Tab 20

Supply Chain Risk and Resilience: Linking Multimodal Transportation and Global Economic Models

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March 16th, 2022

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GOAL: Resilience-focused Supply Chain Policy Interventions

California Transportation Commission

Transportation Supply Chain Model

Econometric Modeling

Data Management

Risk and Resilience Analytics

ERDC Toolbox
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Transportation

Ports

Ships

Freight

Consumers

Challenge

Ocean lines optimize cost per container

Port terminals optimize container flow

Warehouses optimize location/capacity

Freight corridors optimize traffic flows

Resilience

System Performance

Disruption

Minimize

Plan | Absorb | Recover | Adapt

Efficiency

High Cost

Current Strategy

A

C

Direction of Improvement

B

Low Cost

Low | High
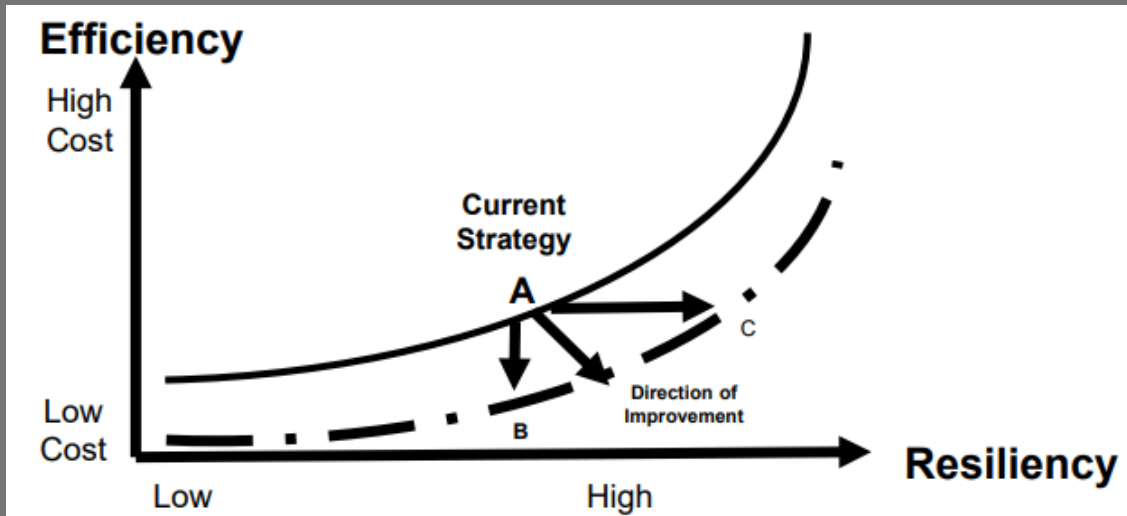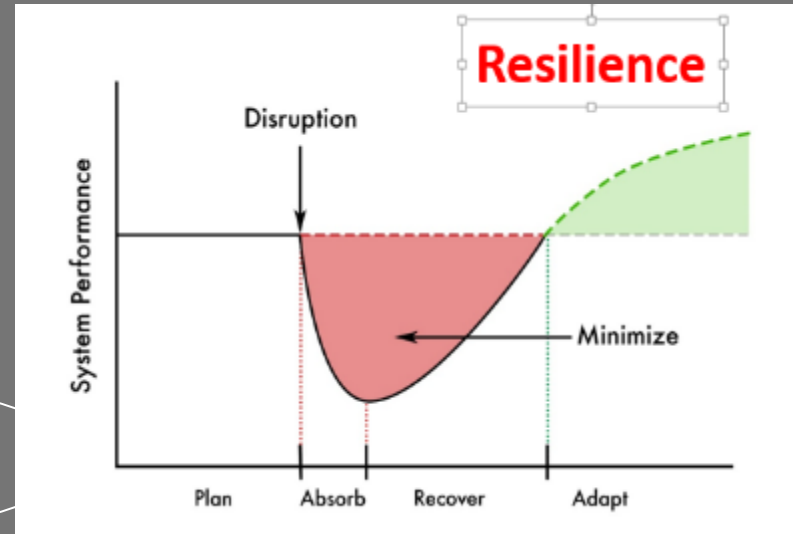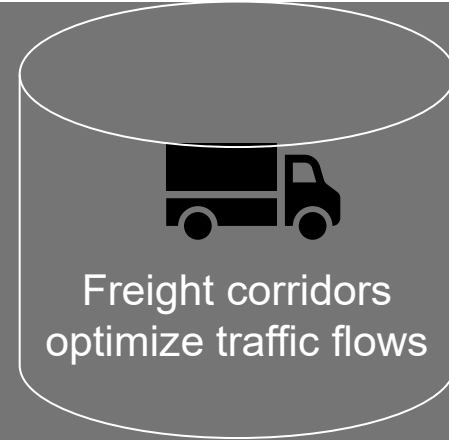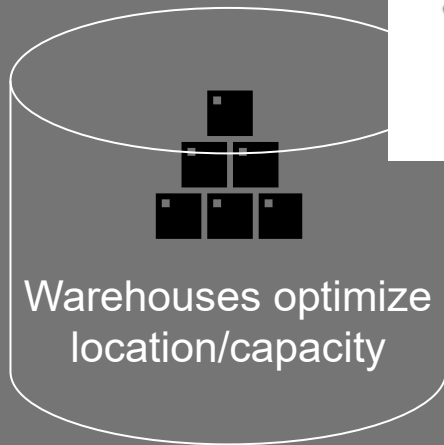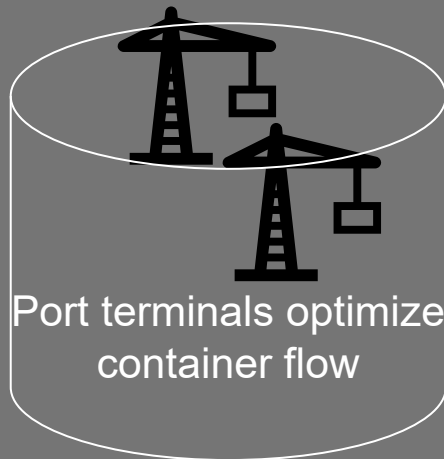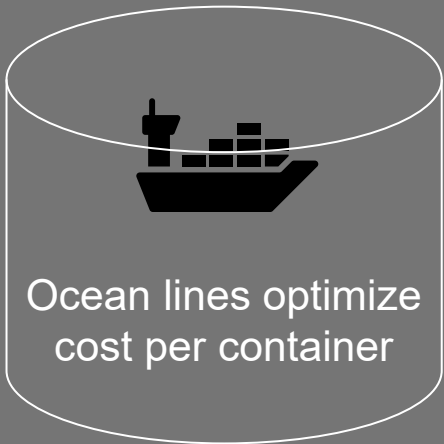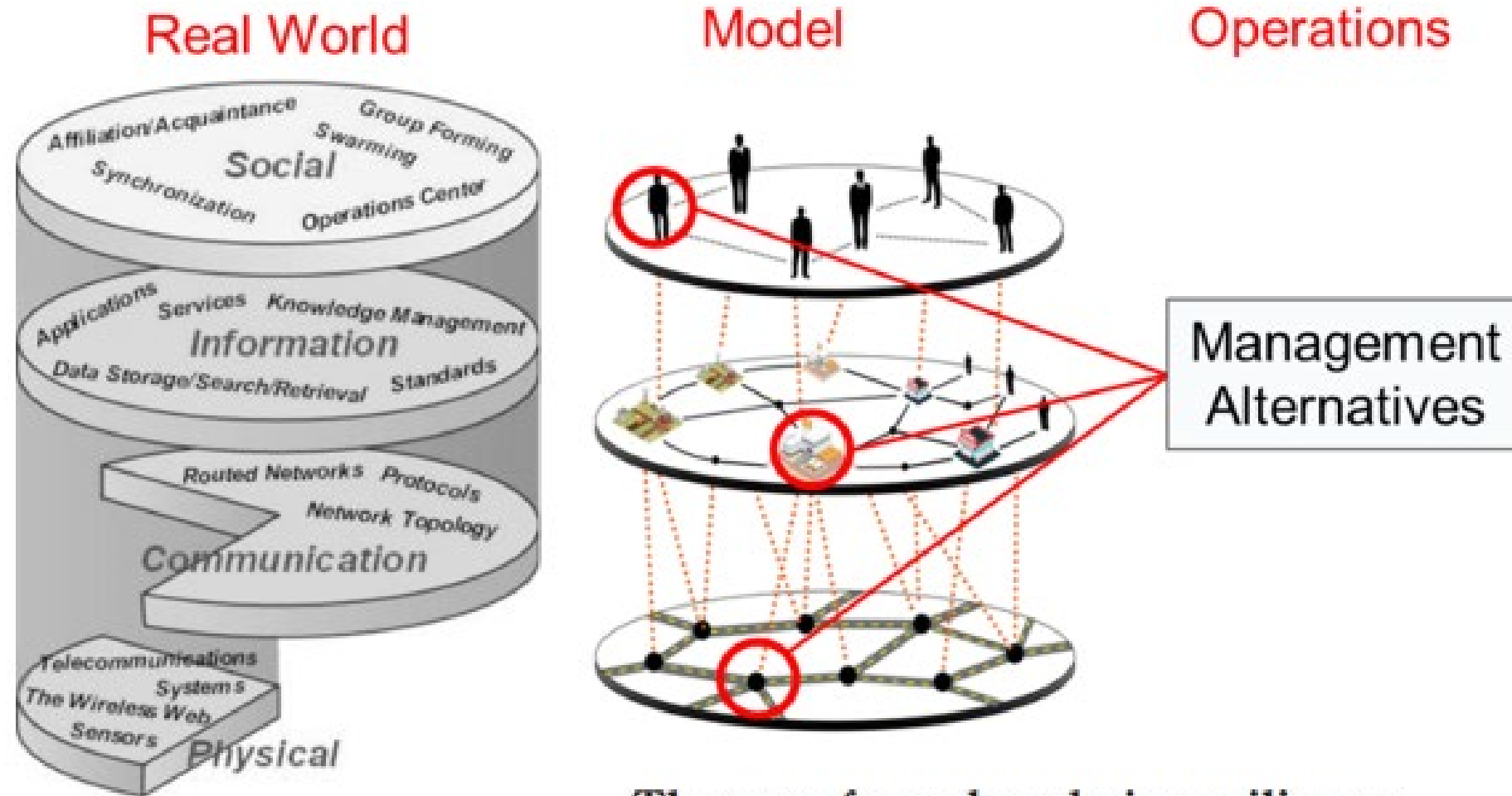
Resiliency

Supply Chains have been optimized for efficiency at component levels.

The main opportunities for improvement are for resilience.

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Vision for System Resilience

The case for value chain resilience
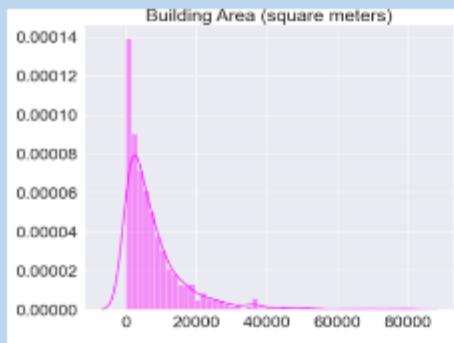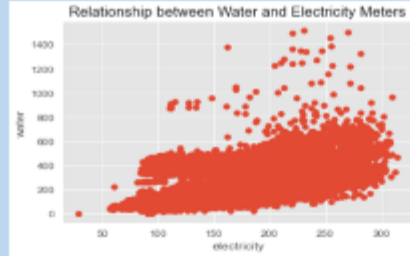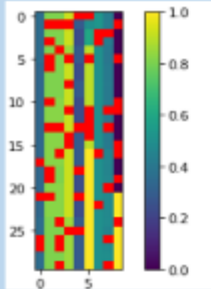
Igor Linkov, Savina Carluccio, Oliver Pritchard, Áine Ni Bhreasail,
Stephanie Galaitsi, Joseph Sarkis and Jeffrey M. Keisler

Technical Approach

Resilient systems and networks rely on the ability to prepare, withstand, respond and adapt to evolving threats

Data Analytics

Explainable Models and Methodology

- Causal Analysis
- Machine Learning
- Relational Inference
- Anomaly Detection
- Feature Importance
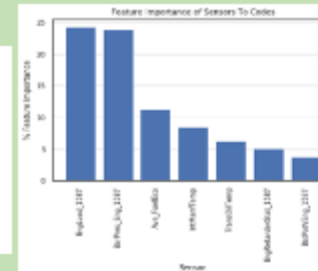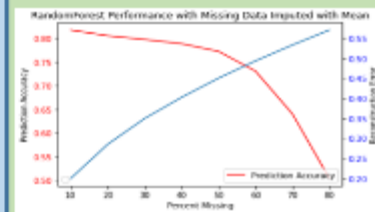
Understanding and Improving Resilience

- Lower energy costs, detect cyber attack, ...
- Proactive vs reactive response
- Decision support
- Gain insights

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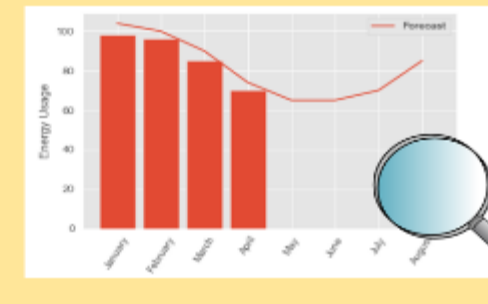
Mathematical Framing
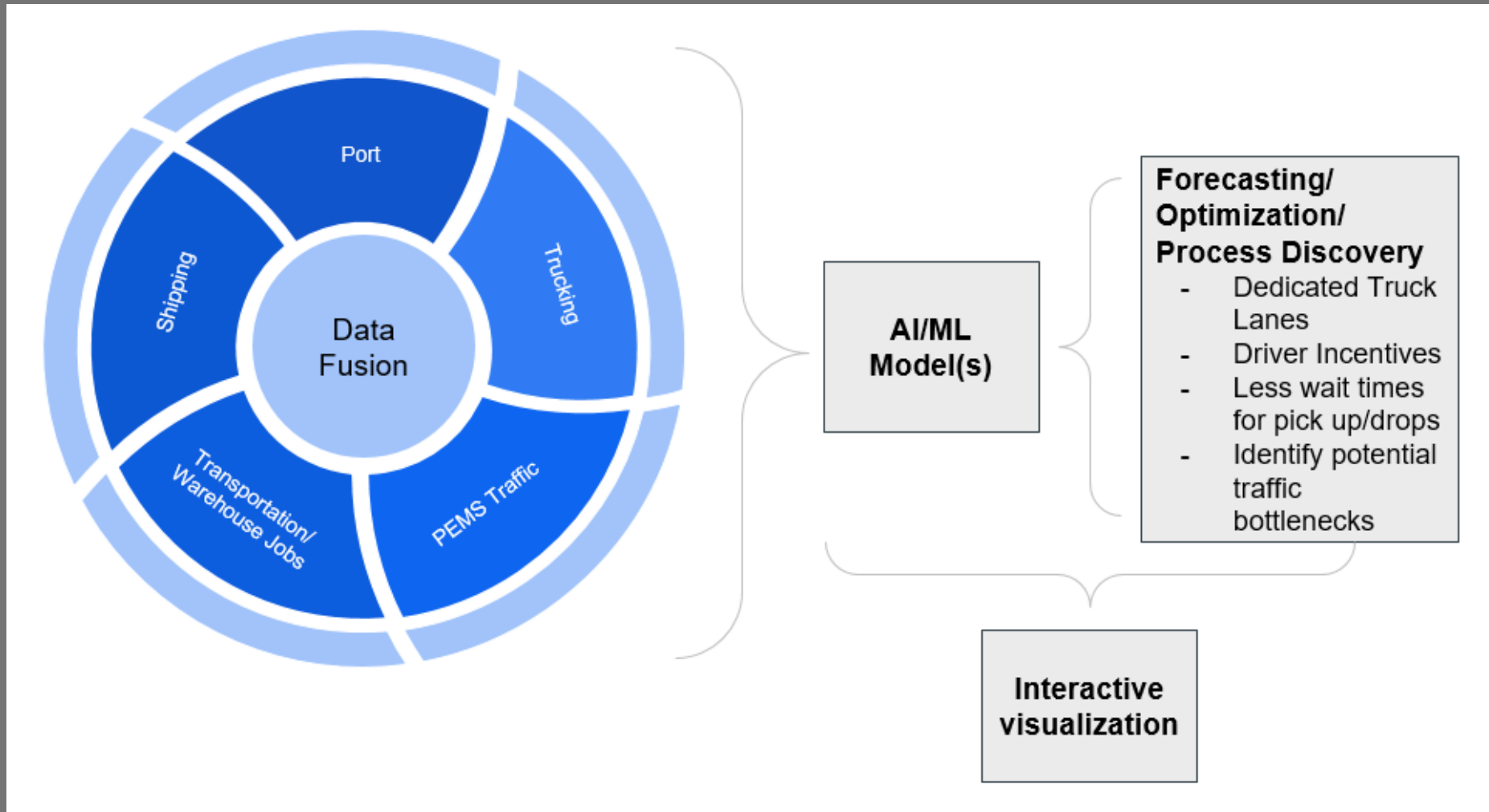
Visualizing Interconnected Network with Subsequent Stress Testing
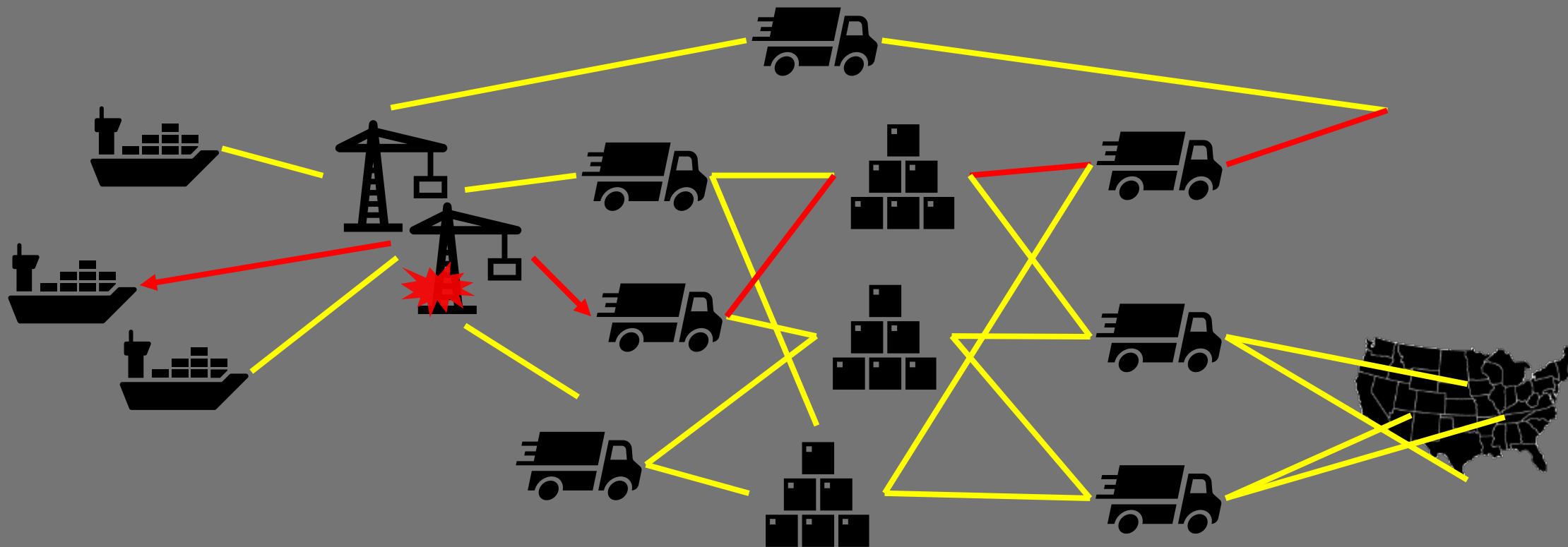
Long-term goal: develop tools to improve resilience of ship/port/freight operations against disruptions that cascade across different parts of the CA supply chain.

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DATA: Truck Activity Monitor (TAMS)
UCI Institute of Transportation Studies

TAMS Project has developed unique sensor package which provides counts of various vehicle types using "Inductive Inference". Historic data (2016-2017) being used as baseline for Causal Analysis modeling

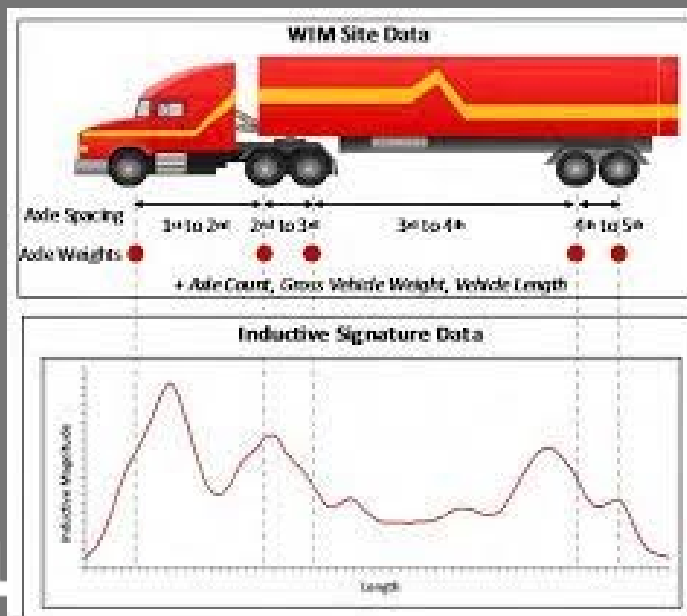|				
2	MU	Single	82	Dump_Small_Basic Platform
3	MU	Single	70	Pickup/Utility_Small_Basic Platform
4	MU	Single	77	Pass Vehicle_Small_RV Trailer
5	SU	SU	2	20ft Bus
6	SU	SU	20	Platform_2
7	MU	Single	71	Pickup/Utility_Small_Livestock
8	MU	Single	86	Service_Small_Small Trailer
9	MU	Single	72	Pickup/Utility_Small_Towed Vehicle
10	MU	Single	89	Service_Small_Towed Vehicle
11	MU	Single	69	Pickup/Utility_Small_RV Trailer
12	SU	SU	5	Bobtail
13	MU	Single	73	Platform_Single_Basic Platform
14	MU	Single	85	Platform_Small_Basic Platform
15	SU	SU	7	Concrete
16	SU	SU	8	Conv. Van
17	SU	SU	9	Crane/Winch
18	SU	SU	10	Dump_Single
19	MU	Multi	32	Curtainside Van

WIM Site Data

Axle Spacing   1st to 2nd   2nd to 3rd   3rd to 4th   4th to 5th

Axle Weights

+ Axle Count, Gross Vehicle Weight, Vehicle Length

Inductive Signature Data

File Name

Causal Analysis for LA Logistics Flows

TAMS
Port Traffic
Hourly Data
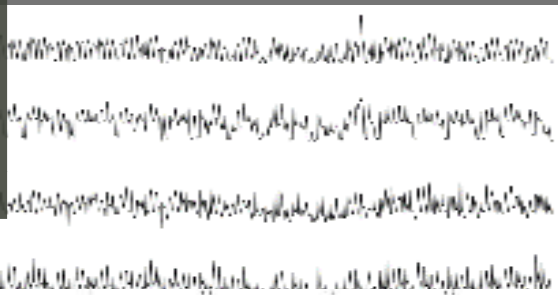
710N

57N

57S

AI Estimates
Port Traffic
Turnaround

TAMS
Sensor
57 Hwy

TAMS
Sensor
710 Hwy

8 & 9 AM
Port Traffic

4 Hour
Inferred Pickup Time
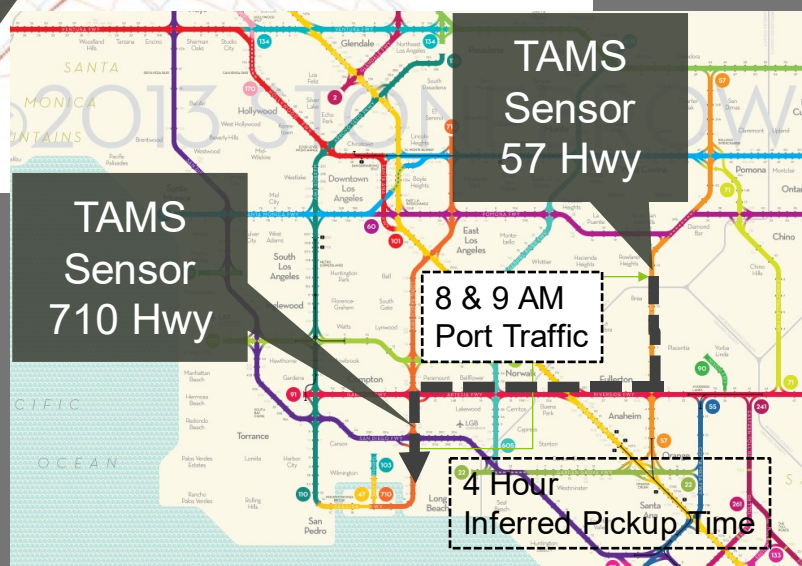
Develop AI-based Model for Logistics Challenges:
- EXAMPLE: Estimating Operator Service Times directly from Sensor Vehicle Class Counts with AI-based Causal Analysis
- **Are Port Congestion and Traffic Delays making Drayage Operation unviable?**
- **Use AI Model to evaluate Avoidance and Mitigation Strategies:**
  - Key Freight corridor expansions
  - Diverting or prioritizing traffic on specific highway segments, lanes, times of day
  - Land use planning controls (e.g., incentives to expand warehouses or transloading at specific locations)
  - Investment in infrastructure of alternative modes (e.g., rail)
  - Incentives to balance variance in round-trip under stress

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What is Unique about ERDC/CTC Approach:

I-710 (Source: SCAG)

- **We lead the state-of-the-science in Integrating Logistics Models with AI and Resilience Analytics:**
  - **Methodology is validated through publications in top scientific journals (Nature, Science, Transportation Research)**

- **We have an extensive analytical understanding of Californian infrastructure and supply chains – many of our leading publications use Californian cities as case studies. Our approaches are immediately applicable to CA's needs.**

- **Validated through applications in different projects with DOD, DHS, DOC and other agencies**

- **Linkage with Global Economic Models**

- **Unbiased Evaluation: Federal/State Agency Execution**

Source: Caltrans

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Additional Slides

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Traffic Data For Destination 7009 in Direction 1

RandomForest Performance with Missing Data Imputed with MidaSPY

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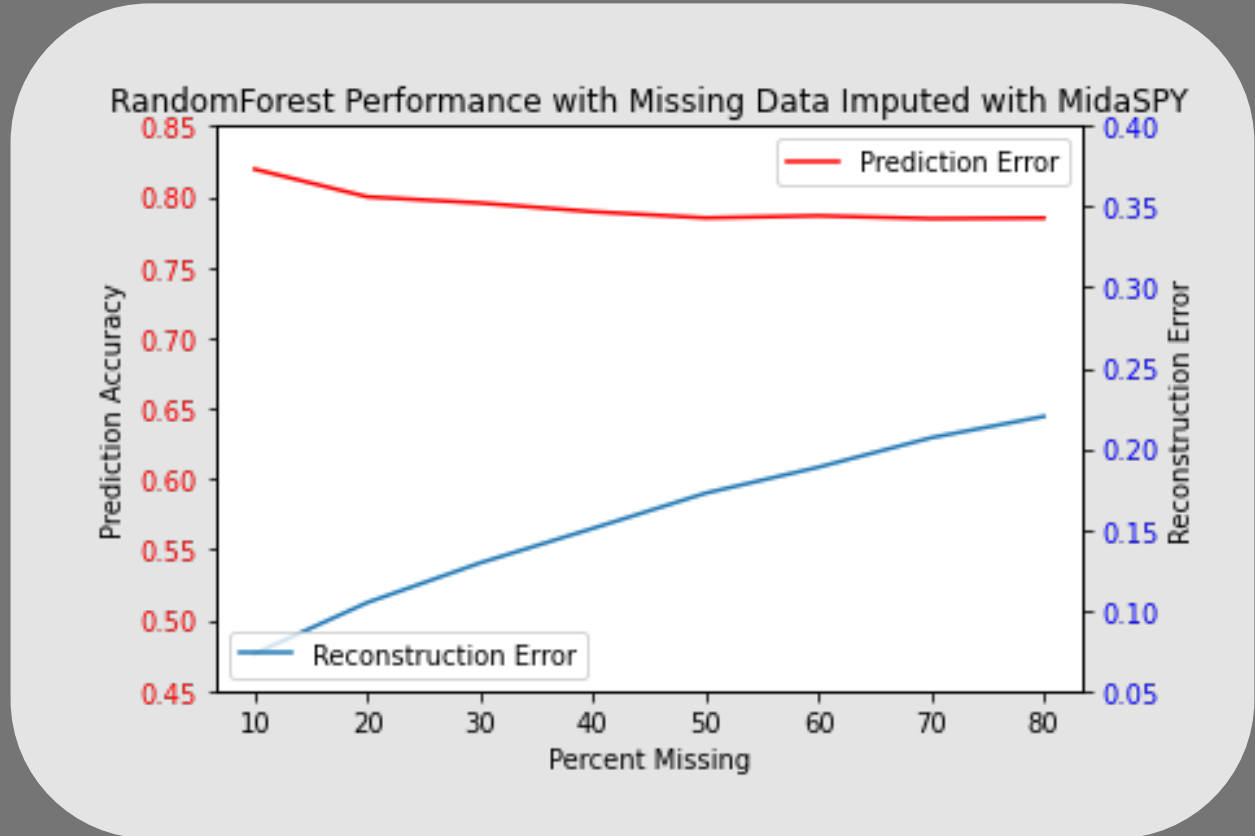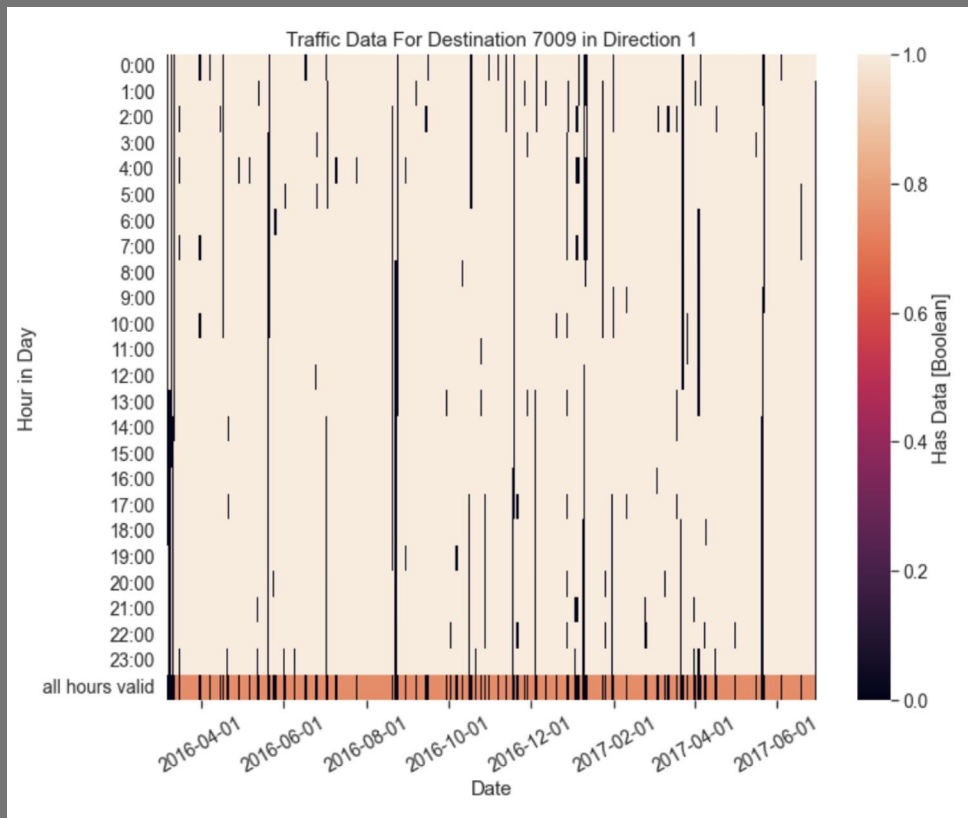
Preliminary Results for Port-Freight System

- **Goal:**
  - Characterize major freeways and off ramps related to hourly traffic patterns, according to port-related activity and passenger traffic, and the level of stress caused.

- **Tasks:**
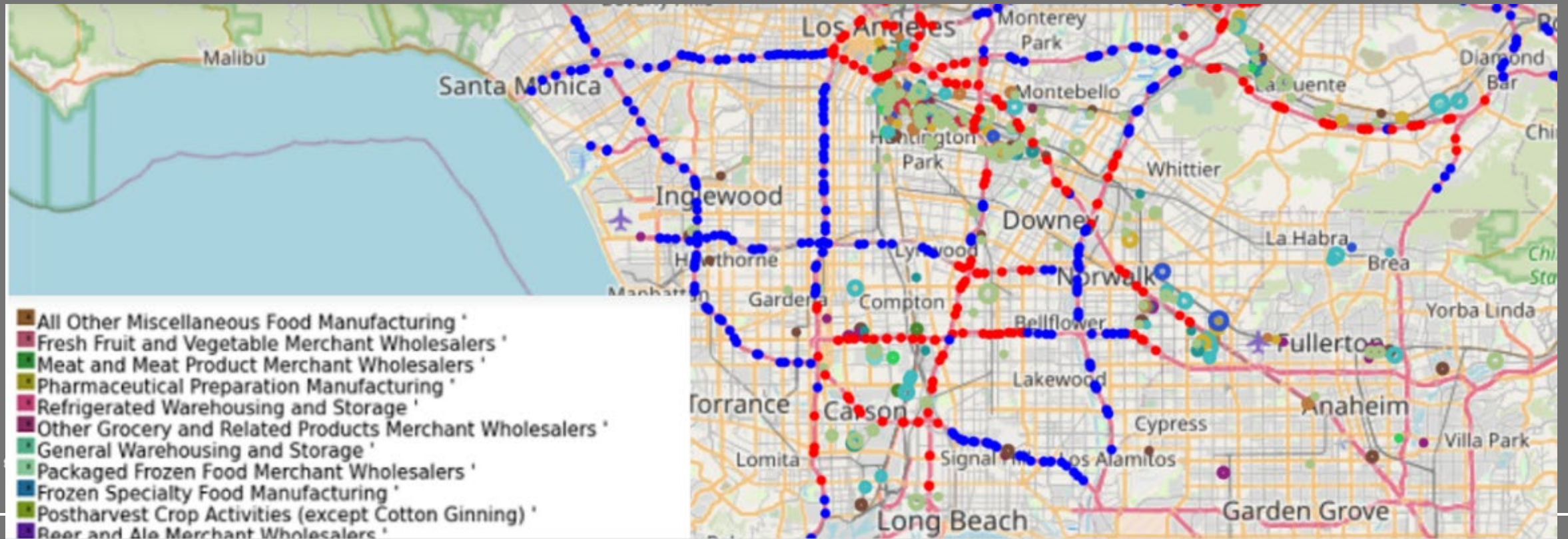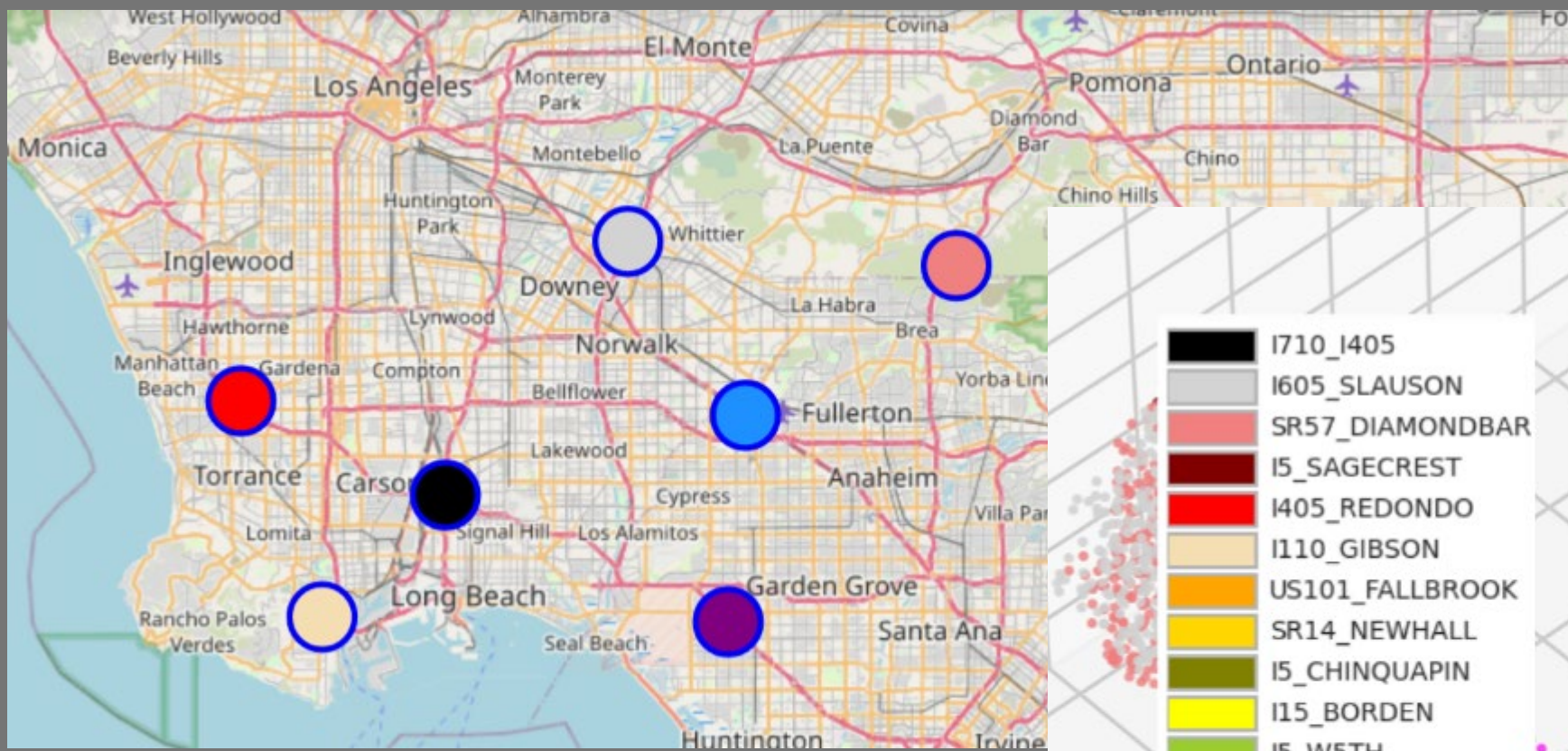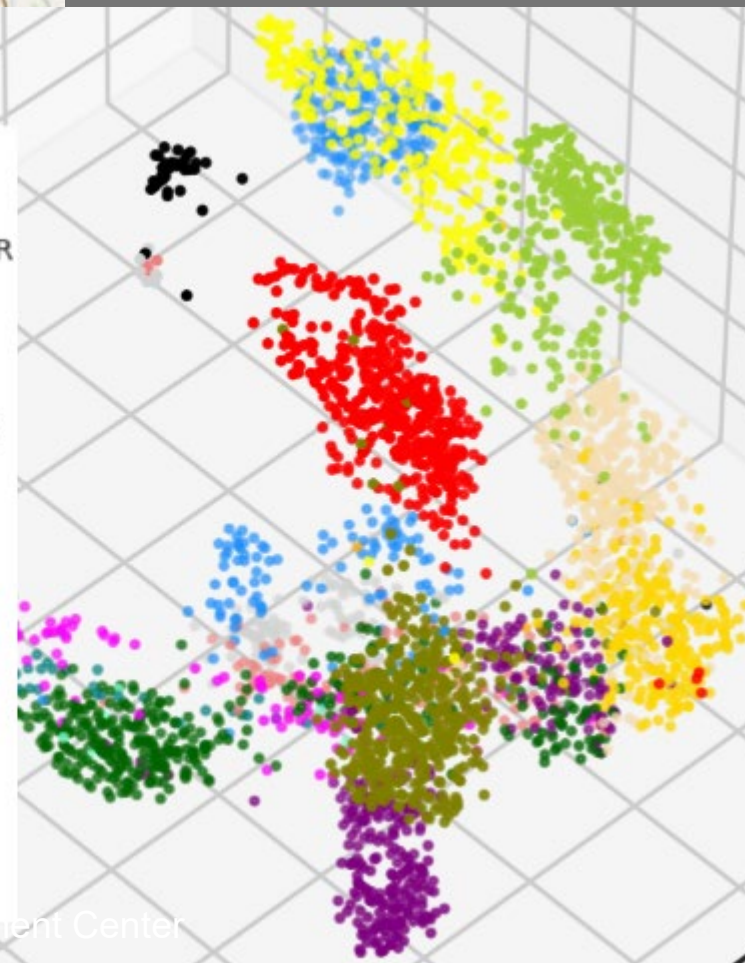 - Collect data from multiple sources: Caltrans, UC Irvine, SCAG, CARB
  - Causal analysis of effect of freight traffic around the Port on traffic on locations farther on corridors.

All Other Miscellaneous Food Manufacturing '
Fresh Fruit and Vegetable Merchant Wholesalers '
Meat and Meat Product Merchant Wholesalers '
Pharmaceutical Preparation Manufacturing '
Refrigerated Warehousing and Storage '
Other Grocery and Related Products Merchant Wholesalers '
General Warehousing and Storage '
Packaged Frozen Food Merchant Wholesalers '
Frozen Specialty Food Manufacturing '
Postharvest Crop Activities (except Cotton Ginning) '
Beer and Ale Merchant Wholesalers '

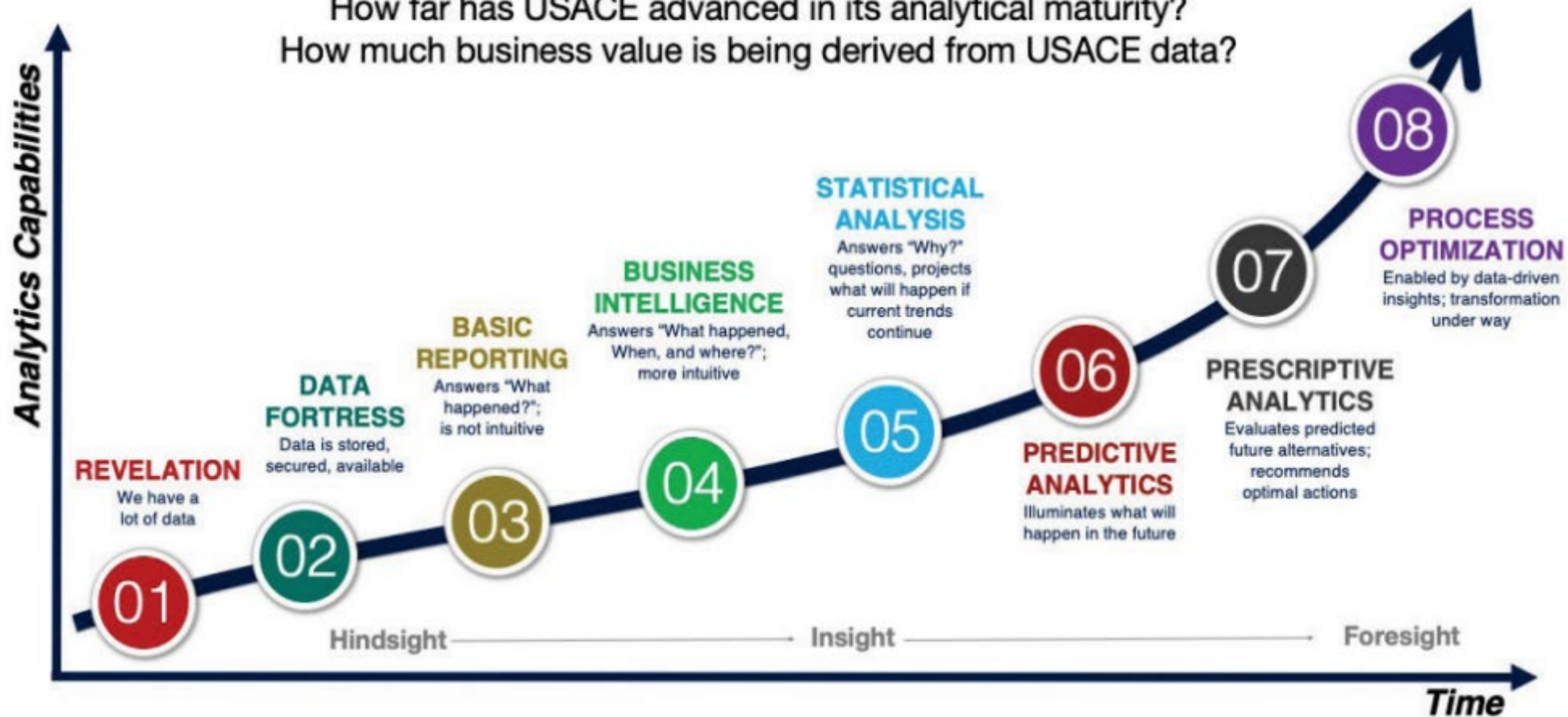# Characterizing Different Clusters of Activity Near LA

- LA Traffic data is merged with CARB/SCAG's warehouse data to identify patterns of activity around Los Angeles.
- Patterns within a low dimensional representation of the data (right) show that there is a strong relationship between location and traffic.

Legend:
- I710_I405
- I605_SLAUSON
- SR57_DIAMONDBAR
- I5_SAGECREST
- I405_REDONDO
- I110_GIBSON
- US101_FALLBROOK
- SR14_NEWHALL
- I5_CHINQUAPIN
- I15_BORDEN
- I5_W5TH
- I805_4TH
- I5_SR76
- I15_SR76
- I5_WESTERN
- I405_EDWARD
- I5_SANLUISREY

Data Analytics Value Curve

Future Tasks

- **Task 2: Gathering and preparation/imputation of incomplete historical data with CalTrans and Commission staff to develop statewide and Los Angeles multi-aspect traffic models**

- **Task 3: Data analytics and causal analysis for interconnected Ports and freight corridors**

- **Task 4: Development of future scenarios and stress testing strategies**

- **Task 5: Resilience analytics toolkit**

- **Task 6: Optimization of policy decisions**

> **Long-term goal: data-driven predictions that allow for redirecting traffic across CA.**

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