Disaster Response Planning and Logistics
A Unique Challenge
Most don’t realize the number of national disasters each year and the full requirements of a response.

What is the timeframe that drive the response timeline?

What impact does policy have?

To what extent should survivors be considered self sufficient?
Examining a framework for looking at Disaster Surge Requirements

- **Multiplicity**: Maintaining the capability to respond to multiple disasters regardless of their severity
- **Density**: Scaling responses to account for variances in populations and infrastructure impacted by the disaster
- **Intensity**: Adapting responses to provide adequate support to disasters of varying intensities
The objective of supply chain disaster response is theoretically simple…but operationally and organizationally complex.

- Transportation with damaged infrastructure and constrained fuel
- Supplier Capacity if number of functioning suppliers is reduced
- Survival Needs coupled with a hoarding mentality
- Inventory Planning Safety Stock for multiple sequential or simultaneous disasters
- Distribution with law enforcement restrictions and constraints due to damage or looting
- Uncertain disaster density, intensity, and multiplicity

These challenges defy blanket application private sector best practice and defy translation of requirements and complexities into a traditional model.
Intense public scrutiny only intensifies the pressure

“Tons of Food Spoiled As FEMA Ran Out Of Storage Space”
(Washington Post, 4/12/07)

“Food stored by FEMA spoils”
(United Press International, 4/13/07)

FEMA Wastes $40 Million in Food for Katrina”
(CBS News, 4/13/07)

“Pre-Prepared Meals Wasted”
(CNN: American Morning, 4/26/07)

FEMA Ice Goes To Waste”
(WVUE-TV-New Orleans 7/4/07)

“FEMA Dumps Ice In Storage”
(FOX Report, 7/4/07)

“Doesn’t FEMA Know There Are Starving Children? $40 million in Food Thrown Away”
(Associated Content, 4/13/07)

“Stockpiled Food Goes Bad”
(CNN: The Situation Room, 4/13/07)

“FEMA let millions of meals rot on Gulf Coast”
(Washington Post, 4/13/07)

“Another FEMA goof”
(Bradenton Herald, 4/26/07)

FEMA To Melt $24 Million In Unused
(Congressional Quarterly 7/16/07)
No matter the preparation, there will always be the unknown and unexpected
### Applying analytics to the landscape of disaster response

<table>
<thead>
<tr>
<th>Degree of Complexity</th>
<th>Competitive Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stochastic Optimization</td>
<td>How can we achieve the best outcome including the effects of variability?</td>
</tr>
<tr>
<td>Optimization</td>
<td>How can we achieve the best outcome?</td>
</tr>
<tr>
<td>Predictive modeling</td>
<td>What will happen next if?</td>
</tr>
<tr>
<td>Forecasting</td>
<td>What if these trends continue?</td>
</tr>
<tr>
<td>Simulation</td>
<td>What could happen.... ?</td>
</tr>
<tr>
<td>Alerts</td>
<td>What actions are needed?</td>
</tr>
<tr>
<td>Query/drill down</td>
<td>What exactly is the problem?</td>
</tr>
<tr>
<td>Ad hoc reporting</td>
<td>How many, how often, where?</td>
</tr>
<tr>
<td>Standard Reporting</td>
<td>What happened?</td>
</tr>
</tbody>
</table>

Based on: Competing on Analytics, Davenport and Harris, 2007

**Prescriptive**

**Predictive**

**Descriptive**
Disaster Supply Chain Response Simulation
Defining a model to address the supply chain challenge

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribute emergency supplies such as water, meal, blankets, generators and tarps to disaster victims in the event of various natural and man-made disasters in a timely and effective manner to save and sustain lives, minimize suffering, and protect property.</td>
<td>• Assess the effectiveness of disaster response plan for distributing emergency supplies to disaster victims. • Evaluate the impact of transformation/improvement initiatives. • Identify bottlenecks, risks and improvement opportunities. • Provide decision support for developing an effective disaster response plan.</td>
</tr>
</tbody>
</table>

**Technical Solution**

**Agent-based simulation**
- Simulate the flow of emergency supplies and optimize the selection of shipment destinations and cross-shipping between distribution points.

**Large-scale logistics optimization algorithms**
- Optimized cargo or personnel movements to maximize time-definite delivery at lowest overall logistics costs.

**Web-enabled dashboard**
- Geographic information system (GIS) for capturing, managing, analyzing, and displaying geographically referenced information.
New Madrid Scenario
Intra-plate earthquake in the southern and mid-western United States

- Earthquake occurs at 2:00 AM on February 7th
- Event represents rupture of three New Madrid Fault segments simultaneously with magnitude, $M_w = 7.7$
- Modeled as sequential rupture of individual segments similar to 1811-1812 series of events over several months
- Severe shaking occurs throughout western Kentucky, Tennessee, southeastern Missouri, northeastern Arkansas and southern Illinois with localized amplification of ground shaking due to variations in soil conditions
- Significant ground deformations likely in soft soils, particularly near riverbeds
- Aftershocks around magnitude 6, $\sim M_w 6$, are likely in the days and weeks after the main shock

<table>
<thead>
<tr>
<th>FEMA Region</th>
<th>State</th>
<th>Commodities (First 72 hours)</th>
<th>Water</th>
<th>MREs</th>
<th>Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Liters</td>
<td>Truckloads</td>
<td>Number</td>
<td>Truckloads</td>
</tr>
<tr>
<td>Region IV</td>
<td>Alabama</td>
<td>1,823,169</td>
<td>102</td>
<td>1,215,446</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Kentucky</td>
<td>2,641,557</td>
<td>147</td>
<td>1,761,038</td>
<td>81</td>
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<tr>
<td></td>
<td>Mississippi</td>
<td>2,225,166</td>
<td>124</td>
<td>1,483,444</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Tennessee</td>
<td>6,765,444</td>
<td>376</td>
<td>4,510,296</td>
<td>207</td>
</tr>
<tr>
<td></td>
<td>Total RIV</td>
<td>13,455,336</td>
<td>749</td>
<td>8,970,224</td>
<td>412</td>
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<tr>
<td>Region V</td>
<td>Illinois</td>
<td>2,044,269</td>
<td>114</td>
<td>1,362,846</td>
<td>63</td>
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<td></td>
<td>Indiana</td>
<td>1,755,087</td>
<td>98</td>
<td>1,170,058</td>
<td>54</td>
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<tr>
<td></td>
<td>Total RV</td>
<td>3,799,356</td>
<td>212</td>
<td>2,532,904</td>
<td>117</td>
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<tr>
<td>Region VI</td>
<td>Arkansas</td>
<td>3,045,516</td>
<td>169</td>
<td>2,030,344</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Total RVI</td>
<td>3,045,516</td>
<td>169</td>
<td>2,030,344</td>
<td>93</td>
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<tr>
<td></td>
<td>Missouri</td>
<td>2,706,450</td>
<td>150</td>
<td>1,804,300</td>
<td>83</td>
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<td>2,706,450</td>
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<td></td>
<td>Total</td>
<td>23,006,658</td>
<td>1,280</td>
<td>15,337,772</td>
<td>705</td>
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</table>

| Region VII  |Arkansas | 3,045,516 | 169 | 2,030,344 | 93 | 8,121,376 | 203 |
|             |Total RVI | 3,045,516 | 169 | 2,030,344 | 93 | 8,121,376 | 203 |
|             |Missouri | 2,706,450 | 150 | 1,804,300 | 83 | 7,217,200 | 180 |
|             |Total RVII | 2,706,450 | 150 | 1,804,300 | 83 | 7,217,200 | 180 |
|             |Total | 23,006,658 | 1,280 | 15,337,772 | 705 | 61,351,088 | 1,533 |

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<th>Impact County (IC)</th>
<th>Water</th>
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<th>Ice</th>
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<td>Truckloads</td>
<td>Number</td>
</tr>
<tr>
<td>Alabama</td>
<td>1,646,337</td>
<td>92</td>
<td>1,097,558</td>
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<tr>
<td>Arkansas</td>
<td>1,304,613</td>
<td>68</td>
<td>869,742</td>
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<tr>
<td>Illinois</td>
<td>521,913</td>
<td>27</td>
<td>347,942</td>
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<tr>
<td>Indiana</td>
<td>1,073,664</td>
<td>92</td>
<td>715,776</td>
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<tr>
<td>Kentucky</td>
<td>1,162,497</td>
<td>65</td>
<td>774,998</td>
</tr>
<tr>
<td>Missouri*</td>
<td>2,227,620</td>
<td>119</td>
<td>1,485,080</td>
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<tr>
<td>Tennessee</td>
<td>4,713,111</td>
<td>262</td>
<td>3,142,074</td>
</tr>
<tr>
<td>Total IC</td>
<td>12,649,753</td>
<td>723</td>
<td>8,433,170</td>
</tr>
</tbody>
</table>

Modeling Challenges for Disaster Response

Goals
- Best possible coverage
- Allocation/Adjudication
- Transportation planning and scheduling
- Sensitivity analysis

Challenging Factors
- Non-stationary demands and unstable supply chains
- Uncertain/unknown demands and capacities
- Multiple sourcing from dynamic supply points
- Joint sourcing and transportation decisions with disruptions
- Adjudication/Allocation for fairly balancing coverage
New Madrid Scenario
Coverage simulation: Sample Snapshot
Key Takeaways

- There is no perfect solution
  - Mitigation of damage – the magnitude and timing of the disaster prevents perfect coverage
  - Application of sophisticated analytic techniques could help drive coverage improvements of up to 9.6% leading to an estimated 57.1% coverage for the given scenario constraints.
  - Seemingly modest improvement would still result in an additional 1.5M days of water rations with improved distribution

- Location flexibility and additional scalability of potential distribution of staging areas can drive substantial improvements

- Scalability of supply capacity becomes both a critical success factor and challenge
Mobile adoption continues to explode

41% Compound Annual Growth Rate (CAGR)

Wearable Wireless Devices

1 Trillion Connected Sensors

5.6 Billion Personal Devices Sold

2013 2014 2015

The onset of social and mobile presents a wide range of new opportunities

- Mobile represents a shift from a hardened infrastructure to one more individual and flexible
  - Provides an avenue to push and receive real time information immediately
  - Can be used to identify and locate victims in need

- Hurricane Sandy showed the power utilizing mobile and social media to generate and transmit data
  - Agencies pushed information through twitter and Facebook and manage information
  - FEMA and the Red Cross mined tweets and posts for actionable information that were out to response teams
  - Disaster reporter apps receive structured disaster reports
Applying analytics to growing amounts of unstructured data to glean insights?

- How much do we leave untapped if we don’t go after the unstructured data?
- What innovative applications can we apply to drive more effective disaster response?
- What are the challenges that come with the data?
Thank you!

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