Coordinated Transit Response Planning and Operations Support Tools for Mitigating Impacts of All-Hazard Emergency Events

First International Conference on Surface Transportation System Resilience to Climate Change and Extreme Weather Events
Washington, D.C.
Session: Weather and Climate: Different Sides of the Same Coin
16 September, 2015
(3:30pm-5:00pm @ NAS 120)

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Severe weather is a recurring problem for transit agencies

- August 22, 2014: flooding delayed the start of nine PACE bus routes
- Flooding prevented Pace drivers from reaching the agency's Southwest Division garage facility to begin their normal routes early Friday morning
- June 26, 2013: Severe weather causing major delays on many routes
- Transit agencies build their facilities on the land no one wants. PACE has grades in 10-year flood areas.
- February 2, 2015: After nearly 36 straight hours of snowfall, the Chicago area was digging out from more than 19 inches. Pace experiencing delays due to the snow
- Oil spills as an additional threat
Climate change makes things worse...

- Climate change impacts are occurring now and will increase in the future.
- The amount of long-lived emissions already in the atmosphere means that a significant level of climate change is inevitable.
- The most disruptive near-term impact is likely to be intense rainfall that floods subway tunnels and low-lying facilities, bus lots, and rights-of-way.
- Transit systems need to adopt and be prepared for those changes.
- Rising sea-levels, compounded by worsening storm surges.
- Heat waves will stress materials, buckle rails.
- Landslides, heavy snowfall, wildfires, droughts, and power blackouts also pose threats.

Ways to prepare:
- Flood Mitigation
- Improve operation strategies

Flood mitigation projects are expensive
- Deep Tunnel Project for Chicago (Tunnel and Reservoir Plan): Commissioned in the mid-1970s, completion of the system is not anticipated until 2029. Over $3 billion has been spent on the project.

Highway system is under stress. Number of vehicle registration keeps increasing

- Highway systems are under stress:
  - Illinois-northwest Indiana region suffered the misery of 61 extra hours behind the wheel on average in 2014
  - 55 hours lost in 2009
  - Interstate 90/94 has three spots in the top 20

In Chicago 29 extra gallons of fuel burned per commuter last year

Technology allows for Transit Systems to be More Adaptive

- Automatic Vehicle Location is a standard feature of most of the bus systems
- High frequency updates from every vehicle (30 second is an accepted practice). Reliable connectivity is a given
- Other sources of real-time data is being collected
  - Automated passenger counts (APC). Modern APC have measurement error as low as 5%. Some of them can distinguish between children and adults
  - Fare data (Cubic’s Ventra, GFI, LECIP)
- Back end IT infrastructure (relational databases, Trapeze TransitMaster)
- Communication standards: J1708

- This summer (2015) Google Maps announced that it is now using real-time transit information to calculate commute times in Chicago
  - current arrival and departure times
  - service alerts
  - Available in many metropolitan areas
  - The CTA and Pace are among roughly 125 agencies across the world for which Google Maps uses real-time data
In this project

- **Small to medium** size events (a few roads are blocked, garage is not accessible, ...)
  - Flood
  - Snow storm
  - Rail accident
  - Major road accident

- Events happen on a short notice (we can prepare for planned road closures, spatial events,...)

- Decisions need to be made in **real-time** or nearly real-time

- How can we leverage existing data sources to implement real-time decision support system?
In this project: Goals

- Developing a decision support system to assist decision makers in transportation and transit agencies to assess the spectrum of impacts of a specific event (natural and man-made disasters) on transport infrastructure in both a planning and operational context.

- Based on computerized and expert analyses, recommending the most effective solutions to rescue and evacuate people and passengers from the affected areas using all available resources including transit assets in real time.

- Prioritizing rescue and evacuation tasks to leverage resources efficiently and effectively.
Some previous work

- **Transit Operations Decision Support System (TODSS)**
  - Computer Aided Dispatch and Automated Vehicle Location systems resulting in information overload for the dispatchers
  - prioritizing their workloads and discerning patterns of operational problems
  - feasible to add TODSS into an existing ITS environment
  - Incident management
  - Vehicle management
  - fixed-route bus service

- **Regional Transportation Simulation Tool for Emergency Evacuation Planning (RTSTEP)**
  - Large-scale evacuations from major cities
  - No-notice events (chemical or radiological attacks, hazardous material spills, or earthquakes)
  - Accommodation of emergency evacuation traffic throughout a very large area
Proposed System Architecture: Planning and Real-Time

- Bus Fleet
- Transit Operator
- Transit Master IBS
- Routes & Schedule
- External Events
- Demand Forecast
- Fleet Allocation
- Routes & Schedules
- Rules

Public

- Connection points for different components and stakeholders

Flowchart illustrating the integration of various systems and their interactions in the proposed system architecture.
Integrated Transportation System Model (POLARIS)

- POLARIS is an agent-based transportation system model
- Decision making is decentralized. Each traveler has its own goals and behaviors. All aspects of activity and travel are represented in a single model
- Travelers are autonomous and can adopt to current conditions (congestion, mode availability, information available)
- Not restricted to a limited number of market segments (user groups)
- The agent based framework is flexible and can accommodate other types of agents (buildings, authorities, smart infrastructure)

NETWORK MODEL
- Managed Lanes
- Controlled intersections (traffic signals)
- Traveler information systems and
- Traffic management
- Multimodal travel (Integrated corridor management)
Integrated Transportation System Model (POLARIS)
Individual Activity Travel Patterns Allow Accurate Drive Cycle Evaluation

In Chicago over 46% of time away from home is not at a work or school location.
Using POLARIS and Autonomie to analyze the impact of Real-Time for mitigating traffic incident delays

- Variable Message Signs deployment along interstates and major arterials
- Active management pushes incident messages to relevant signs along route
- Drivers’ en-route switching behavior using bounded rationality triggered by messages
Case Study: Chicago CBD VMS Analysis

- VMS deployment along all interstates and major arterials
- Active management pushes incident messages to relevant signs along route
- Drivers’ en-route switching behavior using bounded rationality triggered by messages

- VMS management coupled with incident response reduces delay by 18% in the CBD
- Benefits would be even greater under more limited driver information (i.e. all drivers have access to current pre-trip info)
Outputs

- **Network Performance** (measures of effectiveness)
  - Time delay per road segment basis
  - Time delay for each traveler

- **Demand**
  - Shifts in departure times
  - Shifts in destinations choices
  - Cancelled activities
  - Route switches
Summary

- Current technology and algorithms allow real-time decision making
- By incorporating real-time methodologies into existing IT infrastructure of transit agencies we can be better prepared for no-notice events
- Capabilities developed at Argonne and PACE allow for implementing a prototype of the real-time transit system management tools
- Working with legacy IT infrastructure is tricky but doable
- Demand forecasting and real-time updating is tricky but doable