NYS Resiliency Institute for Storm Emergencies (NYS RISE)

Subtask 1.2:

Scenario-Driven and Real-Time Information based Storm and Evacuation Plan

Led by:

Prof. Kaan Ozbay (NYU)

Prof. Colle (SBU)

Prof. Bokuniewicz (SBU)

Prof. Bowman (SBU)

Mar 27, 2014 Meeting

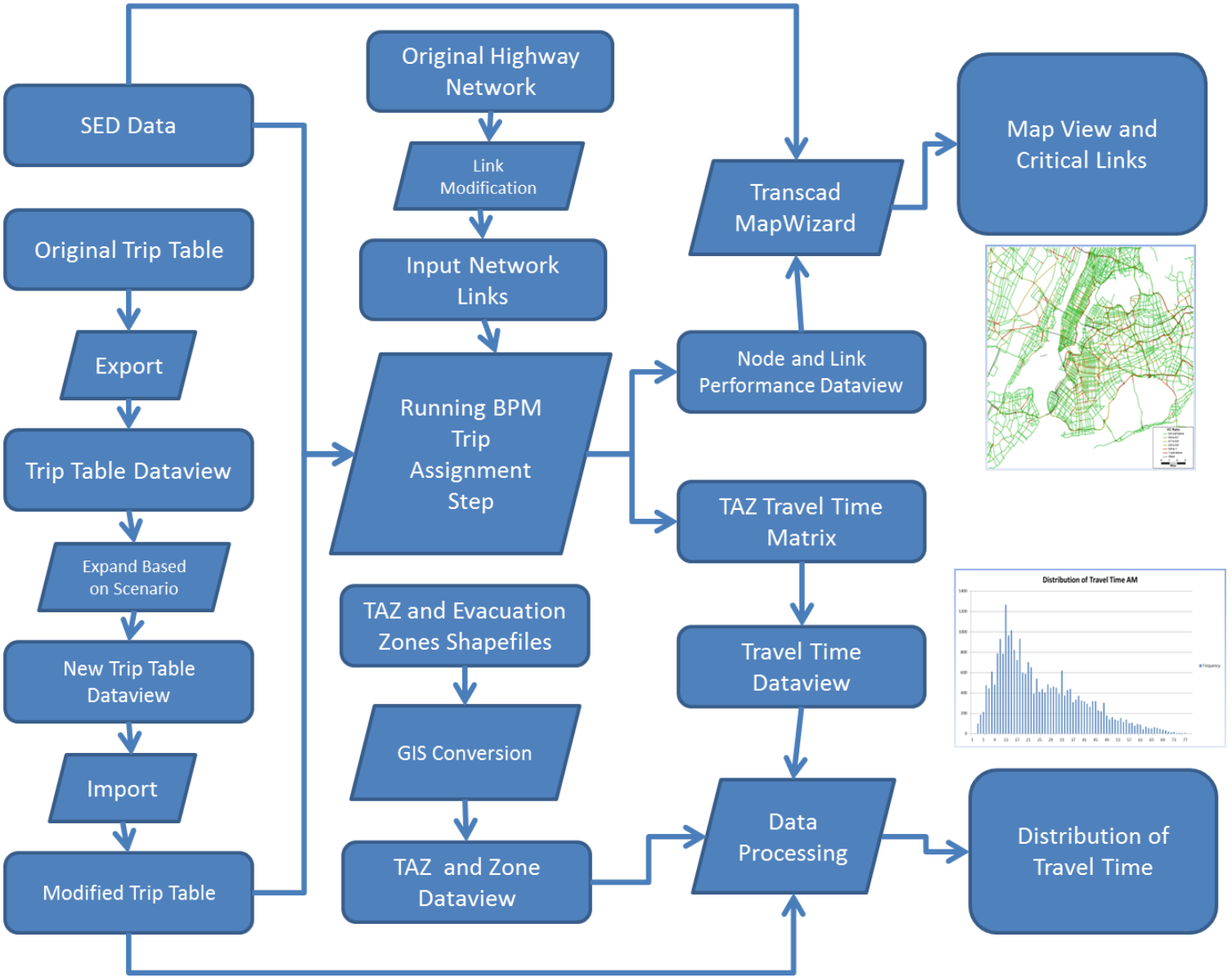
Objectives

- Consider different storm and evacuation scenarios

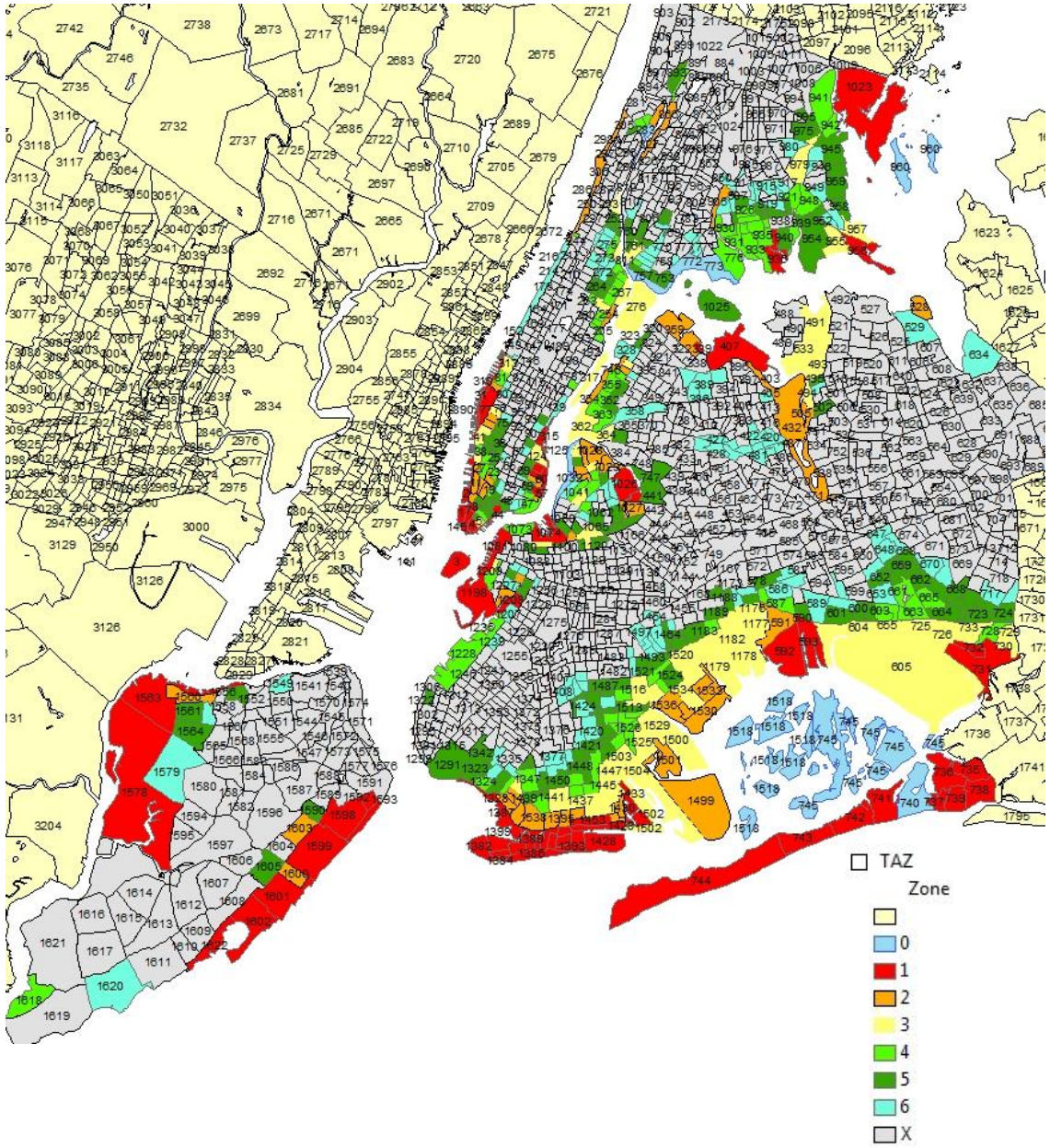
- Run Network Model (TransCAD BPM) for:
  - traffic assignment with 4 time periods (AM, MD, PM, NT) (**Period-based Assignment**)
  - quasi-dynamic approach with modified OD matrices to reflect 1-hr temporal resolution (**Hourly Assignment**)

- Compare period and hourly assignment results with respect to:
  - major bottlenecks (V/C ratios)
  - evacuation times from vulnerable zones to safe zones
  - performance of critical roadway segments (by deleting links)

Methodology: Data Processing Flowchart



Study Area : Evacuation Zones



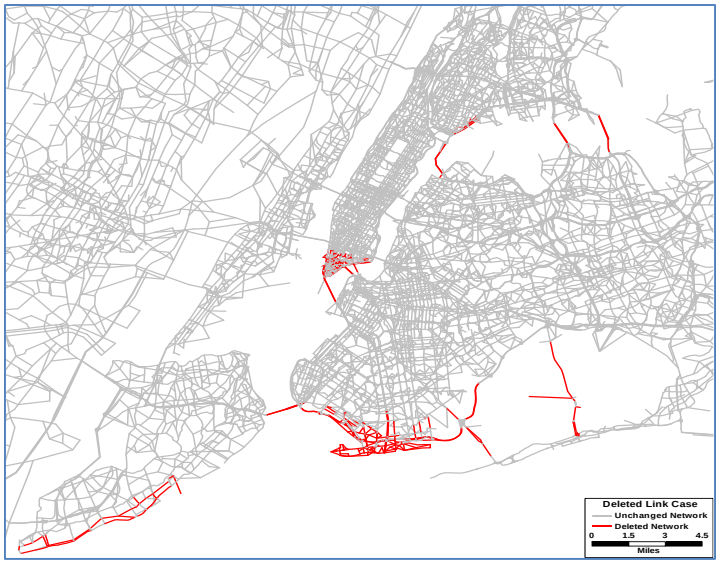
- Originally, 6 levels of evacuation zones in NYC's Hurricane Contingency plan
- Colors represent different threat levels based on storm surge impact
- Smaller the number, the more vulnerable the area
- Areas outside 6 levels are safe zones (zone x)
- All shelters are located in safe zones
- Subtask 1.2 uses TAZs for analysis. Thousands of TAZs within NYC were categorized based on evacuation zones by assigning geometric center of TAZ as reference point to define evacuation zone level for that TAZs
- This adjustment resulted in only slight variation from original evacuation zones

Methodology: Test Scenario Descriptions

Scenario	Description
Scenario 1	***Trip Table Assumptions*** • Trips from TAZ in evacuation zone 1 and ending in any TAZ outside zone 1, increased by 30% • Trips from TAZ in evacuation zone 2 and ending in any TAZ outside zones 1&2, increased by 20% • Trips from TAZ in evacuation zone 3 and ending in any TAZ outside zones 1, 2 &3, increased by 15% • Trips from TAZ in evacuation zone 4 and ending in any TAZ outside zones 1, 2, 3 & 4, increased by 10% • Eliminated trips to TAZ in evacuation zone 1 (set to 0). ***Highway Network Assumption***: • Same as base scenario, using HB2005B network
Scenario 2 (Deleted Links)	***Trip Table Assumptions:*** • Same as Scenario 1 ***Highway Network Assumption***: **Deleted Links Case** • Some links in evacuation zone 1 is flooded and eliminated from the network • Some critical bridges and tunnels are closed
Scenario 3	***Trip Table Assumptions:*** • Trips from TAZ in evacuation zone 1 and ending in any TAZ outside zone 1, increased by 100% • Trips from TAZ in evacuation zone 2 and ending in any TAZ outside zones 1& 2, increased by 80% • Trips from TAZ in evacuation zone 3 and ending in any TAZ outside zones 1, 2& 3, increased by 60% • Trips from TAZ in evacuation zone 4 and ending in any TAZ outside zones 1, 2, 3 & 4, increased by 40% • Trips from TAZ in evacuation zone 5 and ending in any TAZ outside zones 1, 2, 3,4&5, increased by 20% • Eliminated trips to TAZ within evacuation zone 1 (set to 0). ***Highway Network Assumption***: • Same as base scenario, using HB2005B network
Scenario 4 (Deleted Links)	***Trip Table Assumptions***: • Same as Scenario 3 ***Highway Network Assumption***: • Same as Scenario 2 **(Deleted Links Case**)

Methodology: Deleted Links

Deleted links
-Part of Coney Island
-Southeast of Staten Island
-Belt Parkway from Exit 4 to Exit 13 (Near the Seashore)
-Minor Links in Downtown Manhattan
Deleted bridges and tunnels
-Verrazano Narrows Bridge
-Battery Tunnel
-RFK Bridge
-Whitestone Bridge
-Throgs Neck Bridge
-Marine Parkway Gil Hodges Memorial Bridge
-Cross Bay Bridge



Methodology : BPM Hourly Assignment

- Modify original 2005B network and Scenario 3
  - Link capacity and trip table converted to hourly by simple division by no. of hours in each period (AM 1/4, MD 1/5, PM 1/4, NT 1/11)
- In simulation results, if an actual time in OD matrix > 60 mins, add proportion of incomplete trip to next hour's trip table.
- Consider four periods separately

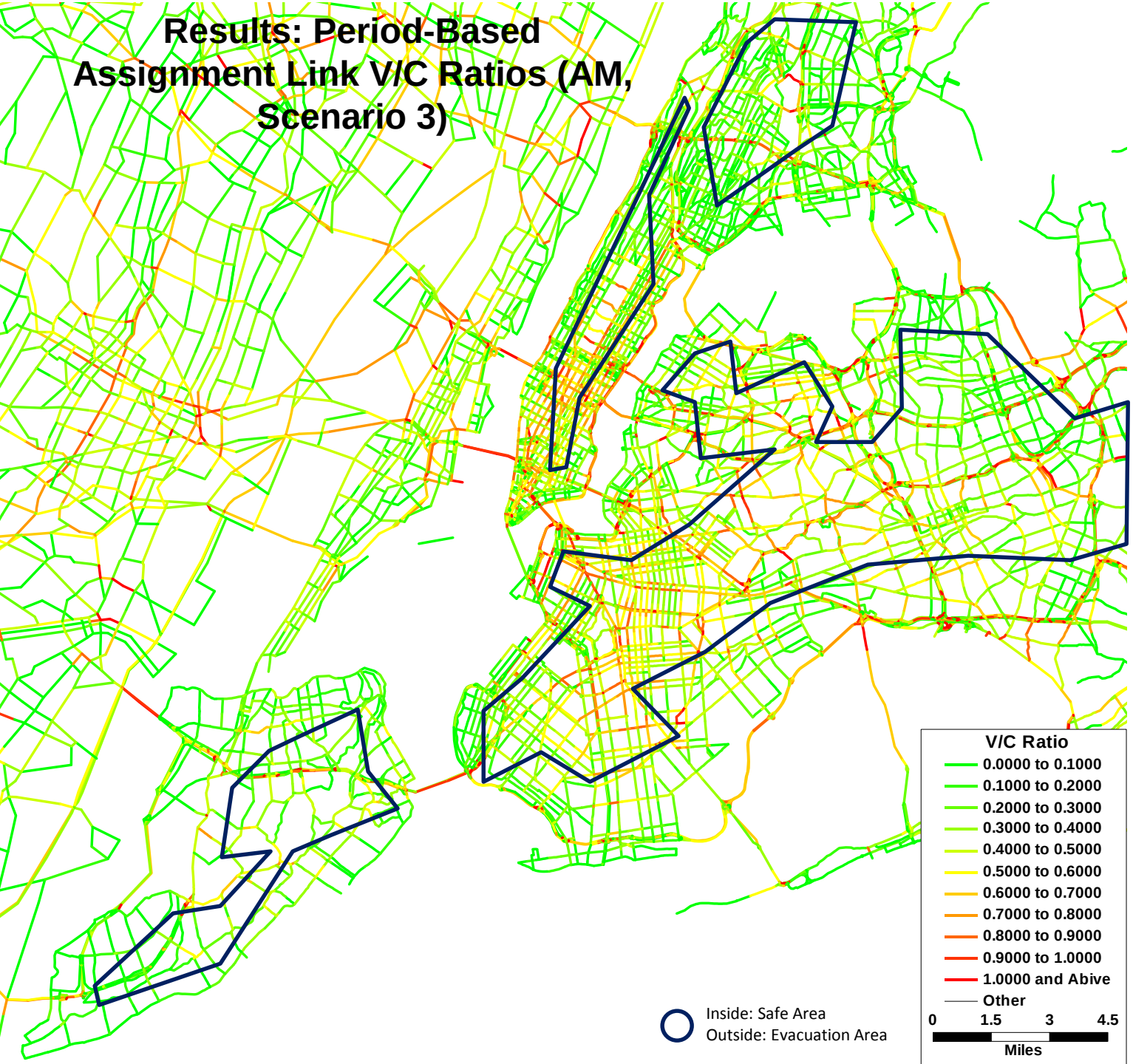
- For AM Period, set 4a as total trips from zone A to zone B, and initial hourly trip demand is *a*.
- For 6-7 AM period, run the assignment, and get *t* (in minutes) as time from A to B; if *t*>60 minutes, calculate trip demand of next hour by:

$$a_1 = a + a * \frac{t-60}{t}$$

- Run model for the (n-1)th hour, then calculate nth hour trip demand by:

$$a_n = a + a_{n-1} * \frac{t_{n-1}-60}{t_{n-1}}$$

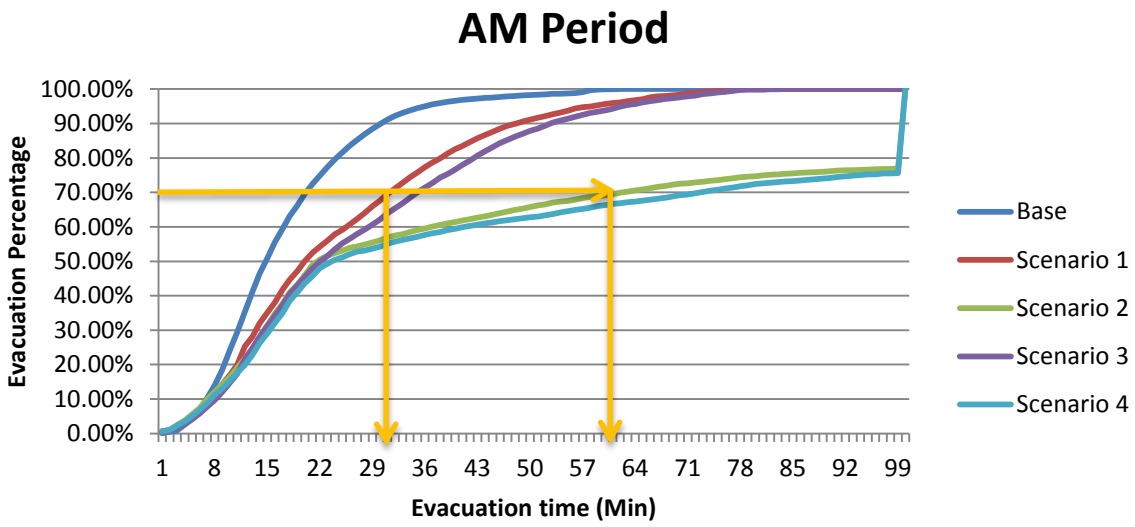
Results: Period-Based Assignment Link V/C Ratios (AM, Scenario 3)



-Period-based assignment results for other periods and scenarios not shown for brevity here. For comparison with hourly assignment, only period-based AM, Scenario 3 V/C ratios shown.

-Similar to VMT's, V/C ratios are also slightly on the higher side for hourly assignment.

Results: Period-Based Assignment Evacuation Times



Scenarios 2 and 4 (deleted link cases) have much ***higher evacuation times*** compared to their complete-network counterparts (Scenarios 1 and 3, respectively).

e.g. in Scenario 2: 70% of population is evacuated in about 62 mins, while the same amount is evacuated in about 31 mins in Scenario 1.

Time of Day	AM			MD			PM			NT		
Scenario	1	2	By	1	2	By	1	2	By	1	2	By
Total Trips (From Zone 1 to Zone X)	25,279	23,464	-7.2%	46,624	43,041	-7.7%	39,351	34,636	-12%	22,164	19,481	-12%
50% Evacuation Time (Min)	20.0	21.6	+8%	16.2	19.5	+20%	18.3	22	+20%	13.3	15.3	+15%
90% Evacuation Time (Min)	48.2	>100	> +200%	39.2	>100	> +200%	43.4	>100	> +200%	29	74.2	+155%

Next Steps

In terms of research,

- complete all the hourly assignment runs and compare to period-based assignments for all time periods and scenarios.
- possibly run Dynamic Traffic Assignment with 1-hour temporal resolution using TransCAD Planning Tool and comparing the results with the quasi-dynamic approach summarized here.

In terms of project milestones and schedule:

- **Jan 15:** Approval of task recommendations by the sponsor
- **Mar 1:** Submission of the draft report for review and comments
- **Mar 15:** Start the review of the draft report
- **Mar 31:** Submission of Interim report
- **Aug 31:** Submission of the final report

Tasks	Nov	Dec	Jan	Feb	Mar	April-August
Task 1: Literature Review						
Task 2: Phone Interviews						
Task 3: Development of Recommendations						
Task 4: Development of Evaluation Plan						
Task 5: Interim Report						
Task 6: Generalization of Results						
Task 7: Final Report						

APPENDIX

Progress to Date

- Literature review and draft report completed
- Classic period-based BPM assignment completed
- Storm and evacuation scenario development done
- Hourly BPM assignment (quasi-dynamic) 70% done
- Preliminary results analyzed and compared

Study Area : NYMTC BPM Transportation Network

- Covers almost all major transportation facilities within Lower NY/ Western CT/ Northern NJ region
- Includes TAZ -level demographic data based on household surveys
- Models both highway and transit networks
- Number of highway links: 53,399
  - 39 characteristic for each link including number of lanes, restrictions, length, speed, and travel time average flow by time of day (AM,MD,PM,NT)
- Highway modes: SOV, HOV, Taxi, Commercial Vehicles, Trucks

Methodology : BPM Period–based Traffic Assignment and Scenario Assumptions

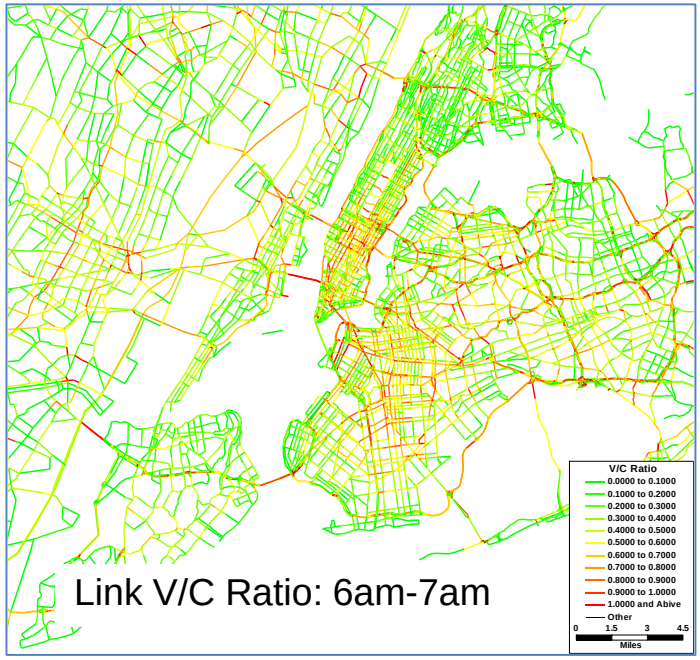
- 4 **Time Periods**: AM peak (6am – 10am), Midday(MD, 10am – 3pm), PM peak(3pm – 7pm), Night(NT, 7pm – 6am)
- 6 Transportation **Modes**: Drive Alone, HOV 2, HOV 3+, Taxis, Trucks, Other Commercial
- Simulation Based on:

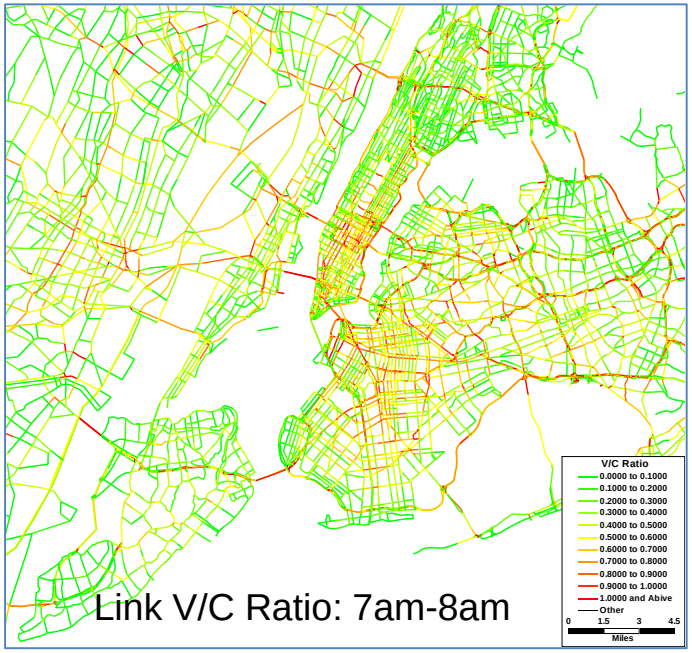
  -Trip Tables: NYBPM 2005 Base Year

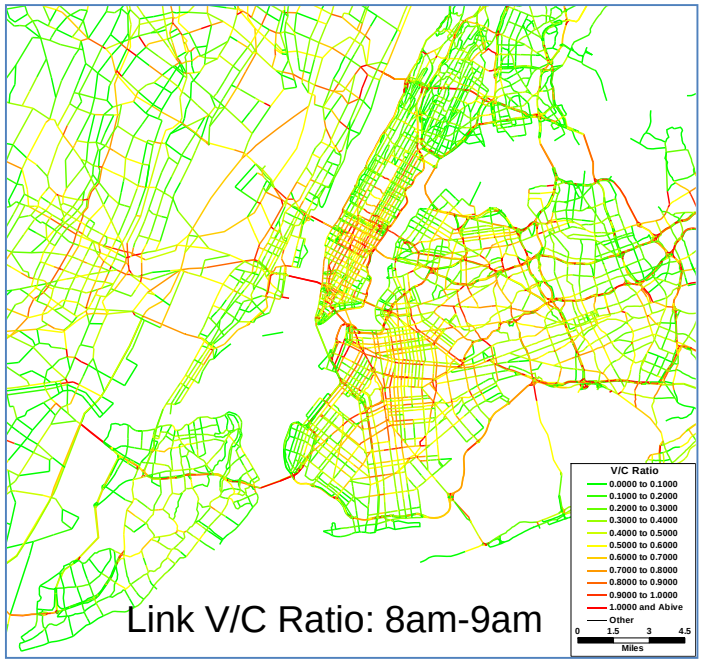
  -Highway Network: 2005B Network
- Five **Scenarios**: Base case scenario plus 2 demand cases intersecting with 2 kinds of networks (complete and deleted links cases) making 4 other scenarios, hence 5 total
- Category 3 Hurricane (Same category as Sandy)
- 14% Shelter rate, up to 418,600 people go to shelters ***(0.14 shelter rate*2,990,000 people in total to be evacuated=418,600)***
- Housing and Evacuation data: 2010 census data.
  - Number of People need to be evacuated:
    - Zone 1: 370,000
    - Zone 1 & 2: 620,000
    - Zone 1, 2 & 3: 1,020,000
    - Zone 1, 2, 3 & 4: 1,470,000
    - Zone 1, 2, 3, 4 & 5: 2,230,000
    - Zone 1, 2, 3, 4, 5 & 6 2,990,000 ← Total no.of people to be evacuated
- Evacuation Direction:
  - Stage 1: evacuation from TAZs to other zones
  - Stage 2: From TAZs within evacuation zone to nearest TAZs where evacuation center is located in

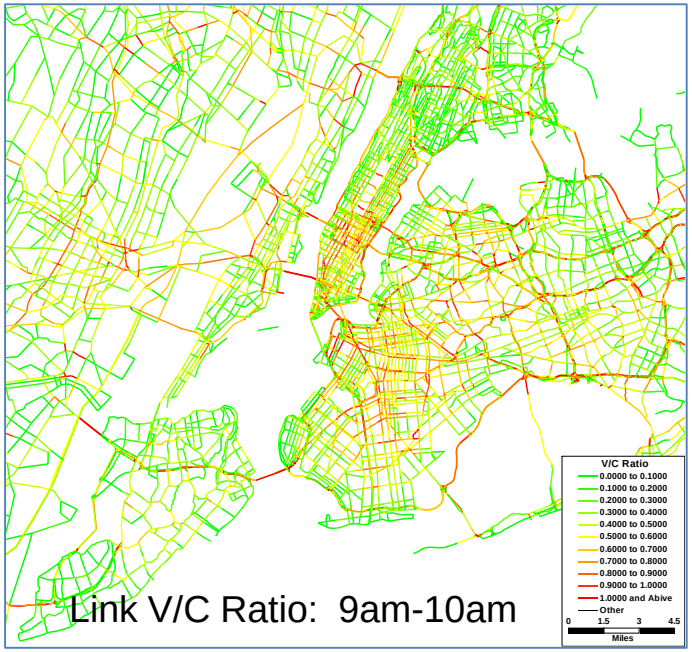
- O-D pairs for Evacuation:
  - Internal Trips: Trips within evacuation zones are prohibited, so internal trips are diverted to nearest TAZ with evacuation centers
  - Outgoing Trips: Remain Unchanged
  - Incoming Trips: Not allowed and set to zero
  - External Trips: Remain unchanged, however some adjustments may be made, since some important links(bridges, tunnels) may be closed by government order

Results: Hourly Assignment V/C Ratios (AM, Scenario 3)









Results: Period-Based Assignment VMT and VHT

Time of Day	VMT (of Entire Period, Miles)					VHT(of Entire Period, Hours)				
	Base Scenario	Scenario 1	Scenario 2 **(Deleted Links)**	Scenario 3	Scenario 4 **(Deleted Links)**	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
AM	67,805,152	67,451,349	68,352,381	68,222,754	69,193,535	2,356,042	2,332,362	4,901,552	2,389,894	5,467,542
MD	100,644,730	100,340,589	101,199,410	101,607,546	102,494,423	3,377,278	3,363,308	4,792,917	3,452,461	5,244,125
PM	78,790,026	78,672,519	79,236,066	80,013,551	80,599,031	2,918,332	2,913,576	4,062,504	3,034,204	4,560,843
NT	51,612,553	51,439,874	51,585,793	52,176,979	52,256,993	1,361,900	1,356,093	1,404,275	1,380,454	1,432,635

Deleting critical links, bridges, tunnels results in **major speed reductions** in the network, ***especially in AM and PM periods***. E.g. for PM period, compare Scenarios 1 and 2: 78,672,519/2,913,576=**27 mph** with 79,236,066/4,062,504=**19 mph**

Results: Hourly Assignment VMT and VHT (AM, Scenario 3)

	VMT	VMT Increase from Last Hour (%)	VHT	% of Total VMT	VHT Increase from Last Hour (%)	% of Total VHT
6-7	17,266,140	0	626,772	24.05%	0	23.47%
7-8	17,898,480	+3.66%	662,955	24.93%	+5.77%	24.83%
8-9	18,220,055	+5.52%	683,569	25.38%	+9.06%	25.60%
9-10	18,412,142	+6.64%	696,673	25.64%	+11.15%	26.09%
Total	71,796,817	-	2,669,969	100.0%	-	100.0%
AM Period-based Assignment (Scenario 3)	68,222,754	-	2,389,894	-	-	-

As dynamic assignment takes care of ***incomplete trips***, total VMT for hourly assignment is larger than that of period-based assignment.