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Design for Evacuation: Improving City Evacuation Instructions

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KEYWORDS *Cognition, education, evacuation, semiotics, wayfinding, performance, public*

ABSTRACT A recent benchmark concluded that only 9% felt confident in knowing how to respond to a city evacuation order. The benchmark also indicated that 80% would not know how they would be notified, and 86% would not know what to do should they be notified. This paper links the taxonomy of semiotics and visualization currently used in two approaches of evacuation information—city and aircraft scenarios—and provides juxtapositional perspectives in visual representation, as well as addressing issues of effectiveness of communication, planning, and training. Evacuation materials look and perform differently, not only due to spatial and logistical constraints (such as between city and aircraft scenarios), but also in evacuees' communicative relationships (receiving, reading, and comprehending instructional information). Cognitive variables in the psychology of emergency ingress and egress, collective behavior, tunnel vision, and issues in temporary cognitive paralysis are applied to the assessment and evaluation of evacuation documents. The assessment and conclusion in addressing current evacuation material will be presented as a proposal for a city public pre-evacuation campaign improving resident education, training, and "path knowledge."

INTRODUCTION "Evacuation" is not an entirely abstract concept, especially to those who attended grade school in the United States and performed the countless required evacuation drills conducted there. During World War II the United States government introduced a systemic public awareness campaign in anticipation of a nuclear attack. *Duck and Cover* was a social guidance film demonstrating instructions and reenactments of emergency procedures in the event of a nuclear attack. A live-action version of the film was aired on television while an animated version was created for grade schools starring Bert the Turtle as an anthropomorphic character for safety (*Duck and Cover* was written by Raymond Mauer and directed by Anthony Rizzo, produced by Archer Films, under contract of the United States Civil Defense Branch, 1951/1952).

Institutions in the United States continue to use the catchphrase "duck and cover" as part of emergency preparedness protocol, allied with other catchphrases such as: "drop, cover, and hold on" (for earthquakes), "stop, drop, and roll" (for fires), and "tuck and hold" (for tornadoes). I remember, as a child, hearing these kinds of phrases; the repetition of safety drills from my youth is anchored to my learning development, and I have retained these instructions as long-term childhood memories.

Repetition and consistencies in the construct of text (verbal or printed instructions), spatial recognition (constructed and complete cognitive map of an area), and image (tone and appearance of instructions), shape social conventions and expectations for both school and workplace evacuation "path knowledge."[1] Path knowledge is spatial familiarity with the physical surrounding environment and the ability to establish a mental map of various routes and detours within that space. Emergency planning and training (e.g., emergency drills) help develop a sound cognitive map toward comprehensive path knowledge.[2] In the event of an actual emergency a person's cognitive attention will be abruptly interrupted by an environmental clue, such as an earthquake, the smell of smoke, or nearby people responding to an alert. These variables can signal and initiate a response to previous path knowledge, actions, and expectations already learned in previous training experiences. For example, airline passengers are presented with required safety demonstrations and material that is similar irrespective of the airline. Therefore, "Frequent flyers" develop healthy emergency path knowledge because of mandated, repetitious, and consistent emergency safety review before every flight. This systemic campaign regulated by the FAA builds a mental map specific to the space of an aircraft, conventions, and expectations. In 1992, Trans World Airlines Flight 843, airborne for six seconds, aborted the take-off with 292 passengers. The plane had a full tank of fuel and ignited when the force of the abrupt landing fractured the right wing. With fire and smoke filling the plane, there was "almost no panic, little screaming or pushing—an almost eerie sense of order amid the glow of flames and the life-or-death evacuation."[3] Within 2–3 minutes, 292 passengers were evacuated, which was a demonstration of an extremely high level of coordination.

Residential evacuation, however, has not used the same tactics in establishing path knowledge. In 2010, a benchmark study conducted after the Southern California fires during 2007 and 2008, concluded that 80% of the people who lived in the vicinity of a major fire did not know how they would be notified if they needed to evacu-

ate and 86% did not know what to do after they were notified. The survey demonstrated weak route knowledge concerning local shelters, emergency routes, expectations, and protocol for picking up young schoolchildren. Most participants in the survey would rely on watching the news, contact through local authorities or media-technologies, or the influence of neighbors, all of which require learning new information at the very time of evacuation. In a presentation given by John and Barbara Sorensen at the Natural Evacuation Conference[4] they indicated that factors impacting warning evacuation response include: the construct of the warning message, experience of the population from past evacuation exercises, perceived risk and belief of harm, social interaction, and individual characteristics. During the 2007 San Diego wild fires it was estimated that only 59% of the threatened population actually evacuated. Reasons for those who did not evacuate included the following: 55% of residents did not feel threatened; 36% were not notified to evacuate; 8.2% stayed to protect their property; 4% stayed to protect their animals; and 2% said they just could not leave.[5]

The lack of a pre-existing instructional campaign for evacuation creates unacceptable amounts of new information, concerns, and protocols to be learned at the time of immediacy. Dr. John Leach is a lecturer in the Department of Psychology at the University of Lancaster, United Kingdom. His interests in cognition and human performance in extreme situations is discussed in his published works, including an article in A*viation, Space & Environmental Medicine* entitled "Why people 'freeze' in an emergency: Temporal and cognitive constraints on survival responses." He states, "'Freezing' causes evacuation delays which increase the danger, establishing a closed loop process and further extending evacuation delays. This behavior can be accounted for by considering the temporal constraints on cognitive information processing in a rapidly unfolding, real-time environment."[6] In 2008, Catharine Skipp, of Newsweek, interviewed Dr. Irwin Redlener about why some people ignore evacuation orders.[7] Redlener is the director of the National Center for Disaster Preparedness and associate dean for public-health advocacy and disaster preparedness at the Mailman School of Public Health at Columbia University. When asked by Skipp "What kind of person stays," Redlener shares current information:

> *We just did a study on evacuations under scenarios of disasters without warnings. We are very concerned about disasters that occur without warning when we have to do evacuations in real-time—in essence, immediate—for example, an earthquake or a terrorist nuclear attack. We found about two thirds of people with children would not comply with official orders to evacuate until and unless they were able to retrieve their children from school or day care. If we have two thirds of the population with children that would not comply, what we would have is evacuation chaos and an absolute breakdown of disaster response in circumstances that provided no warning. Under those circumstances, unless we get much better at having well-developed disaster plans that parents were comfortable with, we can anticipate extreme chaos as public officials would be unable to stop parents determined to get their kids.*

This paper describes the process toward developing a public information campaign that can improve situational cognitive path knowledge in evacuation preparedness. Semiotics, textual, and visualization factors currently used in evacuation information will be assessed and a proposed campaign will be presented. Cognitive variables, including considerations in the psychology of emergency ingress and egress, collective behavior, phenomenon of tunnel vision, and issues in temporary cognitive paralysis will be applied in addressing current evacuation material.

EMERGENCY BEHAVIOR

Issues of stressed cognition (including the quality of retained information, effects of timed tasks, phenomenon of tunnel vision, and information overload) have been integrated into the interdisciplinary discourse between psychology, information design, and interaction design. However, stressed cognition respecting reading and comprehension performance during dramatic shifts in cognitive demands caused by an abrupt change in the environment is not commonly considered, particularly when an event is perceived as urgent or dangerous. Artifacts that have been designed for specific situational communication—first-aid pamphlets, instructions for epinephrine injections, evacuation aids—must recognize the importance of understanding the impact of this shift in cognition.

Memory and the ability to problem-solve and assess are vulnerable when confronted by an urgent situation. This vulnerability is subject to the phenomena of tunnel vision and/or temporary cognitive paralysis. Tunnel vision has been associated with extreme stress, information overload, and exhaustion in which primitive tasks become central to cognitive processing and problem-solving capabilities are limited.[8] A person with tunnel vision may be unable to respond at the appropriate level the situation requires. Temporary cognitive paralysis, such as when

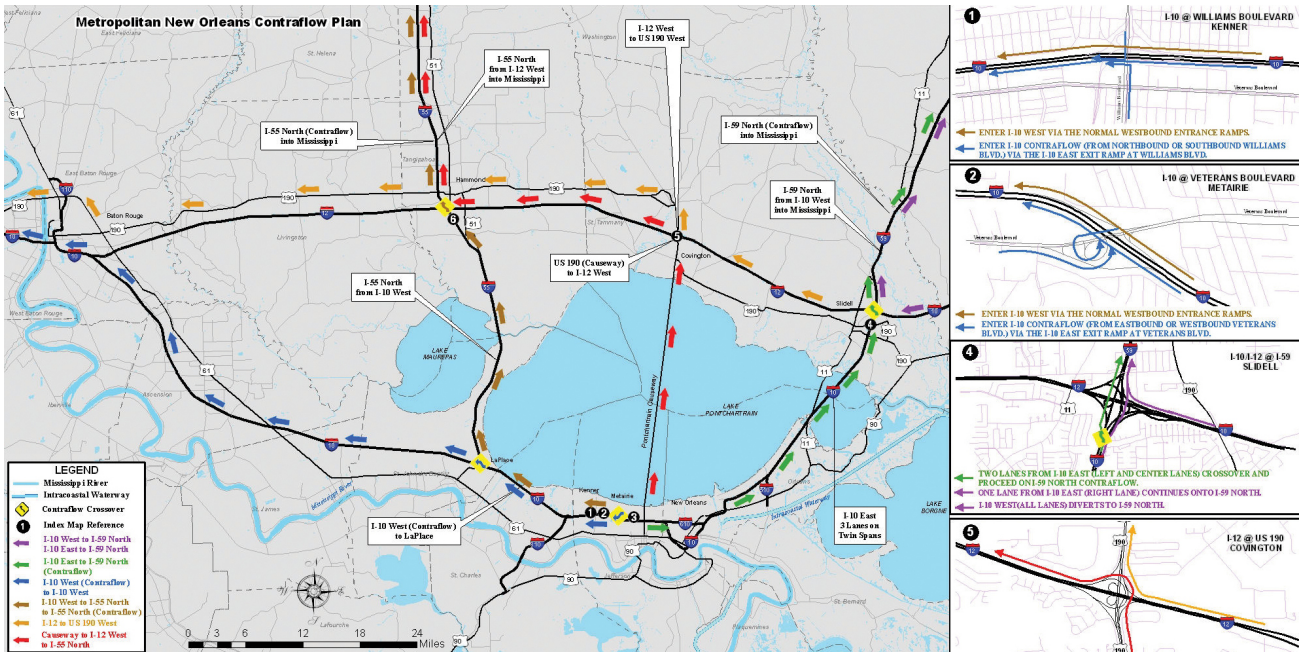

IMAGE SOURCE: LOUISIANA HOMELAND SECURITY & EMERGENCY PREPAREDNESS

FIGURE 1: *Metropolitan New Orlean Counterflow Plan*

people "freeze" in an emergency, is also associated with people experiencing dramatic shifts in cognitive demands as a result of an abrupt change in the environment.[9] Variables that affect cognitive paralysis include limited reaction time, perception of danger to themselves, and previous training or experience.[10]

The literature regarding human behavior, including social attachment and crowd psychology, helps initiate an understanding of these dramatic shifts in cognitive demands. Although panic does not play a major role in evacuation behavior, theories of panic provide helpful models when looking at fundamental stability when confronted with instability. When an individual is faced with an evacuation order, instincts for self-preservation supersede all other social activities or daily routines.[11] Micro populations (e.g., neighborhoods) will begin to absorb feedback regarding their own actions through the verbal and non-verbal responses of others. The more pressure and immediacy individuals feel when they are in danger, the more unstable social attachment and conventions become. If an individual begins to act aggressively or "speeds" his or her actions in a way that is out of sync with everyone else, this may lead into "survivor's competition," where panic occurs as a response to the perceived need for self-preservation.[12] Panic is not usually the issue with city evacuations; rather, the issue is people's delay in evacuating. Crowd psychology and group affiliations offer a benefit in this case. When a group agrees on certain behavior and expectations, members of that group will act accordingly.[13] Thus, if a group is prepared and trained for sudden changes that require evacuation, expectations and behavior patterns will have already been defined. Social attachment will drive individual expected actions that had already been established.

Demographics, cultural experience, social conventions, and population density deploy variables that affects individual and group mental responses to visual, spatial, written, and verbal communicative triggers. It is also important to distinguish the travel patterns and travel behavior of a specific population. Whether the evacuation involves one neighborhood, or an entire city, the day-to-day travel pattern will change abruptly. For example, the evacuation map below was distributed in New Orleans. New Orleans uses a counter-flow plan that gives all roads a one-way designation during an evacuation.

This is counterintuitive to normal travel behavior and social expectations but effectively uses the city's infrastructure to expedite an evacuation. The question then becomes an issue of training: is the public aware of this change in expected behavior before the activity of driving on the "wrong" side of the road is required of them? Will people tend to crowd onto the "normal," expected on-ramps as they would habitually? The table below compares evacuation travel with other travel, which is useful not only to assess existing evacuation material but also to help design instructions with evacuation travel specifics.[14]

Specific demands for evacuation travel

Evacuation travel	Other travel
Action of travel is "ordered" and not voluntary	Action of travel is self-motivated
Travel is based on time limitations, usually as "quick as possible"	Travel is planned in advance with a personal preference of time allowance
Travel patterns are focused and direction of travel is shared by surrounding population	Travel patterns are diverse and distributed due to individual variety of destinations
Evacuation travel is new, with no prior experience in planning for this kind of travel	Past travel experience can be used as a reference to plan and prepare
Spontaneous surge of population density traveling at once affecting traffic control	Travel can be planned around social patterns of traffic density and control
Travelers experience frustration, anxiety, fright, anger, irritation, tunnel vision, temporary cognitive paralysis	Travelers are generally calm, with possibilities of positive responses, anticipation and irritation

THOMAS, BEST AND LIEBERMAN 2010

FIGURE 2:
A comparison of evacuation travel with other types of travel.

Other variables affecting successful residential evacuation include weather, time of day, transport modality, density and demographics of the evacuating population, geographical nature of location, and impact of the disaster to the area.[15]

In order to better anticipate behavior and response to an evacuation order, personas can be used from data collected by people living in a specified area. The collection of data includes information from those who have and who have not experienced evacuation in order to get an accurate representation of the population. Konrad Baumann exemplifies the use of personas in his paper, "Personas as a User-Centred Design Method for Mobility-Related Services" for *Information Design Journal*.[16] Cooper, Reimann, and Cronin list the principal steps as: "1) identify behavioral variables; 2) map interview subjects to behavioral variables; 3) identify significant behavior patterns; 4) synthesize characteristics and relevant goals; 5) check for redundancy and completeness; 6) expand description of attributes and behaviors; and 7) designate persona types."[17] In the context of evacuations, the target group will include a certain number of people with differing needs, lifestyles, training, etc., but it is in their shared objective and imitation of travel during evacuation that personas can be constructed and helpful in understanding communication objectives.

A parallel approach of summarized data, presented at the National Evacuation Conference by Thomas, Best, and Lieberman, included the specific characteristics of an evacuation trip, characteristics of the evacuating population, and the capacity of the transportation infrastructure.[18] The data "summariz[ed] the different population groups, their evacuation choices and the applicable Evacuation Time Estimates."[19] Influenced by Baumann's concepts concerning the creation of personas,[20] and Thomas et al's concepts concerning the collection of data specific to evacuation characteristics,[21] eight personas were developed that profile relevant subjects living within a potential wild fire evacuation zone in Orange County, California.

Persona Carol

Persona Carol, 23 years old, just graduated from college. She is unemployed and moved to a new city with her parents. Carol was born with an acute hearing impairment and she relies solely on sign language, reading lips or written form as means of communication. She volunteers at a local school as a teacher's assistant 5-days a week while she is applying for teaching jobs. She relies on her parents and the local bus routes for transportation.

Characteristics

FAMILY
- ❒ Parent/Guardian
- ❒ Single parent
- ❒ Grandparent
- ❒ Caretaker
- ■ Dependent

PROFESSION
- ❒ Student
- ❒ Employed
- ❒ Self-employed
- ■ Unemployed
- ❒ Retired

DEMAND GROUP
- ❒ Permanent resident
- ❒ Employee—live in another city
- ■ Living in city less than 6 months
- ❒ Visitor/Tourist

Modality

TRANSPORT NEEDS
- ❒ Personal car
- ❒ Shared household car
- ■ Public transport
- ❒ Walk/Bike
- ❒ Medical transport

DAILY ACTIVITIES
- ❒ Drop-off/Pick-up schoolchildren
- ❒ Carpool
- ❒ Commute to school or office
- ■ Public transport to school or office
- ❒ Other

Daily demands

50% OF THE DAY I AM...
- ❒ Driving
- ■ At home/errands
- ❒ At work
- ❒ At school
- ❒ Other

25% OF THE DAY I AM...
- ❒ Driving
- ■ At home/errands
- ❒ At work
- ❒ At school
- ❒ Other

25% OF THE DAY I AM...
- ❒ Driving
- ■ At home/errands
- ❒ At work
- ❒ At school
- ❒ Other

Evacuation event

NOTIFICATION
- ❒ I *do know* how I would be notified to evacuate if I were not at home
- ❒ I *do know* how I would be notified to evacuate if I were at home
- ■ I *don't know* how I would be notified to evacuate my home
- ❒ I would call the police/fire dept for more information
- ❒ I would rely on the news/radio
- ■ I would rely on neighbors

LIMITATIONS
- ■ There is a language barrier if I was given verbal evacuation instructions only in English (this also includes sign language)
- ■ I am visiting, or just moved, and unfamiliar with the city
- ❒ Myself or a family member has special medical/physical needs
- ❒ I don't have access to a cell phone or the internet

FAMILY WHEREABOUTS
- ❒ I *do know* the evacuation process at my child/children's school
- ❒ I *do know* the evacuation process at my own, or spouse's, workplace
- ❒ I *don't know* the evacuation process at my child/children's school
- ■ I *don't know* the evacuation process at my own, or spouse's, workplace
- ❒ I would not evacuate until I pick-up my child/children from school
- ❒ I would not evacuate until I pick-up my aging parent(s) from the convalescent home/hospice

EXPERIENCE/TRAINING
- ❒ I have evacuated before
- ■ I *have not* evacuated before

FIGURE 3A: *Persona Jennifer is a stay-at-home mother with two young school children.*

Persona Joe

Persona Joe, 79 years old, has been living in the same city since his early twenties. He is married of 51 years and have shared the births of seven grandchildren. Joe and his spouse are retired and live in a residential home for active seniors. Their adult children live other states and rely on medical transport to get them to-and-from errands, outdoor activities and doctor appointments. Joe requires a cane to walk due to a permanent knee disability. Ten years ago they had to evacuate their home due to a wild fire.

Characteristics

FAMILY
- ❒ Parent/Guardian
- ❒ Single parent
- ■ Grandparent
- ❒ Caretaker
- ❒ Dependent

PROFESSION
- ❒ Student
- ❒ Employed
- ❒ Self-employed
- ❒ Unemployed
- ■ Retired

DEMAND GROUP
- ■ Permanent resident
- ❒ Employee—live in another city
- ❒ Living in city less than 6 months
- ❒ Visitor/Tourist

Modality

TRANSPORT NEEDS
- ❒ Personal car
- ❒ Shared household car
- ❒ Public transport
- ❒ Walk/Bike
- ■ Medical transport

DAILY ACTIVITIES
- ❒ Drop-off/Pick-up schoolchildren
- ❒ Carpool
- ❒ Commute to school or office
- ❒ Public transport to school or office
- ■ Other

Daily demands

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- ❒ At school
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Evacuation event

NOTIFICATION
- ■ I *do know* how I would be notified to evacuate if I were not at home
- ❒ I *do know* how I would be notified to evacuate if I were at home
- ❒ I *don't know* how I would be notified to evacuate my home
- ■ I would call the police/fire dept for more information
- ■ I would rely on the news/radio
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LIMITATIONS
- ❒ There is a language barrier if I was given verbal evacuation instructions only in English (this also includes sign language)
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FAMILY WHEREABOUTS
- ❒ I *do know* the evacuation process at my child/children's school
- ■ I *do know* the evacuation process at my own, or spouse's, workplace
- ❒ I *don't know* the evacuation process at my child/children's school
- ❒ I *don't know* the evacuation process at my own, or spouse's, workplace
- ❒ I would not evacuate until I pick-up my child/children from school
- ❒ I would not evacuate until I pick-up my aging parent(s) from the convalescent home/hospice

EXPERIENCE/TRAINING
- ■ I have evacuated before
- ❒ I *have not* evacuated before

FIGURE 3B: *Persona Joe is retired and lives with his partner of 51 years in an active senior's retirement home.*

Persona Jennifer

Persona Jennifer, 35 years old, was a school teacher for ten years. She currently stays home with her two young children. She takes her 11-year old daughter to school every morning and her 3-year old son to preschool twice a week. Her youngest child relies on asthma medication twice a day. Her family has been living in the same home for 10 years and are well-adjusted to the community. She is unfamilar with the evacuation procedures at her child's school and would rely on her cell phone to contact her family and get more information. Her spouse is a police officer for another city and is away from home 10-hours a day.

Characteristics

FAMILY
- ■ Parent/Guardian
- ❒ Single parent
- ❒ Grandparent
- ❒ Caretaker
- ❒ Dependent

PROFESSION
- ❒ Student
- ❒ Employed
- ❒ Self-employed
- ■ Unemployed
- ❒ Retired

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- ❒ Carpool
- ❒ Commute to school or office
- ❒ Public transport to school or office
- ❒ Other

Daily demands

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- ❒ At school
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- ❒ At work
- ❒ At school
- ❒ Other

25% OF THE DAY I AM...
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- ❒ At home/errands
- ❒ At work
- ❒ At school
- ❒ Other

Evacuation event

NOTIFICATION
- ❒ I *do know* how I would be notified to evacuate if I were not at home
- ❒ I *do know* how I would be notified to evacuate if I were at home
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LIMITATIONS
- ❒ There is a language barrier if I was given verbal evacuation instructions only in English (this also includes sign language)
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- ■ I would not evacuate until I pick-up my child/children from school
- ❒ I would not evacuate until I pick-up my aging parent(s) from the convalescent home/hospice

EXPERIENCE/TRAINING
- ❒ I have evacuated before
- ■ I *have not* evacuated before

FIGURE 3C: *Persona Carol just graduated from college and is a volunteer as a teacher's assistant while she applies for work. She was born with acute hearing impairment and relies on sign language, reading lips and writing as forms of communication.*

EVACUATION COMMUNICATION

In a previous paper, "The Taxonomy of Urgent Wayfinding,"[22] I wrote about the effects of reading and comprehension in four proposed scenarios: *leisure*—being able to process information voluntarily with minimal anxiety; *direct*—processing an instruction or noticing a change in environment but not necessarily threatening or limited by time; *urgent*—processing information with alertness within various levels of anxiety and time limitations'; and *emergency*—immediately affected by the environment in a threatening way, resulting in less time to process information, reading and comprehension susceptible to tunnel vision, and temporary cognitive paralysis.

Reverse 911 calls are widely used by local governments and emergency services to inform the public to evacuate. For most people, this may be the first source of information and/or instructions for evacuation. A tsunami warning triggered by an earthquake in Japan on March 11, 2011, reached a resident in Newport Beach, California, as a reverse 911 call at 4 a.m. Since he was still asleep when the earthquake struck Japan and had not heard any reports from media, the 911 reverse call was the first information he had. Reverse 911 systems rely on a database of landline phone numbers collected from city-registered addresses. A pre-recorded message is able to distribute information to a large group of people at the same time. For cell phones, each individual user must register with a participating program. The issue involved with cell phones and other wireless services is that telecommunication infrastructures are prone to vulnerabilities caused by instantaneous density of users and may well overwhelm communication grids.[23]

In the United States, the Emergency Alert System (EAS) uses radio and television alerts that are coordinated with and activated by FEMA, the Federal Communications Commission, and the National Weather Service. The EAS system replaced the Emergency Public Broadcast System that was used in the United States from 1963 to 1997. The EAS is regulated by the Public Safety and Homeland Security Bureau, but each state has its own EAS plan. Although the information being distributed by reverse-911 calls and the EAS is consistent, the issue is that these modes of communication distribute information and instruction at the time of impact and/or immediate action is required. The model below reflects this distribution of information relating to time and the levels of reading and comprehension of

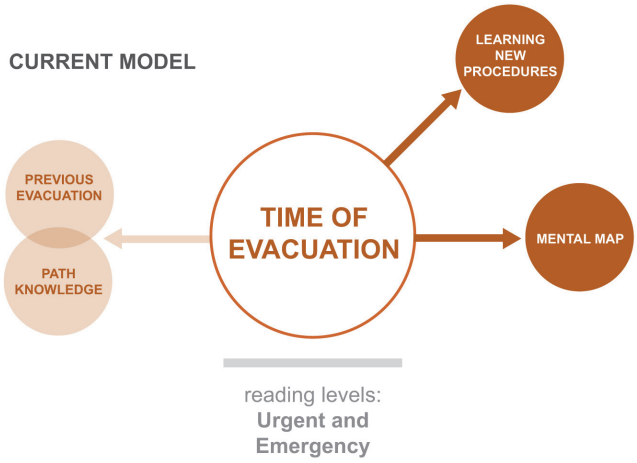


FIGURE 4: *A current model showing the distribution of information as it relates to time and the levels of reading and comprehension*

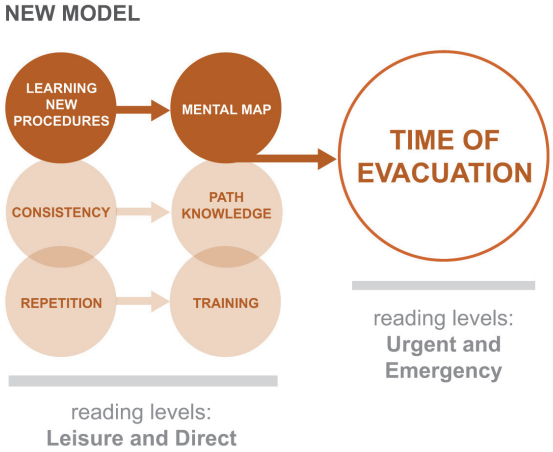


FIGURE 5: *Proposed model showing the role of a pre-evacuation campaign and learning new information as it relates to the levels of reading and comprehension*

the people receiving the information. A small percentage who have evacuated in the past may rely on previous experience and recall routes they used (i.e. path knowledge) as well as recollect evacuation procedures from memory.

A model plan would improve individuals' familiarity with evacuation routes (i.e., path knowledge), especially for those who have no prior evacuation training or experience, and provide time to associate and develop a mental map based on the new information well in advance of the need for action. New information is repeated, incorporated as a social expectation, and developed into a retainable mental model, thereby better positioning the person at time of evacuation.

Although some cities have tried to develop and/or increase public awareness toward the importance of evacuation preparation, such as offering emergency preparedness workshops, there has not been a systemic approach to evacuation-route knowledge. Materials are distributed to the public as evacuations occur. Information is available online but only if someone volunteers to access it (which is usually not until the information is needed). Where exercises and drills are mandated in the workplace or in schools, residential evacuation exercises are non-existent. Airline safety cards work because before each flight the Federal Aviation Administration requires a review of evacuation procedures and material. A frequent flyer will have had countless exposures to this information so that when an emergency oxygen mask is deployed, chances are that passenger will recognize what it is, what it is for, and how to use it. Passengers recognize the consistent narrative of visual and textual grammar regardless of the commercial airline they are using. Although the visualization and use of graphic variables are widely diverse, the consistencies of the overall narrative structures develop and sustain stable mental maps (FIGURE 6).

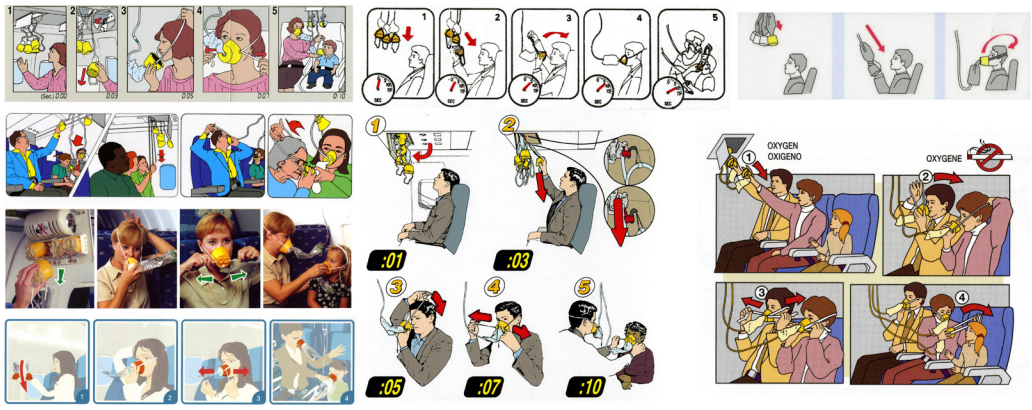


FIGURE 6: *Variations in showing how to apply an oxygen mask during an in-flight emergency*

SOURCES (FROM TOP LEFT COLUMN): CONTINENTAL 757, BRITISH AIRWAYS 737, AMERICAN AIRLINES 757, CATHAY 747, IBERIA 321, ALASKA 737, RYANAIR 737 AND US AIRWAYS A320

VISUALIZATION USED IN EVACUATION INSTRUCTIONS

In 2008, I conducted a national search for evacuation material distributed by local emergency agencies. The entire collection was presented in maps, as shown in FIGURE 2, and was only available online. As mentioned earlier, telecommunication infrastructures are not always reliable during mass evacuation, "…even in the most developed economies, catastrophic events routinely overwhelm communications grids. In fact, in these settings the sheer variety and complexity of network infrastructure and the far greater needs and expectations of victims and responders increases the likelihood that any single system may fail."[24] It is relevant to note my observation on the role of technology respecting preparedness. While living in Pasadena, California, I received a pamphlet each year from Pasadena's Integrated Waste Management regarding trash and recycling information. This reminds me of the airline safety card in that information is placed in front of you, whether in the form of a pamphlet, video, or demonstration, and exerts its message without your needing to search for it. I knew more about my trash schedule than I did about evacuation preparedness.

Technology (e.g. Internet, smart phones, laptops, GPS navigation systems, etc.) is a valuable resource, but limitations must also be acknowledged. Technology relies on a power source, whether someone already "owns" a device or is registered for a service. A person must volunteer to access information; even though technology is instantaneous and has the ability to simultaneously distribute information to large populations in different locations, it would be foolish to rely on technological devices as the sole portal to emergency information. This may also be the reason we see posted ephemera as a present and consistent response when searching for missing people after a disaster. Below is a collection of images taken from major events where people developed "hardcopy" informa-

FIGURE 7: *Thai hospital after the Indian Ocean earthquake in 2004; the streets of Mianyang after Sichuan earthquake in 2008 (Life); wall in New York after September 11, 2001; and postings after the Japanese earthquake and tsunami in 2011 (The Sacramento Bee).*

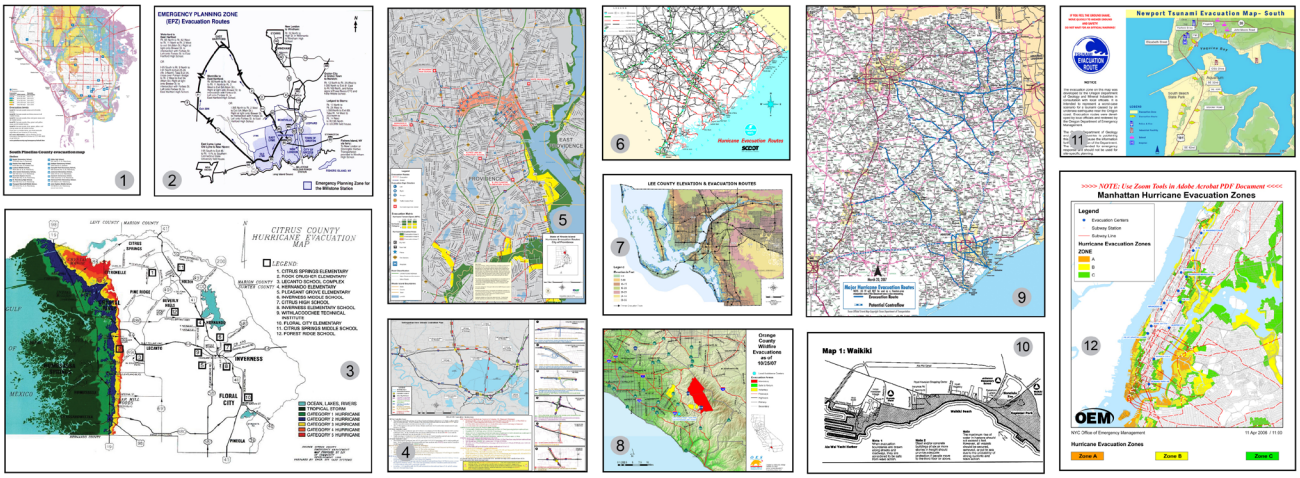


FIGURE 8: *Twelve evacuation maps used in the United States.*

tion systems in an effort to finding missing people, even though personal technology had long been integrated in these societies.

The problem with using maps as a general solution for evacuation instructions is the skill level required in wayfinding and map reading. The maps are usually never seen prior to an evacuation order, and visualization of instructions ranges from diagrammatic to re-appropriated road atlases. In the past, the graphic variables of these "road maps" have been sporadic, and many were lacking fundamental principles in visual construction. Most materials relied on "the map" as the main visual infrastructure, however, beyond this layer there were major problems in lower levels of the information. Jacques Bertin is a theorist of graphic representation who developed principles of the semiology of graphics in order to thoroughly understand visual language. He suggests that if similar graphic variables for the same kind of information are used, the images should demonstrate "maximum visibility."

Closer review of these maps reveals severe misuses of graphic variables—scale, color, typography, texture, shapes, composition, line, value, and orientation—and poorly executed visual constructions, which exemplifies issues that urgent and emergency cognition were not being addressed.

> *[Perception and behavior] breakdown in visual-motor coordination, an increase in apparent movement phenomena, increases in color saturation, decline in size and shape constancies, loss of accuracy in tactual perception and spatial orientation, increase in persistence of auto kinetic effect, larger figural aftereffects, difficulty in focusing, fluctuating curvature of lines and surfaces, and a general decrease in the efficacy of perceiving relevant stimuli.*[25]

The day of the recent Japanese earthquake and tsunami, I was scheduled to travel to Santa Monica, California. Because of the potential tsunami arriving on the west coast of the United States, Santa Monica was on alert for an evacuation. I searched online under "Santa Monica evacuation 2011." FIGURE 9 shows the PDF file I downloaded from the Santa Monica Fire Department website.

Upon review of the cropped version of the Santa Monica evacuation map and legend, red overwhelms the lower level information, including school locations, a safe refuge center, evacuation route directional arrows, and the typography for smaller street labels. Even at a leisure level of reading, the visual construction of this map is difficult and time-consuming. Considering the cognitive

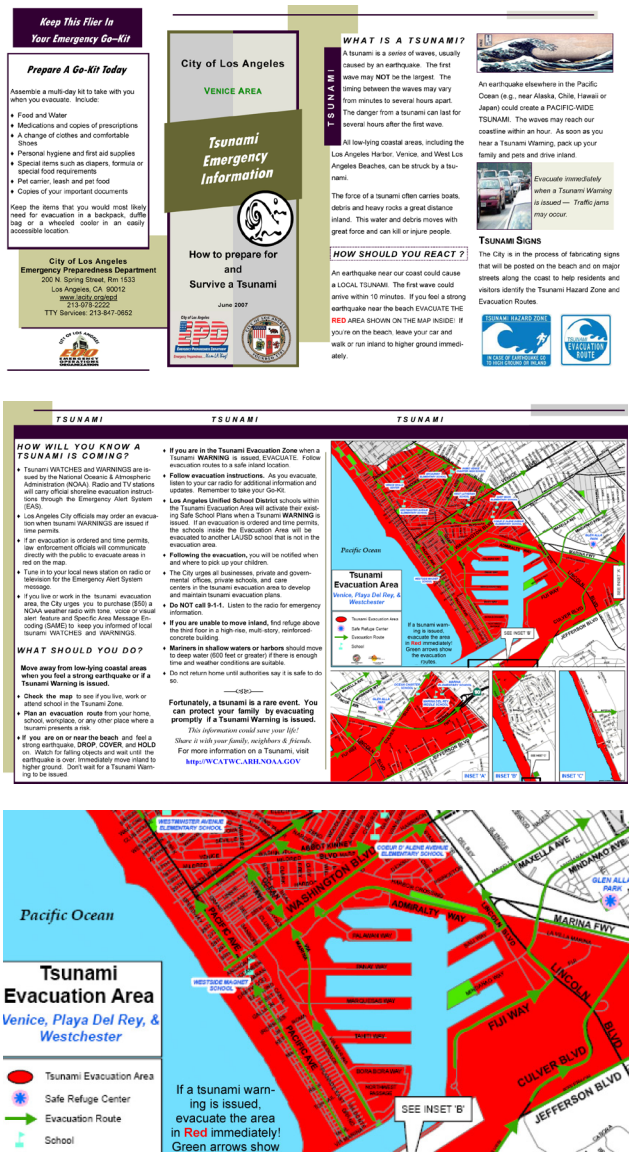
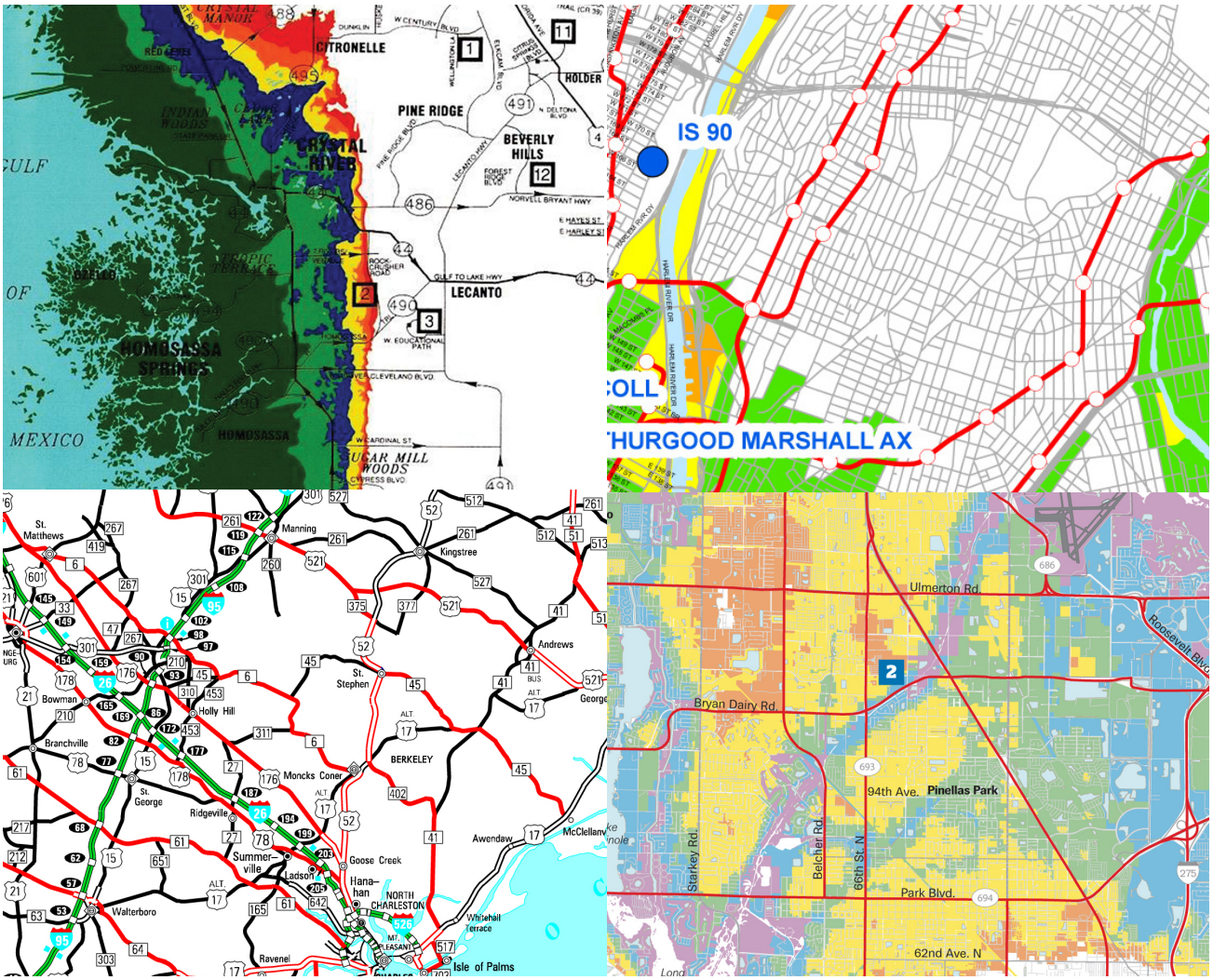


IMAGE SOURCE: CITY OF LOS ANGELES EMERGENCY PREPAREDNESS DEPARTMENT, SANTA MONICA FIRE DEPARTMENT (2011)

FIGURE 9: *"How to prepare for and survive a tsunami" Map source: Full page views of 1 and 2, and cropped view of page 2 from the City of Los Angeles Emergency Preparedness Department, Santa Monica Fire Department.*



IMAGES SOURCES: VARIOUS STATE GOVERNMENT AGENCIES. SEE BACK OF PAPER FOR SPECIFIC SOURCES.

variables at the time of evacuation, including learning new information under time constraints, this document fails to effectively communicate its intention.

Images such as the maps in FIGURE 10, are additional examples that contain numerous layers of graphic variables that affect length of components. A "component" is a single layer in an image that contains graphic variables. The more graphic variables are used in a single layer, and the more layers that are "stacked" on top of one another, the more complex the reading of the final image and meaning. Bertin terms this the "length of components". Components should support the intended image and message with careful consideration when organizing and numbering the visual separations (i.e. components) including icons, typography, foreground, background, color-coding, etc.[26] If graphic variables out-number the length of components, the macro image and final meaning

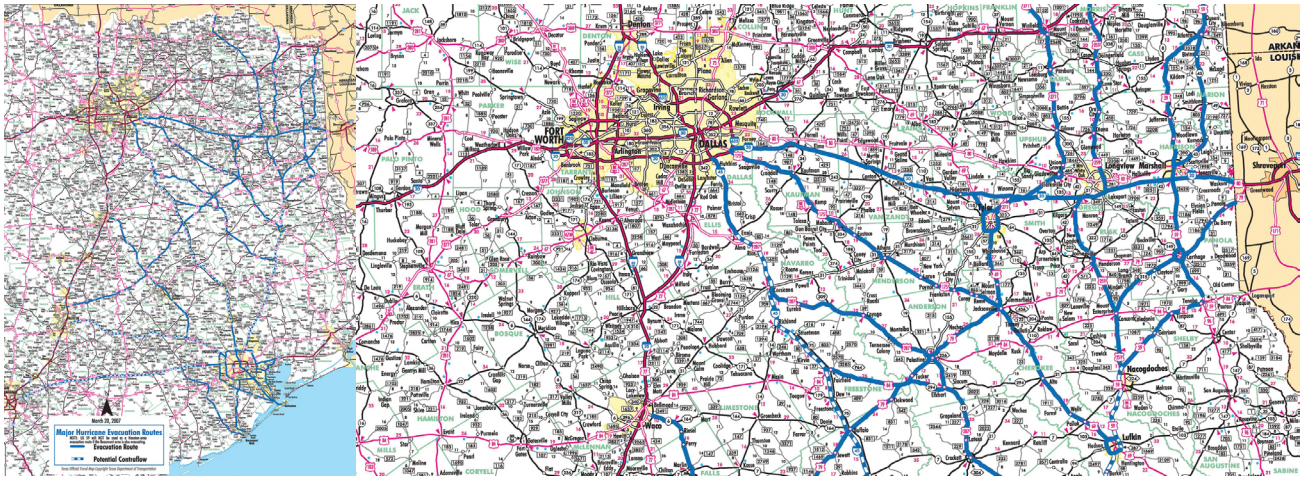
FIGURE 10: *Maps displaying various graphic variables as it relates to length of components.*

get lost in complexity and disorganization.

The map below, FIGURE 11, is also an example of how graphic variables out-weigh the length of components. The final message of this image is a mix of a very detailed road atlas and simple evacuation instructions that are superimposed on each other. When zoomed in for a detailed view, this map reveals sections of blue lines that turn into dashed lines. Referencing the legend, this graphical change signifies roads that have been transformed into same-directional highways. The density of this image makes it taxing to scan, filter, collect, memorize, and retain information that is specific to an evacuee. Bertin writes about the "rules of legibility" that include issues of graphic density, angular and retinal legibility. "Signifiers of routes, paths, streets and highways are susceptible to angular legibility. Bertin defines angular legibility as lines that are affected by changes of direction, resulting in lines causing angles. Map scale, exaggerations of directional change and angles approaching 0° or 180° all affect the legibility of angles."[27]

Evacuation material is also consistent and repetitive in the overuse of arrows to portray movement. Within our social convention, the arrow is understood to represent movement; arrows are visual verb phrases that, when used in these kinds of instructional maps, instruct movement from a two-dimensional printed page to actions that take place in three dimensions: the real-world.[28] FIGURE 12 illustrates arrows being used in both airline safety cards and city evacuation maps. These arrows are used specifically for evacuation movement, and it is interesting to see how airline safety cards and city evacuation maps are similar in arrow distortion, the use of perspective, and the competitive graphic variables that surround them.

In addition, putting aside the issues of relying on



MAP SOURCE: TEXAS DIVISION OF EMERGENCY MANAGEMENT, HOUSTON

FIGURE 11: *Map demonstrating poor graphic density, angular and retinal legibility.*

IMAGES SOURCES: VARIOUS STATE GOVERNMENT AGENCIES. SEE BACK OF PAPER FOR SPECIFIC SOURCES.

FIGURE 12: *Arrows used in airline safety cards and city evacuation maps*

an overwhelmed and vulnerable telecommunication infrastructure, the depiction of arrows used on smart phones and GPS devices present the same weak constructions (FIGURE 13). Without verbal or written instruction, these "visual verb phrases" would not visually function independently.

PRE-EVACUATION PUBLIC EDUCATION CAMPAIGN

Communication used at the time of evacuation, no matter how aggressive in language or how mindful the pre-planning, is susceptible to psychological and cognitive variables that shift from normal comprehension to unexpected human behavior and responses. In order for comprehension, memory, and retention to become more successful with this kind of cognitive shift, exposure to information and training must be consistent, repeated, exercised, and drilled.[29]

Below are some examples of the evacuation material that was distributed during the 2008 Orange County, California fire evacuations.

Currently, residences must volunteer to access evacuation information on the web prior and during an evacuation potential. The following pre-evacuation public education campaign addresses this concern and would rely heavily on the annual distribution of printed evacuation information that would be mailed to residences. Issues in the psychology of emergency ingress and egress, collective behavior, tunnel vision, as well as in temporary cognitive paralysis, have added significant design considerations in the creation of consistent visual and textual grammar towards maximum visibility. Graphic variables, length of components, graphic density, and angular legibility has been simplified and reduced to priority information and reading demands.

The first design draft was chosen for a city in Orange County, Brea, California. The relationship between text and pictorial renderings is borrowed from the narrative approach used in airline safety cards and utilizes a direct-conversation choice in language. The choice for size, tri-fold, and two-color format considers logistical ability to allocate resources to this campaign, including: printing, updating information, and mailing. Each city in the county would have the same template containing information that is specific to each city. A benchmark for this first design draft will be conducted in order to test for effectiveness and usability. The printed document will

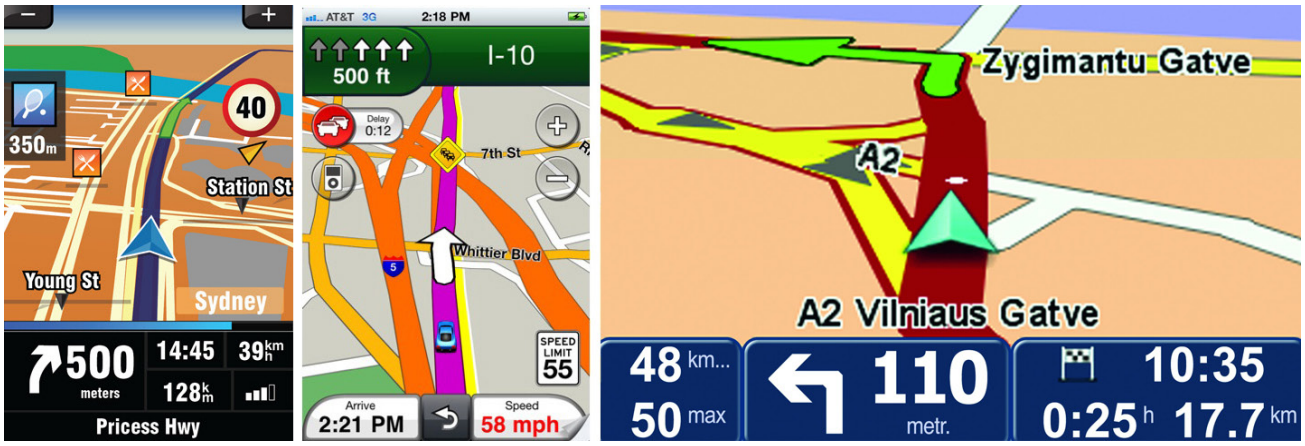
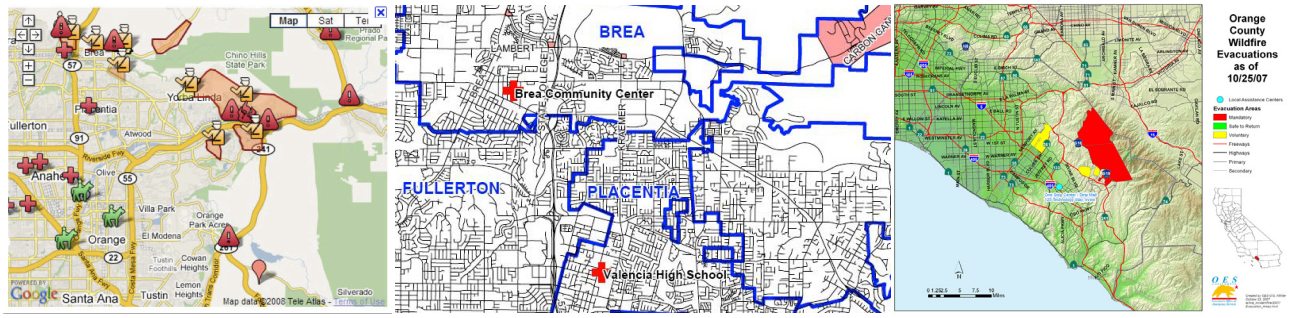


IMAGE SOURCES: SYGIC GPS NAVIGATIONZ GARMIN STREETPILOT AND TOMTOM NAVIGATION SCREEN

FIGURE 13: *Arrows used in navigation software*



VARIOUS STATE GOVERNMENT AGENCIES
IMAGE SOURCES LISTED AT END OF PAPER

FIGURE 14: *Evacuation material distributed during the 2008 Orange County, California fire evacuations*

FIGURE 15:
First design draft of a public evacuation campaign that would be mailed to city residences every year. This design campaign will begin a benchmark process and will be tested for usability in Summer 2012.

lead the evacuation campaign, followed by online and mobile access in order to achieve maximum visibility. The campaign will be revised and mailed annually.

The campaign revises formal visualization to an appropriate length of components at a leisurely reading level, when information can be better retained, understood and memorized. Because it is difficult to test document performance used for urgent or emergency scenarios, this design approach will be tested for performance under non-emergency conditions. By beginning with this scenario an understanding to the rationale and function of why these documents exist, how they are created, and whether they are useful for effective evacuation, can be evaluated.

BIOGRAPHY

Claudine Jaenichen received her BFA in graphic design at CalArts and her terminal degree in information design at the University of Reading in England. Her design and research projects apply issues in cognition and emergency psychology when assessing document performance and semiotics used in evacuation information. She is an Associate Research Fellow for Communication Research Institute.

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FIGURE 1: New Orleans, Louisiana. Louisiana Homeland Security and Emergency Preparedness. Viewed March 22, 2008. New Orleans area counter flow maps, hurricane and evacuation related information (Adobe Acrobat).

FIGURE 2: Thomas et al., "Addressing Uncertainty."

FIGURE 3: Jaenichen, "Taxonomy of Urgent Wayfinding."

FIGURE 6: From top left column, Continental 757; British Airways 737; American Airlines 757; Cathay 747; Iberia 321; Alaska 737; RyanAir 737; and U.S. Airways A320.

FIGURE 7: Thai hospital after the Indian Ocean earthquake in 2004; the streets of Mianyang after Sichuan earthquake in 2008 (*Life*); wall in New York after September 11, 2001; and postings after the Japanese earthquake and tsunami in 2011 (*The Sacramento Bee*).

FIGURE 8: 1) Pinellas County, Florida. Pinellas County Emergency Management. Viewed March 31, 2008. http://www.pinellascounty.org/emergency/Local.htm; 2) Town of Waterford, Connecticut. Viewed March 22, 2008. http://www.waterfordct.org/evacuationmap.jpg; 3) Citrus County, Florida. Board of County Commissioners. Viewed March 22, 2008http://www.bocc.citrus.fl.us/disaster/images/evacuation_map_land.jpg; 4) Louisiana Homeland Security & Emergency Preparedness; 5) Providence, Rhode Island. State of Rhode Island Emergency Management Agency. Viewed March 22, 2008. http://www.riema.ri.gov/hazards/hurricane_evac.php; 6) Charleston, South Carolina. South Caro-

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FIGURE 9: Full page views of 1 and 2, and cropped view of page 2 from the Santa Monica/Venice, California. City of Los Angeles Emergency Preparedness Department. Viewed March 13, 2011. Tsunami Brochure - (RED Santa Monica - Venice).pdf http://santamonicafire.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=22085&libID=22800

FIGURE 10: 1) Citrus County Board of County Commissioners, Florida; 2) South Carolina Department of Transportation; 3) The New York City Office of Emergency Management Hurricane Evacuation; and 4) Pinellas County Emergency Management, Florida.

FIGURE 11: Texas Division of Emergency Management, Houston.

FIGURE 12: Continental 757; British Airways 737; Alaska 737; British Airways 747; Virgin Atlantic A340; and Delta 767; Louisiana Homeland Security & Emergency Preparedness; Lee County, Florida Division of Public Safety Emergency Management; and State of Rhode Island Emergency Management Agency

FIGURE 13: Image sources: Sygic GPS navigation software, Garmin StreetPilot and TomTom Navigation Screen

FIGURE 14: Map sources: Orange County Governor's Office of Emergency Services, California (2008); OCRegister.com (October 18, 2008); and Orange County Fire Authority (November 16, 2008).