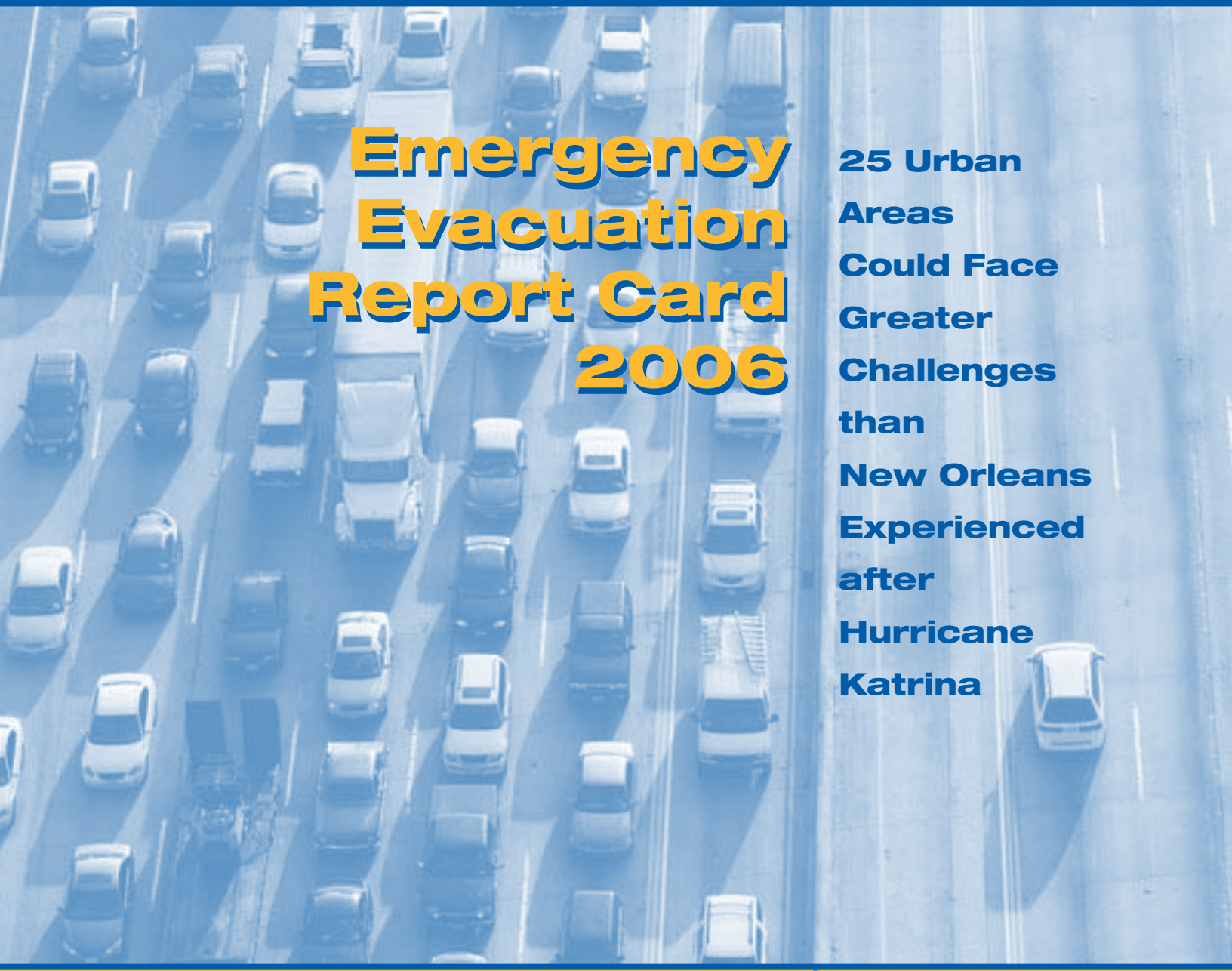

Emergency Evacuation Report Card 2006

25 Urban Areas Could Face Greater Challenges than New Orleans Experienced after Hurricane Katrina

New research findings by the American Highway Users Alliance

AMERICAN HIGHWAY USERS ALLIANCE

Acknowledgements

The American Highway Users Alliance (The Highway Users) gratefully acknowledges the American Bus Association (ABA) for providing special assistance in the funding of this study. The American Bus Association is the trade organization of the intercity bus industry with about 1000 motorcoach owner and tour company members in the United States and Canada. Its members operate charter, tour, regular route, airport express, special operations and contract services. Another 2,300 members are travel and tourism organizations and suppliers of bus products and services who work in partnership with the North American motorcoach industry.

The Highway Users also thanks its 300 member associations and companies for the support of this study through their annual membership dues. Highway Users members have charged the organization with representing the best interests of the driving public, whether they travel by car, bus, truck, recreational vehicle, or motorcycle.

Our members pay taxes that finance transportation spending programs and advocate public policies that dedicate those taxes to improved highway safety and mobility.

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EXECUTIVE SUMMARY

The potential for terrorist attacks and last year's New Orleans' flood destruction underscore the necessity for providing sufficient evacuation capacity from the nation's urban areas. Yet, the Department of Homeland Security says, "Significant weaknesses in evacuation planning are an area of profound concern." The Emergency Evacuation Report Card is an initial attempt to assess the evacuation capacity of the 37 largest urban areas – those with more than 1,000,000 population. Evacuation planning is new to US urban areas and, as a result, evacuation capacity can be expected to fall short of optimal levels.

Automobiles: The Principal Evacuation Resource: The overwhelming majority of households have their own cars. As a result, urban areas principally rely on private automobiles for evacuation and on the publicly provided highways. Those without access to automobiles also rely on the highways, because buses are the most important alternative to cars for evacuation.

Evaluation Method: Three factors are used to evaluate evacuation capacity: Exit Capacity, Internal Traffic Flow and Automobile Access. Based upon this analysis, urban areas are assigned scores of from 0 to 100 in Exit Capacity and Internal Traffic Flow. These factors are weighted at 50 percent each. The combined score is then multiplied by an Automobile Access percentage to produce an Evacuation Capacity Index. Letter grades from "A" to "F" are assigned based upon the evaluation factor scores and the Evacuation Capacity Index.

Exit Capacity is an estimate of the ability of routes leading out of the urban area to accommodate the evacuating population. The evaluation standard is a 12-hour theoretical exit route capacity or a 50 percent capacity with full use of contra-flow operations (all lanes in the outward direction). Kansas City and Columbus achieve grades of "A," while Indianapolis, Cincinnati, Memphis, Pittsburgh, Orlando and Dallas-Fort Worth receive "B" grades. Twenty urban areas receive "F" grades, with New York, Chicago, Miami, San Diego and Seattle scoring the lowest.

Internal Traffic Flow is an estimate of the ability of roadway systems within the urban area to deliver traffic to the exit routes. Cleveland and Pittsburgh achieve grades of "A," while Kansas City, Memphis, Columbus, New Orleans and Providence receive "B" grades. Eight urban areas receive "F" grades, with Los Angeles, Chicago, Washington, San Francisco-San Jose and Atlanta scoring the lowest.

Automobile Access is an estimate of the percentage of the population that will be evacuated by car. Automobile Access is estimated based upon the share of households owning cars and the experience in New Orleans of people without cars who evacuated with friends and relatives. Automobile Access is the one evaluation criteria in which all urban areas score well. All but one of the 37 urban areas received a grade of "A," and one, New York, received a "B."

Evacuation Capacity Index: Kansas City achieves the highest overall Evacuation Capacity Index and is the only urban area with a grade of "A." Columbus, Memphis and Pittsburgh receive "B" grades. Seven urban areas receive "C" grades, while six receive "D" grades. Twenty urban areas receive "F" grades, with the lowest scores being in Los Angeles, Chicago, New York, Miami and San Francisco-San Jose (Table ES-1).

Influencing Factors: Various factors are associated with higher Evacuation Capacity Index scores. Generally, the higher scoring urban areas have lower population densities, more intense roadway systems (greater capacity) and do not have significant geographical barriers blocking exit directions.

Planning for the Mass Transit Dependent: Governments must undertake special efforts to plan effectively for the evacuation of people without access to cars. While people without cars plan and execute their own evacuations on publicly provided infrastructure, people without cars must depend on government to provide the necessary evacuation transportation, Authorities face even greater challenges in the New York urban area, due to the unusually high number of mass transit dependent households. The principal resources of evacuation for the mass transit dependent are buses (transit buses, school buses and motor coaches), with a supplemental role for commuter rail, Amtrak and, to a lesser extent, subway and light rail systems. Based upon the experiences in New Orleans and Houston, it is clear that there are considerable opportunities for improvement in mass transit dependent evacuation programs.

Recommendations: The following recommendations are offered to improve urban evacuation planning:

- A National Standards and Reporting System should be established.
- Roadway Capacity should be expanded.
- Automobile Access should be expanded.
- Comprehensive Urban Area Evacuation Operations Planning should be completed.

Conclusion: There is considerable latitude for improving the evacuation capacity of the nation's urban areas. Such a program will be most effectively delivered through an objective evaluation system, which leads to effective measures to improve evacuation capacity.

Table ES-1

Evacuation Capacity Index: Urban Area Grades

RANK	URBAN AREA	SCORE
GRADE: A		
1	Kansas City	90.0
GRADE: B		
2	Columbus	82.3
3	Memphis	80.5
4	Pittsburgh	80.4
GRADE: C		
5	Indianapolis	79.2
6	Cincinnati	79.0
7	Cleveland	74.5
8	Orlando	74.1
9	San Antonio	73.5
10	St. Louis	70.6
11	Dallas-Fort Worth	70.5
GRADE: D		
12	New Orleans	67.3
13	Austin	66.2
14	Providence	65.9
15	Milwaukee	65.2
16	Baltimore	62.6
17	Sacramento	60.3
GRADE: F		
18	Denver	59.8
19	Tampa-St. Petersburg	58.9
20	Virginia Beach	57.4
21	Houston	54.8
22	Boston	49.4
22	Philadelphia	49.4
24	Atlanta	48.1
25	Portland	47.7
26	Minneapolis-St. Paul	47.5
27	Las Vegas	47.4
28	Detroit	47.3
29	Washington	44.9
30	Phoenix	43.6
31	Seattle	39.9
32	San Diego	37.8
33	San Francisco-San Jose	37.2
34	Miami	36.9
35	New York	31.5
36	Chicago	28.0
37	Los Angeles	25.6

INTRODUCTION

American urban areas face unprecedented threats that could require evacuation, the most obvious of which relate to terrorism, which was brought to attention so vividly by the events of September 11, 2001. Certainly, each of the nation's largest urban areas could fall victim to a terrorist attack. At the same time, the destruction in New Orleans from the floods associated with Hurricane Katrina showed the potential for devastation that can occur when an unfortunate worst combination of destructive circumstances combine.

It has become clear that each urban area needs to be prepared to evacuate its citizens in the event of catastrophe. Urban areas are preparing disaster readiness plans, which include detailed plans for evacuation. The federal government is making funding available to assist in this effort. Yet, a recent report by the Department of Homeland Security indicates that much more progress is needed to ensure that the disaster plans are sufficient to the need. In issuing an evaluation of urban area disaster planning, the Department stated, "Significant weaknesses in evacuation planning are an area of profound concern."[1]

Purpose of the Emergency Evacuation Report Card

The Emergency Evacuation Report Card is an initial evacuation capacity evaluation for the largest urban areas in the United States. It estimates the comparative capacity of highway systems both in capacity for exit from urban areas and the internal traffic circulation necessary to access the exit points. Further, the Emergency Evacuation Report Card provides information on planning for evacuation by households who do not have access to personal vehicles.[2] Evacuation planning is new to US urban areas and, as a result, evacuation capacity can be expected to fall short of optimal levels.

The principal purpose of this report is to compare evacuation capacity among urban areas with the objective of encouraging consistent, quantitatively based and effective practices for evacuation planning. The analysis is based upon a requirement that the entire urban area be evacuated, which is certainly possible. It is also possible that evacuations will be limited to small zones within an urban area.

The Principal Resources of Evacuation: Highways and Cars

The principal resources of urban evacuation are private cars and publicly provided highways. The automobile is the dominant mode of transport in US urban areas.[3] The automobile is the principal mode of transport within the 37 urban areas with more than 1,000,000 population. Automobiles account for 96 percent of travel or more in 36 urban areas, while in the New York urban area, automobiles account for more than 90 percent of travel.[4]

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[1] *Fact Sheet: Nationwide Plan Review Initial Conclusions,* http://www.dhs.gov/dhspublic/interapp/press_release/press_release_0929.xml and Nationwide Plan Review, Phase 2 Report, http://www.dhs.gov/interweb/assetlibrary/Prep_NationcwidePlanReview.pdf, Department of Homeland Security, June 2006.

[2] Personal vehicles include automobiles, sport utility vehicles and personal trucks. The terms "automobile" and "car" in this report refer to all personal vehicles.

[3] Contrary to popular belief, the automobile is used for the majority of travel in all high-income world urban areas with the exception of Tokyo-Yokohama, Osaka-Kobe-Kyoto and Hong Kong (International Union of Public Transport – UITP, *Millennium Cities Database,* Brussels: 2002).

[4] Automobile share as a percentage of mechanized transportation mode. http://www.publicpurpose.com/ut-uspt2003share.pdf. (The Public Purpose, www.publicpurpose.com, is a website of Wendell Cox Consultancy.)

Streets and highways have long been recognized as the avenues of urban and even national productivity. Research documents the importance of roadways in urban economic performance. For example, the Texas Transportation Institute annually measures traffic congestion in large US urban areas and estimates the cost to local economies of traffic congestion.[5] The most recent estimate is $63 billion, an amount equal to more than the gross state product of Nebraska. Recent reports in Portland, Oregon and Vancouver, BC document the business losses that have already occurred and could occur in the future from failure to provide roadway capacity sufficient to accommodate demand.[6] University of Paris research underscores the importance of improving traffic flows by documenting the economic gains that occur from simply making more jobs accessible to people in a fixed period of time (such as 30 minutes).[7]

However, highways have another, increasingly important function – providing evacuation routes in times of emergency. With nearly all travel in urban areas being by cars or streets and highways, it can be no other way. Moreover, this is not likely to change. The substantial mass transit expansions that have occurred in many urban areas have not materially reduced the share of travel by car.[8] Moreover, most such improvements have been for the purpose of internal circulation within urban areas, rather than the exit capacity that is required for evacuation. Thus, urban areas are principally dependent upon highways and automobiles for evacuation.

...the interstate system is reasserting itself as a major element of national security

Much of the urban highway evacuation capacity, both in exit routes and in internal circulation routes is provided by the interstate highway system, which was originally called the "National System of Interstate and Defense Highways." The system's defense role became less important with the fall of Communism and the end of the Cold War. Now, due to the increasing threat of terrorism, the interstate system is reasserting itself as a major element of national security (and defense), principally due to its capacity for handling mass evacuations.

America's comprehensive highway system and the broad availability of cars greatly simplify evacuation planning. For the vast majority of households, government's planning role is limited to providing the highway infrastructure and managing its operation during an evacuation. The government role in planning for the evacuation of the mass transit dependent population without access to automobiles is far more complex.

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[5] http://mobility.tamu.edu/ums/.

[6] Economic Development Research Group, *The Cost of Congestion to the Economy of the Portland Region,* December 5, 2005: http://www.metro-region.org/library_docs/trans/coc_exec_summary_final_4pg.pdf
and Delcan and Economic Development Research Group, *Economic Impact Analysis of Investment in a Major Commercial Transportation System for the Greater Vancouver Region,* July 2003: http://www.gvgc.org/pdfs/SW1040_FinalReport_Revised2.pdf.

[7] Remy Prud'homme and Chang-Woon Lee (1998), "Size, Sprawl, Speed, and the Efficiency of Cities," Paris, France: Obervatoire de l'Économic et des Institutions Locals.

[8] See http://www.publicpurpose.com/ut-uspt1983share.pdf,

Further, the recent experience in New Orleans shows that mass transit, even when available in considerable amounts,[9] may not always be sufficiently deployed to serve even the needs of the minority of residents who do not have access to cars.

Even so, highways are necessarily the principal infrastructure of evacuation. A well functioning evacuation system for people without access to cars would necessarily rely on buses, which would rely on highways.

A well functioning evacuation system for people without access to cars would necessarily rely on buses, which would rely on highways.

The Recent Experience

The nation has had two well-publicized experiences with urban evacuations over the past year. The Hurricane Katrina evacuation of the New Orleans area and the Hurricane Rita evacuation of the Houston area provided much to criticize. In New Orleans, officials were faulted for not having ordered the mandatory evacuation earlier, which lost valuable time. Similarly, the Mayor of New Orleans has been criticized for failing to use hundreds of available buses from the city's transit agency and school district to evacuate the large number of people who did not have cars for fleeing on their own. By contrast, in Houston, local officials managed to use their transit and other bus resources effectively.

Nonetheless, one crucial element of the evacuation worked well in both urban areas – the highway system. In both New Orleans and Houston, hundreds of thousands of households managed to flee the urban areas using their private cars on the highways. This is not to suggest that things worked perfectly. There were monumental traffic jams. There were fuel shortages.

There is little detailed data on the Houston and New Orleans evacuations. However, Louisiana Governor Kathleen Blanco has estimated that 92 percent of the 1.3 million residents of the New Orleans area were evacuated.[10] Only those who either chose to stay or had no access to automobile transportation were left in the urban area.

In fact, it appears that friends and relatives evacuated a large number of car-less people in New Orleans. Based upon Governor Blanco's estimate that 92 percent of metropolitan area residents were evacuated, it appears that friends and relatives who had cars evacuated more than one-half of the car-less households. United States Census data indicates that 82 percent of New Orleans area households had access to cars in 2000, which would suggest that 10 percent of car-less households were evacuated by car, leaving eight percent behind. Moreover, some of the households that did not evacuate had cars available, but chose not to leave, which suggests that the share of car-less households evacuated by friends and relatives may have been even higher.

[9] The Regional Transit Authority in New Orleans has a high level of transit service and the fifth highest ridership per capita of any large US transit agency (http://www.publicpurpose.com/ut-us97pc-sys.htm).

[10] The *Federal Response to Hurricane Katrina: Lessons Learned,* Washington: The White House, February 2006, p 29 (http://www.whitehouse.gov/reports/katrina-lessons-learned.pdf).

TABLE 1

Urban Areas Over 1,000,000 Population

CODE	URBAN AREA	ESTIMATED POPULATION (JULY 1, 2005)	POPULATION (APRIL 1, 2000)	LAND AREA: SQUARE MILES: (2000)	DENSITY: POPULATION PER SQUARE MILE (2000)
ATL	Atlanta	4,050,000	3,500,000	1,963	1,783
AUS	Austin	1,050,000	902,000	318	2,835
BAL	Baltimore	2,080,000	2,076,000	683	3,041
BOS	Boston	4,050,000	4,032,000	1,736	2,323
CHI	Chicago	8,620,000	8,308,000	2,123	3,914
CIN	Cincinnati	1,550,000	1,503,000	672	2,238
CLV	Cleveland	1,770,000	1,787,000	647	2,761
COL	Columbus	1,200,000	1,133,000	398	2,849
DEN	Denver	2,170,000	1,985,000	499	3,979
DET	Detroit	3,930,000	3,903,000	1,261	3,094
DFW	Dallas-Fort Worth	4,670,000	4,146,000	1,407	2,946
HOU	Houston	4,280,000	3,823,000	1,295	2,951
IPS	Indianapolis	1,310,000	1,219,000	553	2,205
KC	Kansas City	1,440,000	1,362,000	584	2,330
LA	Los Angeles	14,910,000	14,040,000	2,330	6,026
LV	Las Vegas	1,630,000	1,314,000	286	4,597
MEM	Memphis	1,020,000	972,000	400	2,431
MIA	Miami	5,330,000	4,919,000	1,116	4,407
MIL	Milwaukee	1,320,000	1,309,000	487	2,687
MSP	Minneapolis-St. Paul	2,530,000	2,389,000	894	2,671
NO	New Orleans	1,010,000	1,009,000	198	5,102
NY	New York	18,210,000	17,800,000	3,353	5,309
ORL	Orlando	1,360,000	1,157,000	453	2,554
PGH	Pittsburgh	1,720,000	1,753,000	852	2,057
PHI	Philadelphia	5,270,000	5,149,000	1,800	2,861
PHX	Phoenix	3,460,000	2,907,000	799	3,638
POR	Portland	1,720,000	1,583,000	474	3,340
PRV	Providence	1,200,000	1,175,000	504	2,332
SA	San Antonio	1,470,000	1,328,000	408	3,257
SAC	Sacramento	1,580,000	1,393,000	369	3,776
SD	San Diego	2,790,000	2,674,000	782	3,419
SEA	Seattle	2,850,000	2,712,000	954	2,844
SF	San Francisco-San Jose	5,360,000	5,320,000	963	5,523
STL	St. Louis	2,140,000	2,078,000	829	2,506
TSP	Tampa-St. Petersburg	2,280,000	2,062,000	802	2,571
VB	Virginia Beach	1,460,000	1,394,000	527	2,647
WDC	Washington	4,280,000	3,934,000	1,157	3,401
Average					3,222

Notes: 2000 data from US Census
2005 estimate based upon corresponding metropolitan area growth rate from 2000 to 2005
Los Angeles includes Riverside-San Bernardino, Mission Viejo and Thousand Oaks. San Francisco-San Jose includes San Francisco, San Jose and Concord. See Appendix 2: Methodology

Evaluating Evacuation Capacity

The Emergency Evacuation Report Card covers the 37 urban areas[11] with more than 1,000,000 population as of 2005 (Table 1).

Three criteria are used in evaluating evacuation capacity of urban areas. These include (1) exit capacity from the urban area, (2) traffic flow in urban areas and (3) automobile access.

- **Exit Capacity:** Exit Capacity refers to the capacity of major roadways leading out of an urban area to handle an evacuation of urban area residents. An urban area with a greater Exit Capacity will be better prepared for evacuation.

- **Internal Traffic Flow:** Expeditious evacuation of an urban area requires that traffic flow well within the urban area, as people seek to reach the exit roadways. An urban area with better Internal Traffic Flow will be better prepared for evacuation.

- **Automobile Access:** Certainly, the Hurricane Katrina experience showed that people without access to automobiles face more significant evacuation challenges than those with automobiles. An urban area with greater automobile accessibility will be better prepared for evacuation.

These three evaluation factors are then combined into an overall Evacuation Capacity Index. The factors and the Evacuation Capacity Index are converted to letter grades from "A" to "F." (Table 2). The analysis below summarizes the results for each of the three evaluation factors as well as the overall Evacuation Capacity Index. The methodology is described in Appendix 2.

Table 2

Grading System: Evacuation Capacity Index and Evaluation Factors

SCORE	GRADE
90 to 100	A
80 to 89	B
70 to 79	C
60 to 69	D
60 and Below	F

[11] Urban areas (also called urbanized areas) are areas of continuous urban development. Urban areas are different from metropolitan areas both in being smaller geographically and in not containing surrounding rural (undeveloped) territory. Urban areas are also different from cities, which are municipalities, such as the city of Chicago or the many cities that comprise its suburbs (for example, the city of Naperville, the city of Kenosha, etc.). In the United States, urban areas are always smaller than cities (municipalities).

Exit Capacity

The most fundamental issue in evacuating an urban area is the capability of the roads to provide an exit for the population.

Exit Capacity was estimated by identifying the higher capacity roadways leading from each of the urban areas and estimating their capacity. This included all freeways, toll roads, frontage roads and major express arterials (roadways with comparatively few traffic signals), all with four or more lanes.[12] The number of lanes available was determined at the urban area boundary, using maps and satellite photography. Additional evacuation capacity could be provided by more locally oriented and smaller capacity roads, however these were excluded from the analysis because of the overwhelming importance of the higher capacity roads. Higher exit capacity not only improves evacuation out of urban areas, but also increases the potential for dispersing evacuation traffic outward from urban areas.

Kansas City scores highest in Exit Capacity, at 98, for a grade of "A."

The standard for evaluation was the theoretical capacity of the roadways at the exit points over a 12-hour period. Of course, during periods of high demand, with evacuation representing the highest demand, roadways do not operate at full capacity, as was evident from the experiences in New Orleans and Houston. Nonetheless, the 12-hour theoretical standard is useful for comparison. In fact, up to this theoretical capacity could be accommodated by exit routes by an effective employment of contra-flow (converting inbound lanes to outbound operation) if the roadways were able to handle 50 percent of their theoretical capacity.

The capacity of each urban area's roadways to evacuate the population was estimated. The resulting percentage was converted into a number from 0 to 100, so that, for example, an urban area with an exit capacity of 75 percent would receive a score of 75.

None of the 37 urban areas achieved a 100 percent score in Exit Capacity, which means that none appears to have the theoretical capacity to evacuate all of its citizens in a 12-hour period at peak efficiency (Table 3 and Figure 1). Eight of the 37 urban areas score 80 or higher in exit capacity.

Kansas City scores highest in Exit Capacity, at 98, for a grade of "A." Columbus also achieves an "A," with a score of 91 in Exit Capacity. Columbus, like Cincinnati and to a lesser extent, Cleveland, has profited from the Ohio state highway construction program that has widened a number of intercity freeways to 6-lanes, instead of the more usual 4-lanes.

Four urban areas achieve grades of "B," Indianapolis and Cincinnati tied with a score of 89. Memphis (88), Pittsburgh (83), Orlando (83) and Dallas-Fort Worth (82) were also above 80.

[12] At least two lanes in each direction.

TABLE 3

Exit Capacity Scores

RANK	CODE	URBAN AREA	EXIT CAPACITY (0-100)	EXIT CAPACITY GRADE
1	KC	Kansas City	98	A
2	COL	Columbus	91	A
3	IPS	Indianapolis	89	B
3	CIN	Cincinnati	89	B
5	MEM	Memphis	88	B
6	PGH	Pittsburgh	83	B
6	ORL	Orlando	83	B
8	DFW	Dallas-Fort Worth	82	B
9	SA	San Antonio	77	C
10	BAL	Baltimore	73	C
11	STL	St. Louis	71	C
12	NO	New Orleans	67	D
12	CLV	Cleveland	67	D
14	DEN	Denver	64	D
15	SAC	Sacramento	63	D
16	AUS	Austin	62	D
17	MIL	Milwaukee	61	D
18	PRV	Providence	59	F
19	TSP	Tampa-St. Petersburg	56	F
19	HOU	Houston	56	F
21	WDC	Washington	47	F
22	ATL	Atlanta	46	F
23	VB	Virginia Beach	41	F
24	BOS	Boston	40	F
24	PHI	Philadelphia	40	F
26	LV	Las Vegas	39	F
27	DET	Detroit	38	F
28	POR	Portland	37	F
29	MSP	Minneapolis-St. Paul	33	F
30	SF	San Francisco-San Jose	28	F
31	PHX	Phoenix	25	F
32	LA	Los Angeles	24	F
33	SEA	Seattle	21	F
34	SD	San Diego	20	F
34	MIA	Miami	20	F
36	CHI	Chicago	17	F
37	NY	New York	14	F

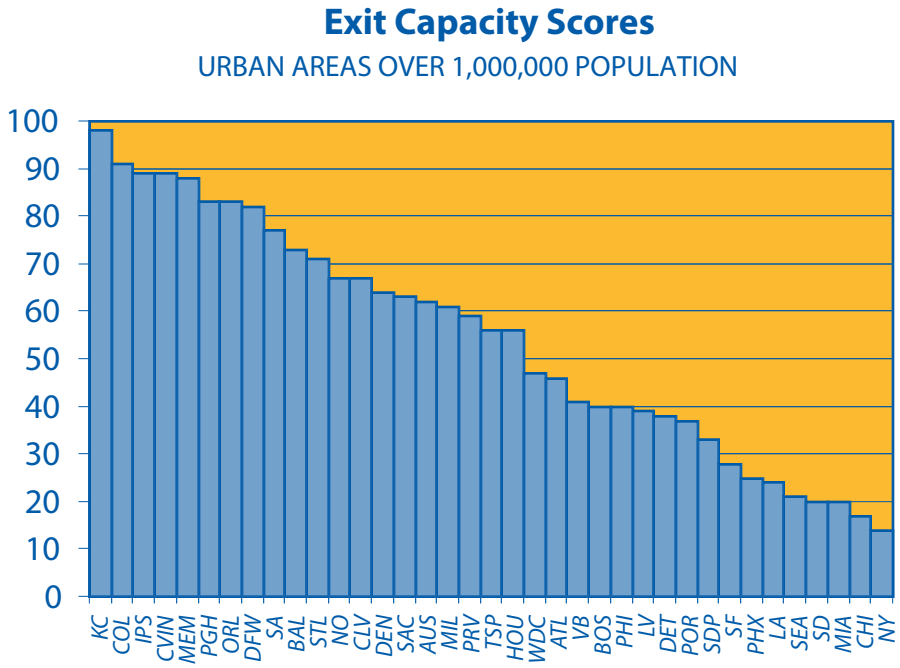

Figure 1

Internal Traffic Flow

Traffic flow within the urban area is important because virtually all evacuation trips begin within the urban area and operate on internal roadways until they exit (Exit Capacity, above).

The Texas Transportation Institute has developed the "Travel Time Index," which is the principal indicator of traffic congestion in US urban areas. The delay from estimated in the Travel Time Index is used for the Internal Traffic Flow factor. For example, an urban area with no travel delay scores 100 in Internal Traffic Flow, while an urban area with a 40 percent average travel delay scores 60 in Internal Traffic Flow (100 minus 40).

Seven of the 37 urban areas achieve Internal Traffic Flow scores of 80 or greater (Table 4 & figure 2). The most favorable Internal Traffic Flow score is in Cleveland, at 91, followed closely by Pittsburgh (90), both achieving grades of "A." Kansas City scores 89 for a high "B." Memphis (82), Columbus, New Orleans[13] and Providence (tied at 81) also received "B" grades.

Twenty-two (22) of the urban areas scored below 70 in Internal Traffic Flow, for grades of "D" or "F." The lowest score is in Los Angeles, at 30, for a grade of "F." Seven other urban areas score under 60 (for a grade of "F"), including Chicago, Washington, San Francisco-San Jose, Atlanta, Miami, Houston and San Diego.

[13] New Orleans information is based upon data from before the Hurricane Katrina related flooding. For a comparison of the estimated "before and after" population, see http://www.demographia.com/db-katrinano.htm (Demographia, www.demographia.com, is a website of Wendell Cox Consultancy.)

TABLE 4

Internal Traffic Flow Scores

RANK	CODE	URBAN AREA	INTERNAL TRAFFIC FLOW (0-100)	INTERNAL TRAFFIC FLOW GRADE
1	CLV	Cleveland	91	A
2	PGH	Pittsburgh	90	A
3	KC	Kansas City	89	B
4	MEM	Memphis	82	B
5	COL	Columbus	81	B
5	NO	New Orleans	81	B
5	PRV	Providence	81	B
8	MIL	Milwaukee	79	C
8	VB	Virginia Beach	79	C
10	CIN	Cincinnati	78	C
10	SA	San Antonio	78	C
10	STL	St. Louis	78	C
13	IPS	Indianapolis	76	C
14	AUS	Austin	75	C
15	ORL	Orlando	70	C
16	PHI	Philadelphia	68	D
17	TSP	Tampa-St. Petersburg	67	D
18	BOS	Boston	66	D
18	MSP	Minneapolis-St. Paul	66	D
20	PHX	Phoenix	65	D
21	DFW	Dallas-Fort Worth	64	D
22	BAL	Baltimore	63	D
22	POR	Portland	63	D
22	SAC	Sacramento	63	D
25	DET	Detroit	62	D
25	SEA	Seattle	62	D
27	LV	Las Vegas	61	D
27	NY	New York	61	D
29	DEN	Denver	60	D
30	SD	San Diego	59	F
31	HOU	Houston	58	F
31	MIA	Miami	58	F
33	ATL	Atlanta	54	F
34	SF	San Francisco-San Jose	51	F
35	WDC	Washington	49	F
36	CHI	Chicago	43	F
37	LA	Los Angeles	30	F

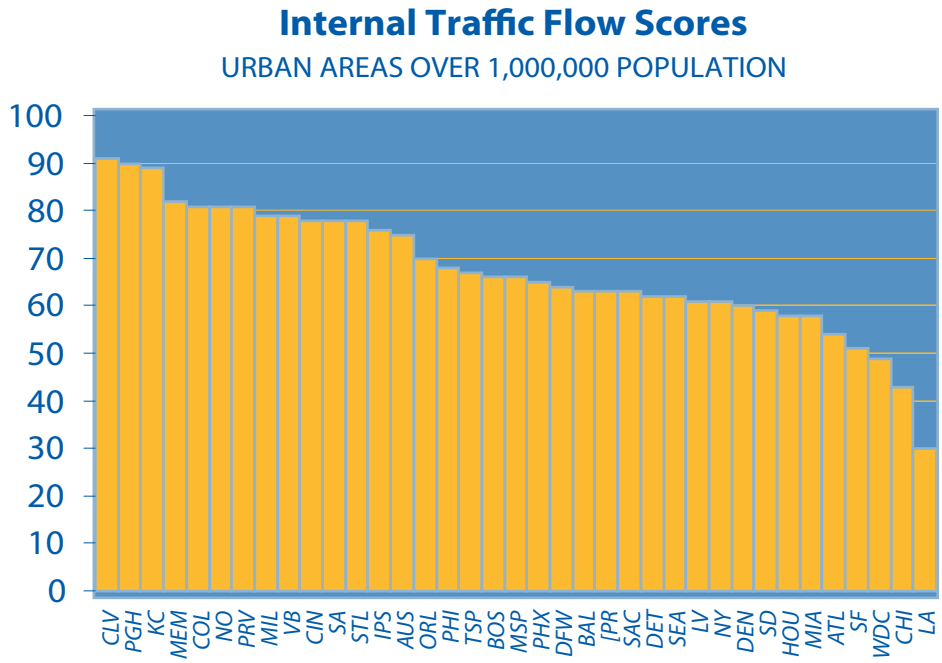

Figure 2

Automobile Access

Automobiles provide by far the greatest and most reliable means of evacuation. Fortunately, the vast majority of American households have access to automobiles, without which the mass evacuations of New Orleans and Houston could not have been accomplished.

Data from the 2000 census was to estimate the percentage of households having access to automobiles in each urban area. In 21 of the 37 urban areas, 90 percent or more of households had access to an automobile, while the figure exceeded 85 percent in all but three urban areas (Table 5). Only in New York (at 67.6 percent) is automobile access under 80 percent. Based upon the New Orleans experience, it is assumed that one-half of people who do not have automobiles will be evacuated in the cars of friends and relatives. The urban areas all score well on automobile access, indicating that the private resources of urban areas are well positioned to handle evacuations (Figure 3). All but one of the urban areas scores above 90 percent in Automobile Access, achieving grades of "A."

Fortunately, the vast majority of American households have access to automobiles, without which the mass evacuations of New Orleans and Houston could not have been accomplished.

Only New York scores lower, at 83.8 percent, for a grade of "B." The low New York score reflects the hyper-densities in the four large boroughs of the city of New York (Brooklyn, the Bronx, Manhattan and Queens), which make intense mass transit service feasible, allowing many households that can afford cars to use transit instead for their daily commutes. This is illustrated by the fact that nearly 55 percent of the nation's urban rail service is in the New York urban area.[14]

[14] Estimated from United States Department of Transportation Federal Transit Administration National Transit Database, 2004 (using vehicle miles).

TABLE 5

Automobile Availability and Automobile Access Scores

RANK	CODE	URBAN AREA	AUTOMOBILE AVAILABILITY	AUTOMOBILE ACCESS	AUTOMOBILE AVAILABILITY GRADE
1	AUS	Austin	93.5%	96.8%	A
2	DFW	Dallas-Fort Worth	93.5%	96.7%	A
3	ORL	Orlando	93.2%	96.6%	A
4	PHX	Phoenix	92.9%	96.4%	A
5	DEN	Denver	92.4%	96.2%	A
6	ATL	Atlanta	92.2%	96.1%	A
6	IPS	Indianapolis	92.2%	96.1%	A
8	HOU	Houston	91.9%	96.0%	A
8	KC	Kansas City	92.1%	96.0%	A
10	COL	Columbus	91.8%	95.9%	A
10	SD	San Diego	91.7%	95.9%	A
12	SAC	Sacramento	91.6%	95.8%	A
12	SEA	Seattle	91.5%	95.8%	A
14	TSP	Tampa-St. Petersburg	91.5%	95.7%	A
15	MSP	Minneapolis-St. Paul	91.0%	95.5%	A
15	POR	Portland	91.1%	95.5%	A
15	VB	Virginia Beach	91.1%	95.5%	A
18	LV	Las Vegas	90.3%	95.2%	A
19	DET	Detroit	90.1%	95.1%	A
19	SA	San Antonio	90.2%	95.1%	A
21	STL	St. Louis	90.0%	95.0%	A
22	LA	Los Angeles	89.3%	94.7%	A
23	CIN	Cincinnati	89.1%	94.6%	A
24	MEM	Memphis	89.0%	94.5%	A
24	MIA	Miami	89.0%	94.5%	A
26	SF	San Francisco-San Jose	88.5%	94.3%	A
27	CLV	Cleveland	88.4%	94.2%	A
28	PRV	Providence	88.1%	94.1%	A
29	WDC	Washington	87.8%	93.9%	A
30	MIL	Milwaukee	87.0%	93.5%	A
31	BOS	Boston	85.8%	92.9%	A
32	CHI	Chicago	85.5%	92.7%	A
32	PGH	Pittsburgh	85.4%	92.7%	A
34	BAL	Baltimore	83.5%	91.8%	A
34	PHI	Philadelphia	83.6%	91.8%	A
36	NO	New Orleans	82.0%	91.0%	A
37	NY	New York	67.6%	83.8%	B

Note: Automobile Access calculated assuming that one-half of the people without automobile availability will be evacuated in the cars of friends or relatives.

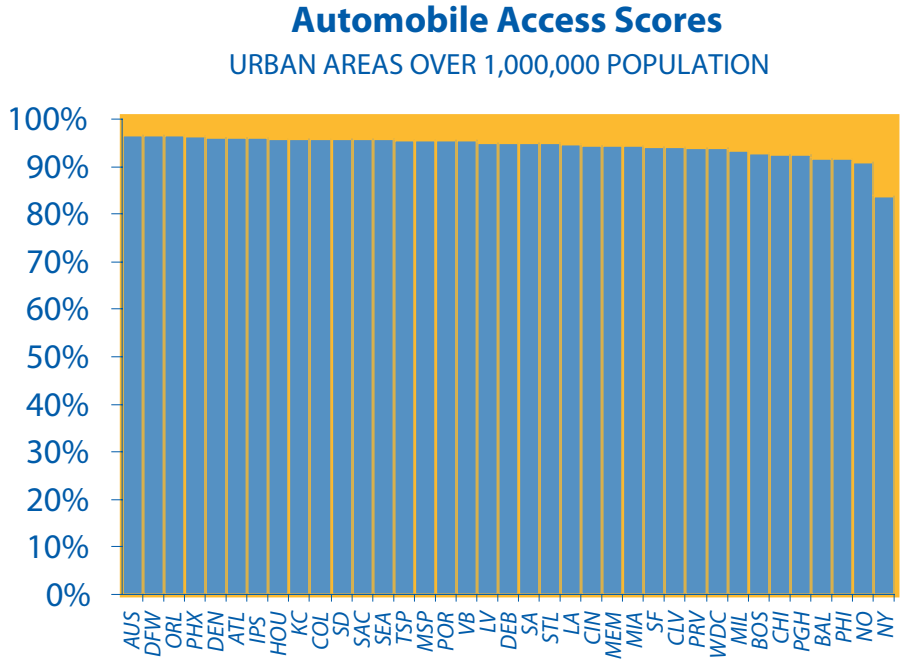

Figure 3

Evacuation Capacity Index

The Evacuation Capacity Index combines the Exit Capacity, Internal Traffic Flow and Automobile Access scores into a single measure. Exit Capacity and Internal Traffic Flow are each weighted at 50 percent of the score to produce the Roadway Capacity score, which is a measure of the ability of the road system to evacuate the population of the urban area. To reflect the fact that not all of the population will have access to cars, the Roadway Capacity score is adjusted downward by the Automobile Access score to produce the Evacuation Capacity Index.

Four of the 37 urban areas achieve a grade of "A" (Table 6). Only Kansas City achieves a grade of "A," with an Evacuation Capacity Index of 90.0. Kansas City achieves a grade of "A" in all three evaluation categories. Three urban areas achieve grades of "B," with Columbus at 82.3, Memphis at 80.5 and, Pittsburgh at 80.4.

Seven of the urban areas were graded "C," (scoring between 70 and 79), while six earned a "D" grade, scoring between 60 and 69. Twenty (20) urban areas were given a failing grade of "F." The lowest scores were achieved in Los Angeles, Chicago and New York (Table 7 & Figure 4).

Tables A-1 and A-2 portray the scores and grades alphabetically by urban area (Appendix A).

TABLE 6

Evacuation Capacity Index: Urban Area Grades

RANK	URBAN AREA	SCORE
GRADE: A		
1	Kansas City	90.0
GRADE: B		
2	Columbus	82.3
3	Memphis	80.5
4	Pittsburgh	80.4
GRADE: C		
5	Indianapolis	79.2
6	Cincinnati	79.0
7	Cleveland	74.5
8	Orlando	74.1
9	San Antonio	73.5
10	St. Louis	70.6
11	Dallas-Fort Worth	70.5
GRADE: D		
12	New Orleans	67.3
13	Austin	66.2
14	Providence	65.9
15	Milwaukee	65.2
16	Baltimore	62.6
17	Sacramento	60.3
GRADE: F		
18	Denver	59.8
19	Tampa-St. Petersburg	58.9
20	Virginia Beach	57.4
21	Houston	54.8
22	Boston	49.4
22	Philadelphia	49.4
24	Atlanta	48.1
25	Portland	47.7
26	Minneapolis-St. Paul	47.5
27	Las Vegas	47.4
28	Detroit	47.3
29	Washington	44.9
30	Phoenix	43.6
31	Seattle	39.9
32	San Diego	37.8
33	San Francisco-San Jose	37.2
34	Miami	36.9
35	New York	31.5
36	Chicago	28.0
37	Los Angeles	25.6

Table 7

Evacuation Capacity Index and Grades

RANK	CODE	URBAN AREA	EVACUATION CAPACITY INDEX	EVACUATION CAPACITY GRADE	EXIT CAPACITY (0-100)	INTERNAL TRAFFIC FLOW (0-100)	AUTOMOBILE ACCESS
1	KC	Kansas City	90.0	A	A	B	A
2	COL	Columbus	82.3	B	A	B	A
3	MEM	Memphis	80.5	B	B	B	A
4	PGH	Pittsburgh	80.4	B	B	A	A
5	IPS	Indianapolis	79.2	C	B	C	A
6	CIN	Cincinnati	79.0	C	B	C	A
7	CLV	Cleveland	74.5	C	D	A	A
8	ORL	Orlando	74.1	C	B	C	A
9	SA	San Antonio	73.5	C	C	C	A
10	STL	St. Louis	70.6	C	C	C	A
11	DFW	Dallas-Fort Worth	70.5	C	B	D	A
12	NO	New Orleans	67.3	D	D	B	A
13	AUS	Austin	66.2	D	D	C	A
14	PRV	Providence	65.9	D	F	B	A
15	MIL	Milwaukee	65.2	D	D	C	A
16	BAL	Baltimore	62.6	D	C	D	A
17	SAC	Sacramento	60.3	D	D	D	A
18	DEN	Denver	59.8	F	D	D	A
19	TSP	Tampa-St. Petersburg	58.9	F	F	D	A
20	VB	Virginia Beach	57.4	F	F	C	A
21	HOU	Houston	54.8	F	F	F	A
22	BOS	Boston	49.4	F	F	D	A
22	PHI	Philadelphia	49.4	F	F	D	A
24	ATL	Atlanta	48.1	F	F	F	A
25	POR	Portland	47.7	F	F	D	A
26	MSP	Minneapolis-St. Paul	47.5	F	F	D	A
27	LV	Las Vegas	47.4	F	F	D	A
28	DET	Detroit	47.3	F	F	D	A
29	WDC	Washington	44.9	F	F	F	A
30	PHX	Phoenix	43.6	F	F	D	A
31	SEA	Seattle	39.9	F	F	D	A
32	SD	San Diego	37.8	F	F	F	A
33	SF	San Francisco-San Jose	37.2	F	F	F	A
34	MIA	Miami	36.9	F	F	F	A
35	NY	New York	31.5	F	F	D	B
36	CHI	Chicago	28.0	F	F	F	A
37	LA	Los Angeles	25.6	F	F	F	A

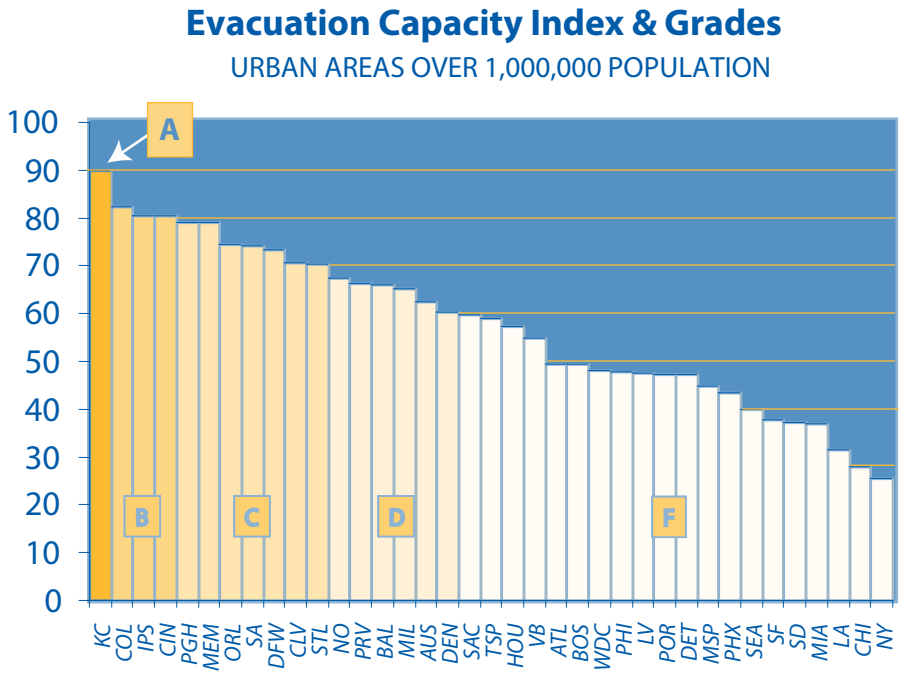

Figure 4

Evacuation Challenges

Urban areas face considerable, yet differing challenges in attempting to improve their evacuation capacity. Much of the difference in Evacuation Capacity Index scores between urban areas is associated with the following factors.

Geographical Barriers: Urban areas with geographical barriers face particular challenges in Exit Capacity and as a result tend to score lower in the Evacuation Capacity Index (Table 8). In some urban areas, water barriers or international boundaries block one or more exit directions. The seven urban areas with the lowest Evacuation Capacity Index scores all have such geographical barriers (Los Angeles, Chicago, New York, Miami, San Francisco-San Jose, San Diego and Seattle). It is necessary to concentrate more roadway capacity in the directions without barriers to improve Exit Capacity in these urban areas. Among the urban areas with higher Roadway Capacity Scores (between 75 and 100), only 11 percent (one out of nine urban areas) has a geographical barrier. In contrast, more than 60 percent of the urban areas scoring between 25 and 49 (eight out of 13 urban areas) have geographical barriers, illustrating the importance of such barriers (Table 9).

High Population Density: Higher population density is associated with higher traffic volumes,[15] and with lower Evacuation Capacity Index scores (Figure 5). Thus, more robust roadway systems must be in-place to provide sufficient traffic flow where densities are higher. Generally, sufficient roadway robust systems have not been provided and, as a result, traffic congestion tends to be worse. Higher population densities thus

[15] See How Higher Density Makes Congestion Worse, http://www.publicpurpose.com/pp57-density.htm.

mean that internal roadway systems and exit routes must have greater capacity to function adequately. In the cases where urban areas seek to implement strong densification or "smart growth" policies (such as Portland, Seattle or Denver), greater roadway expansion will be necessary to accelerate highway capacity improvements to maintain sufficient evacuation capacity. However, densification policies have generally been accompanied by the strategies to reduce the rate of highway expansion, thereby worsening evacuation capacity.

Ten of the 11 urban areas with the lowest scores have population densities that are higher than average. Lowest scoring Los Angeles has the highest population density in the nation. The urban areas with higher Roadway Capacity scores (between 75 and 100) are 38 percent less dense than those scoring between 75 and 100, further illustrating the negative relationship between population density and evacuation capacity (Table 9).

Densification policies have generally been accompanied by the strategies to reduce the rate of highway expansion, thereby worsening evacuation capacity.

Roadway Capacity: Some urban areas have roadway systems with particularly limited capacity. This severely limits Internal Traffic Flow and is associated with lower Evacuation Capacity Index scores (Figure 6). For example, Las Vegas, Chicago, New York, Portland. Phoenix, Washington and Atlanta, which score low in the Evacuation Capacity Index, have roadway capacity ratings well below average. Atlanta is an unusual case. Atlanta has the lowest population density in the world of any urban area with more than 1,000,000 population.[16] Atlanta's has a particularly weak roadway system that is overly dependent upon freeways, with little arterial capacity and thus few routes that can be used as alternates to its freeways (Table A-3).[17] The urban areas with higher Roadway Capacity scores (75 to 100) have 45 percent more roadway capacity than the lower scoring (25 to 49) urban areas, illustrating the effectiveness of greater roadway capacity in improving evacuation capacity (Table 9).

Lack of Automobile Access: Most urban areas have high rates of automobile access. New York is the only urban area with a substantially lower Automobile Access score, which has the impact of reducing its Evacuation Capacity Index score by more than 15 percent. Nonetheless, the Evacuation Capacity Index in all urban areas could be improved if more households owned cars. This would also have significant positive impacts in job access, thereby providing a means of entry to the economic mainstream by low-income households. Low rates of automobile availability can be moderated by various policies that would seek to increase the number of low-income households with cars.[18]

[16] *Demographia World Urban Areas,* http://www.demographia.com/db-worldua.pdf, February 13, 2006.
[17] The deficiencies of the Atlanta roadway system are outlined in Wendell Cox and Alan Pisarski, *Blueprint 2030: Affordable Mobility and Access for All of Atlanta and Georgia* (Atlanta: Georgians for Better Transportation, 2004). http://ciprg.com/ul/gbt/atl-report-20040621.pdf.
[18] The empowering effect of car ownership on low-income households is described in Evelyn Blumenberg and Margy Waller, "The Long Journey to Work: A Federal Transportation Policy for Working Families," Center for Urban and Metropolitan Policy, Brookings Institution, July 2003, Margy Waller and Mark Alan Hughes, "Working Far from Home: Transportation and Welfare Reform in the Ten Big States," Progressive Policy Institute, August 1, 1999 and Anne Kim, "Why People Need Affordable Cars," Blueprint: Ideas for a New Century, February 11, 2003, at www.ndol.org/ndol_ci.cfm?contentid=251220&kaid=114&subid=143.

TABLE 8

Urban Areas by Geographical Barriers (Water or International Border)

NO DIRECTIONAL BARRIER	ONE OR MORE DIRECTIONAL BARRIER
Atlanta	Baltimore
Austin	Boston
Cincinnati	Chicago
Columbus	Cleveland
Dallas-Fort Worth	Detroit
Denver	Houston
Indianapolis	Los Angeles
Kansas City	Miami
Las Vegas	Milwaukee
Memphis	New Orleans
Minneapolis-St. Paul	New York
Orlando	Providence
Philadelphia	San Diego
Phoenix	San Francisco-San Jose
Pittsburgh	Seattle
Portland	Tampa-St. Petersburg
Sacramento	Virginia Beach
San Antonio	
St. Louis	
Washington	

Density & the Roadway Capacity Scores

URBAN AREAS OVER 1,000,000 POPULATION

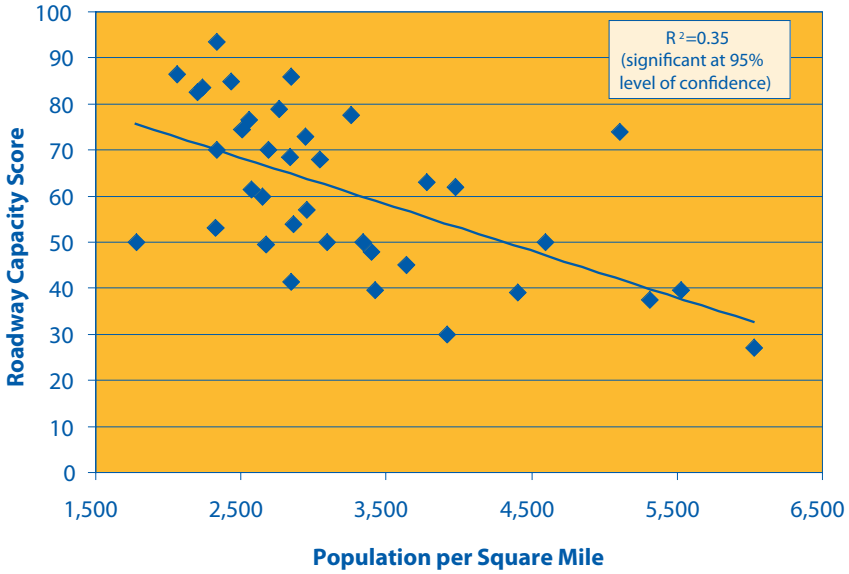

Figure 5

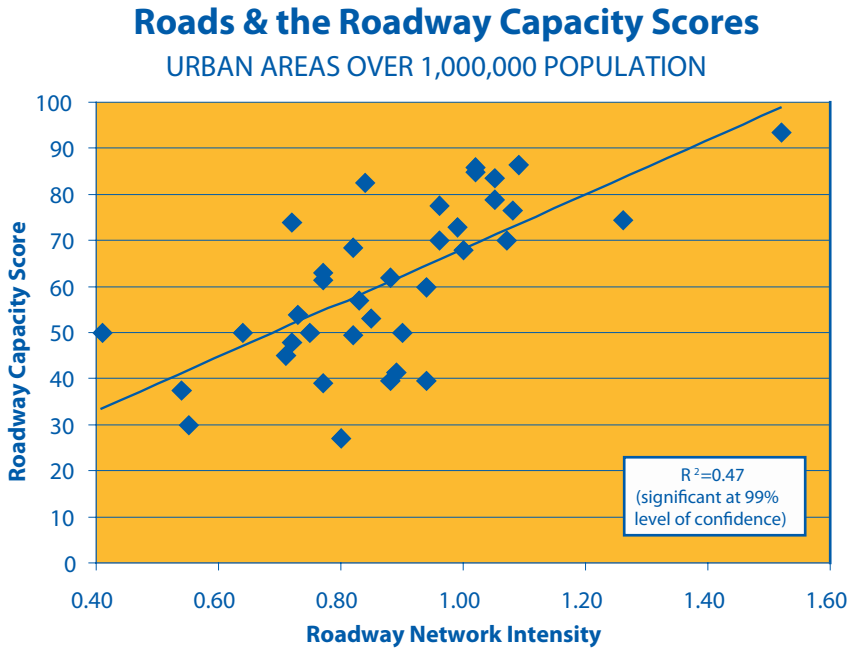

Figure 6

TABLE 9

Roadway Capacity Score and Influencing Factors

CATEGORY	AVERAGE POPULATION DENSITY	AVERAGE ROADWAY INTENSITY	DIRECTIONAL GEOGRAPHICAL BARRIERS
Higher: 75-100	2,520	1.07	11%
Middle: 50-74	2,956	0.89	53%
Lower: 25-49	4,049	0.74	62%
No Cases: 0-24		No Cases	
Higher Category Compared to Lower Category	**-37.8%**	**45.2%**	**-81.9%**

However, evacuation capacity is as important in urban areas with unique challenges as it is urban areas with low population density, strong roadway systems, high automobile ownership rates and without geographical barriers. Thus, adequate protection of the citizenry will require greater efforts in the more disadvantaged urban areas.

Planning for the Mass Transit Dependent

Public planning for people without access to cars (mass transit dependent) is far more complex than the planning for automobile evacuation. For those with cars, the public role is simply to manage the best use of infrastructure that is in place. Much of the planning for households with cars — the operational planning — is conducted by the

households themselves, who provide for their own movement by car using the government provided infrastructure already in place.

However, government must plan for the movement of the mass transit dependent. This includes not only the vast majority whose lack of automobile access arises from low-income, but for those with higher incomes who choose to live and work relying on transit and walking and have chosen to not purchase an automobile. This latter category of households is principally concentrated in the New York urban area, which is discussed below.

Generally, people who are not able to evacuate by means of cars are dependent upon transit. The responsibility for the evacuation infrastructure and evacuation operations will fall on government, for people without cars, regardless of their income levels. Some of the higher income households living in places like the core of New York or Chicago might be able to rent cars, but the demand for rental cars would far exceed the supply.

Resources for Mass Transit Dependent Evacuation

There are considerable resources available for evacuating the mass transit dependent in each of the urban areas.

Buses: Buses would be the most important mechanism of evacuation for people without cars. Most urban areas have a significant supply of buses, which could be used to carry people directly to evacuation centers, often returning to take additional trips. The bus resources include the following:

Buses would be the most important mechanism of evacuation for people without cars.

- **Mass transit buses:** There are approximately 60,000 urban transit buses in the United States. Most of these buses have been purchased principally with federal tax funding and these public resources should be a principal means of mass transit dependent evacuation.

- **School buses:** The nation has 425,000 school buses, of which at least 200,000 school buses[19] in urban areas and a total of 425,000 school buses including those in rural areas.

- **Motor coaches:** There are approximately 40,000 motor coaches in the nation, many of which are in urban areas. The motor coach industry provides charter, tour, intercity, airport express, special operations and contract services (commuter, school and transit) services. Motor coaches provide an additional benefit, in being able to accommodate personal effects more readily.

[19] School buses are the largest mass transit mode in the nation on school days, carrying approximately 65 percent more passenger miles than all of the nation's mass transit agency modes combined, including buses, metros (subways), light rail, etc. See: http://www.publicpurpose.com/sch-tr96.htm.

Paratransit Vehicles: There are also at least 35,000 paratransit vehicles ("dial-a-ride"), operated under the auspices of social service and mass transit agencies. These vehicles play a special role because most are equipped for serving handicapped citizens who find it difficult to use buses.

Commuter Rail: In a few areas, high-capacity commuter rail systems can play a supplemental role, especially in New York and Chicago and to a lesser extent in Boston and Philadelphia. These commuter rail systems could carry large numbers of people to train stations, generally at the end of the line (usually on the periphery of the urban area or somewhat beyond), where buses would distribute people to shelters outside the urban areas.[20] Bus transportation would be necessary so that the large numbers are not left stranded within urban areas near railroad stations where there is insufficient capacity to accommodate them.

Other urban areas, such as Los Angeles, San Francisco, Washington and Baltimore have commuter rail systems, but have considerably less capacity both in available routes and operating vehicles (trains) than New York, Chicago, Boston and Philadelphia.

Subways and Light Rail: Subway and light rail systems, such as the New York subway, the Washington Metro and light rail lines such as those built in Portland or San Diego can also be used as a resource to supplement evacuation system. Subways and light rail are generally local transportation systems, with routes generally serving areas that are more central. Their principal use would be feeding buses that would complete the evacuation to outside the urban area.

Amtrak: Amtrak could also play a minor role, especially in the Northeast Corridor, where its resources are concentrated. Here again, Amtrak evacuation would need to be coordinated with connecting bus service from railroad stations to shelters, so that evacuees are not stranded at railroad stations.

Taxicabs and Rental Cars: Taxicabs could be used by mass transit dependent households, though would be beyond the financial means of most low-income households.

Evacuation Centers: The horror stories from the mass evacuation centers in New Orleans (the Super Dome and the convention center) illustrate the difficulty of providing logistical support to overly large facilities. Generally, it will be preferable to move mass transit dependent households to more dispersed locations, outside the disaster area.[21]

[20] Passenger rail systems can be vulnerable in emergencies. For example, during the recent storms (June 2006) in the Washington, DC area, two Virginia commuter rail lines shut down, while the Maryland lines ran abbreviated schedules. There were also significant service disruptions on the Washington Metro subway.

[21] For a description of the experience at the large New Orleans evacuation centers, see Douglas Brinkley, *The Great Deluge Hurricane Katrina, New Orleans and the Mississippi Gulf Coast,* New York: William Morrow, 2006.

The Unique Challenge of New York

The New York urban area has nearly double the number of auto-less households as the next most mass transit dependent urban area, New Orleans. As noted above, this is possible because of the high level of service provided by transit agencies in the hyper-dense city of New York, where many households choose to not have a car, despite having sufficient income. Elsewhere, most auto-less households have no car because they have insufficient income.

The New York urban area has nearly double the number of auto-less households as the next most mass transit dependent urban area, New Orleans.

Yet, differences in income among the mass transit dependent will be largely irrelevant in an evacuation. Higher-income auto-less households will have little advantage over their lower-income counterparts. Some may be able to take advantage of rental cars or taxis, but those resources will fall far short of the demand.

The distribution of auto-less households in the New York urban area generally corresponds with design of mass transit services. Approximately 80 percent of the auto-less households live in the city of New York, where there is intensive transit service. It can be expected that the city's subway (metro) system will provide mobility for auto-less households to commuter rail stations, where people can transfer to trains that take them to bus staging stations outside the urban area. Others can be taken to peripheral subway stations, where they can board buses to complete their evacuation.

Thus, evacuation planning in New York will be a considerably greater burden for governments than it is where a far lower share of the population is mass transit dependent.

Opportunities for Improvement in Mass Transit Dependent Planning

Considerable use was made of motor coaches in the New Orleans and Houston evacuations. The American Bus Association, the national trade association of the motor coach industry, has examined the experience and made recommendations for improving evacuation planning. For example, it is important to provide for driver logistics, such as food and lodging. Some motor coach operators report having had drivers working for weeks and being forced to sleep on buses. As has been clear in media reports, there were significant coordination problems in the government response effort and those were evident to bus operators. There were significant communications difficulties and there was a failure to use Internet resources to a significant extent. There were also contractual, deployment and payment difficulties.

A lack of available drivers was cited as a reason why Regional Transit Authority buses did not play a major role in evacuating citizens from New Orleans. Planning must be improved so that personnel of organizations with evacuation resources understand what is expected of them and are effectively deployed.

Transportation operators need to be paid promptly, whether they are mass transit agencies, school districts or private bus companies. There is a need to facilitate the contracting and deployment process, so that transportation operators are aware of what is required of them and confident that they will be paid. There may be a need to establish "standby" or expedited contracts in advance so that the transaction time in arranging for evacuation services is minimized.

There may be a need to establish expedited bus exclusive routes, so that buses can avoid the worst traffic congestion. This could make it possible for buses to make return trips, multiplying the number of people who can be evacuated. Most urban areas have a number of lower capacity, two lane roads that could be used as exclusive bus routes for exiting the urban area, which might be preferable to attempting to enforce exclusive bus lanes on the overcrowded routes being used by cars.

There may be a need to establish expedited bus exclusive routes, so that buses can avoid the worst traffic congestion.

Each of these issues should be addressed in a comprehensive, cooperative planning process that includes government agencies and all potential providers of evacuation services, as recommended above. Finally, the American Bus Association has developed "Partnering Principles" that would facilitate a more effective response in the future.[22] These principles should apply, as appropriate, to the relationship between government agencies and all transportation operators, not just motor coach operators.

Additional Issues

In planning the operation of mass evacuations, authorities should consider issues such as the following:

- Maximum use of contra-flow operations on roadways
- Use of roadway shoulders as additional lanes
- Suspension of tolls on all roadway facilities
- Strategic use of lower capacity exit routes, such as two-lane highways
- Use of global positioning systems for providing directions to disperse traffic to underutilized routes both within the urban area and once it has exited the urban area.
- Strategies for ensuring adequate fuel supplies, both in the evacuation and during the return trip

[22] Partnering Principles, American Bus Association, www.buses.org/downloads/2787.cfm

RECOMMENDATIONS

The following recommendations are offered based upon the analysis above.

- **A National Standards and Reporting System should be established:** A national urban evacuation standards and reporting system should be established in a cooperative effort involving governments at every level and other appropriate interests. Such a system would provide more detailed information on the issues of Exit Capacity, Internal Traffic Flow Automobile Access and other important issues that might be identified. Comparative data should be regularly reported on urban areas. The standards and reporting system could be established through consultation between urban areas, with the technical assistance of the Federal Highway Administration, the Department of Homeland Security and other appropriate organizations.

- **Roadway Capacity should be expanded:** Each urban area should undertake roadway capacity expansions to make necessary improvements to the evacuation system. This would include not only construction of new and expanded roadways, but also capacity expansions through improved traffic management and other strategies that enhance the more efficient operation of roadways. There is particular potential for improving roadway capacity and better using existing capacity through information technology (Intelligent Transportation Systems). This can include vehicle guidance systems, ramp metering with emergency gates, and expanded systems for providing information to drivers – especially on traffic conditions and alternate routes.

- **Automobile Access should be expanded:** Governments should seek to employ strategies that increase automobile ownership among low-income households that do not have access to automobiles. An important step in this direction was taken by the Clinton administration in establishing regulations to encourage households on public assistance to own their own cars.[23]

- **Urban Area Evacuation Operations Planning should be completed:** Each urban area should establish a participative evacuation planning program that includes appropriate government and private interests. The principal purpose of this planning program would be to establish the operational framework for managing mass evacuations. This would include not only highway management, but also programs to provide evacuation services to mass transit dependent populations. Additional observations are provided on this process below.

CONCLUSION

There is considerable latitude for improving the evacuation capacity of the nation's urban areas. Such a program will be most effectively delivered through an objective evaluation system, which leads to effective measures to improve evacuation capacity.

[23] Press release, "President Clinton Announces Transportation Grants to Help Low-Income Families," White House, October 16, 2000.

APPENDIX 1: SUMMARY DATA

TABLE A-1

Evacuation Capacity Index and Grades: Alphabetical List

RANK	CODE	URBAN AREA	EVACUATION CAPACITY INDEX (0-100)	EVACUATION CAPACITY GRADE	EXIT CAPACITY	INTERNAL TRAFFIC FLOW	AUTOMOBILE ACCESS
24	ATL	Atlanta	48.1	F	F	F	A
13	AUS	Austin	66.2	D	D	C	A
16	BAL	Baltimore	62.6	D	C	D	A
22	BOS	Boston	49.4	F	F	D	A
36	CHI	Chicago	28.0	F	F	F	A
6	CIN	Cincinnati	79.0	C	B	C	A
7	CLV	Cleveland	74.5	C	D	A	A
2	COL	Columbus	82.3	B	A	B	A
18	DEN	Denver	59.8	F	D	D	A
28	DET	Detroit	47.3	F	F	D	A
11	DFW	Dallas-Fort Worth	70.5	C	B	D	A
21	HOU	Houston	54.8	F	F	F	A
5	IPS	Indianapolis	79.2	C	B	C	A
1	KC	Kansas City	90.0	A	A	B	A
37	LA	Los Angeles	25.6	F	F	F	A
27	LV	Las Vegas	47.4	F	F	D	A
3	MEM	Memphis	80.5	B	B	B	A
34	MIA	Miami	36.9	F	F	F	A
15	MIL	Milwaukee	65.2	D	D	C	A
26	MSP	Minneapolis-St. Paul	47.5	F	F	D	A
12	NO	New Orleans	67.3	D	D	B	A
35	NY	New York	31.5	F	F	D	B
8	ORL	Orlando	74.1	C	B	C	A
4	PGH	Pittsburgh	80.4	B	B	A	A
22	PHI	Philadelphia	49.4	F	F	D	A
30	PHX	Phoenix	43.6	F	F	D	A
25	POR	Portland	47.7	F	F	D	A
14	PRV	Providence	65.9	D	F	B	A
9	SA	San Antonio	73.5	C	C	C	A
17	SAC	Sacramento	60.3	D	D	D	A
32	SD	San Diego	37.8	F	F	F	A
31	SEA	Seattle	39.9	F	F	D	A
33	SF	San Francisco-San Jose	37.2	F	F	F	A
10	STL	St. Louis	70.6	C	C	C	A
19	TSP	Tampa-St. Petersburg	58.9	F	F	D	A
20	VB	Virginia Beach	57.4	F	F	C	A
29	WDC	Washington	44.9	F	F	F	A

Table A-2

Urban Area Scores and Evacuation Capacity Index: Alphabetical List

CODE	URBAN AREA	EXIT CAPACITY (0-100)	INTERNAL TRAFFIC FLOW (0-100)	ROAD CAPACITY SCORE (0-100)	AUTOMOBILE ACCESS	EVACUATION CAPACITY INDEX (0-100)	EVACUATION CAPACITY GRADE
ATL	Atlanta	46	54	50.0	96.1%	48.1	F
AUS	Austin	62	75	68.5	96.8%	66.2	D
BAL	Baltimore	73	63	68.0	91.8%	62.6	D
BOS	Boston	40	66	53.0	92.9%	49.4	F
CHI	Chicago	17	43	30.0	92.7%	28.0	F
CIN	Cincinnati	89	78	83.5	94.6%	79.0	C
CLV	Cleveland	67	91	79.0	94.2%	74.5	C
COL	Columbus	91	81	86.0	95.9%	82.3	B
DEN	Denver	64	60	62.0	96.2%	59.8	F
DET	Detroit	38	62	50.0	95.1%	47.3	F
DFW	Dallas-Fort Worth	82	64	73.0	96.7%	70.5	C
HOU	Houston	56	58	57.0	96.0%	54.8	F
IPS	Indianapolis	89	76	82.5	96.1%	79.2	C
KC	Kansas City	98	89	93.5	96.0%	90.0	A
LA	Los Angeles	24	30	27.0	94.7%	25.6	F
LV	Las Vegas	39	61	50.0	95.2%	47.4	F
MEM	Memphis	88	82	85.0	94.5%	80.5	B
MIA	Miami	20	58	39.0	94.5%	36.9	F
MIL	Milwaukee	61	79	70.0	93.5%	65.2	D
MSP	Minneapolis-St. Paul	33	66	49.5	95.5%	47.5	F
NO	New Orleans	67	81	74.0	91.0%	67.3	D
NY	New York	14	61	37.5	83.8%	31.5	F
ORL	Orlando	83	70	76.5	96.6%	74.1	C
PGH	Pittsburgh	83	90	86.5	92.7%	80.4	B
PHI	Philadelphia	40	68	54.0	91.8%	49.4	F
PHX	Phoenix	25	65	45.0	96.4%	43.6	F
POR	Portland	37	63	50.0	95.5%	47.7	F
PRV	Providence	59	81	70.0	94.1%	65.9	D
SA	San Antonio	77	78	77.5	95.1%	73.5	C
SAC	Sacramento	63	63	63.0	95.8%	60.3	D
SD	San Diego	20	59	39.5	95.9%	37.8	F
SEA	Seattle	21	62	41.5	95.8%	39.9	F
SF	San Francisco-San Jose	28	51	39.5	94.3%	37.2	F
STL	St. Louis	71	78	74.5	95.0%	70.6	C
TSP	Tampa-St. Petersburg	56	67	61.5	95.7%	58.9	F
VB	Virginia Beach	41	79	60.0	95.5%	57.4	F
WDC	Washington	47	49	48.0	93.9%	44.9	F

Table A-3

Roadway Network Intensity

CODE	URBAN AREA	FREEWAY INTENSITY	RANK	PRINCIPAL ARTERIAL INTENSITY	RANK	ROADWAY NETWORK INTENSITY	RANK
ATL	Atlanta	0.62	16	0.13	36	0.75	29
AUS	Austin	0.56	22	0.26	23	0.82	24
BAL	Baltimore	0.74	7	0.26	20	1.00	10
BOS	Boston	0.59	19	0.26	21	0.85	20
CHI	Chicago	0.31	36	0.24	28	0.55	35
CIN	Cincinnati	0.77	5	0.28	18	1.05	6
CLV	Cleveland	0.79	4	0.25	26	1.05	7
COL	Columbus	0.80	3	0.23	32	1.02	8
DEN	Denver	0.57	21	0.31	14	0.88	19
DET	Detroit	0.49	25	0.42	3	0.90	16
DFW	Dallas-Fort Worth	0.67	11	0.32	11	0.99	11
HOU	Houston	0.58	20	0.25	27	0.83	22
IPS	Indianapolis	0.55	24	0.29	17	0.84	21
KC	Kansas City	1.29	1	0.24	30	1.52	1
LA	Los Angeles	0.46	27	0.34	9	0.80	25
LV	Las Vegas	0.29	37	0.11	37	0.41	37
MEM	Memphis	0.60	18	0.42	2	1.02	9
MIA	Miami	0.39	32	0.38	6	0.77	28
MIL	Milwaukee	0.56	23	0.41	4	0.96	12
MSP	Minneapolis-St. Paul	0.63	14	0.19	34	0.82	23
NO	New Orleans	0.37	35	0.35	8	0.72	32
NY	New York	0.38	33	0.16	35	0.54	36
ORL	Orlando	0.62	17	0.46	1	1.08	4
PGH	Pittsburgh	0.73	8	0.36	7	1.09	3
PHI	Philadelphia	0.44	29	0.29	16	0.73	30
PHX	Phoenix	0.39	31	0.32	10	0.71	33
POR	Portland	0.44	30	0.20	33	0.64	34
PRV	Providence	0.76	6	0.32	12	1.07	5
SA	San Antonio	0.73	9	0.23	31	0.96	13
SAC	Sacramento	0.46	28	0.31	13	0.77	27
SD	San Diego	0.69	10	0.25	25	0.94	14
SEA	Seattle	0.63	13	0.26	24	0.89	17
SF	San Francisco-San Jose	0.62	15	0.26	22	0.88	18
STL	St. Louis	0.99	2	0.27	19	1.26	2
TSP	Tampa-St. Petersburg	0.37	34	0.40	5	0.77	26
VB	Virginia Beach	0.64	12	0.29	15	0.94	15
WDC	Washington	0.48	26	0.24	29	0.72	31
Average		0.59		0.29		0.88	

Roadway Intensity: Freeway equivalent lane miles per 1,000 population
Calculated from 2004 Federal Highway Administration data (freeways, 2004) and Texas Transportation Institute data (principal arterials, 2003).

APPENDIX 2: METHODOLOGY

The methodology used in the Emergency Evacuation Report Card is described below.

Urban Areas: Urban areas represent geography that is contiguously developed for urban uses, such as residences, employment and supportive transportation (such as airports and roadways within the urban area). An urban area is different from a metropolitan area, which includes rural areas beyond the urban area from which there is significant commuting to the urban area for employment. The analysis uses urban areas as defined by the 2000 United States Census, with populations adjusted from 2000 to 2005 based upon the metropolitan area rate of population increase. Urban areas with more than 1,000,000 estimated population in 2005 were used in the analysis.

The Los Angeles and San Francisco (San Francisco-San Jose) urban areas were expanded to include substantially adjacent urban areas within US Bureau of the Census consolidated areas and to include urban areas that are maintained as separate by the Bureau of the Census but included by the Federal Highway Administration and the Texas Transportation Institute.

The Los Angeles urban area includes the census-designated Los Angeles and Riverside-San Bernardino urban areas. The Los Angeles urban area also includes the Mission Viejo and Thousand Oaks urban areas, which are considered separate by the Bureau of the Census but included in Los Angeles by the Federal Highway Administration and the Texas Transportation Institute.

The San Francisco-San Jose urban area includes the census-designated San Francisco and San Jose urban areas and the Concord urban area, which is considered separate by the Bureau of the Census but included in San Francisco by the Federal Highway Administration and the Texas Transportation Institute.

Exit Capacity: The capacity of each urban area's roadways to evacuate the population was estimated.[24] The standard for evaluation was the theoretical capacity of the roadways at the exit points over a 12-hour period. During periods of high demand, with evacuation representing the highest demand, roadways do not operate at full capacity. However, up to this theoretical capacity could be accommodated by exit routes by an effective employment of contra-flow (converting inbound lanes to outbound operation) if the roadways were able to handle 50 percent of their theoretical capacity.

The resulting percentage of population that could be evacuated was converted into a number from 0 to 100, so that, for example, an urban area with an exit capacity of 75 percent would receive a score of 75.

[24] A capacity per lane of 2,200 cars was used for grade separated roadways (freeways and tollways) and 1,500 for principal arterials and frontage roads.

Internal Traffic Flow: Internal Traffic Flow is estimated using the most recent Travel Time Index (2003), which is produced by the Texas Transportation Institute. The Travel Time Index estimates the average travel delay on urban highway systems during peak hours. For example, an urban area with a Travel Time Index of 1.40 has an average peak period travel delay of 40 percent compared to travel during non-congested periods. The travel delay is used to estimate Internal Traffic Flow. For example, an urban area with no travel delay (a Travel Time Index of 1.00) scores 100 in Internal Traffic Flow, while an urban area with a 40 percent travel delay (Travel Time Index of 1.40) scores 60 in Internal Traffic Flow (100 minus 40). The Internal Travel Flow scores for the consolidated urban areas (Los Angeles and San Francisco-San Jose are weighted on a traffic volume basis.

Roadway Capacity: The Roadway Capacity Score is the combined Exit Capacity and Internal Traffic Flow score, with each weighted at 50 percent.

Automobile Access: Automobile access was estimated for each urban area using data from the 2000 United States Census for households with automobiles. The Automobile Access factor was estimated, based upon the New Orleans experience, that friends and relatives would evacuate one-half of the households who do not have access to automobiles by automobile. Thus, an urban area in which 90 percent of households have cars would have an Automobile Access factor of 95 percent (one-half of the auto-less would not be evacuated by car).

Evacuation Capacity Index: The Evacuation Capacity Index for each urban area is determined by multiplying the Automobile Access score (percentage) by the Roadway Evacuation Score.

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