Developing Traffic Evacuation Strategies for Large-Scale Public Events

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Outlines

- Modeling challenges and advantages of simulation based platform for public event evacuation
- Descriptive versus prescriptive modeling concept
- No-notice evacuation scenarios for a Cardinal football game

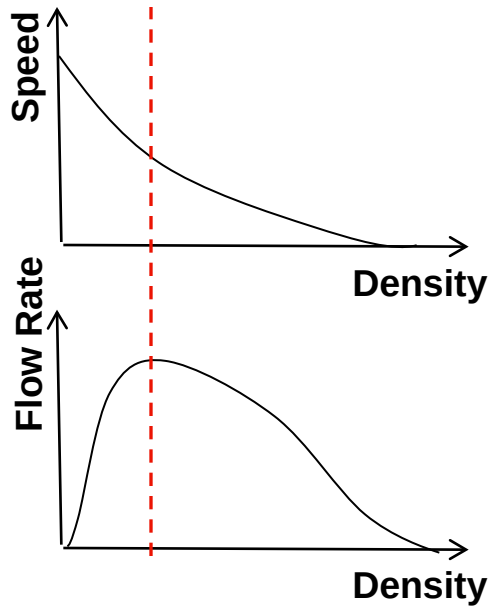
DynusT - Dynamic Traffic Simulation Assignment Model

- Large-scale area-wide vehicular traffic simulation and decision model
- Developed since 2002, 50+ international agency users
  - **ELP, PAG, MAG, DRCOG, PSRC, SFCTA, HGAC, Las Vegas, NC Triangle, Guam, Florida, SEMCOG, Toronto, SACOG, Mississippi, North Virginia, I-95, US36, New York, Bay Area)**
- Evacuation Modeling Deployments
  - **Arizona, Minnesota, Mississippi, Virginia, Florida, Texas, New York, Canada, Illinois**
- Fast simulation/computation
- Realistic behavior rules
  - **Microlike mesoscopic traffic simulation**
  - **Route choice and information response**
- Open Source

DynusT

Important Facts about Traffic Flows

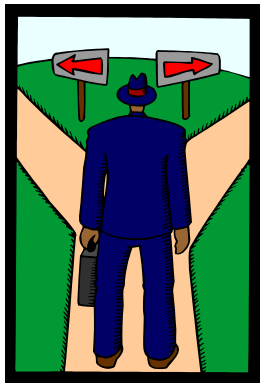
- Congestion is nonlinear, resulted from complex interactions between users, infrastructure and controls
- Speed and flow rate drop beyond a tipping point
- Evacuation Time $\neq \dfrac{Total\ \#\ of\ Evacuees}{Capacity}$



Rice and Congestion (WSDOT)

Modeling Challenges for Public Event Evacuation

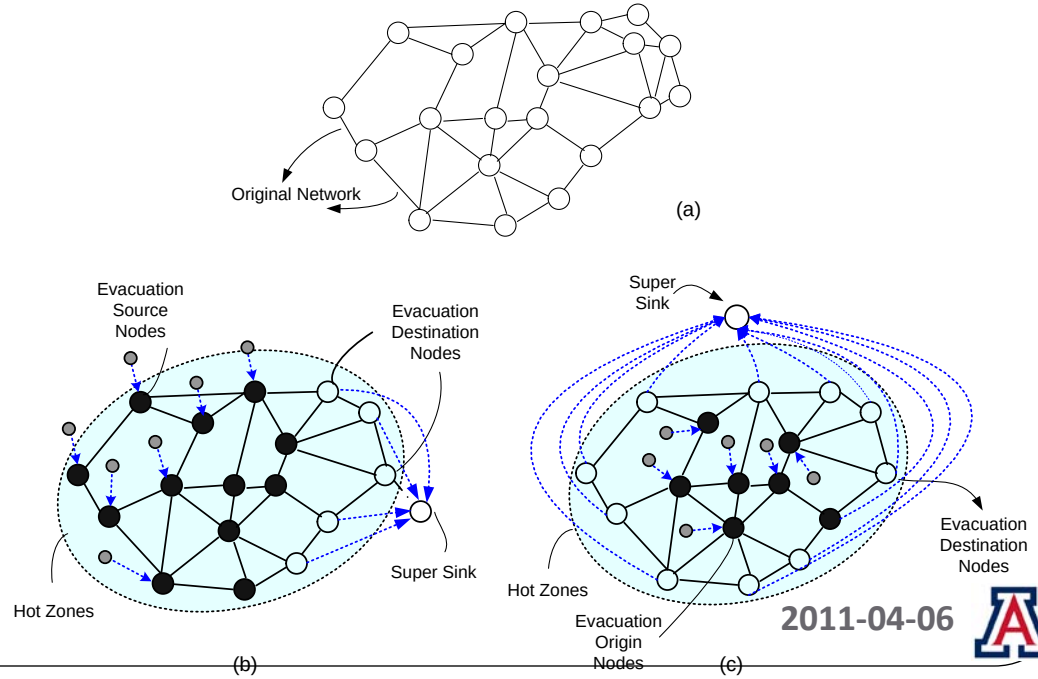
- Evacuees making various pre-trip and en-route decisions
  - **Where to go, when to leave, which route to take**
  - **How to respond to information (radio, signs, etc.)**
- Roadways/intersections capacity
  - **Capacity**
- Traffic management strategies
  - **Diversion/detour**
  - **Reversible/contra flow lanes**
  - **Advisory or mandatory information, etc.**



Descriptive vs. Prescriptive Modeling Concept

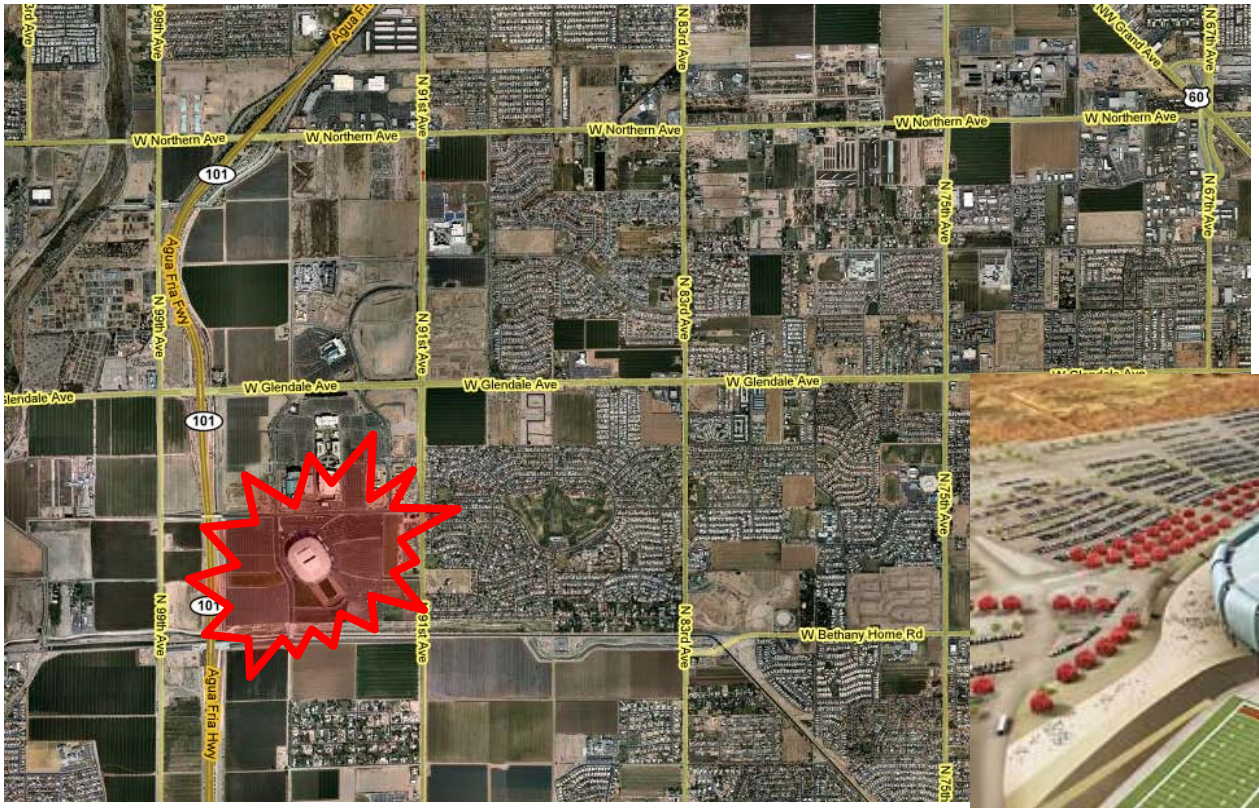
- Descriptive
  - **Prediction driven**
  - **Evacuation behavior not regulated but predicted**
  - **Analyze What-If scenarios**
  - **Objective implicit**

- Prescriptive
  - **Optimization oriented**
  - **Evacuation behavior regulated**
  - **Formulate optimal solution**
  - **Objective explicit**



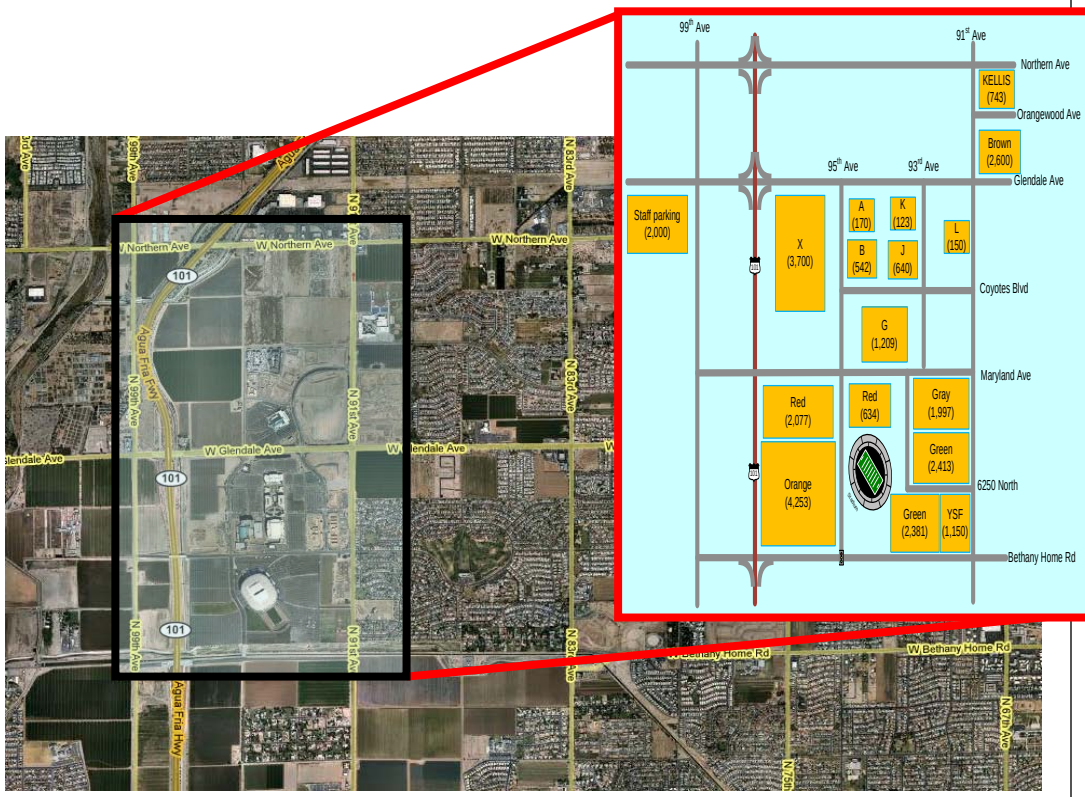
Evacuation Scenarios

- Cardinal Game Scenario – No-notice evacuation

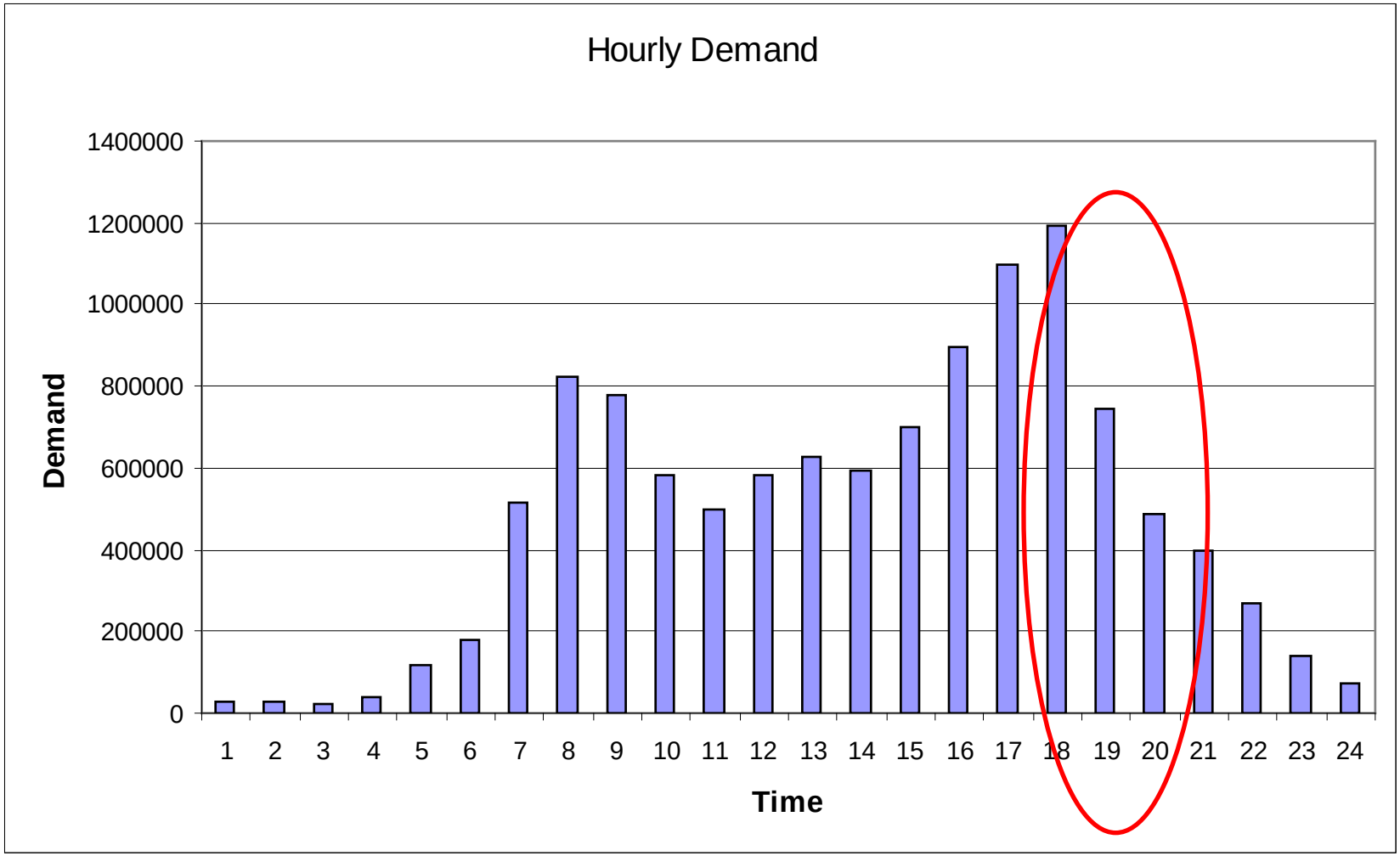


Cardinal Game Scenario - No-notice Evacuation

- University of Phoenix Stadium
- Scenario
  - **Game kick-off: 7:00 pm**
  - **Bomb threat: 7:30 pm**
- 26,780 vehicles evacuated
- Baseline strategy: Glendale's 2007 traffic control plan



24-Hr Background Traffic Pattern

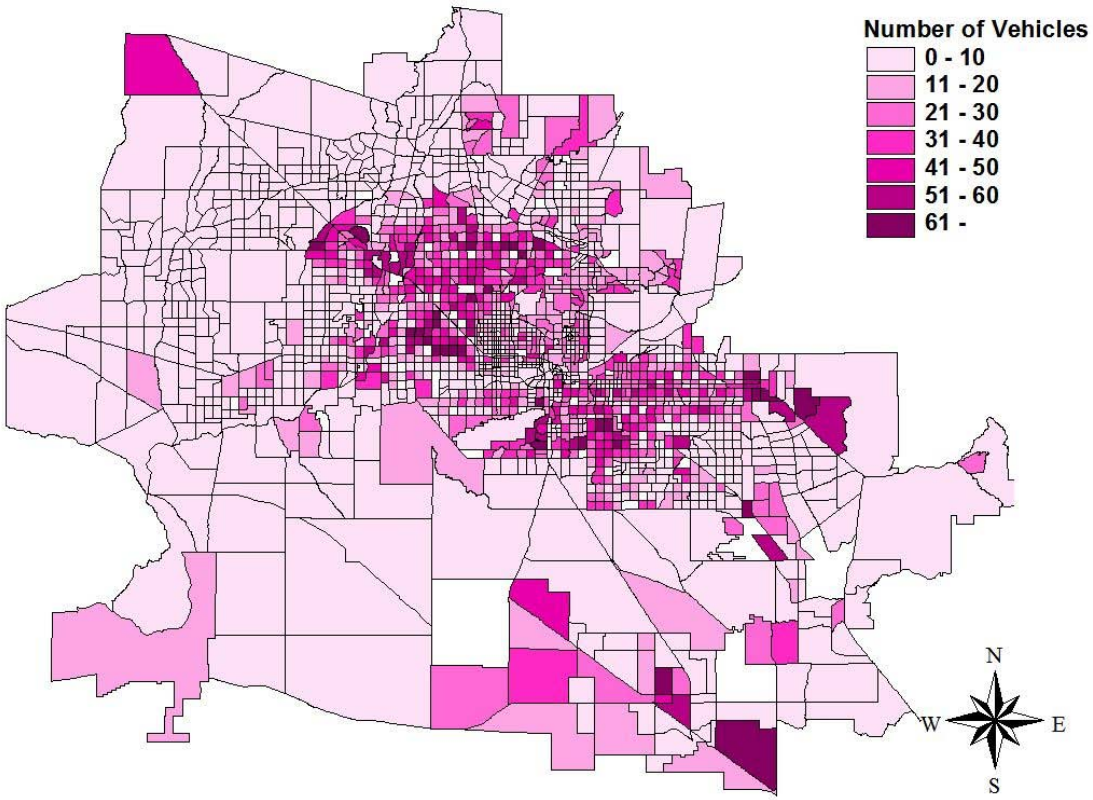


Evacuation Trip Generation

- Game traffic
  - **Stadium capacity -63,000 people**
  - **10% transit, shuttle**
  - **80% carpool**
  - **10% drive alone**
  - **Parking capacity - 26,780 vehicles**
  - **Destination is home**
- Background traffic (5 hours, 7 pm to midnight, weekday)
  - **Auto – 1.7 million**
  - **Truck – 0.3 million**

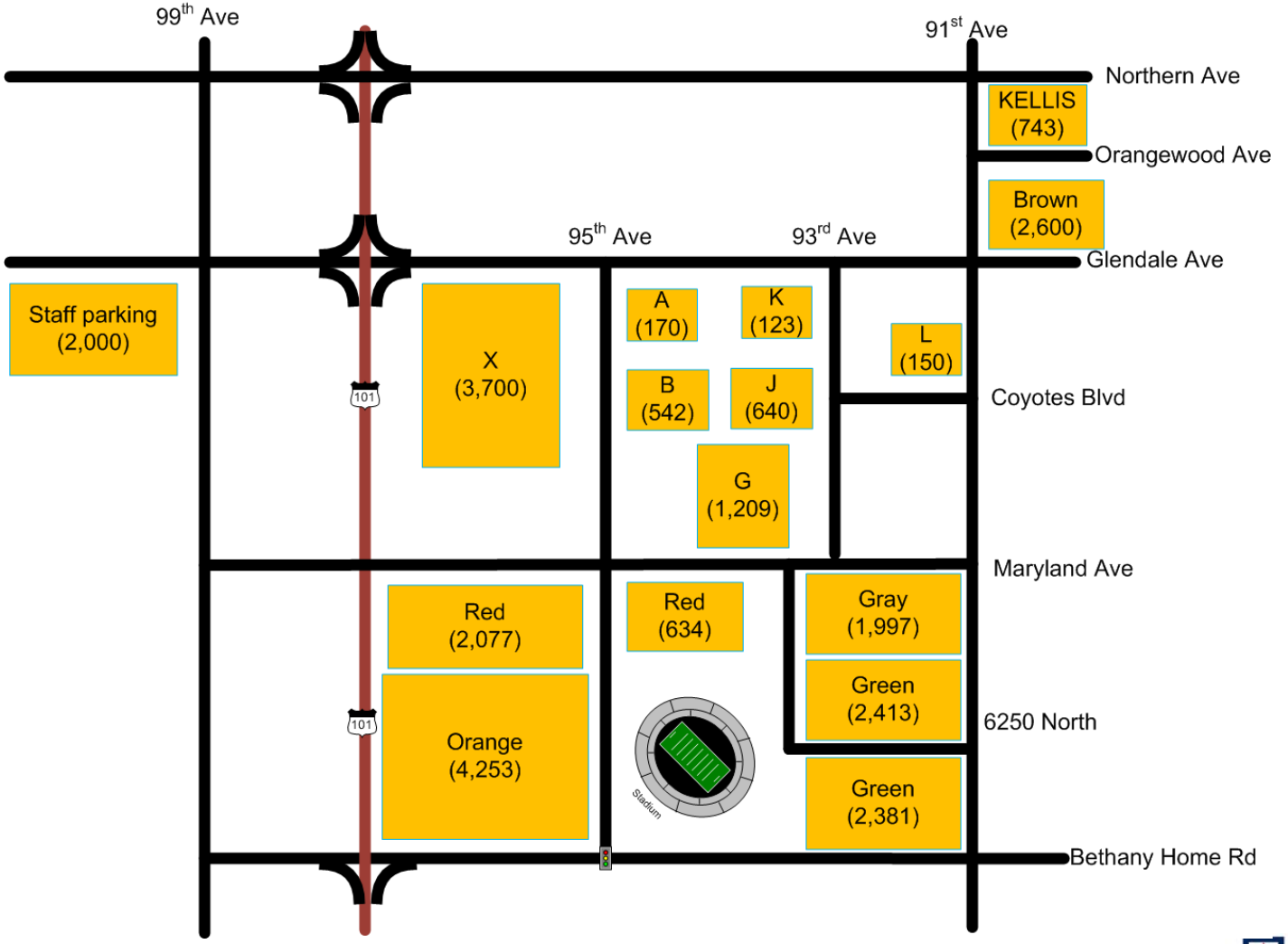
Evacuation Trip Destinations

- Assumed distribution from Home Based Other (HBO) trip purpose from Maricopa Association of Governments (MAG)



Parking Lot Capacity

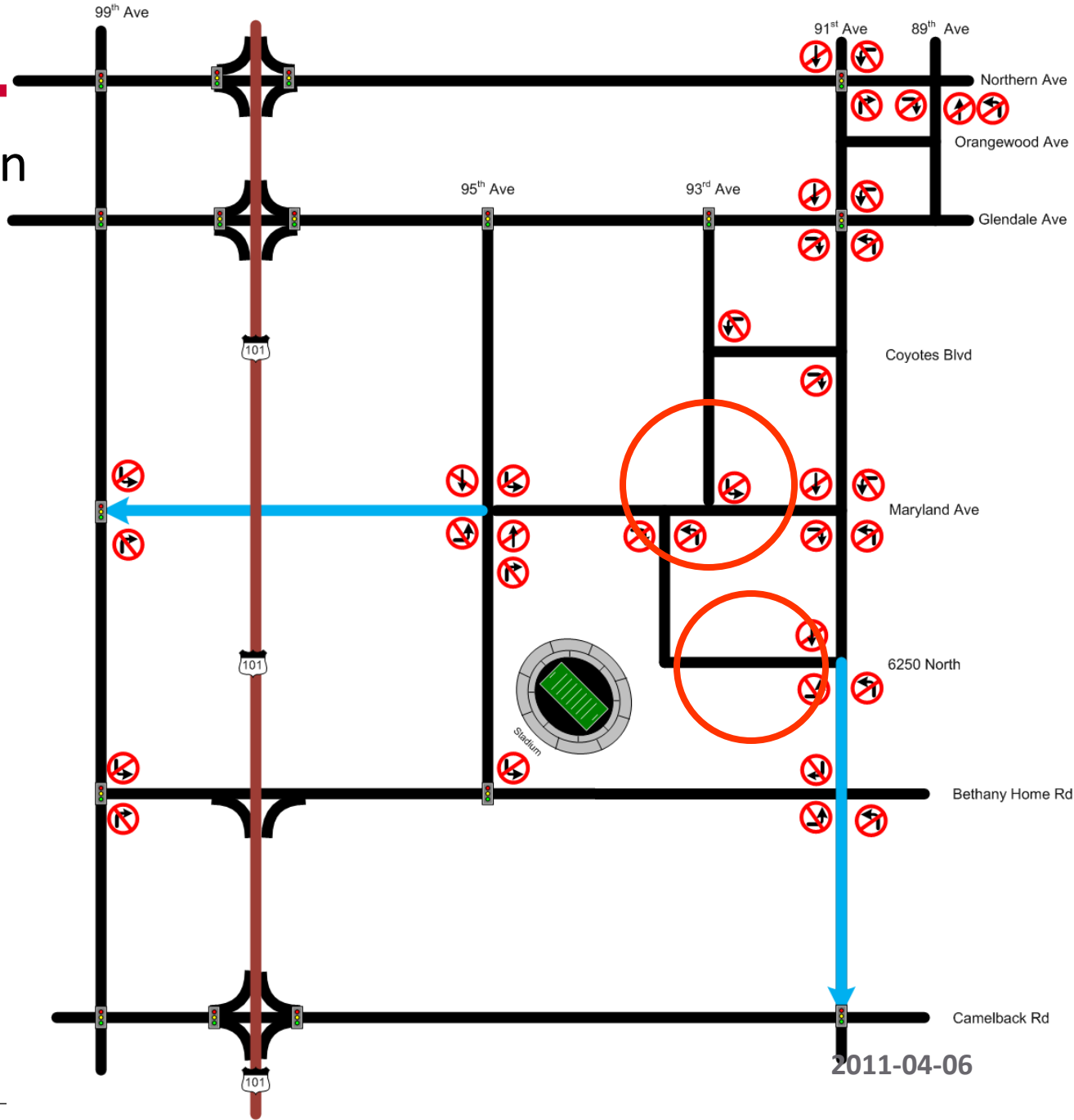
- 26,780 vehicles



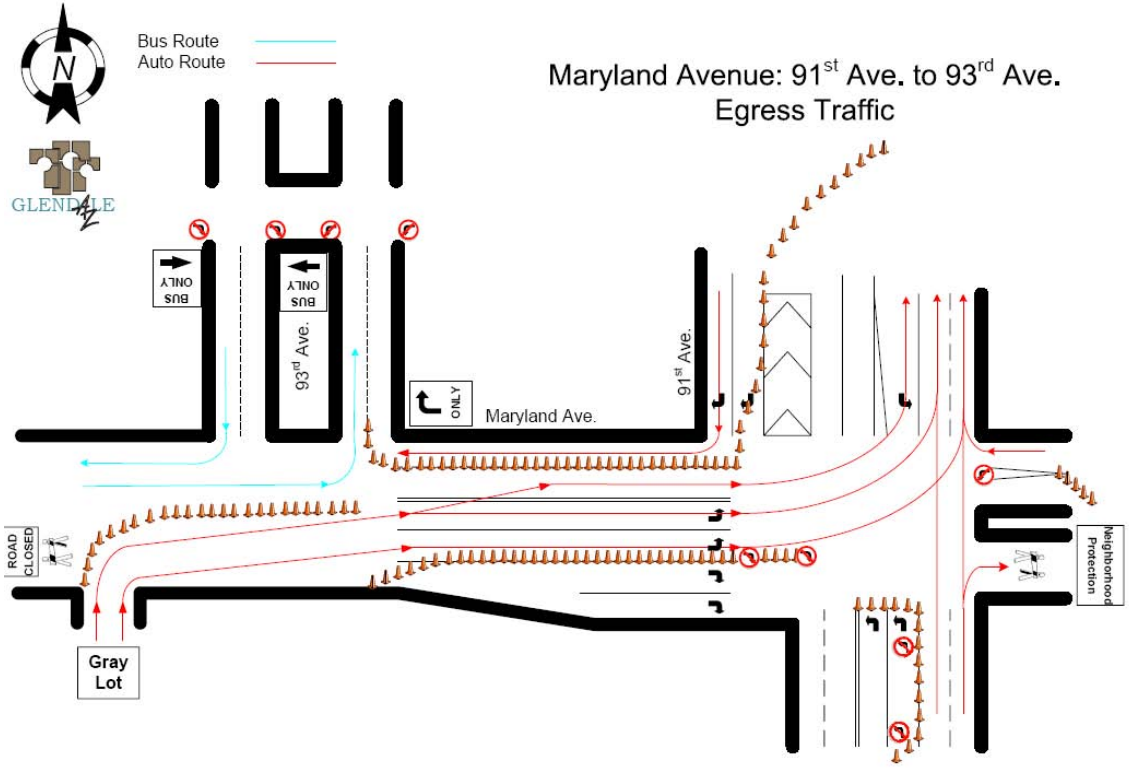
Assumptions for Cardinal Game Scenario and Glendale Traffic Plan

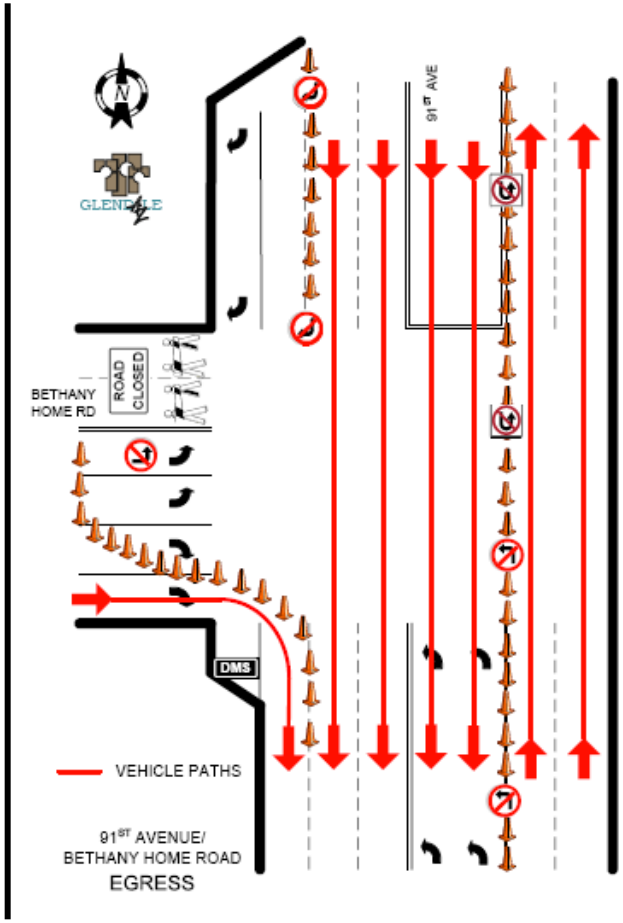
- Background Traffic
  - **MAG travel OD data**
  - **Follow habitual routes**
  - **Habitual routes found through dynamic traffic assignment**
- Simulation scenario: 7:00pm – midnight
  - **Vehicles follow habitual routes**
  - **Routes execute current Glendale Game Plan**

Glendale Traffic Plan



Examples of Lane Management in Glendale Game Plan (Egress)





- Source: City of Glendale 2007 Arizona Cardinals Football Games Traffic Operations Plan

Evacuation Scenarios Examined

- "Routine" case – Game stops at 10 pm, traffic leaves 9-10 pm following habitual routes, with the Glendale Game Traffic Plan.
- Most Aggressive – Threat occurs at 7:30 pm, extremely panicky loading – 5 min; traffic follows Glendale Game Traffic Plan.
- Aggressive – Threat occurs at 7:30 pm, heavily concentrated loading – 15 min; traffic follows Glendale Game Traffic Plan.
- Less Aggressive – Threats happens at 7:30 pm, high loading - 30 min load; traffic follows Glendale Game Traffic Plan.

Comparisons of Evacuation Scenarios

Statistic	Routine	Most Aggressive	Aggressive	Less Aggressive
Avg. Seat to Home Time (min)	124.4	130.0	133.4	134.0
Avg. Street to Home Time (min)	91.5	95.0	95.2	95.0

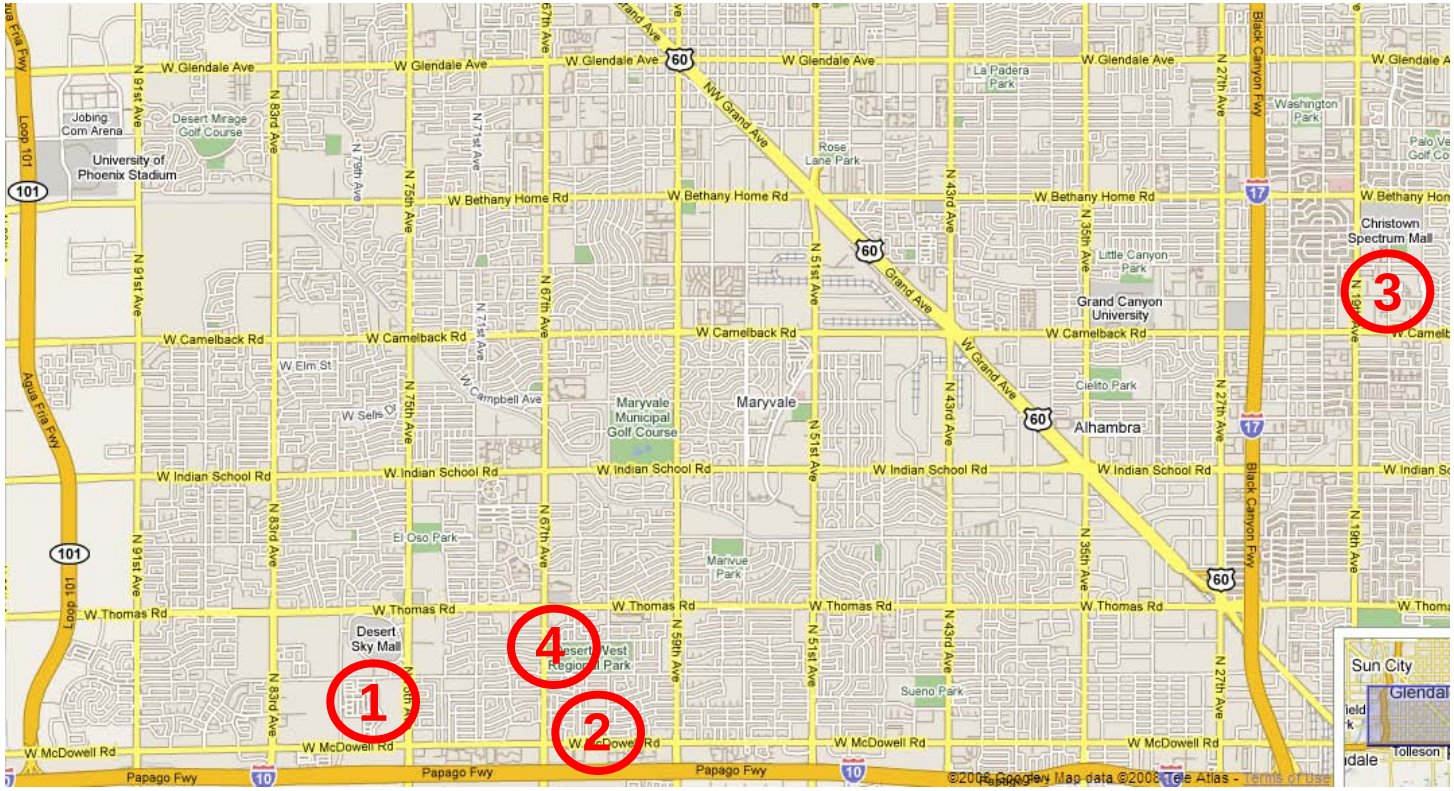
Prescriptive-Descriptive Strategy Development

Key Concepts

- **Hot Zone defined by approximately 3-mile radius from stadium.**
- **Evacuees do not head home directly; they leave the hot zone efficiently first and then go home**
- **Vehicles move following designated directions in hot zone.**
- **No vehicle (except emergency) allowed to move into the hot zone.**
- **Strategy includes**
  - Reduced conflicting movements at intersections.
  - Reverse lanes (contra-flow) on critical routes with high volume.

Shelters Designation

- **Desert Sky Mall**
- **2. Desert West Regional Park**
- **3. Christown Spectrum Mall**
- **4. West Highland Shopping Center**

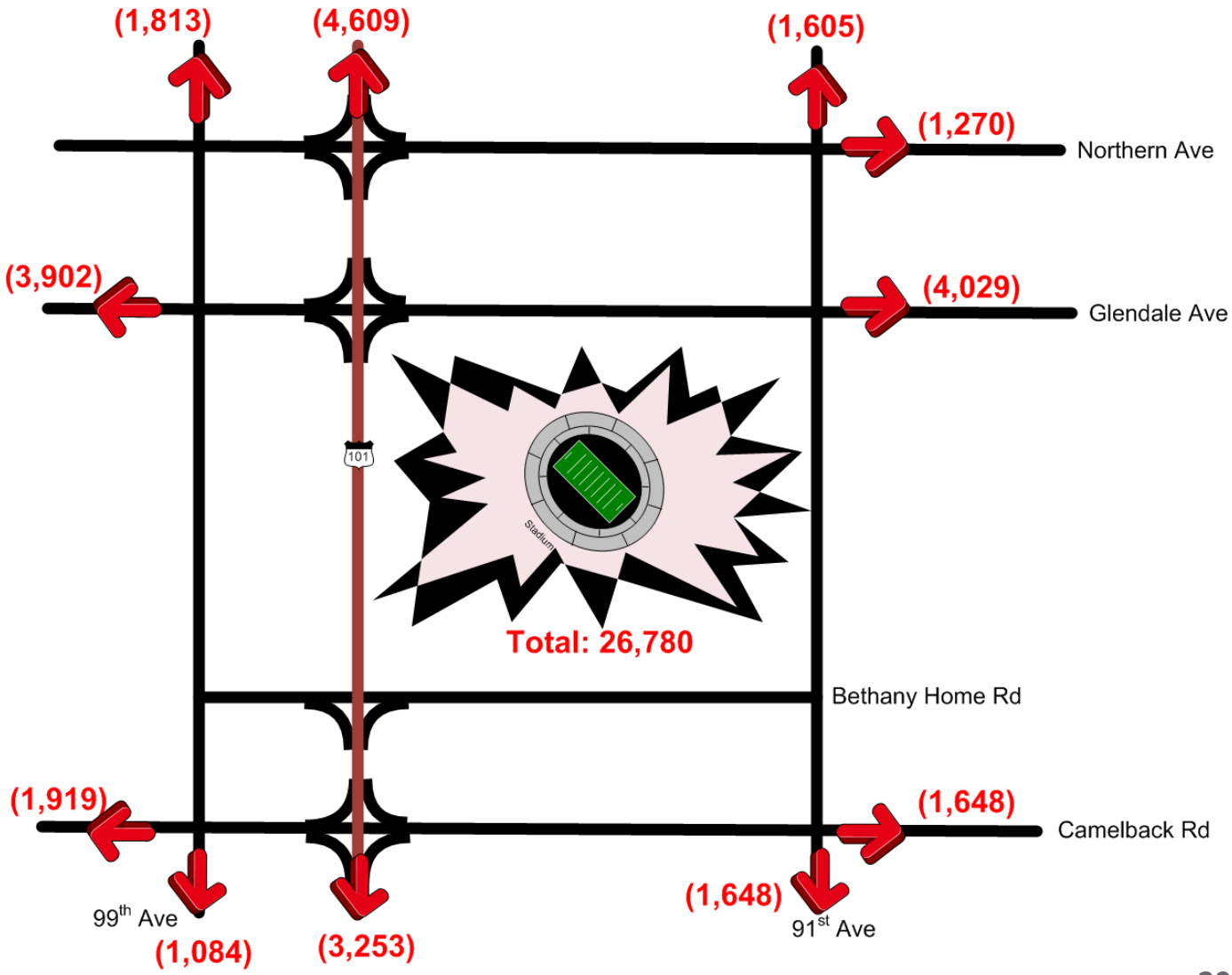


Modeling and Simulation Methodology

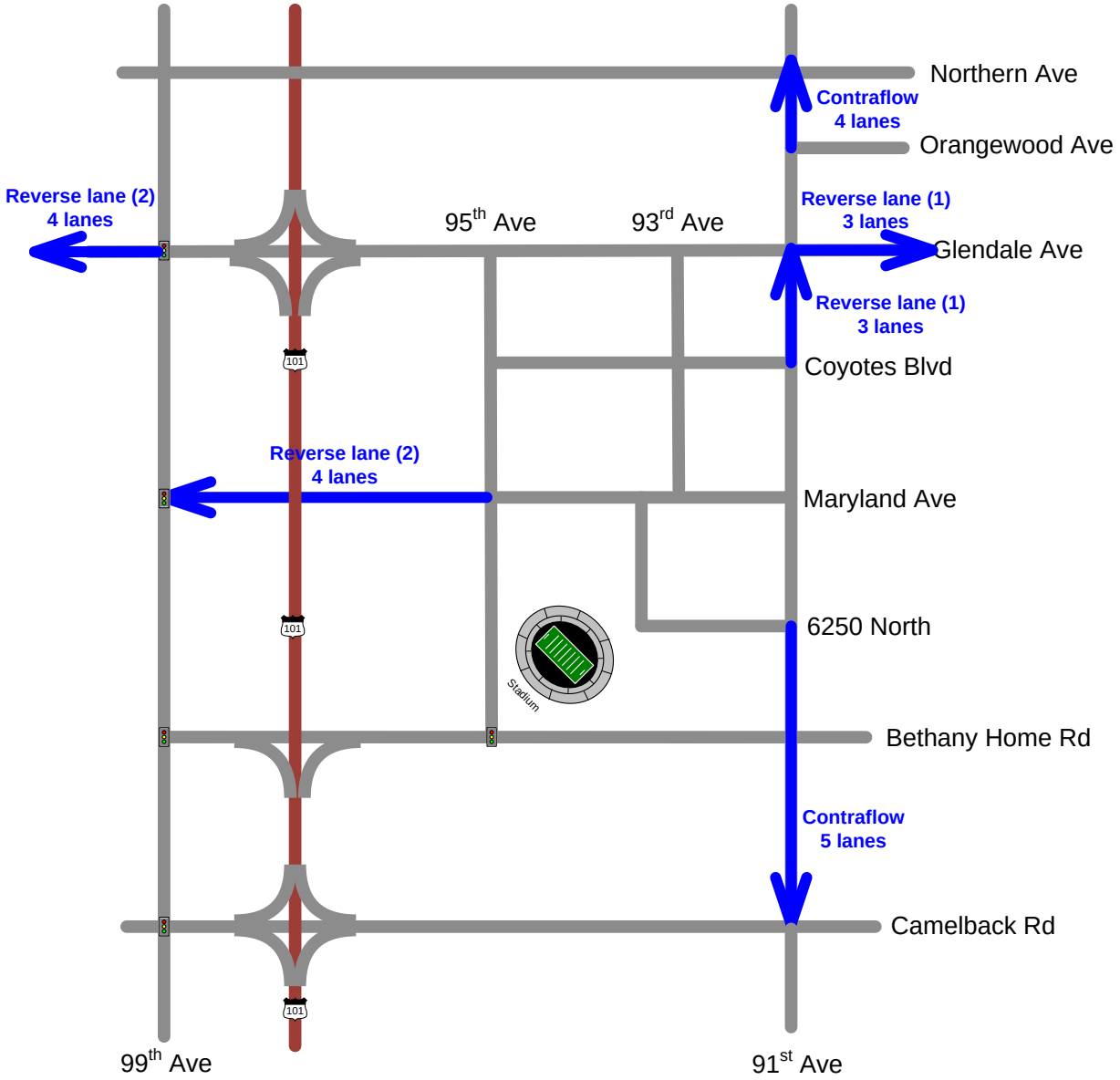
Prescriptive Modeling Methodology

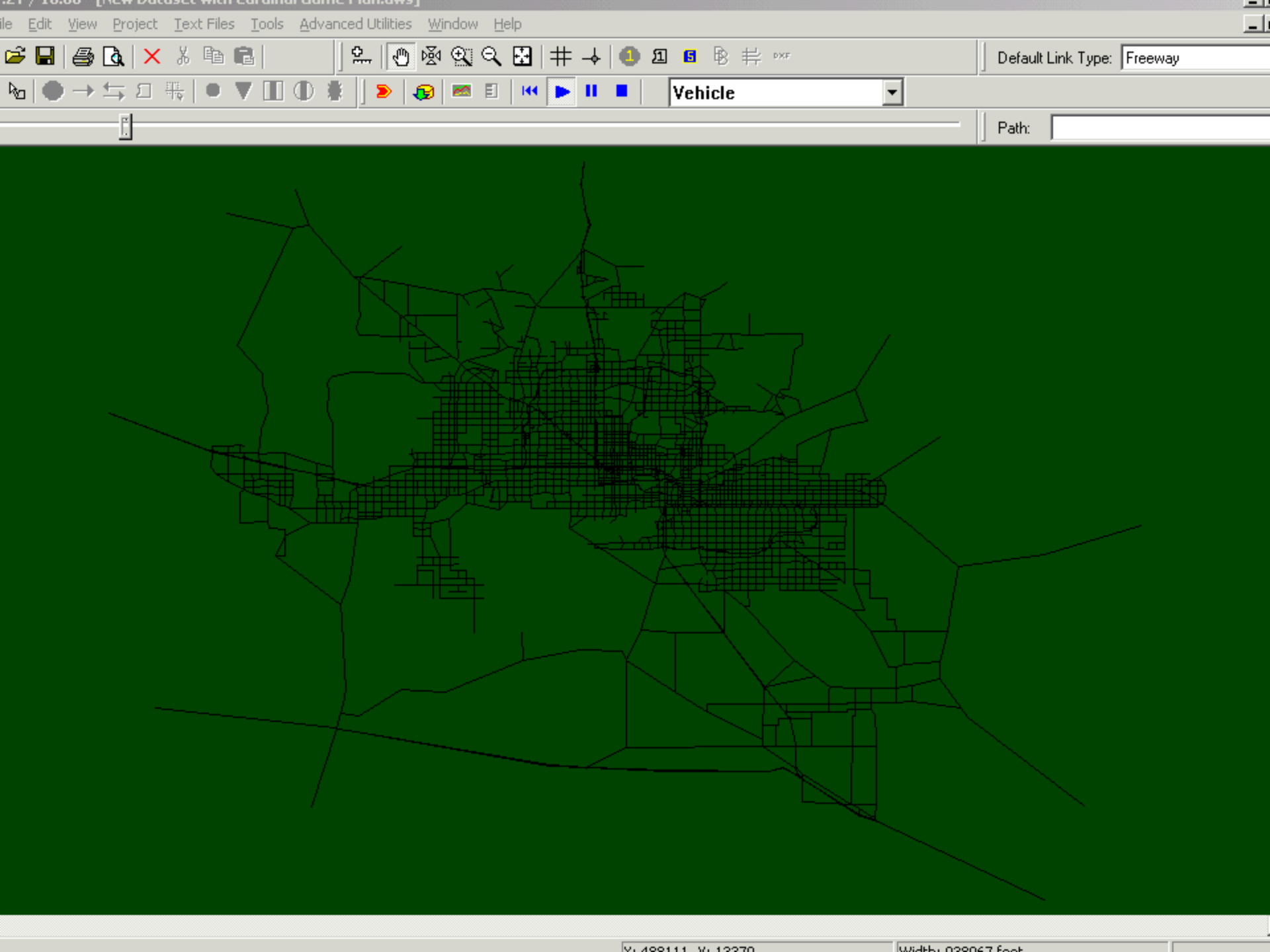
- **Optimizes destination choice and route choice simultaneously**
- **Aims for earliest total time out of a hot zone**
- **Simulation model evaluates optimal traffic management decisions**

Directional Outbound Flow



Strategy Development – Contra-flow plan

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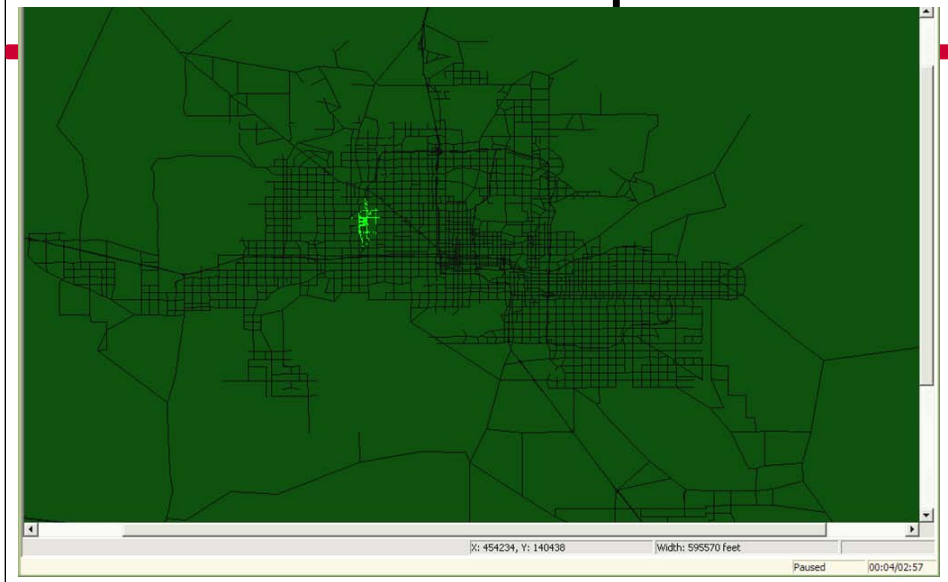
Simulation Snapshots



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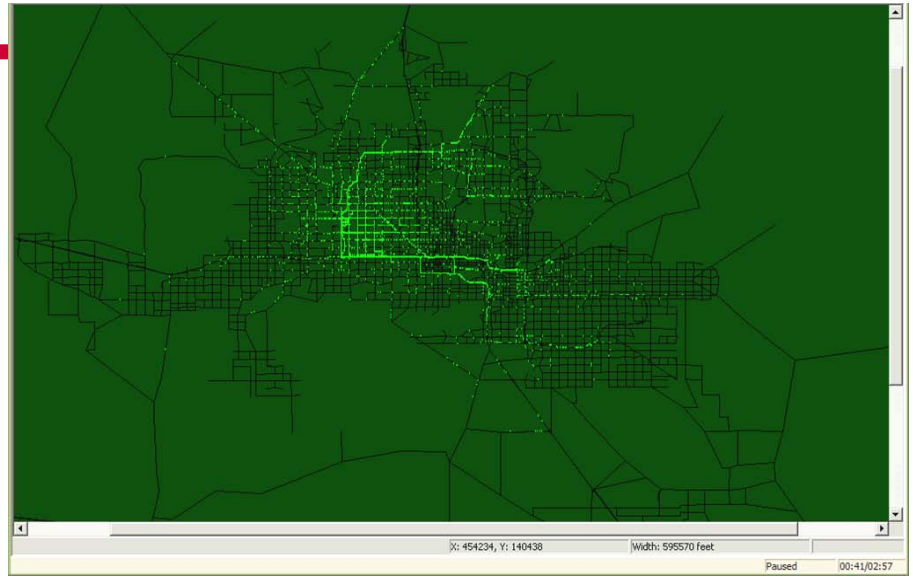

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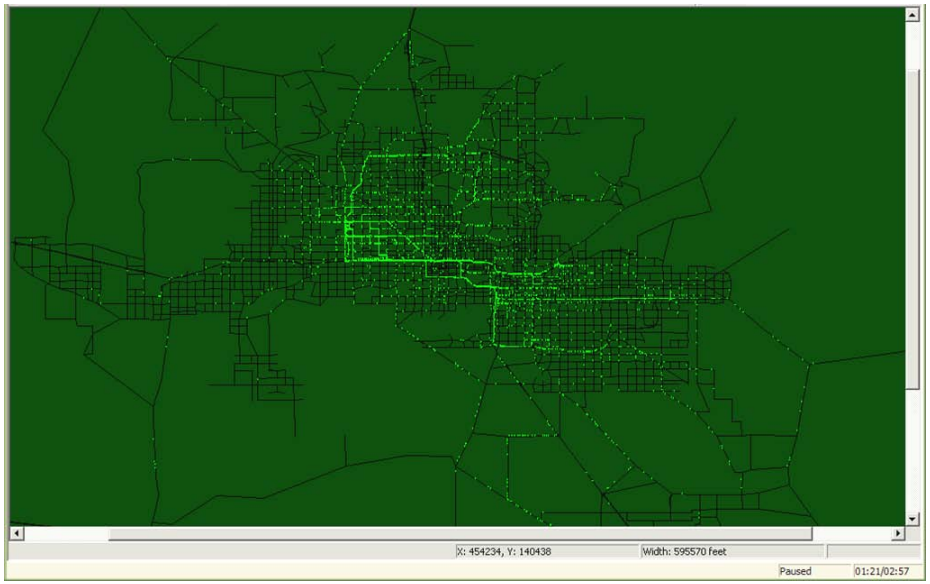

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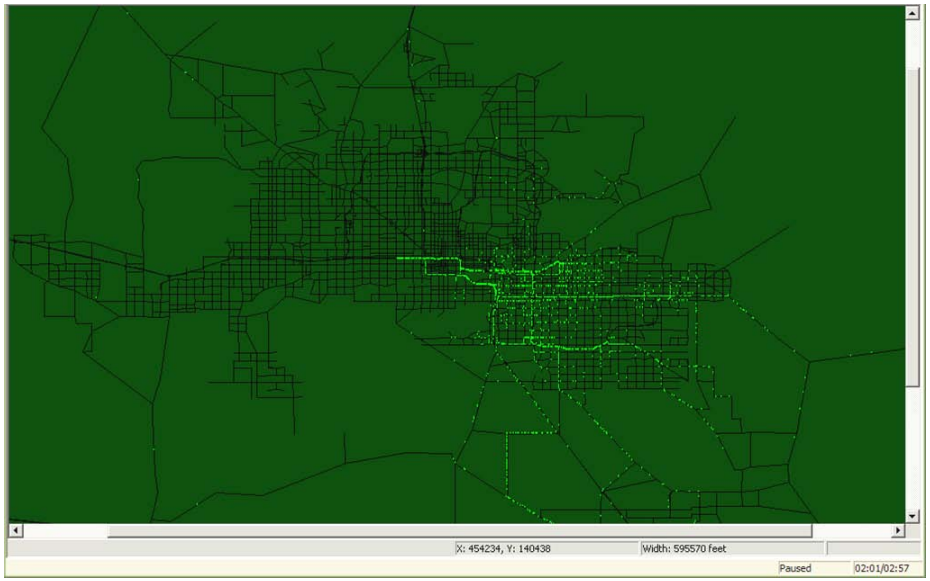

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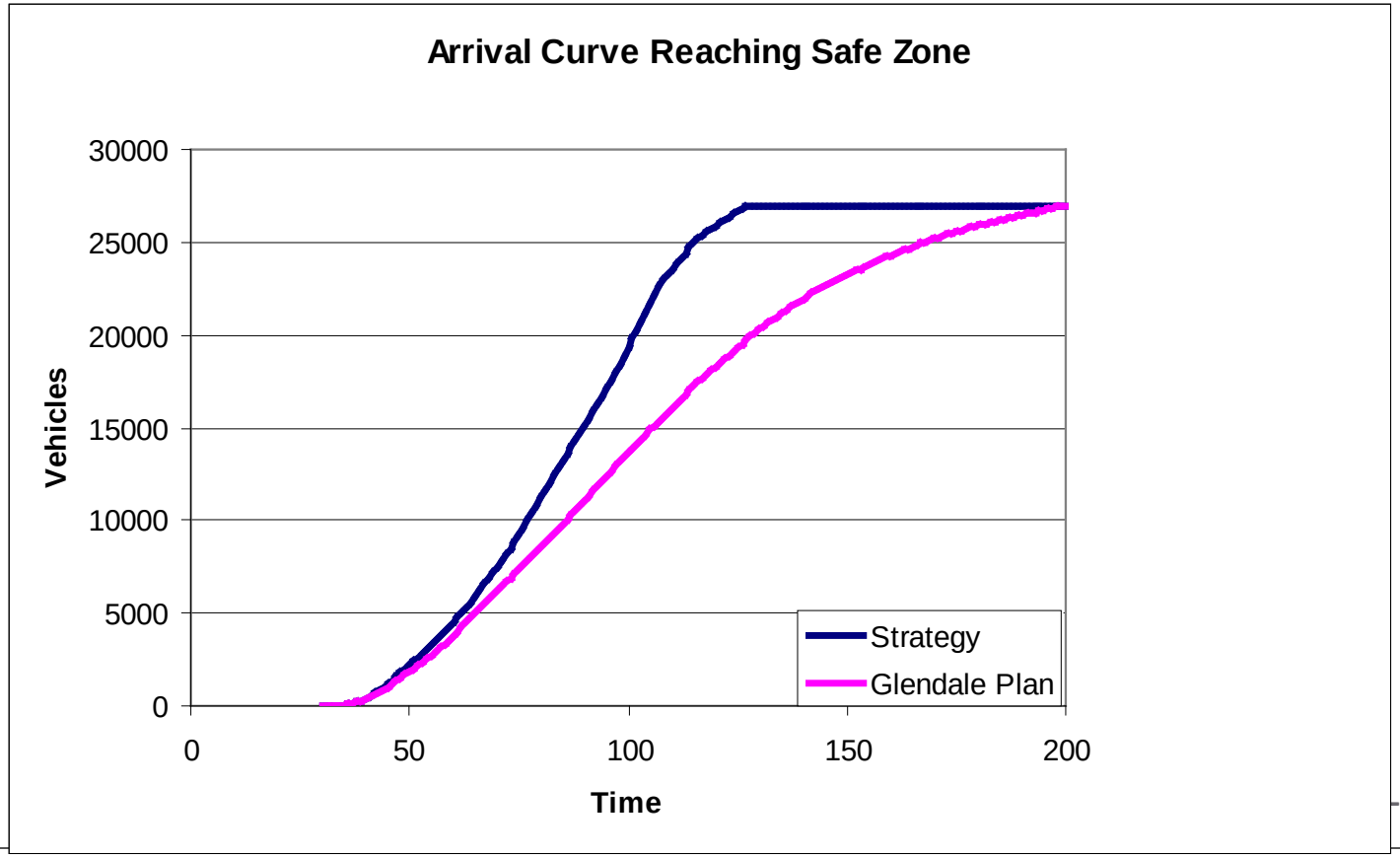
Strategy Evaluation Summary

- Glendale game plan vs. new strategy
  - **Before: took 165-167 min to move all vehicles to safe zone**
  - **Now: this number reduced to 90 min**
  - **Before: took 91-95 min moving**
  - **Now: this it takes 107 min (because longer distance)**
  - **Before: took 123-132 min to reach home**
  - **Now: this it takes 118 min**

Strategy Evaluation

- Arrival curve to reach the hot zone boundary
- Evacuation starts at 30 minutes, clearance time for strategy is 90 minutes, clearance time for Glendale game plan is 168 minutes



Evacuation on Foot

- Evacuation on foot not considered in this study due to bomb threat
- For a real life-threatening disaster, evacuation on foot is likely and need to be modeled
- Peds flow impedes traffic flow
- Strategies can be considered and modeled
  - **Minimize mix peds and auto traffic by separate routes**
  - **Bus bridges to move peds out of hot zone to designated transit hub**
- Decisions related to permitting peds or auto evacuation

Conclusions

- Planning for complex operations
- Computerized model does not replace human judgments, but it helps evaluate complex scenarios
- Prescriptive strategies useful for zone-based evacuation
- Current plan effective but proposed method enables further improvements
- DynusT realistically depicts route choice for both background and evacuee traffic from origins to destinations
- The developed technology advantageous to large-scale problems

Thank You

Any Questions?

More information:
http://dynus.net