipment imbalance
- Imbalances of inbound and outbound movements
  - Driver and equipment availability

Source: Livetrucking.com

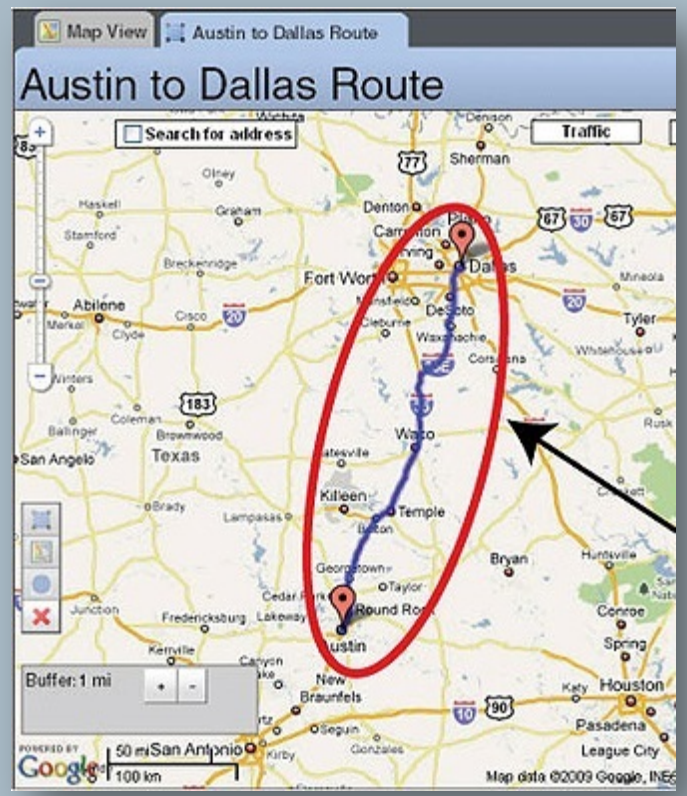
Interview Findings – Responses and Strategies at Pick Up Locations

- Monetize the delays
  - Charge detention fees for trucks held more than 2 hours
  - Typical fee is about $60/additional hour
  - Charge for additional transportation costs to make up lost time
- Leave vendor with an incomplete order
- Seek vendors with facilities proximate to the destination
  - Ranges from next to plant to within one-day's drive
- Review use of vendor if problems are consistent
- Pick up containers at port and store in company yard for next day delivery
- Increase secured truck parking at vendor to facilitate off-peak pick up
- Cease serving vendor

Interview Findings – Responses and Strategies at Drop Off Locations

- Monetize the delays
  - Charge for missing delivery windows
  - Concerns about predatory/excessive penalty fees
- Become a shipper of choice
- Increase inventory held on-site/safety stock
- Cease serving the customer

Interview Findings – Responses and Strategies for In-Transit Inconsistencies



Source: Huffington Post

- Use routing software combined with trucker knowledge
- Use real-time tracking of trucks and loads
  - Virtual fencing
  - "Green, yellow, red" tracking
- Increase buffer times
- Rearrange pick up/drop off schedule for multi-stop runs
- Monetize the delays
  - Renegotiate rates and metrics with customers
  - Charge a premium
- Cease serving area or corridor.

Interview Findings – Responses and Strategies within Trucking Operations

- Increase driver pay and/or number of drivers
- Change driving patterns
  - Substitute rail for longer distance moves
  - Establish a relay system
  - Consider team drivers to address hours of service rules
- Develop or use companies with final mile expertise

The Take Aways – A Transforming Context

- Recognize different locations and causes of inconsistent travel times
- Follow demand parameters
- Pressure for on-time deliveries and lower costs
- Track new technologies
- Disseminate best practices

The supply chain is ever evolving.

Thank You

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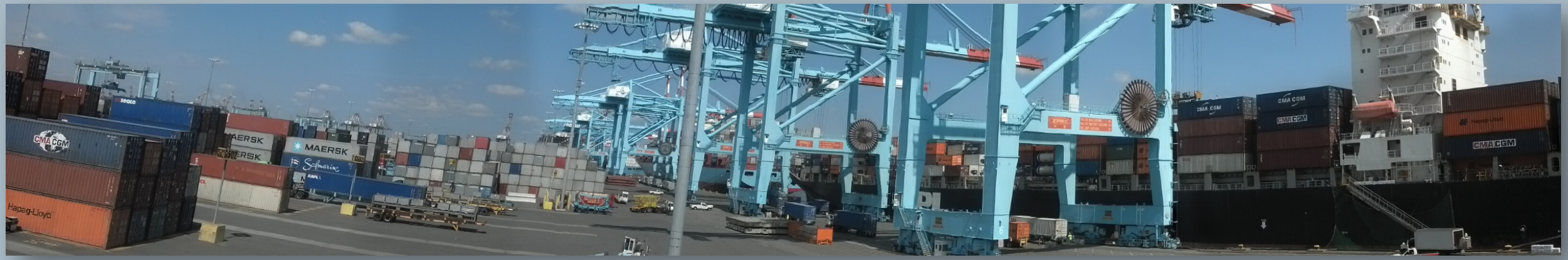

Truck Value of Reliability:
Status of Research and Overview of NCHRP 07-24

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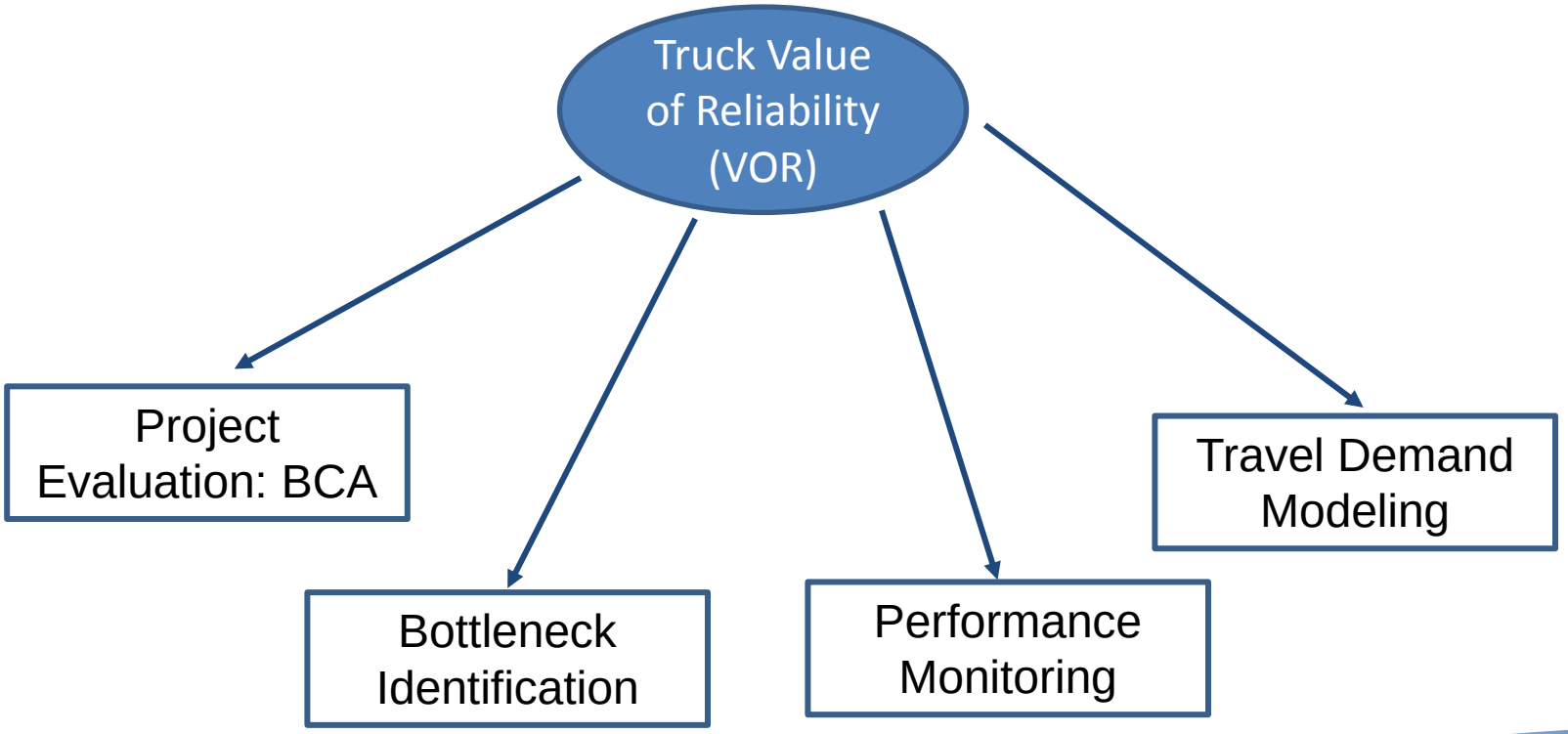
Value of Reliability

In many freight cases Value of Reliability is as important or more important than Value of Time!



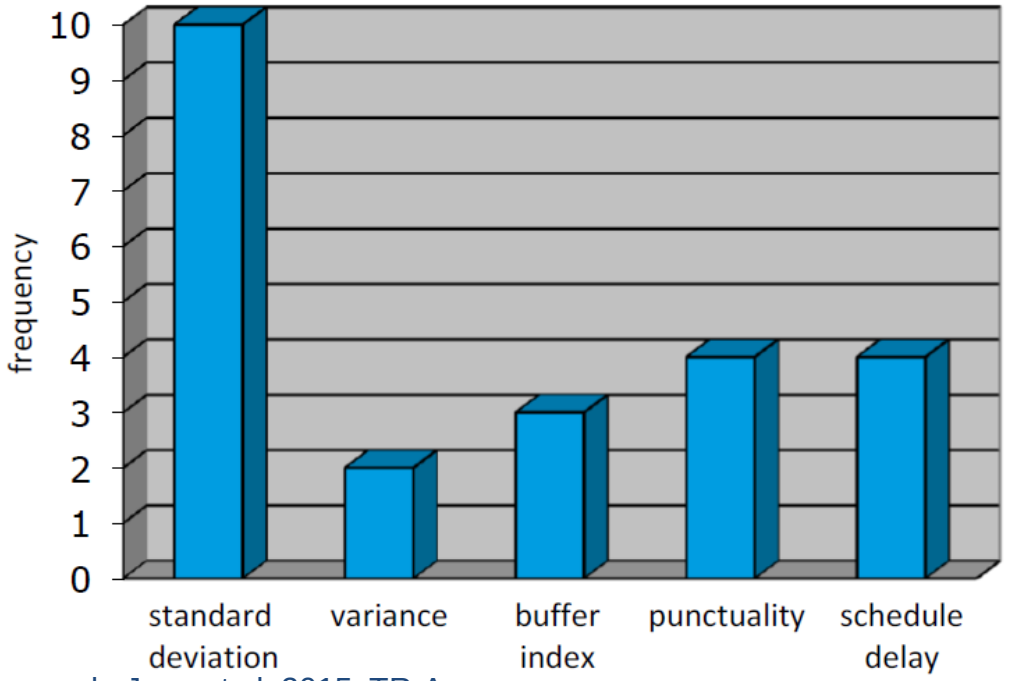
Three Important Research Questions

1. **How to measure truck reliability?**
2. **How to estimate the value of truck reliability?**
3. **How to forecast the reliability of a road network?**

How to measure truck reliability?

Definition of reliability should reflect costs

International experts were asked how reliability should be measured for use in BCA



de Jong et al. 2015, TR-A.

How to measure truck reliability?

- **National Performance Research Data Set**
  - Vehicle probe data, collected and processed under USDOT contract, and distributed to states without charge
  - Provides average speeds for trucks and passenger vehicles at sample points on the highway network, for trucks and passenger vehicles, at 15 minute increments, all day, every day
  - Allows us to calculate average travel times and other information

- **Newly-adopted Federal reporting requirements**
  - Starting in 2018, states must report to US DOT a Truck Travel Time Reliability (TTTR) score for truck performance, measured on interstates
  - The TTTR measures reliability in terms of the predictability of speed. Effectively, it tracks the extra time built into freight schedules to achieve 95% on-time delivery
  - TTTR is calculated to capture peak, off-peak and weekend periods

How to measure truck reliability?

North & East Directions

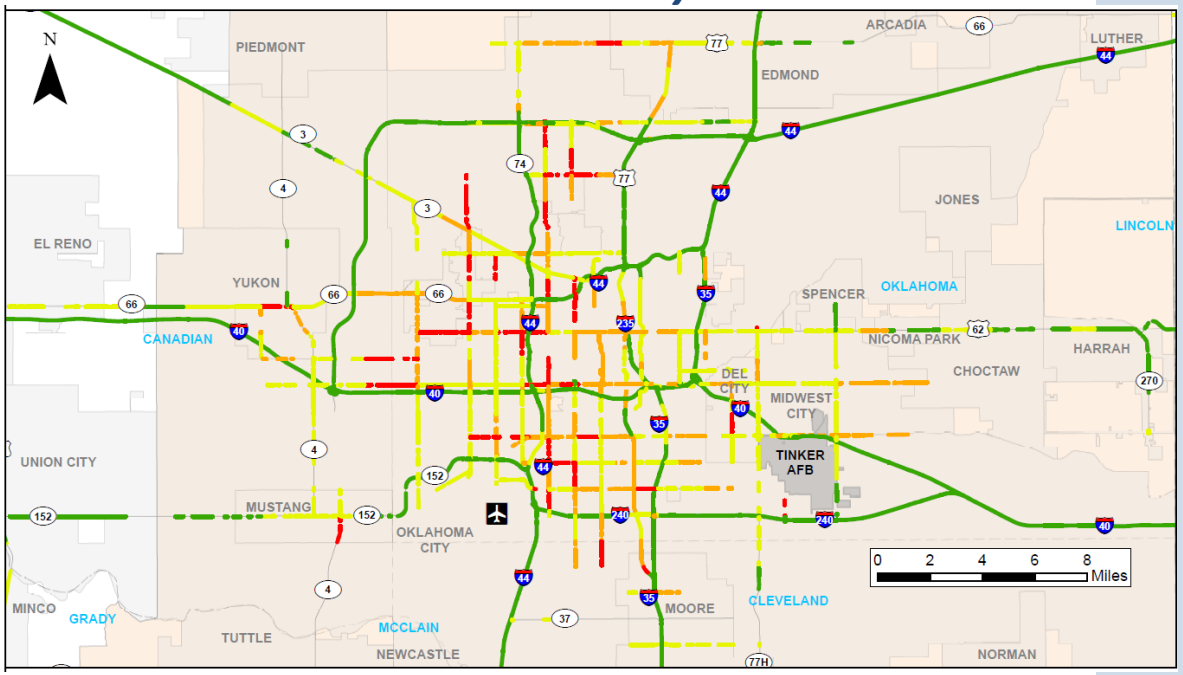
$$TT\ Index = \frac{95^{th}\ Percentile\ TT}{50^{th}\ Percentile\ TT}$$

- Major Airports
- Waterway Ports
- Ports of Entry

Time Travel Index

- 1 - 2.5
- 2.5 - 6
- 6 - 10
- 10+

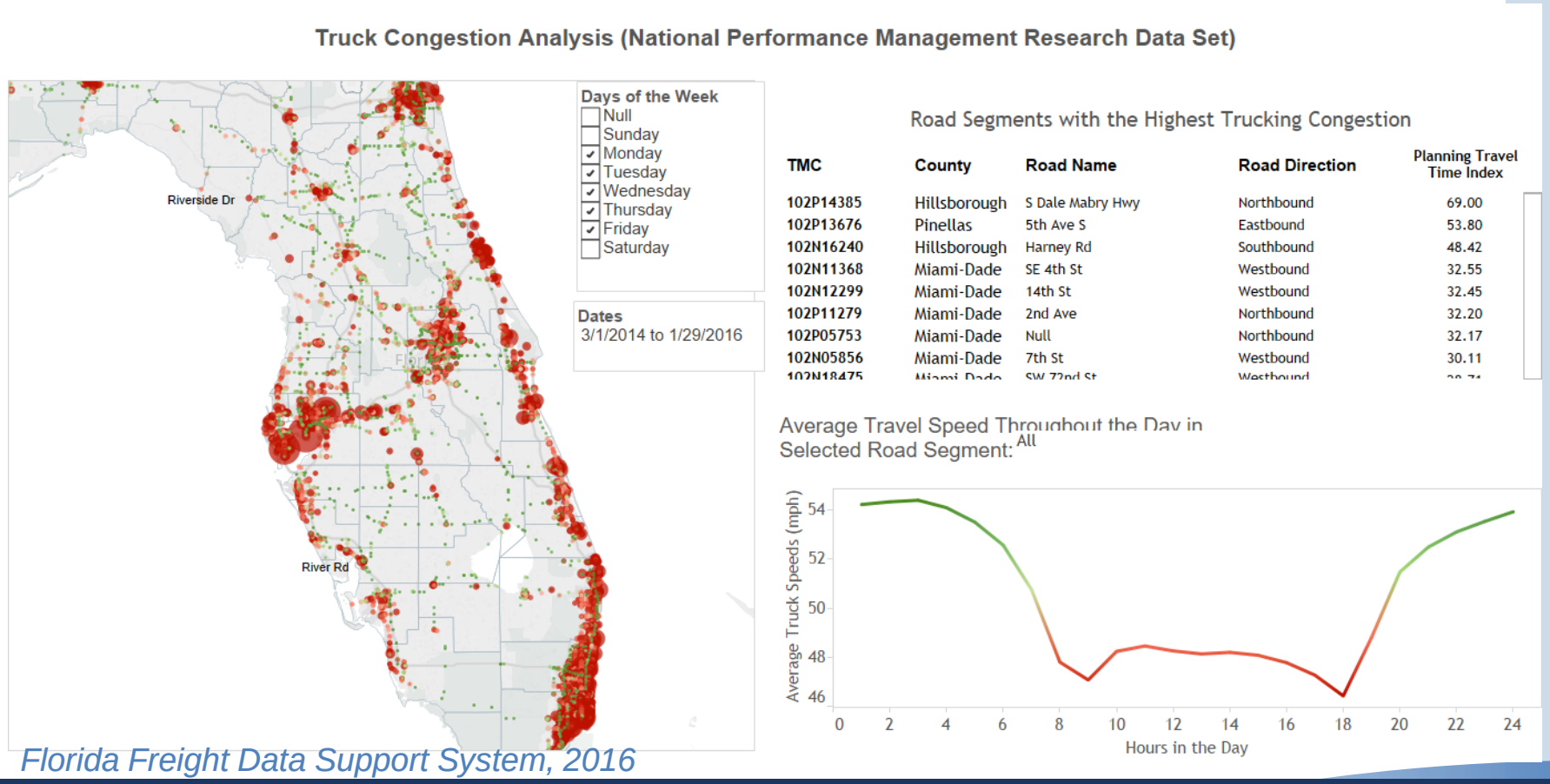
Oklahoma City



Oklahoma State Freight Plan Update 2017

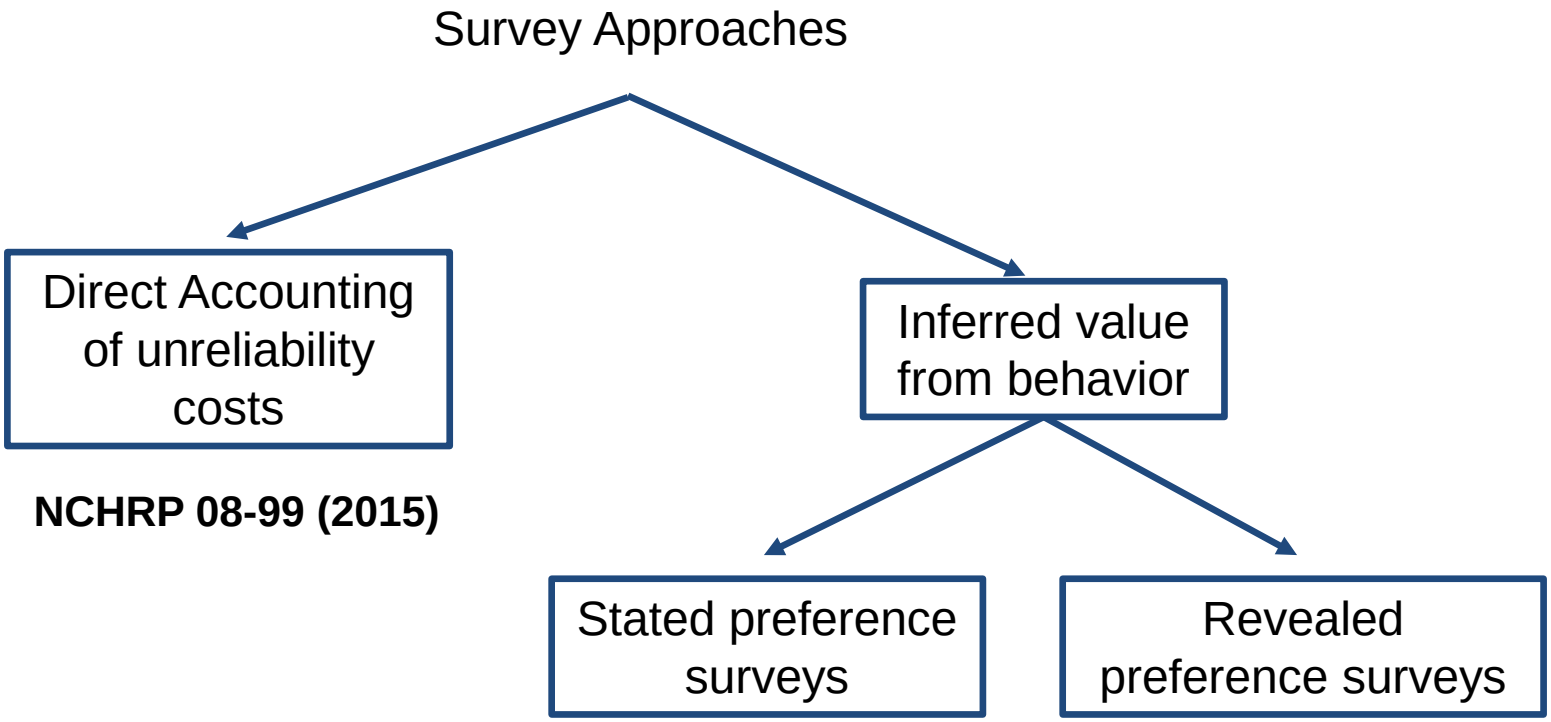
How to measure truck reliability?

NPMRDS Analysis Tool



Florida Freight Data Support System, 2016

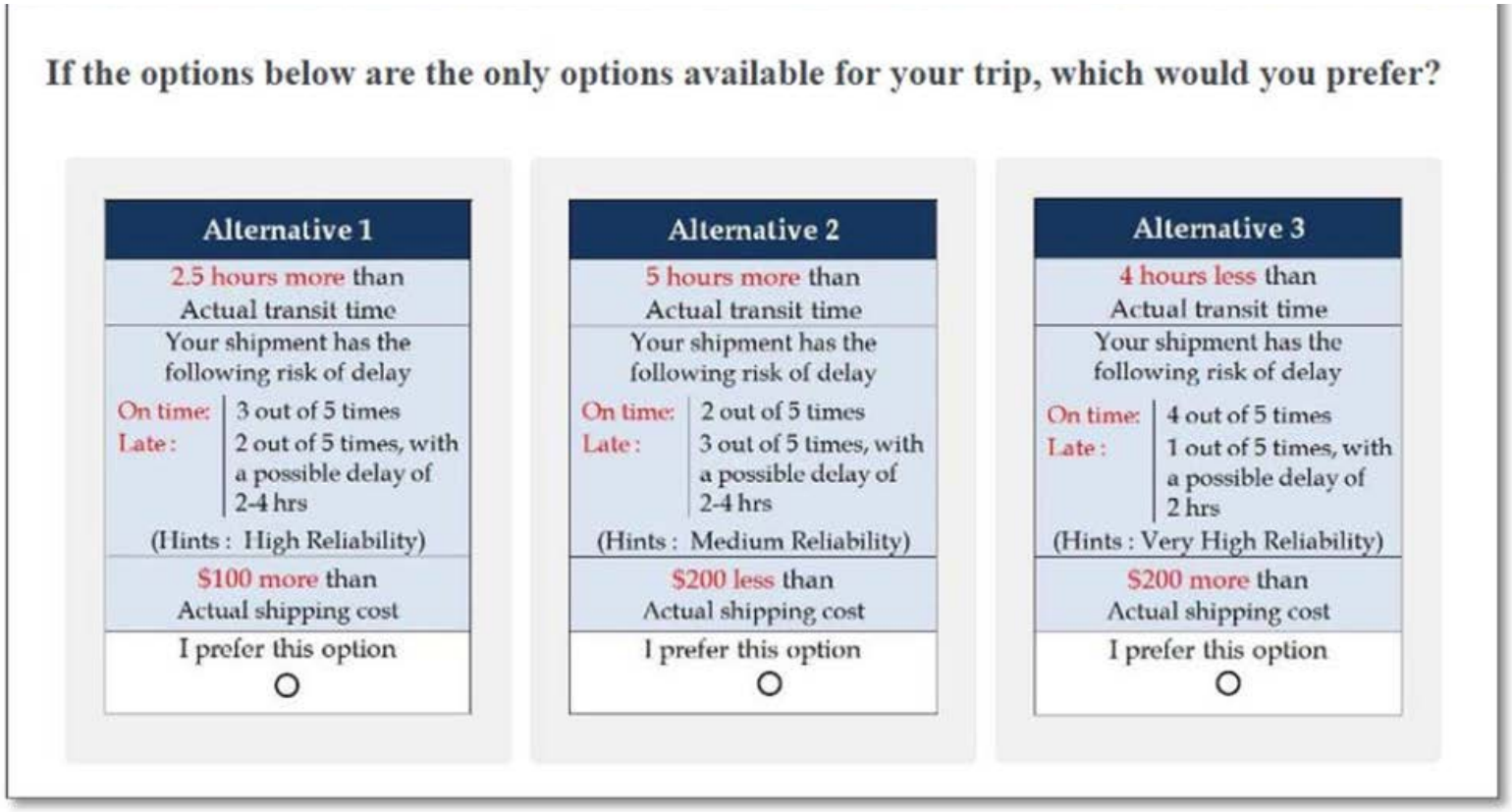
How to estimate value of truck unreliability?



- **NCHRP 08-99 (2015)**
- **NCHRP 07-24 (2018)**

How to estimate value of truck unreliability?

Florida Stated-Preference Survey to infer Truck VOR



If the options below are the only options available for your trip, which would you prefer?

Alternative 1	Alternative 2	Alternative 3
2.5 hours more than Actual transit time	5 hours more than Actual transit time	4 hours less than Actual transit time
Your shipment has the following risk of delay	Your shipment has the following risk of delay	Your shipment has the following risk of delay
On time: 3 out of 5 times Late: 2 out of 5 times, with a possible delay of 2-4 hrs	On time: 2 out of 5 times Late: 3 out of 5 times, with a possible delay of 2-4 hrs	On time: 4 out of 5 times Late: 1 out of 5 times, with a possible delay of 2 hrs
(Hints : High Reliability)	(Hints : Medium Reliability)	(Hints : Very High Reliability)
$100 more than Actual shipping cost	$200 less than Actual shipping cost	$200 more than Actual shipping cost
I prefer this option ○	I prefer this option ○	I prefer this option ○

Kollol Shams & Xia Jin, 2017, TRB Annual Meeting 2017

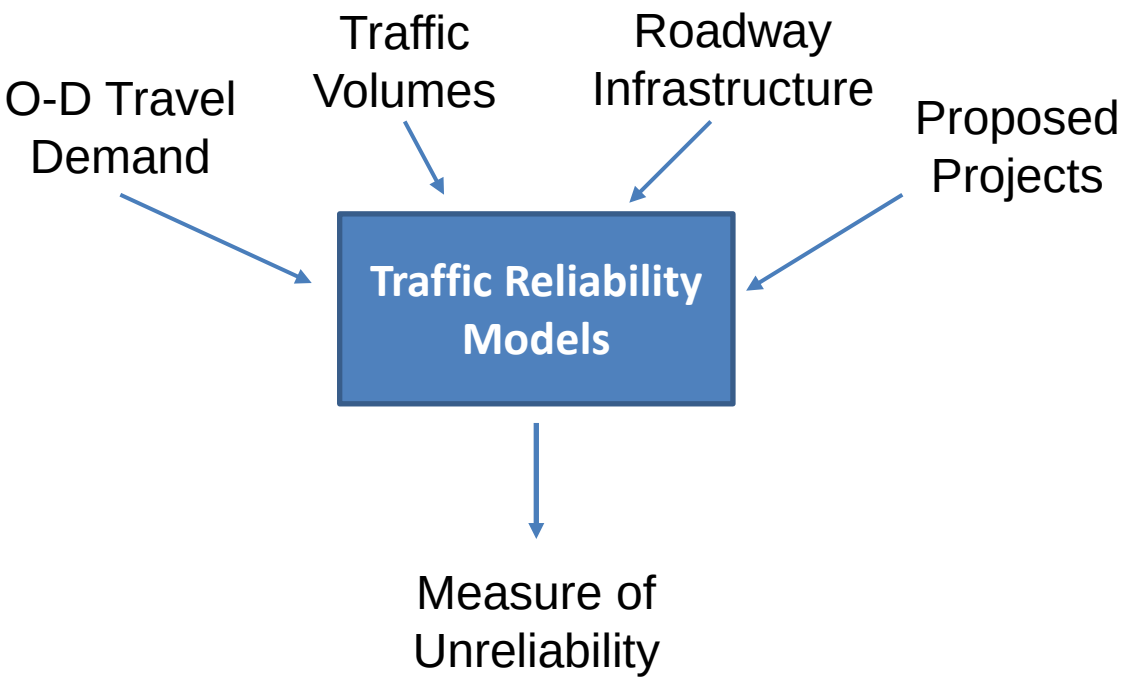
How to estimate value of truck unreliability?

Where?	Who?	How?	What?
Australia	Wigan et al (2000)	SP Survey 43 firms	Truckload vs less-than truckload, urban vs intercity
UK	Fowkes (2007)	SP Survey	Reliability ratios: 0.38 (shippers)
Italy, Switzerland	Beuthe & Bouffioux (2008)	113 firms	VOR from $.02 to $5.5 per ton.
Norway	Halse et al. (2010)	SP Survey 757 firms	Reliability ratios: 1.2 (shippers), 0 (Carriers). VOR from $12 USD to $387 USD
The Netherlands	Significance et al. (2013)	SP Survey	Reliability ratios: 0.9 (shippers), 0.28 (carriers), 0.37 (overall)
The Netherlands	de Jong et al. (2014)	SP Survey 812 firms	Multimodal. VOR from $29 USD to $10,205 USD.
FL, US	Shams & Jin (2017)	SP Survey 150 firms	Truck. VOR from $122 USD to $307 USD

How to estimate value of truck unreliability?

- Stratification of Value of Reliability (what affects costs?)
  - Magnitude: usual variation, unusual variation, extreme variation
  - Commodities and industries
  - Geography
  - Type of supply-chain: push vs. pull, linked-trips, intermodal transfers
  - Firm size and level of sophistication: ability to cope
  - Shipment size
  - Shipment length
  - Truckload vs Less-than-truckload, in-house trucking, 3PL/4PL
  - Urban vs intercity
  - Time of day of shipment
- Increases data requirements
- Sample size!

How to Forecast Network Reliability?



How to Forecast Network Reliability?

Where?	Who?	What?
UK	Arup 2003; Department for Transport (DfT)	Reliability model as a function of volume
Australia	Australian Transport Council (2006); Wang (2014)	Reliability as a function of volume/capacity ratio.
New Zealand	NZ Transport Agency (2010)	
Netherlands	Kouwenhoven et al. (2005); Van Lint et al. (2007); Hellinga (2011) Peer et al. (2012); Kouwenhoven (2014)	Reliability as a function of travel times; Reliability as a function of mean delay and length
Sweden	Eliasson (2006); Kristoffersson and Engelson (2008); and Kristofferson (2011)	SILVESTER model. Reliability as a function of travel time/free flow travel time. Unreliability affects travel behavior.
Denmark	Fosgerau and Fukuda (2010);	Reliability as a function of speed and flow. Not good for extreme delays.
Germany	Geistefeldt et al. 2014; MacDonald (2009); Palsdottir (2011)	Model estimated on simulated data;

de Jong et al. 2015, Transportation Research Part A

How to Forecast Network Reliability?

- TRB Strategic Highway Research Program: Reliability
  - 2013 - Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools, L04
    - Incorporating reliability in planning tools
    - Does not monetize unreliability costs
  - 2010 - Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies, L03
    - Developed model of reliability
  - 2016 - Value of Travel Time Reliability in Transportation Decision Making, L35
  - 2016 - Guide to Establishing Monitoring Programs for Travel Time Reliability, L02
  - 2014 - A Framework for Improving Travel Time Reliability, L17

Overarching Findings

- Need to think about planning applications when estimating VOR
  - What data sets are available to public agencies?
- Reliability costs could have comparable magnitude as travel time costs
- VOT more important for passenger but VOR more important for freight
- Only Australia and New Zealand include truck reliability in project BCA, Important!

NCHRP 07-24 (Phase II)

- Build on NCHRP 08-99 (Phase I)
- Collaboration between:
  - WSP|Parsons Brinckerhoff
  - Texas A&M Transportation Institute
  - Abt SRBI
  - Prof Robert Noland, Rutgers University
- Estimate Truck VOR simultaneously with developing planning application
- Consider important stratification
  - supply-chain type, commodity type, etc.
- Conduct nationwide survey of shippers and carriers
- Leverage existing travel time data: NPMRDS
- Guidance to practitioners