

CONTRA FLOW OPERATIONS FOR HURRICANE EVACUATION: LESSONS LEARNED FROM AN ALABAMA CASE STUDY

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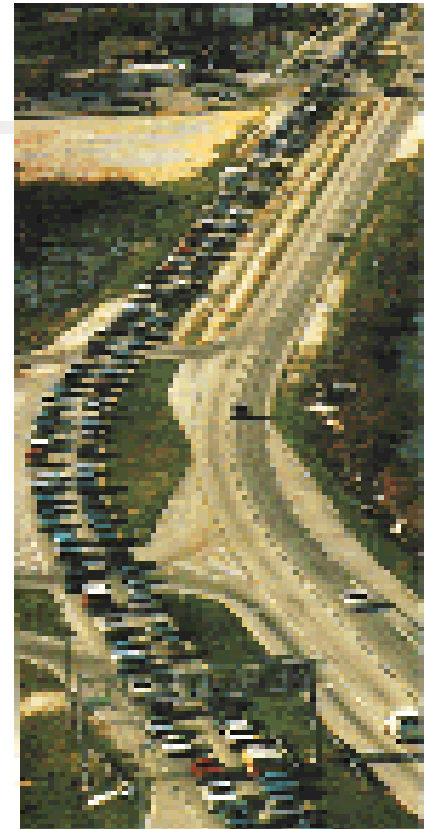
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Problem Statement

- Hurricanes are prevalent in the Atlantic Ocean and Gulf of Mexico.
- Governments and transportation planning agencies must prepare and plan for evacuation of residents
- **Contra-flow operations** is a strategy for evacuation but feasibility & operationality require further study as reservations exist.

AL Experience with Contra-Flow

- ALDOT has a detailed plan for reverse laning of I-65 for hurricane evacuation.
 - Evacuation routes and termini
 - Plan implementation procedures and requirements
- Plan was fully implemented successfully in the past
 - Hurricane Ivan on Wed, 9/15/04
 - Hurricane Dennis on Sat, 7/9/05



AL Contra-Flow Operations

■ KEY FEATURES

- Twenty-Eight (28) major Traffic Control Locations
- Dedicated Equipment
- “Fold-Down Signage”
- Variable Message Boards
- Highway Advisory Radio





Alabama Case Study-Ongoing

- University of Alabama at Birmingham on behalf of ALDOT
- Test and refine existing contra-flow procedures along the I-65 evacuation corridor
- Ultimately allow ALDOT to use real-time traffic data to assess hurricane evacuation situations and unforeseen events



Project Objective

- Investigate the impacts of:
 - Notification lead time on evacuation performance
 - Storm severity and evacuation area on performance
 - Seasonal variations in evacuations (tourists)
 - I-65 lane reversal impacts on other evacuation routes
 - Alternate termini for evacuation and the impact on local traffic, and
 - Unexpected evacuation events

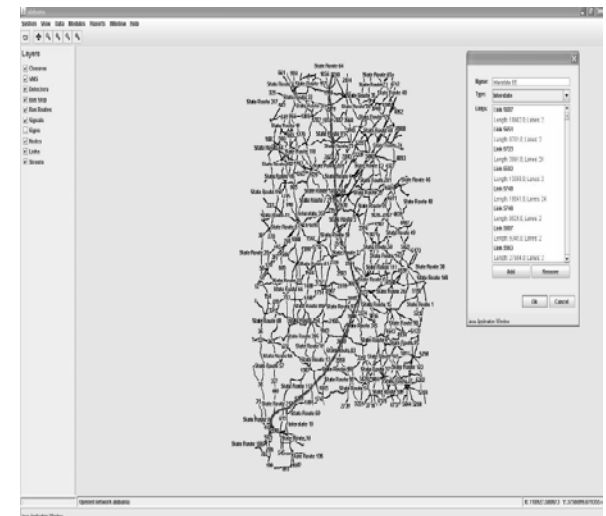
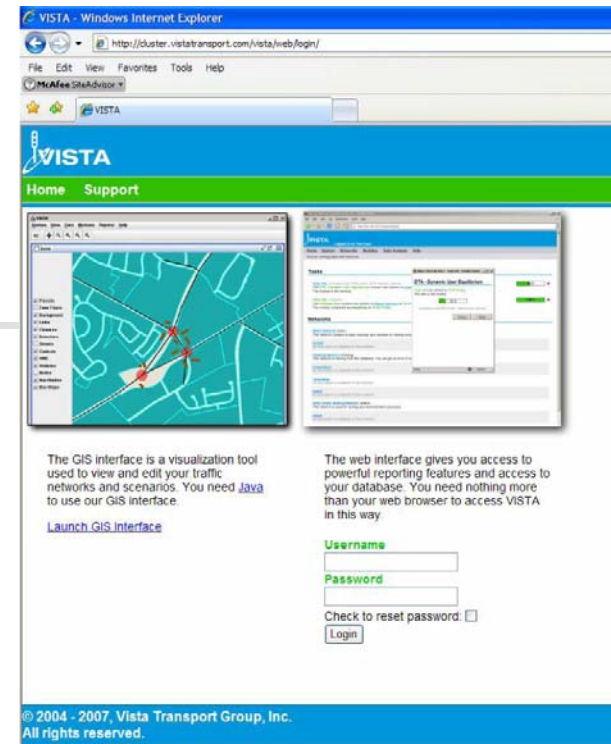


Alabama Case Study Methodology

- Literature Review
- Site selection
- Simulation model Selection
- Data collection
- Scenario development
- Model development, testing & adjustments
- Summary of results
- Conclusions and recommendations

What is VISTA?

- The Visual Interactive System for Transport Algorithms (VISTA)
- Can be used for planning, engineering, and operations
- VISTA provides dynamic traffic assignment
 - Path based; accounts for driver behavior and ITS technologies
- Internet-based



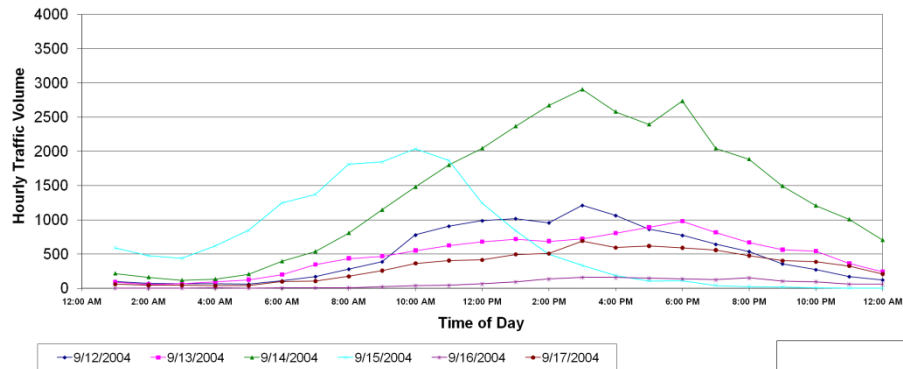
Geometric and Traffic Data Collection

- Lane geometry and interchange configurations along major routes (Google maps and site visits)
- Available traffic count data from previous evacuations and lane reversals
- Signal timing data
- TRANPLAN

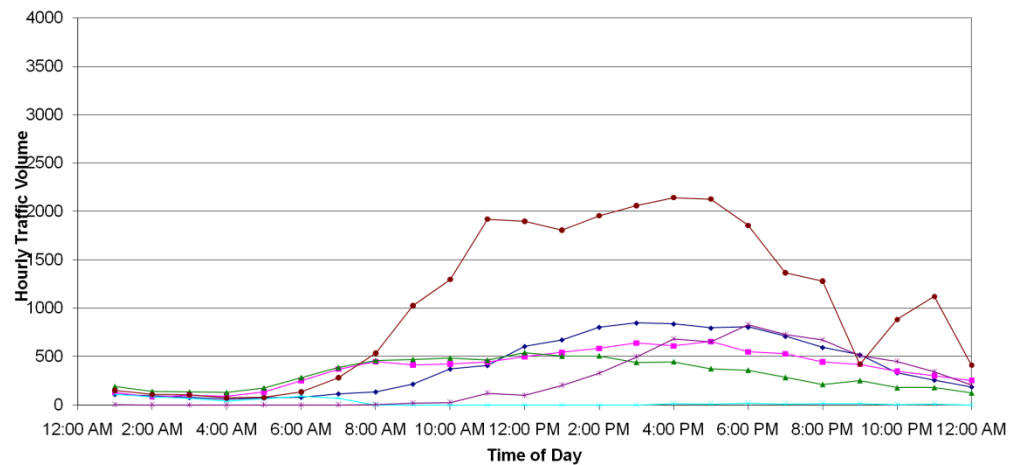


Traffic Data

NB I-65 at MP 42



SB I-65 at MP 42





Evacuation Data Collection

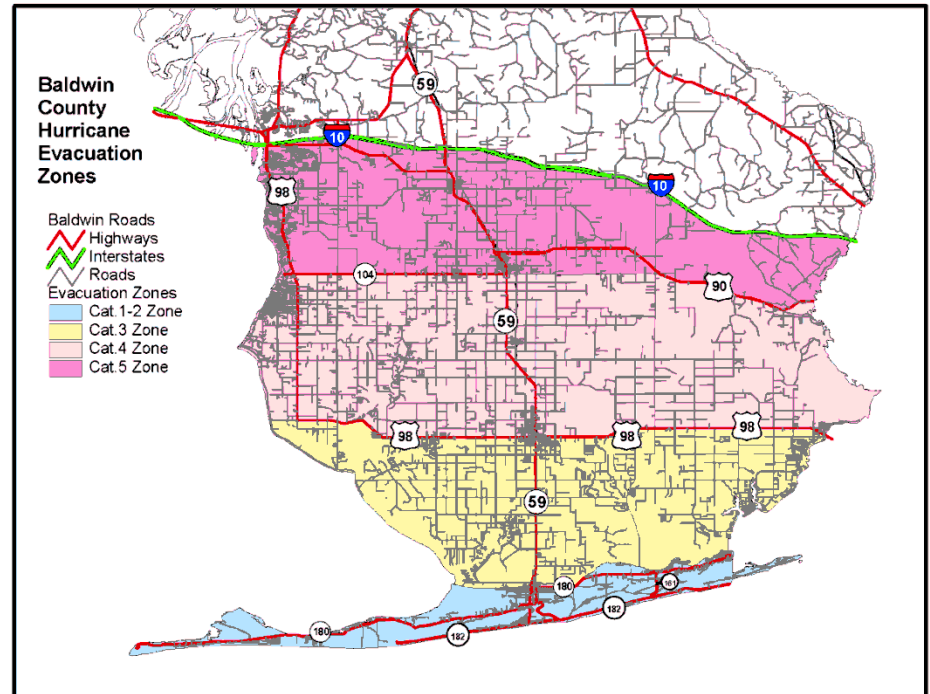
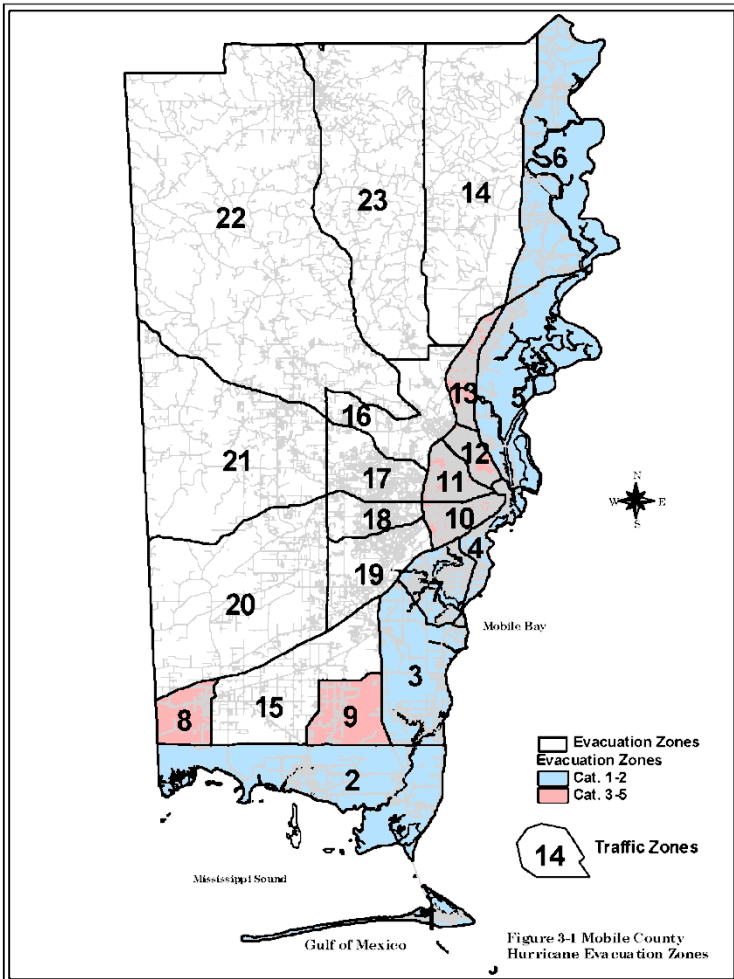
- **Demographic data** for the evacuation region to estimate travel demand during the various evacuation scenarios
- United States Army Corps of Engineers (USACE) data used to develop traffic demand profiles for low and high hurricane intensity conditions

Model Development and Calibration



- Construction of a model of the major evacuation corridors using the VISTA model.
- Calibration using traffic counts from recent evacuations and travel time data
- Challenges:
 - Evacuation Zone Data Development
 - Evacuation Road Network Preparation

Evacuation Zones





Alabama Network Scenarios

| Serial | Network Name | Reversal | End Location | Reversal Information | | |
|--|--------------|----------|--------------|----------------------|------------|-----------|
| | | | | Duration (hrs) | Start Time | End Time |
| Low Severity Storms – Category 1-2 | | | | | | |
| 1 | NL3100 | No | | 0 | N/A | N/A |
| 2 | FL3116 | Full | US-31 | 16 | 5:00 a.m. | 9:00 p.m. |
| 3 | PL3116 | Partial | US-31 | 16 | 5:00 a.m. | 9:00 p.m. |
| High Severity Storms – Category 3-5 | | | | | | |
| 4 | NH3100 | No | US-31 | 0 | N/A | N/A |
| 5 | FH3116 | Full | US-31 | 16 | 5:00 a.m. | 9:00 p.m. |
| 6 | PH3116 | Partial | US-31 | 16 | 5:00 a.m. | 9:00 p.m. |

Network-Wide Results

Low Intensity Hurricanes (Category 1, 2)

| | Loaded Vehicles | Entered Total TT (H) | AVG TT (M) | Entered Veh. VMT (Miles) | AVG Speed (Miles/hr) |
|---|------------------------|-----------------------------|-------------------|---------------------------------|-----------------------------|
| NL3100- No Reversal | | | | | |
| All Vehicle | 1087810 | 167547 | 9.24 | 8828190 | 52.69 |
| Evacuee | 35045 | 50156 | 85.87 | 3248543 | 64.77 |
| Car | 1052765 | 117390 | 6.69 | 5579647 | 47.53 |
| PL3116 - Partial Reversal 16 Hours | | | | | |
| All Vehicle | 1082432 | 163843 | 9.08 | 8668139 | 52.91 |
| Evacuee | 35045 | 49994 | 85.59 | 3250823 | 65.02 |
| Car | 1047387 | 113849 | 6.52 | 5417316 | 47.58 |
| FL3116- Full Reversal 16 Hours | | | | | |
| All Vehicle | 1082432 | 164057 | 9.09 | 8662865 | 52.80 |
| Evacuee | 35045 | 50038 | 85.67 | 3245882 | 64.87 |
| Car | 1047387 | 114019 | 6.53 | 5416983 | 47.51 |

Network-Wide Results

High Intensity Hurricanes (Category 3,4,5)

| | Loaded Vehicles | Entered Total TT (H) | AVG TT (M) | Entered Veh. VMT (Miles) | AVG Speed (Miles/hr) |
|---|------------------------|-----------------------------|-------------------|---------------------------------|-----------------------------|
| NH3100- No Reversal | | | | | |
| All Vehicle | 781442 | 472021 | 36.24 | 22376909 | 47.41 |
| Evacuee | 106349 | 398109 | 224.61 | 18862814 | 47.38 |
| Car | 675093 | 73912 | 6.57 | 3514095 | 47.54 |
| PH3116 - Partial Reversal 16 Hours | | | | | |
| All Vehicle | 778748 | 468251 | 36.08 | 22278233 | 47.58 |
| Evacuee | 106349 | 396090 | 223.47 | 18856652 | 47.61 |
| Car | 672399 | 72161 | 6.44 | 3421581 | 47.42 |
| FH3116- Full Reversal 16 Hours | | | | | |
| All Vehicle | 778748 | 391547 | 30.17 | 21300923 | 54.40 |
| Evacuee | 106349 | 319364 | 180.18 | 17880833 | 55.99 |
| Car | 672399 | 72183 | 6.44 | 3420090 | 47.38 |

Corridor Results-1

All Hurricanes; NB Direction

| Scenario | Low Intensity Hurricanes (Category 1, 2) | | | High Intensity Hurricanes (Category 3, 4, 5) | |
|-------------------------------|---|--------|--------|--|--------|
| | NL3100 | PL3116 | FL3116 | PH3116 | FH3116 |
| Path Length (Mile) | 133.21 | 129.03 | 132.87 | 129.03 | 132.87 |
| Free Flow Travel Time (M) | 116.30 | 112.30 | 115.60 | 111.10 | 114.4 |
| Simulation Travel Time (M) | 697.80 | 673.80 | 693.60 | 688.57 | 687.69 |
| Total Delay (M) | 581.50 | 561.50 | 578.00 | 577.47 | 573.29 |
| AVG Delay (Minute/Mile) | 4.37 | 4.35 | 4.35 | 4.48 | 4.31 |

Corridor Results

All Hurricanes; Reversed SB Direction

| Scenario | Low Intensity Hurricanes (Category 1, 2) | | | High Intensity Hurricanes (Category 3, 4, 5) | | |
|-------------------------------|---|--------|--------|---|---------|--------|
| | NL3100 | PL3116 | FL3116 | NH3100 | PH3116 | FH3116 |
| Path Length (Mile) | - | 129.56 | 132.61 | - | 129.56 | 132.61 |
| Free Flow Travel Time (M) | - | 113.80 | 115.80 | - | 112.50 | 114.50 |
| Simulation Travel Time (M) | - | 682.80 | 694.80 | - | 1039.90 | 688.01 |
| Total Delay (M) | - | 569.00 | 579.00 | - | 927.40 | 573.51 |
| AVG Delay (Minute/Mile) | - | 4.39 | 4.37 | - | 7.16 | 4.32 |



Summary Results

- For Category 1-2 storms lane reversal is not justified from the system's operation point of view
- For High Storm Category
 - No statistically significant improvement in network performance is achieved from **partial lane reversal**
 - Significant improvements in travel time and speed can be achieved for evacuating vehicles, should a **full lane reversal** is implemented.
 - Along the I-65 corridor, the full lane reversal yields also the best results, while partial reversal is not justified.

Work in Progress



- Test the impact of moving the northern terminal to another location
- Report on the impact of evacuation duration on network performance
- Model unexpected events (i.e., incidents) during an evacuation



Hurricane Evacuations- Lessons Learned -1

- Targeted evacuations are important.
 - Non-essential evacuations increase congestion
 - Detailed plan with evacuation zones
- Evacuation timing
 - Strong winds occurs long before the eye of the storm comes ashore (“landfall”)
- Tourist population
- ITS Technologies

Hurricane Evacuations – Lessons Learned-2

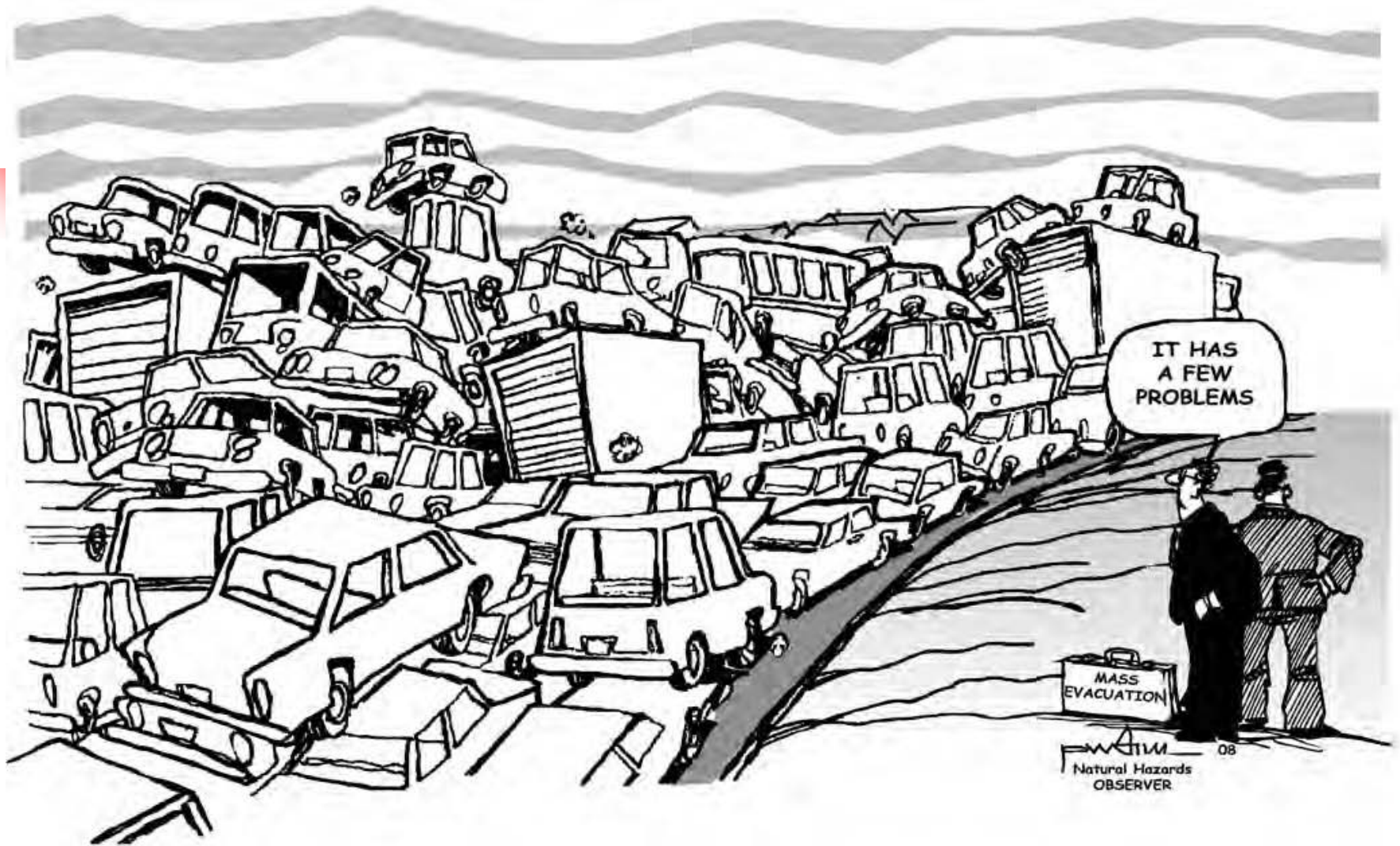
- Re-entry criteria
 - Often overlooked; Must be planned for in advance
 - Road & bridge safety evaluation before use
- Coordination among states



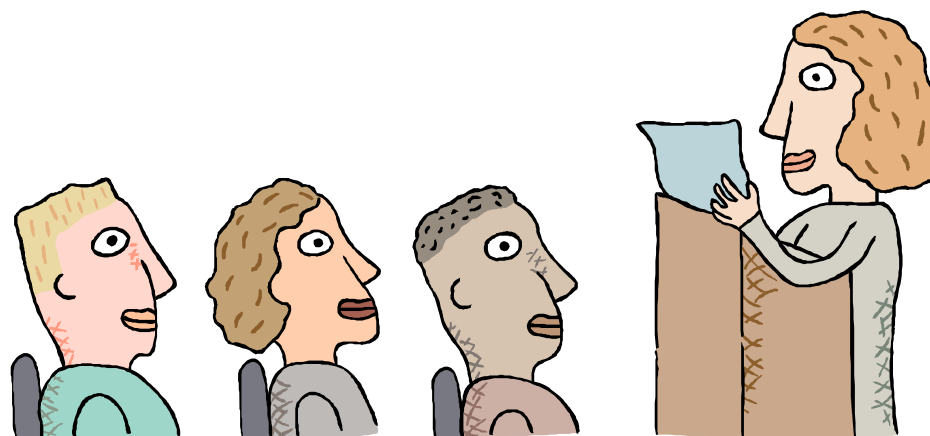
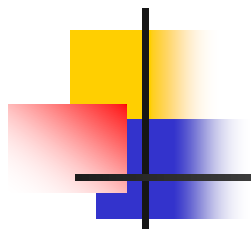


AL Simulation Study Lessons Learned and Recommendations

- Large scale models pose a lot of challenges and require many resources
- Lack of reliable evacuation demand data continues to be an obstacle
- Off-line analysis is appropriate for planning; however, dynamic models are needed
- Expanding ITS capabilities along AL's evacuation routes is recommended for improved evacuation operations
- Cost/benefit analysis can identify options with the highest potential return for the investment



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QUESTIONS AND COMMENTS