Hyper-Connected Additive Manufacturing Tire Supply Chain

Jie Li[1] and Xiangjun Wang[2]

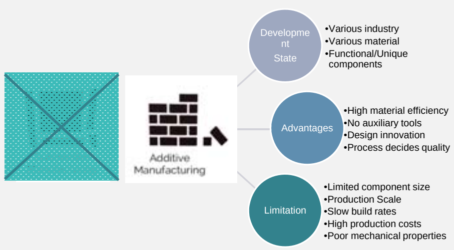
1,2. Georgia Institute of Technology, Atlanta, US

Keywords: *Physical Internet, Hyper-Connected, Additive Manufacturing, Tire Supply Chain*

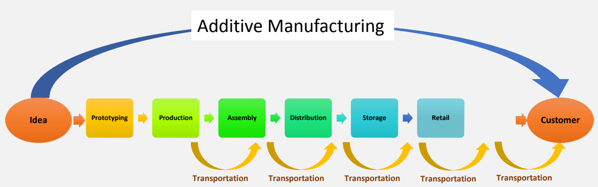
Abstract

The purpose of this project is to demonstrate a vision of supply chain in an Additive Manufacturing dominated world.

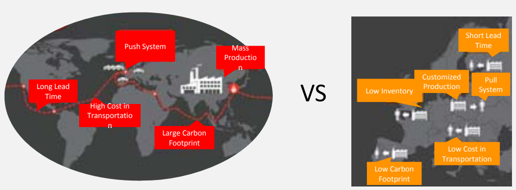
Additive Manufacturing (AM)



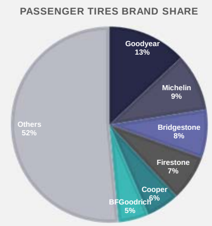
The Impact of AM on Supply Chain



Features of AM-based Supply Chains	
Product Design • Lightweight products • Functional complexity • Freedom of design • Limited number of materials, type of materials	**Production Line Design** • Less consumption of resources • Process automation
Device Design • Laser development • Printers with bigger build chamber • Less setup time	**Facility Design** • Less energy usage and waste • Fixture less manufacturing • Less equipment costs • Fewer and less-skilled operators • Lower inventories
Supply Chain Design •New business models (sell design instead of physical products, New industry of production of AM equipment) • Mass customization/personalization • Demand variation • Short lead time	 • Less number of suppliers • Less transportation, production close to consumers • Distribution centers that store blueprints rather than physical products



How will AM change Tire Supply Chain



59 tire plants , with capacity of **$310.1 million** tires

348 radial passenger tire sizes, Potential SKUs could be **10 times** at least

Each independent dealer buys from at least **5 distributors,** Each independent dealer offers at least **13 brands**

Each type of tire need a **unique mold – Thousands of Mold,** Each mold cost **$ 50,000 ~ 70,000**

How will AM change Tire Supply Chain

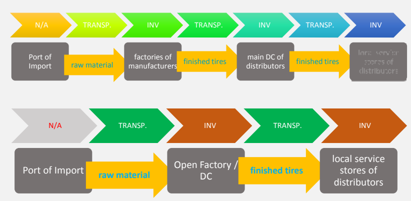
One Machine, Thousands Type of Tire

Just need 3D Model, and different material proportion

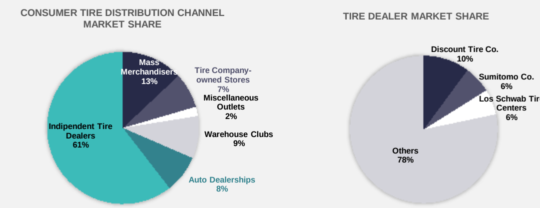
Less setup time No auxiliary tool

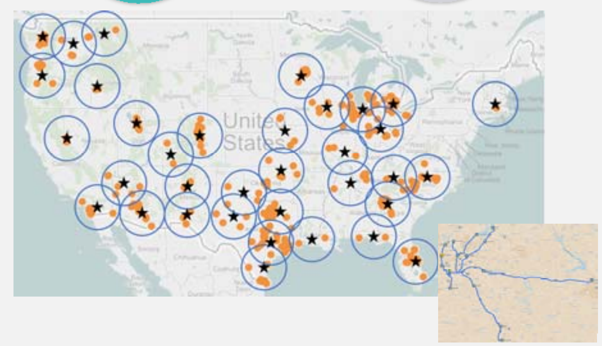
Each mold cost **$ 50,000 ~ 70,000**

Each AM Machine cost **$ 5,000 ~ 50,000**



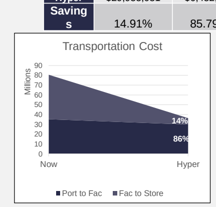
How will AM change Tire Supply Chain

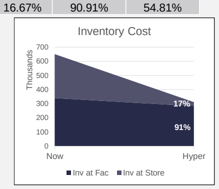




Component	Percentage	Raw Material Source
Natural rubber	14 %	United States is the #2 largest importer of natural rubber and accounts for 13% of the import market worldwide. 89% of its import is from Asia. To simplify calculation, suppose all import are from Asia and all cargo from Asia get into the U.S. via port of LA/Long Beach.
Synthetic rubber	27 %	United States is the #1 largest exporter of Synthetic Rubber and accounts for 15% of the export market worldwide. Therefore, this part is not taken into account.
Carbon black	28 %	United States is the #4 largest exporter of Carbon Black and accounts for 6.9% of the export market worldwide. For the same reason as Synthetic rubber, this part is not taken into account either.
Steel	14 – 15 %	United States is #2 largest importer in steel wires, and 70% of its import is from Asia, suppose all import are from Asia and all cargo from Asia get into the U.S. via port of LA/Long Beach.
Fabric	16 – 17 %	Only about 3% of these materials are from import, so for the same reason as previous, this part is not taken into account.

	Port to Fac	Fac to Store	Inv at Fac	Inv at Store	Total
Now	$35,203,188	$45,390,874	$339,435	$311,148	$81,244,645
Hyper	$29,955,031	$6,452,250	$282,862	$28,286	$36,718,429
Savings	14.91%	85.79%	16.67%	90.91%	54.81%





HYPERCONNECTED SMART CITY ATLANTA

Georgia Tech ISyE Stewart School of Industrial & Systems Engineering

Atima Goel – Chanya Kobsirisawat – Rimadina Nawangwulan – Amber Chowdhary – Yi Kai Hsiung – Matthew Thornton – Deleeepkumar Chandar

Faculty Advisor: Dr. Benoit Montreuil

Atlanta Today

- Terminus to The World's busiest Airport
- Economic hub for the entire South-East
- 5.5 Million people in the Metro area

Logistics Problem

Congested Roads	• Lack of proper public transportation • Too many private vehicles and trucks on road
Longer travel distance & time	• "Suburban Sprawl" • Longer commute time
Issues with security in downtown	• Crime rate of 75 per one thousand residents • Midtown one of the least favorable locations
Social issues	• MARTA is not well-adopted by more wealthy people • Socioeconomic stigma associated with MARTA • De-facto racial segregation within the city

Challenges

Increasing private vehicles on road
- 6% Population growth
- 5% Employment growth
- On average 0.72 vehicles registered per person

Capacity constraint on infrastructure
- Congestion at the junction of interstates, interchanges and city roads

Poor utilization of public transport
- Horizontal population distribution
- Lower population density

What needs to be done:

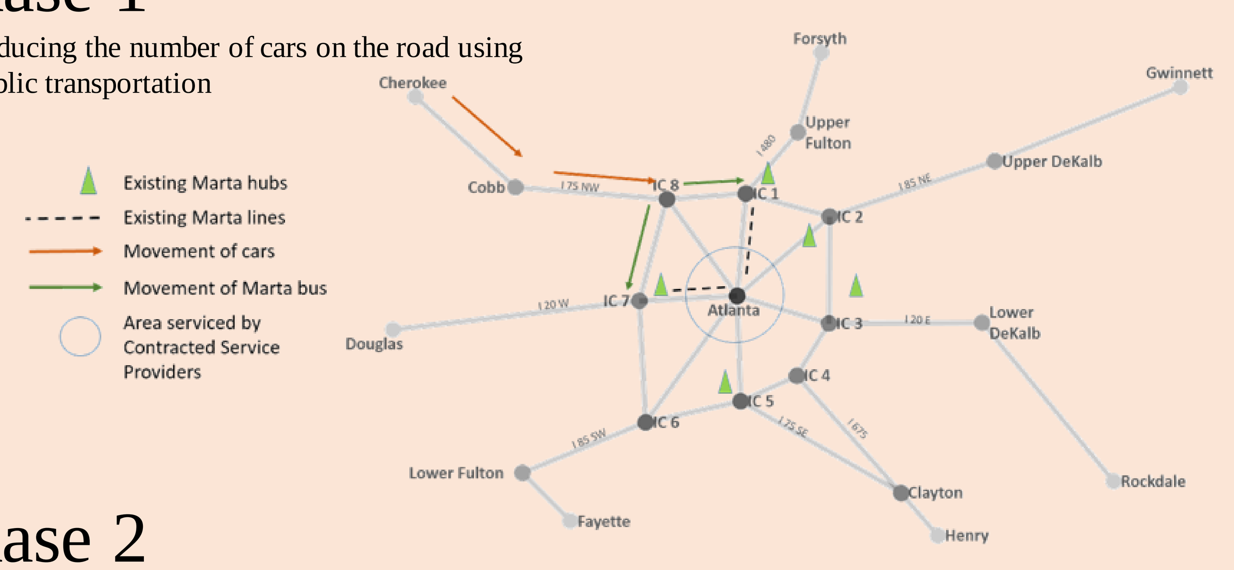
To reduce congestion on the roads
- Reduce number of cars
- Increase utilization of public transport
- Increase neighborhood density around MARTA
- Introduce smaller buses and carpools

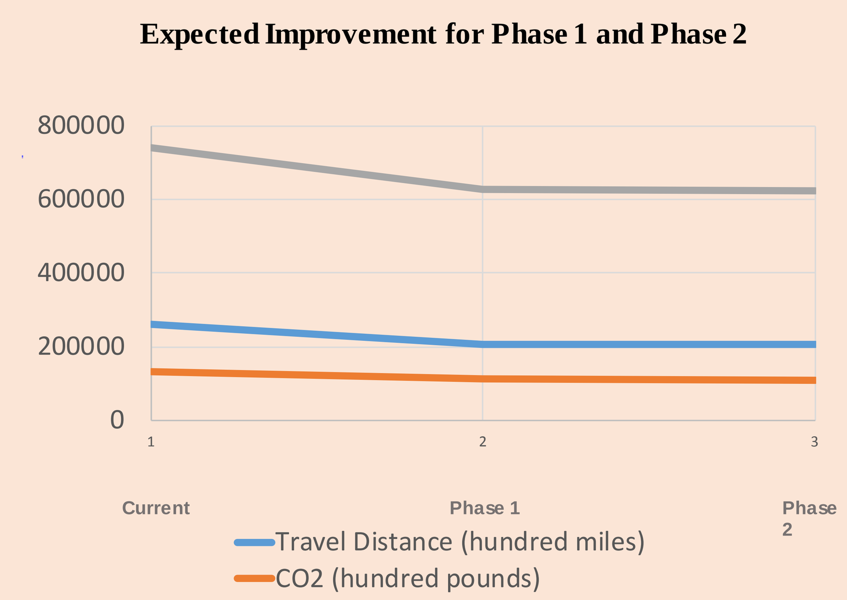
To find alternative routes and modes for freight
- Utilize MARTA infrastructure to transport freight
- Improving Georgia Navigation System for truckers

People Transportation

Phase 1

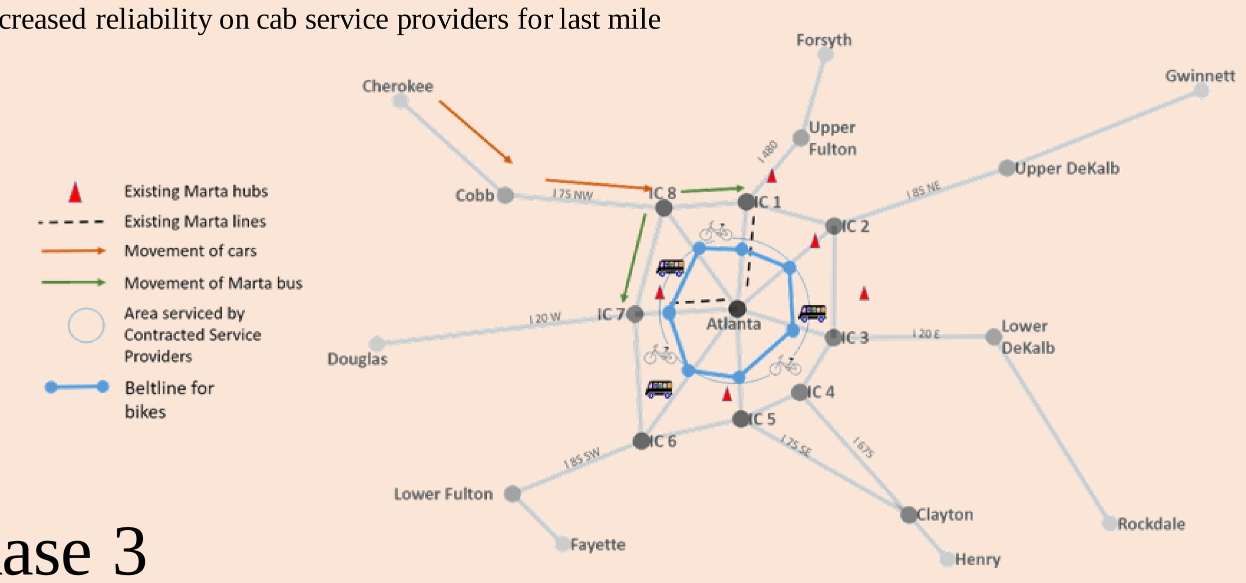
- Reducing the number of cars on the road using public transportation

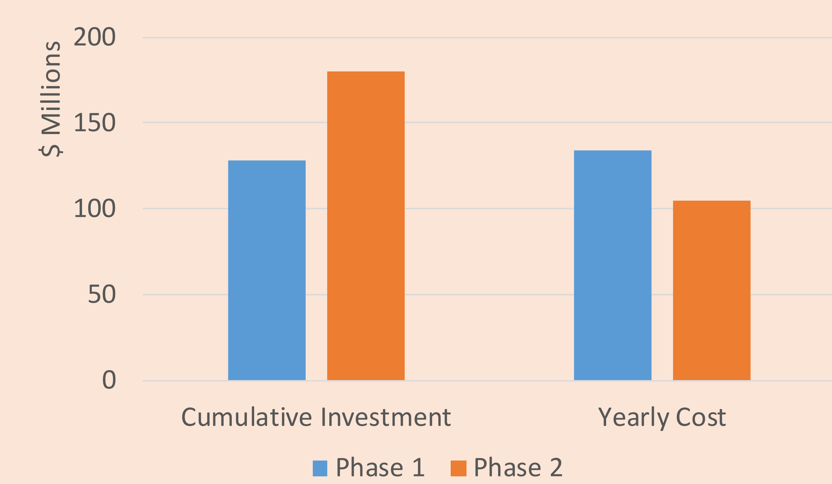




Phase 2

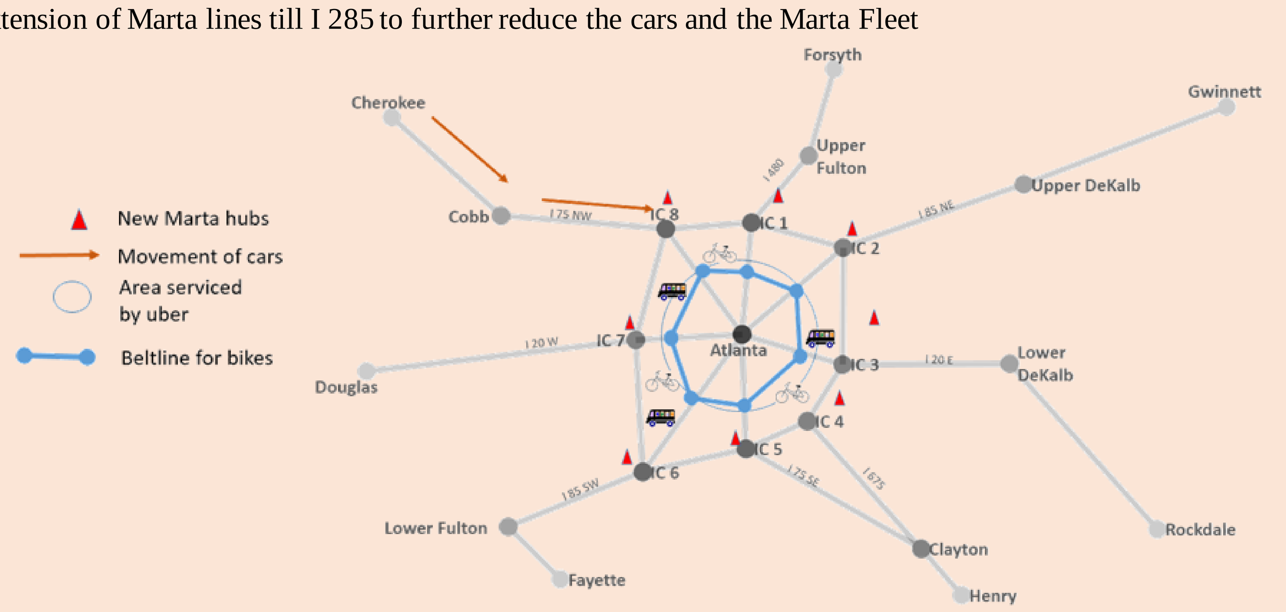
- Decreased reliability on cab service providers for last mile





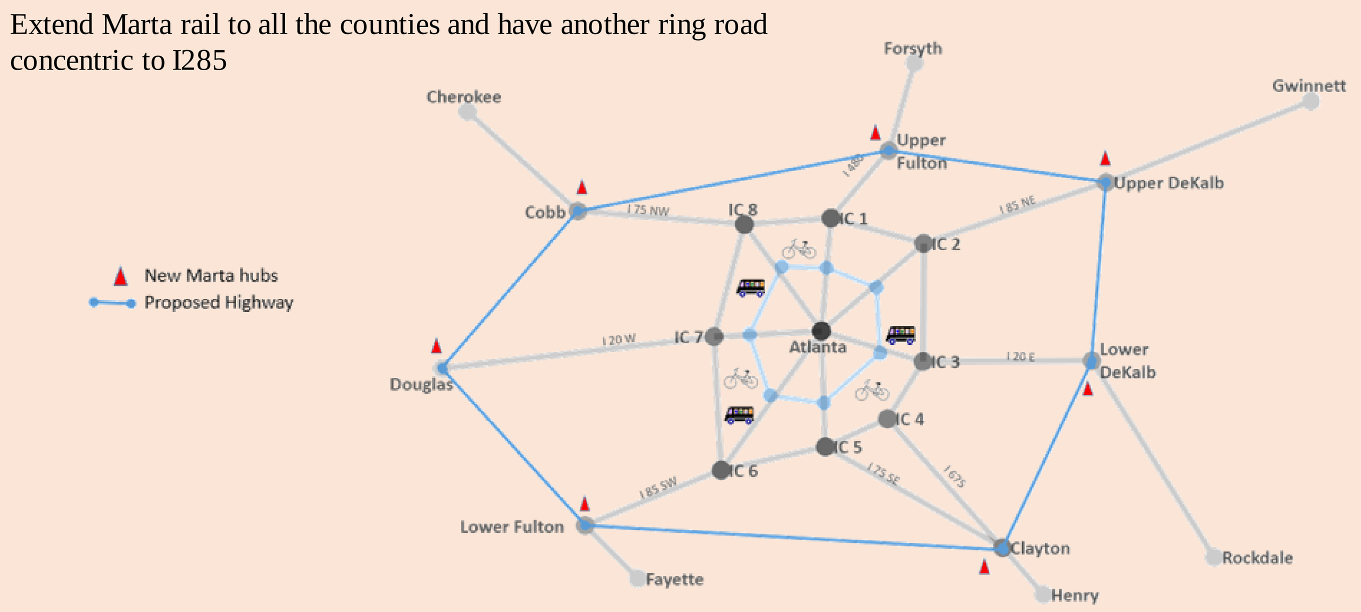
Phase 3

- Extension of Marta lines till I 285 to further reduce the cars and the Marta Fleet

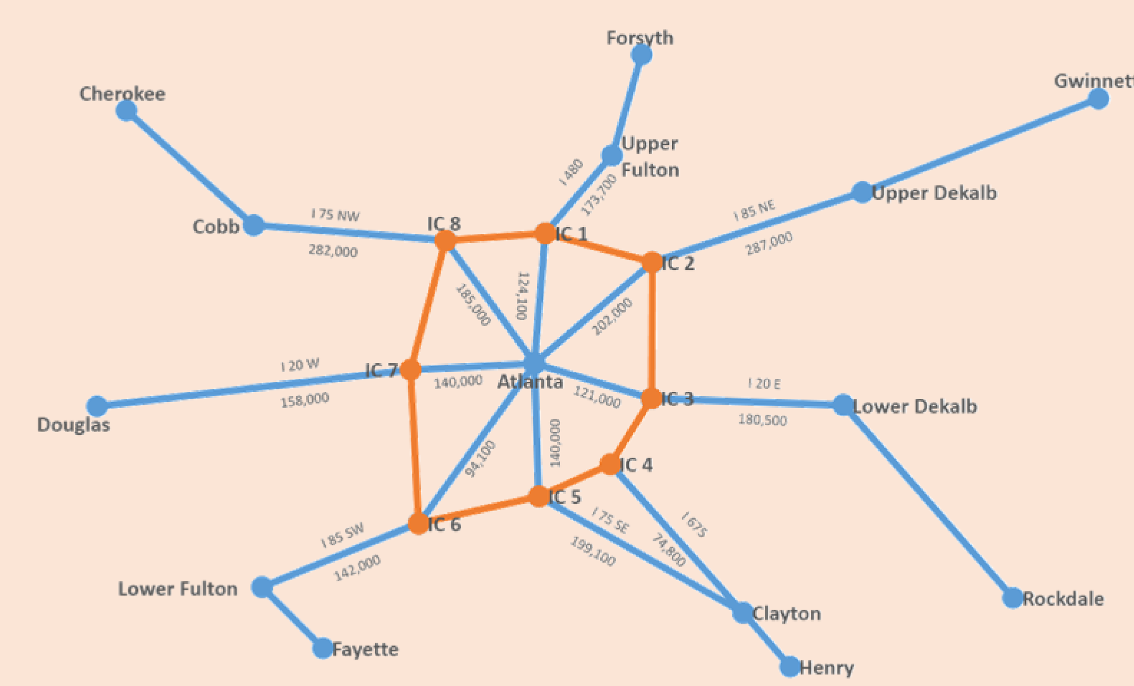


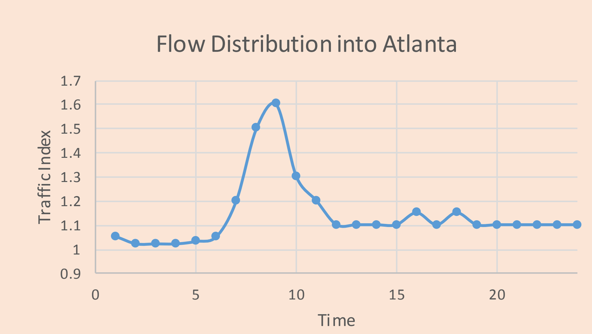
Phase 4

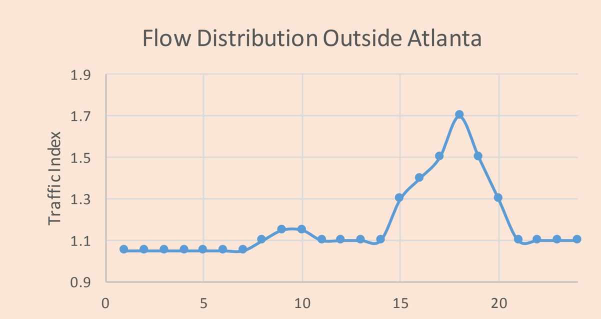
- Extend Marta rail to all the counties and have another ring road concentric to I285



Current Situation: Average Daily Flow

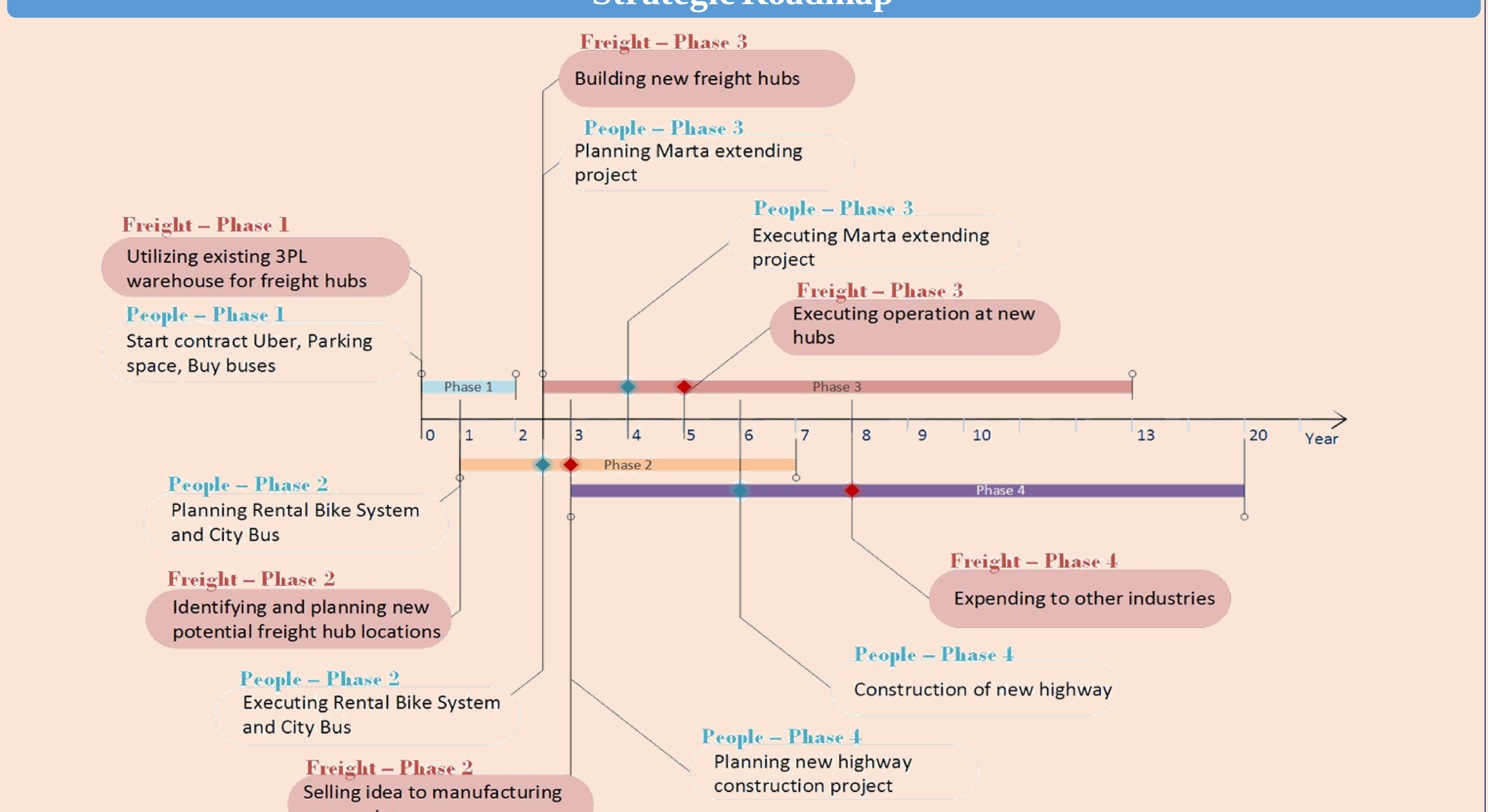






- Atlanta Metropolitan Area has trucks and trains going in to the city to deliver the products to be consumed by its city population
- Number of truck movement is higher for out-bound than in-bound

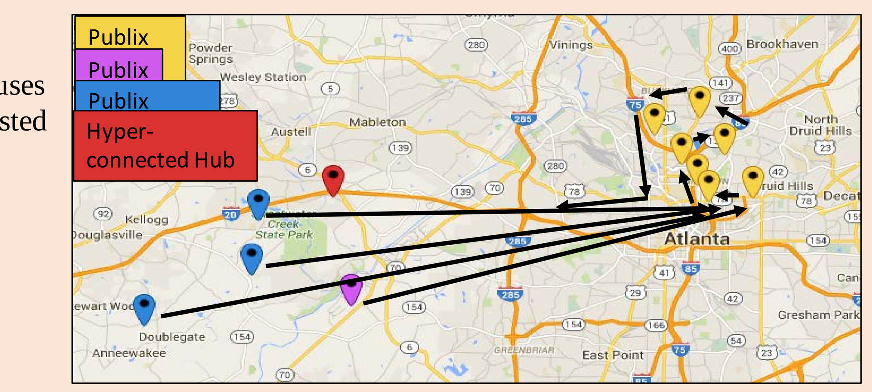
Strategic Roadmap

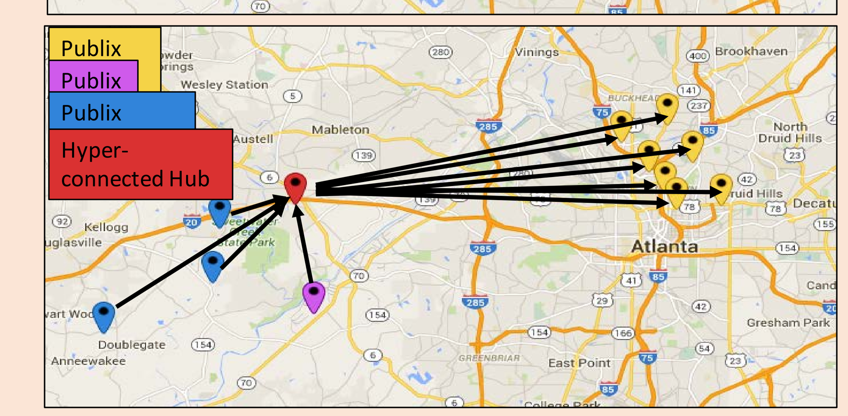


Freight Transportation

Phase 1

- Utilizing existing third party warehouses as freight hubs located outside congested areas





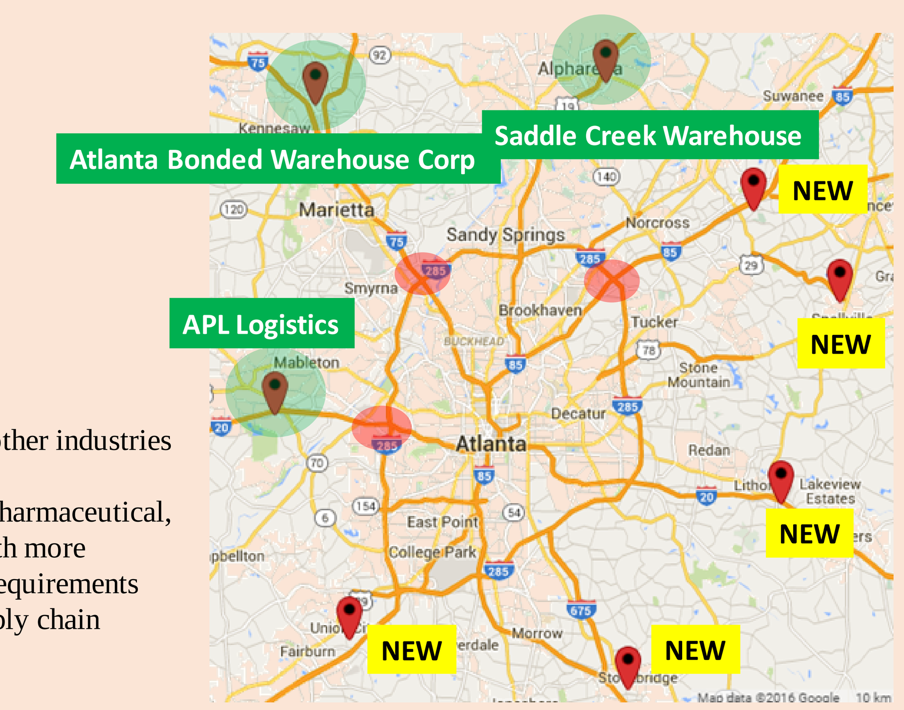
Phase 2

- Identifying and planning for new freight hubs
- Campaigning hyperconnected concept to other industries

Location	Latitude	Longitude
Marietta	34.04	(84.57)
Duluth	33.95	(84.11)
Alpharetta	34.06	(84.27)
Snellville	33.87	(84.02)
Lithonia	33.70	(84.08)
Stockbridge	33.53	(84.24)
Union City	33.58	(84.54)
Douglasville	33.77	(84.62)

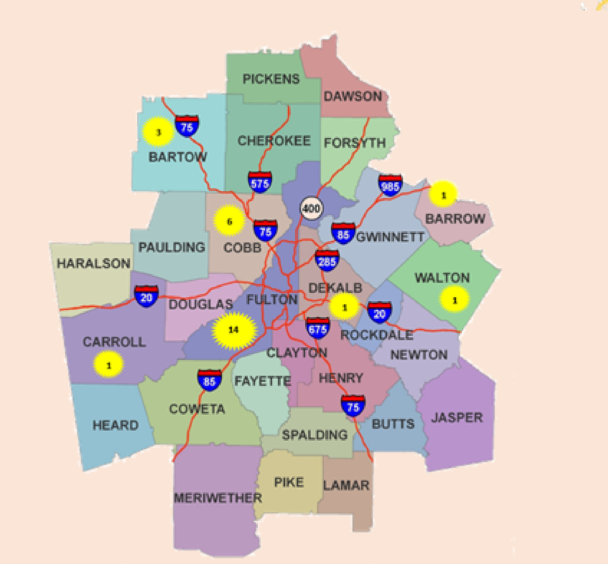
Phase 3

- Building new freight hubs
- Executing the operation at new freight hubs

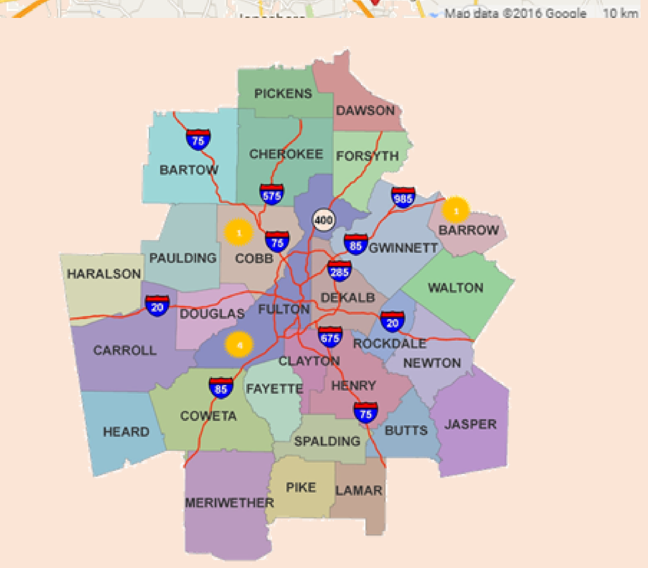


Phase 4

- Extending the implementation to other industries
- Intermodal or cold supply chain, pharmaceutical, chemical, and others industries with more specific and stringent warehouse requirements can adopt the hyperconnected supply chain model.



Cold Storage Locations around Georgia



Intermodal Facilities around Georgia

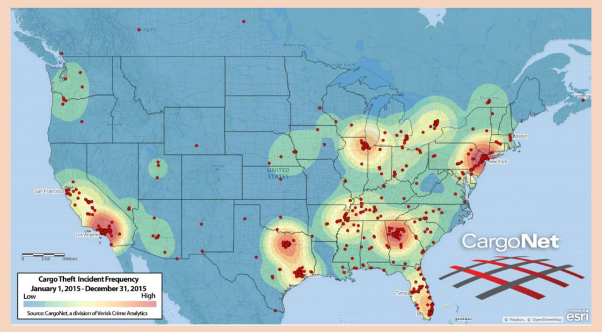
Source: http://www.atlantaregional.com/info-center/gis-data-maps/gis-maps

Route Determination for Mitigating the Risk of Cargo Theft

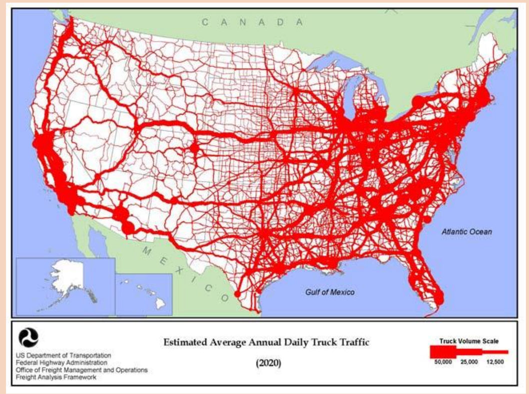
Satya S. Malladi, Prof. Alan L. Erera, Prof. Chelsea C. White III
ISyE, Georgia Institute of Technology

Introduction

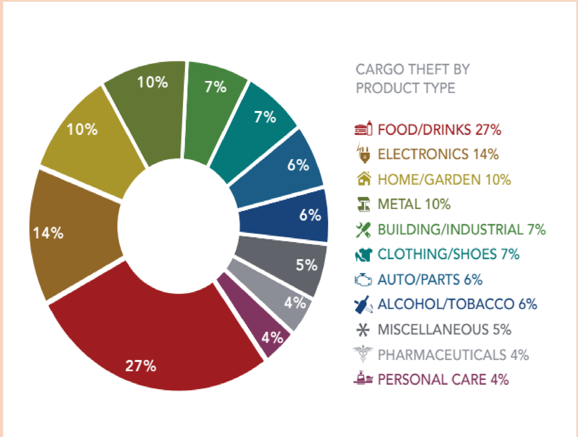
- > 800 incidents of cargo theft in 2015
- The average value lost per load in 2014 was $232,924
- Rose 36% in 2014 compared to 2013
- Sophisticated cargo thieves; intelligent and adaptive



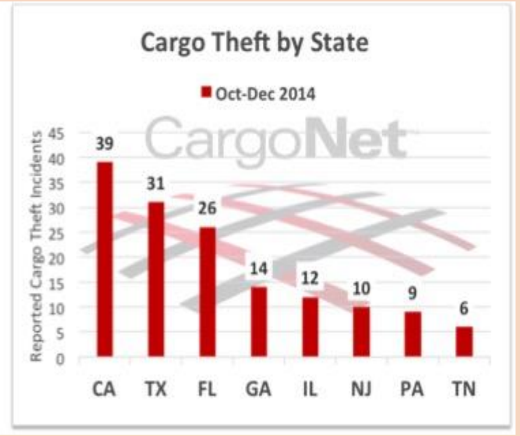
Cargo theft heat map



- Food and beverages – **most stolen (28%)**
- Stolen loads of nuts, seafood & meat, dairy & eggs, cookies & snacks: > doubled since 2012

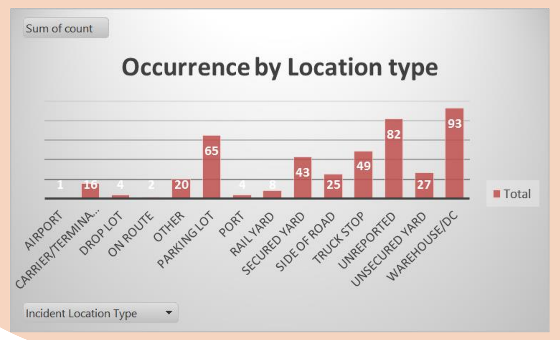


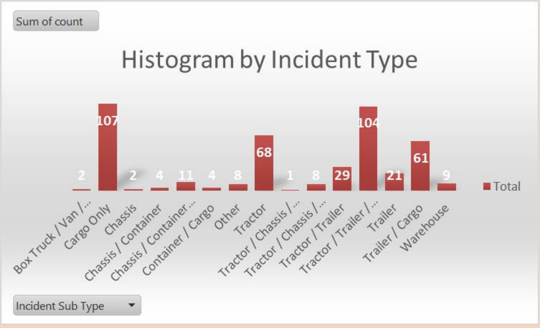
FreightWatch, 2013



CargoNet, 2014

- 'Hot' commodities in the black market
- Easy dissipation; tracking difficulty
- Risk of contamination & reinsertion into food supply chain
- Morbidity, mortality and stress on healthcare system





Characterizing Risk

- Risk highest when truck is stopped
- Stop: A location at which the truck is stationary long enough for a theft to occur.
- Question: where will the truck stop?
- Two cases: a) stops are known, b) stops are unknown
- Risk of cargo theft depends on: geographical location, type of stop, type of commodity, duration of stop, time of day
- Location types: Parking lots, secure yards, truck stops, warehouses/DC, side of road
- Challenges:
  - Not all thefts are reported.
  - Total freight movement volumes are difficult to obtain

Risk Calculation

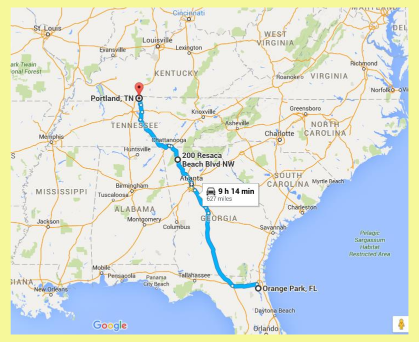
Formulation of Risk

$k_i: i = 1, \dots, N$ incidence points (from cargo theft data).

$$R(x) = \sum_{i=1}^{N} r(k_i, x), \text{ where, } r(k,x) = \begin{cases} \frac{K}{d^2(k,x)} & J\,mi < d \le \sqrt{K}\,mi \\ K & d < J\,mi \\ 0 & d > \sqrt{K} \end{cases},$$

where, $d(x,y)$ = aerial distance between two points x and y.

$$1 \le r(k,x) \le K$$



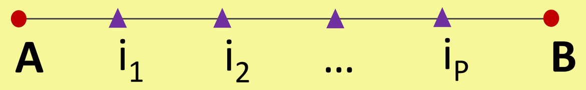
Risk Score: with J=1; K = 10,000, $R(x) = \sum_{i=1}^{N} r(k_i, x)$ = 10488.34

Path Risk Calculation

When truck stops are known:

- When there are M truck stops along a path, risk of the path is calculated as: $R(P) = \sum_{j=1}^{M} R(x_j)$
- Value of loss at each of the theft incidence locations may be used to compute a weighted path risk as follows: $R(x) = \sum_{i=1}^{N} w_i\, r(k_i, x)$, $w_i = \frac{c_i}{\sum_{k=1}^{N} c_k}$, where c_i is the value of loss at the ith truck stop.

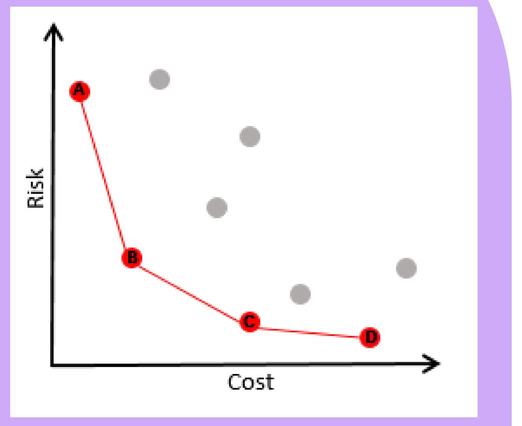
When truck stops are unknown:



- Risk zones:
  - Risk measure of a zone is the average of risk measures of points in the zone.
  - Risk measure of a stop = risk measure of the zone
- Potential stops on a route and the likelihood of a stop
- Risk measure of a route: weighted sum of risks at potential stops

Non-dominated Paths and Scenarios

- We determine measures of ***cost*** and ***risk*** for each path (route).
- "*Less is better*" for both objectives.
- Path 1 ***dominates*** Path 2 if:
  - i. Path 1 costs less than Path 2 ***and***
  - ii. Path 1 is less risky than Path 2.
- A path is ***non-dominated*** if no other path dominates it.
- The most preferred path is a non-dominated path.



Scenario 1: Given: origin, destination, routes *by the TM*

- For each route:
  - Determine potential stops and their likelihood
  - Calculate risk measure of the route
  - Calculate cost measure of the route
- Determine non-dominated set of routes

Scenario 2:Given: origin, destination

Generate K-best *cost* routes

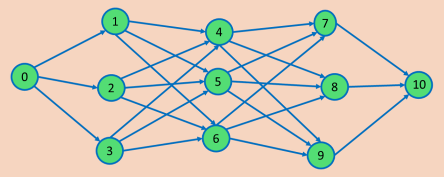
For each route:

Determine potential stops and their likelihood
Calculate risk measure of the route
Calculate cost measure of the route

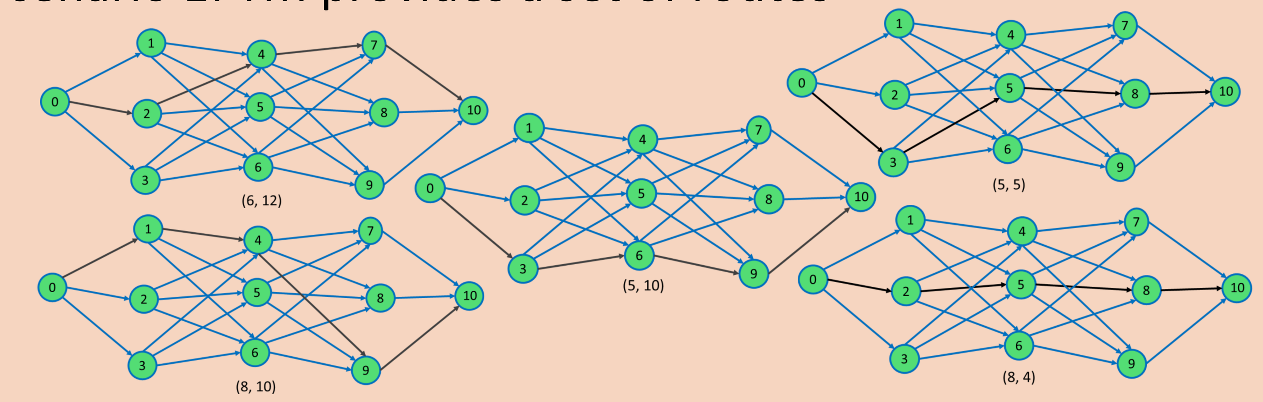
- Determine non-dominated set of routes

Scenarios

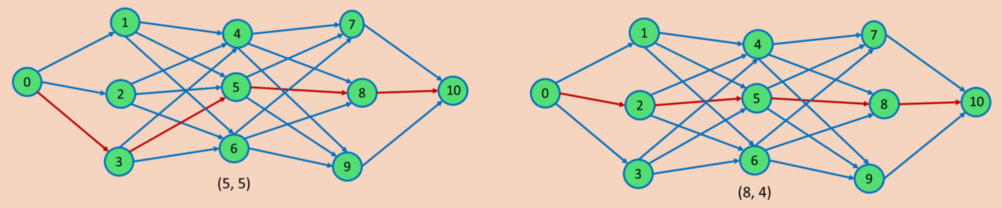
Example of road network
Source = 0, destination = 10



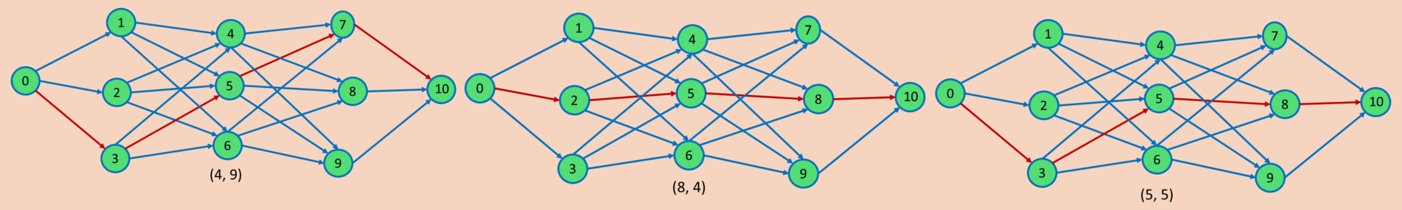
Scenario 1: TM provides a set of routes

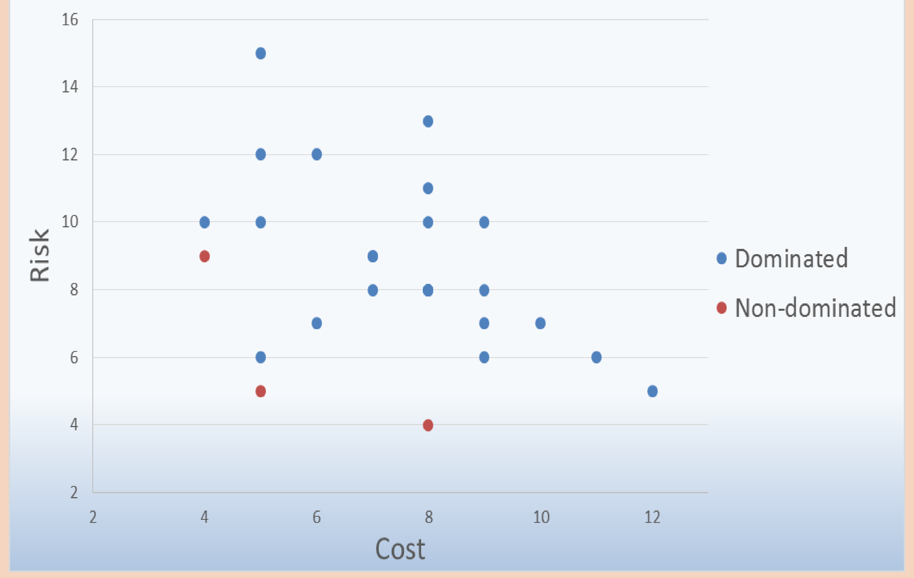


- Dominance Check: (6,12), (5,5), (8,10), (8,4), (5,10)
- Non-dominated: (5,5), (8,4)



Scenario 2: Generate non-dominated routes





Risk vs Cost plot: 24 dominated and 3 non-dominated

Scenario 2 would usually result In more non-dominated paths (better also).

Summary Comments

- Zones – already provided
- Zone risk – computed offline
- Finding the zone of any given point – simple look up
- Determine potential stops – user input
- Determine likelihood that a stop will occur – user input
- Software development and debugging
- Integrate with CRISTAL

Acknowledgements:
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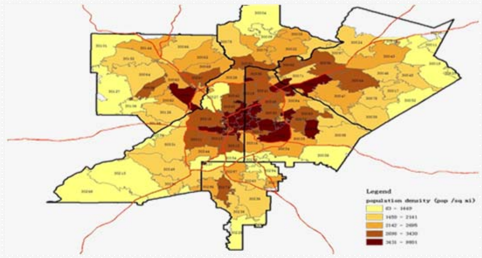
SMART CITY ATLANTA

Xiaoxiao Tan – Adrian Zambrano – Manav Kotian
Chanya Kobsirisawat – Ganny Arman – Ernesto Peña
Georgia Tech

PROBLEM STATEMENT

Design an innovative **hyperconnected last-mile distribution strategy** that strengthens Atlanta's logistics network while **mitigating congestion** and **environmental externalities**



Facts

- Atlanta is a major freight transportation and distribution center.
- Atlanta's population increases around 66% during the daytime.
- Commute times are the 10th longest in USA.
- The Atlanta region is served by 5 regional transit system providers. i.e. MARTA
- Georgia ranks 8th in terms of CO2 emissions.

OUR DESIGN

Supported Tools

- Barcode System
- Screen Panel
- Automated Locker
- Smartphone Application

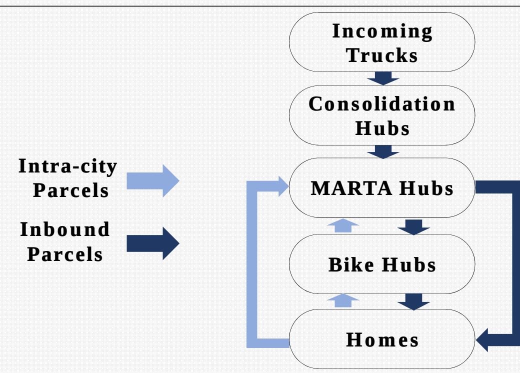
- **3 Truck Consolidation Hubs:** Receiving Parcels from Other Cities
- **33 MARTA Station Hubs:** Parcel Consolidation
- **94 Bike Hubs:** Last Mile Delivery by Bike

On average, 24,000 parcels arriving in Atlanta every day; 91 parcels arriving per hour at each MARTA station

Workforce Management:

- Consolidation hubs: 30 employees
- MARTA hubs: 109 employees
- Bike hubs and MARTA hubs: 555 bikers

SDC : Cloud-based Supply Chain Operation System



Parcel Flow

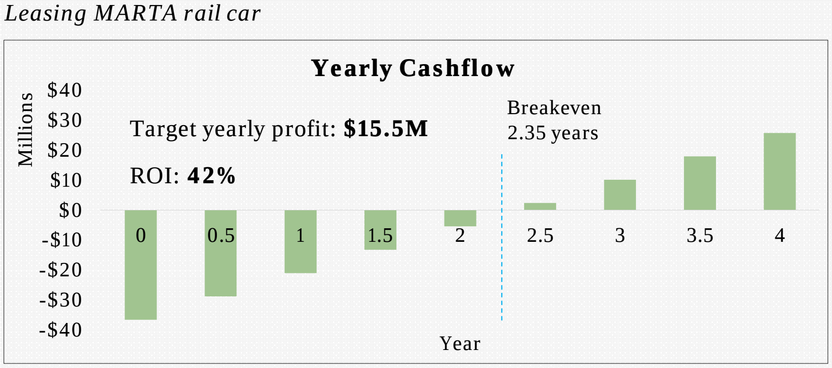
SOCIOECONOMIC ANALYSIS

➢ **Investment Cost:** Initially **$36 Million**
Consolidation Hubs
Bike & Marta Hubs
SDC
Bikes & Lockers

➢ **Operational Cost: $28 Million/year**
Bikers
Administrators
Overhead
Leasing MARTA rail car

➢ **Funding**
Advertisement
Partners
Government
Loans

➢ **Income**
Minimum Charge at $5/Parcel vs. UPS Ground $6.94/Parcel



Increase:
Employment Rate
Public Participation
Sustainability Awareness
Community Morale
Improved Lifestyle

Decrease:
GHG Emission
Fuel Consumption
Less Traffic
Noise Pollution

SUMMARY

1. **Smart Data Center (SDC)** | Crowdsourcing Online System
2. **Parcel Consolidation Hubs** | Receive Parcels from other cities
3. **Exploiting current MARTA Service** | Parcel Transportation
4. **MARTA Station Hubs** | Transport Parcels to Bike Hubs
5. **Bike Hubs** | Last Mile Delivery by Cargo Bikes

Smart Public Transportation Design

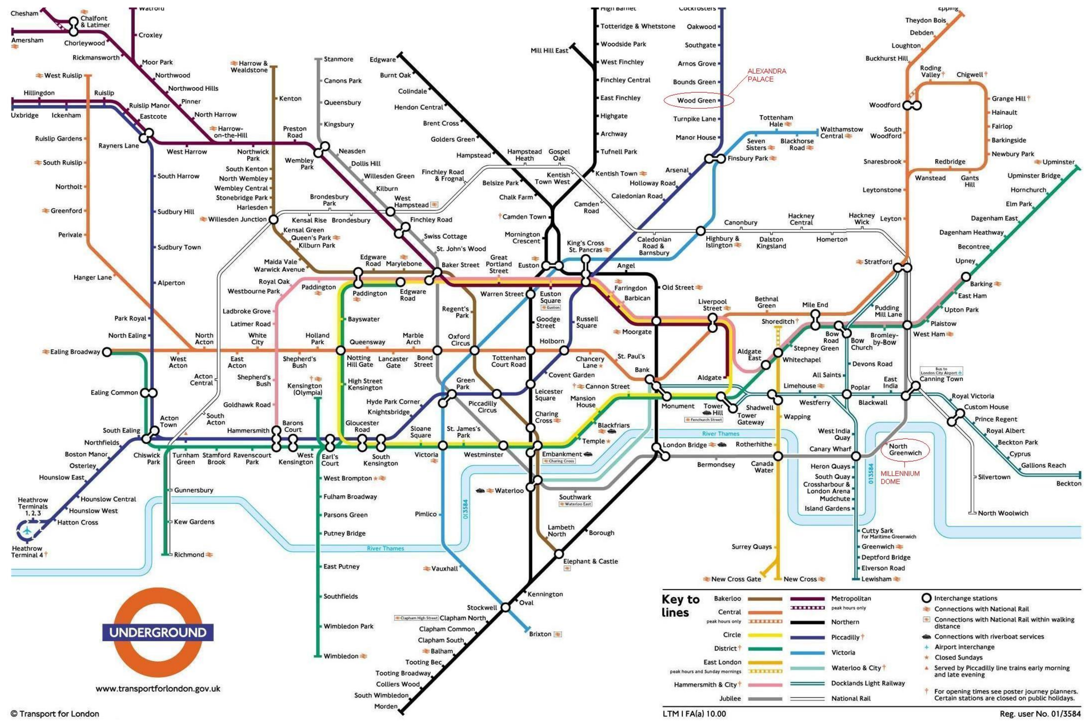
Martin Rolland – Ganny Arman – Archit Shetty

Commuting in NYC

Bowery Street to Rector Street
Route: Bowery Street on Brown Line – Interchange with Red Line 2-3 – Interchange with Red Line 1 on Chamber Street 1-2-3- Rector Street Station

Commuting in London

Kensal Green to Holland Park
First Route: Kensal Green on Brown Line-Interchange-Yellow Line or Green Line – Interchange – Holland Park
Second Route: Kensal Green on Brown Line-Interchange-Pink Line or Dark Yellow Line – Interchange – Holland Park
Third Route: Kensal Green on Orange or Brown Line-Interchange-Orange Line or Striped Green Line – Interchange – Holland Park

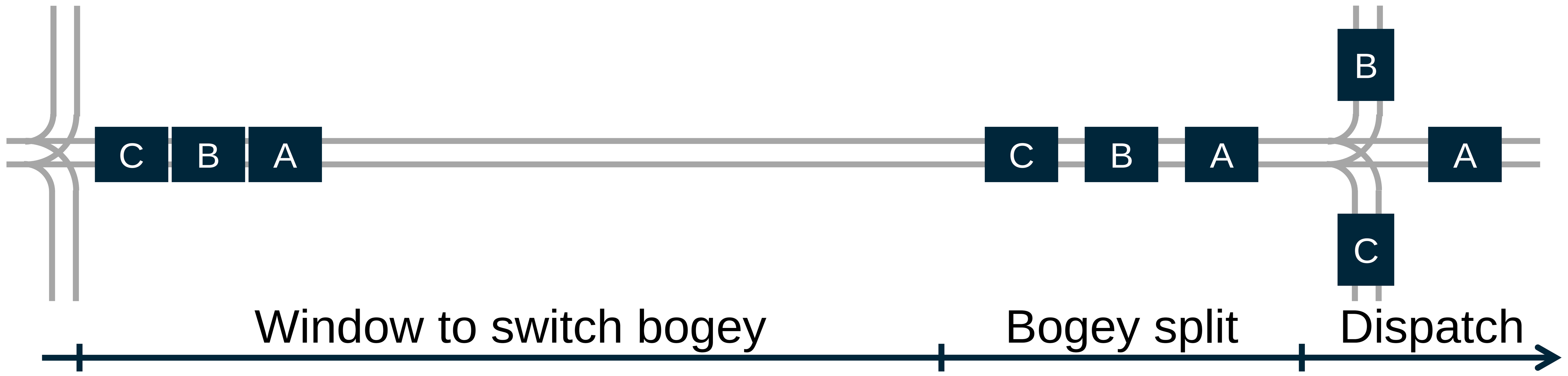


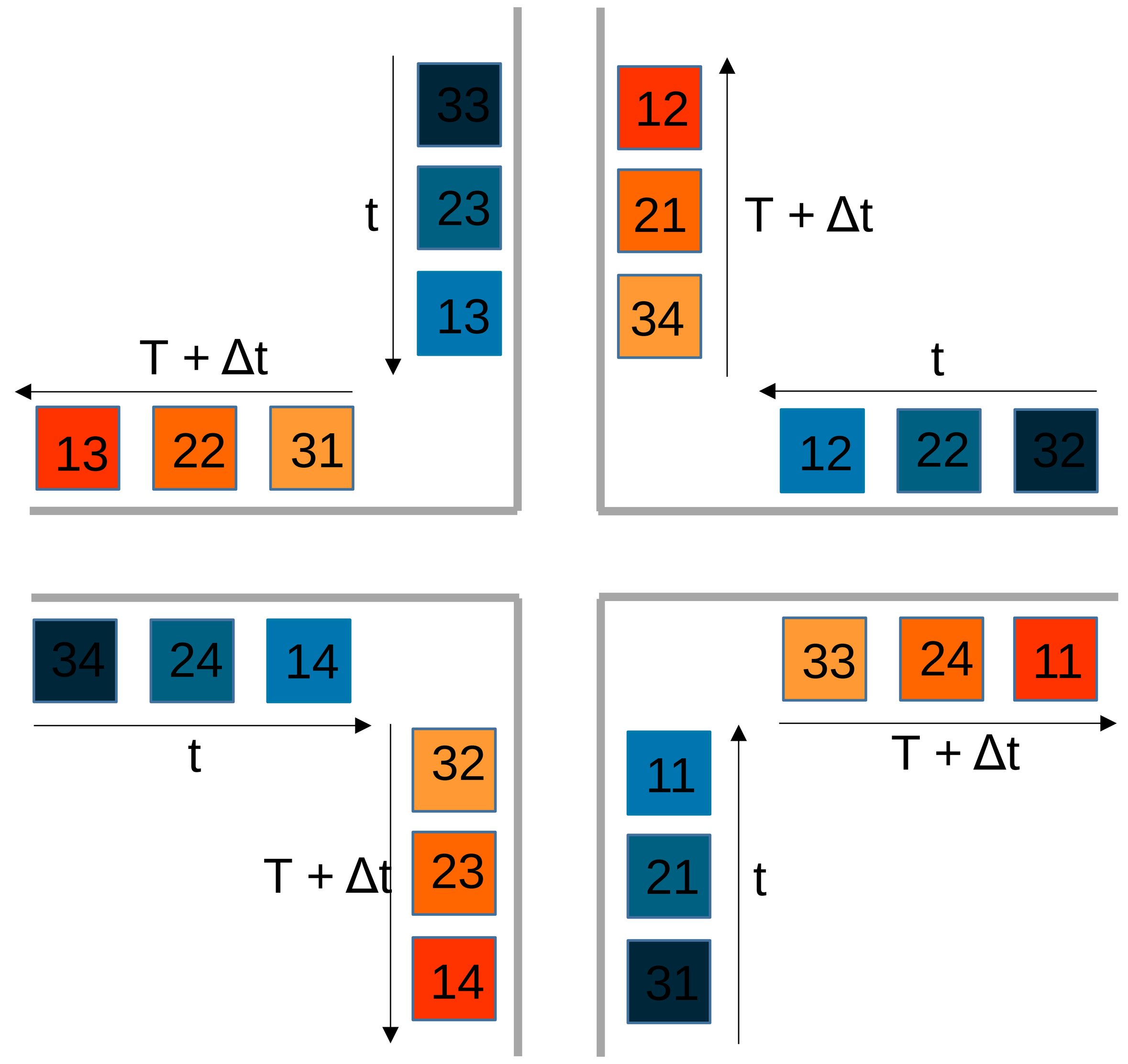
Concepts

- Build a network, not lines
- Gridding enable the n-connection of a point (A line is network of 2connections point)
- The travel time between each point will be similar
- Each connection or a point is a station
- The grid is a network, not just a collection of lines
- The network is synchronized

At the intersection, bogeys choose direction
- Each bogey has different path
- Travelers change bogey in-transit
- Bogey splits before arriving in station
- Bogeys gather in station

Each vehicle has n-1 bogeys
(A 4 intersection will have only 3 bogeys)





Implementation

Divide City into Areas of Interest
Chose a gridding design
Examples:
- High Density residential areas
- High Density of business areas
- Touristic places
- Airports

Design a Local Network
Connect new network to current public transportation facilities: train stations, airports…

Benefits

- No need of transfer in station
- Less waiting time in station
- No people waiting in stations
- Time synchronized
- Several shortest paths
- Possibility to exclude Station in emergency situation (reliability)
- High accessibility of the network from any station

Going further

- Infinite possibility of sub-lines
- The network can grow at the speed of the city
- Connect this network to current public transportation solutions

Q&A

What defines a good public transportation system?

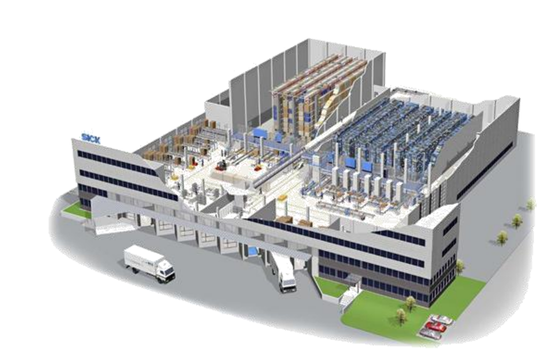
	NYC	London
Fast	Yes	Yes
Non-Complex Route	Yes	No
Operational Reliable	No	No
Minimize Transfer	No	Yes
Time Reliable	No	No
Multiple Shortest Path	No	No
Easy Access	No	Yes
High level of connectivity	No	Yes

P.I. for Public transportation

Objectives: Find an easy to understand and reliable solution
- Goods → People
- Container → Bogey
- Hubs → Stations








We assume that the commuters travelling as the cartons being shipped. The bogey ferrying the commuters will act as the container. And finally, the station where the bogeys detach and attach themselves to different bogeys and also commuters board or disembark from bogeys will be the hubs where exchange of cartons and containers took place.

06-29-2016

Georgia Tech | ISyE Stewart School of Industrial & Systems Engineering

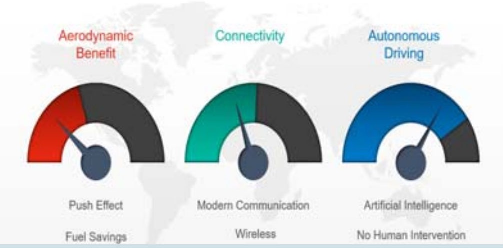
IPIC 2016 | IPIC 2016 - 3rd International Physical Internet Conference June 29-July 1, 2016 | Atlanta, GA USA

Truck Platooning | Case Study & *Application Proposal*

Caline El Khoury , MS in Supply Chain Engineering
Michael Khoury , MS in Supply Chain Engineering

Faculty Advisor : Professor Benoit Montreuil

Overview



Advantages & Disadvantages

Pilot Programs

Technology | Peloton Platooning

- Platooning system with short-range communication-based safety system
- Reduces collision-related expenses and fuel costs due to reduction in aerodynamic drag
- System controls acceleration and braking
- Peloton's cloud-based network operation center, locates every Peloton-equipped truck and notifies them of potential platooning opportunities

Platooning in PI World

- DC and Cross Docs can be the starting point of platoons
- Open Hubs can be the physical meet up point for potential platoons
- In Collaborative world, companies can deploy trucks at specified timings to maximize platooning benefits

USA Platooning Case Study

Fuel Cost : $310 per truck per day
$2,635,160 per 8500 trucks per day
That is a lot of money

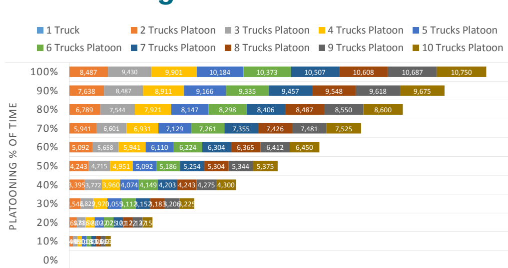
Fuel Savings: 10% per truck per day (2 trucks platoon)
$19,764 per 8500 trucks per day
$7,213,752 per 8500 trucks per year
And that is a lot of savings

Fuel Savings: 50% per truck per day (2 trucks platoon)
$98,891 per 8500 trucks per day
$36,068,762 per 8500 trucks per year
Total success

Savings Summary

	Fuel Savings/Truck
2 Trucks Platoon	7.50%
3 Trucks Platoon	8.33%
4 Trucks Platoon	8.75%
5 Trucks Platoon	9.00%
6 Trucks Platoon	9.17%
7 Trucks Platoon	9.29%
8 Trucks Platoon	9.38%
9 Trucks Platoon	9.44%
10 Trucks Platoon	9.50%

Fuel Savings Per Truck Per Year

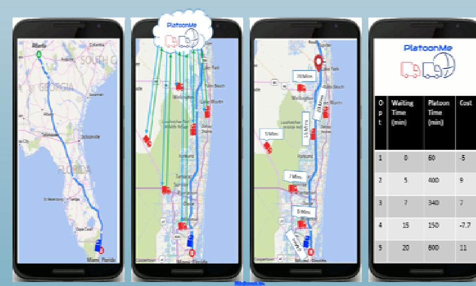


PlatoonMe Application

The idea of this mobile application came up when we were thinking about the practical implementation of platooning and the necessity to have a mean that can link the data and preference for each stakeholder interested in having a platooning match, whether it is an instantaneous match or pre-scheduled platoon.

PlatoonMe Systems

- Matching Algorithm
  Vehicle type, Start/End Point, Departure Time, Instantaneous or Prescheduled
- Displaying the matches
- Savings Estimation and Money Transfer between stakeholders
  Vehicle type, Distance, Time as Platoon Leader
- Make use of fixed traveling schedules, creating virtual meet up hubs
  Usage of Ant colony Algorithm



Extra Features

- 01 Investigate in Car Platooning
- 02 social media options between same platoon
- 03 Platoon History of each member
- 04 # of polar bears saved

PlatoonMe

About us

Michael Khoury
Phone: 404-626-3413
Email: michael.khoury@gatech.edu
LinkedIn: linkedin.com/in/michaelgkhoury

Caline El Khoury
Phone: 678-978-2565
Email: calinekhoury@gatech.edu
LinkedIn: linkedin.com/in/calinekhoury