

# Future Freight Flows: Today & Tomorrow

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15 June 2017



ctl.mit.edu

## MIT FreightLab

Finding better ways to design, procure, manage, and assess freight transportation networks across all modes and regions.



# FreightLab – Partial Research Project List

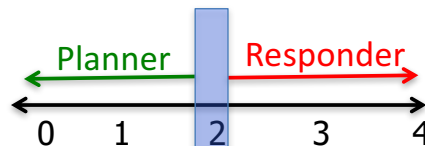
- Optimal Transportation Procurement
- Global Ocean Transport Reliability
- Transportation Portfolio Design & Management
- Freight Transportation Productivity
- Carrier Fuel Burden
- Same Day Fleet Load Acceptance
- Small Carrier Profitability Strategies
- Direct to Store Delivery Strategies
- The Living Plan – Robustness vs. Flexibility
- Supply Chain Complexity
- Disruptions of Dominant Distribution Design



Underlying Question . . .  
How to deal with variability & uncertainty?

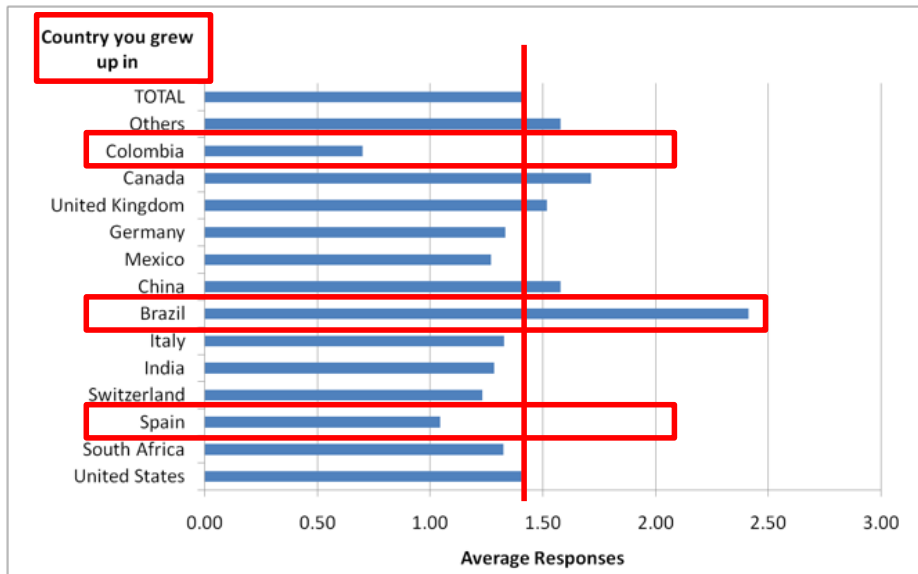
## Planning (Prevention) versus Responding

- MIT CTL Global Risk Survey
  - 1,500 responses from 70 countries
  - Rating from 0 (100% Prevention) to 4 (100% Response)
- Average overall was 1.41
  - 54% Planners
  - 16% Responders
  - 30% On the Fence
- Demographic Drivers
  - Gender
  - Geography
  - Job Function

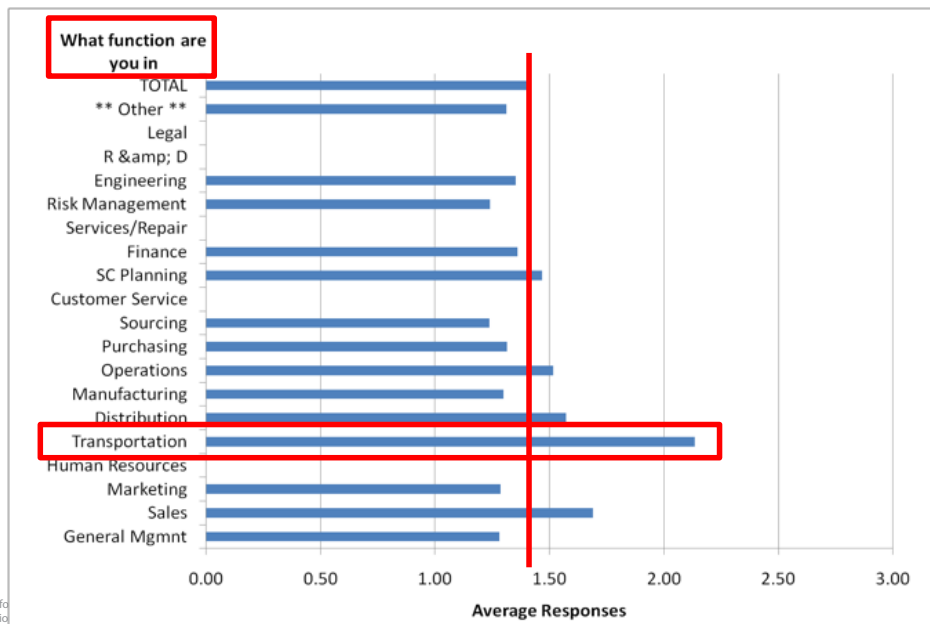


**Women are Responders**  
**Men are Planners**  
**(1.60 vs. 1.37)**

## Geography – Of birth, not work!



## Job Role or Function

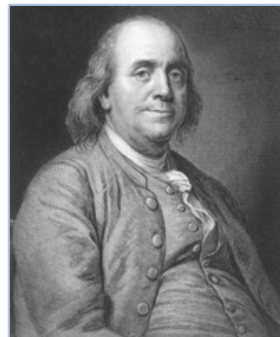


## The Living Plan: Robust vs. Flexible Planning

## Is Ben Franklin still correct?



"An ounce of  
prevention is worth a  
pound of cure"  
Poor Richard's Almanac



# What is the problem?

## Overall Research Questions

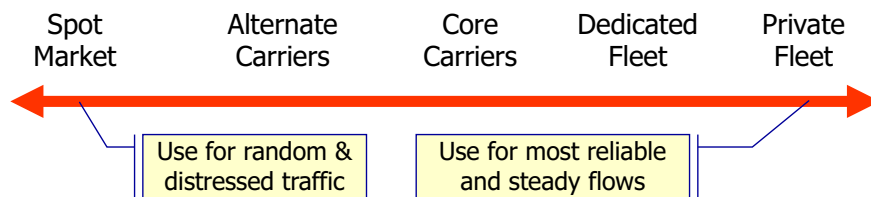
1. How should a firm best select, on a strategic basis, what types of contractual relationship to use for which segments of its freight transportation network?
2. How should this decision fit into the general transportation procurement process?
3. How can we balance robustness with flexibility?

## Research Approach

- Partnered with Wal-Mart
- Extended research team (Dr. Francisco Jauffred co-PI)
- Developed and implemented stochastic optimization model
- Integrated in WM procurement process

# Current Transportation Practice

- There is a continuum of relationships for TL based on:
  - Ownership of Assets versus Control of Assets
  - Responsibility for utilization
  - On-going commitment / responsibilities
  - Shared Risk/Reward – Flexible contracts

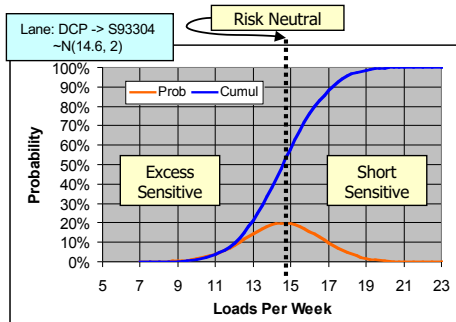


# How much volume to assign to the fleet?

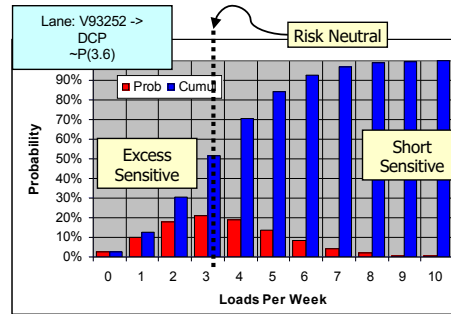
Assigned Fleet Volume (AFV) per Week = AvgVol + (Buffer Volume)

The “Buffer Volume” captures our confidence level. It can be positive or negative:

- > 0 indicates we prefer excess fleet capacity over being short (**Short Sensitive**)
- < 0 indicates we prefer short fleet capacity over having excess (**Excess Sensitive**)
- = 0 indicates we are indifferent to having excess or short fleet capacity (**Risk Neutral**)



Continuous Lane

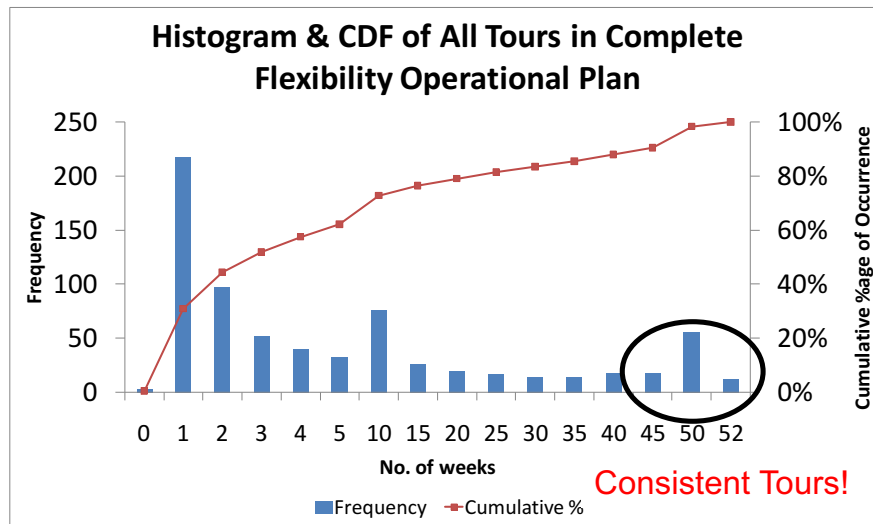


Intermittent Lane

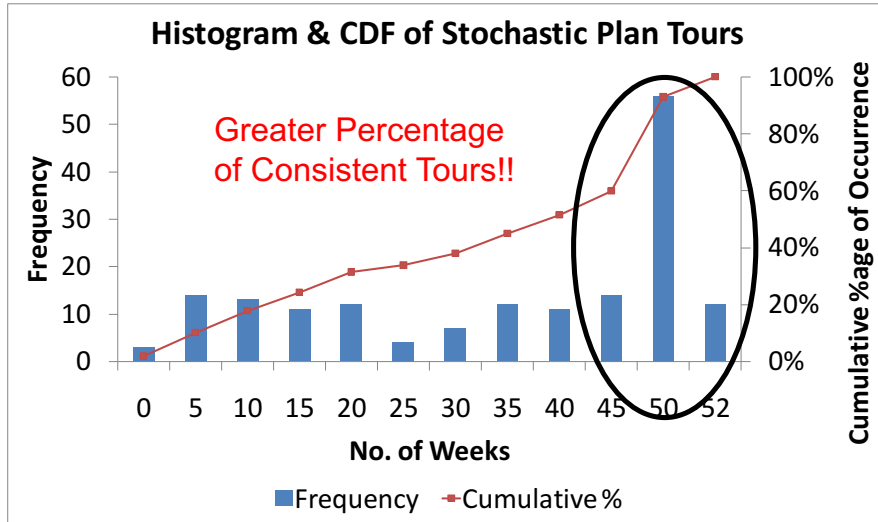
How do we determine the acceptable risk to calculate the optimal “Buffer”?



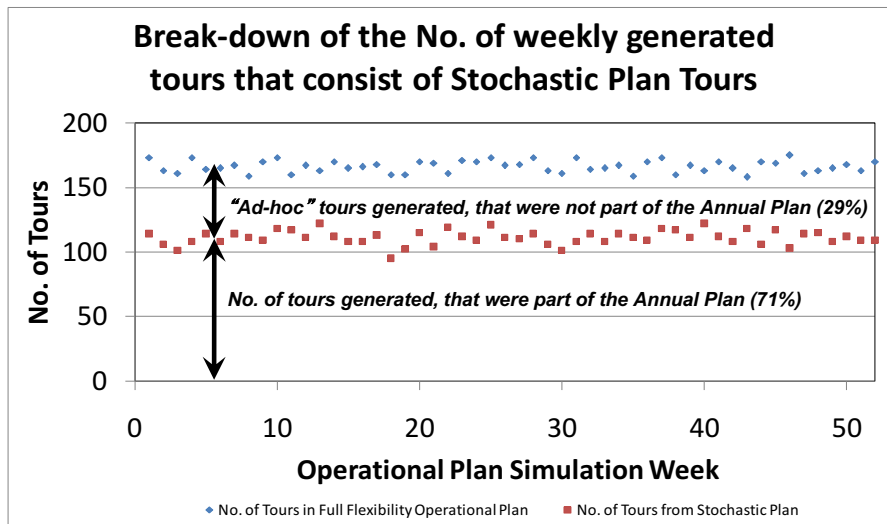
# All Tours Generated “Optimally” Each Week



# Annual Planned Tours that Appear in Weekly



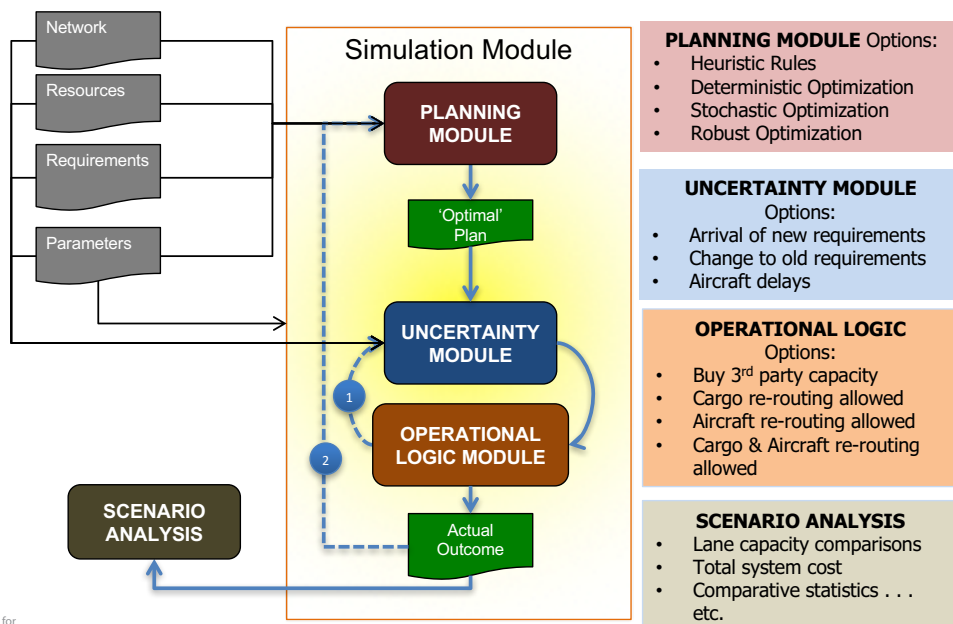
# Comparing “Plan” versus “Operational” Tours



# US TRANSCOM Project

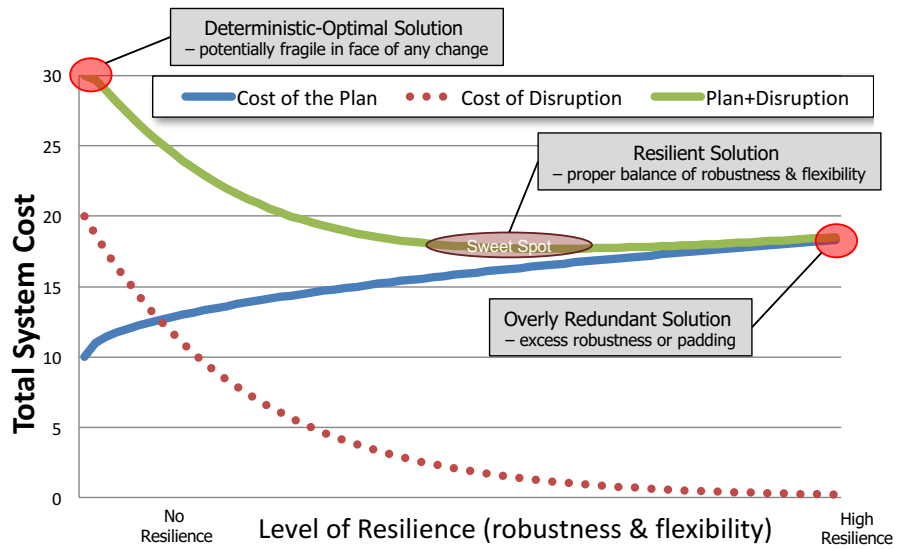
- Explore, develop, and evaluate algorithmic techniques, methodologies, and approaches to better solve the tactical aircraft planning and scheduling problem for USTRANSCOM – especially considering uncertainty and variability in missions.
- Sub-Objectives
  1. Formulate and create code prototypes of candidate resilient optimization models
  2. Examine the trade-off between robust planning and flexibility in response
  3. Create a simulation test bed to enable hands-on testing and evaluation of different planning models, operational policies, and other factors

# Simulation Test Bed Overview





# Resilience Tradeoff

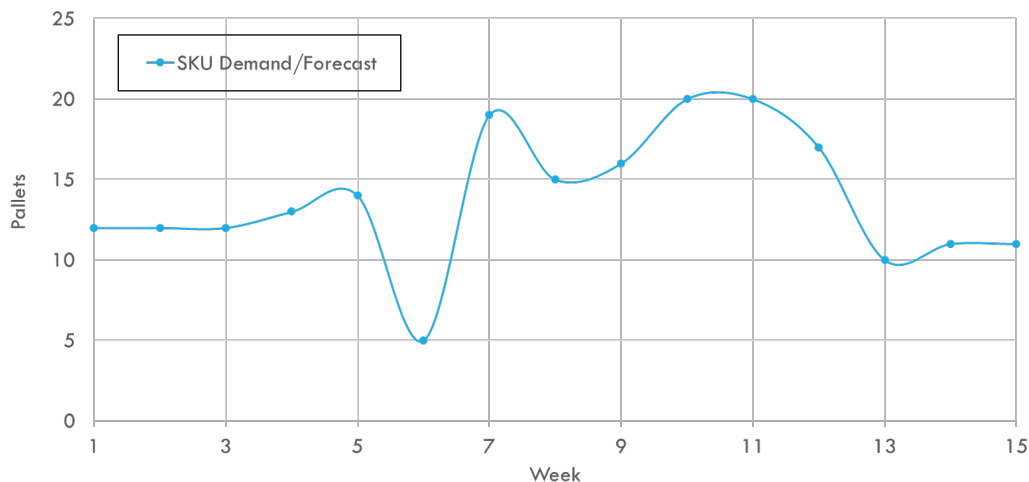
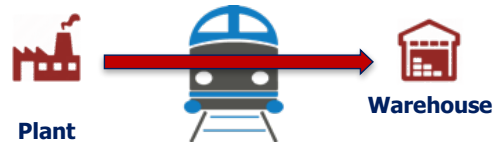


# Synchromodal Flow

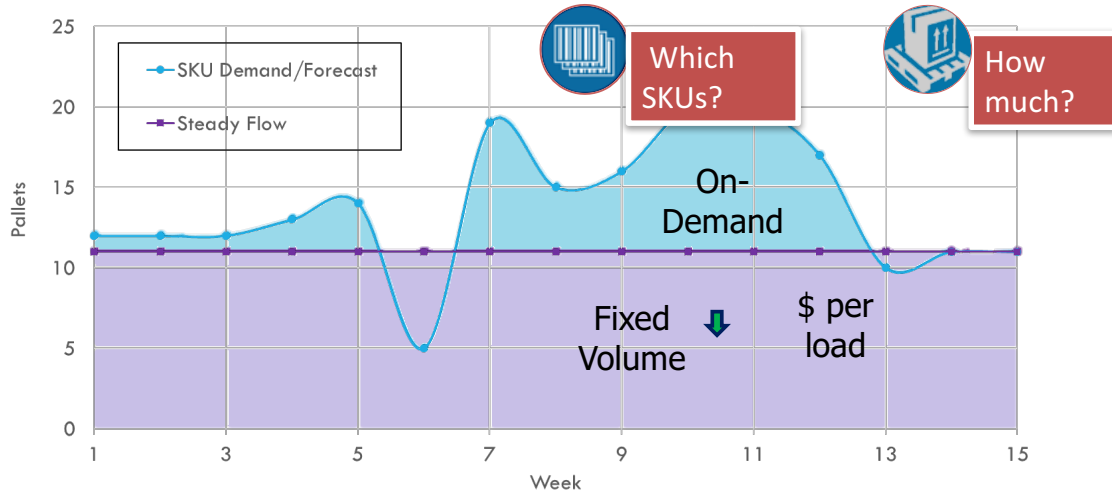
# Synchronizing The Supply Chain

- Overall Research Questions
  1. How can we identify SKUs that can be manufactured, transported, and distributed in stable quantities over an extended period of time?
  2. Where do the savings come from for this synchronized flow?
  3. How can we maintain/update this synchronomodal plan going forward?
- Research Approach
  1. Worked with large consumer packaged good (CPG) manufacturer
  2. Thesis by Priya Andleigh and Jeffrey Bullock, supervised by Dr. Ahmad Hemmati
  3. Developed model for identifying candidate SKUs and quantifying the benefits.

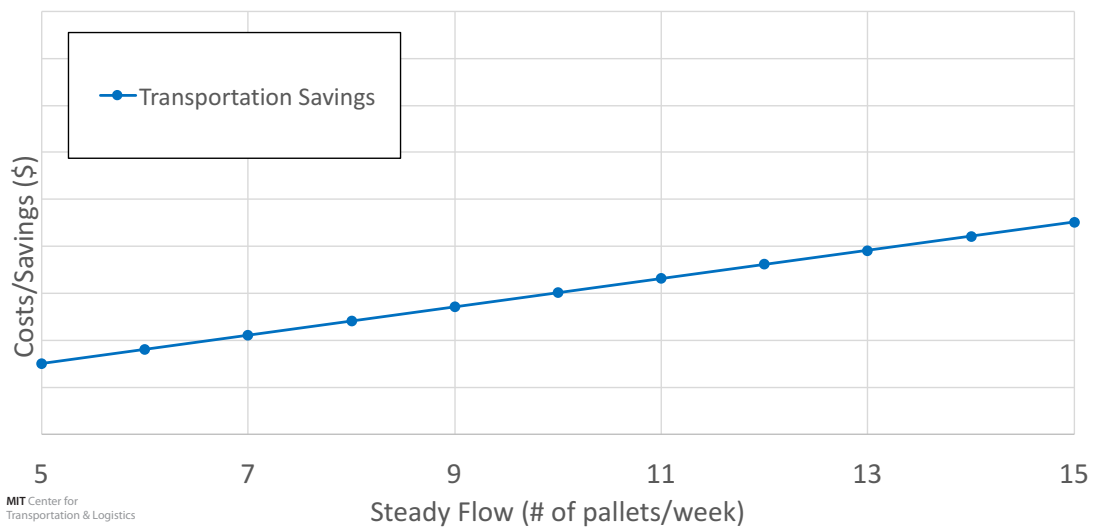
## Project Objective



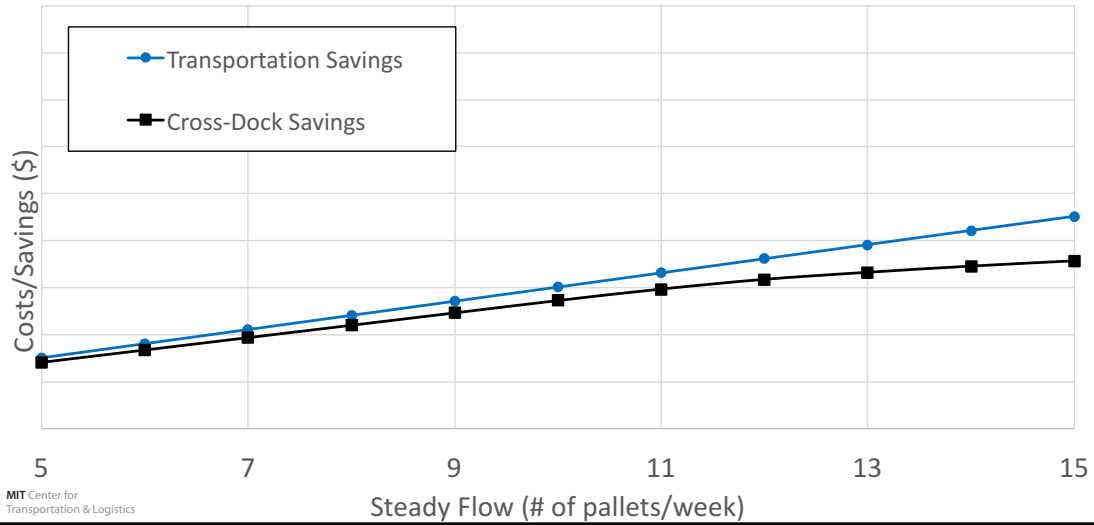
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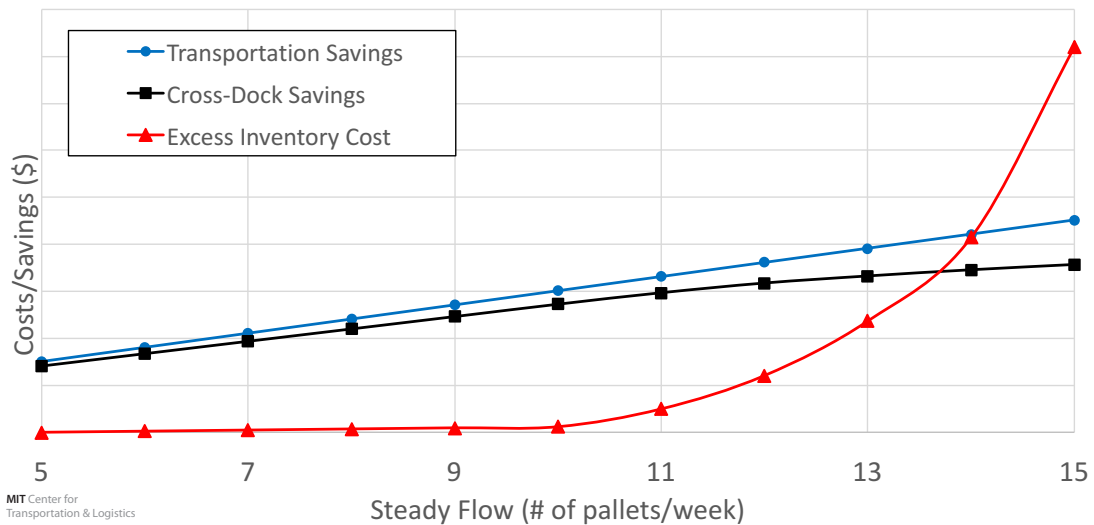
# Steady Flow Trade-offs



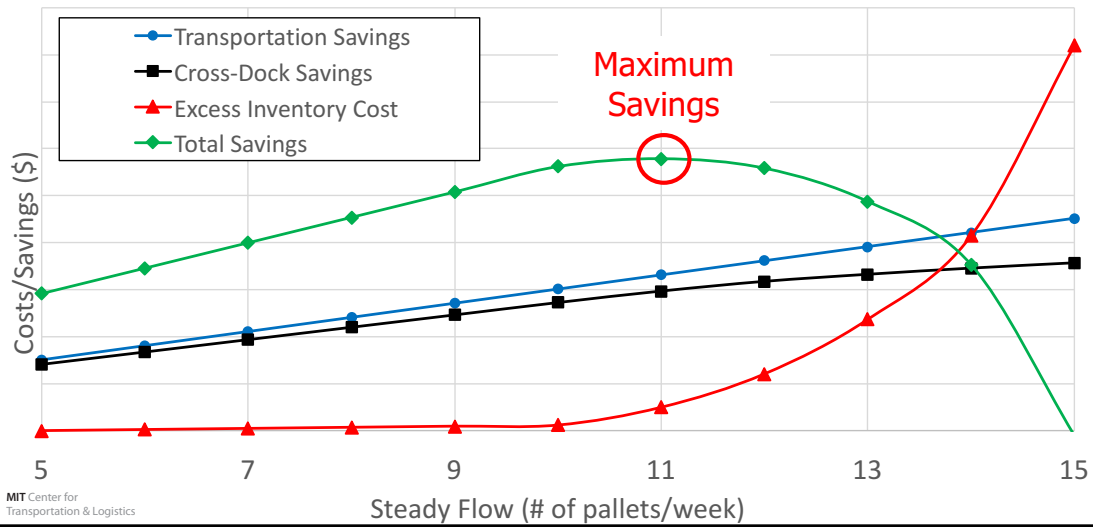
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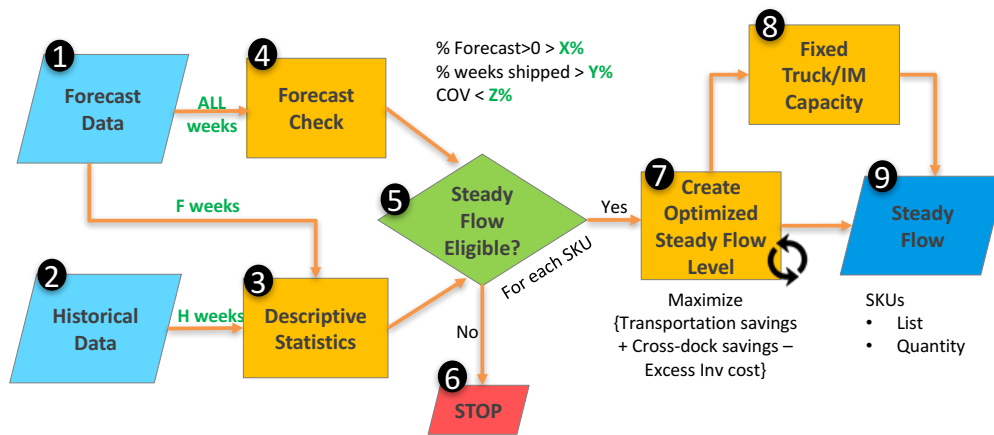
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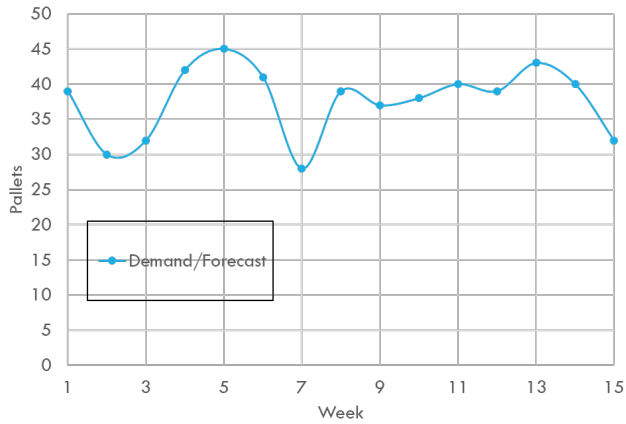


# Methodology



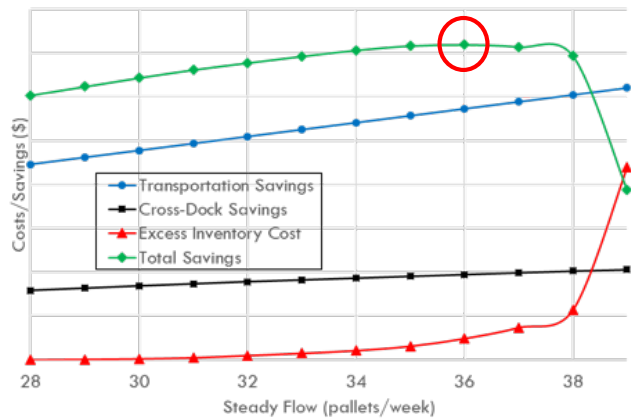
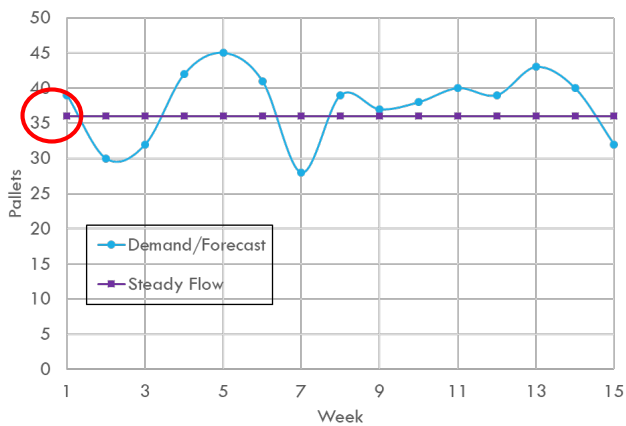
# SKU Example 1

Demand Characteristics			
Minimum (pallets/week)	28	% weeks shipped	100%
Mean (pallets/week)	37.7	COV	0.13
Std Dev (pallets/week)	4.80		
Moderate Volume, Stable SKU			



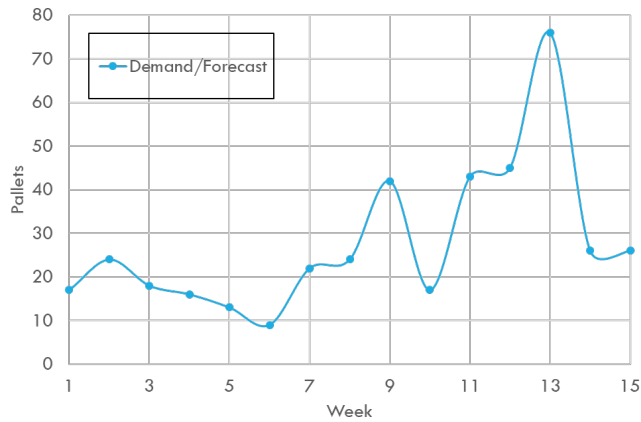
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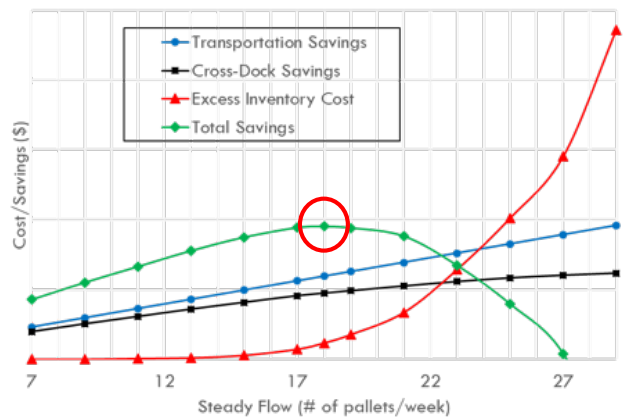
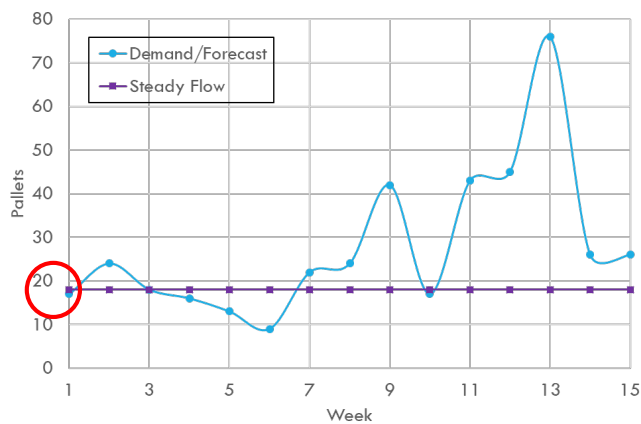
# SKU Example 2

Demand Characteristics			
Minimum (pallets/week)	9	% weeks shipped	100%
Mean (pallets/week)	27.9	COV	0.60
Std Dev (pallets/week)	16.7		
High COV SKU			



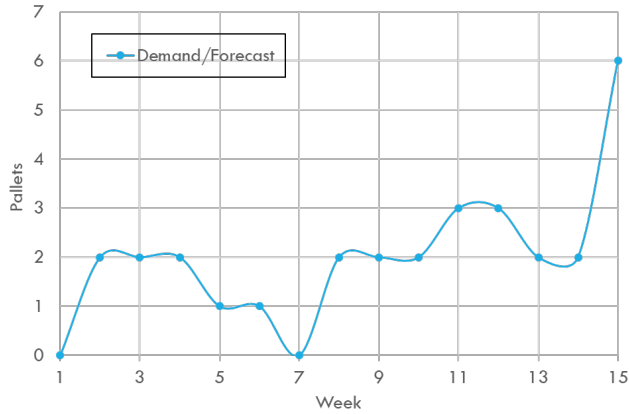
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High COV SKU			



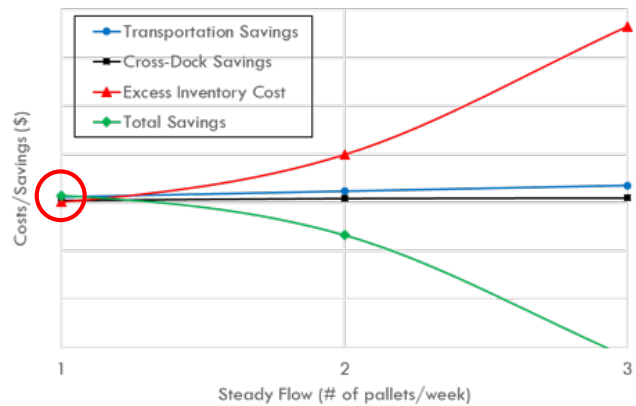
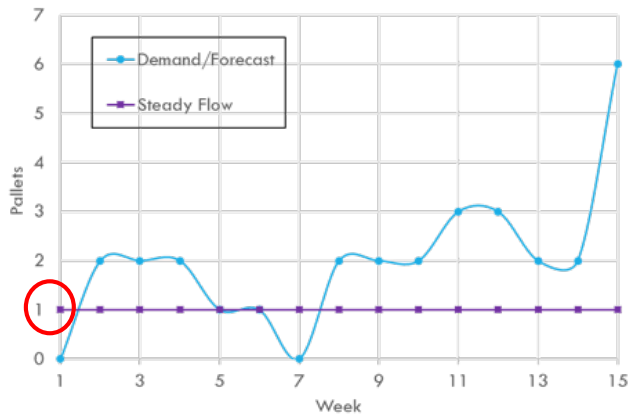
# SKU Example 3

Demand Characteristics			
Minimum (pallets/week)	1	% weeks shipped	87%
Mean (pallets/week)	2.3	COV	0.52
Std Dev (pallets/week)	1.20		
Low Volume, Not Shipped Every Week			



# SKU Example 3

Demand Characteristics			
Minimum (pallets/week)	1	% weeks shipped	87%
Mean (pallets/week)	2.3	COV	0.52
Std Dev (pallets/week)	1.20		
Low Volume, Not Shipped Every Week			





# Implications

- Identifying the “steady movers” has benefits beyond just transportation stability.
- Allows for manufacturing and cross-docking improvements.



## Global Ocean Transportation Reliability

# Lead / Transit Time Reliability

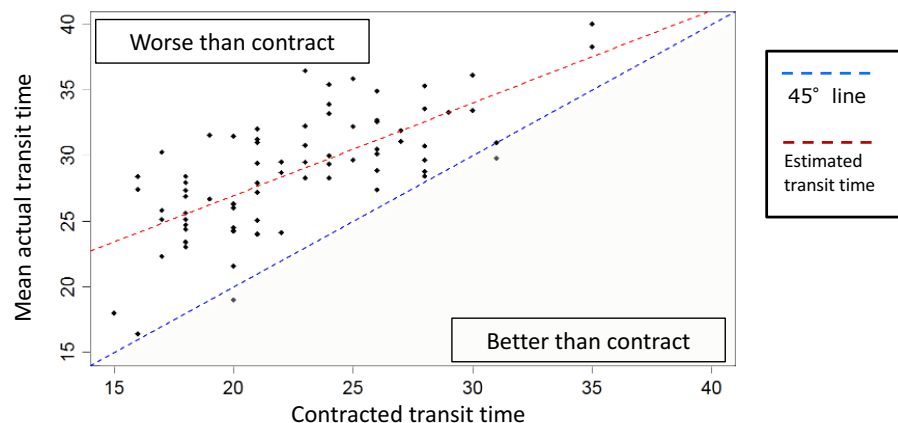
- Key Questions:
  - What is the definition of reliability within a firm?
  - What are the sources of unreliability/variability?
  - How can the current situation be improved?
- Two Dimensions of Reliability
  - Credibility
  - Schedule Consistency



Material adapted from Arntzen, B. (2011) "Global Ocean Transportation Project," Internal MIT Center for Transportation & Logistics (CTL) Report.

## Observations from Practice

Contract reliability in procurement and operations do not always match

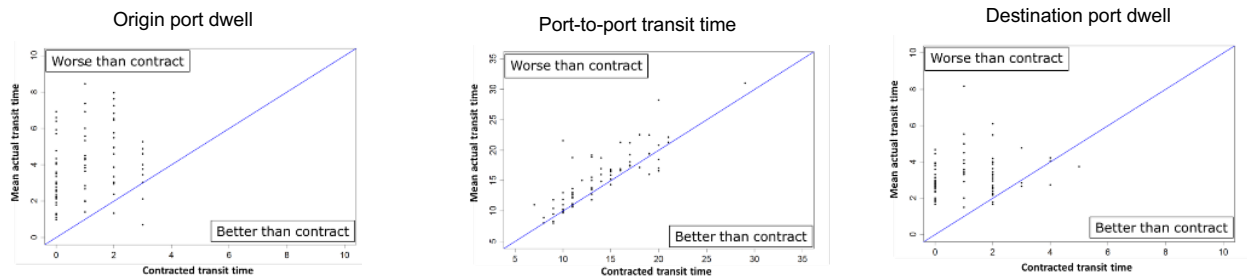


Material adapted from Caplice, C and Kalkanci, B. (2011) "Managing Global Supply Chains: Building end-to-end Reliability," Internal MIT Center for Transportation & Logistics (CTL) Report.



# Observations from Practice

Contract reliability differs dramatically across different route segments

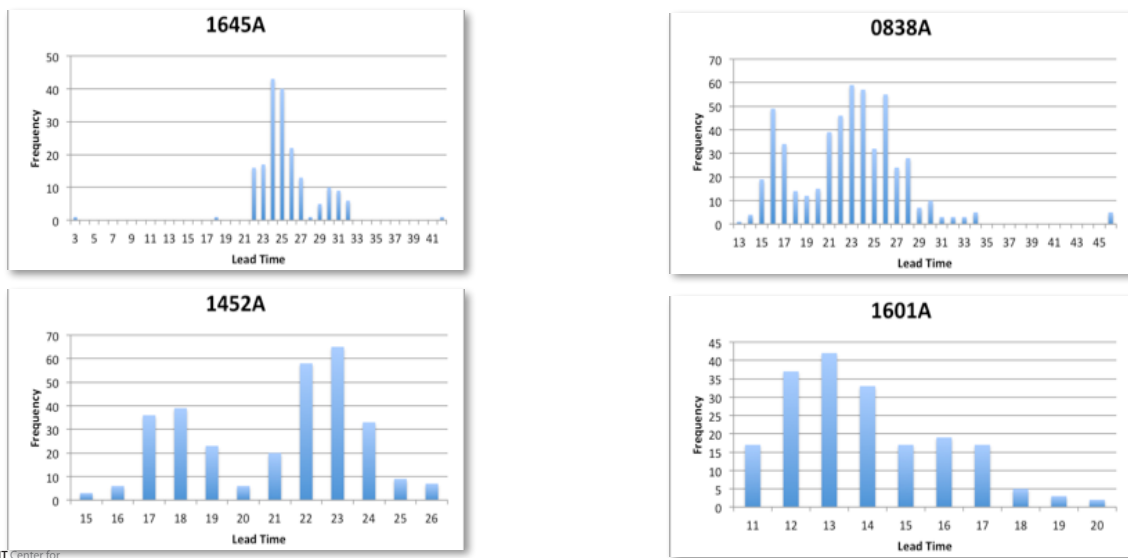


While accurate estimates of the port-to-port transit times exist, there is only limited information on port dwell times.

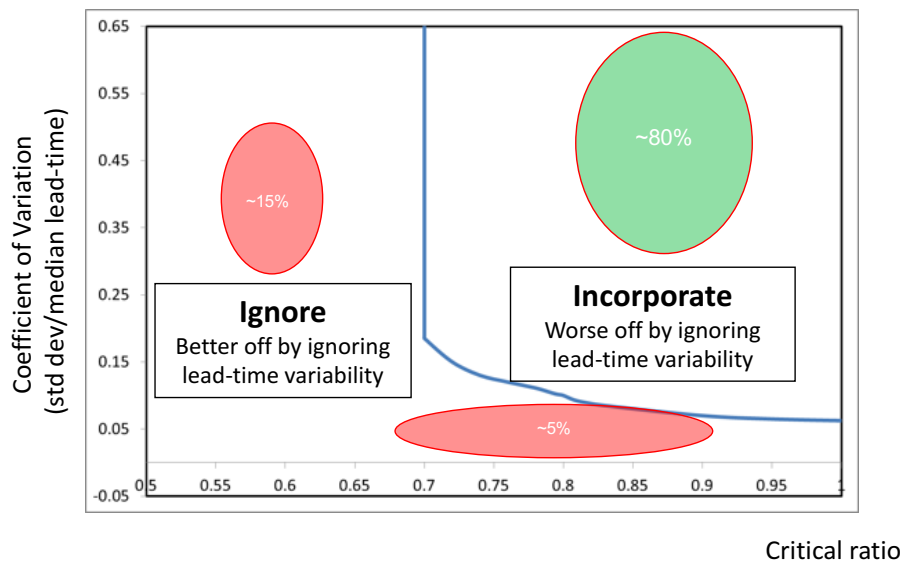


# Observations from Practice

Distributions are not always symmetric or uni-modal.



## When should your ERP consider variability?



## Handling Today's Variability

- Use portfolio of transportation solutions
  - Identify best use of Robust & Flexible options
  - Determine optimal allocation across the network
- Segment the product by variability
  - Identify candidate SKUs for synchromodal flow
  - Benefits extend beyond just transportation savings
- Ignore it
  - Identify when it is worthwhile to invest or not

## Shifting to Tomorrow

*Variability becomes Uncertainty*

## Freight Transportation Planning is hard.

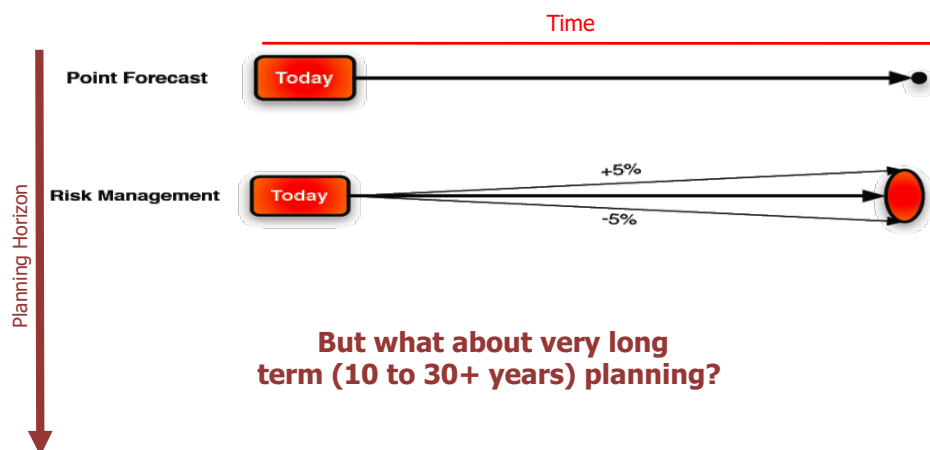
- Hard for shippers,
- Harder for carriers,
- **Hardest** for government planners!
  - Infrastructure planning timeframe is decades
  - Diverse and vocal constituents (NIMBY, BANANA)
  - Pallets don't vote
  - Both modal and jurisdictional silos
  - Revenue sources are decreasing dramatically
  - Removed from the system users

Recognized by FHWA & NCHRP – thus the NCHRP 20-83 Projects

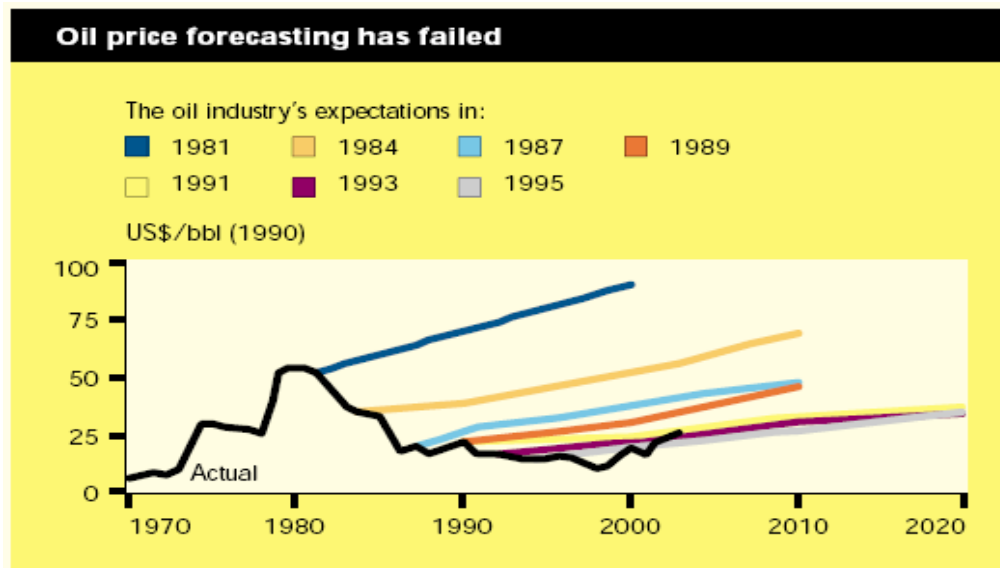
# NCHRP 20-83(1) Project Objectives

- Two Objectives:
  - “Provide decision makers [state DOTs] with a critical analysis of the driving forces behind high-impact economic changes and business sourcing patterns that may effect the US freight transportation system [in the year 2030 & beyond].”
  - “Better enable informed discussions of national, multi-state, state, and regional freight policy and system investment priorities.
- Details:
  - National Academies - Transportation Research Board (TRB) & National Cooperative Highway Research Programs (NCHRP)
  - First of 7 projects focused on “long-range strategic issues”
  - Develop and deliver methodology through 6 workshops

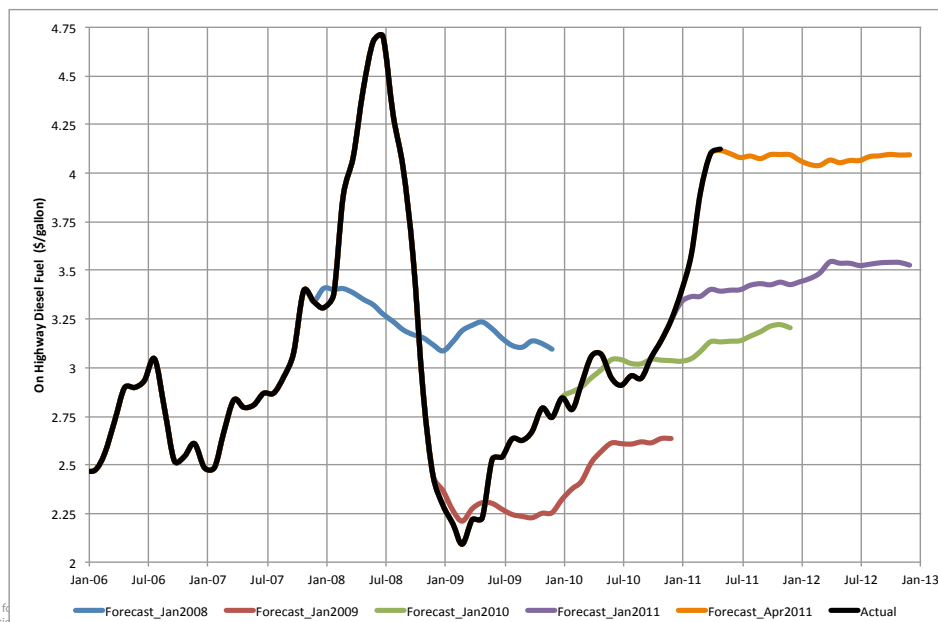
# Different Methods for Planning



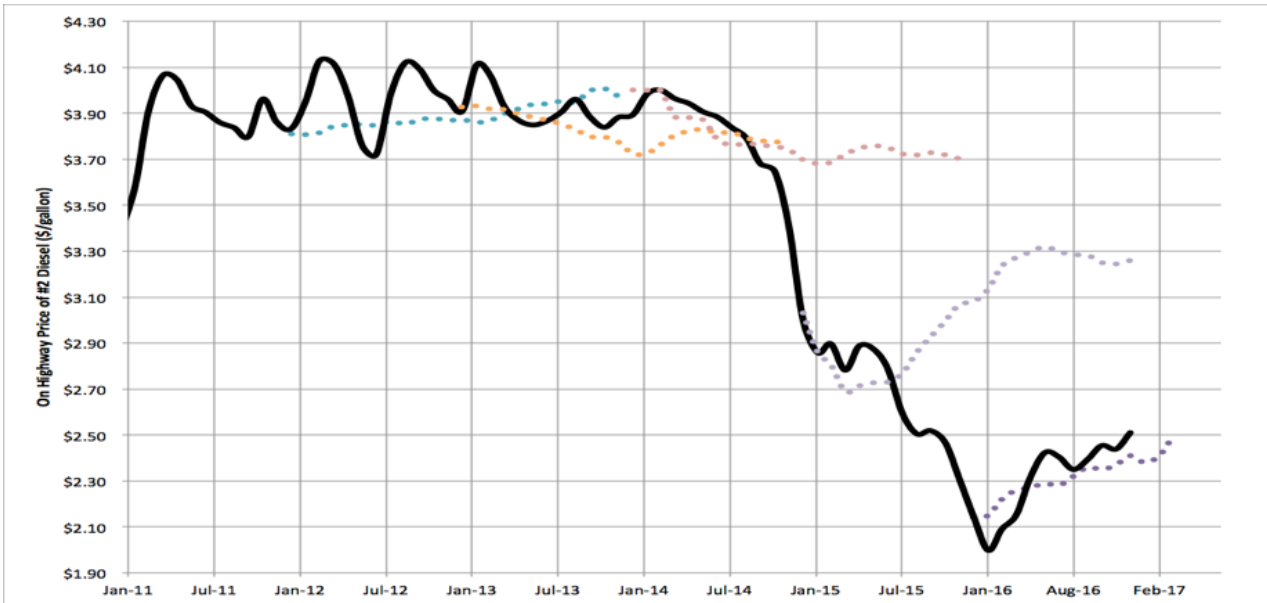
# Longer term planning is impacted by events



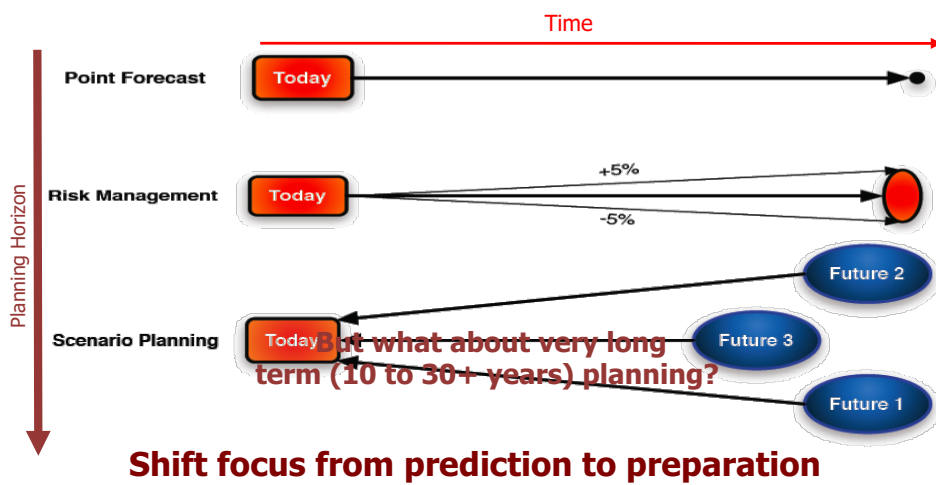
# Poor Forecasting is not a thing of the past . . .



# Still not a thing of the past . . .



# Different Methods for Planning





# Future Freight Flow Scenarios

We created 4 FFF scenarios for November 2, 2037

ONE WORLD ORDER



Naftástique!



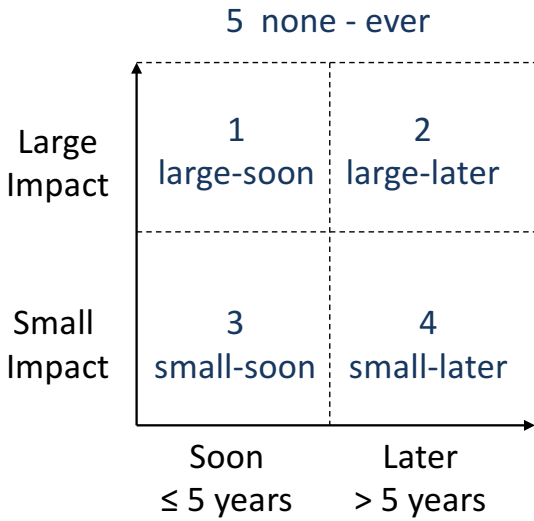
MILLIONS  
OF MARKETS



- Running 6 workshops across the US
- Over 300 shippers, carriers, and government planners
- Development of “Scenario Planning Toolkit” for state DOTs

## Technology Opinions

# Technology Trends & Impact



## Hot Topics Hit List

- Uber for Freight
- Delivery Drones
- Autonomous Trucks
- Mobile Computing
- Additive Mfg

# Digital Freight Matching

# Uber for X



# Why not Uber for Freight?



Road haulage  
**The appy trucker**

Digital help is at hand for a fragmented and often inefficient industry



TECH  
**Startups Accelerate Efforts to Reinvent Trucking Industry**

Companies aim to leverage drivers' smartphones to quickly connect them with nearby companies looking to ship goods



**Why does venture capital love logistics startups?**

Reynolds Hutchins, Associate Editor | Mar 01, 2016 7:12PM EST



>200 Transportation Electronic Marketplaces existed in 1999, but essentially none survived in their original form.

<i>Name</i>	<i>Year estab.</i>	<i>Origin Country</i>	<i>Market focus</i>
<i>eLogistics</i>	1999	UK	Road
<i>Freightgate</i>	1999	USA	Road, ocean, air
<i>FreightMatrix</i>	1999	USA	Road
<i>Freightquote</i>	1998	USA	Multimodal
<i>Internet Truckstop</i>	1995	USA	Road
<i>NTE</i>	1995	USA	Road
<i>Nistevo</i>	1997	USA	Road, rail, ocean
<i>Roadrunner</i>	1998	UK	Road
<i>Teleroute</i>	1988 (1999)	Belgium	Road
<i>Timocom</i>	1997	Germany	Road
<i>Wtransnet</i>	1997	Spain	Road

The last time VCs thought freight was sexy . . .

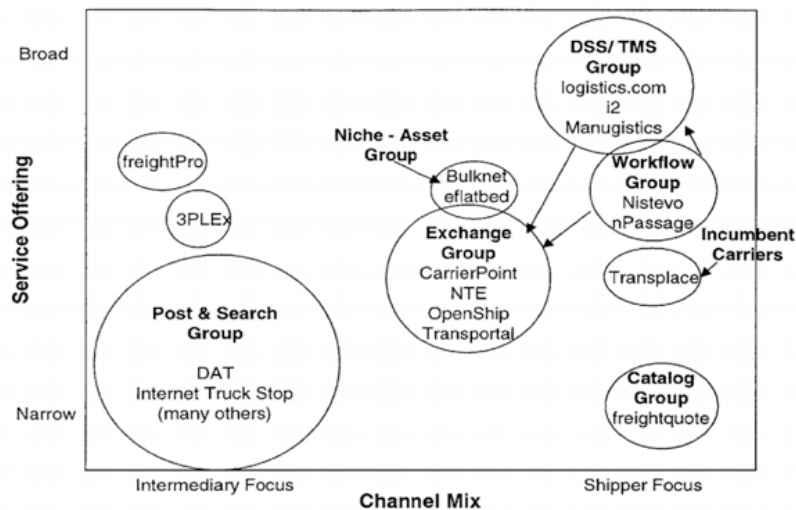
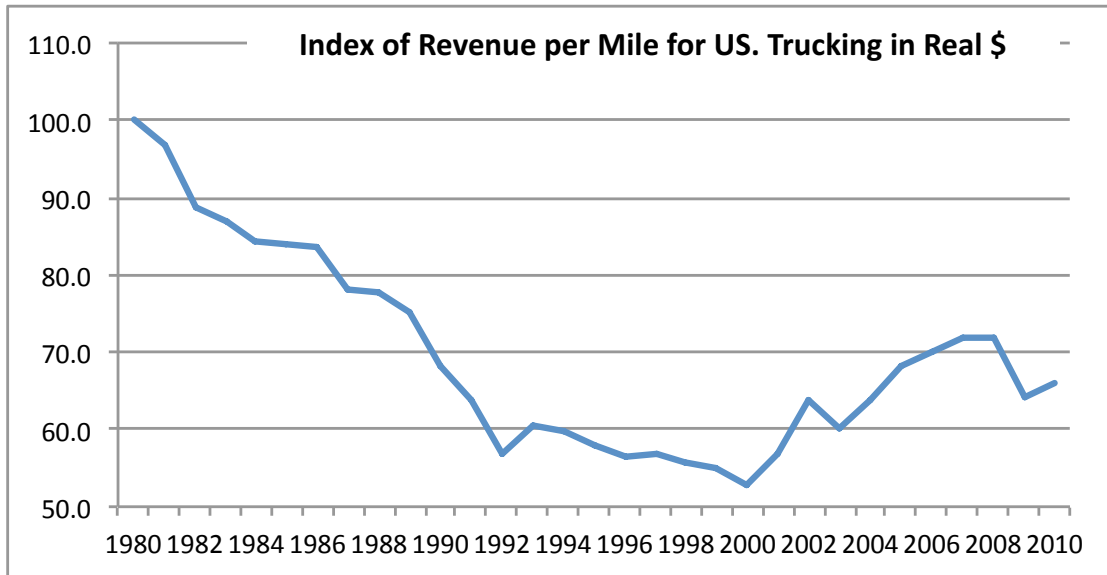


Figure 2-3 Strategy Map for Truck Transportation Marketplaces

## Most Recent Real Disruption?      Deregulation



59

## Does the Uber model fit?



- What do we do when we uber?
  1. Contact a single source through an App
  2. "Real time" visibility of nearby vehicles
  3. Matched to one of multiple underlying providers
  4. Payment handled off line, estimated in advance
  5. Pricing varies based on surging

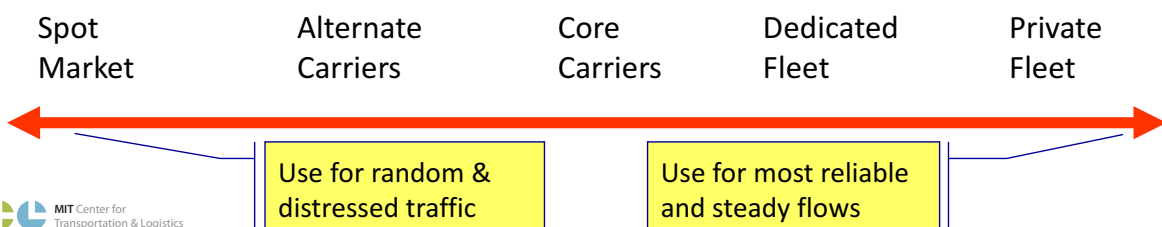
Is Uber just Freight Brokerage for Passengers?

# How do the Markets Compare?

	PAX	FRGT
Competitive Market	Local Monopolies (taxis)	Highly Competitive

# Transportation Portfolio Continuum

- Different network segments require different relationships
- Segmentation of network and carriers by needs
- Continuum from one-off transactions to ownership
  - Ownership of Assets versus Control of Assets
  - Responsibility for utilization
  - On-going commitment / responsibilities
  - Shared Risk/Reward – Flexible contracts



## Proposed value to better matching

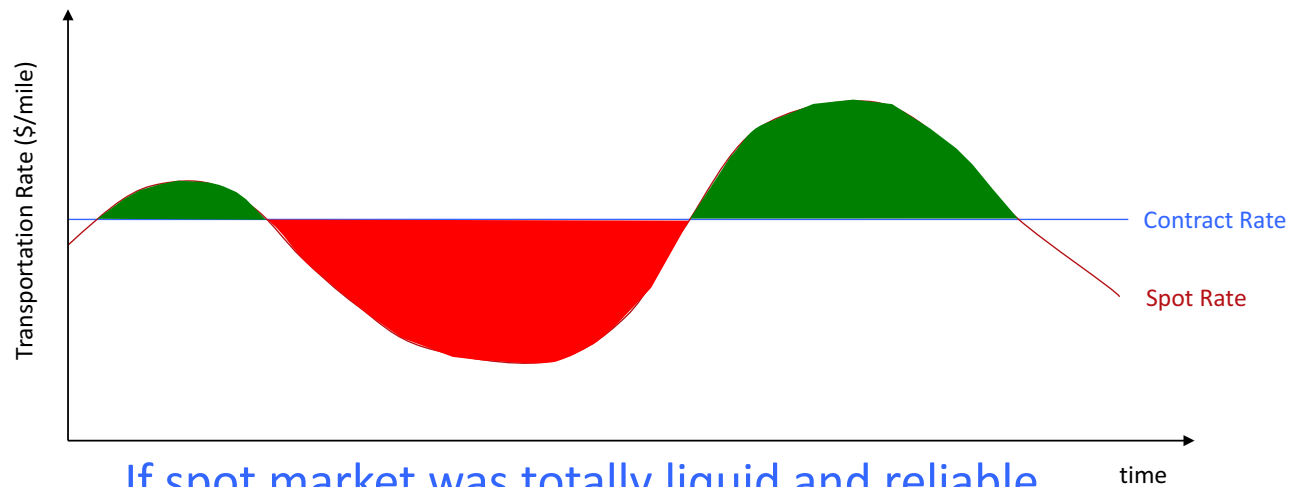
- Improved vehicle utilization
  - Estimates in US 10%-30% empty miles
  - Differs by length of haul & carrier size
- Reduced transactional inefficiencies (friction)
  - Streamline matching, payment, notification, visibility, etc.
  - Does visibility of nearby trucks add value to a shipper?

## My Take-Aways on “Uber for Freight”

- Most start ups in this space hate the name!
- Some start ups do have have improved functionality . . .
  - Evolutionary more than revolutionary,
  - Serving to increase customer expectations, but
  - Worthwhile functionality is being incorporated within TMS or brokers.
- Demise of brokers has been greatly exaggerated (again)
  - Middleman’s role is growing, not being diminished
  - Promised “two party” transactions are really “three party”
  - Potential consolidation in brokerage space – strong economies of scale
- Area for fit: Local real-time, on-demand delivery



## Begs a bigger question . . .



If spot market was totally liquid and reliable,  
would it lead to the end of annual contracts?

## Delivery Drones

# Trend: Delivery Drones

- What is it?
  - An unmanned aircraft that can navigate autonomously, without direct human control or is guided remotely.
  - Initially used in military operations in 2000
  - Commercial use now common in filming, disaster management, search & rescue, geographic mapping, precision agriculture, wildlife monitoring, etc.
- What is status today?
  - Drone Deliveries Have Already Happened
    - On Dec. 7 2016, Amazon Prime delivered an Amazon Fire TV and a bag of popcorn by drone to a man near Cambridge, UK.
    - Flirtey and 7-Eleven delivered a chicken sandwich, donuts, candy, Slurpees and hot coffee via drone in July 2016 in Reno NV.
  - Countries have varied restrictions

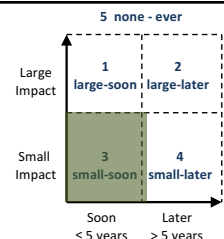


December 2016 Connect Robotics delivered food for an old men in the mountains of Portugal.

- Commercial Drones
  - Market size ~\$550M in 2014 and forecast to \$1B in 5 years
  - Sales grew >200% last 2 years with > 2.5M in use in US

# Trend: Delivery Drones

- Direct Impact:
  - Able to send small loads to remote locations quickly
  - Expands delivery capabilities using “open air” without using existing infrastructure
  - Essentially a new transportation mode for very fast replenishment of very small shipment size over a close distance.
- Potential Longer Term Indirect Impacts
  - Amazon was awarded a patent for an "airborne fulfillment center" which essentially is blimp with a fleet of drones for delivery.
  - Will complement (but not replace) existing last mile delivery techniques – will find a niche with most delivery companies
  - Provide ultra-fast replenishment for high end items



# Autonomous Trucks

## Trend: Autonomous Trucks & Vehicles

- What is it?
  - Trucks and other vehicles that can operate with minimal (or no) human interaction.
  - Established Levels of Automation
    - No Automation (Level 0)
    - Function-Specific Automation (Level 1)
    - Combined-Function Automation (Level 2)
    - Limited Self-Driving Automation (Level 3)
    - Full Self-Driving Automation (Level 4)
- What is status today?
  - Autonomous Delivery Already Happened
    - First paid autonomous delivery occurred in Colorado in October 2016.
    - Otto delivered full TL of beer
  - Major investments in technology
    - Uber acquired Otto in 2016 for \$680M
    - Intel acquired Mobileye in 2017 for \$15B



- Where can it be used?
  - Linehaul Corridors
  - Local delivery
  - Intra-Yard



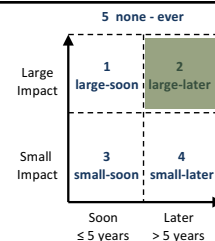
## Trend: Autonomous Trucks

### ■ Direct Impact:

- Single day range of trucks could double (~1000 miles)
- Lower fuel costs due to lower speeds
- Ubiquity of truckload is combined with low cost of intermodal (truck-rail)

### ■ Potential Longer Term Indirect Impacts

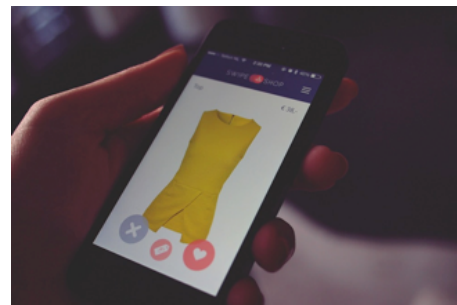
- Reduction in number of distribution centers and thus lower overall inventory levels
- Concentrated corridor traffic with terminals for local driving for last mile
- Dissolution of TL carriers to independent driving entities
- Large job loss in long-haul trucking



# Mobile Computing

## Trend: Mobile Computing

- What is it?
  - Technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link.
- What is status today (2016)?
  - Mobile data traffic has grown 18-fold over the past 5 years
  - 8 billion mobile devices (325 million wearable devices) currently in use
  - Average smartphone usage grew 38% in 2016 with the Middle East and Africa showing 65% CAGR in mobile data traffic growth (most anywhere!)
  - Smartphones are used as phones less than 3% of the time
  - Online shopping behavior differs by platform: laptops & tablets vs. smartphones



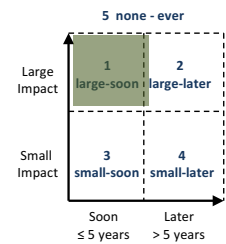
# Trend: Mobile Computing

## Direct Impact:

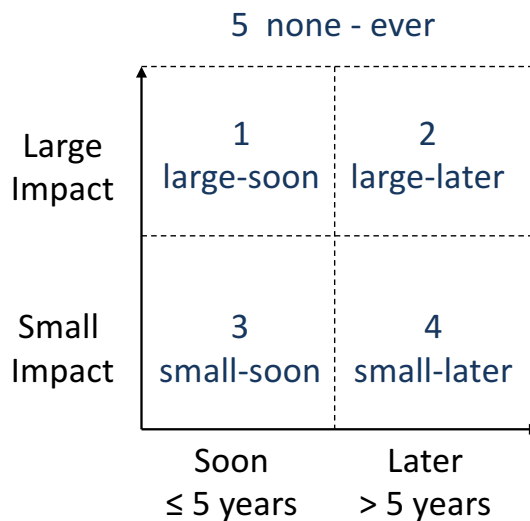
- Able to access data and systems from anywhere
- Enables new paradigms of shopping and thus retail supply chains (omnichannel)

## Potential Longer Term Indirect Impacts

- Transformation of retail shopping industry and experience
- Complete shift to Cloud computing for enterprise and other applications
- Decentralize operations for many processes



# What other trends or technologies???



## Key Take-Aways

- Handling Variability Today
  - Manage a complete transportation portfolio
  - Segment out stable flow through supply chain
  - Understand when not to bother
- Preparing for Uncertainty for Tomorrow
  - Focus on preparation rather than prediction
  - Involve larger group on scenario planning



“Wilson & Dexter – disrupting the dominant design daily”  
Yankee Golden Retriever Rescued Dogs ([www.ygrr.org](http://www.ygrr.org))