Automated Freight – Challenges and Opportunities

Pennsylvania Automated Vehicle Summit 2018
Session 2b. "Goods Movement, Logistics, and Automated Freight"

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Trends Impacting Freight
Manufacturing and Marketing Changes

- Manufacturing
  - Origins – Global economy
  - Just-in-time

- How we buy things
  - E-Commerce

- Goods movement
  - Port-centric
  - More handling & transfers
  - Timeliness
E-Commerce Sales Growth

Sales in Billions

Source: Mike Ross, 2017
U.S. Truck Freight Numbers

- USDOT projects that overall freight levels will increase 40% by 2045
  - Truck tonnage will increase 44%
- Over 500,000 trucking companies in the US
  - 97% have fewer than 20 trucks
- 70% of all goods (by weight) in the US move by truck
  - 97% of all consumer goods
- Future modal shares are expected to shift more to truck
  - Over 80% of US communities are served only by truck
  - If rail intermodal use doubled by 2020, market share will still be less that 2%

Source: D. Bennett, 2017
Freight by Mode

Exhibit 1-17 Tonnage on Highways, Railroads, and Waterways, 2010
Highway Freight Growth

Truck Freight 2011 vs 2040 (projected)

Average Daily Long-Haul Traffic on the NHS: 2011

Average Daily Long-Haul Traffic on the NHS: 2040

Transportation Funding

- Shrinking fuel tax base
  - Vehicle efficiency
  - Electrification
- General funds used for highway trust fund?
- Vehicle Miles Traveled usage-based fees
  - Require tracking
  - Likely to incite heavy users
- Significant expansion unlikely

U.S. Infrastructure Funding Shortfall

U.S. Infrastructure needs more than $3.3 trillion in spending over the next decade, according to the American Society of Civil Engineers. More than 43 percent ($1.4 trillion) remains unfunded through 2025.

<table>
<thead>
<tr>
<th>2016-2025 INFRASTRUCTURE FUNDING</th>
<th>TOTAL NEEDS</th>
<th>FUNDED</th>
<th>FUNDING GAP</th>
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<tbody>
<tr>
<td>Surface Transportation</td>
<td></td>
<td></td>
<td>53.9%</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
<td>19.0%</td>
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<tr>
<td>Airports</td>
<td></td>
<td></td>
<td>26.8%</td>
</tr>
<tr>
<td>Water/Wastewater</td>
<td></td>
<td></td>
<td>70.0%</td>
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<tr>
<td>Inland Waterways &amp; Marine Ports</td>
<td></td>
<td></td>
<td>40.5%</td>
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</tbody>
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Source: American Society of Civil Engineers
The I-81 Corridor

- Six states
- Extends from I-40 in TN to the Canadian Border in NY
- Appalachian track
- Relatively rural
- Diverse weather
- Varying topography

<table>
<thead>
<tr>
<th>State</th>
<th>mile</th>
<th>km</th>
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<tbody>
<tr>
<td>TN</td>
<td>75.66</td>
<td>121.76</td>
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<td>VA</td>
<td>324.92</td>
<td>522.91</td>
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<td>WV</td>
<td>26.00</td>
<td>41.84</td>
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<td>MD</td>
<td>12.08</td>
<td>19.44</td>
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<td>PA</td>
<td>232.63</td>
<td>374.38</td>
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<tr>
<td>NY</td>
<td>183.60</td>
<td>295.48</td>
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<tr>
<td>Total</td>
<td>854.89</td>
<td>1,375.81</td>
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</table>
Interstate-81 Services Key Megaregions

Source: Center for Quality Growth and Regional Development (CQGRD), Georgia Institute of Technology, 2009
The I-81 Corridor - Freight

- Primary north-south freight corridor along the eastern part of the U.S.
- 38% of total volume - designed for 15% truck volume
- Freight traffic growth exceeds the national average
- Panamax traffic through eastern seaboard ports
- New, large manufacturing and distribution centers
Crash Incidents

Cumberland Co. officials, PennDOT mulling costs of proposed I-81 barriers

Fiery wreck hurts two after lumber truck blows tire on I-81 North in Montgomery County

Three injured in I-81 crossover crash near Carlisle Sunday

Tractor-trailer crash shuts down all lanes of I-81 near Chambersburg
Truck Crash Causation

- Driver drowsiness
- Driver distraction
- Equipment failure
- Light vehicle drivers
- Curve rollovers
- Shifting loads
Crash Impacts

- Loss of one lane of two reduces overall capacity by 65%
- Crash incidents account for ~25% of congestion nationwide
- 30 crashes/year with clearance times greater than 6 hours (VA)
- 35% fatal crashes involve trucks (not over-represented)
- 22% of non-fatal crashes involve trucks
The Economic Costs of Crash Congestion

“When employees cannot get to work our lines do not run!!! – Cost Impact $700/min or $42,000 per hour”

“When our components do not make it to vehicle assembly plants!!! – Cost Impact $1,500/min or $90,000 per hour”

Impact of Incidents

I-81 Example Crash

- Incident involving tractor-trailer
- Duration: 12 hours
- Est. queue length: 8 miles
- Vehicle hours of delay: 16,355
- Est. delay cost: $612,000

Source: Center for Advanced Transportation Technology- Regional Integrated Transportation Information System (RITIS)
Why Automate Freight?

• Commercial driver shortage
• Efficiency
• Reduced congestion (highway, city)
• Better use of existing infrastructure
• Safety!
Humans can be great drivers

An alert, attentive, sober driver is very good at avoiding crashes

Farber & Paley (1993) modeled driving behavior and found that an average U.S. driver will make approximately 3 million successful braking maneuvers with one failure during 25 years of driving

~94% of crashes result from human error

Machines don’t get:
- Distracted
- Fatigued
- Drowsy
- High
- Mad
Freight Automation Applications
Highway

From Starsky.io

From Otto
Urban Freight Automation
Unmanned Aerial Vehicles (UAV)
Unmanned Aerial Vehicle (UAV) – Primary Uses

- Physical presence/deterrents (e.g., clearing wildlife from runways)
- Transport
  - Goods
  - Weapons
  - Materials (e.g., pesticides)
  - People
- Elevated and mobile platforms
  - Remote sensing - observation
  - System host (e.g., cellular communication nodes, DSRC)
Going Airborne – UAV Freight

- Paradigm shift in how we transport stuff
- 3D versus 2D
- Unrestricted by constrained pathways
- Speed
- Ground congestion
- Energy Efficiency

“Shifting smaller package delivery from trucks to drones results in a net savings of 5.7 percent of the overall energy used.” (*RAND Corporation)

24 https://www.rand.org/pubs/research_reports/RR1718z1.html

Images from UPS
UAV Transport of Time-Critical Deliveries

- Automatic External defibrillator
- Poison antivenin

Images from Alec Momont
Unmanned Aerial Vehicle (UAV) – Primary Uses

- Physical presence/deterrents (e.g., clearing wildlife from runways)
- Transport
  - Goods
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UAV Incident Response

- Expedited incident assessment
- Informed response
- Response prioritization
- Crash site reconstruction

*3D Model constructed from UAS for forensic analysis

Crash Simulation Video Footage
UAV Identification of traffic hazards

• Traffic volume, flow (machine vision)
• System management
• Road/rail weather hazard ID (ice, snow, puddling)
Deployment of UAVs from remote platforms for incident surveillance

- UAVs “roosted” at geographically distributed locations
- Automated and/or piloted remotely
- Acquired data streamed to TOC
- Existing camera towers or other locations provide:
  - Power for battery recharging
  - Secure perch
  - Data link -- data type determines transmission mode (cellular, RF, fiber, etc.)
Airspace Management - FAA
Proposed Airspace Apportionment
Mixed-Domain Management Model – Which DOT?