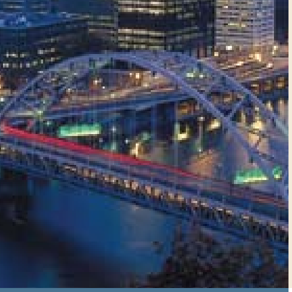

University of Pittsburgh

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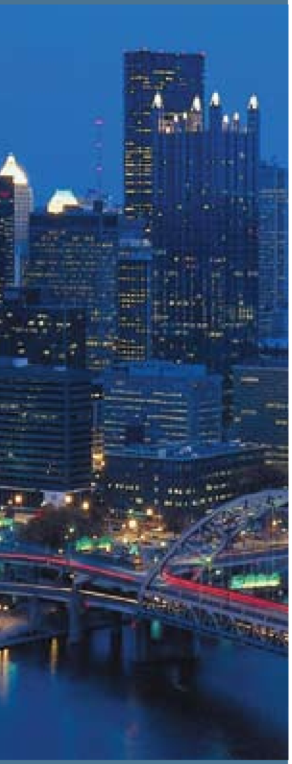

New Disaster Modeling System Assists in Emergency Planning

By Larry Shuman, Bopaya Bidanda, Bryan Lawson, Ken Sochats, and Carey Balaban

Emergency planning requires new tools to adjust dynamically to changes in the urban environment and simulate responses to a variety of emergencies. An interdisciplinary team of University of Pittsburgh researchers from the Swanson School of Engineering and the Schools of Information Sciences and Medicine has been developing these new tools for a disaster simulation system.

This "all hazards" disaster modeling system, called the Dynamic Discrete Disaster Simulation System (D4S2), is tested in the City of Pittsburgh. The authors present a case that overspecification of emergency plans becomes ineffective and potentially counterproductive when emergencies are large and dynamic and require specialized assets. Dealing with complex and rapidly changing emergencies requires adaptive tools that can provide emergency managers with information to make decisions and evaluate the consequences of those decisions.

History of Emergency Planning

Today, there are problems with the state of emergency planning and plans. D4S2 can help to make emergency planning more robust.

Emergency plans serve us well in preparing for day-to-day emergencies that are small, localized, numerous, and uniformly distributed throughout a city. The goal of an emergency plan is to provide stakeholders with an equal and effective response to all hazards. The optimal strategy is to locate response assets as close to the event as possible, which generally results in response assets evenly distributed throughout the city.

While this problem statement is a simplification, it is not too far from the current mode of emergency planning. City planners and emergency agencies normally tend to distribute their emergency response assets (fire, police, emergency medical services [EMS]) to address everyday emergencies. Factors such as population density, occurrence rates, topography, and transportation networks are taken into account to adjust the assets' locations. Political factors also weigh in to the plan. Every citizen wants emergency response to be quick and nearby.

There are several impediments to achieving the goal of rapid and even response. Some emergency assets are so specialized (e.g., hazmat, SWAT, bomb squads) that a city may only have one or a few units. Hospitals and other assets are treated as fixed assets in the planners' equations since they are located by the goals of their respective owners rather than by emergency response.

This mode of planning can be extended to moderately sized emergencies. In the case of special events (e.g., sporting events, parades), assets are temporarily reallocated and/or a reserve force is maintained to support potential response.

■■■ *continued on page 2*

Internal Migration Within Southwestern Pennsylvania: Update for 2007

Population change at the local level is impacted not just by the migration flows of people into or out of the Pittsburgh region, but also constant movement of people within the region. There is a consistent exchange of population across counties within Southwestern Pennsylvania. Data from the Internal Revenue Service (IRS) county-to-county migration data sets are compiled here to measure migration within the Pittsburgh region. Data are presented for the seven counties that constitute the Pittsburgh metropolitan statistical area: Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, and Westmoreland, along with three adjoining counties: Greene, Indiana, and Lawrence.

Migration flows within Southwestern Pennsylvania are dominated by flows to and from Allegheny County. Annual migration from Allegheny County to the nine remaining counties of Southwestern Pennsylvania was estimated at 10,748 between 2006 and 2007. Over the same period, 8,132 persons were estimated to have moved into Allegheny County from those nine counties. Figure 1 shows the annual flow of migration between Allegheny County and the nine remaining counties of Southwestern Pennsylvania between 2000 and 2007.

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Large emergencies present an even greater challenge for disaster planning. Large emergencies often require assets from the entire city, or beyond the city, acting as a kind of surge capacity. Large events also may change the basis upon which the plans were made, such as when roads, bridges, and tunnels become inaccessible.

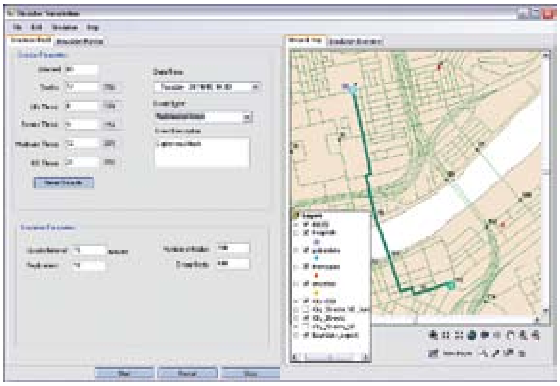


Figure 1

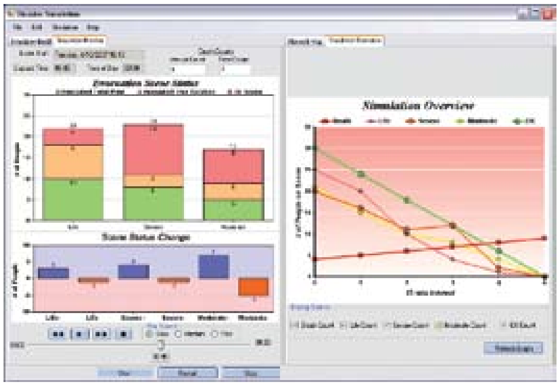


Figure 2

The basic problem with this type of emergency plan is that it is brittle. Cities change. Economic development and major real estate projects rearrange the shape and distribution of activities and people in a city. New areas that open for development—such as waterfronts, hillsides, and limited-access neighborhoods—are often, by their nature, harder to respond to in emergencies.

In many cities, emergency response is less uniform across neighborhoods because of these kinds of change. More frequent replanning is problematic, because the real and political costs of reallocating response assets are very high.

A New Tool: D4S2

D4S2 provides an independent laboratory for testing how the type and scale of an event, situational variables, and command decisions affect responders' efficiency and effectiveness in dealing with disasters. D4S2 seamlessly integrates commercially available off-the-shelf components, including ArcGIS 9.2, Rockwell Automation's Arena discrete event simulation with a custom-built rule-based decision modeling system, and a control interface that mirrors an emergency operations center.

The City of Pittsburgh provides the development case for the construction and validation of the system. Many insights were gleaned as a result of applying D4S2 to specific disaster scenarios in Pittsburgh.

D4S2 contains more than 100 layers of geographic, asset, and other geo-referenced information. The geographic data describe infrastructure and physical details, such as roads, waterways, and topography. Information about emergency response resources—such as fire, police, and EMS units—is stored in the geo-database and associated with the infrastructure. Real-time environmental data such as weather and traffic conditions are also part of the system.

When used with the simulation model, the geographic information system (GIS) can feed data to the simulator and make the simulation more realistic and robust. Keeping the geographic-related data in an independent GIS system simplifies the system deployment process. The disaster simulation system also can be quickly implemented in any area that has the appropriate GIS data.

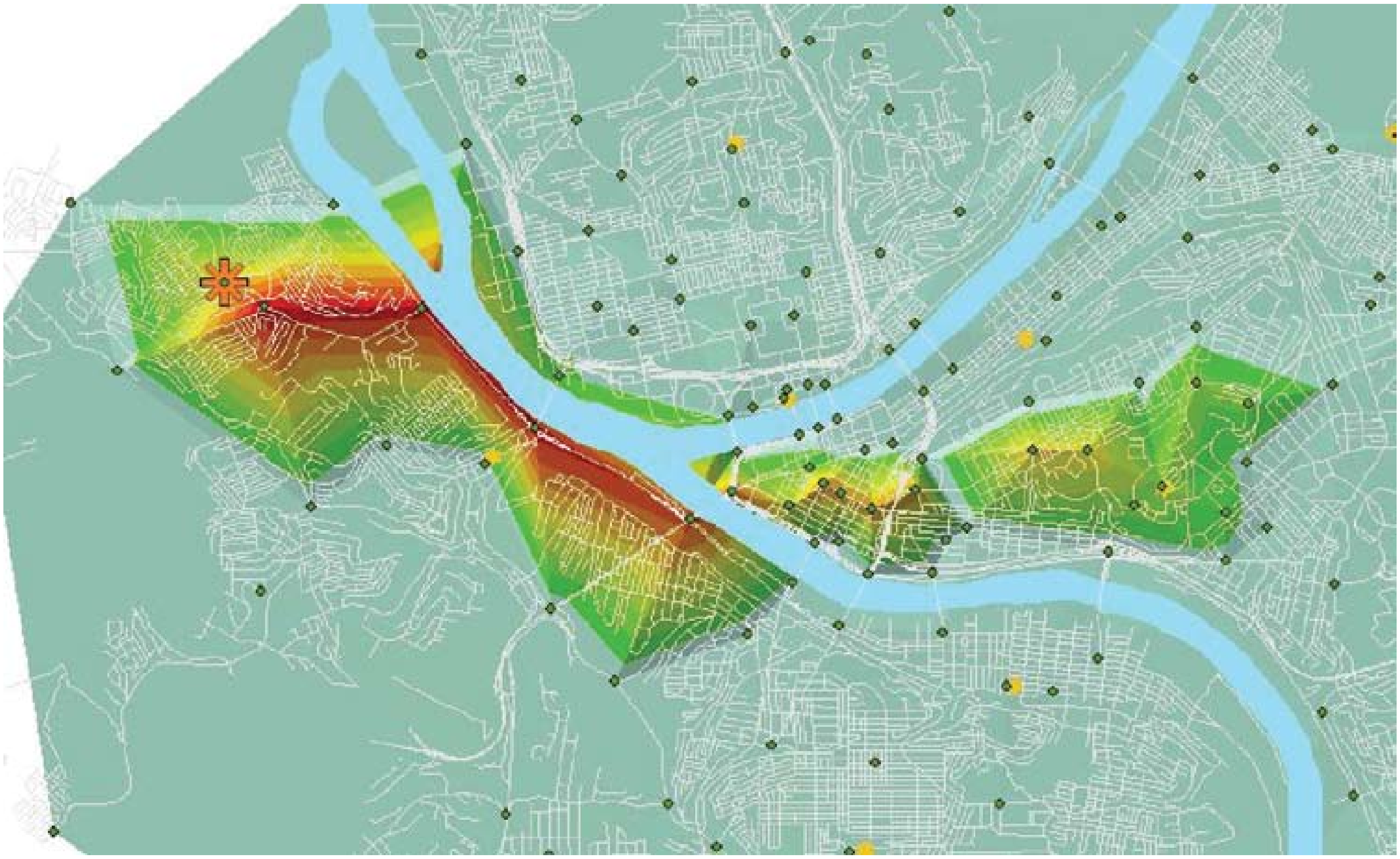
The simulation model allows us to create any number, type, and size of emergency events. In essence, the system "reads the map" and forms a simulation model. The simulation model uses discrete event simulation as the main construct and models the emergency response system as a transportation network. Important street intersections are chosen as network nodes. The response vehicles are the entities moving along the network and performing various response tasks. The entities are built in different layers, such as cars on the roads, trains on the railways, boats in the rivers, and helicopters in the air. D4S2 uses an innovative method to model other pieces of the system to reduce computational efforts.

In addition to discrete event simulation, D4S2 uses agent-based simulation techniques to incorporate more realistic and flexible entity operations and interactions. Agent-based modeling originated from artificial intelligence. A computer agent is an autonomously controlled entity that can perceive its own operations as well as the surrounding environment, compile the predefined rules to make operational decisions, and act based on these decisions. The individual agents operate on their own but are affected by other agents and the environment.

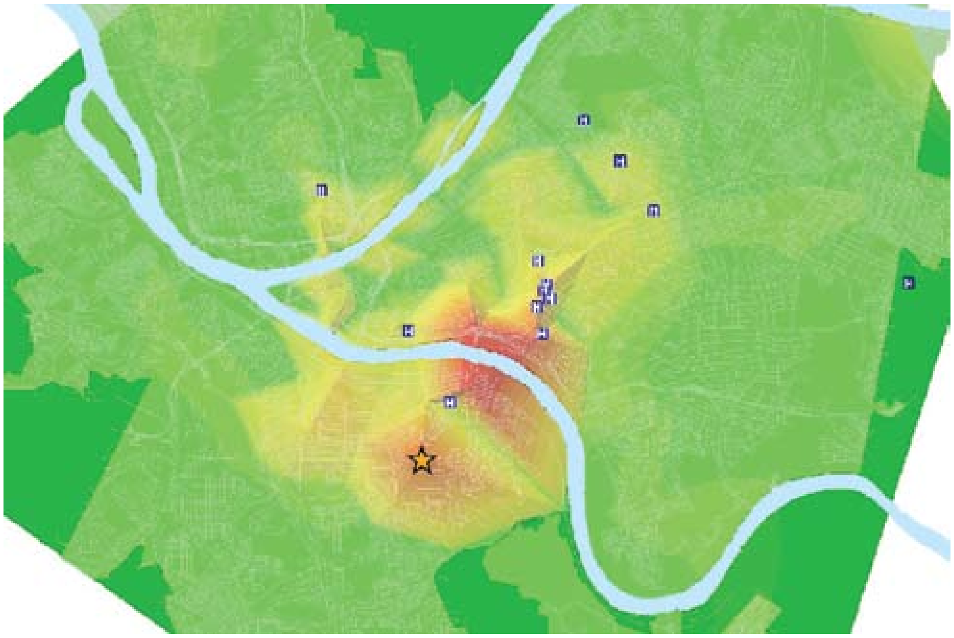
The behavior and interaction of the agents are defined by rules derived from industry standards, training, best practices, exercises and research on first responders, emergency managers, dispatchers, the public, terrorists, other actors, and environmental factors. All of the rules are formulated to the if-then format to state explicitly the conditions and consequences. A software module—the knowledge engine—uses the rules in conjunction with the system's data and user input to make decisions. These decisions may change the simulation, move assets within the GIS, or cause other actions to be taken.

Each component continuously informs the others of decisions and other changes as the events unfold. The model provides an independent laboratory for testing how the type and scale of an event, situational variables, and command decisions affect responders' efficiency and effectiveness in dealing with disasters.

Users interact with the system through interfaces modeled after existing emergency operations center interfaces. The figures above show two interface displays. Figure 1 is the event specification interface. This allows the user to define, in detail, the characteristics of an emergency (location, type, time, casualties, etc.). The system builds in event profiles from the 15 emergency event scenarios created by the Department of Homeland Security. In addition, casualty distributions from the experience of the military are available to help the user describe an event. The user is completely free to override these aids.



Map 1



Map 2

Figure 2 shows the results of a simulation of the event. In particular, the display shows the status of victims over time and the evacuation of those victims from the scene. VCR-like controls allow the user to move to any interval in the simulation; interrupt the simulation; introduce new events; change rules, decisions, or parameters; and resume the simulation. Essentially everything is in the control of the user.

Simulation Results

Map 1 shows the traffic congestion resulting from a D4S2 simulation of a hypothetical explosion in the West End effecting 80 casualties. The simulation uses the existing dispatch and triage protocols. The simulation encompasses the response of emergency equipment to the emergency and the evacuation of casualties from the emergency. In this emergency, the casualties must be transported from the West End to Oakland, where the bulk of the serving hospitals are. The map is colored red for highest traffic congestion, yellow for moderate congestion, and green for minor congestion.

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Table 1 compiles data on the most recent annual migration flows between each pair of counties within Southwestern Pennsylvania. The migration flows from Allegheny County over this period is 3,619 people who moved from Allegheny County to Westmoreland County, followed by 2,524 who moved from Allegheny County to Washington County. Over the same period, 2,623 people moved from Westmoreland into Allegheny County, and 1,790 people moved from Washington into Allegheny County. More than 28,000 people were estimated to have moved between counties in Southwestern Pennsylvania between 2006 and 2007.

Table 2 compiles the largest net migration flows between each pair of counties within Southwestern Pennsylvania between 2006 and 2007. The largest net migration flow was the 996 additional people who moved from Allegheny to Westmoreland County compared to the number who moved from Westmoreland to Allegheny County.

The IRS migration data use administrative records (income tax returns) from the IRS individual master file to produce statistics on the movement of people between counties across the country. The individual master file includes a record for every Form 1040, 1040A, and 1040EZ individual income tax return filed by citizens and resident aliens. Statistics derived from individual income tax returns are based on year-over-year changes in the addresses reported by tax filers.

The IRS does not release any data on individual taxpayers but aggregates the total number of people who move between each pair of counties. Additionally, data are suppressed for county-to-county migration flows with less than 10 filings in a given year. For each pair of counties that the IRS identifies as having a flow of migrants, the IRS reports the total number of filings along with the total number of exemptions claimed, the median adjusted gross income, and the aggregate adjusted gross income for that set of filings. The migration data reported here reflect the total number of exemptions claimed on tax filings, which is considered to be a proxy for population.

IRS migration data are not a complete picture of migration flows in the United States. A significant amount of migration in the United States comes from international immigrants who are typically not residents needing to file IRS tax returns before entering the country. The IRS migration statistics mostly capture domestic, or internal, migration of population within the United States.

The IRS data do not capture all domestic migration due to the fact that not everyone files a tax return. Students, senior citizens, those who have recently lost a spouse, or others with low income are some of the populations that are not captured well by IRS tax filings. Overall, the IRS migration data are estimated to capture more than 80 percent of the movement of the population domestically within the United States.

IRS migration data are one of the primary data sources used by the Census Bureau to calculate annual estimates of population change by county. The Census Bureau uses IRS migration data to derive net domestic migration rates for the household population younger than age 65. The Census Bureau calculates net domestic migration rates for the household population age 65 and older from tabulations of Medicare enrollees in each county obtained from the Centers for Medicare and Medicaid Services. ■

Figure 1. Annual Migration Flows Within Southwestern Pennsylvania: 2000–07

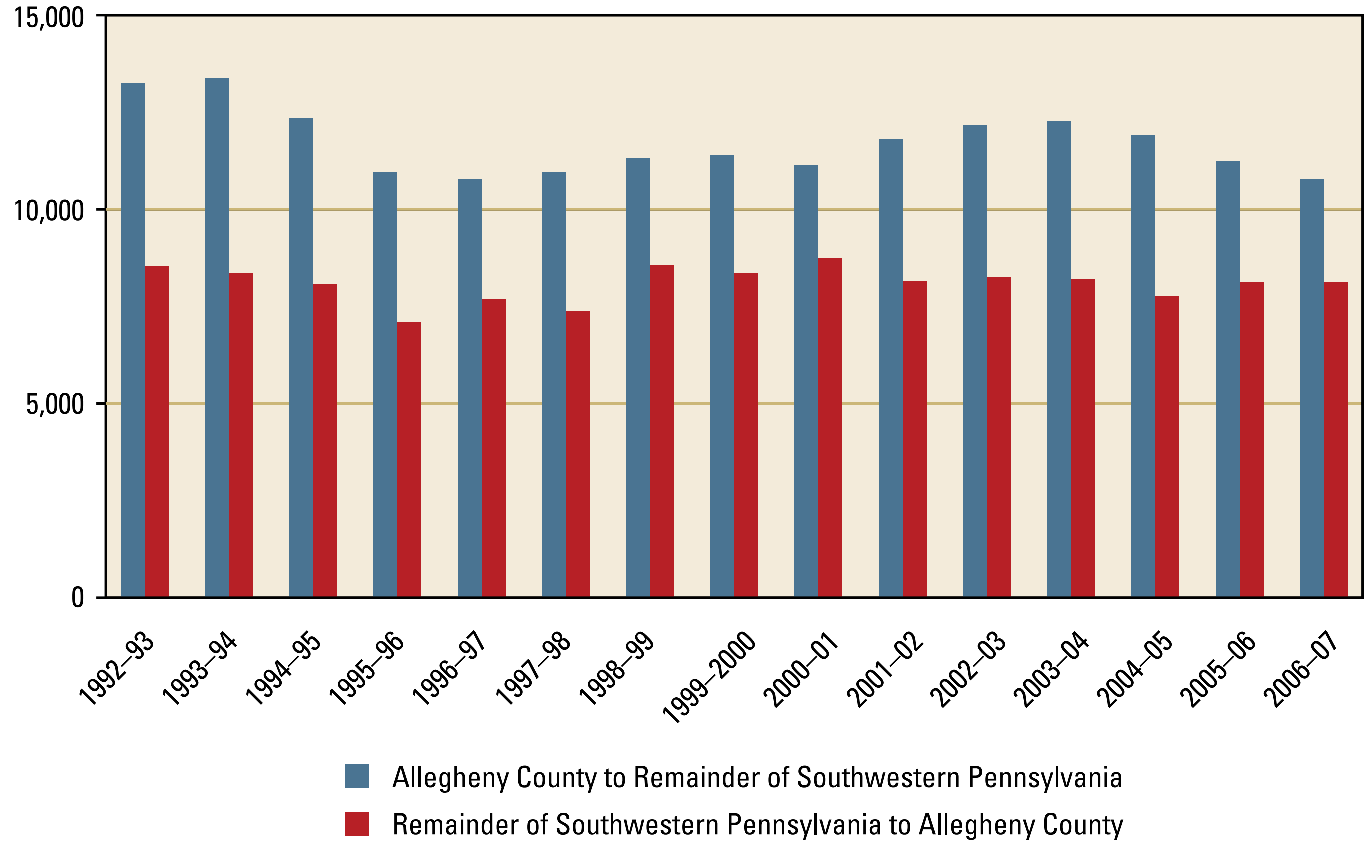

Table 1. Recent County-to-County Migration Flows Within Southwestern Pennsylvania 2006–07

Destination County

Originating County

	Allegheny	Armstrong	Beaver	Butler	Fayette	Greene	Indiana	Lawrence	Washington	Westmoreland	Subtotal
Allegheny		324	1,537	2,090	273	62	161	158	2,524	3,619	**10,748**
Armstrong	305		*	261	*	*	190			451	**1,207**
Beaver	1,174	*		355	*	*	15	372	97	64	**2,077**
Butler	1,405	215	404		30	*	29	220	62	145	**2,510**
Fayette	304	*	22	20		131	*	*	334	727	**1,538**
Greene	82	*	*	*	124		*	*	279	31	**516**
Indiana	250	170	*	32	25	*		*	25	353	**855**
Lawrence	199	*	266	178		*			31	21	**695**
Washington	1,790	*	81	77	349	285	26	*		464	**3,072**
Westmoreland	2,623	460	74	244	770	17	364	35	437		**5,024**
Subtotal:	**8,132**	**1,169**	**2,384**	**3,257**	**1,571**	**495**	**785**	**785**	**3,789**	**5,875**	

*10 or fewer tax filings between counties

Source: University Center for Social and Urban Research, University of Pittsburgh, from IRS data

Table 2. Net Migration Between Counties Within Southwestern Pennsylvania July 1, 2006 through July 1, 2007

Destination County

Originating County

	Armstrong	Beaver	Butler	Fayette	Greene	Indiana	Lawrence	Washington	Westmoreland
Allegheny	19	363	685	-31	-20	-89	-41	734	996
	Armstrong		0	46	0	0	20	0	0
		Beaver	-49	-22	0	15	106	16	-10
			Butler	10	0	-3	42	-15	-99
				Fayette	7	-25	0	-15	-43
					Greene	0	0	-6	14
						Indiana	0	-1	-11
							Lawrence	31	-14
								Washington	27

Source: University Center for Social and Urban Research, University of Pittsburgh, from IRS data

continued from page 3

Map 2 shows the response congestion pattern for an emergency in the South Side area. The pattern is significantly different from the West End emergency. While the traffic is still concentrated in Oakland where the hospitals are, it is much more spread out because there are multiple bridges that are hospital route candidates.

Information from simulations such as these can provide emergency managers with real-time information on which roads to keep open and alternative vehicle routing and can support other kinds of decision scenarios.

Simulations of events all have unique and different response patterns. As the magnitude of the event increases, the pattern of response is further distorted and shaped by terrain, ambient traffic, weather, and other conditions. The results of our simulations support the first responder observation that "every emergency is unique."

Simulation and Emergency Planning

Emergency plans and planning can be helped by simulations in three major ways. First, simulation can provide a better basis for distributing response assets during the planning process. As the simulations above demonstrate, response, even to minor emergencies, can vary widely because of the complexities of the city. These differences in response are not always evident or predictable.

Second, simulation can help in evaluating and testing the viability of the emergency plans. As the city changes, simulations can help emergency managers and planners determine whether the plans will be effective in addressing anticipated emergencies. The simulations will then provide data for the planners to replan.

Finally, there is a point where the size, type, or characteristics of an emergency are beyond what the plans anticipated or are capable of dealing with. Simulation is a very good solution to providing the kinds of information that is needed in near-real time. Simulation systems such as D4S2 are very adaptive to changing environments and event progressions. ■

Larry J. Shuman (shuman@pitt.edu) is professor and associate dean for academic affairs in the Swanson School of Engineering. Bopaya Bidanda (bidanda@pitt.edu) is chair of the Department of Industrial Engineering and Ernest E. Roth Professor of Industrial Engineering in the Swanson School. Bryan Lawson (bdl8@pitt.edu) is project manager at the Visual Information Systems Center in the School of Information Sciences. Ken Sochats (sochats@pitt.edu) is GIS specialist at the University Center for Social and Urban Research and director of the Visual Information Systems Center. Carey Balaban (balabancd@upmc.edu) is professor in the School of Medicine.

Survey Research Program and Qualitative Data Analysis Program Enhance Capabilities

By Scott Beach and Don Musa

The University Center for Social and Urban Research (UCSUR) Survey Research Program (SRP) and Qualitative Data Analysis Program (QDAP) have recently added new technology and infrastructure to enhance their capabilities in collecting and analyzing social science data.

For many years, SRP has conducted computer-assisted telephone interviews, and UCSUR maintains a 32-station phone bank for the conduct of telephone surveys. SRP recently has developed capabilities in the area of interactive voice response (IVR) technology. This system, which should be familiar to anyone who has ever called a customer service center, involves a recorded voice administering survey questions, with respondents replying by using the keys on a touch-tone telephone or simply speaking the answer. Responses are automatically entered into a database for statistical analysis.

IVR systems are used in research in two primary ways, and SRP recently has conducted both types of studies.

The first application is for studies that require participants to provide multiple reports (e.g., several times per day) on events, reactions, perceptions, or feelings as they occur in the natural environment. Participants can "call" the IVR system, which conducts an automated data collection protocol without the need for a human interviewer.

The system is also "smart" enough to automatically place outbound calls when a participant misses a scheduled appointment. SRP is employing IVR technology in this way in a study of the effects of hemodialysis on sleep patterns in renal patients, who call the system up to four times daily to report symptoms.

The second application of IVR systems is in the collection of data on sensitive topics such as drug use or sexual behavior. The IVR system eliminates the need for the survey respondent to report embarrassing or illegal activity to another person. Research has shown that IVR systems result in more valid reporting of sensitive data than traditional interviews. In this application, live interviewers conduct the majority of a survey, with a switch to the IVR system for the sensitive questions. SRP recently conducted a study with adults age 60 and older in Allegheny County using IVR to obtain reports about elder abuse, and found higher prevalence of psychological abuse with IVR than with human interviewers.

QDAP is a newer UCSUR program. QDAP provides qualitative data transcription, coding, and analysis services, utilizing commercially available qualitative data software (see *Pittsburgh Economic Quarterly*, March 2007). QDAP is in the process of expanding to offer qualitative data collection as well as analytic services.

Qualitative data collection services to be offered will include in-depth interviewing, the conduct of focus groups, and more specialized techniques (e.g., cognitive interviewing). QDAP's goal is to provide start-to-finish qualitative methods expertise and services for any research project.

Most of the qualitative data coding and analysis carried out by QDAP has utilized the commercial software package Atlas.ti, and QDAP offers training in the use of this software, both on an individual and group basis. However, QDAP also has recently made available a free online qualitative data analysis program, the Coding Analysis Toolkit, developed by former QDAP Director Stuart Shulman. This program consists of a Web-based suite of tools facilitating efficient and effective postcoding analysis of qualitative data that has been coded using commercial software such as Atlas.ti.

Both the SRP and QDAP programs are expanding their capabilities and strive to maintain state-of the-art methodological expertise and services. ■

Scott Beach (scottb@pitt.edu) is director of UCSUR's Survey Research Program. Don Musa (dmuc@pitt.edu) is interim director of QDAP.

Pittsburgh Neighborhood and Community Information System Joins National Neighborhood Indicators Partnership

The Pittsburgh Neighborhood and Community Information System (PNCIS)—see *Pittsburgh Economic Quarterly*, March 2008 and March 2007—recently has become a partner of the National Neighborhood Indicators Partnership (NNIP), based at the Urban Institute in Washington, D.C. NNIP promotes the development, use, and expansion of neighborhood information systems by local policymakers and community organizations.

PNCIS, housed at the University Center for Social and Urban Research (UCSUR), brings together more than 50 neighborhood-level indicators from a variety of administrative data sources. PNCIS supports efforts to reduce blight, promote neighborhood investments, and improve communities through the collection, maintenance, and analysis of high-quality, neighborhood-level data. UCSUR works directly with the city of Pittsburgh, Carnegie Mellon University, and 10,000 Friends of Pennsylvania on PNCIS.

As a NNIP partner, PNCIS has access to resources and expertise on community information systems through the 29 other NNIP partners across the United States. We look forward to our new partnership and working with NNIP to support the continued development of PNCIS.

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Fax: 412-624-4810
E-mail: ucsur@pitt.edu
Web site: www.ucsur.pitt.edu

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Assistant Editor
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