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14. ABSTRACT

The primary purpose of the CURE Project is to demonstrate whether or not there is a model or models of a Multi-Casualty Incident Center (MCIC) that can provide necessary surge capacity of hospital resources and personnel in the event of disasters. The CURE project team believes that a CURE Center, with access to state-of-the-art medical and information technologies, can provide cost-effective patient care surge capacity during incidents of natural, accidental, and intentional disasters. The specific objectives of the project were to: develop estimates of the number and acuity of patients requiring medical care after a disaster, develop and describe the concept of operations for a CURE Center, describe a model CURE Center, demonstrate and evaluate capabilities of this model, and validate the model. A systematic review of existing disaster literature has been performed and estimates of patient characteristics were made. An expert panel symposium was held to review this information and help finalize the conceptual requirements for a CURE Center. Using this information, along with facility requirements identified from geographical information systems analysis for the potential CURE site selected, a concept of operations for a CURE Center in the Loma Linda area was developed. Both print and video format for graphic demonstrations of the concept were developed. During this final research period, application of best practices and available modeling were used to validate the concept. Additionally, development of a Geographic Information System (GIS) based disaster tool was completed.

15. SUBJECT TERMS
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Introduction

The primary purpose of the Convertible Use Rapidly Expandable (CURE) Project was to demonstrate whether or not there is a model or models of a Multi-Casualty Incident Center (MCIC) that can provide necessary surge capacity of hospital resources and personnel in the event of disasters. This is a resource sorely needed within military and civilian environments, both in Southern California and around the world. Previous work reported on in this project has shown that by developing a site-specific plan for surge, a community can provide the necessary medical care required during emergency incidents. Advanced technologies, including telemedicine, web-based geographic information systems, portable Mesh communications systems, and space-saving, combined medical technologies serve to link separate surge centers and deliver quality medical care in alternative care sites.

During this CURE Project research period, two additional tasks were addressed. First, the team updated the data regarding surge requirements, then applied these data to the CURE Concept for validation of the model. Additionally, development of a Geographic Information System-based disaster tool was completed. These tasks are discussed in detail in the following pages.

Several articles have been published or prepared for publication during the tenure of this research. Copies of these are included as addenda to this report.

Administrative and Logistical Matters

On April 27, 2009, the Office of Sponsored Projects Management (OSPM) submitted a request to USAMRAA on our behalf for a final No Cost Extension (NCE). The NCE was requested because of the delay of the final execution of the contractual agreement between ESRI and LLUMC, and the associated time needed to complete the scope of work activities. We were granted the NCE by USAMRAA until October 31, 2009 (Research ending September 30, 2009). The extension also provided supplementary time for the CURE team to complete two additional tasks that included the following items:

1) Updating the data regarding surge requirements and applying the data to the CURE Concept for validation of the model
2) Completion of a Geographic Information System-based disaster tool.

Due to the NCE indicated above, certain staffing and effort for the period of the extension were modified in accordance with the remaining tasks. Subsequently, Dr. Lynch reduced her effort on the project to 20% and Dr. Corbett reduced his effort to 5%.

Scientific Progress for the No Cost Extension Period

Task 1: Update Previous Medical Data and Provide Quantifiable Data Analysis

Introduction

Emergency Department (ED) overcrowding is a nation-wide problem affecting the preparedness and safety of our health care system. Its causes are myriad and its consequences far-reaching. Overcrowding can reduce health care quality by increasing the potential for medical errors, prolonging pain and suffering, and reducing patient satisfaction with services.[1] The Institute of Medicine recently released a report that focused on three areas of emergency care: the prehospital care system, emergency departments, and pediatric emergency care.[2,3,4]

Capacity statistics that were cited indicate that an increasing demand for service, coupled with dwindling capacity, is stretching the system to breaking point. For example, the number of ED visits increased by 27% from 1993 to 2003, from 90 million to 114 million, although the population only increased by 12%. During the same period, 425 EDs closed and the number of hospital beds decreased by 200,000.[3]

Providing healthcare during a large-scale public health emergency presents significant challenges for healthcare facilities, licensed healthcare professionals, local health departments and communities. During emergency events, healthcare systems must convert quickly from their existing patient capacity to "surge capacity" – a significant increase beyond usual capacity – to respond to the needs of affected individuals.[5] Development of surge capacity for treating patients after a disaster is both essential and complicated.[6,7]   Local health departments and communities must be prepared to address gaps where the capacity of healthcare systems is exceeded.

The Convertible Use Rapidly Expandable (CURE) Project is designed to provide medical care for mass casualties during a major disaster. This care is conceived as being provided in space normally designed for an alternative purpose, such as a classroom, auditorium, cafeteria, library, or a parking garage. In previous reports, this concept was applied to an educational complex at Loma Linda University Medical Center. Initial assessment of potential patient numbers and acuity was performed during an extensive literature search. Additionally, an Expert Panel Symposium was convened to advise the CURE Team regarding optimal facility attributes, likely patient injury and illness patterns, and current best practices. This information was utilized during the initial planning states of a potential CURE Center.

During this current No Cost Extension period, the CURE Team set out to update the previous data and provide quantifiable data analysis where possible. These efforts were divided into the following tasks:

A. Describe the current surge response to hospitals and the regular surge of patient using the emergency department.

B. Perform an updated literature search regarding surge capacity in response to disasters

C. Project estimates of casualties and medical needs based on currently available models or best practices.

D. Estimate types and numbers of medical care providers required for responding during a triage deployment of the CURE Center, and for a critical care deployment.

E. Assess CURE Center projections during a disaster simulation exercise and revise as needed.

Definition of Surge Capacity

The concept of surge capacity is fairly new in the medical literature. One of the earliest definitions of medical surge capacity, published by the Joint Commission on accreditation of Healthcare Organizations (JCAHO) in 2003, states "Surge capacity encompasses potential patient beds; available space in which patients may be triaged, managed, vaccinated, decontaminated, or simply located; available personnel of all types; necessary medication, supplies and equipment; and even the legal capacity to deliver health care under situations which exceed authorized capacity. [7] (JCAHO 2003). The term is defined by the Agency for Healthcare Research and Quality (AHRQ) as "a healthcare system's ability to expand quickly beyond normal services to meet an increased demand for medical care in the event of bioterrorism or other large-scale public health emergencies."

Quantifying surge capacity focuses on items that can be acquired and measured. The AHRQ definition has broadened to include three essential categories of resources: beds, staffing, and supplies and equipment. However, it is important to note that surge capacity is not simply the accumulation of resources. Effective surge planning is not a "just in time event", but requires specific activities.

Developing metrics useful in determining surge

With the emphasis on evidence-based medicine, all sectors of medicine are diligently trying to ground their practice in metrics. However, in the science of surge, metrics are sadly lacking.

Proposals to improve surge capacity are abundant; however, surge capacity is poorly defined and there is little evidence-based comprehensive planning. There are no validated measures of effectiveness to assess the efficacy of interventions.

Handler, et al, state that research into the metrics of the science of surge is incomplete, research funding is inadequate, and we lack a criterion standard metric for identifying and quantifying surge capacity. [9] As noted in this same publication, metrics move the science of surge from the subjective and anecdotal to the objective and empirical.   In order to make this move, a panel was convened during the *Academic Emergency Medicine* Consensus Conference, "Establishing the Science of Surge," held in San Francisco, CA during May 2006. During this conference, the panel developed several consensus statements regarding further research into surge. These include that research and funding are needed to validate practical, high-value normalized metrics and tools that identify and characterize surge deficits and capacity, to develop metrics that have the highest utility in guiding the management of surge, and that a national registry to created for the purpose of collecting data from a representative national sample. Before implementing programs and processes to manage surge capacity, it is imperative to validate assumptions and define the underlying components of surge. [10]

As the nation prepares for a possible pandemic (H1N1 Influenza), these statements become even more imperative. However, no national registry has been established, and funding for surge research remains at a minimum. Thus far, no " practical, high value normalized metrics and tools" have been validated as a way to evaluate and manage surge.

The initial steps in developing metrics require that the various components be identified. Dynamic programming algorithms suggest that the optimal solution to a problem is a combination of optimal solutions to its subproblems. [11] The subproblems in surge capacity are, in effect, the components of surge. The challenge, of course, is that we now must go about the process of identifying all of the components of surge, recognizing that many of the subcomponents may be obscure. Through a systematic process of exploring the components of surge, we can develop a realistic dynamic model to evaluate and determine the best practice in building surge capacity. [10] By defining the domains of surge, which Barbisch and Koenig describe as stuff (supplies and equipment), staff (personnel), and structures (facilities), and putting them into context of policies and procedures, and the federally mandated National Incident Management System, we can build a systems approach and begin to operationalize surge capacity. Critical points of failure exist when subcomponents are not synchronized. For example, the supplies and equipment must have the requisite and appropriately trained personnel to run the equipment.

Daily Surge vs. Disaster Surge

The two concepts are similar in that both contend with a sizable increase in medical or public health resource demand and challenge system capacity. However, extraordinary surge, a term reserved for catastrophic events, is larger scale, more complex, and has incremental nonlinear multi-component interactions with capacity than daily surge. [12] Daily surge response capability invokes only routinely available capacity (resources). At the other end of the continuum, a disaster plan is activated, triggering augmentation or alternate management of resources on a much larger scale as a means to accommodate the surge.

The predictable daily flow of patients is evident as a characteristic diurnal curve, beginning to increase between the hours of 0800 and 0900, peaking from noon to 2200, then slowly decreasing until reaching it low point between 0500 and 0600 in the morning. [13] The ability of the ED to react to an unexpected surge in demand for services thus varies based on time of day, with there being greater surge capacity in the early mornings when ED census and arrival rates are typically lower.

Many factors other than the sheer volume of newly arrived patients contribute to ED crowding, such as length of stay, acuity, and need for inpatient services. Simple statistics such as daily volume or patient arrivals per hour provide incomplete information. Surge is also affected by the volume of patients with emergency needs, and the complexity of cases involved, which plays a role in resource depletion.

Disasters are highly variable in the pattern of surge that is produced. While it is tempting to think of surge following a disaster as a single spike in volume, some natural disasters such as floods and hurricanes may produce sustained increases in demand for services where the surge is sustained over weeks, months, or years. [14]

In their research, Asplin, Flottemesch and Gordon contend that there are two elements that determine ED census trends. The first is the predictable daily census pattern that is driven by historic patient arrival times. The second is unpredictable. It is created by unexpected deviations from these historic patterns.[15] Using census data from a Level 1 trauma center, Flottemesch developed a mathematical model of ED census that showed that the following:

1. ED census is cyclical and follows predictable patterns according to the time of day, day of week, and time of year, and these patterns are determined by arrivals.

2. Current ED census is determined by three things: prior census, current arrivals, and current departures, and

3. Sudden, unexpected surges in expected arrival patterns may have long-lasting effects upon census levels.

Based on information from the hospital, census peaks in the afternoon (2-5pm) and remains high until late evening, then declines until the early morning (6-7) at which time it begins to increase. The curve's amplitude (i.e. peaks and troughs) appears to be unique to the day of the week, with Monday having the highest peak and Thursday with the lowest trough. The authors propose that all EDs experience similar ebbs and flows.

Additionally, ED census does not change at a constant rate. ED census at any point in time can be calculated by adding to the prior period's census, the difference between the number of current arrivals and current discharges. The authors describe the dynamic nature of ED census using a series of equations. The predictive accuracy of the model, as well as the properties of individual components, is related directly to the underlying efficiency of operations and design within the ED. The model is a theoretical approach for understanding the ED length of stay (LOS) and the quality of care. The authors contend that, once the model is calibrated to the patterns of a particular ED, it can be used to monitor daily surges and evaluate improvement initiatives. Understanding the variables related to daily surge may in turn lead to a better understanding of catastrophic surge.

Current Surge Best Practices

Initial development of the CURE Project surge capacity was determined through consideration of the following:

- Federal benchmarks established by the National Bioterrorism Hospital Preparedness Program (NBHPP) administered by the Health Resources and Services Association (HRSA),
- Current medical literature, and
- Advice and consultation (Expert Panel Symposium)

The Health Resources and Services Administrations (HRSA's) capacity projections in a mass casualty event are based on population. A critical benchmark identified by HRSA for regional surge capacity for the care of adult and pediatric victims of terrorism and other public health emergencies are as follows:

Establish systems that, at a minimum, can provide triage treatment and initial stabilization, above the currently daily-staffed bed capacity, for the following classes of adult and pediatric patients requiring hospitalization within three hours in the wake of a terrorist incident or other public health emergency:

- 500 cases per million population for patients with symptoms of acute infections disease, especially smallpox, anthrax, plague, tularemia, and influenza,
- 50 cases per million population for patients with symptoms of acute botulinum intoxication or other acute chemical poisoning, especially that resulting from nerve agent exposure,
- 50 cases per million population for patients suffering burn or trauma,
- 50 cases per million for patients manifesting the symptoms of radiation-induced injury, especially bone marrow suppressions (reference)

HRSA benchmarks focus on preparing for moderate regional incidents, such as an earthquake, fire, flood, or regional terrorist events. HRSA benchmarks are expected to be inadequate for responding to catastrophic events such as pandemic influenza or a Katrina-type hurricane.

This population-based surge capacity target serves as the basis for other HRSA requirements, for example in addition to beds, surge requires adequate staffing, equipment, and supplies to care for surge patients.

Within the area served by Loma Linda University Medical Center (LLUMC), the population is estimated to be nearly 3 million. This same area is served by over twenty hospitals, for a total of over 4,800 acute care beds. Note that this figure does not include local military hospitals (Weed Army Hospital at Fort Irwin and Twentynine Palms Naval Hospital) or the Jerry L. Pettis Veteran's Administration Hospital, which could add further beds to the response. LLUMC supplies about 16% of these beds. However, it should be noted that LLUMC is the only Level 1 trauma center in the area for adults and pediatric patients. The two county facilities (Arrowhead Regional Medical Center and Riverside County Regional Medical Center (ARMC) are both Level 2 Trauma Centers. The local burn unit is located at ARMC.

With the local population estimated at 3 million, and the HRSA guidelines expecting 500 cases per million population for patients with symptoms of acute infections disease (worst case scenario), especially smallpox, anthrax, plague, tularemia, and influenza, then an estimated 1500 patients would seek care within the Inland Empire. Based on these figures, LLUMC should plan on treating 237 patients for this type of event. Since LLUMC is the tertiary referral center, it can be supposed that many of the smaller community hospitals will request to transfer patients to this facility. If we increase the total number of patients presenting to LLUMC to 20%, that would result in 300 patients presenting to LLUMC for care.

Current surge plans within the hospital allow for immediate surge of approximately 20% by practicing early discharge, cohorting patients in two stepdown-capable units and one intensive care unit, as well as utilizing the two affiliated hospitals, Loma Linda Univeristy Medical Center East Campus and Loma Linda Heart and Surgical Hospital. This would provide for about 150 patients immediately and keeps patients within traditional patient care settings. Additional surge capacity can be obtained by placing patients in hallways and other clinical spaces, cancelling of elective surgeries, use of the PACU and other procedure areas (eg. GI lab, Cardiac Cath lab, etc.). These measures will result in an additional 25 to 75 beds. The ED itself can care for at least 6 intensive care patients and supply another 4 monitored beds. This may necessitate utilizing a surge tent outside the ED for evaluating new patients presenting to the ED for care. With these measures, a total of 235 patients can be cared for at the peak of a pandemic. Should additional beds be required, the CURE Center could be activated. This would provide an additional 40 beds with critical care capacity, and 18 beds for basic or telemetry use. It is presumed that if these beds are needed, an emergency declaration would have been declared allowing the activation of the CURE Center. This activation brings the total surge capacity of LLUMC to 293.

In preparation for a possible surge of patients during the H1N1 pandemic, LLUMC administrators have already met with the surrounding hospitals to orchestrate a regional response. Additional measures have included augmentation of staffing schedules, to include increased coverage from internists, nursing staff, and respiratory therapists. Additional equipment, including ventilators, has been acquired. Pharmacy has increased their stock of necessary antibiotics, as well as sedation medications and other anticipated medications. If necessary, there will be limitations to staff vacations and suspension of house staff work hour rules to increase work force. It is anticipated that the State Department of Public Health will address issues concerning the use of tents and suspension of staffing ratios, if needed. These measures will help ensure adequate staffing and equipment.

Projected Patient Numbers and Acuities Using Modeling Techniques

Modeling programs are available to estimate the numbers and acuities of patients that may seek care during a disaster. Two such programs, HAZUS, developed by FEMA, and FluSurge from the CDC were used to estimate the surge requirements for the area surrounding the CURE Center.

Estimating patient surge during an earthquake using HAZUS

HAZUS: Hazard Prediction and Analysis

HAZUS is geographic information system (GIS) software created by the National Institute of Building Sciences and the Federal Emergency Management Agency to predict losses from a variety of disasters including earthquake, winds, and floods. Much of the HAZUS database relies on the 1990 census which creates divisions based on census tracks. A census track is a unit of 4 thousand people "of similar characteristics".

The software can create different levels of analysis based on the availability of inputted local data. A superficial analysis might only include population densities, geographical information and soil analysis. A more detailed analysis might include highway bridge inventories, critical structures (e.g. hospitals, schools, fire stations), transportation systems, residential building types, water distribution facilities, etc. [16] HAZUS can predict direct and indirect economic losses, residential structure damage, transportation corridor damage, critical asset damage, and casualties from a given earthquake scenario. Moreover this GIS technology provides a spatial analysis of these effects potentially allowing planners to best anticipate areas needing attention.

A sample HAZUS output describing possible casualties resulting from a 6.9 magnitude earthquake on the North Hayward Fault is shown in Table 1. Note that the analysis can not only provide information about the numbers and severity of injuries, but can also make predictions based on the time of day of the event.[17]

	2:00 AM				2:00 PM				5:00 PM			
	At Home	At Work	Commute	Total	At Home	At Work	Commute	Total	At Home	At Work	Commute	Total
Severity 1	430	12	0	442	82	498	0	580	97	235	2	334
Severity 2	75	2	0	78	14	92	0	106	17	43	2	62
Severity 3	7	0	0	8	1	12	1	14	2	6	3	11
Severity 4	7	0	0	8	1	12	0	13	2	6	1	8
Total:	520	15	0	535	99	613	2	714	118	290	7	415

Severity 1 - Injuries requiring basic medical aid without requireing hospitalization
Severity 2 - Injuries requiring a greater degree of medical care and hospitalization, but not expected to progress to a life threatening status
Severity 3 - Injuries that pose an immediate life threating condition if not treated adequately and expitiously. The majority of these injuries are a result of structural collapse and subsequent collapse or impairment of the occupants.
Severity 4 - Instantaneously killed or mortally injured

Study Region: Thirty Census Tracts in Alameda County Comprising of City of Berkeley, California

Scenario: North Hayward Fault, Magnitude 6.9

Table 1: Sample casualties generated by HAZUS

The California Geological Society used HAZUS to create a variety of earthquake scenarios in California. The predicted losses were for buildings only and did not take into account damages to dams, power lines, bridges, injuries, and deaths. Effects due to landslides and tsunamis were also not considered. Finally, indirect losses (lost employment, import-export losses, lost income, etc.) were not calculated and may be several times the direct losses.[18]

The Working Group on California Earthquake Probabilities has created a model that predicts an 86% probability that a magnitude 7 or greater earthquake will occur within southern California before 2024.[19] The 30 year rupture probabilities for the three major faults in the San Bernardino area (The San Bernardino Valley section of the San Jacinto Fault, The San Jacinto Valley section of the San Jacinto Fault, the San Bernardino Section of the San Andreas Fault) are 37, 43, and 28%, respectively.

In San Bernardino County, there are two scenarios with earthquakes immediately adjacent to Loma Linda. The first is a rupture of the southern San Andreas Fault and the second is a rupture of the San Jacinto fault, with damages of 18 and 7 billion dollars, respectively. The shake maps for all southern California scenarios are shown in the Appendix A. [20]

HAZUS was used recently to generate an earthquake disaster used in a statewide drill. Loma Linda participated in this drill and was able to evaluate their level of preparedness for patient surge during the event.[21] The drill included eight counties: Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura, and was named the Great Southern California ShakeOut. For the drill, the earthquake was defined as occurring at 10:00 a.m. on November 13, 2008.
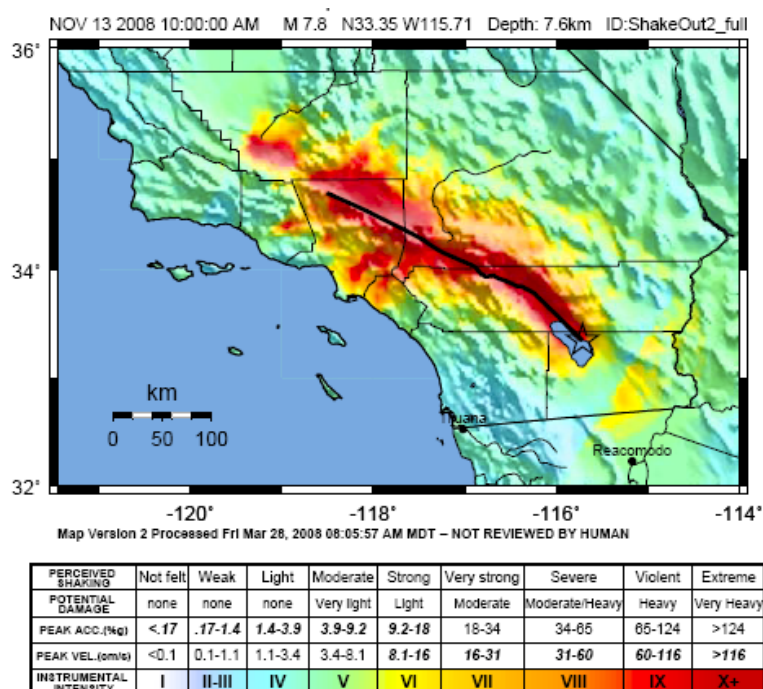

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 1: HAZUS map of Great Southern California ShakeOut

The hypothetical scenario described how a magnitude 7.8 Southern California earthquake - similar to the recent earthquake in China- would impact the region, causing loss of lives and massive damage to infrastructure, including critical transportation, power, and water systems.

In the scenario, the earthquake would kill 1800 people, injure 50,000, cause $200 billion in damage, and have long-lasting social and economic consequences.

The Scenario outlines a hypothetical earthquake in which:[22]

- The strongest shaking and greatest damage is near the stretch of the San Andreas Fault that extends through the fastest growing areas of Southern California, including the Coachella Valley, Inland Empire and Antelope Valley.

- At least 10 million people will be exposed to heavy shaking. California's efforts at mitigation have concentrated on life safety and have been largely successful. Thus, in spite of the large numbers of people in highly shaken areas, deaths are estimated at only 1,800.

- Building types known to be vulnerable to damage and collapse, do indeed sustain major damage. All un-reinforced masonry buildings within 15 miles of the San Andreas Fault are completely destroyed. Those that are not retrofitted kill many occupants. Many other older building types without retrofitting contribute to over $33 billion in damage to buildings.

- The fault offsets all lifelines crossing into Southern California at Cajon Pass (Interstate 15), San Gorgonio Pass (Interstate 10) and along Route 14, including pipelines, power lines, roads, railways, telecommunications and aqueducts.

- Strong shaking continues in downtown Los Angeles for 55 seconds - nearly 8 times longer than in the Northridge Earthquake

- The prolonged, strong shaking heavily damages and sometimes collapses hundreds of old brick buildings, thousands of older commercial and industrial concrete buildings, many wood-frame buildings, and even a few, high-rise steel buildings. Over 600,000 buildings suffer at least some damage that causes tens of thousands of injuries and hundreds of deaths, and leaves many thousands of people without homes or jobs.

- Fire doubles the fatalities and economic losses. Around Southern California, there will be 1,600 fires started large enough to warrant a 911 call, and some fires merge into conflagrations that burn hundreds of city blocks. Assuming no Santa Ana winds, the models still indicate a further $65 billion in direct losses and $22 billion in indirect losses from the fires.

- Nearly two thirds of the hospital beds are non-functional in Los Angeles, Orange, Riverside, and San Bernardino counties. At the same time, 50,000 people will seek treatment at emergency rooms.

- Thanks to a $6 billion investment in seismic safety, the State highway system fares well. However, although collapse is avoided, some bridges are non-functional so that much of the highway is not passable on the day of the event. The long duration of shaking takes a greater toll on bridges and overpasses under the jurisdiction of cities and counties where the retrofitting processes are not complete or have not begun.

- The largest long-term economic disruption comes from damage to the water distribution system. Damage to this system will be so extensive that some areas will have to replace the whole system, and some buildings will be without water for as long as 6 months. The direct and indirect business interruption costs attributed to the lack of water will be $50 billion.

The effects of an earthquake of this magnitude can be broken down into the various counties. Data generated by HAZUS for the areas surrounding LLUMC are listed in the tables below:

Riverside County—Casualties 2 AM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	54	13	1	2	69
Commercial	16	4	1	1	21
Educational	0	0	0	0	0
Commuting	0	0	0	0	0
Single Family	681	96	4	6	788
Other Residential	2774	650	43	72	3540
Total	**3564**	**772**	**50**	**84**	**4471**

Riverside County—Casualties 2PM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	388	91	7	11	497
Commercial	1130	278	40	77	1525
Educational	281	65	9	17	372
Commuting	0	0	0	0	0
Single Family	166	24	1	2	193
Other Residential	721	170	12	19	922
Total	**2695**	**630**	**68**	**127**	**3520**

Riverside County—Casualties 5PM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	242	57	4	7	310
Commercial	942	234	35	64	1276
Educational	23	5	1	1	30
Commuting	0	0	0	0	0
Single Family	264	38	2	3	306
Other Residential	1001	234	16	27	1279
Total	**2485**	**572**	**58**	**103**	**3217**

San Bernardino County—Casualties 2AM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	65	15	1	2	84
Commercial	37	9	1	3	50
Educational	0	0	0	0	0
Commuting	0	0	0	0	0
Single Family	1537	195	6	10	1749
Other Residential	3330	781	58	100	4269
Hotels	28	6	1	2	36
Total	**4997**	**1007**	**68**	**117**	**6188**

San Bernardino County—Casualties 2PM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	472	111	9	16	608
Commercial	2520	651	96	188	3456
Educational	785	178	23	45	1032
Commuting	0	0	0	0	0
Single Family	339	44	2	2	388
Other Residential	741	174	14	23	951
Hotels	5	1	0	0	7
Total	**4862**	**1159**	**145**	**275**	**6441**

San Bernardino County—Casualties 5PM

	Level 1	Level 2	Level 3	Level 4	Total
Industrial	295	69	6	10	380
Commercial	2056	533	79	153	2822
Educational	82	18	2	5	678
Commuting	0	0	0	0	0
Single Family	594	77	3	4	678
Other Residential	1220	286	22	38	1566
Total	**4256**	**985**	**113**	**210**	**5565**

The exercise also estimated the available hospital functionality. At time 0, 3 days, 7 days, 30 days, and 90 days.

Riverside County—Hospital Functionality

		Day 1	Day 3	Day 7	Day 30	Day 90
Large Hospital	# beds	2083	1600	1610	2049	2081
	%	100	77	77	98	99
Medium Hospital	# beds	680	553	555	664	679
	%	100	81	81	97	99
Total	# beds	2763	2184	2196	2707	2760
	%	100	79	79.5	98	99

San Bernardino County—Hospital Functionality

		Day 1	Day 3	Day 7	Day 30	Day 90
Large Hospital	# beds	3613	1474	1518	3421	3609
	%	100	41	42	68	99
Medium Hospital	# beds	915	730	734	906	914
	%	100	79	80	99	99
Small Hospital	# beds	202	167	168	200	202
	%	100	82	83	99	100
Total	# beds	4730	2371	2420	4527	4725
	%	100	50	51	96	99

To put these numbers in perspective, consider a case in point—the Northridge earthquake of 1994. The Northridge earthquake was not catastrophic in magnitude, measuring only 6.7-6.8.

However, it took place in a heavily populated urban area of some 9 million. The lessons learned can be constructive at many levels, including mitigation and preparedness. The challenges that were created for delivery of medical care and relief efforts are particularly instructive. The earthquake occurred on Martin Luther King Day, a federal holiday, at 04:30 AM. This timing may have limited injuries since fewer people were out when the shaking occurred. There were 58 deaths, 1, 500 hospitalizations, and 16, 000 injuries requiring treatment.[23]

Data collected after the Northridge Earthquake showed that the majority of patients presenting for care were the ambulatory patients, rather than via EMS transport. During the initial 24 hours, ambulatory patients numbered approximately 95 per hour, with those admitted for earthquake-related injuries were approximately 15 per hour. These numbers fell off dramatically over the next few days, with 25 patients per hour up to 48 hours, admissions of 5 per hour, and 72 hours only 15 earthquake related patients per hour, with 2 admissions per hour. [23]

Based on these data, and information generated by HAZUS during the Great Southern California Shakeout, a maximum of 4,862 Severity Level 1 patients would present to local hospitals for care after that magnitude of earthquake, with the majority presenting within the first 24 hours. Using the CURE concept and a network of CURE Centers, these patients could be diverted to CURE triage centers. Supposing that approximately 20% of these would present to LLUMC, approximately 975 Level 1 patients could present to the triage center. This would likely occur over the first 24-hour period and require the ability to hold and eventually transport these patients for low-level care. Another 230 patients of Level 2 severity could present to the CURE triage center and could have care initiated on-site. Then those requiring admission would be transferred to acute care facilities. Based on HAZUS Hospital Functionality estimates, sufficient beds would be available within the region to handle the number of patients requiring admission, approximately 1,300 total, but this may require transporting patients to hospitals outside of their immediate location. The CURE Center can help manage these patients as they await transport, and via the use of AEGIS, keep updated on the number of patients requiring transport, and the number and location of beds available. Those patients requiring immediate stabilization (Severity Level 3) would be transported directly to emergency departments. The CURE Center could also provide morgue services for a number of Severity Level 4 victims.

Estimating Surge for Pandemic Influenza Using FluSurge 2.0

Disasters such as earthquakes, although there may be aftershocks, are more of a 'point in time' disaster, with expected peaks of surge, then trailing off in the need for surge capacity. Some disasters, such as floods and pandemics, are longer lasting and may affect a region for weeks, even months, at a time. To estimate the numbers of patients that might be generated during a pandemic, the Centers for Disease Control and Prevention (CDC) developed a program, FluSurge.[24] This program allows for customization of characteristics of the pandemic. For example, under expected patient surge associated with pandemic influenza, if one assumes that 25% of the population will become ill, of these 4.4% will be admitted to the hospital, 15% of those admitted will require ICU care and 7.5% will require ventilator care. FluSurge allows customization of attack rates, percent of admissions/ICU/ventilator use, duration of illness and duration of each phase. (Table 2) FluSurge also provides estimates of the total number of staffed general-medical-surgical beds, critical care beds (including both ICU and monitored beds), and ventilators needed during an influenza pandemic. While medical surge would exist throughout the pandemic, the greatest need for surge capacity is expected to occur in 2-3 waves of 6-8 weeks over an 18-24 month period. The highest demand is projected to occur in

week 5 of the first cycle. Estimates also assume a pandemic midway between the mild 1968 influenza pandemic and the severe 1918 influenza pandemic.

Assumptions:

No. 1	Average length of non-ICU hospital stay for influenza-related illness (days):	
No. 2	Average length of ICU stay for influenza-related illness (days):	
No. 3	Average length of ventilator usage for influenza-related illness (days):	
No. 4	Average proportion of admitted influenza patients will need ICU care:	
No. 5	Average proportion of admitted influenza patients will need ventilators:	
No. 6	Average proportion of influenza deaths assumed to be hospitalized:	
No. 7	Daily percentage increase in cases arriving compared to previous day:	

Table 2: FluSurge allows the user to customize the characteristics of the pandemic

Below are tables depicting the need for surge during a pandemic with 15% attack rate and 25% attack rate in the area served by LLUMC. (Tables 3-8, developed from FluSurge 2.0 available at http://www.cdc.gov/flu/tools/flusurge/)

Pandemic Influenza Impact / Attack Rate	15%
Total Hospital Admissions	
Most Likely Scenario	*886*
Minimum Scenario	313
Maximum Scenario	1,203
Total Deaths	
Most Likely Scenario	*165*
Minimum Scenario	83
Maximum Scenario	291

Table 3: Total admissions and deaths with 15% flu attack rate

Hosp Adm. / Week	1	2	3	4	5	6	7	8
Most Likely Scenario	53	89	133	*168*	*168*	133	89	53
Minimum Scenario	19	31	47	59	59	47	31	19
Maximum Scenario	72	120	180	228	228	180	120	72

Table 4: Hospital admissions per week at 15% attack rate

Pandemic Influenza Impact / Weeks		1	2	3	4	5	6	7	8	9	10
Hospital Admission	Weekly admissions	53	89	133	168	168	133	89	53		
	Peak admissions/day				26	26					
Hospital Capacity	# of influenza patients in hospital	39	65	98	124	128	113	86	57		
	% of hospital capacity needed	6%	10%	15%	19%	20%	17%	13%	9%		
ICU Capacity	# of influenza patients in ICU	8	17	26	34	37	36	29	20		
	% of ICU capacity needed	1%	2%	3%	5%	5%	5%	4%	3%		
Ventilator Capacity	# of influenza patients on ventilators	4	8	13	17	19	18	14	10		
	% usage of ventilator	1%	1%	2%	2%	3%	3%	2%	1%		
Deaths	# of deaths from influenza			10	16	25	31	31	25	16	10
	# of influenza deaths in hospital			7	12	17	22	22	17	12	7

Notes:
1. All results shown in this table are based on most likely scenario.
2. Number of influenza patients in hospital, in ICU, and number of influenza patients on ventilators are based on maximum daily number in a relevant week.
3. Hospital capacity used, ICU capacity used, and % usage of ventilator are calculated as a percentage of total capacity available (see manual for details).
4. The maximum number of influenza patients in the hospital each week is lower than the number of weekly admissions because we assume a 5-day stay in general wards (see manual for details).

Table 5: Impact on hospitals per week, at 15% attack rate

Pandemic Influenza Impact / Attack Rate	25%
Total Hospital Admissions	
Most Likely Scenario	*1,476*
Minimum Scenario	522
Maximum Scenario	2,004
Total Deaths	
Most Likely Scenario	*275*
Minimum Scenario	138
Maximum Scenario	485

Table 6: Total admissions and deaths with 25% flu attack rate

Hosp Adm. / Week	1	2	3	4	5	6	7	8
Most Likely Scenario	89	148	221	*280*	*280*	221	148	89
Minimum Scenario	31	52	78	99	99	78	52	31
Maximum Scenario	120	200	301	381	381	301	200	120

Table 7: Hospital admissions per week at 25% attack rate

Pandemic Influenza Impact / Weeks		1	2	3	4	5	6	7	8	9	10
Hospital Admission	Weekly admissions	89	148	221	280	280	221	148	89		
	Peak admissions/day				44	**44**					
Hospital Capacity	# of influenza patients in hospital	65	109	163	206	213	188	144	94		
	% of hospital capacity needed	10%	17%	25%	32%	**33%**	29%	22%	15%		
ICU Capacity	# of influenza patients in ICU	13	28	43	57	62	60	48	33		
	% of ICU capacity needed	2%	4%	6%	8%	**8%**	8%	6%	4%		
Ventilator Capacity	# of influenza patients on ventilators	7	14	22	29	31	30	24	17		
	% usage of ventilator	1%	2%	3%	4%	**4%**	4%	3%	2%		
Deaths	# of deaths from influenza			16	27	41	52	52	41	27	16
	# of influenza deaths in hospital			12	19	29	37	37	29	19	12

Table 8: Impact on hospitals per week, at 25% attack rate

Based on these numbers, a pandemic with 15% attack rate could most likely be handled through existing surge policies in place at the hospital. If the attack rate is increased to 25%, additional surge capacity may be required, and under these circumstances, activation of the CURE Center Critical Care facility could supply the increased requirement.

Estimate types and numbers of medical care providers required for responding during a triage deployment of the CURE Center, and for a critical care deployment

The deployment of the CURE Center occurs when emergency conditions exist and hospitals are not operating "as usual." Staffing needs during a CURE Center deployment are made under the following assumptions:

Key assumptions:

- An emergency proclamation is in place and that licensing and regulatory requirements have been modified under the proclamation,

- Austere nurse-to-patient staffing of 1:5 for Critical Care or Monitored Beds and 1:20 for Other Medical-Surgical Beds.

- Do not expect mutual aid for at least 72 hours, and assume need to self-sustain without re-supply of equipment, supplies, and staff;

- Assume 30% of staff will not report to work due to inability to get there, illness, or safety concerns

- Children ages 0-13 represent 20% of California's populations (based on Department of Finance 2005 population data)

During a CURE Center triage deployment, a minimum of two triage teams are expected to be operating within the Primary Triage Area. Each of these areas will require an advanced provider (MD or NP, an RN, and paramedic. Additionally, three areas for secondary triage will be in operation. (See Figure 2 below.)

Figure 2: CURE Center Triage

CURE will operate under the Incident Command System with the following setup:
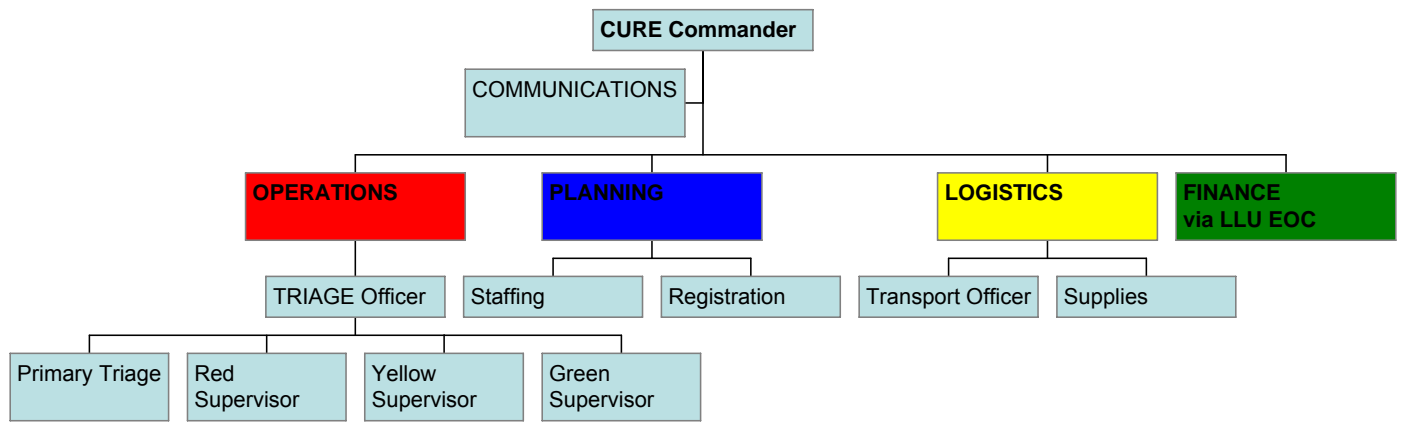
Figure 3: Incident Command Structure for CURE

Additionally, if Level 2 Severity patients are being treated at the CURE Center, a holding center and exam rooms will be activated. (Figure 4 below.)
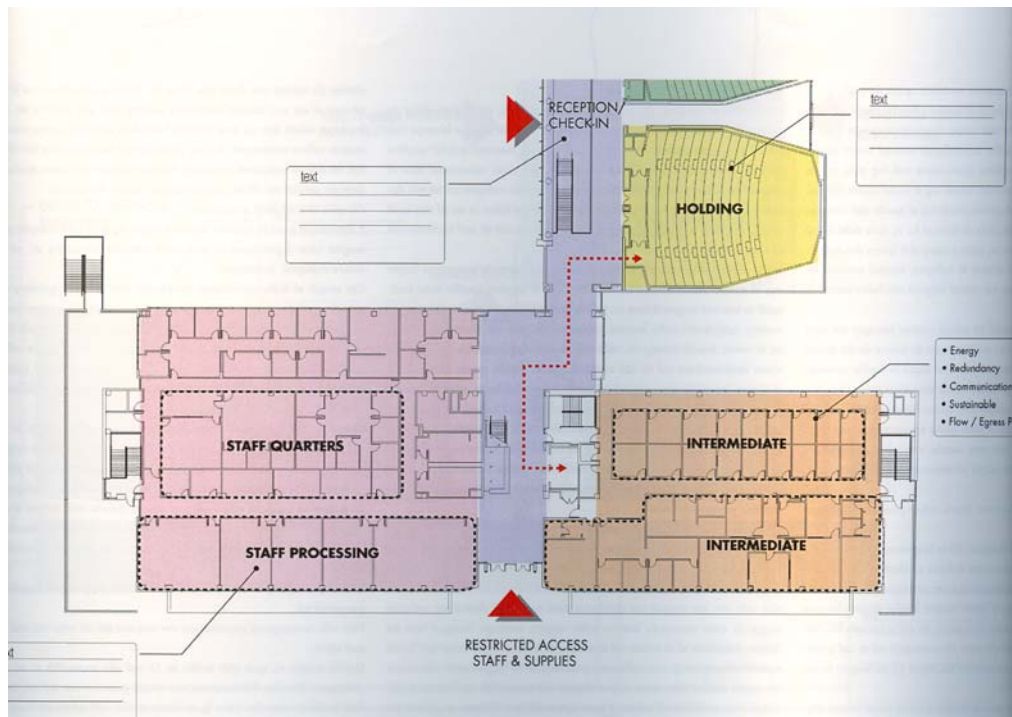
Figure 4: Intermediate care rooms and holding area for Level 2 Severity patients

The table below summarizes medical staffing needs for the CURE Center during a Triage Deployment.

	No. of sites	Personnel per site	Total
Primary Triage	2 (min)	1 MD or NP 1 RN 1 PM	2 MD or NP 2 RN 2 PM
Primary Triage	5 (max)	1 MD or NP 1 RN 1 PM	5 MD or NP 5 RN 5 PM
Secondary Triage	3	2 MD or NP 2 RN 2 PM	6 MD or NP 6 RN 6 PM
Incident Command		1 Commander 2 Comms Sup 2 Comms 4 Operations 2 Planning Sup 3 Registration 2 Staffing 2 Logistics Sup 2 Transport Ofc 3 Supply Ofc	1 Commander 2 Comms Sup 2 Comms 4 Operations 2 Planning Sup 3 Registration 2 Staffing 2 Logistics Sup 2 Transport Ofc 3 Supply Ofc
Secondary Holding Area		2 Holding Area Teams (reception, registration, social services)	2 receptionists 2 registration clerks 2 social workers
Secondary Treatment Area		6 RNs 3 Sec/Techs	6 RNs3 Sec/Techs

Table 9: Medical staff required for CURE Triage Activation

During activation of the CURE Center for Critical Care, additional types of personnel will be required. The figure below shows the area that will be providing critical care.
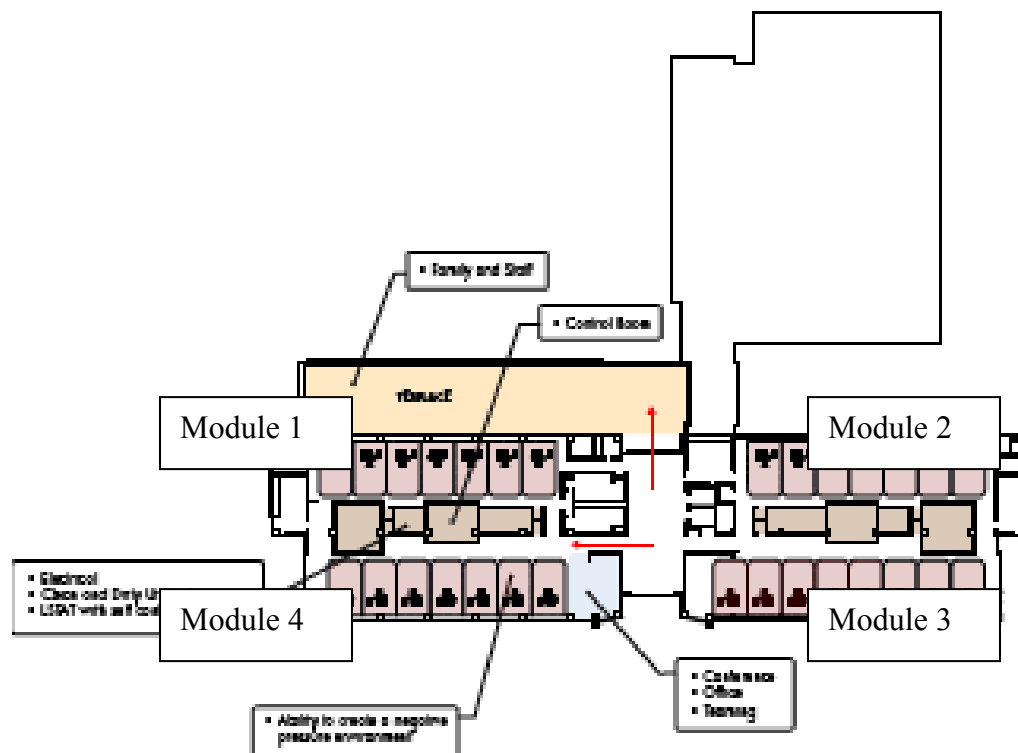
Figure 5: The CURE Center during critical care deployment

The CURE Center Critical Care Center is divided into 4 modules. Modules can be activated/deactivated according to need. Each module will be managed by healthcare teams which include:

- 1 physician medical director
- 1-2 physicians
- 1 charge nurse
- 3 nurses
- 2 patient care technicians
- 1 secretary
- 1 pharmacist
- 2 respiratory therapists
- 1 radiology technician
- 2 housekeeping staff
- 1 cardiac monitoring technician

Initial staffing for a Triage activation will come from the Emergency Department and supplementation via the hospital's emergency staffing protocols. Staffing for a Critical Care deployment will occur through the hospital's disaster staffing system.

Task 2: Complete the Development of a GIS-based Disaster Tool

Introduction

The Advanced Emergency Geographic Information System (AEGIS) provides a platform for first responders, incident commanders, and other public safety personnel to collaborate during daily use, emergency incidents, disasters, and tactical operations. The system includes a wide range of information in one location spanning far beyond individual agency Computer Aided Dispatch (CAD) data and other information collected from other entities. CAD data from a variety of participants would be included with links to analysis tools that previously were not part of the AEGIS system. AEGIS provides various layers of information in an intuitive format maximizing the content that is necessary to make appropriate and informed decisions. Providing pertinent real time information to responders, incident commanders, dispatchers, and managers enhances cognitive processes and ensures safe resource management and field level performance.

AEGIS displays a group of tools that collectively provide diverse information designed to improve responder collaboration, cognitive processes, and safety. It allows users to consider a variety of information, interpret and analyze trends and threats, share information and communicate with other responders, and make timely informed decisions. It is especially suited for those situations such as mass casualty incidents, disasters, or operations where a great amount of information must be considered quickly. It is designed to be agency independent and can be used equally well in daily operations and response. The system is designed to expand and contract, accommodating the Incident Command Structure, to include only the information that is necessary for the level of response and operational success.

The Advanced Emergency Geographic Information System (AEGIS) is a GIS-based disaster and emergency incident management tool. Previously described as a prehospital emergency management tool, in the first USAMRAA, DoD funded contract (Award DAMD17-03-2-0061), entitled Demonstrating Innovative Solutions to Care for Others Via Electronic Real-Time Information and Emergency Services (DISCOVERIES. During the second USAMRAA, DoD funded contract (Award W81XWH-05-1-0596), entitled Research and Development of a Convertible Use Rapidly Expandable Model for Response to Disasters and Mass Casualties (CURE Project), it was developed into a disaster management tool. To achieve this, several upgrades were made to the system which required migration of the prototype to a different operating system. Upgrades to the system included interactive capabilities for information updates and communications, Incident Command System integration, handheld mobile capability, field editing, and secure access parameters.

Technology Specifications

Mobile User:

- Windows Mobile 5 or 6

- 512 SD RAM card or larger
- AEGIS Mobile - Handheld version 3.25

Specific testing has been completed using various handheld devices running Windows Mobile 5 and 6. A Trimble Nomad was the primary test device.

Desktop User:

- Windows XP or Vista
- 512 MB RAM or larger
- AEGIS Mobile - Desktop version 3.25
  (Current development does not support Windows 7)

Browser User:

- Windows XP or Vista
- Windows Internet Explorer 7.0.x
(Current development does not support Windows 7 or browser versions lower or higher than 7.0.x)
- Display for large screen viewing optimized for 17"- 54" monitors

Server Specifications:

- PowerEdge T300 Tower ServerQuad Core Intel Xeon X5470, 3.33GHz, 2x6M Cache, 1333MHz FSB

- Operating System: Windows Server 2003, Enterprise x64, Incl 25 CALs

- Memory: 16GB DDR2, 667MHz, 4x4GB, Dual Ranked DIMMs

- Primary Hard Drive: 500GB 7.2k RPM Serial ATA 3Gbps 3.5-in Hot PlugHard Drive

- 2nd Hard Drive: 500GB 7.2k RPM Serial ATA 3Gbps 3.5-in Hot Plug Hard Drive

- Hard Drive Configuration: Hot Plug Add-in SAS6iR(SATA/SAS Controller)support 2 Hard Drive-RAID 1

- Network Adapter: On-Board Dual Gigabit Network Adapter

- DVD Drive: 16x DVD+/-RW, Internal SATA

- System Documentation: Electronic System Documentation

- Chassis Configuration: Chassis with Hot Plug Hard Drive and Redundant Power Supply

- Hardware Support Services: 3 Year ProSupport for IT and NBD On-site Service

- Power Cords: Power Cord, NEMA 5-15P to C13, wall plug, 10 feet,Quantity 2

- Microsoft SQL Server 2008 Standard

- (1Socket),OEM,NFI, With Media

- ArcGIS Server 9.3.1 Advanced Enterprise for One Server with Four Cores

System Capabilities

The DISCOVERIES AEGIS system included fire response, automatic vehicle location, weather and road conditions, traffic and road conditions, locations of key facilities, and local traffic cameras. The information is presented as a Geographic Interface that provides general spatial orientation in a local or regional orientation.

AEGIS can accept real-time photographs taken at the scene, IP (including other camera systems with IP feed outputs) Camera data, and individual requests for services and resources. Information is geographically appropriate and user selectable.

Enhancements to the system under the CURE Project provided through a mobile platform include NIMS compliant incident command tools and the ability to add incident specific information such as road blocks, location of command posts, and assigned personnel. Information can be added by personnel on scene and communicated across platforms for local and distant command and control or intuitive situational assessment.

Additional new features include the ability to insert field data objects, such as creating real-time fire perimeters, communications between tracked assets using various voice communication solutions, and a floating dashboard to organize these various communication components. This version of AEGIS includes agency specified incident notification and an incident ticker tape for ongoing notifications and communication.

The following illustrations represent several screen shots displaying the various capabilities of the AEGIS System:
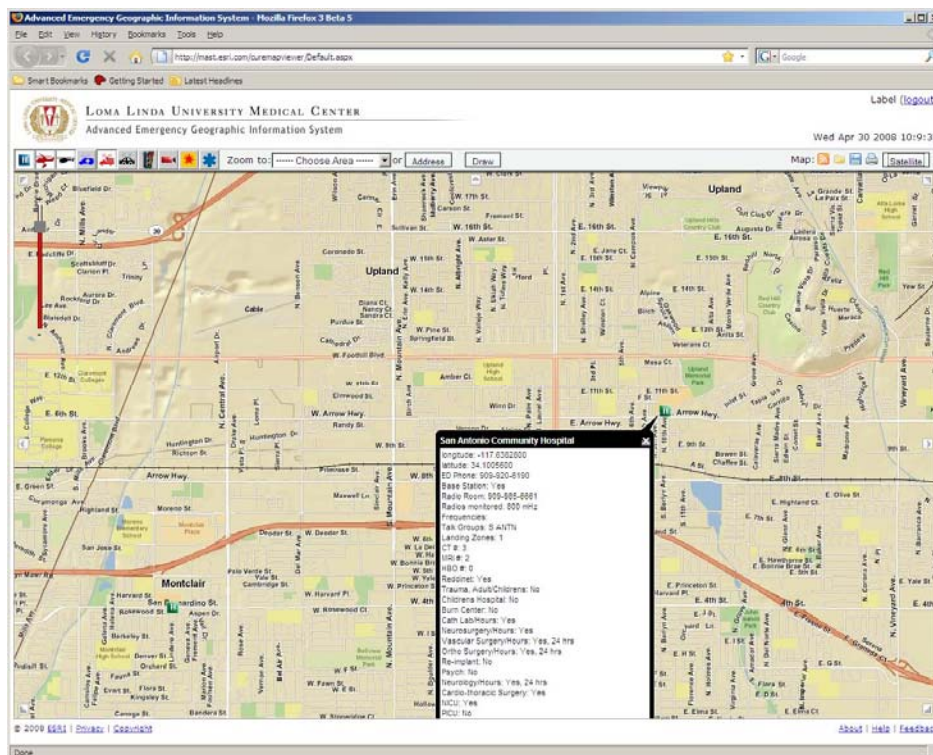
Figure 1: Hospital location, capabilities, and ED status via color-coding
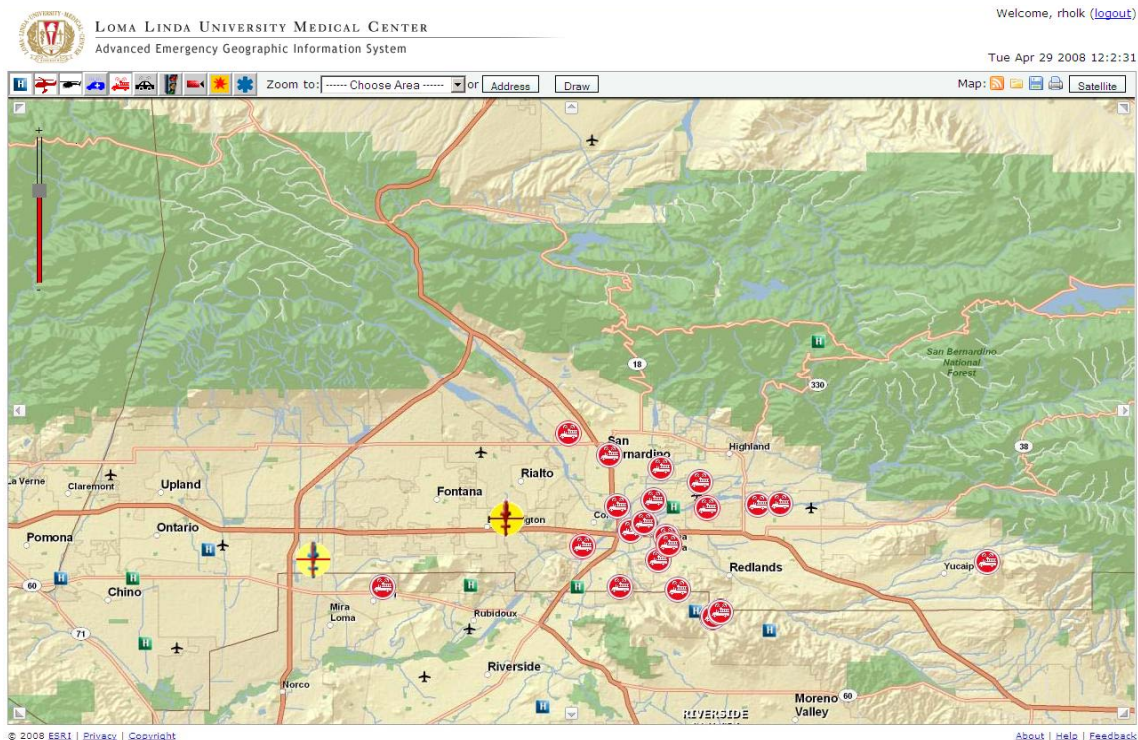
Figure 2: Tracking of fire service apparatus via Automatic Vehicle Locators (AVLs)
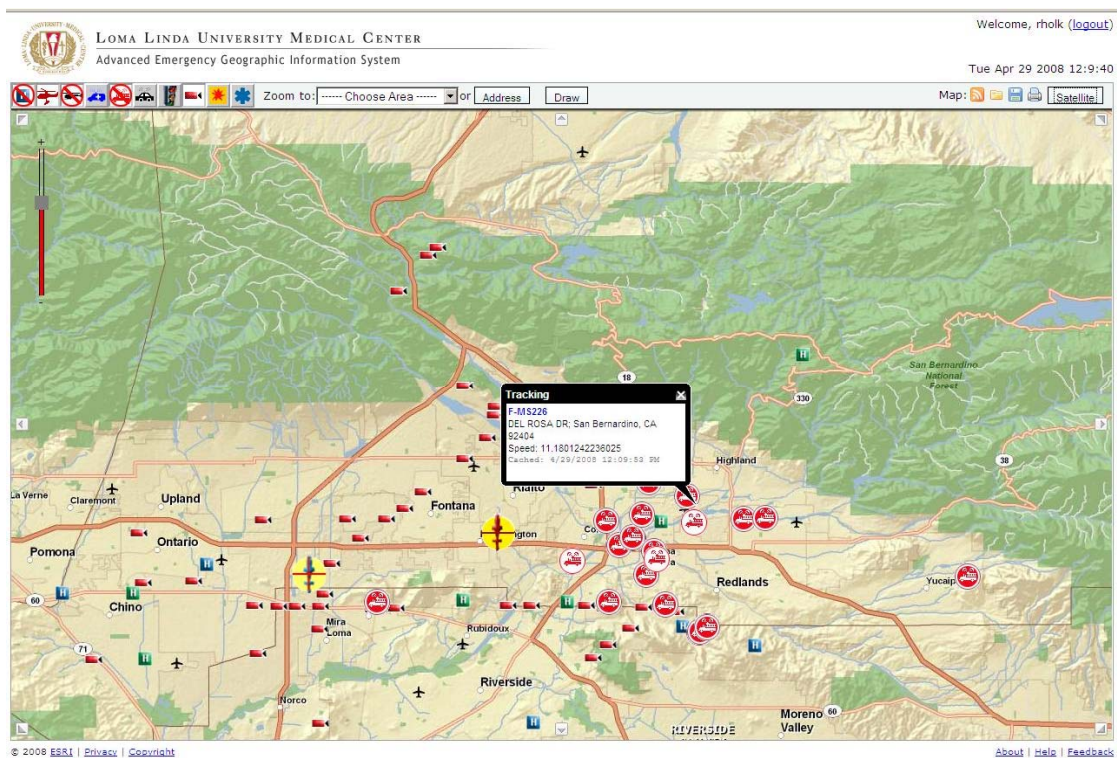
Figure 3: Additional fire service apparatus via AVLs and various traffic camera locations
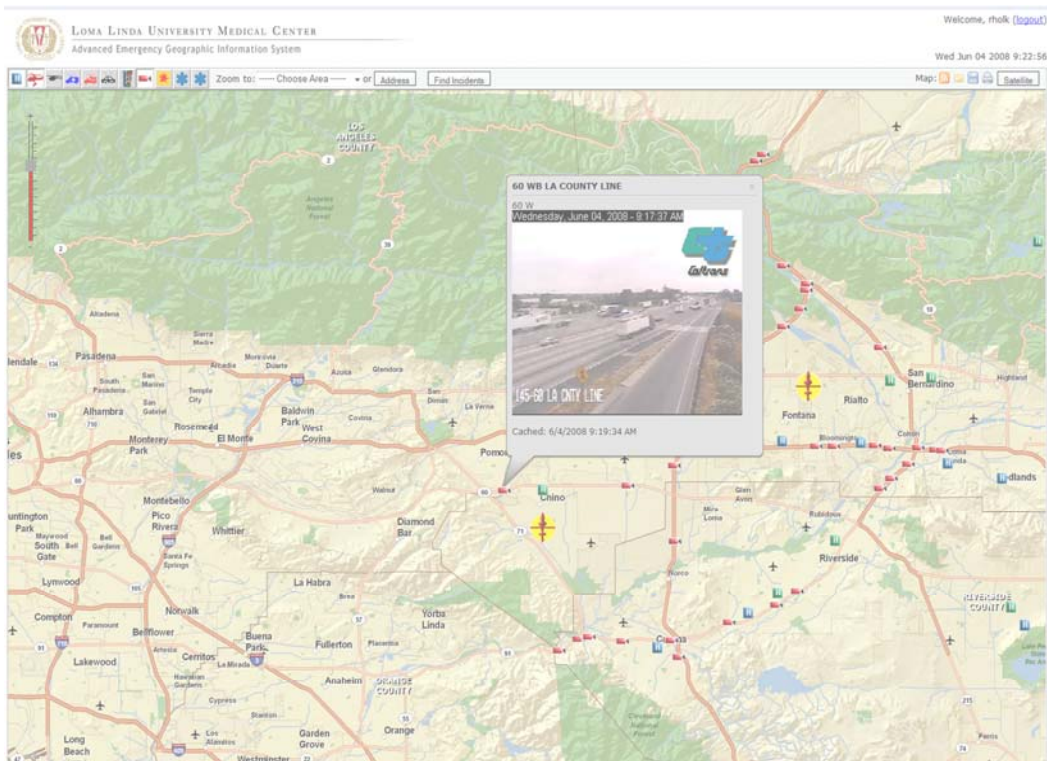
Figure 4: Current CHP incidents
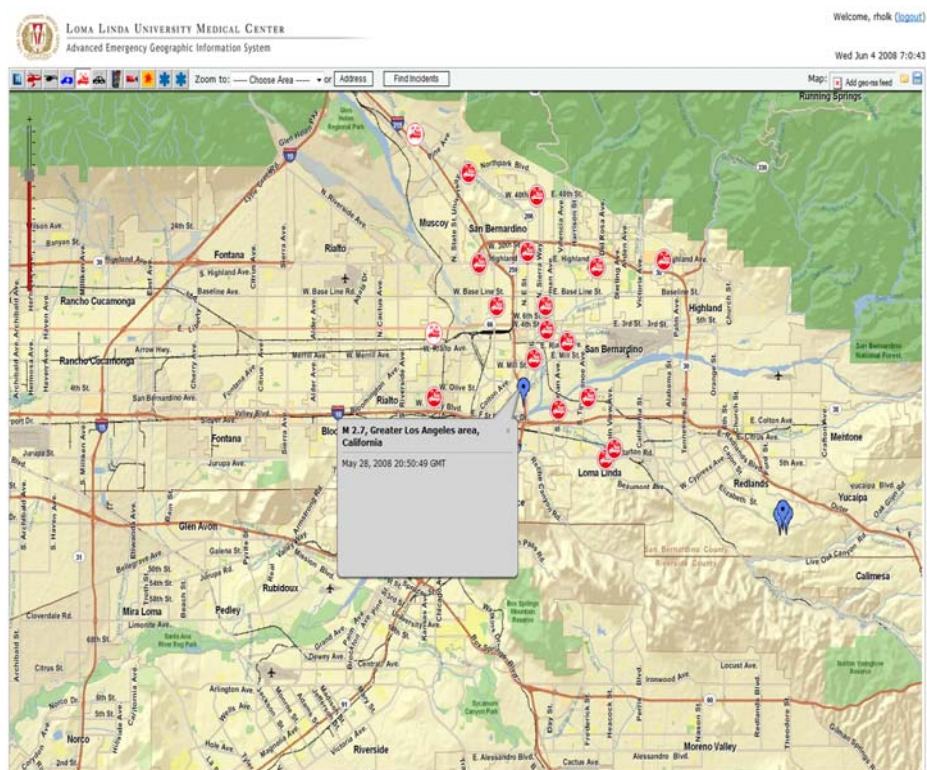
Figure 5: USGS report of earthquake epicenter
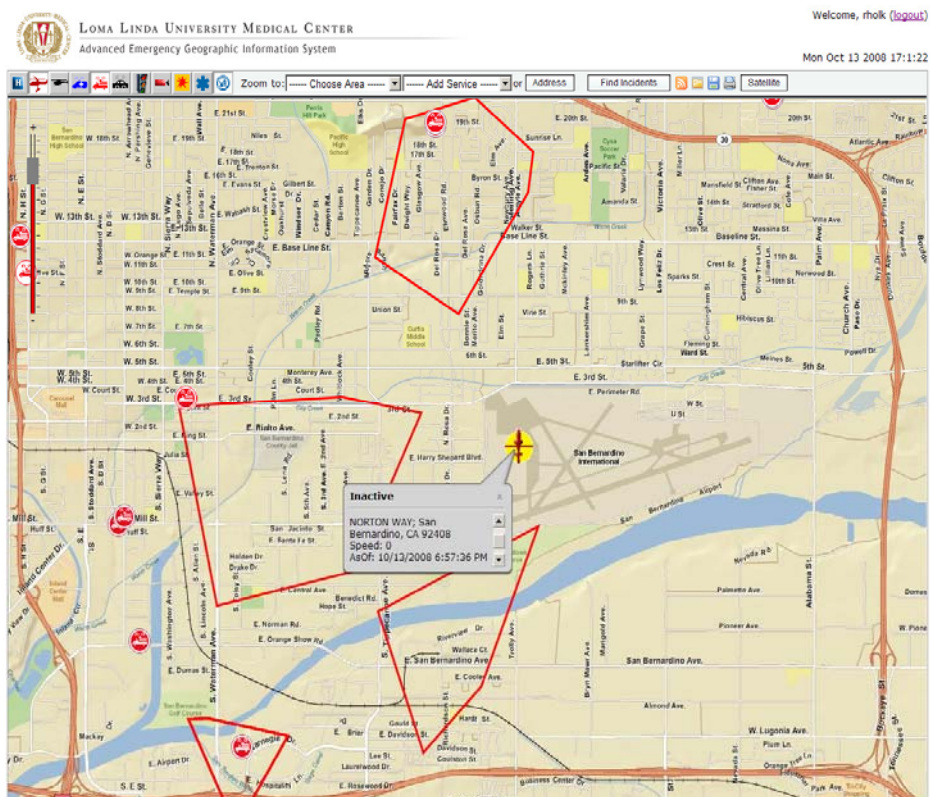
Figure 6: Various incidents defined by boundaries

Future directions

AEGIS creates a unique level of situational awareness, which has not been available before. The spatial representation of the disaster, the wealth of information for decision support contained in the data layers, an understanding of adjacent critical structures, and the understanding of resources available with current asset allocations, all will allow managers to make well informed decisions in real time. Moreover, since AEGIS will be available on any number of portable devices, managers, field commanders, and personnel will all have access to this information. Via these mobile devices, field responders can provide accurate, timely, on-scene information to the system. Those involved in disaster response will be able to communicate action plans, alerts, assignments, Incident Command roles, and other critical spatial and temporal information.

Additionally, AEGIS will include quality improvement and public information components. Incident events and management decisions will be recorded and catalogued for further analysis. Reports can be generated to describe incident conditions, resource allocation decisions, manpower allocation, injuries, property damage, and incident costs as appropriate. Access to this information provides an opportunity to examine critical decision-making and determine what contributes to efficient and effective decisions. Incident reports will permit participants to analyze, refine, and improve disaster response activities, both in real time and in anticipation of future incidents. Information officers will be able to use the tool as a portal for information requests. AEGIS will be able to quickly generate reports and summaries both for use in action plan development and for general distribution to the public.

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This system will be of value to those in an Emergency Operations Center, and to those at the scene of major incidents and disasters. When everyone involved understands the areas of need, the resources available, and the moment-to-moment changes in the event, well informed managers could make decisions.

An enhanced version of AEGIS would include the integration of CAD dispatch data with information provided from other pertinent resources, providing an additional level of communication and surveillance tools that allow users to monitor single or multiple events and response from many agencies. The ability to monitor and analyze Fire, EMS, and Public Safety call trends and individual events over a period will lead to all hazard surveillance. Linear data, related to EMS calls, is analyzed and displayed on AEGIS as a pie chart icon or in clusters as a scatter chart.
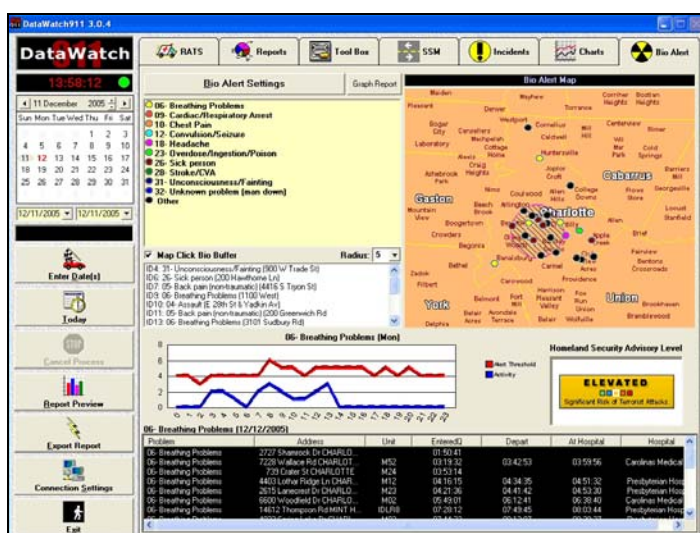
Linear Analysis Data

Triage Symbol

This enhanced system would provide a unified platform for authorized personnel and agencies to view the data accumulated from a variety of resources and a mechanism to communicate between disparate systems. This may take the form of text messaging, data, and voice communication. The result is a platform that can be used in a fixed or mobile location on any web enabled device providing the greatest flexibility of information sharing between deployed personnel. For command centers, the enhanced AEGIS system provides the greatest flexibility in awareness and analysis by integrating the information on large screen or multiple displays.

AEGIS interactive training modules are proposed for this release of the enhanced version of AEGIS. This allows near real time scenarios of natural and manmade emergency situations to

be simulated in the AEGIS framework. This interactive platform allows AEGIS users to participate in simulated field scenarios, practice response alternatives, and record for interactive training or follow-up debriefing and training. Participants not only learn how to use the program, they practice their response in simulated emergency situations.

The enhanced system includes interactive training modules to simulate selected natural and manmade events such as hurricanes, earthquakes, multiple vehicle incidents, or terrorist attacks. The individual modules are goal oriented and timed scenarios that are played on the system interface and can be tracked in real time or saved for later evaluation. Participants not only learn how to use the program, they practice their response in simulated emergency situations. Each module is response level and discipline oriented and branched to influence the outcome of the scenario and the success of the mission.

The continued development and geographical integration of information necessary for multiple agency response, voice and data communication, electronic medical record integration, joint military/civilian response interface, data analysis, automatic vehicle tracking, and all hazards surveillance can also enhance existing military health systems. Understanding the operational conditions at all levels and across agencies, both military and civilian, is necessary for prompt response, proper allocation of resources, and responder safety. Providing this information seamlessly to all authorized users will allow for improved patient assessment and treatment in the field and during transport.

Key Research Accomplishments

Please see the Body and Appendices of this report.

Reportable Outcomes

Please see attachments.

Conclusions

The CURE Project has shown that communities can develop individualized plans that provide specific medical surge solutions during disasters. By networking with other communities via telemedicine and geographic information systems, regions can respond quickly and efficiently to increased medical needs during large-scale disasters. Simulations applying these concepts have shown that it is applicable in various environments. This concept has been presented to the Inland Counties Emergency Medical Agency (ICEMA), the governing agency for prehospital and disaster care for San Bernardino, Mono, and Inyo counties in Southern California, and accepted for development of a regional approach for surge capacity.

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Appendices

A. Earthquake faults in local region

B. CURE book

C. CURE Publication

D. AEGIS chapter in <u>GIS in Hospital and Healthcare Emergency Management</u>

E. Proceedings from the Expert Panel

- Bioterrorism and Public Health Emergencies

- CURE Project - Surge Capacity

- Surge Capacity

F. AEGIS in Emergency and Disaster Response – <u>Fire Magazine</u> Article

G. How GIS is Changing Loma Linda University Medical Center Article – <u>ESRI</u> Article

H. Hospital Implements High-Tech Emergency Response System - <u>Information Week</u> Article

I. Using Geographic Information to Aid Patient Care - <u>EMS Responder</u> Article

J. CURE Film (available upon request)

K. CURE Interactive (available upon request)

L. CURE book (hardcopy) (available upon request)

Appendix A

Shake Maps for Southern California Scenarios

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Puente Hills Scenario
Scenario Date: Sat Jan 11, 2003 04:00:00 AM PST   M 7.1   N33.93 W117.95   Depth: 12.5km

PLANNING SCENARIO ONLY -- PROCESSED: Thu Feb 27, 2003 09:29:56 AM PST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 10. Scenario Shakemap for a rupture of the Puente Hills thrust fault, beneath the center of Los Angeles.

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Newport-Inglewood M6.9 Scenario
Scenario Date: Fri Aug 3, 2001 05:00:00 AM PDT   M 6.9   N33.78 W118.13   Depth: 6.0km

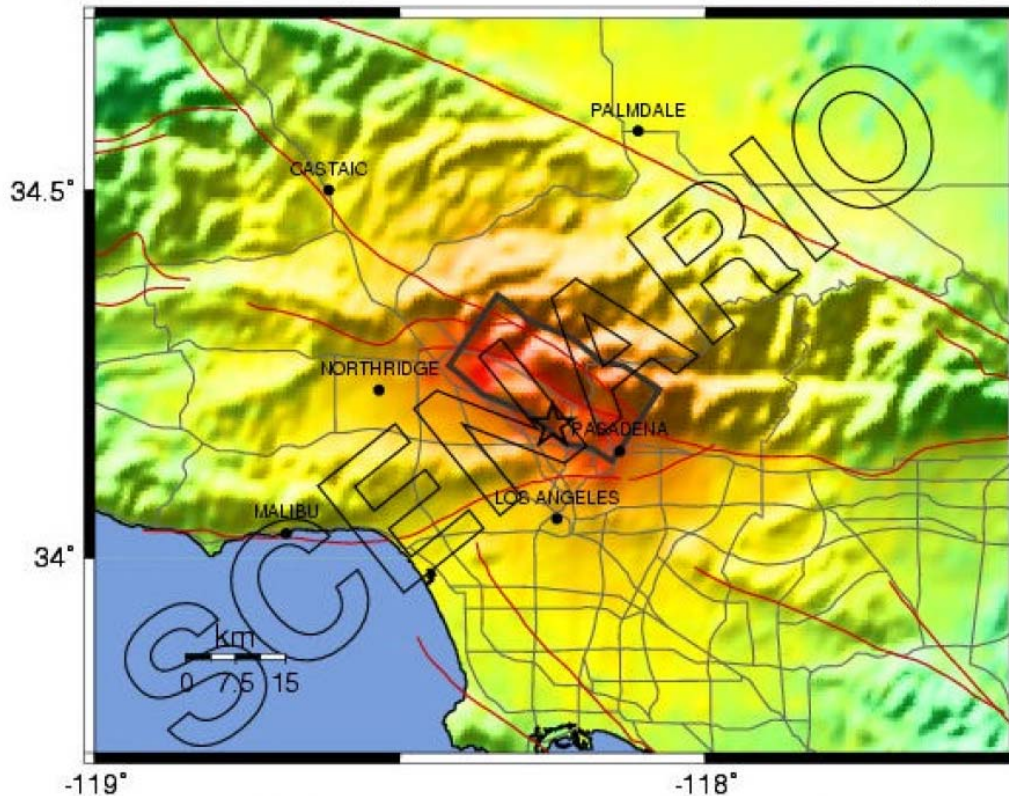PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:01:27 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 13. Scenario Shakemap for a rupture of the Newport-Inglewood fault in an earthquake similar to, but larger than the 1933 Long Beach earthquake.
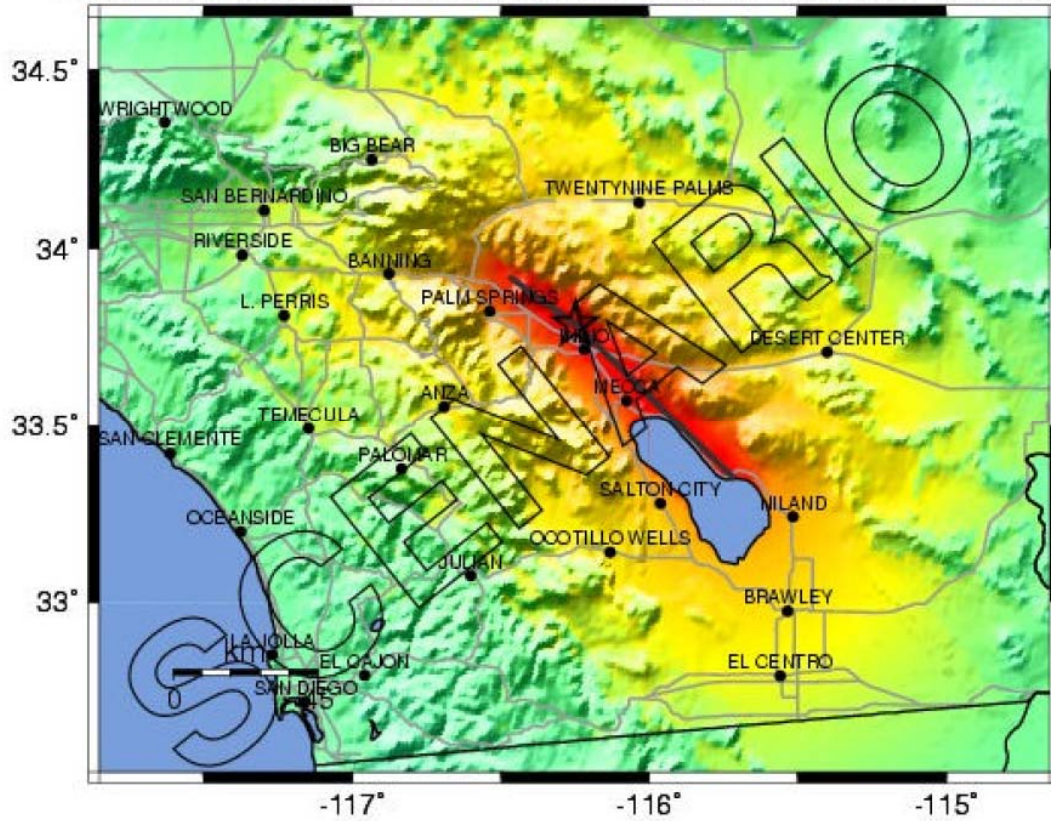
SCENARIO: S-4
Palos Verdes M7.1 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Palos Verdes M7.1 Scenario
Scenario Date: Fri Aug 3, 2001 05:00:00 AM PDT   M 7.1   N33.75 W118.28   Depth: 10.0km
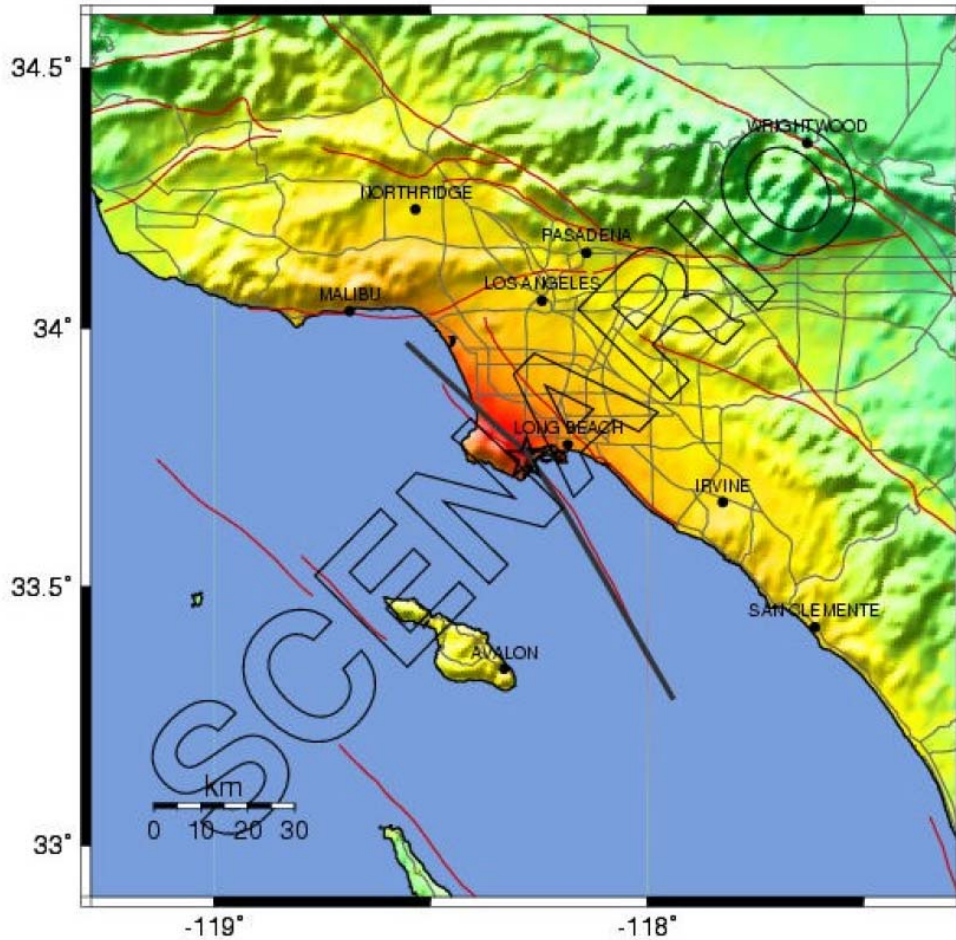
PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:06:42 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-5
San Jacinto M6.7 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for San Jacinto M6.7 Scenario
Scenario Date: Fri Sep 14, 2001 07:00:00 AM PDT   M 6.7   N34.02 W117.24   Depth: 10.0km
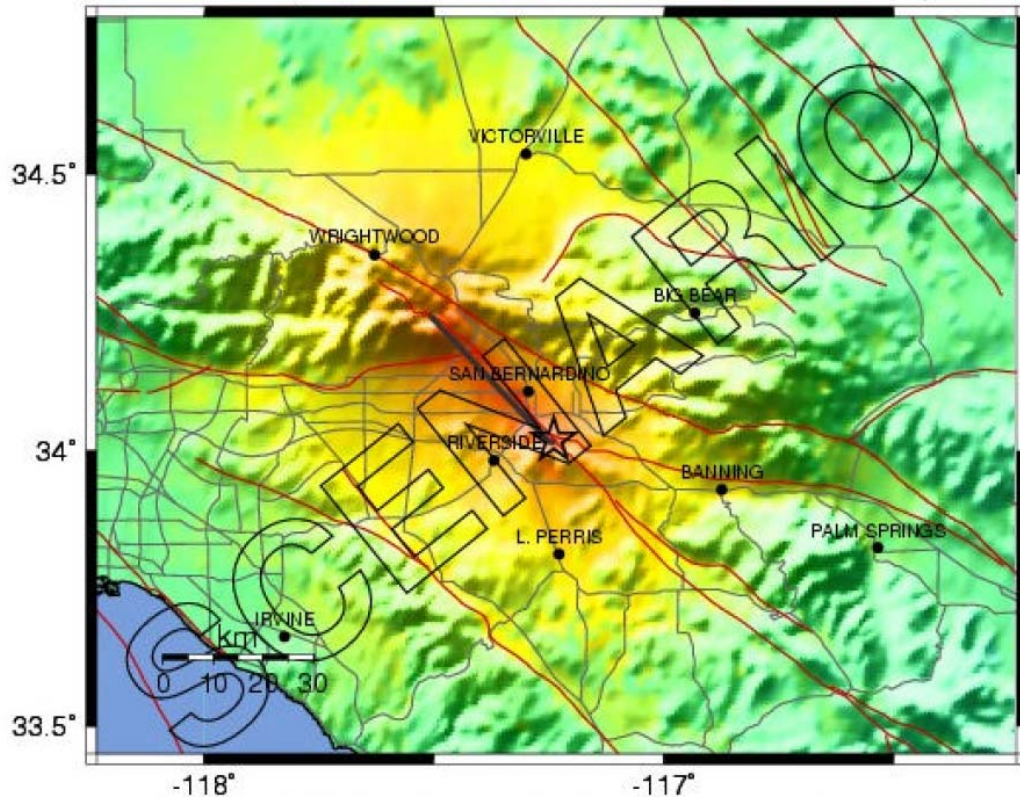
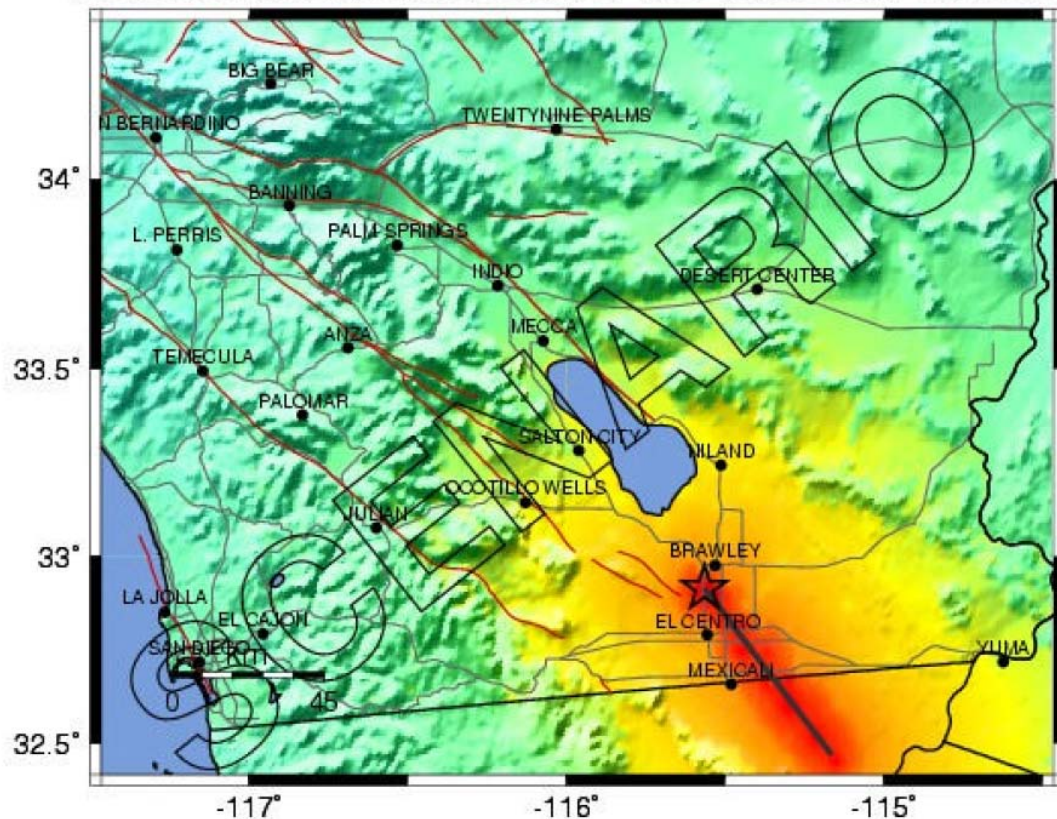PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:29:03 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-6
Verdugo Fault M6.7 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Verdugo Fault M6.7 Scenario
Scenario Date: Tue Oct 30, 2001 04:00:00 AM PST   M 6.7   N34.18 W118.25   Depth: 6.0km

PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:40:13 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-7
Coachella Valley M7.1 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Coachella Valley M7.1 Scenario
Scenario Date: Wed Nov 14, 2001 04:00:00 AM PST   M 7.1   N33.79 W116.25   Depth: 10.0km

PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 03:14:26 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-8
San Andreas southern rupture

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for San Andreas southern rupture Scenario
Scenario Date: Wed Nov 14, 2001 04:00:00 AM PST   M 7.4   N33.92 W116.47   Depth: 10.0km
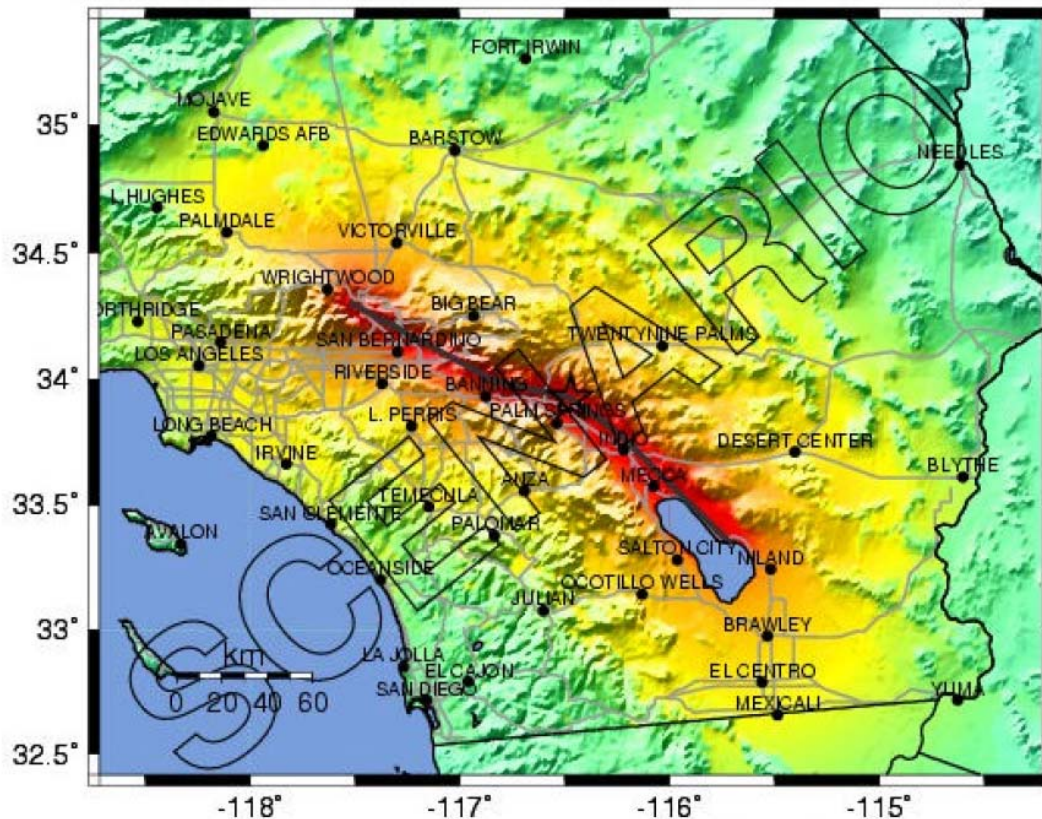
PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:23:34 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

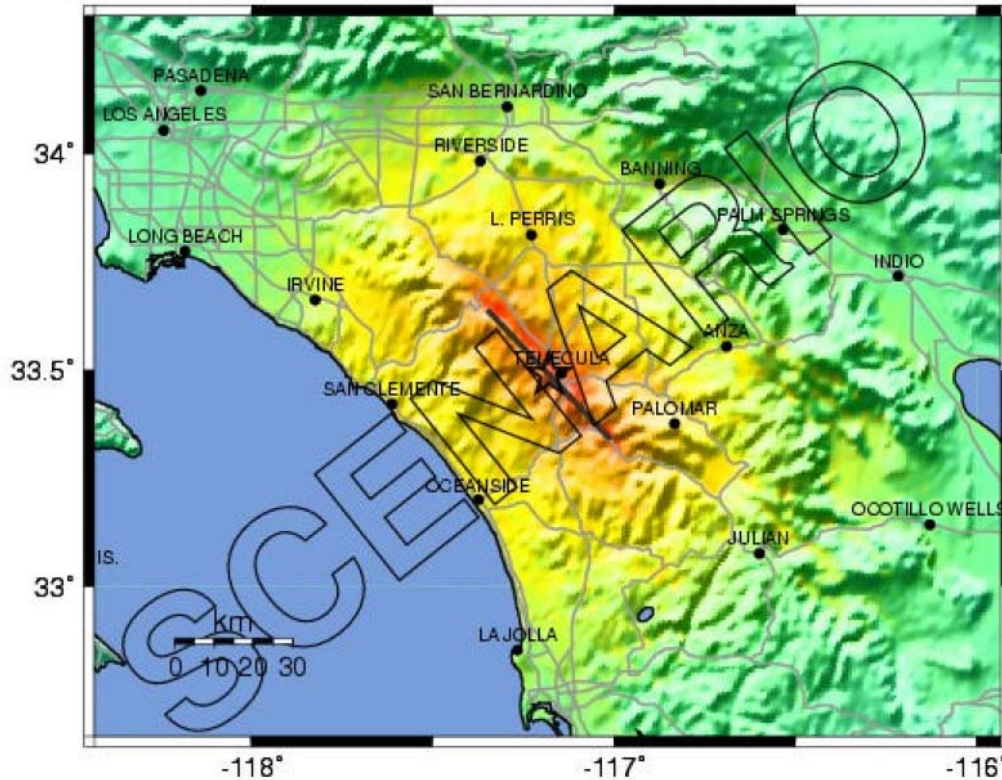# SCENARIO: S-9
Imperial M7.0 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Imperial M7.0 Scenario
Scenario Date: Sat Jan 26, 2002 08:45:00 AM PST   M 7.0   N32.91 W115.57   Depth: 10.0km

PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 03:23:23 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-10
San Andreas 1857 rupture

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for San Andreas 1857 rupture Scenario
Scenario Date: Fri Feb 15, 2002 08:00:00 AM PST   M 7.8   N35.70 W120.30   Depth: 10.0km

PLANNING SCENARIO ONLY -- PROCESSED: Sun Feb 23, 2003 08:28:56 PM PST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-11
Whittier M6.8 Fault Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Whittier M6.8 Fault Scenario
Scenario Date: Mon Mar 11, 2002 04:00:00 AM PST   M 6.8   N33.96 W117.96   Depth: 10.0km
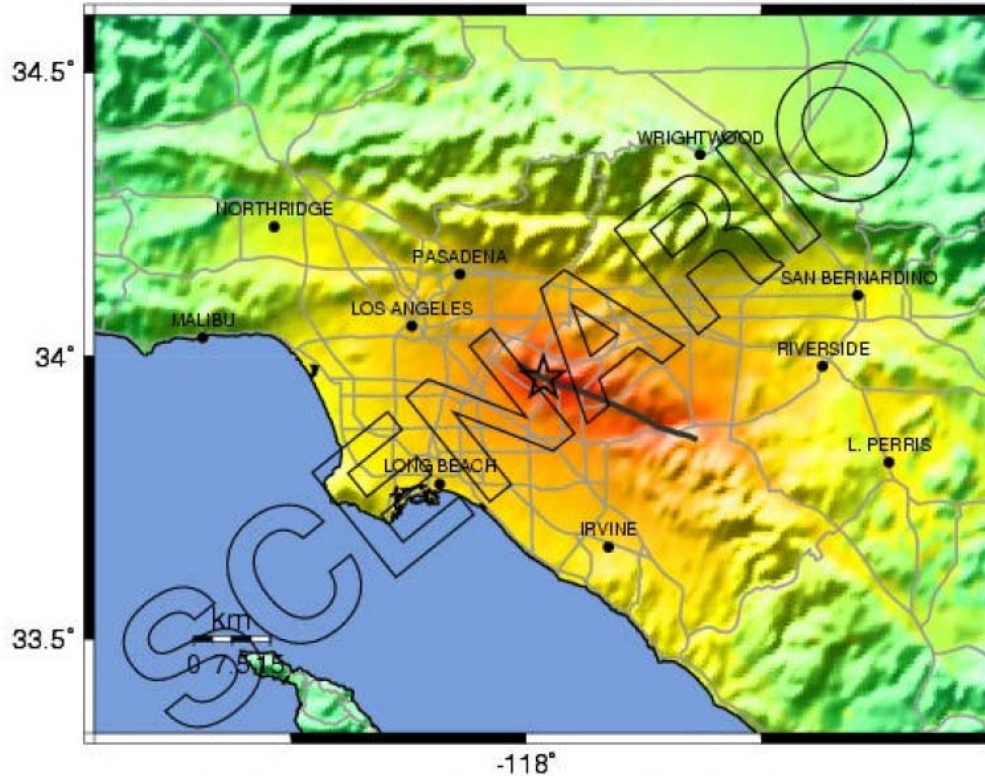
PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:45:43 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-12
Raymond Fault M6.5 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Raymond Fault M6.5 Scenario
Scenario Date: Thu Apr 4, 2002 09:15:00 AM PST   M 6.5   N34.14 W118.06   Depth: 13.0km
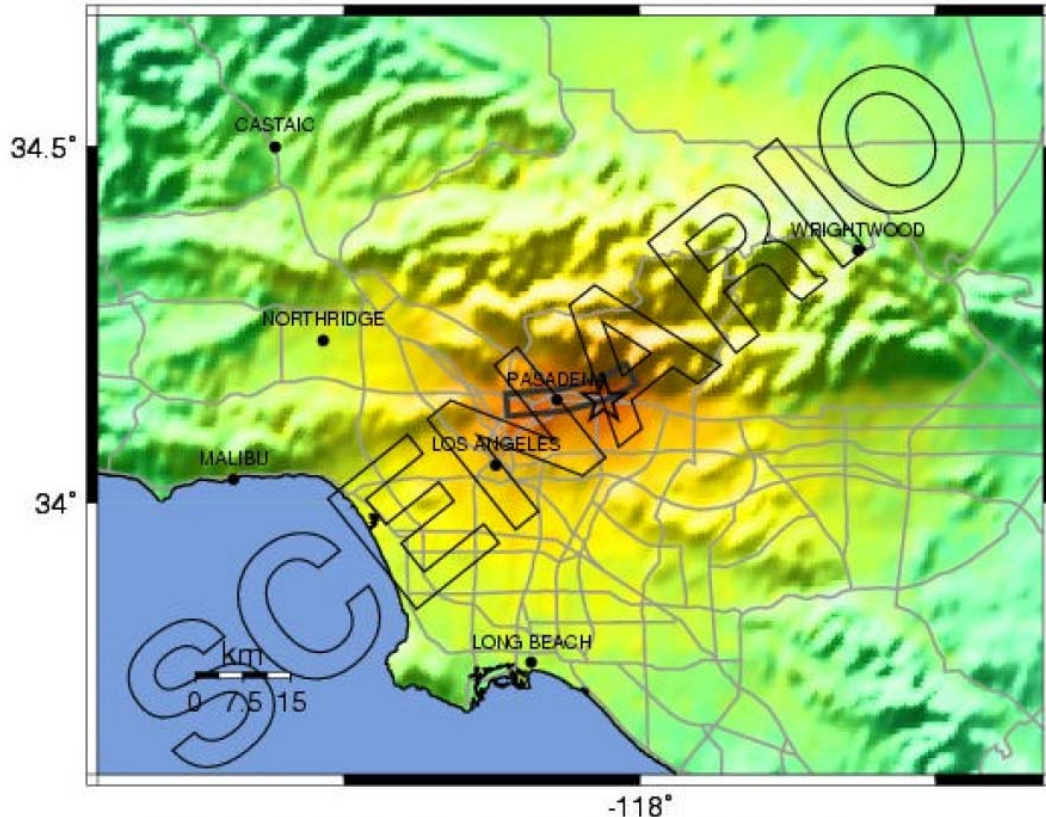
PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 02:12:15 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-13
Elsinore Fault M6.8 Scenario

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for Elsinore Fault M6.8 Scenario
Scenario Date: Wed Apr 10, 2002 05:00:00 AM PDT   M 6.8   N33.49 W117.18   Depth: 6.0km

PLANNING SCENARIO ONLY -- PROCESSED: Tue Jul 30, 2002 01:47:02 PM PDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

SCENARIO: S-14
San Joaquin Hills

-- Earthquake Planning Scenario --
Rapid Instrumental Intensity Map for San_Joaquin Fault Scenario
Scenario Date: Sat Jan 11, 2003 04:00:00 AM PST   M 6.6   N33.50 W117.75   Depth: 7.5km
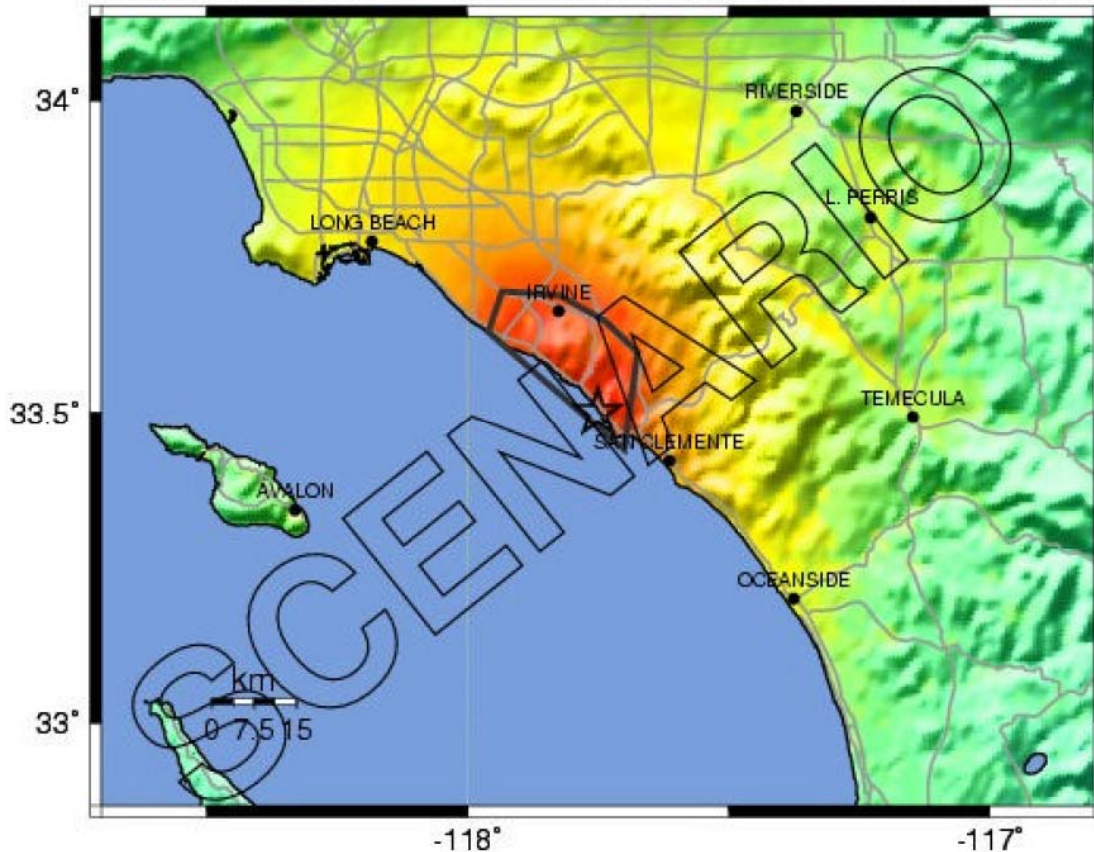
PLANNING SCENARIO ONLY -- PROCESSED: Sat Jan 25, 2003 07:12:13 PM PST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Appendix B

The Loma Linda University CURE Project Team knows our lives will be disrupted by disasters. When—not if—is the only question. The disaster may be natural, accidental, or intentional in nature. Unnecessary deaths will occur if there is not a plan that includes the probability of multiple casualties. A surging increase in casualties will overwhelm the local community's ability to provide care. This leads to the concept of Convertible Use Rapidly Expandable (CURE) space as a crucial addition to a community's resources.

The central concept of the Loma Linda University CURE Center Project is to provide care for mass casualties in a space normally designed for a different purpose, such as a classroom, auditorium, cafeteria, library, or parking garage. Corollary concepts include the technologies necessary for treating dozens or hundreds of patients at once. Such a CURE Center will require the resources and planning to be able to assess and treat a full spectrum of patient needs, from simple injuries to complex medical conditions. Cutting edge communication and modular technologies will be required for this to become a reality.

A flexible, graded response is a necessary characteristic of this concept. This allows the CURE Center to expand and contract as necessary, both in size and function. Cost-effectiveness is one of the results. Whereas new hospital beds cannot be brought on line in hours or even weeks, a CURE Center will be able to provide a Convertible Use space that is Rapidly Expandable. This, in turn, will help a community deal with the inevitable surging increase of patient care requirements resulting from a disaster.

A CURE Center will act independently from a hospital in times when the hospital is damaged but will also be designed to work in concert with the hospital when the hospital is overwhelmed. This requires extensive community planning. Interactions with other resources, such as public and private first responders, regional command structures, communication centers, and military installations will be necessary. These conversations and planning efforts will be richly rewarded.

The CURE Project Team understands that when disaster strikes, going home is not an option. Presented here is our approach to this reality.

Loma Linda University CURE Center Project

Introduction

Section 1.0

PROBLEM STATEMENT

The impact of reported disasters around the world is enormous. Millions of people are injured or displaced, and thousands die every year. In 2001 alone, more than 170 million people were affected by a disaster. This is due to factors such as weather, rapid urbanization, poor land use, and environmental destruction. In addition, 98% of those killed or affected by natural disasters live in developing countries, underlining the link between poverty and vulnerability to disaster. Several specific events have captured the attention of populations, governments, and healthcare organizations within the United States and around the world. In 2001, there were the 9-11 terrorist attacks and the anthrax attacks, in 2003 the Severe Acute Respiratory Syndrome (SARS) epidemic and the Bam earthquake in Iran, in 2004 the Indian Ocean tsunami, in 2005 Hurricane Katrina overwhelmed the Gulf Coast and New Orleans, and 2008 brought Myanmar flooding, volcanic eruptions in Chile, and earthquakes in China. Such events generate worldwide media coverage, raising interest in disaster readiness and increasing the scrutiny of existing preparedness efforts. This scrutiny has led to a growing realization that nearly all currently accepted disaster preparedness practices are based largely upon anecdote and lack systematic study or objective validation.

Our nation, our state, and our region are inadequately prepared to deal with natural, accidental, and intentional disasters. Preparing for a variety of potential scenarios as well as a wide range of casualties presents an awesome challenge. It is unlikely current medical response systems have the patient care "surge capacity" or the expertise to respond to any but the most minor disasters. No adequate all-encompassing definition for "surge capacity" exists. In hospitals, it has been thought of as having or being able to mobilize the necessary components to care for a sudden, unexpected increase in patient volume that exceeds current capacity. The same conceptual definition can be applied to the larger community, not merely to hospitals. In either application, essential components of surge capacity include staffing, equipment and supplies, and structure (physical structure and management infrastructure).

The American healthcare system exists very close to the margins of full capacity and complete resource utilization. Nearly every city, nationwide, experiences hospital diversions, closures and a decreasing number of beds. Additional issues of nursing shortages and "just in time" supplies seriously challenge the healthcare system's flexibility. Recent disasters and potential critical events have highlighted the necessity for patient care surge capacity in the system. This compels political and medical planners to find rapid, efficient, cost-effective, and manageable solutions for the inevitable surge capacity needed within an already overtaxed healthcare system.

Emergency Departments (EDs), long considered the linchpin for caring for casualties after a catastrophic event, are markedly overcrowded. Development of surge capacity for treating patients after a disaster is essential to a community's disaster readiness. The ability to provide patient care areas from convertible space is not only cost-effective but necessary. Continued development and evaluation of a Convertible Use Rapidly Expandable (CURE) disaster response model will provide better patient care options in a fiscally responsible manner.

Recent disasters have changed the way we look at these events since traditional disaster planning has concentrated on focal incidents. Previous responses to environmental disasters have involved protecting citizens from adverse events and resuscitating survivors after the fact. However, in the 21st century we have learned this approach is ineffective when responding to terrorist attacks, biological events, and catastrophic hurricanes such as Katrina. Authorities point out the multitude of ways we were unprepared for Katrina. In addition, we are now forced to look at types of disaster we have not seriously considered as threats in the past, such as emerging infectious diseases or bioterrorism incidents. These types of incidents will require hospitals to address prolonged periods of intense demand for services rather than the more time-limited natural disasters.

Surge capacity is a complex regional issue. Appropriate management of high consequence critical events encompasses hospitals, emergency response systems, jurisdictions, and multiple disciplines. When reduced to the simplest of terms, the ultimate goal in a critical event is to increase the capacity for patient care. The goal of the CURE Project Team is to discover flexible, innovative, and expandable solutions for emergency care during a critical event in order to provide surge capacity.

Specific examples:
- Data from two hospital systems after the Pentagon attack on September 11, 2001, found bed capacity could be increased by only 10 to 20% in the first few hours after notification of the incident. Increases beyond this would be nearly impossible without significant preplanning.

- The 2003 SARS epidemic in Singapore resulted in the screening of 11,461 people in EDs in a two and a half month period.

- During the 2003 SARS outbreak in Toronto, the Hospital for Sick Children had many more patients admitted than usual. This occurred despite public wariness of the ED, afraid of contracting SARS in the ED waiting room. Thus, the total census of the ED decreased but the total number of inpatients increased.

- Forrest General Hospital in Mississippi treated 500 patients (usual census is 230) the day after Hurricane Katrina in 2005, and some hospitals affected by Katrina were without access to outside resources such as supplies or ambulances for 72 hours or longer.

Clearly, an effective response will require a coordinated mobilization of both local and regional resources. This required coordination must consider historical realities. Disaster responses have not consistently done well with their command structures, public relations, and communication systems. Potentially useful information for emergency management techniques are scattered across numerous agencies, public and private, and communication capabilities and adaptabilities have frequently not been up to the task. For example, mobile phone and long distance communication experienced almost complete disruption after Katrina. Over 60% of communication networks were still inoperable three weeks later. Satellite communications were overwhelmed, did not work reliably inside of buildings, and only about 50% of the time from the outside. The only functional phones were direct landlines dependent upon intact wires. As a result of the communications breakdown, no city-wide command and control could be established. A public health crisis ensued along with a public relations nightmare.

Better planning and innovations are needed because patient care surge needs will, at some point, overwhelm a community's resources if no planning is done. Coordinating in advance with community and regional resources, along with understanding available technologies and communication capabilities, will provide the best chance for success. The development of a CURE Center, with access to state-of-the-art medical and informational technologies, will provide cost-effective patient care surge capacity during disaster incidents.

PROCESS

The CURE Project Team undertook a process to develop an idealized CURE Center and applied that methodology to design a CURE Center specific to the area surrounding Loma Linda, in Southern California. This section may be thought of as a description of the steps taken to design a CURE Center specific to a geographical location and its existing resources and capabilities.

DISASTER RELATED INJURIES AND FATALITIES

The Loma Linda University (LLU) CURE Project Team completed annotated bibliographies and descriptive briefs specific to Southern California for several types of disasters. The intent of this exercise was to develop indices that might be used to predict expected fatalities and injury acuities associated with specific types of disasters.

The literature reviews demonstrated that although the characteristics of the individual disasters were well documented, most of the literature contained surprisingly few predictors of the number and acuity of patients presenting to medical facilities. In most instances, fatalities were known but numbers and types of casualties were not routinely reported.

In addition to the literature review, the CURE Project Team used readily available modeling software, such as HAZUS from the Federal Emergency Management Agency, in development of the CURE Center concept. The CURE Project Team also used current Health Resources and Services Administration guidance from the National Bioterrorism Hospital Preparedness Program to further assist in planning of the CURE Center.

The goal was to allow the triage, treatment, and initial stabilization of 500 adult and pediatric patients per 1,000,000 population (1,500 for the LLU CURE Center region) and have critical care capabilities for 40 beds with respiratory isolation.

CURE PROJECT TEAM COMPOSITION

In assembling a CURE Project Team, consideration should be given to including a spectrum of professions such as emergency medicine, public safety, fire, healthcare administration, emergency responders, public health, clergy, logistics, communications, transportation, and construction. Such inclusive representation, either as team members or team consultants, will encourage community investment in the project and incorporate the expertise of individuals vital to the success of a CURE Center.

The LLU CURE Project Team included individuals with backgrounds in emergency medicine, public health, environmental health, information and medical technology, hazardous materials, computer simulation, healthcare administration, clinical care, and communications. Many members of the team had specific knowledge and experience in disaster preparedness, response, and mitigation. The LLU CURE Project Team additionally enlisted the help of an expert group of professionals as an advisory panel.

PROFESSIONAL ADVISORY PANEL

The LLU CURE Project Team convened an Expert Panel Symposium, inviting the participation of leaders in disaster planning and management to advise the CURE Project Team regarding optimal facility attributes, potential technologies, and likely patient injury and illness patterns. In the absence of clear scientific evidence that can be used for disaster planning and response, an expert advisory panel provides a particularly useful way to incorporate the experience of individuals outside of the expertise of the planning group. The LLU CURE Project Team found the interaction with the Expert Panel Symposium vital to the planning process.

Invitations for the LLU CURE Center Expert Panel Symposium went to various expert representatives from the military, specialists in disaster medicine and infectious disease, hazardous materials experts, and individuals—including local and regional leaders—with extensive experience in responding to and evaluating disaster incidents. Several keynote speakers were invited to address the symposium regarding military perspectives on disasters, patient care surge challenges, bioterrorism concerns, public health perspectives, and communication strategies during disaster events. Additionally, disaster management tools were discussed. Terrorist events were specifically included by understanding the Israeli experience. The symposium included breakout sessions and panel discussions to provide the CURE Project Team with expert advice in the development of the CURE Center concept.

PHASES OF DEVELOPMENT

Regional Hazard Analysis

The CURE Project Team conducted a regional hazard analysis to identify the most probable disaster to strike the region. Community recall, written records, and oral tradition were consulted to determine the types and frequency of natural disasters that are common in the area. An evaluation of natural, accidental, and intentional disasters was conducted with the assistance of professionals trained in these areas. It was determined an all hazards approach would be used for disaster planning though weight should be given to the most frequent or probable disasters for a given locale. The Loma Linda area is surrounded by several major faults and experiences regular earthquakes. In planning for the LLU CURE Center, the CURE Project Team determined a major earthquake would be the most likely scenario causing the activation of a CURE Center in the local region.

Regional Resources Inventory

After completing the hazard analysis, the CURE Project Team sought an understanding of the region's resources that would be available for disaster response. This resulted in a resource inventory, allowing the team to identify and understand gaps in available assets. Resources evaluated included regional hospitals, plans for patient care surge capacity, location and size of major buildings, existing emergency plans, prehospital emergency medical services, transportation corridors, personnel, utilities, and other essential services.

CURE Center Location

The hazard analysis and the resource inventory were used to determine the location for a CURE Center and the type of services it needed to provide. The CURE Project Team employed Geographical Information System (GIS) technology to locate and better define the hazards and resources. Capabilities specific to the area were added into the GIS database in a graphical format, enabling the CURE Project Team to choose an appropriate location for the CURE Center. The location was chosen because of its proximity to a major medical center and major transportation routes. In addition, plans for significant new construction made the location desirable. For a location with no new construction, suitable space and floor plans to allow for retrofitting would need to be identified.

CURE Center Design

A systematic review of existing disaster literature was performed and estimates of patient characteristics were made. The Expert Panel Symposium reviewed this information and helped finalize the conceptual facility requirements. The architectural requirements for the CURE Center include spaces large enough to accommodate the necessary medical, logistical, and communications technology as well as the patients and healthcare personnel. Patient flow and work flow models were incorporated into the plan.

Applicable medical technologies for the CURE Center were explored and conceptually integrated into the CURE Center concept. Site security, safety, and communication plans were developed. Syndromic surveillance technologies to be used in the CURE Center were also investigated.

CURE Center Operations Plans

A review of existing disaster literature, team experience, and the Expert Panel Symposium were used to help finalize the concept of operations for a CURE Center. Cost-effectiveness was considered, and compared to the much greater expense of developing new critical care beds within a hospital setting. The operational plan conceives of testing the CURE Center initially, for ease of actual deployment, by utilizing simulations, computer modeling, and disaster drills. The various components of the CURE Center will be assessed as to their response under these simulated pressures, and the concept of operations will be adjusted accordingly. Additional evaluation of the CURE Center operations plan will be undertaken after every actual deployment.

Loma Linda University CURE Center Project

Components of a CURE Center Project
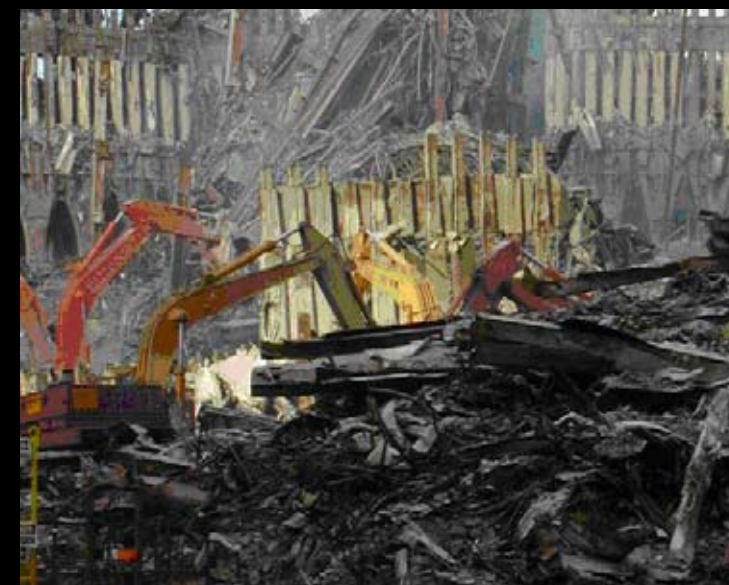
WHY A CURE CENTER?

With hospitals in every community operating close to or at capacity, the ability to provide patient care surge capacity during an emergency is drastically limited. Most hospitals, including Loma Linda University Medical Center and Children's Hospital (LLUMC&CH), have plans in place that could increase patient capacity by about 15% within a few hours of a disaster. These plans include discharging and transferring current inpatients, boarding patients in hallways and nonclinical areas, cancelling elective procedures, and converting procedure and postoperative areas into patient care areas. These measures will provide a quick but limited response. However, when the need is overwhelming or prolonged, other strategies must be employed. Many communities have responded with plans for alternate care sites, facilities that would be able to provide medical care when hospitals or other traditional settings for medical treatment are overwhelmed.

Alternate care sites are not a new concept. During the 1918 influenza pandemic, aircraft hangars, churches, schools, and other available large buildings were designated as emergency hospitals to care for patients. More recently, after Hurricane Katrina, multiple alternate care sites were set up throughout Louisiana, Mississippi, and Texas. The largest of these, located in the Louisiana State University Pete Maravich Assembly Center in Baton Rouge, ultimately treated approximately 6,000 patients, and is considered to be the largest acute care field hospital in United States history.

However, a recent examination of the concept of alternative care facilities found many inconsistencies in what the concept, in practice, actually means. A sobering difference in functions and unpredictable levels of medical care, along with uneven availability of supplies and other support was noted. Additionally, the alternative sites had difficulties in providing the services hospitals currently provide, especially during times when resources were limited. In the future, patients who require care in a hospital may be unwilling to go to alternative sites if they believe the care received will not be comparable.

GUIDING PRINCIPLES

The challenge for a CURE Project Team is to develop a multicasualty incident center that is flexible, independent, integrated into the community response, state-of-the-art, and cost-effective.

FLEXIBLE

One of the critical elements in developing and possessing patient care surge capacity is space availability. Within most hospitals, space is at a premium, and the idea of setting aside areas for the potential accommodation of disaster victims is not feasible. Even storage of additional equipment (such as decontamination tents, extra gurneys, etc.) is rarely possible. The core concept of a CURE Center is to provide mass casualty care in a space normally designed to serve another function, such as a classroom, auditorium, cafeteria, or parking structure. This could be a location within a medical complex but just as easily could be located elsewhere in the community. Applying the concept of convertible use allows planners to establish CURE Centers in a variety of buildings. Without the constraints of a hospital location, the potential for surge capacity is greatly increased.

A CURE Center is also conceived to be rapidly expandable, illustrated by a creative adaptability not merely in size but also in function. This allows provision of care at various levels of patient acuity with the innate flexibility to adapt quickly to disaster challenges. For example, in the event of a large scale infection or bioterrorism incident, a CURE Center could provide urgently needed critical care, including ventilators and isolation. For disasters resulting in large numbers of victims, redirecting the less acute patients to a CURE Center could enable the more critically injured to be treated at hospitals.

INDEPENDENT

A CURE Center should be able to function independently from other systems. This capability allows a CURE Center to provide care regardless of the type of incident. Necessary technologies include separate generators, lighting, communications, climate control systems, and water purification. Medical requirements include oxygen generation, point of care laboratory testing, radiographic equipment, pharmaceutical supplies, and medical equipment. Other capabilities, such as decontamination, will be determined by assessing the needs of the incident and the local community.

INTEGRATED INTO COMMUNITY RESPONSE

A CURE Center represents a local and regional asset. Although it is able to function independently, it must be integrated into the community response. The process by which each CURE Center is developed ensures a fit with each community's specific needs. Involvement of local disaster managers and responders in this process facilitates coordination of the various entities with a CURE Center. Likewise, this process provides awareness of the asset and the ability to implement it when needed.

Development of activation protocols and communication links with local and regional disaster management systems further enhances the integration into the disaster response structure.

STATE-OF-THE-ART

A CURE Center is state-of-the-art in the medical care it can provide, as well as in the other technologies that support it.

While a CURE Center can provide care for a large spectrum of patient acuities, one of its key features is the potential for critical care capability. Utilizing compact and innovative medical equipment, the continuum of care provided will be adaptable to many treatment requirements. Radiographic capabilities include fluoroscopy, x-ray, and ultrasound. Point of care laboratory services and pharmaceutical caches are critical components. Medical expertise is available via telemedicine connections. Patient tracking systems and electronic medical records are integrated into the regional system. Additionally, systems to provide patient and caregiver safety, including negative pressure isolation, surveillance, and site security, are built into the operations.

Communication systems are flexible, portable, and redundant. These provide communications within the CURE Center and to local and regional resources. An integrated emergency data system, the Advanced Emergency Geographical Information System (AEGIS), is being developed. AEGIS will provide real time static and dynamic information about the incident along with improved communications and situational awareness.

COST-EFFECTIVE

To respond effectively to a disaster, advanced planning is critical. Planning for a CURE Center is no exception. Because a CURE Center is designed into a facility that has an everyday use, expenses for a CURE Center involve only those of procuring equipment and supplies. When exploring and planning the cost of a CURE Center, comparison with other figures may be helpful. Current costs for adding intensive care unit beds in a hospital approach two million dollars per bed. A Federal Emergency Management Agency news release in early 2007 stated that federal funding for Hurricanes Katrina and Rita had exceeded $30 billion. Over $1.5 billion of this is approved under a heading for "Other Needs Assistance" that includes individual medical and dental expenses. In contrast, expected costs in 2008 for each CURE Center bed, if critical care functions are desired, would be less than $300,000.

UNIVERSAL APPLICATION

CURE Center concepts are projected to be adaptable to military or civilian medical facilities, whether they are large or small, urban or rural. By providing a guide for development of a CURE Center, individual users can design a site-specific CURE Center tailored to the local resources and hazards. It is conceivable communities could work together to form regional CURE Centers, taking advantage of the resources of many areas. Ideally, there would be a network of CURE Centers, connected via shared technologies including telemedicine, providing a unified response to disasters regardless of location.

In addition to medical facilities, these concepts may be adaptable to smaller community sites where traditional healthcare facilities are meager and hospitals are some distance away. Coordination with the healthcare facilities would of necessity occur, but community leaders could join with regional or state officials in determining their local hazards. After the probable hazards were identified, the community would determine what level of response it could sustain, given its funding sources and available volunteers. Decisions about the degree of shelter or medical care would be part of the planning process and be dependent on both local resources and the ability of more distant resources to arrive quickly. Realizing that application of a CURE Center concept in a more remote location will be rudimentary, the importance of integrating communication technologies, including telemedicine, is an obvious goal.

FOUR PILLARS

During the development of the CURE Center concept, four recurring themes drew the specific attention of the LLU CURE Project Team. These came to be understood as four required pillars of a CURE Center Project.

On the following pages, each pillar is presented: Operations, Communications, Technology, and Environment.

OPERATIONS

REQUIRED FUNCTIONS

An operational plan is designed to specifically deal with future events that have unpredictable timing, magnitude, location, and effects. The importance of such a plan is in its inherent goal of assuring preparedness for response. A CURE Center operational plan should provide a coherent approach to disaster response and serve as a common reference point for CURE Center activities. The plan should clearly allocate responsibilities, provide a basis for coordinated action, and provide a setting within which to review and evaluate needs. A CURE Center should not duplicate or compete with a functioning community disaster response, act independently of the community or hospital, or seek to control the overall disaster response.

A CURE Center operational plan needs to be able to operate independently of other local disaster plans, while simultaneously integrated with them. A CURE Center plan will include measures to define a CURE Center's required functions and to develop specific protocols. Establishing communication systems and information management systems is a key component of the plan as is the preparation for unique staffing needs, including security. Additionally, regulatory issues of a local, state, or federal nature must be taken into consideration. Particular care is required in defining how a CURE Center response will be integrated with the community and Incident Command. A clearly identified activation plan is essential to this integration.

INTEGRATION WITH THE COMMUNITY AND INCIDENT COMMAND

A CURE Center is conceived as being a local and regional asset. Integral to its development at Loma Linda University (LLU) was the convening of an Expert Panel Symposium, which was comprised of local and national experts in disaster planning and management. Ascertaining the opinions and views of local leaders, about how a CURE Center could best fit the needs of the local community, was an important part of the Expert Panel Symposium. For example, two possible functions of a CURE Center were developed through the Expert Panel Symposium process. One, a CURE Center should plan to function as a focal point for triage and two, the community or region may need a CURE Center to provide critical care if other critical care resources are overwhelmed. With this kind of input from local leaders, a CURE Center can provide the assets considered most important in any region.

Additionally, a CURE Center's technologies will improve the community's ability to coordinate and communicate during a disaster. In order to coordinate the many entities involved in the response, including healthcare systems that are often in competition with each other and therefore do not have existing interactive systems in place, critical information must be shared and immediately available to the decision makers. However, the fragmented nature of emergency communication and data systems results in the inability to share this information easily between prehospital providers, hospitals, public health officials, and public safety agencies. The AEGIS system is being developed to facilitate this process, so that those involved will have an up-to-date overview of the incident as well as a potential venue for seamless interactions and integration. This will lead to a substantially enhanced capability to quickly and appropriately deploy resources.

An essential component of organization and coordination for a CURE Center is its integration into the local Incident Management System. For example, the LLU CURE Center is an asset provided by Loma Linda University Medical Center (LLUMC) and operates under its auspices and licensing. Its activation is through the LLUMC Emergency Operations Center (EOC). Additionally, as a community asset, San Bernardino County EOC can make a request for activation of the CURE Center to LLUMC administration or LLUMC EOC (if the EOC has already been activated.) Thus, a CURE Center can be viewed as another resource available for responding to mass casualty emergencies. Community integration will be further enhanced with a CURE Center's participation in local and statewide disaster drills.

ACTIVATION PLAN

Any community planning for a CURE Center must identify the specific process for activating its CURE Center. This portion of the planning will of necessity include community leaders from local public responders and the existing emergency response system and, if applicable, local public health authorities and hospitals. The activation protocols will depend on the eventual characteristics and capabilities planned into the CURE Center.

For example, in the assessment process with community leaders, it was determined that the LLU CURE Center would have two primary roles: a triage center function and a critical care function. The time framework for the activation process will differ for these two functions. Any decision to activate the CURE Center for a triage center function must occur without delay. Once activated, starting triage functions within one hour would provide a useful and effective response. The critical care function should have a similar ability to start operations in a timely manner, considered to be within six hours of an activation request. The needs for critical care capacity will require significantly more integration between regions and distant hospitals as well as preparation time for setting up equipment.

Therefore, the LLU CURE Center activation process must have both an external (community) and internal (hospital) mechanism. It is felt that the CURE Center activation process must be well integrated with the LLUMC disaster activation to avoid confusion and provide a clear benefit to the regional disaster response.

In planning for a disaster response, each community considering a CURE Center model will work within its region to develop an activation plan. In addition, damage assessments and readiness checklists should be prepared. Before full activation can take place, the site must be known to be safe, and communications must be secured with command structures and potential transport agencies.

OPERATIONS

REGULATORY PARAMETERS

A CURE Center planning process must take into account regulatory issues of multiple jurisdictions. These issues include—depending on the local planning process—building codes, licensing of healthcare providers, accreditation of healthcare facilities, and the local protocols for prehospital triage, transport, and treatment of patients. The Incident Command process, with its protocols and hierarchy, is also a piece of the overall regulatory process to consider.

In the face of an overwhelming disaster, shelter of any and all kinds will be sought by the survivors. Advance planning for these difficult circumstances will reduce human suffering and save lives. As communities or larger jurisdictions explore planning for disasters, gaining regulatory approval for various logistics and various shelter arrangements will become necessary. Coordination of such basic arrangements with appropriate local agencies will increase the chance for successful deployment of any disaster response. As the planning matures to the point where medical care is included, such as a CURE Center, gaining approval in advance becomes a necessity for even modest success. Since healthcare is in general one of the most regulated industries in the United States, any planning of a medical nature will be arduous but will be well rewarded should a disaster strike.

It is useful to consider an example. If a community decision is made to build a new high school gymnasium, it is obvious that typical structural and environmental city, county, and state building codes would apply. Codes will regulate the size of the building, the capacity, the number of rest room facilities, and the heating, ventilation, and air conditioning requirements. There will be specific requirements for ingress and egress and attention to fire escape routes. Codes will specify the number of parking spaces, and the number of these allocated for the disabled. This is of course only a fraction of the number of requirements which would need to be met. If the planning process for this hypothetical gymnasium identified a local need for a disaster shelter facility, and those needs could be blended into the gymnasium concept, additional coordination with local officials would need to take place. As introductory examples, controlled access and security issues would be raised to a new level. Decisions would need to be made as to capacity and duration of use. If the planning process determines medical treatment facilities for a disaster should also be incorporated into the new gymnasium, then healthcare licensing issues would need to be a part of the process.

Building codes become more stringent and staffing issues arise as to essential skills and required licensure of personnel. Approval to include medical care would depend on the circumstances surrounding any given disaster declaration and the planning in advance regarding licensure. Actually activating the gymnasium as a medical care facility requires definition in each jurisdiction. Who does this? There is not a consistent simple answer across the fifty states. The answer in some jurisdictions is the local public health officer or the local Incident Commander. In other jurisdictions it may be a state official. Clearly, identifying the activation plan is essential. For all the community planning necessary to make this gymnasium a shelter and/or medical care facility, the details of the regulatory environment cannot be ignored.

Licensing as a medical care facility brings healthcare accreditation standards to bear on planning for a CURE Center. The most well known accreditation agency is The Joint Commission. Another is the Healthcare Facilities Accreditation Program. While both of these agencies are recognized by the federal government as able to evaluate and accredit a hospital, the federal agency Centers for Medicare & Medicaid Services sometimes evaluates a hospital independent of a private agency. Patient safety and patient care documentation issues are important in all of these evaluations. Whether or not a given disaster patient care site can or even should be required to fulfill typical hospital expectations for documentation and care, planning to meet these expectations to the extent reasonably appropriate is essential. A CURE Center will be best served by partnering with a local healthcare system for licensing issues.

The nature of each disaster will have a ripple effect through the local community and wider jurisdictions depending on its scope. It is arguable that Katrina's ripple effect included several states if not the entire nation. A dangerous earthquake in a high density population will impact far more than one or two counties. Healthcare and shelter issues could quickly expand to Katrina-like concentric rings. Success in caring for the needs of shelter and medical care will depend on planning the operations in advance, and this planning must take into account the relevant regulatory issues.

PROTOCOL DEVELOPMENT

Disaster conditions place many strains on a system already stretched to the limit. Increased demand for medical services may require facilities to expand beyond their current licensed capacity. Equipment and supplies may need to be rationed, and hospitals may find they will be required to provide services they are traditionally not licensed for. Changes in usual standards of care may be required in order to achieve the goal of providing the most good for the most people.

The use of a CURE Center, by definition, requires a disaster declaration and the concomitant potential for altered or austere standards of care. Since a CURE Center is not used as a healthcare facility on a daily basis, operational protocols regarding services in an alternate setting will be needed. For the services provided by a CURE Center, development of practice guidelines will be based on the standard of care and altered only as necessary for austere conditions. Examples include triage, treatment recommendations, and clinical decision rules. Healthcare workers may have their scope of practice expanded to provide services they usually do not perform, such as having nurses or paramedics perform suturing.

A variety of guidelines and protocols should be considered as part of a CURE Center's planning stages, and should reflect available federal guidance whenever possible. Applicable topics include:

- Implementation of altered standards of care
- Protocol development for use of nontraditional facilities
- Training methods for out-of-scope practices
- Training and protocol development for advanced practice providers, registered nurses, respiratory therapists, and paramedics
- Development and implementation of clinical protocols
- Guidance and policies regarding equitable allocation of scarce equipment, supplies, and medications

As guidelines and protocols are developed, it will be helpful to have them reviewed by local and community experts as well as local policymakers.

OPERATIONS

STAFFING PLAN

Staffing a CURE Center will depend on the roles determined during the planning process. Because the roles determined for the LLU CURE Center include both a triage function and a more complex medical care function, staffing the LLU CURE Center is a two part process. This two part process is an example which could be evaluated by other communities planning for a CURE Center.

Through the activation phase of the LLU CURE Center, initial staffing occurs as part of the Emergency Department (ED) disaster plan. When the ED disaster plan is activated and the ED attending physician and charge nurse determine a potential need for activating the CURE Center as a triage center, the staffing plan is immediately set in motion. Initial staffing will come directly from the ED with technicians performing the Readiness Assessment. Nursing and ancillary staff from the ED will also begin to prepare for a potential patient care surge and the CURE Center duties in several ways. With activation, changes in shift duration, staffing ratios, and staff assignments are anticipated. Additionally, it is likely that discharge of stable patients to home or alternative care sites will be accelerated. As more staff is needed, additional personnel will be called in.

When a Disaster Condition is declared by the hospital administration, or the CURE Center is being activated for critical care functions, the hospital disaster staffing plan will be in effect, taking over where the initial ED staffing plan left off. When AEGIS is fully developed, it will be used along with a data layer displaying the residences of hospital employees with contact information. Staff can be selected based on geographical location, department, training, or special skills. Information gathered during the initial assessment will help identify specifically required resources such as capability to care for pediatrics or burn patients. Those employees selected can be contacted automatically via home and cellular phone, pager, and email. A call-in center will direct staff to report to the CURE Center. Registration areas will be activated at the CURE Center to process staff members and provide any additional identification, if necessary.

Located near the staff registration areas are staff respite facilities. Here, staff have access to sleeping areas, showers, food, communications, wellness support, and social services. Through the hospital's general staffing plan, off site care facilities for children and elderly relatives are available. Shuttle services for employees' family members are also provided. Prophylactic medication distribution services for employees and family will decrease staff absenteeism. Pet care has been identified as another area of importance to some employees. All of these considerations reduce barriers identified as impacting a worker's ability and willingness to work.

Staffing requirements in addition to healthcare workers will include:

- Environmental services
- Security
- Couriers
- Shuttle drivers
- Nutritional services

Additionally, the Human Resources Department has developed a plan to credential volunteer healthcare workers, if needed. This emergency credentialing process will increase the number of staff available to the main hospital and the CURE Center. Technologies available to the CURE Center will process temporary identification badges and store credentialing information.

SECURITY

Security plays a critical role during a disaster. Due to the chaos and confusion occurring during the event, and the increased need for medical care in patients under emotional stress and in pain, safety of a CURE Center's staff is paramount. Security management must participate in the development of a CURE Center concept of operations. Security guidelines must be developed for:

- Site security
- Staff and patient safety
- CURE Center access and traffic control
- Removal of vehicles in a CURE Center operational area
- Identification of personnel at a CURE Center's access points
- Security for emergency vehicles
- Site safety for helicopter landing zone, if required
- Lockdown of facility, if needed
- Integration with local police department
- Confiscation and securing of weapons found on patients
- Crowd dispersion measures
- Site assessment for additional vulnerabilities and hazards

FIGURE 1 — *Operations Diagram*
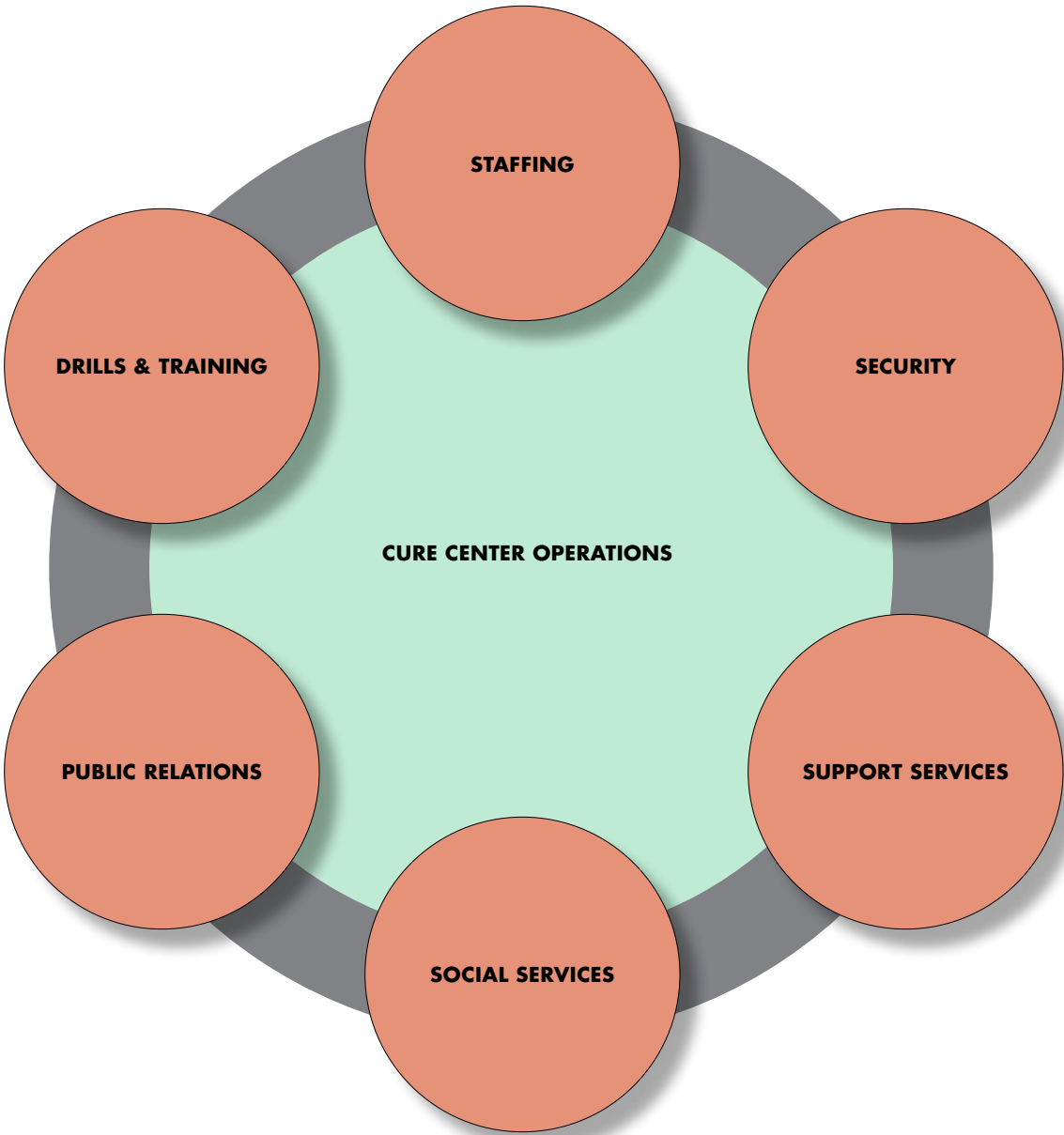
SUPPORT SERVICES

During a disaster, a CURE Center must be able to sustain essential services in order to operate. These include:

- **Power**—a CURE Center will need access to a unique power supply, with back-up generator systems designed to provide for essential functions. Fuel should be maintained both on site and off site for flexibility.

- **Water**—a CURE Center will require potable water, and the potential for an exclusive water supply must be considered. Water purification systems are available for on site use, and arrangements can be made in advance with specific vendors for a supplementary water source as required.

- **HVAC**—in the initial site selection and development of a CURE Center, necessary components for appropriate heating, ventilation, and air conditioning need specific consideration. If portable systems are chosen, their standby locations and potential use will necessitate careful planning. Negative pressure capabilities are also a specific decision as to inclusion and preparation.

- **Nutrition**—prepackaged rations and additional food resources will be required during an activation of a CURE Center. Local partners, such as hospitals, relief organizations, and government agencies need to be determined in advance.

- **Sewage**—if portable facilities will be required, their availability and delivery will need to be worked out during the development process of a CURE Center. Additionally, back-up for the initial plan is required.

- **Accommodation for biohazards**—a variety of challenges will require flexibility and planning with regards to waste, both infectious and noninfectious. Other hazardous materials and conditions, including radioactivity, are possible. The potential need for isolation or quarantine should be considered. In the setting of a CURE Center, deaths will probably occur and a process for managing the deceased must be considered.

- **Other support services**—this includes laundry and nutritional services, laboratory and radiology services, environmental services, and planning for pharmaceutical needs. Some of these services involve supplies that could be packaged in advance, and some services will require partnering during the planning process with hospitals or outside vendors. A specific concept to consider is exclusive access to essential items, such as ventilators.

SOCIAL SERVICES

Social services for patient and family members are important. Up-to-date technologies for patient tracking and registration are available and can be integrated with social services for patient identification. Screened volunteers may also provide an important function in supporting individual efforts to connect with other family members at other sites or to assist in coordination of transportation needs. Clergy representing multiple faiths would also be anticipated to be a part of the larger picture of counseling and social support services.

PUBLIC RELATIONS AND THE MEDIA

Timely and accurate information for the media is important in disaster events, though efforts to do this will need to be balanced initially with higher priorities such as security and patient care needs. A CURE Center will need to identify a spokesperson, and planners should comprehend this will be a 24/7 function. The greater the disaster, the greater will be the media attention. Ideally, selected spokespersons will have had training and experience for this important public interface.

DRILLS AND TRAINING

Preparing for a disaster response by a CURE Center will require much more than developing a detailed, written disaster plan. Essential steps for successful disaster planning include bringing key stakeholders together into interdisciplinary teams as well as assessing current strengths, weaknesses, and resources. The written plan must be disseminated to the key stakeholders and practiced.

Disaster drills and other exercises are designed to test a disaster plan in order to permit staff to become familiar with disaster procedure and improve response to an actual disaster. Practicing a disaster plan will also allow knowledge, skills, and resources to be evaluated. In addition, disaster exercises can provide invaluable data to review, with an eye to both improving the plan and modifying future training as indicated. The improvement process should continuously repeat.

A CURE Center concept will be enhanced by practical hands-on training to identify operational issues and challenges for an actual CURE Center deployment. This will provide opportunities to learn how the community response plan and CURE Center activation are integrated. Practicing disaster skills in this new setting and with infrequently used equipment will ensure a smoother deployment under disaster conditions. Methods to handle large numbers of patients and the ability to work as a team can be assessed during such exercises.

An Evidence Report by the Agency for Healthcare Research and Quality on the effectiveness of hospital disaster drills suggests they can assist in identifying difficulties with Incident Command, communications, triage, patient flow, security, and other issues. Computer simulations and tabletop exercises have been found to be helpful for training key decision makers in disaster response. The role of a CURE Center in the developing science of disaster response could be important, with the potential to evaluate and report on experiences in both drills and actual disaster responses of a CURE Center.

COMMUNICATIONS

FRAMEWORK

As an adjunct to existing community disaster response infrastructure, a CURE Center and its complement of communication capabilities must remain flexible in support of a variety of disaster scenarios.

The criteria for selecting core communication systems should focus on maintaining communication capabilities that are available for ordinary day to day operations of prehospital Emergency Medical Services (EMS) and hospital EDs. Current communication capabilities are generally adequate for the daily events that take place including, for example, an automobile accident with multiple casualties requiring several ambulances to take patients to various local hospitals. When communication system requirements expand beyond the typical daily challenges, the importance of comprehensive planning becomes immediately obvious. Problems involving communication systems infrastructure are virtually inevitable during severe disaster conditions, and even relatively minor events are capable of overwhelming the capacity of landlines and cell towers.

Communication services and capabilities of a CURE Center must support communications for staff and volunteers as well as necessary communications to other community resources, depending on the type of disaster or incident.

CURE CENTER OPERATIONS

A CURE Center requires autonomous communications capability to maintain services internally for CURE Center operations. This autonomous requirement provides redundancy for CURE Center applications and a higher level of confidence that a CURE Center will maintain operations even if there are external communication system infrastructure failures.

Observations of existing communication methods both in civilian hospitals and in military field environments have been used in determining the complement of communication services required to support operations of a CURE Center.

COMMUNITY OPERATIONS

Key to the success of a CURE Center is how a CURE Center communicates with community resources using a coordinated command structure. Working within the National Incident Management Structure, a CURE Center is required to not only communicate with the host hospital or organization, but must also maintain connection to the local disaster management authority. This includes Incident Command as well as Medical Command, during any event.

CURE CENTER COMMUNICATIONS PLANNING

Preparing for communications within a CURE Center Project plan requires coordination with supporting departments of the sponsoring organization and with community resources. Most first responding agencies are heavily dependent on radio communications and hospital or community systems are moving toward web based applications for EOCs. As voice and data services converge, a single method for communications may be possible in the near future. However, this is not practical in 2008. Thus, a CURE Center must plan for current communication capabilities while maintaining systems adaptable to future technologies as they become available.

REDUNDANCY

Consideration must be given to adaptable and alternative solutions for communications in disaster scenarios. There will be predictable disruptions with communications in both urban infrastructures and rural environments where the traditional systems are overloaded or not operating at all. Thought must be given to how a CURE Center will operate under these conditions.

It is important to understand what alternative methods of communication are available in a CURE Center's region. Personnel, ideally, will continue during a disaster to use the same applications and equipment, but planning should contemplate a change in the connectivity method. For example, when terrestrial data and voice lines are not available, will cellular services, wireless services, or satellite services be part of a CURE Center's redundancy plan? A CURE Center planning team must recognize that existing voice and data networks only deliver connectivity for existing applications and systems. Thus, the planning process cannot be limited to the existing networks as this represents merely one layer of communications.

Entirely different applications may be required to communicate the voice and data information necessary for CURE Center operations. If these alternative systems are never used in day to day operations, the potential transition between systems will require specific planning and drilling of key team members.

The importance of redundancy for transmitting data cannot be downplayed. If a CURE Center is part of a larger network, whether hospital-based or community-based, there will be need to maintain records and information services independent from the parent system until such time that the service can be restored. The restoration process during a disaster will itself be challenged by network overloads and many interruptions.

The desire to plan for redundancy will have challenges of its own. In both the public and private sector, financial constraints will almost certainly result in a debate over the costs and benefits of back-up systems. However, failure to comprehend the benefits of redundant communication systems has the potential to cause a CURE Center activation plan to fail when a disaster occurs.

KEY PLANNING STEPS

- List applications, systems, and services required for communications during operation of a CURE Center. Identify a priority level for each item.
- Identify current communication methods for each item.
- Identify any existing alternative communication methods.
- Identify any existing alternative communication networks.
- Identify any existing alternative applications currently available.
- Identify any known security challenges to network operations, patient data, or other communication issues.
- Create a conceptual diagram of the proposed CURE Center network for all methods of communication along with existing applications, systems, and services.
- Compile these plans and share them with other departments or community organizations to present a clear understanding of a CURE Center's objectives, highlighting any unknown or unclear criteria.
- Meet with key leadership personnel to discuss the plans after allowing for a reasonable period of review and questions.
- Resolve any issues raised by the review process and revise plans accordingly.
- Assign a Project Manager and assistants within each discipline covered by the communications plan.

TECHNOLOGY

MEDICAL AND INFORMATION TECHNOLOGY

The LLU CURE Center is designed to be a multicasualty incident center with access to cutting edge medical and information technologies. During times of natural, accidental, or intentional disasters, when a community's patient care surge capacity is overwhelmed, access to such technologies can assist in providing cost-effective patient care.

Specific technologies needed for patient tracking, decontamination, isolation, medical treatment, safety, and security should be explored and integrated into a CURE Center. Such technologies may include remote sensors, robotic devices, telemedicine capabilities, and wireless communication systems, each specifically selected for the region and patient population to be served.

PATIENT TRACKING DEVICE SYSTEMS

Patient tracking device systems which digitally log demographics, current locations, and triage status of patients can significantly improve communications between field personnel and coordinators as they work to effectively deploy resources. Each patient evaluated will be followed in a single, shared system, ensuring the location of every patient is known and that critical patients obtain the medical evaluation required. The instantaneous communication of this patient status information and its potential computer spreadsheet imagery more efficiently allow healthcare providers to collaborate and provide care, especially during times when existing systems have exceeded their surge capacity.

Many catastrophic events have revealed the difficulty in reuniting relatives and loved ones. Having the ability to quickly locate patients can facilitate this process without drawing upon precious resources needed at the scene of the disaster. In addition, patient tracking systems provide a way for all emergency response agencies to input and share valuable information via the same reliable platform. With the ability to relay critical patient information to Incident Command personnel during a disaster, more efficient scene assessment and patient care can be accomplished.

DISASTER TRAINING AND SIMULATION TECHNOLOGY

Disaster training and modeling simulation technology may be used to estimate the number and acuity of patients presenting to the hospital after a disaster as well as providing ways to utilize educational components to augment the training of individuals involved in disaster response. There are many packages currently employed which are specifically designed for disaster training in large scale exercises and disaster medical care. Training medical personnel on such equipment is important to the success of deploying similar technologies during a devastating disaster.

SYNDROMIC SURVEILLANCE

Exploring the technologies available for syndromic surveillance and intelligence gathering is another developing area of technology applicable to a CURE Center. The Centers for Disease Control and Prevention explains the term "syndromic surveillance" as "using health-related data that precede diagnosis and signal a sufficient probability of a case or an outbreak to warrant further public health response." The kinds of data useful for this purpose are extensive. Tracking certain prescription purchases can yield clues to a new disease outbreak in the community. Software to evaluate for trends can monitor real time input from paramedics who use electronic medical records. The purpose of this type of surveillance is ultimately to detect disease outbreak, an application especially useful in bioterrorism preparedness. Emerging systems that gather, collect, and investigate data can be used to place patients into defined syndromic groups. Potential benefits of syndromic surveillance include earlier identification of initial cases and better mapping of subsequent cases when analyzing population characteristics of a recognized outbreak.

PORTABLE ISOLATION AND CONTAINMENT SYSTEMS

In the event of a mass casualty incident or bioterrorism attack, isolation and containment systems that maintain safe air and water are essential to a CURE Center. Air and water filtration systems eliminate pollution and allow for healthy indoor breathing and water purification despite emerging harmful particles inherent to disaster environments. During or after a disaster, having the ability to capture, contain, and neutralize such harmful contaminants under extraordinary circumstances is crucial to the overall ability of the facility to care for patients, staff, families, and the community at large. The effects of unhealthy air and water are particularly significant for young children, asthma sufferers, and the elderly, all populations that a CURE Center will treat during a mass casualty event.

Air Filtration

There are a number of different technologies available for removing harmful substances from the air inside a given facility or area. The range of commercial air purifiers includes electronic air cleaners, hospital negative pressure air purifiers, High Efficiency Particulate Air (HEPA) filters, and living air sanitizers. Such systems reduce exposure to air allergens, bacteria, fungi, viruses, smoke, ozone, volatile organic compounds, and poisonous or noxious gases.

Independent portable isolation units can convert any room or open space into isolated areas within minutes, isolating an infected patient while protecting healthcare workers, and allowing safe patient movement among unprotected populations. These units can be easily configured for use as negative or positive pressure units, or for recirculation. Using HEPA filtration provides the maximum available air filtration for hospital isolation rooms and infection control.

Mobile containment systems can also be used to create positive or negative pressure areas, eliminate biohazards, neutralize contaminated areas, and treat odors. In addition, such systems have the ability to contain and neutralize manmade or naturally occurring biohazards such as tuberculosis, Severe Acute Respiratory Syndrome (SARS), and smallpox. These systems are highly mobile, can be used in a variety of settings, and can be quickly operational, all indispensable qualities during mass casualty incidents.

Additionally, there are products offering surge capacity solutions in portable shelter systems. Such shelters can be configured with portable isolation and containment systems providing isolation, positive or negative pressure environments, heating, ventilation, air conditioning, and air filtration systems in one package.

Water Filtration

Maintaining safe water during mass casualty incidents is another critical component of a disaster response environment. Commercial water filtration systems utilize specific technologies to decontaminate water by removing impurities.

In considering water purification systems appropriate for disasters, characteristics of portability and self containment are essential. The time it takes to deploy such a system and its ability to filter large amounts of water over an extended period of time are also necessary considerations.

EMERGENCY RESPONSE STORAGE SYSTEMS

Traditional storage units and structures may not always be accessible during disasters. The development of a flexible and expandable storage system designed to be moved by a single person and yet versatile enough to adapt to different environments could be extremely valuable. Advanced storage systems designed specifically for emergency response allow for relative decreases in manpower requirements while increasing efficiency and reducing fatigue during actual disaster events. Such systems may include interchangeable containers and multifunction stretchers. Flexible and adaptable equipment can enhance patient treatment and movement capabilities while assisting with deployment and restocking of field medical facilities.

The use of rapidly expandable and independently operated deployment systems can be used to support favorable patient management from triage through staged resuscitative surgical interventions. Choosing modular products that are expandable, multitask oriented, and portable, allows for ease of use by staff and has the advantage of being self-contained during disasters.

TECHNOLOGY

TELEMEDICINE

Telemedicine refers to healthcare delivery where physicians examine distant patients through the use of telecommunication technologies. Telemedicine has the potential to improve delivery of healthcare by bringing a wider range of services to all communities under disaster conditions. Real time assessment of sick and injured patients would assist in deciding which patients need urgent transfer to a regional center. Specialties such as radiology, mental health, infectious disease, and critical care could be accessed from a distance. Beyond urgent healthcare needs, telemedicine is able to enhance training collaboration between health professionals in rural and urban areas.

Utilizing telemedicine capabilities in a CURE Center promotes the creation of a telemedicine network. In such a network, a CURE Center functions as the hub and connects via communication spokes to multiple remote locations, providing an optimal communications framework during a disaster. The CURE Center command center or the ED communications center can provide real time visual connectivity with other healthcare providers in many different environments including field sites, nursing homes, prisons, telemedicine vehicles, rural hospitals, and military bases. Such collaboration is essential for successful communication efforts in disaster management processes.

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

GIS are smart maps that allow users to easily see spatial and temporal relationships in a geographic region, by displaying information in a visual medium which enhances the recognition of patterns and connections between data sets. GIS technology permits multiple data layers within a map such as topography, roads, buildings, and weather. This technology helps the viewer identify and understand critical relationships between these layers at a glance. In addition, GIS can consolidate or overlay the data from numerous sources making it easier and more efficient to understand and utilize the information.

GIS, with the ability to combine information from a variety of sources, including maps, demographic resources, computer models, and remote imaging, can illustrate conditions that make an area more susceptible to disaster, such as the location of earthquake faults, topologies resulting in mudslides and flooding, or weather and climate conditions that may give rise to disaster incidents. Historical information regarding previous disasters can also be mapped. Additionally, complex calculations of hazard risk and probability can be performed. Computer models employing this information can then be accessed repeatedly for various scenarios providing site-specific information for a CURE Center, including estimates of casualties, damage to properties, and the amount of resources required to mitigate the destruction and its aftermath.

GIS can also map the resources available to a region. Information obtained from extensive national data sets of assets can be utilized to assemble a more detailed and customized database specific to a CURE Center locale. These resources can then be matched to the potential need.

By utilizing this innovative technology, a CURE Center planning team will be better able to describe local hazards and local resources. As the team develops an individualized and specific concept of operations, the unique needs and requirements of a local CURE Center will be easier to understand. Augmenting this planning process is a natural role for GIS technology.

Additionally, GIS technology can be utilized during the actual operation of a CURE Center during a disaster event. The Advanced Emergency Geographical Information System (AEGIS) will be an integrated emergency data system, allowing for real time field assessments to be graphically displayed to Incident Command and to a CURE Center, enhancing situational awareness and decreasing unnecessary communications. More detailed descriptions of AEGIS are available in Section 3.0 of this book. This system will improve decision making, syndromic surveillance, and tracking of personnel and patients for increased safety and security.

ENVIRONMENT

Once a community decides to establish a CURE Center, many factors will determine which site is best suited for its location. Ideally, it will be located in an area that is relatively safe from potential hazards but close enough in proximity to be useful in providing immediate patient care. Easy access to major thoroughfares will make ingress and egress less complicated, and a site with multiple entrances will help keep traffic coordinated and flowing.

The site itself will require an area large enough to support the various activities occurring in a CURE Center, including triage. Ample parking for emergency vehicles, staff, patients, and their families is necessary. Proximity to public transportation or railway may facilitate transportation of supplies and patients in and out of the area. The availability of a loading dock can make these transfers less complicated. Community-defined needs, such as decontamination or access to rotary wing aircraft, must be considered and accommodated. Although a CURE Center does not have to be located within a hospital complex, networking with acute care facilities and other medical care sites will be essential. Access to these facilities will make a CURE Center more effective.

When a general area for a CURE Center is designated within the community, existing buildings should be explored for their potential use. The most important requirement, whether using an existing building or planning in advance for a multipurpose use of a proposed new building, is that a selected location has the ability to rapidly convert from its everyday use to a highly technological environment. Additionally, this converted environment must be able to accommodate large crowds in a safe manner. Buildings meeting these requirements will have large entryways, doors, and hallways adequate for gurney transportation. If vertical movement of patients will be necessary, elevators must be ample, both in size and number. Storage on site or nearby allows rapid deployment of portable equipment. Large, flexible areas will simplify the conversion as they will allow for a greater variety of possible functions. The possible activities include not only direct patient care but support services—depending on the local need—such as laboratory, pharmacy, radiology, staff quarters, family areas, and chapel spaces. Investigation into facility capabilities and limitations with regards to adequate toilet facilities, heating, ventilation, air conditioning, lighting, and potable water, along with back-up electrical and filtration technologies, is needed. Communication and telemedicine capabilities will be enhanced if the building is prewired for information technologies and Internet access. Site security will be necessary and the potential difficulties in securing each prospective site should be analyzed with appropriate officials. Buildings meeting most of these requirements, such as public libraries, gymnasiums, and schools, exist in nearly every community.

When a CURE Center is functioning in a triage mode, the site must be able to respond to large influxes of people in a short period of time. In this scenario, scene safety is a priority. The ability to provide circulation of a large number of vehicles in a coordinated fashion through various areas requires a multifaceted approach. Multiple entrances into the site with clearly designated traffic patterns can begin the sorting process and separate patients from staff and other traffic. Controlled access to staff entrances, supply docks, and specialized areas such as decontamination zones or temporary morgue facilities, further reduces chaos and provides another level of security. Separation of traffic from patient care areas increases safety and allows medical care to occur more rapidly and efficiently. Large holding rooms for stable patients awaiting further care or transportation diminishes the crowds while providing the services needed. In clearly designating the different zones of care, orderliness can be superimposed onto a very busy, dynamic environment.

When a CURE Center functions as a site for critical care, the needs are somewhat different. Large numbers of vehicles are less likely though ample parking remains very important. Easy access is essential, with movement of very ill patients from critical care transport teams into the critical care treatment area a priority. Once inside the critical care treatment area, the environment should be much calmer and as quiet as possible. Buildings with adequate insulation and with areas located away from traffic can provide this environment. Features providing patient and family centered care, promoting privacy, and supporting care of the whole person should also be incorporated into a CURE Center design.

For the physical environment to be successful as a CURE Center, it needs to respond to the technological goals of a CURE Center. At the same time it needs to provide a reassuring environment for patients and families which, despite the chaotic circumstances, allows them to feel safe and be confident of quality medical care.

SYNTHESIS

The application of the CURE Center concept to any locale or jurisdiction should be based upon the analyzed threats to the region in the context of the available resources. Bringing together community leaders with disaster specialists will facilitate the process of reaching a consensus about threats and resources. This must be an inclusive process, with the involvement of existing EMS and Incident Command structures, as well as input from military installations in the region. Representatives from healthcare delivery systems of the private and public sectors, public health authorities, and first responders are all important. Specifically, obtaining the involvement of regional EDs will add a unique perspective of the daily interface between the field and inpatient care. Once the threats and resources are understood, the next step is to identify potential sites for the CURE Center(s).

Site selection should be based upon accessibility, safety, convertibility, expandability, and flexibility. Integrating with community resources and command structures must remain a central theme as other site selection issues are decided. Reaching an early regional consensus on the scope of operations for potential sites is a prerequisite for further planning. As the concept of scope is solidified, all operational procedures should be integrated with the disaster response plans for the region. Just as with the initial analysis of threats and resources, working through the process of site selection will be positively influenced by involving a broad representation of the region's decision makers along with the unique interface experience of EDs.

Once the community decides on a scope of operations for its CURE Center, the CURE Center development team will be able to focus successfully on the details of an operational plan. Local and state regulations will play a part, particularly if there is a need to develop longer term shelter or medical care components. The development of specific partnerships may be necessary with identified healthcare facilities. Treatment and transfer protocols will require integration with local EMS systems. Staffing patterns and plans for a comprehensive disaster staffing response may require working with networks of healthcare providers. Transferring patients both to and from the CURE Center will need to be worked into policies and procedures of all the appropriate organizations.

The CURE Center's communication systems and the required technologies will depend on the decisions made about threats, resources, and scope of operations. Assessing the needs in this context will fall to the CURE Center development team, and will require expertise in developing redundancies for communications as well as experience in assessing needed equipment and technologies. Integrating geographical information systems and existing community surveillance systems, with robust and redundant communication systems, represents one example where communications and technology intersect.

Working with the components of the CURE Center concept will begin to move ideas towards reality. The plans and policies will need fulfillment in a site, in a scope, and in consideration of practical challenges. Opening a CURE Center safely, resolving transport issues, accessing stored supplies and equipment, and providing care by a planned cadre of providers are examples of a few of the practical challenges.

The next section will address the application of the CURE Center concept in one specific locale with attention to the details of the process and the requirements for CURE Center activation. There is no doubt a disaster will happen, and no doubt of unforeseen events challenging every set of plans. However, the failure to plan guarantees a poor disaster response in a time of need. Preparation will mitigate disaster consequences and reduce the pain and suffering within the community.

Loma Linda University CURE Center Project
Application of the CURE Center Concept

Section 3.0

APPLICATION TO LOMA LINDA

STRATEGIC PLANNING FRAMEWORK

Loma Linda is located (Figure 2) in Southern California, in an area known locally as the Inland Empire, comprised of the metropolitan areas of San Bernardino and Riverside counties. This is one of the fastest growing metropolitan areas in the United States, with a population of over 3.3 million and increasing at a rate of nearly 100,000 residents per year. Major automobile and railroad thoroughfares connecting Los Angeles with the rest of the nation run through Loma Linda and adjacent communities. In Southern California and specifically in the Inland Empire, earthquakes, wildfires, and floods are a constant threat. The occurrence of a significant disaster has the potential to quickly overwhelm the current capabilities of the local disaster response system. The development of a CURE Center in light of these needs could provide a much needed resource in times of disaster.

Loma Linda University Medical Center and Children's Hospital (LLUMC&CH), the affiliated Medical Center for the CURE Center, is a 797-bed tertiary care facility and Level 1 Trauma Center for both pediatric and adult patients. The Emergency Department (ED) evaluates more than 56,000 high acuity patients a year. An additional 25,000 low acuity patients are seen on campus in a nearby Urgent Care. Of the 56,000 patients evaluated, 22,000 are children. The acuity of the patients entering the ED is high, and 18% of children and 26% of adults evaluated are admitted. As a tertiary care facility, LLUMC&CH commonly treats patients with unusual or complicated medical conditions and accepts incoming transfers of ill or injured patients from many other smaller facilities. LLUMC&CH is home to a cancer treatment and research center, an active transplant service, and large neonatal and pediatric intensive care units.

Figure 2 — *Map of Southern California showing the location of Loma Linda*
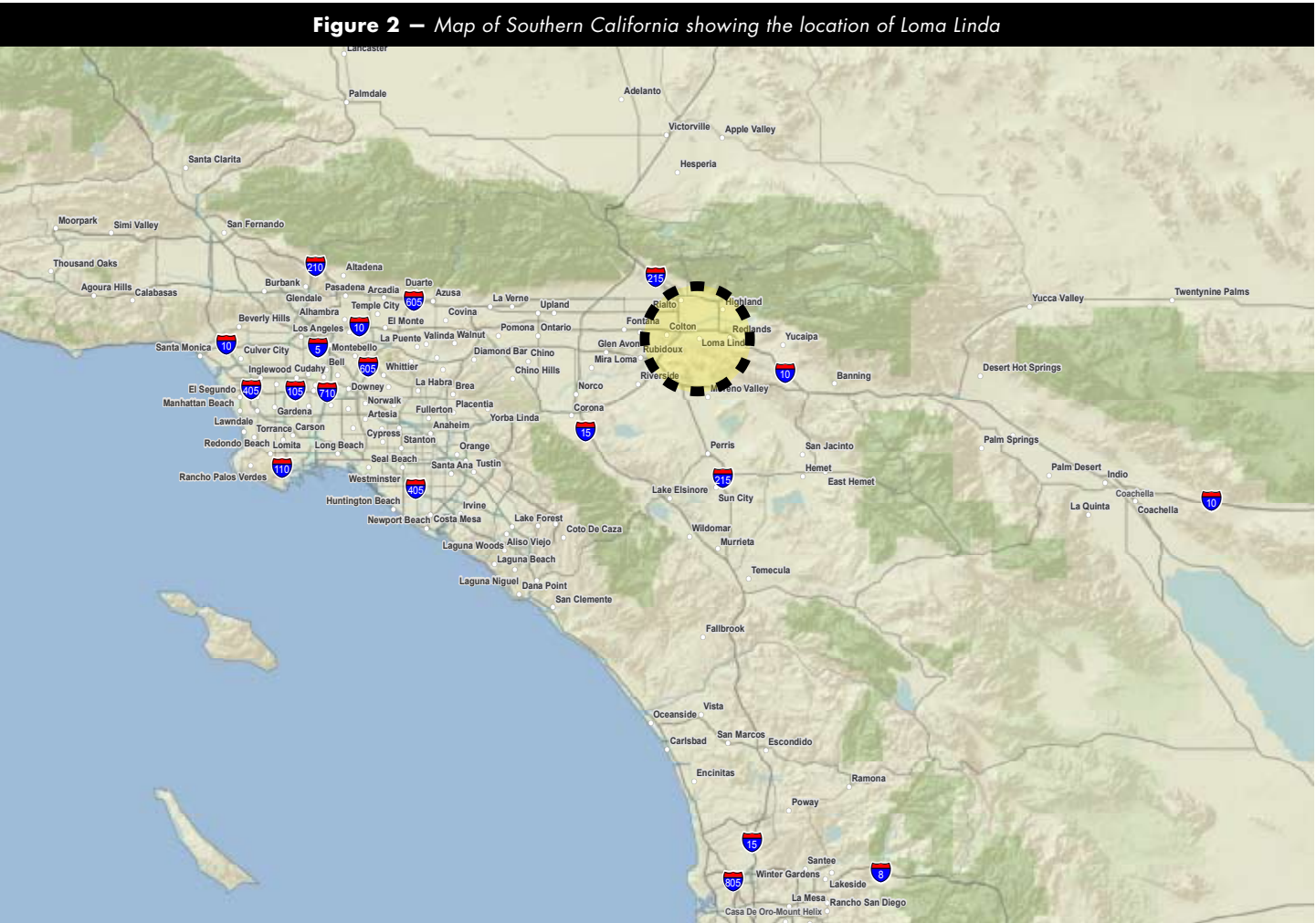
Figure 3 — *Location of the Centennial Complex (top circle) in relationship to LLUMC&CH (lower circle)*
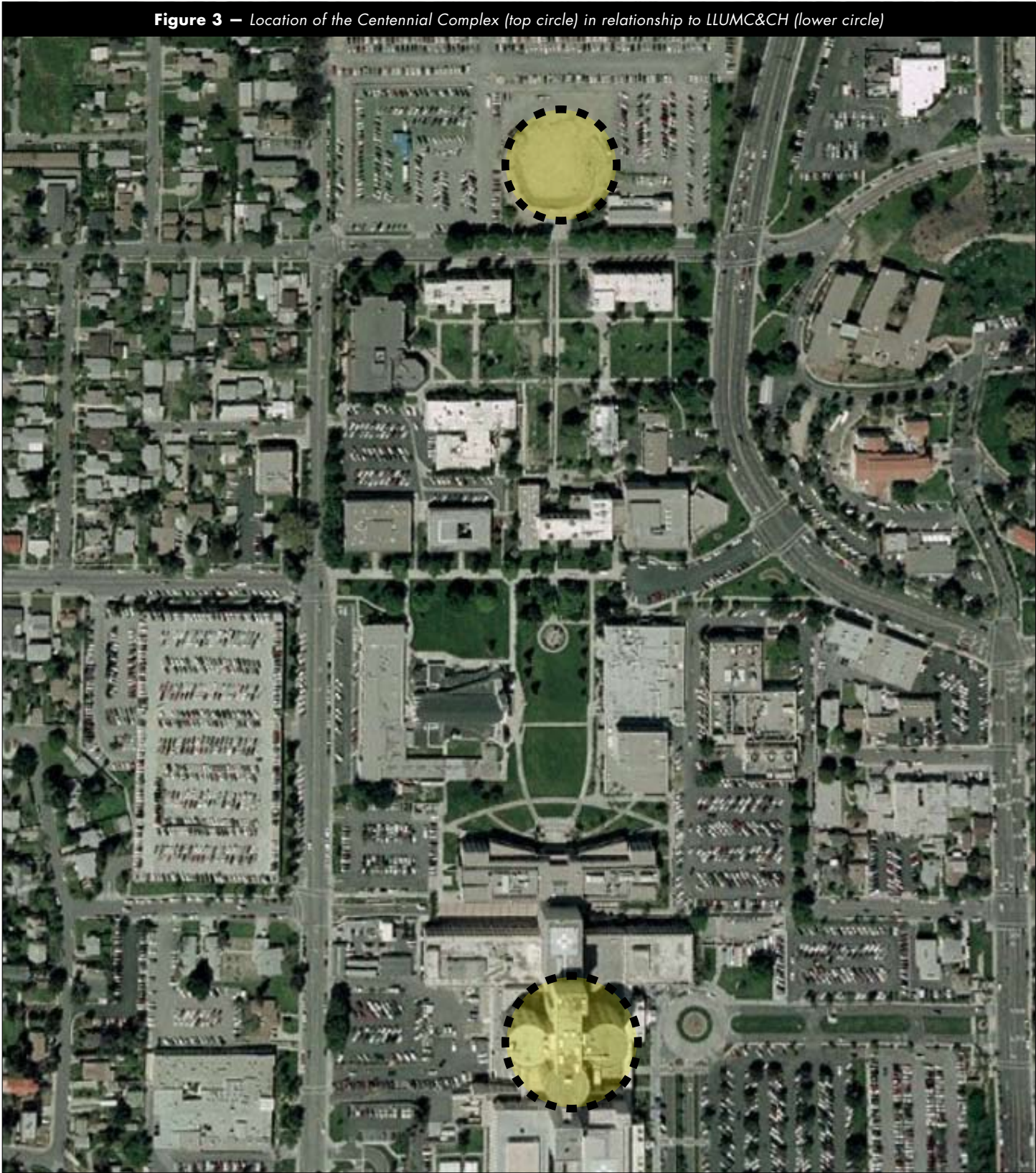
SELECTION CRITERIA

In selecting the site for the Loma Linda University (LLU) CURE Center, several criteria were considered. A location was selected near to the Medical Center (Figure 3) but where traffic can be easily diverted away from the ED without interfering with the transport of high acuity patients to the ED. The site has large open areas that will accommodate the CURE Center activities. Ingress and egress can be controlled, and the area is able to be secured. Supplies from nearby warehouses and the Medical Center can be quickly transported to the receiving area. Easy access to major roads and freeways, a rail spur, and nearby large open fields allow for a variety of transportation options, including helicopters, for moving both patients and supplies in and out of the area.

SELECTED SITE: CENTENNIAL COMPLEX

The concept of flexible use is a core consideration in planning for a CURE Center. The Centennial Complex is well suited for flexible use and its location offers many compatibilities as the LLU CURE Center. The Centennial Complex, under construction in 2008, is a state-of-the-art 150,000 square foot educational multiplex. Classrooms, laboratories, faculty offices, and technologically advanced educational facilities are housed in the four story multiuse building. Key elements of the new complex include an anatomy pavilion, an educational technology center, a skills assessment center, and two large amphitheaters. A Medical Simulation Center with state-of-the-art simulators and video feedback, along with communications equipment, is an important component of the Centennial Complex, enhancing many of the educational activities.

APPLICATION TO LOMA LINDA

ATTRIBUTES AND SYNERGIES

The four levels of the Centennial Complex will provide an extensive array of educational opportunities during normal operations. The floor plans are displayed here along with descriptions of usual activities. For comparison, the potential use of these spaces during disaster operations is also explained. This provides an understanding of the many synergies possible in using an educational building like the Centennial Complex for a CURE Center.

First Floor

Level 1 of the Centennial Complex houses the amphitheaters and the Anatomy Pavilion (Figure 4). Because of the amphitheaters, there are multiple, easily accessed entrances (including ramps) with adjacent large, open reception areas. Facilities to accommodate hundreds of people include wide hallways, multiple toilets, and large elevators. This will enhance movement of patients and staff into and through the CURE Center during its deployment.

Should it be necessary, the Anatomy Pavilion will provide space for decontamination of personnel and patients. The area is well plumbed, making the addition of showering systems easier. A drainage system is in place and surfaces are designed for ease of reconditioning after use. Cold storage areas in this section can be used as temporary morgues, if necessary.

FIGURE 4 — *Floor plan of Level 1*

AMPHITHEATER

ANATOMY PAVILION

COLD STORAGE
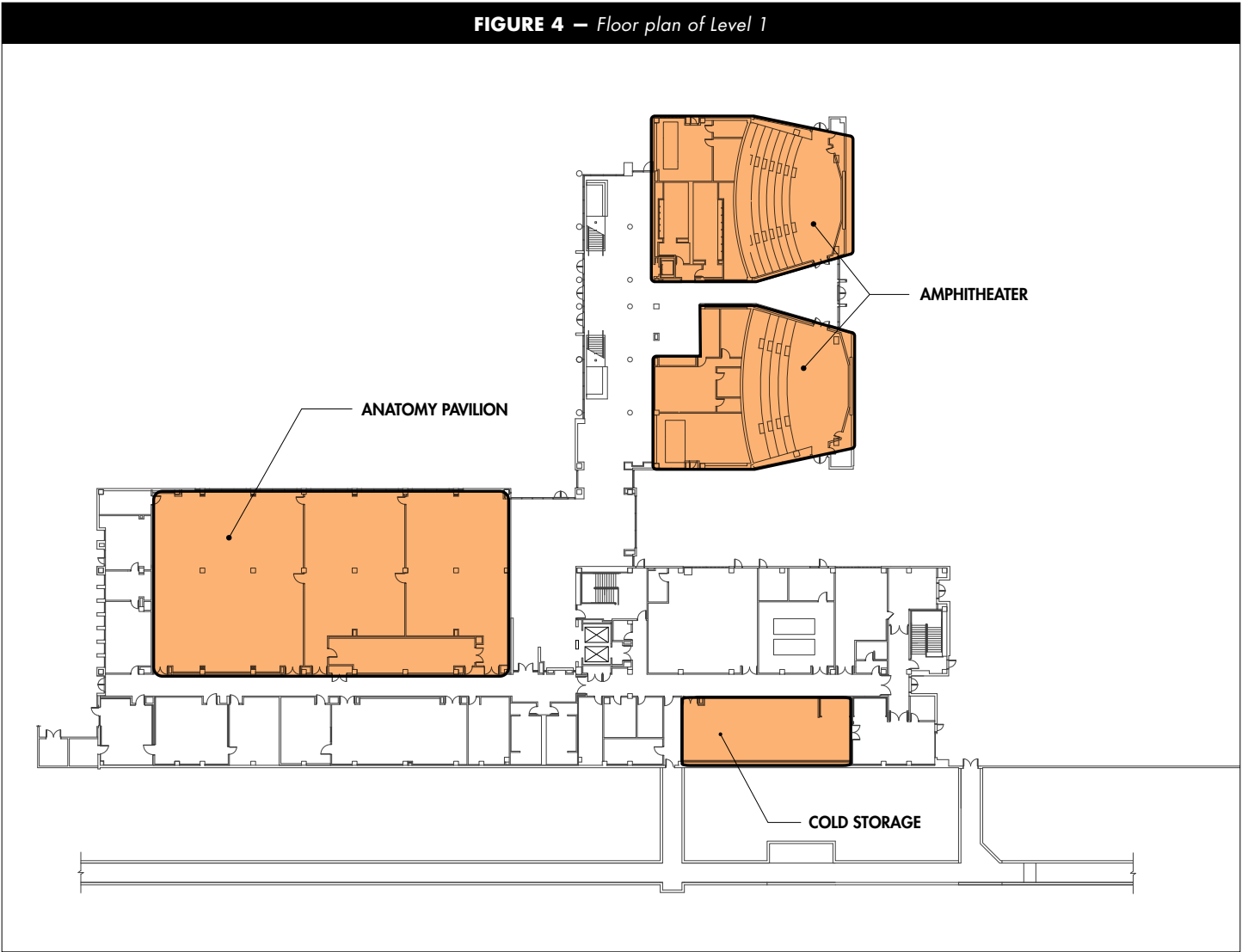
FIGURE 5 — *Floor plan of Level 2*

CLINICAL SKILLS &
ASSESSMENT CENTER

EDUCATIONAL
TECHNOLOGY
CENTER
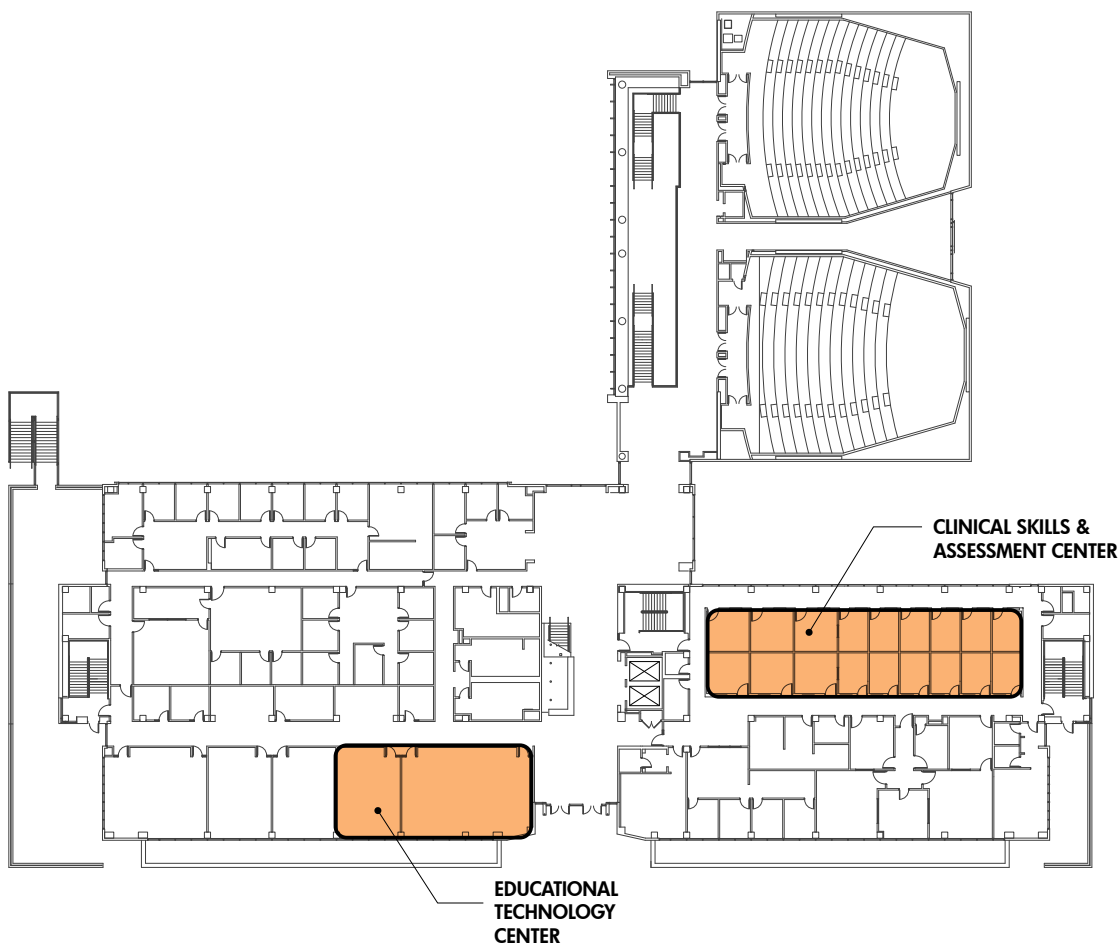
Second Floor

On Level 2, the Centennial Complex is comprised of offices and student learning areas (Figure 5). The Clinical Skills and Assessment Center, with specialized areas set up as exam rooms, provides a good setting for the evaluation and treatment of patients with minor injuries during a disaster. Each evaluation room includes audio, video, and computer equipment, and these offer additional opportunities for technology and communications connectivity during a disaster event.

The Educational Technology Center is also on the second floor. This area incorporates the electronics combining computer, audio, video, and robotics technology as well as connecting classrooms with remote sites. Two way communications are possible for students and teachers in real time interactions formerly achievable only through person-to-person contact. During a disaster, these same connections can provide telemedicine consults with ED personnel or specialists in other disciplines, including infectious disease, trauma, or intensive care. They can also provide direct visual communications with field personnel at the site of a disaster. Additionally, the combination of classrooms and educational technology could provide—even as an actual disaster is unfolding—"just in time" training of personnel at the CURE Center, or be available to offer training at remote sites. Another useful compatibility for the Educational Technology Center is its potential to house a portion of the CURE Center communications equipment.

APPLICATION TO LOMA LINDA

ATTRIBUTES AND SYNERGIES

Third Floor

Two more teaching amphitheaters, as well as student lounges, are on Level 3 (Figure 6). These can easily accommodate staff respite areas. The Geographic Information System (GIS) laboratories on this level can provide additional CURE Center communication and technology access points, as well as make real time incident information available to the CURE Center staff and administration.

FIGURE 6 — *Floor plan of Level 3*

STUDENT LOUNGE

AMPHITHEATERS

GIS LABS
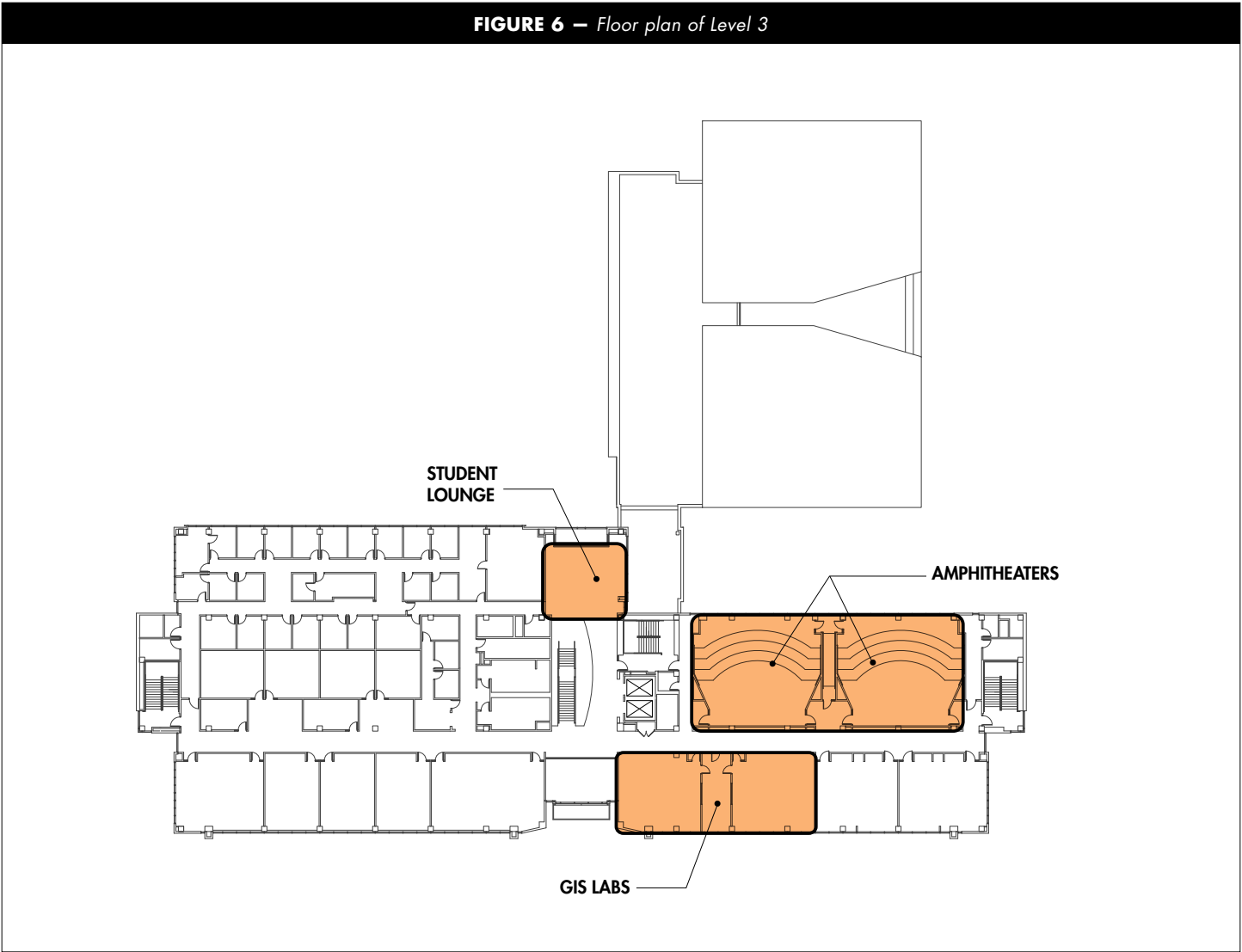
FIGURE 7 — *Floor plan of Level 4*

MEDICAL
SIMULATION
CENTER
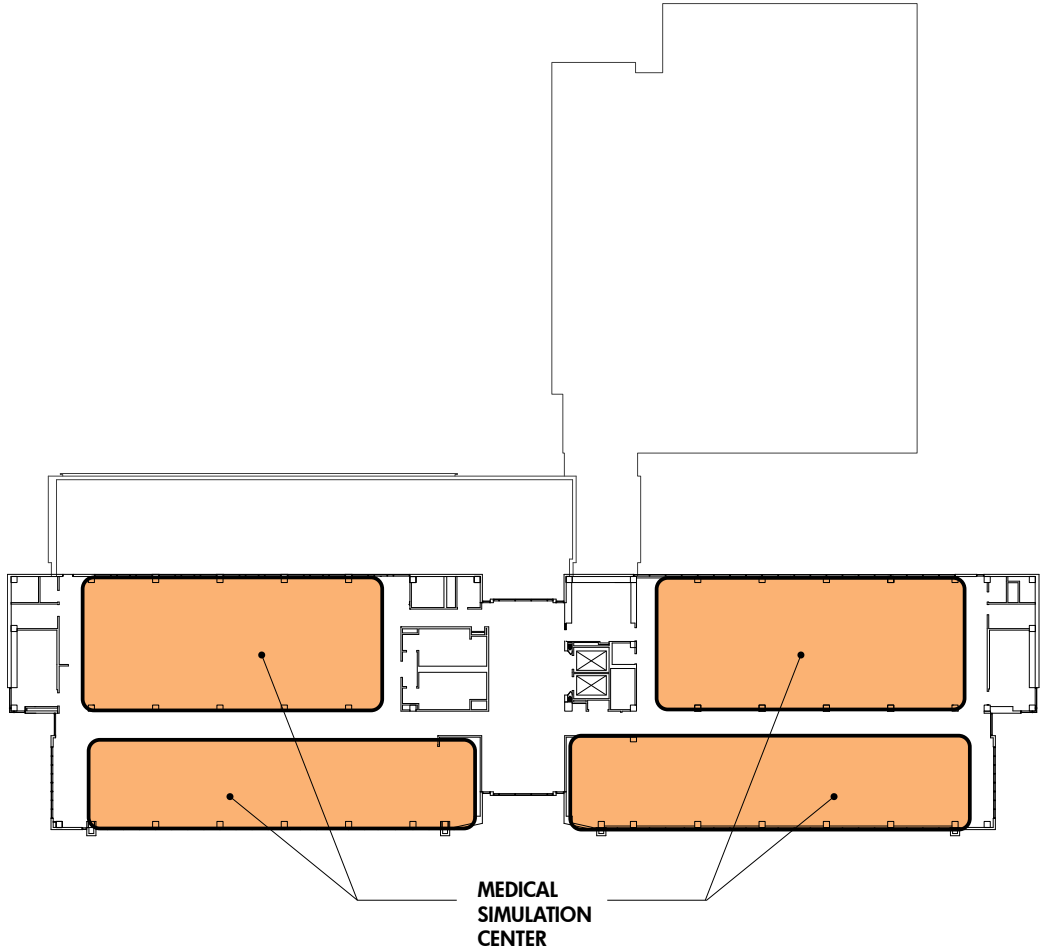
Fourth Floor

Level 4 of the Centennial Complex holds the state-of-the-art Medical Simulation Center (Figure 7). This 30,000 square foot area contains four quadrants, each with its own purpose or theme. One quadrant includes a large space with movable walls, allowing for easy conversion into multiple zones. As part of everyday use, the Medical Simulation Center will provide simulated training environments for the spectrum of healthcare a patient is likely to receive. This includes the capability to train search and rescue teams or other first responders in the initial care of a patient. As patients are brought to a simulated ED, scenarios will change to focus on the training of ED personnel. And, as patients subsequently require surgery or critical care, simulations will be able to focus on teams of surgeons, anesthesiologists, or intensive care specialists.

During disasters, the CURE Center can convert the flexible Medical Simulation Center space into an area for critical care. Other quadrants will provide additional flexible space that can be converted into patient care areas, family rooms, and physician consult areas, as well as radiology, laboratory, and pharmacy suites. The Medical Simulation Center, designed to provide simulated teaching opportunities to all participants on the healthcare team, can also be used during disaster drills for deployments of the CURE Center. These drills will allow participants to train and evaluate the CURE Center functions and be an important part of the quality improvement process for the CURE Center.

SCENARIO A: TRIAGE FUNCTION

ACTIVATION PROCESS

In the event of a large scale disaster occurring in close proximity to the CURE Center, the CURE Center may be activated as a triage center. Studies of past disasters have shown Emergency Departments (EDs) to become rapidly inundated with victims who were able to find their own transportation quickly. Unfortunately, those actually needing all the critical care and trauma services of the ED require paramedic transportation, which means the sickest patients have not arrived as quickly to the ED in past incidents as those finding their own transportation. In a disaster with a CURE Center available and activated as a triage center (Figure 8), those finding their own transportation quickly could be directed away from the ED to the CURE Center for initial triage. Patients evaluated by paramedics and deemed as needing less critical care could be brought by ambulance to the CURE Center. By diverting the less emergent patients away from the EDs, the sickest patients will have a better opportunity to immediately receive the full resources of the ED.

The CURE Center activation process must have both an external (community) and internal (hospital) mechanism (see Figure 9). The decision to activate the CURE Center for triage should occur without delay in order for it to provide an effective response.

The most likely scenario for activation of the Loma Linda University (LLU) CURE Center would start in the ED. When information regarding a multicasualty incident comes in over the ED paramedic base station radio, the ED charge nurse and attending ED physician on duty would determine if there is potential for a disaster condition. If they feel there is, they must also consider if the CURE Center should be activated in its triage capacity. Using standard Loma Linda University Medical Center (LLUMC) disaster activation protocol, this information must then be conveyed to the Security Control Center and a group page for a Disaster Declaration sent out. While the Disaster Declaration administrators confer via conference call, the ED would initiate the department's disaster plan, and begin preparing for possible CURE Center activation by performing a Readiness Checklist. This list will ensure that supplies, pharmaceuticals, and other equipment are ready for deployment and operation. If there is potential for damage to the CURE Center site due to the disaster incident, a Damage Assessment Team must first clear the CURE Center and evaluate the physical plant for operability. Once this is accomplished, the Communications Center in the CURE Center will be activated and the Advanced Emergency Geographical Information System (AEGIS) accessed. If there is a potential need for decontamination of victims, Environmental Health and Safety personnel will be alerted and the necessary supplies and equipment will be prepared. Once the decision is made to activate the CURE Center, these preparations will allow immediate deployment. From the point of activation, readiness is anticipated to be about sixty minutes.

Because the CURE Center is conceived to be a community asset, it may also be requested by the field Incident Commander. Requests for CURE Center activation would be directed from the county Emergency Operations Center (EOC) directly to the LLUMC EOC or hospital administrator.
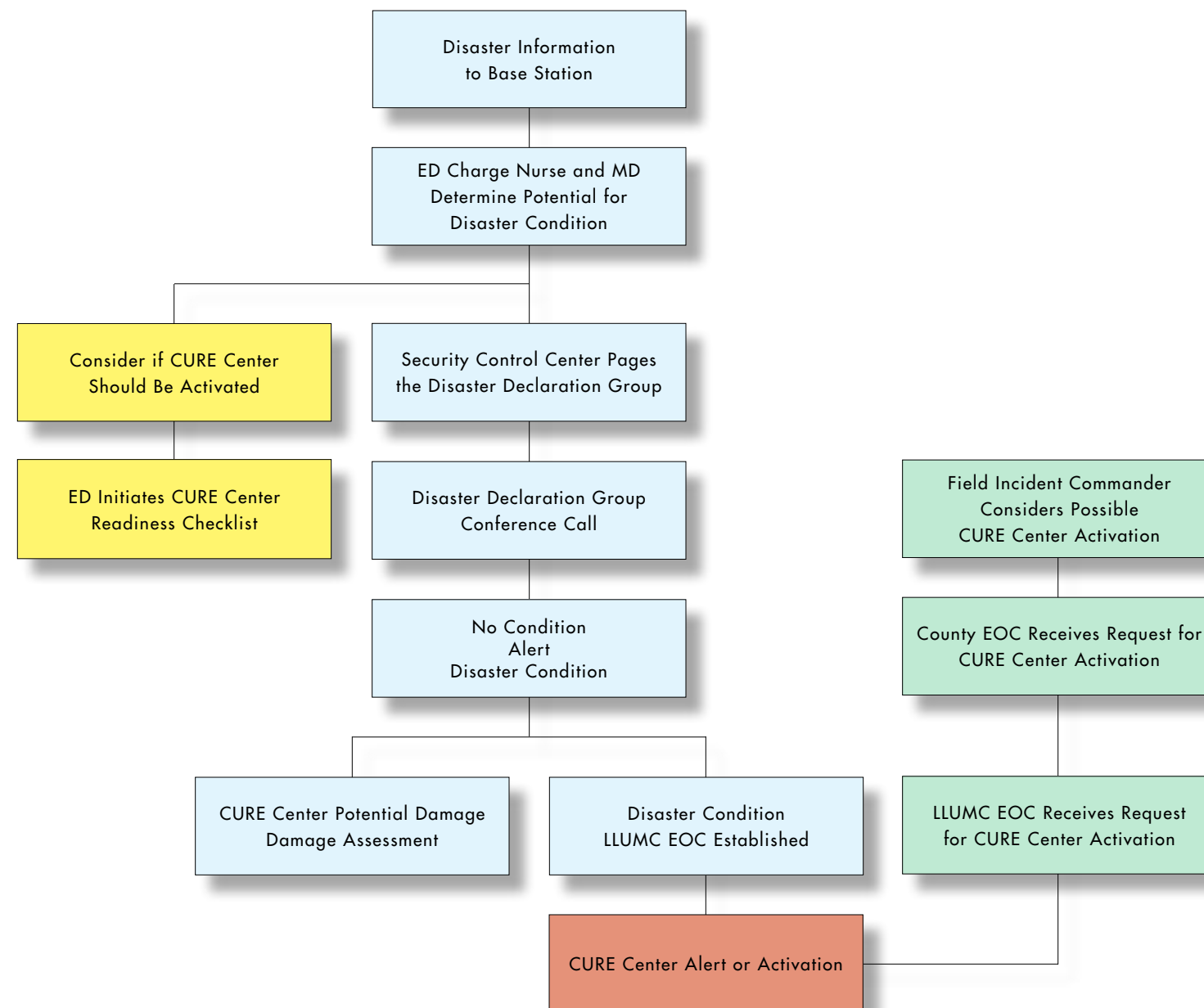

FIGURE 8 — Conversion to Triage Function

OPERATIONS	COMMUNICATIONS	TECHNOLOGY	ENVIRONMENT
• Internal mechanism: Potential for disaster condition evaluated by ED RN and MD • External mechanism: Activation request from Incident Command and EOC • ED disaster plan initiated • Conference call by Disaster Declaration administrators • Readiness Checklist initiated • Activation requested, 60 minute readiness goal • Site security plan activated	• Communications team activates the CURE Center command center • Activate and access networks and systems • Confirm connection to Incident Command and EOC • Internal communications to hospital administration confirmed	• Staff tracking system initiated • ED tracking of developing GIS issues on AEGIS	• Evacuate Centennial Complex • Assess need for site decontamination • Assess CURE Center damage • Environmental Health and Safety personnel alerted

FIGURE 9 — *Activation Algorithm for CURE Center Triage Function*

READINESS CHECKLISTS

Alert Checklist

- Readiness Assessment
  - Assess Need for Decontamination
    - Alert Safety Personnel, if necessary
  - Security Plan activated
  - Pharmaceuticals
  - Supplies
  - Physical plant
  - Computers
  - AEGIS
  - Communications Center

- Initiate Damage Assessment, if necessary
  - Structural
  - Natural gas
  - Mechanical and electrical systems
  - Water supply
  - Waste water
  - Medical gases
  - Elevators
  - Access
  - Exits and egress
  - Fire system
  - Medical core equipment in reserve
  - Landline phone systems
  - Wireless and satellite communication systems
  - Identify biohazards
  - Need for housekeeping

- Staffing Plan
  - ED staff ready for deployment

Activation Checklist

- Readiness Assessment complete
- Damage Assessment complete
- Initial Staffing Plan complete
  - Hospital disaster staffing plan confirmed
- Decontamination Plan, activated if necessary
- Initiate vehicle removal

SCENARIO A: TRIAGE FUNCTION

SITE RESPONSE

Preparing the CURE Center for triage is as much about traffic control as about medical care. In arranging the site, workers must be ready to receive patients as quickly as possible while maintaining an organized response and keeping personnel safe. As graphically displayed (Figure 10), traffic is not allowed in certain areas. Areas without traffic are where the actual triage activities will occur. Access to the triage area and to the overall site is controlled by traffic officers and placement of barriers. Signage clearly describes specific areas and traffic flow. Vehicles entering the site are directed through the queue. This pattern can be shortened or expanded (Figure 11) based on the number of vehicles entering the system. Patients can be transported directly to Primary Triage, or to the Patient Drop Area (seen on Figures 12 and 13) if required. Controlled access is also established at the north end of the site. Here, staff and ambulances designated for transport of patients out of the Secondary Triage zone are able to enter their designated parking and staging areas. If people ambulate onto the site seeking medical care or evaluation, they will be directed to the Green Zone (seen on Figure 13).

FIGURE 10 — *Vehicle access restricted to outside of triage area*
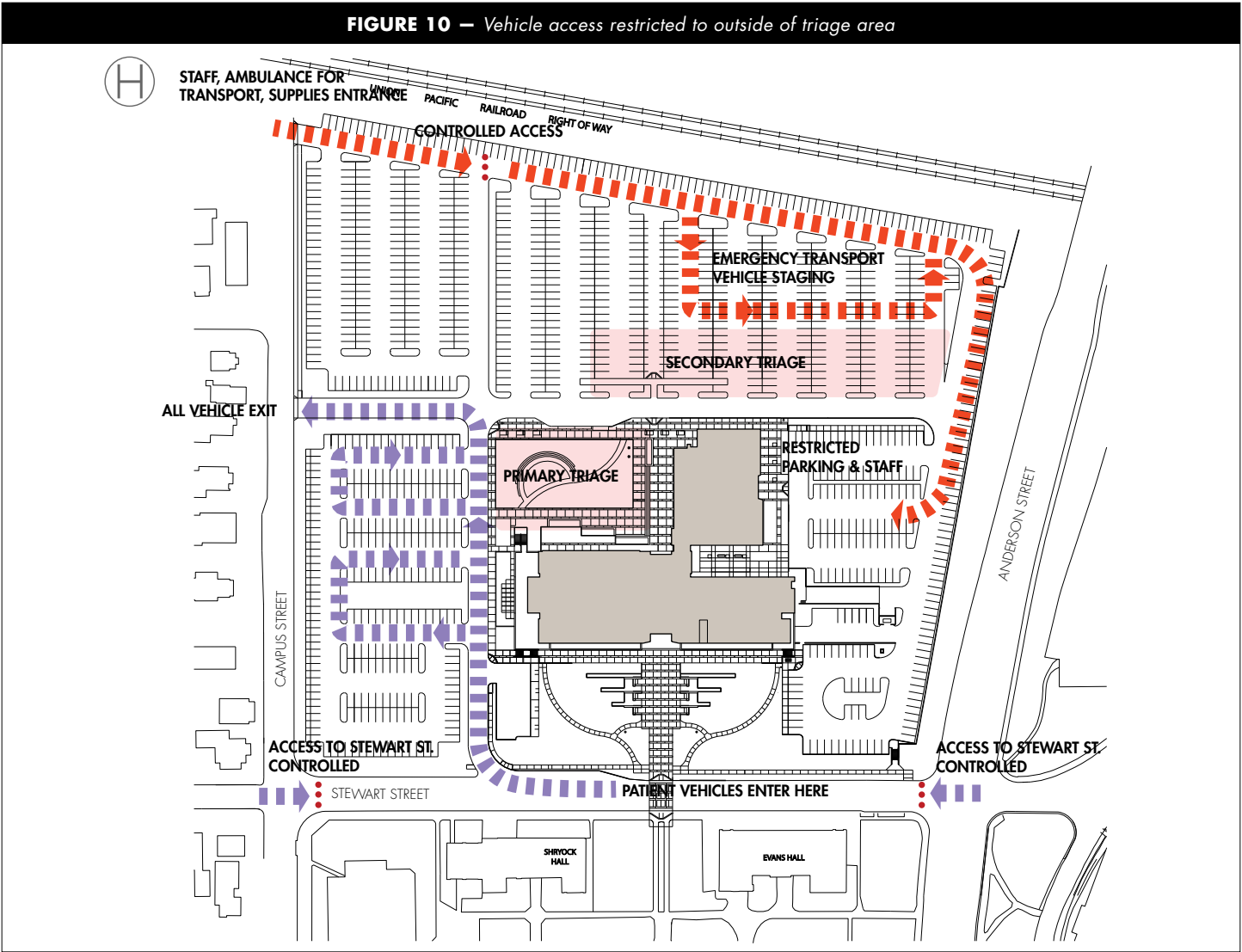
FIGURE 11 — *Traffic patterns can expand and contract as necessary to accommodate the number of vehicles*
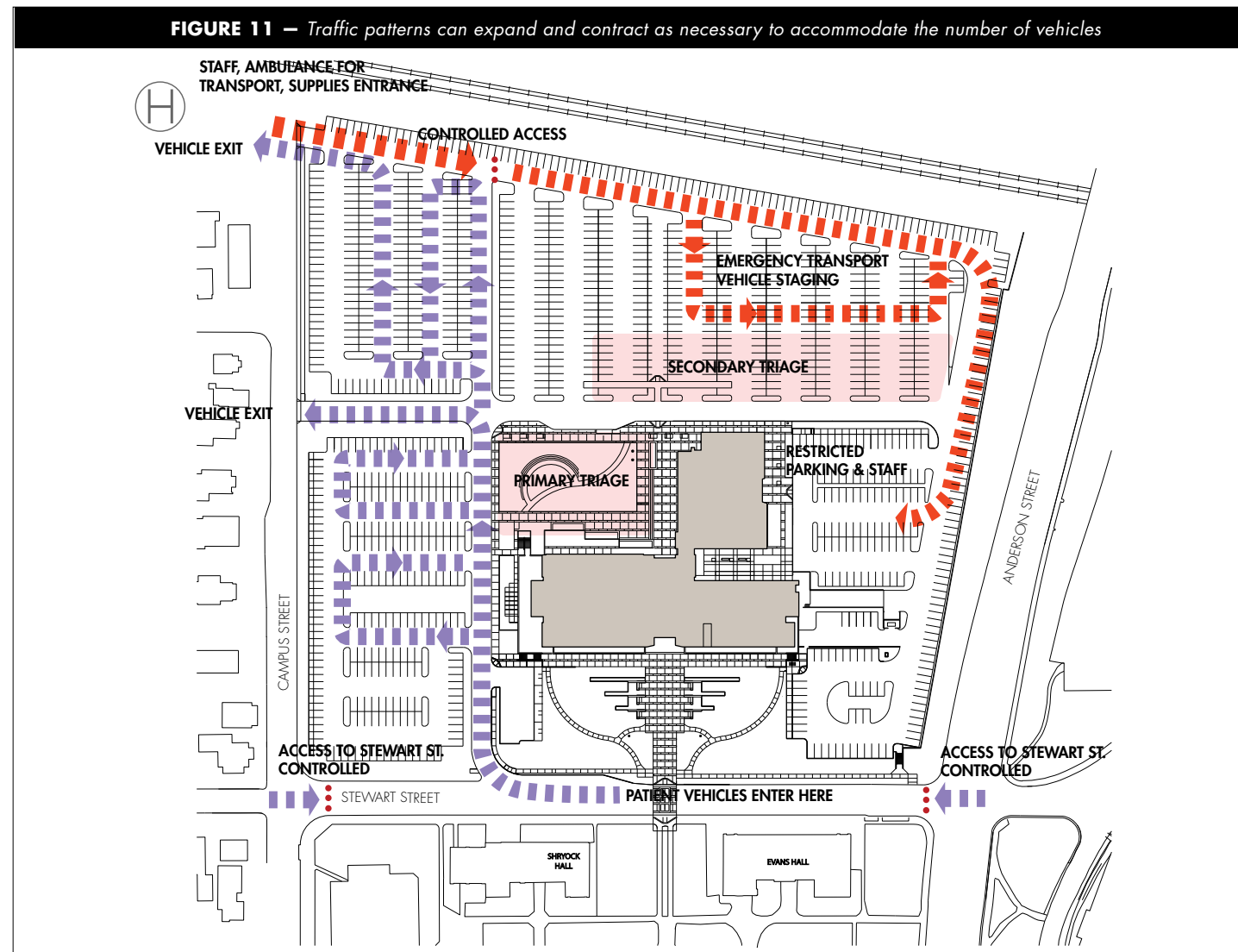
OPERATIONS

- Vehicle removal initiated
- Traffic control officers in place
- Potential for austere conditions evaluated
- Hospital disaster staffing plan implemented
- Staff registration site established
- Staff communications plan initiated
- Security established for staff arrival and departure
- Deploy registration materials and equipment

COMMUNICATIONS

- Radios allocated to key personnel
- Establish internal communication links
- Establish site security and support links
- Establish external communication links

TECHNOLOGY

- Tracking system initiated for on site patients
- Identification badges readied for scanning
- Medical equipment deployed to triage zones
- AEGIS employed by the communications team to link with real time field assessments
- Staff credentialing data system initiated
- AEGIS updated with CURE Center icon when activation complete

ENVIRONMENT

- Signage and barriers placed
- Triage zones defined and established
- Triage supplies and equipment deployed
- Identify specific and/or unique resources needed
- Helicopter landing zone cleared and secured
- Power and water supply confirmed
- Sewage facilities and systems confirmed

SCENARIO A: TRIAGE FUNCTION

SITE RESPONSE

With specific activities confined to the various zones of the CURE Center site, a more organized, secure response is possible (Figure 12). The influx of patients occurs on the western aspect of the site. Making certain they are appropriately directed to triage also takes place in this area. Traffic patterns for staff and supplies interface minimally with those seeking care. Ambulances arriving to transport outgoing critical patients are staged in an area where they can arrive, load patients, and depart the scene without impediment.

In the Emergency Transport Vehicle Staging Area, communications and coordination with area medical facilities to determine resource capabilities and bed availability can occur via established communications. This also enables the Transport Officer to arrange for alternate means of transport, including helicopters and buses. Tracking devices will maintain the whereabouts of individual patients as they are advanced through the system, automatically preserving a log of patients and their destinations.

Site security is established along with the access control. Security also oversees the removal of any vehicles contained within the Secondary Triage area. Communications between security personnel and the CURE Center occur through links between the CURE Center Communications Center (set up during Readiness Assessment) and the Security Control Center. Additional activities in the Communications Center include deploying radios or other communication devices to key personnel, establishing communications with the LLUMC EOC as well as the community EOC, and instituting communications with other facilities.

The staffing plan, initiated during Readiness Assessment, will direct staff to the CURE Center. A staff registration area is located on the south end of the building, providing entry to the CURE Center site in an area not involved with patient care and easily approached from the staff parking. Equipment needed for each triage area (Primary and Secondary) is deployed during the activation process. As staff members are registered, they will report to their assigned areas and check in with their designated supervisors. Staffing charts posted in each area identify each position, current staff member in that role, and lines of communication.

The CURE Center icon will notify the Incident Commander, community EOC, and LLUMC EOC that the activation process is complete.

FIGURE 12 — *Activities occur in specific zones to provide an organized, secure response*

FIGURE 13 — *Patient and Staff Circulation*
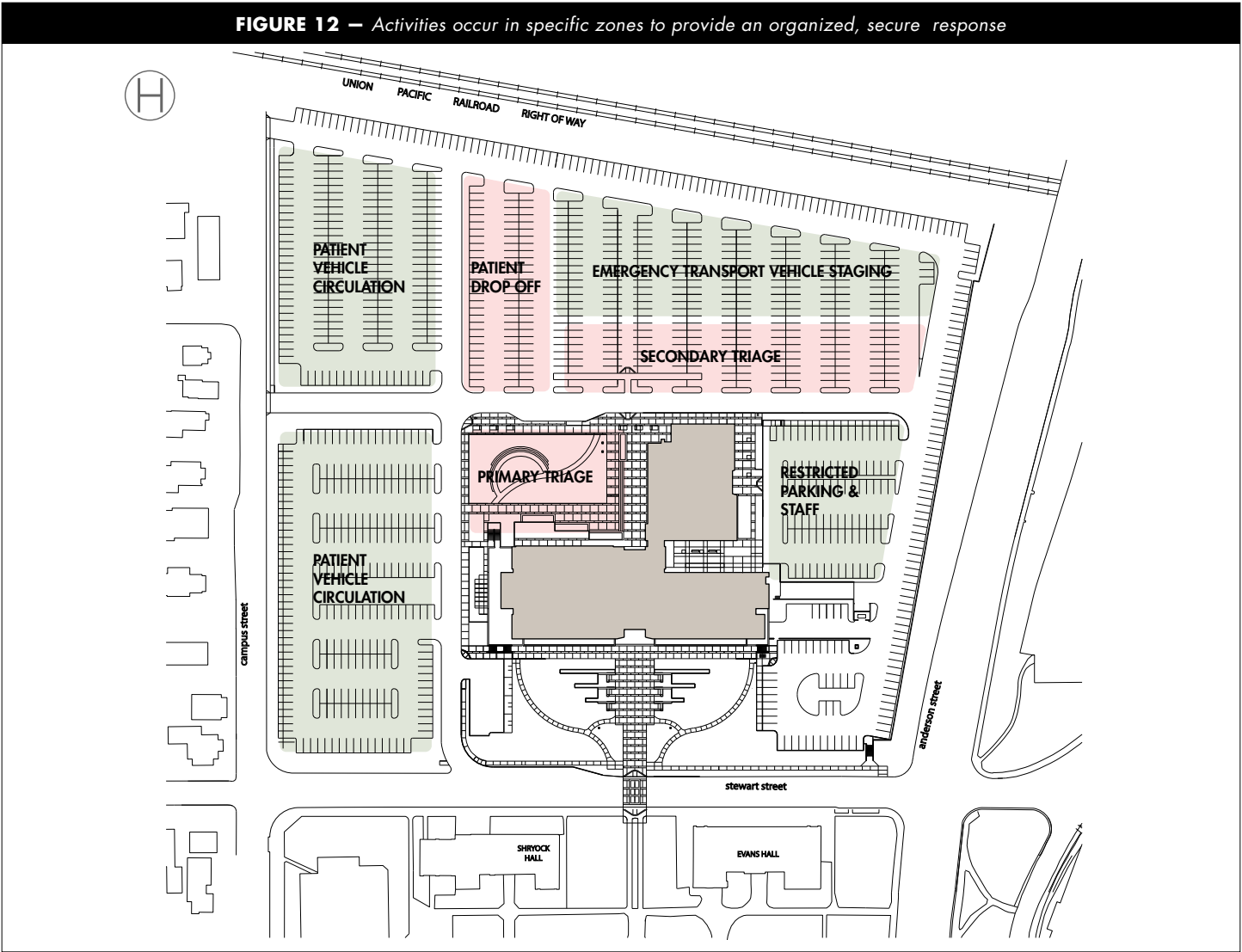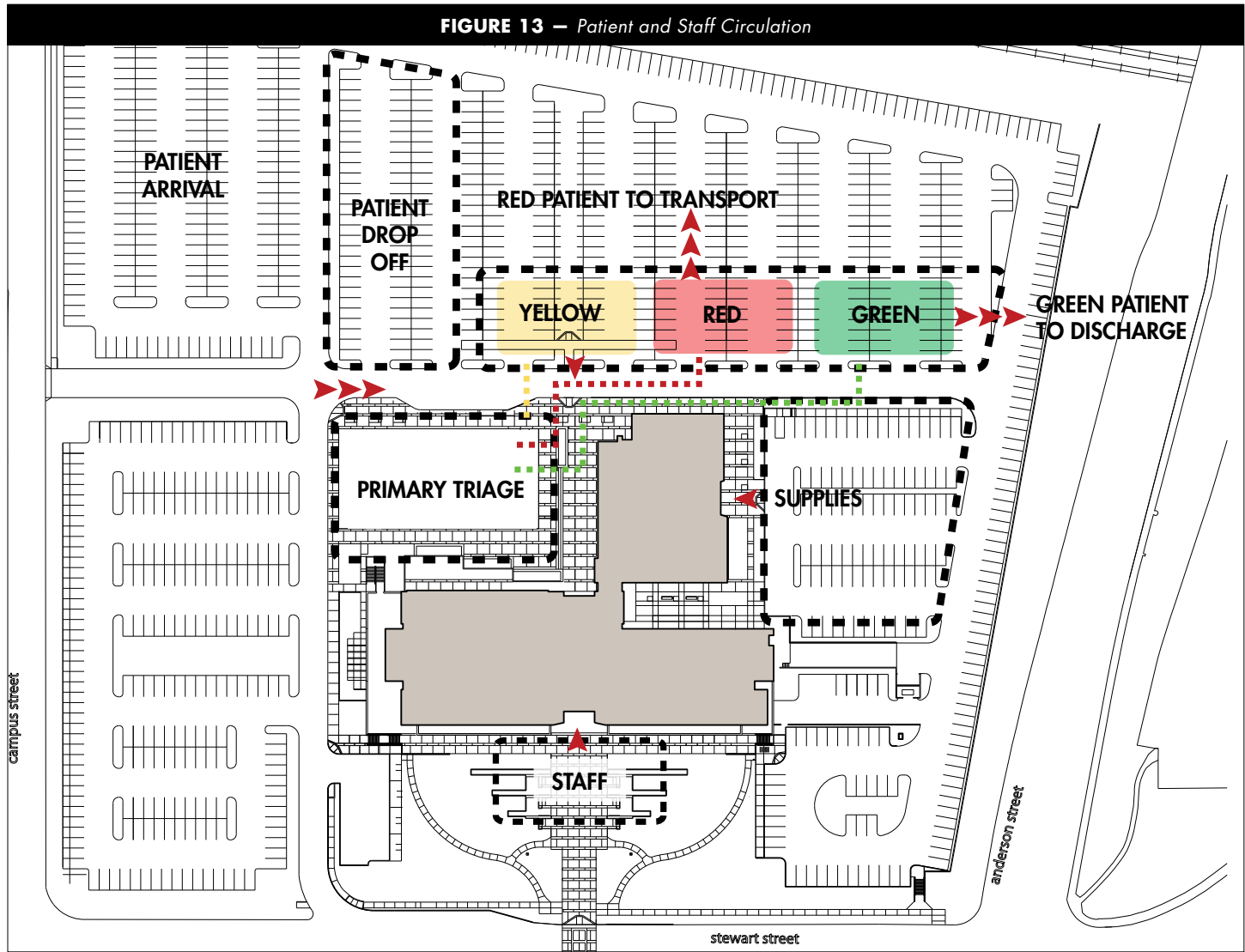
Primary Triage

Patients requiring assessment will enter at Primary Triage (Figure 13) where a four tier tool, such as Simple Triage and Rapid Treatment (START), will be employed. Patients will be placed into categories of priority using the color codes of RED, YELLOW, GREEN, or BLACK. The Primary Triage area will accommodate multiple stations staffed by a triage officer and support staff. After a patient has received this initial evaluation, they will be directed to a designated secondary location. It is possible some patients may arrive walking; they will be directed to the Green Zone. Patients assigned a GREEN color code will be understood by personnel as having minor medical issues and those with a YELLOW color assigned will be understood as having medical issues that can be safely delayed, at least for several minutes. A patient with a RED color category, on the other hand, will require immediate further evaluation and treatment.

Secondary Triage

- RED patients will be moved to the Secondary Triage Red Zone, prioritized, and transported for definitive stabilization and treatment.

- YELLOW patients will be directed to the Secondary Triage Yellow Zone. Priorities of care will be designated for each patient and simple stabilization measures taken. Depending on available resources, yellow patients will be moved (see Figure 15) to Patient Reception/Check-in and to the Yellow Holding area. From here, arrangements for treatment or transport will be made.

- GREEN patients will be directed to walk to the Green Zone where patients will be sorted, transported to a remote site, or discharged depending on available resources.

OPERATIONS

- CURE Center command structure confirmed
- Staff registration personnel in place
- Process initiated for documentation of staff arrival and departure
- Staff deployed to assigned areas
- Patient flow pattern designated and controlled
- Ambulance staging pattern established and secured
- Additional security assets confirmed

COMMUNICATIONS

- Confirm redundancy of communication networks
- Support patient transport communications as needed
- Update Incident Command
- Update EOC(s)

TECHNOLOGY

- Patient tracking system expanded to include transport agencies and other facilities
- Initiate simulation technology to model current disaster and estimate casualties
- Assess need for collaborative resources, such as the Mobile Telemedicine Vehicle

ENVIRONMENT

- Address shelter for triage
- Address shade, beds, and comfort measures
- Nutritional and laundry supplies available
- Equipment deployed and tested in place
- Triage process initiated
- Patients following appropriate sequence through site, assisted by staff as needed

SCENARIO A: TRIAGE FUNCTION

SITE RESPONSE

A Triage Supervisor will provide support and leadership for all triage functions and will provide the CURE Center Commander with reports and updates. The CURE Center Commander will keep the appropriate EOCs apprised of patient numbers and needs.

CHAIN OF COMMAND

The Chain of Command in the CURE Center will follow an organizational chart (Figure 14). It is based on the Incident Command System, a standardized management tool used during large scale incidents. Using this system, the CURE Center Commander will report to the Operations Section Leader of the LLUMC EOC.

Chain of command for the CURE Center will occur through the LLUMC EOC, while the CURE Center Commander will supervise the operations, logistics, planning, and communications taking place at the CURE Center site. Financing of the activation process, staffing, supplies, and ongoing operations will be coordinated by the LLUMC EOC. This may involve local, state, and federal agencies with regards to funding for state or federal disaster declarations.

FIGURE 14 — *Chain of Command in the CURE Center*
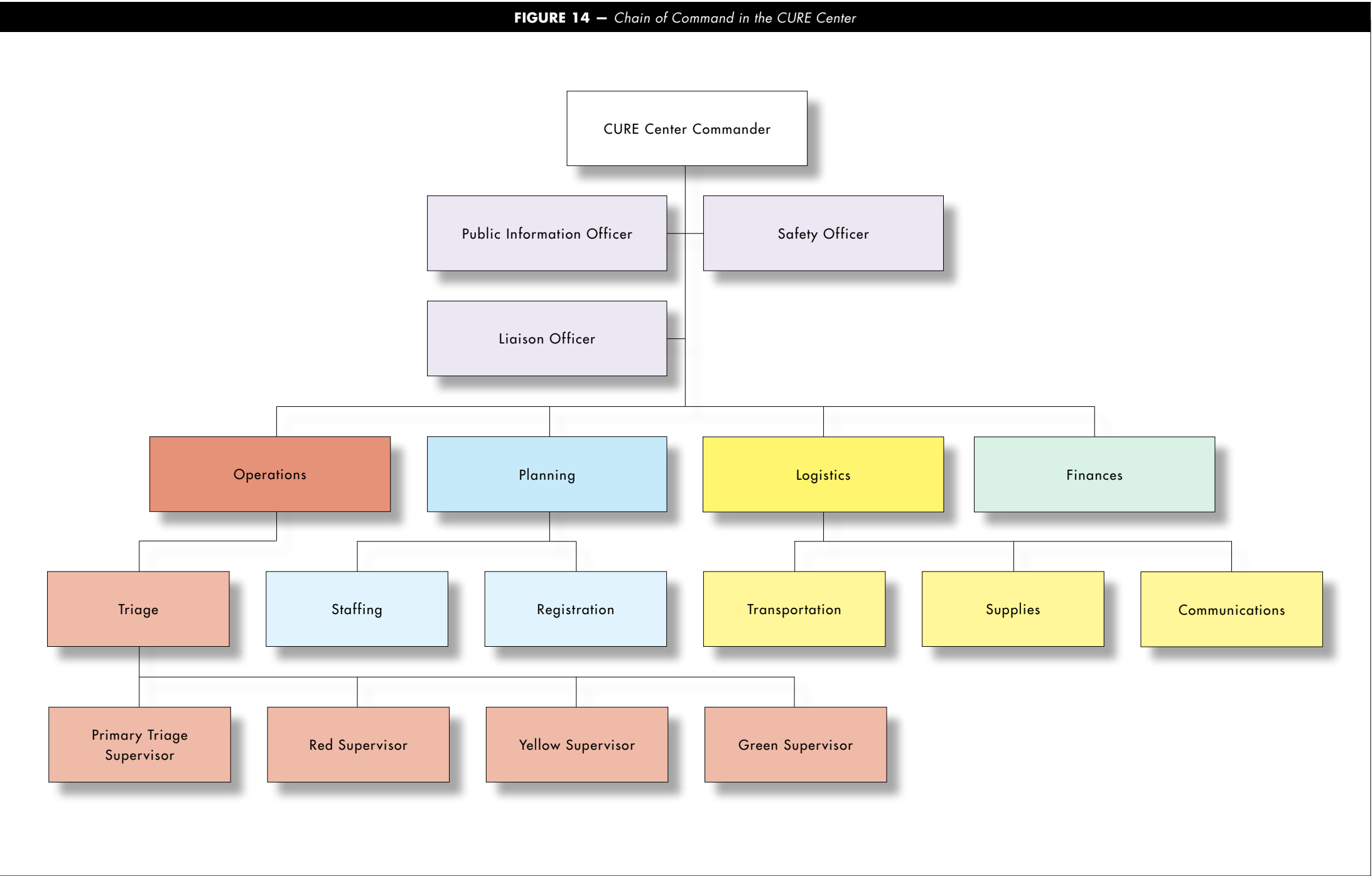
FIGURE 15 — *Site Response on the Ground Level*

GREEN PATIENTS ENTRY

GREEN HOLDING

YELLOW PATIENTS MAIN ENTRY

RECEPTION/CHECK-IN

SUPPLIES ARRIVAL

DECONTAMINATION MAIN PATH

YELLOW HOLDING

EGRESS DOOR

DECONTAMINATION

ELEVATOR

TEMPORARY MORGUE
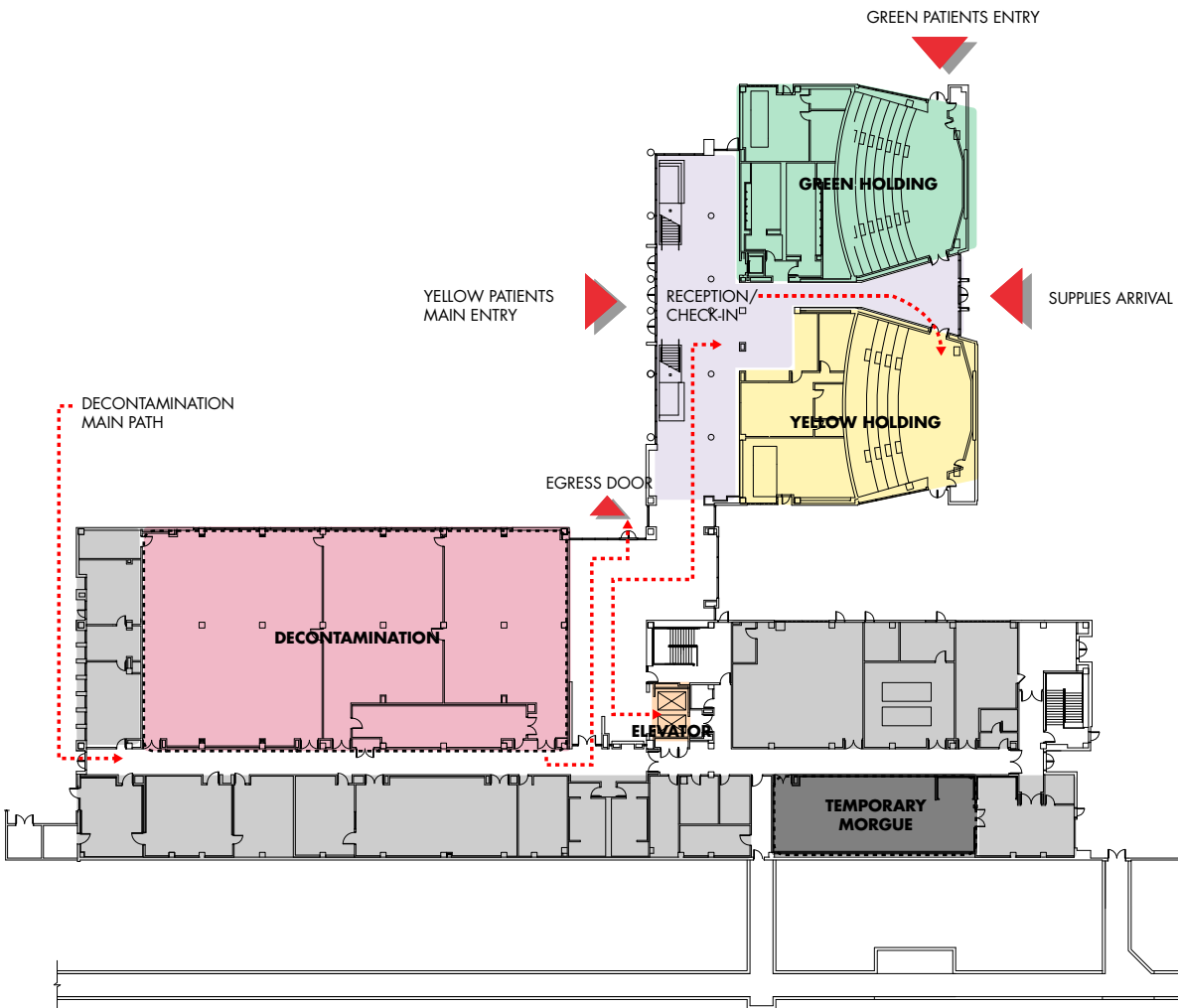
CENTENNIAL COMPLEX UTILIZATION

Ground Floor Response

If the CURE Center Readiness Assessment determines a need for decontamination, safety personnel from Environmental Health and Safety will be alerted immediately (in accordance with the LLUMC disaster plan). While the CURE Project Team does not anticipate needing to decontaminate hundreds of people, there will be patients who bypass field decontamination measures and transport themselves. Depending upon the circumstances, this group of individuals may require decontamination in order to be safely cared for.

A Decontamination Area should have a separate entrance that avoids contamination of the CURE Center facilities and staff. On the Ground Level of the complex (Figure 15), patients needing decontamination can be directed to an entrance located away from the triage area and main entry. At the Loma Linda site, this portion of the building is used for anatomy labs and proves to be a good setting for decontamination activities. This area is large enough to designate both decontamination and clean zones, male and female corridors, water access, a drainage system, and surfaces that can be reconditioned after use.

Further decontamination considerations include provision for nonambulatory patients, non-English speakers, children, and sight or hearing impaired patients and their service animals. Tracking of victims' belongings can be done with the same tracking devices used for the patients.

Once decontamination is complete, patients are able to undergo secondary triage and are accompanied to the appropriate treatment site.

As seen in the site response diagram (Figure 15), patients designated as YELLOW in the Secondary Triage area can be escorted into the building through the Main Entry. Here they enter a large lobby area where further registration can occur. A holding area on this level provides shelter and access to social services personnel. Patients can remain in this area until transported, or until further treatments can be performed on site.

Likewise, patients designated as GREEN can be escorted into the building if needed. Ideally, these patients would be transported to off-site facilities for further treatment, or discharged directly. If this is not possible, they may need to remain in the CURE Center for a period of time. The entrance for GREEN patients is through the northeast corner of the building, away from other entrances, and with easy access to transportation once it becomes available. Separate registration for these patients will occur in the triage and holding areas.

Patients who have expired are placed in the temporary morgue. This is a refrigerated holding area normally used for holding and processing of anatomy specimens.

OPERATIONS

- Implement decontamination plan
- Prepare the temporary morgue
- Staffing in place for patient reception and registration, decontamination clean zone, and temporary morgue
- Prepare media site and identify spokespersons
- Credentialing process established for volunteer staff
- Deactivation team initiates deactivation planning process
- Transportation to off site shelter facilities initiated

COMMUNICATIONS

- Establish decontamination personnel communications link
- Establish communication links for intermediate care on second floor
- Monitor internal systems and network status
- Monitor external systems and network status
- Resolve communication requests from staff
- Continuous status updates through AEGIS

TECHNOLOGY

- Activate automated portions of decontamination
- Patient tracking system initiated in decontamination areas, registration area, and temporary morgue
- Initiate telemedicine networks
- Telemedicine links established for ultrasound and X-ray
- Utilize syndromic surveillance analysis and update Incident Command
- Assess continuous dynamic AEGIS data and adapt response as indicated

ENVIRONMENT

- Set up decontamination areas and corridors
- Set up nonambulatory decontamination area
- Deploy signage to decontamination area
- Prepare intermediate care areas on second floor
- Staff respite areas available for staff on third floor
- Prepare for holding patients on ground floor
- Social services available for patients and staff
- Off site care facilities being established for childcare and elder care

SCENARIO A: TRIAGE FUNCTION

CENTENNIAL COMPLEX UTILIZATION

Second Floor Response

The Yellow Holding Area has access via stairs or elevators to the second floor of the building (Figure 16). Here, classrooms converted to clinical examination rooms provide intermediate care when needed. Through the use of portable equipment, such as x-ray and ultrasound, medical supplies and a pharmaceutical cache, care providers in this area can examine and treat patients. Consultation with the hospital ED or remote healthcare sites can readily take place using telemedicine and communication links.

Staff processing areas are also located on this floor. As the incident progresses, staff members will need to be processed both upon their arrival and their departure.

FIGURE 16 — *Site Response on the 2nd Floor Level*
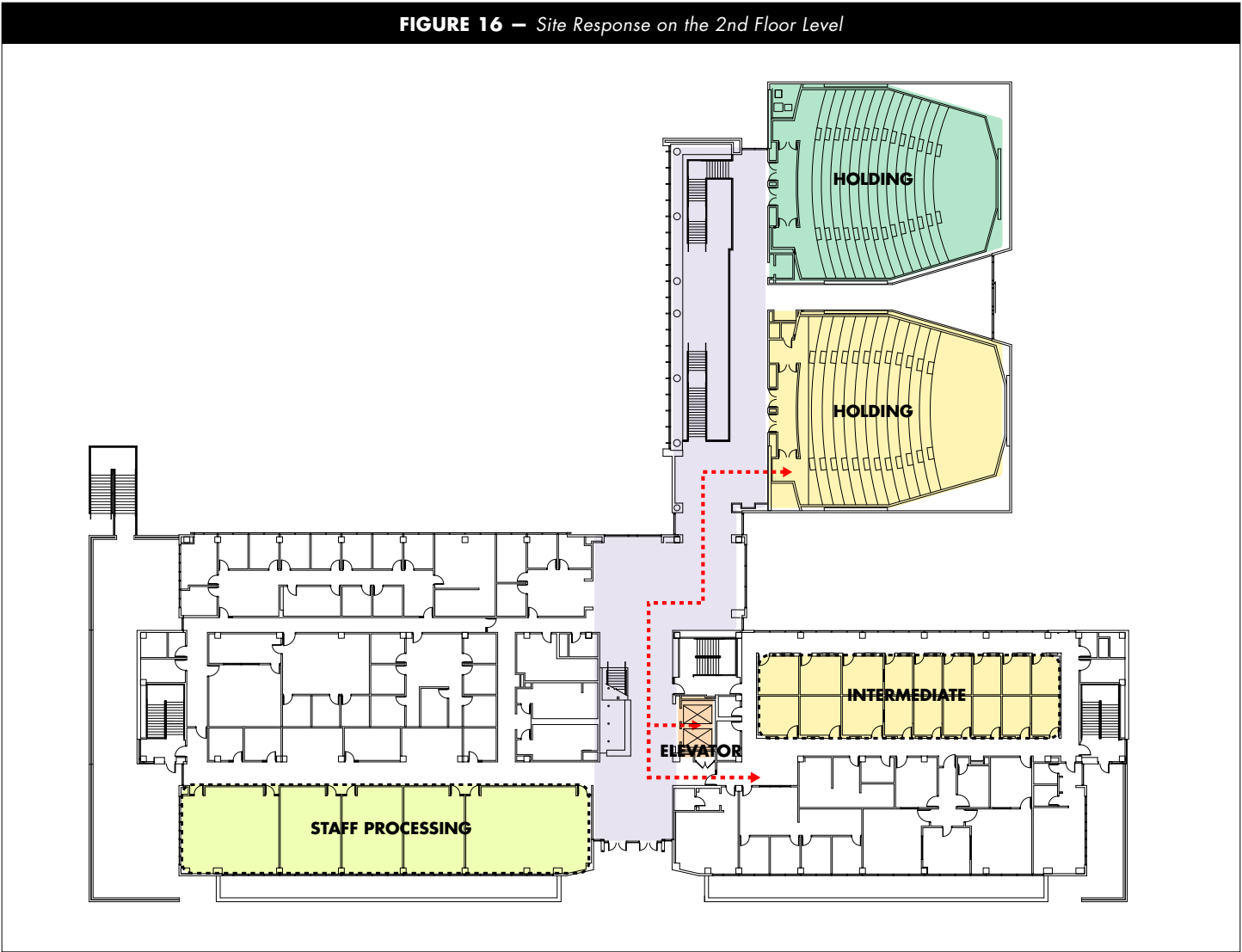
FIGURE 17 — *Site Response on the 3rd Floor Level*

STAFF QUARTERS

STAFF RESPITE

STAFF SUPPORT AREA

STAFF RESPITE

SATELLITE
COMMUNICATIONS
CENTER

STAFF
COMMUNICATIONS
CENTER
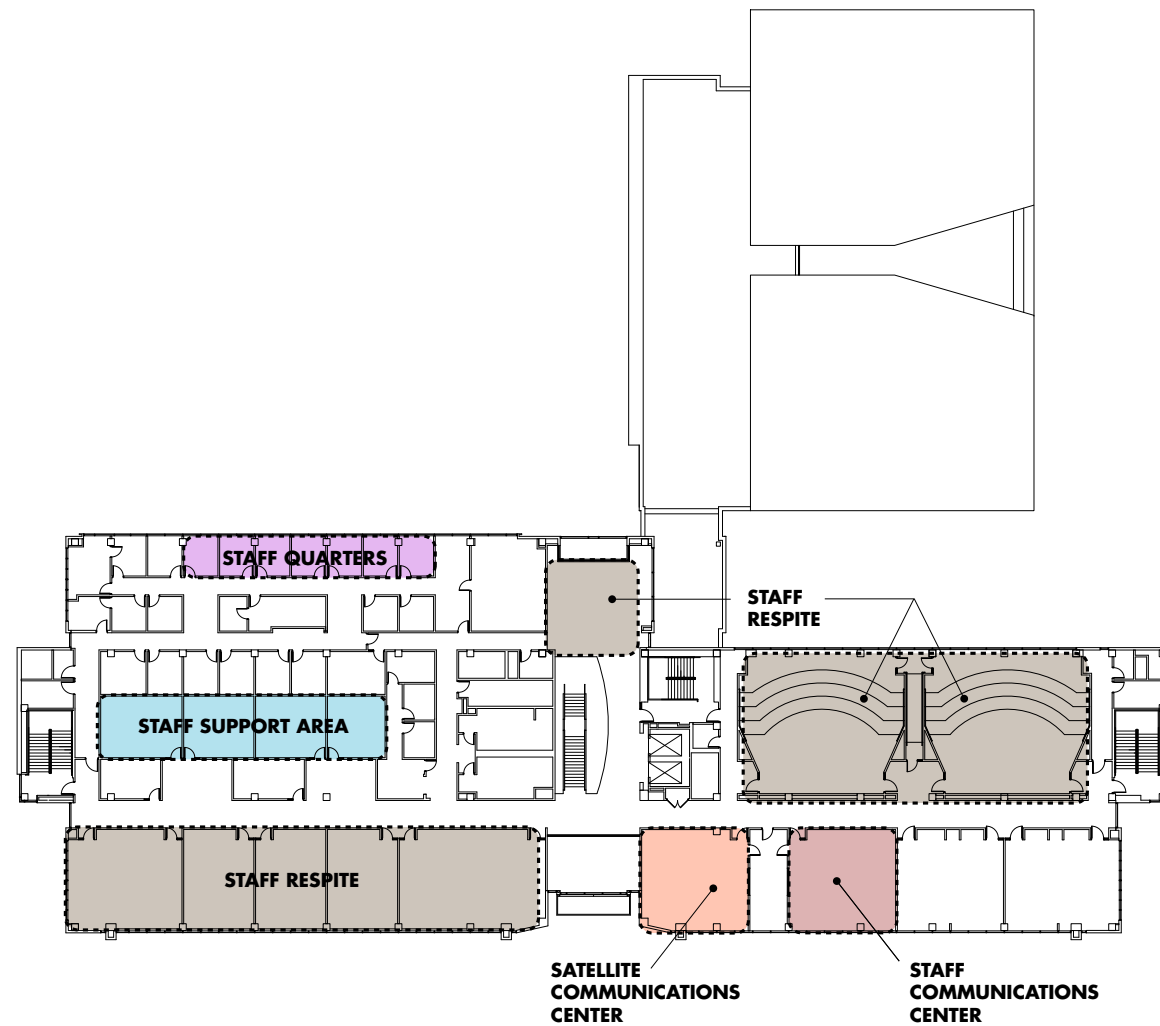
Third Floor Response

Staff quarters (Figure 17) will be supplied with rest areas, food and water. Social Services personnel will be available for staff. Care is taken to make certain staff members have appropriate priority of access in contacting their family. Although there are no on site provisions for family members, the staffing plan includes consideration for child care and elder care services at associated locations.

FIGURE 18 — *Interoperability of CURE Center Communications*

COMMUNICATIONS FRAMEWORK

Once the CURE Center is activated by the LLUMC EOC, deployment of the communication systems start with the checklist of operational priorities along with staff briefings. Activation assumes 24/7 operations, and all network and communication services will need to be resilient in support of this requirement.

The Centennial Complex, chosen for the LLU CURE Center, supports many of the required communication functions. It is clear, however, that interoperability and redundancy of communications (see Figure 18), in support of the CURE Center and its related mobile operations, are important components in designing the communications framework. Collaboration with local and regional first responders is critical and in some CURE Center deployments communications with national resources may be required.

REDUNDANCY AND INTEROPERABILITY

The systems being deployed were chosen based on the need to make the CURE Center a resilient network and autonomous from local communication services, when necessary. While use of most communication system components starts with services provided by the campus network, two additional layers of communications network redundancy were incorporated. If the local campus network or any of the systems within the network are unavailable, the CURE Center will automatically route communications to the next available network.

The first back-up network for the CURE Center connects to a 4.9 GHz private wireless network deployed within the City of Loma Linda. This connects with Emergency Medical Services (EMS) personnel and the City of Loma Linda as well as the Internet. The next back-up is a connection with a satellite network. The satellite network hub is in Atlanta and offers a geographically diverse connection to the Internet. This is an important feature when regional disasters prevent or curtail communications in Southern California or the local community.

While redundancy in communication networks is critical to the CURE Center operations, redundancy in equipment is equally important. The CURE Center is able to share campus resources such as the Mobile Telemedicine Vehicle and Alternative Response Vehicles. A research unit supporting telemedicine, EMS education, and a mobile Medical Simulation Laboratory are all part of the mobile mesh network supporting the CURE Center. This mobile mesh network offers alternative communication systems that are shared with each mobile mesh node. The CURE Center is part of the mesh network as a fixed, not mobile, site. Two different geostationary satellite networks have been deployed along with equipment from two 4.9 GHz wireless vendors to maximize interoperability with first responders. Radio communications within all the mesh network sites incorporate state-of-the-art capabilities for radio patch and trans-coding to VOIP. This allows for maximum interoperability with all civilian and select military organizations.

NETWORK DEPLOYMENT

Deployment of communications for the CURE Center is the same for triage operations or critical care functions except for the devices supporting direct medical care. The communications team will activate the CURE Center command center while medical personnel are establishing support areas and converting the spaces for CURE Center use. Once the command center is operational, the team starts to activate and deploy the network and systems required for operation of the CURE Center. This begins with internal communications to assist with staff organization, then site security and support, and finally with the communication systems allowing for communication to local, regional, and national resources. During the operation of the CURE Center, members of the communications team provide support for ongoing operations, monitor systems and network status, and resolve communication requests from staff.

STAFF COMMUNICATIONS AND SUPPORT OF SYSTEMS

Internal communications for staff organization and operations are provided within a variety of devices. This includes handheld PDAs and cart-mounted devices for patient consultation and care, as well as workstations associated with each portable critical patient care system. Radio communications can be provided through these devices as well as traditional handheld radios. The majority of devices are wireless and operate within an independent wireless network operated by the CURE Center communications team using 802.11a (2.4 and 4.9 GHz frequencies).

NETWORK MONITORING

The command center establishes and monitors all network operations. The network management system provides a clear graphical interface for the communications team. This interface allows the team to evaluate and support all internal communications, all external communication links, and all communication devices in operation.

NETWORK DEACTIVATION

Once the LLUMC EOC has deactivated the CURE Center, the communications staff will begin the process of resolving outstanding device support requests and complete an inventory of communications equipment. Equipment that is not working will be repaired or replaced, and all equipment will be returned to its prior functions within the Centennial Complex or stowed. An evaluation of all the systems utilized and a report of communication challenges encountered will be formalized for CURE Center team self assessment and process improvement.
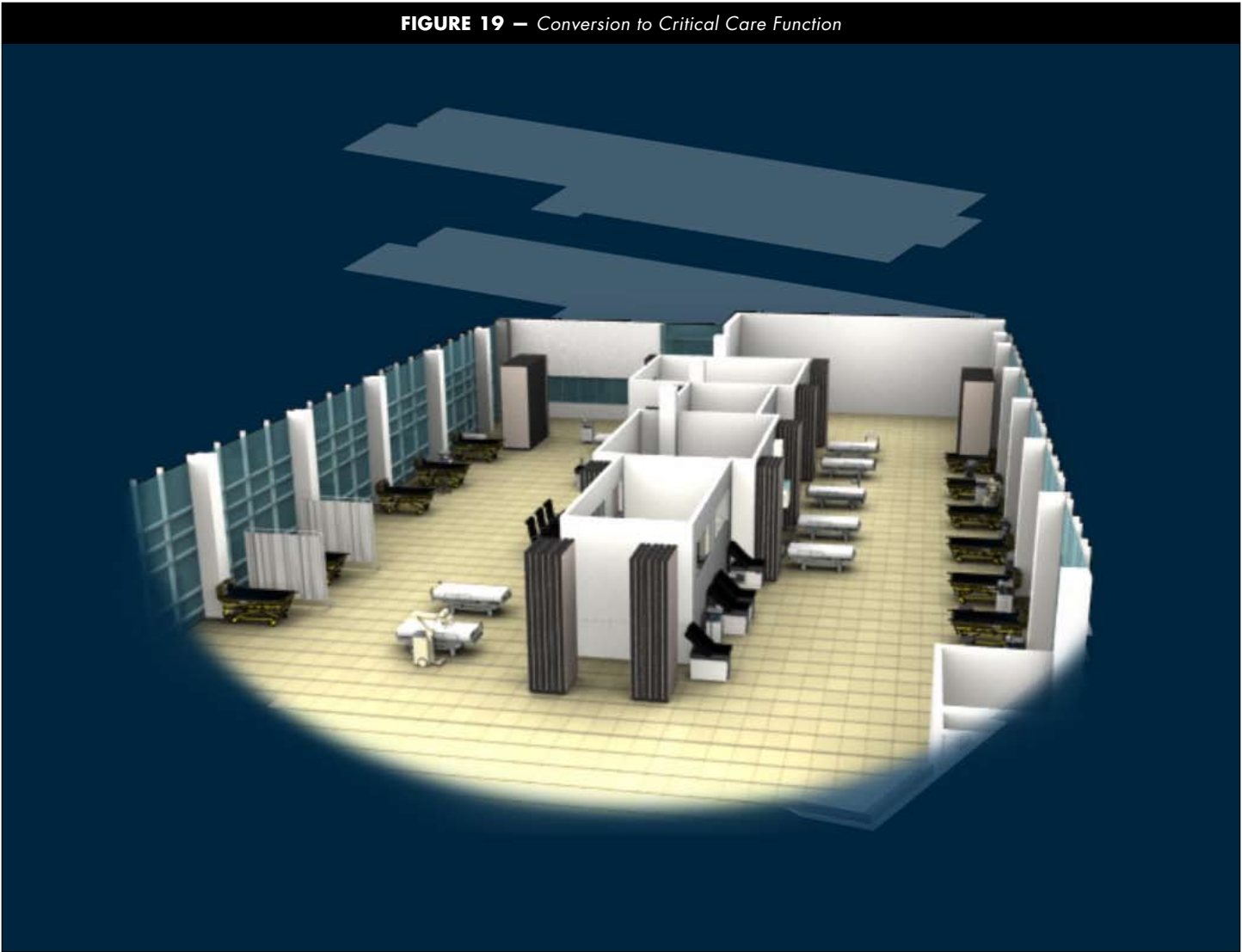
SCENARIO B: CRITICAL CARE FUNCTION

ACTIVATION PROCESS

In the event of a large scale disaster occurring in the geographic region of the CURE Center, the CURE Center may be called upon to provide additional capacity for critically injured or ill patients (Figure 19). A rapid influx of patients is inevitable during any large scale disaster and the American healthcare system is already operating very close to full capacity. Full capacity is evidenced frequently in California (and many other states) with hospital diversions and Emergency Department (ED) diversions occurring daily in many communities. When hospitals are full, no beds are available, and patients back up into the ED or are taken to other hospitals further away. Intensive care unit (ICU) beds are frequently full, and even a small disaster under these circumstances will overwhelm the available hospital resources. In addition to being considered as a triage center, a CURE Center can transition to a higher level of care and coordinate the resources necessary to begin assisting the community with additional critical care capacity. These additional critical care resources are an important function for a CURE Center when other community resources are overwhelmed. There is widespread concern a larger disaster will result in injuries or illnesses which hospitals will not be able to accommodate, particularly if hospital ICU beds are already full. A Convertible Use, Rapidly Expandable (CURE) space to provide additional capacity for critical care will be needed. This additional capacity for critical care is not merely for the local area but for a wider region including nearby counties or states.

The CURE Center is available as either a hospital asset or a community asset when functioning as an additional critical care site during a disaster. The request for critical care activation (Figure 20) can result from a partner hospital assessment or a community assessment. In the Loma Linda example, the CURE Center is activated through the Loma Linda University Medical Center Emergency Operations Center (LLUMC EOC) from either an internal assessment or a community request. The anticipated activation for critical care status will require needs assessments and response evaluations from both the hospital and the community. Since these assessments will require information and time, it is anticipated the CURE Center would be available for critical care patients 6 hours from the activation request.
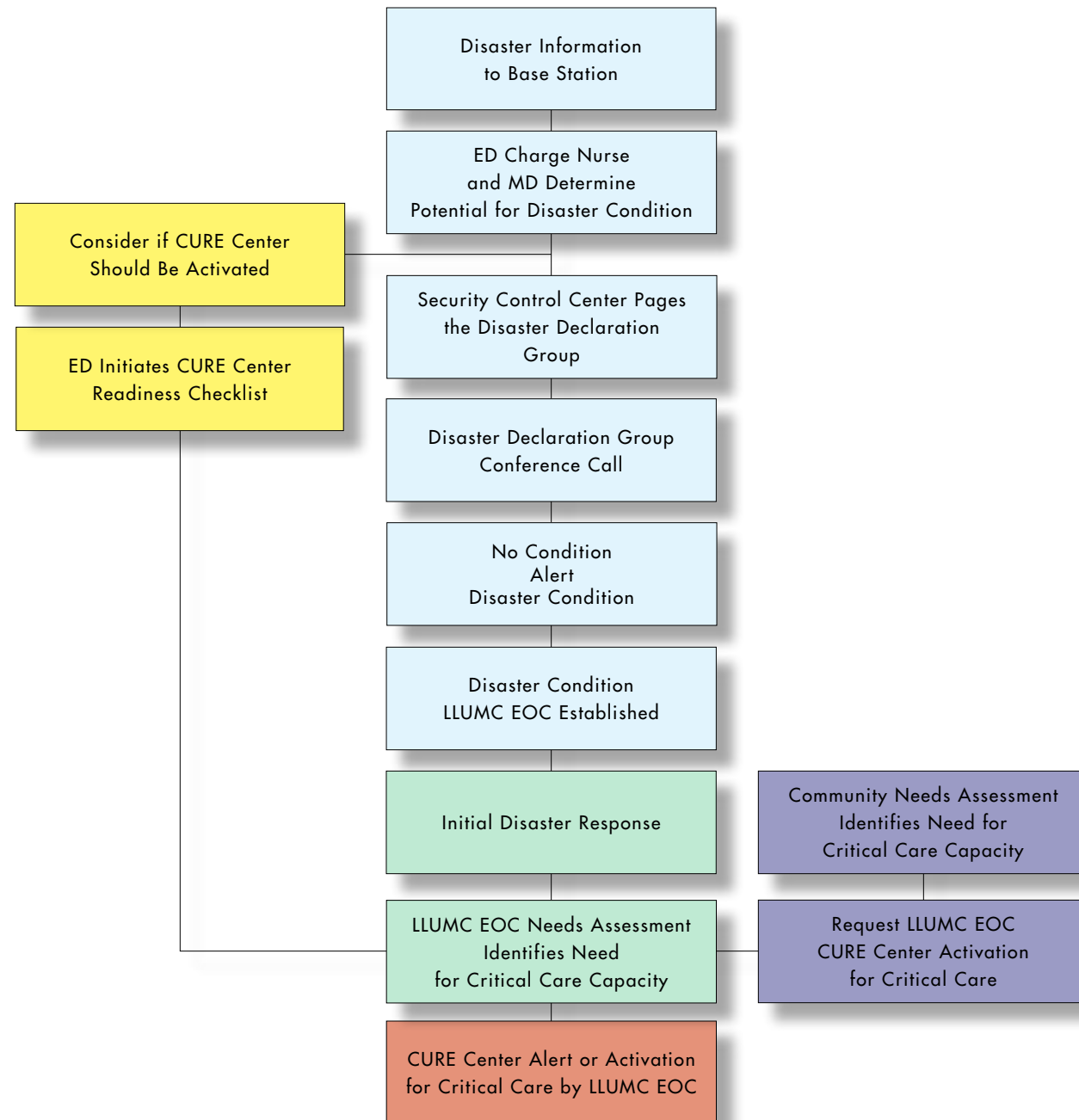

FIGURE 19 — *Conversion to Critical Care Function*

OPERATIONS

- Internal request for activation from partner hospital
- External request for activation from community
- Needs assessment
- Response evaluation
- Activation requested, six hour readiness goal
- Characteristics of incoming patients determined
- Site security plan activated

COMMUNICATIONS

- Communications team activates CURE Center command center
- Activate and access networks and systems
- Confirm connection to Incident Command and EOC
- Internal communications to hospital administration confirmed

TECHNOLOGY

- Staff tracking system initiated
- ED tracking of developing GIS issues on AEGIS

ENVIRONMENT

- Evacuate Centennial Complex
- Assess need for site decontamination
- Assess CURE Center damage
- Environmental Health and Safety personnel alerted

FIGURE 20 — *Activation Algorithm for CURE Center Critical Care Function*

READINESS CHECKLISTS

Alert Checklist
- Readiness Assessment
  - □ Assess Need for Decontamination
    - ▪ Alert Safety Personnel, if necessary
  - □ Security Plan activated
  - □ Pharmaceuticals
  - □ Supplies
  - □ Physical plant
  - □ Computers
  - □ AEGIS
  - □ Communications Center
- Initiate Damage Assessment, if necessary
  - □ Structural
  - □ Natural gas
  - □ Mechanical and electrical systems
  - □ Water supply
  - □ Waste water
  - □ Medical gases
  - □ Elevators
  - □ Access
  - □ Exits and egress
  - □ Fire system
  - □ Medical core equipment in reserve
  - □ Landline phone systems
  - □ Wireless and satellite communication systems
  - □ Identify biohazards
  - □ Need for housekeeping
- Staffing Plan
  - □ ED staff ready for deployment

Activation Checklist
- Readiness Assessment complete
- Damage Assessment complete
- Initial Staffing Plan complete
  - □ Hospital disaster staffing plan confirmed
- Decontamination Plan, activated if necessary

SCENARIO B: CRITICAL CARE FUNCTION

SITE RESPONSE

When the Loma Linda University (LLU) CURE Center is activated solely as a facility to receive critical care patients, traffic is less of a concern than if the CURE Center is activated as a triage center. Ambulances arriving with patients will be directed to the Patient Reception Area (Figure 21) and met by CURE Center personnel. From here the emergency vehicles can exit the area easily.

Interference with incoming ambulances will be minimized by keeping the supplies and staff traffic pattern similar to the pattern planned for the CURE Center triage function. Family members and visitors will arrive in the far western entrances and park in the adjoining area. All of these areas will be identified by signage. Security personnel will be present to help direct those needing assistance.

FIGURE 21 — *Traffic flow during the Critical Care Function of the CURE Center*

OPERATIONS

- Vehicle removal initiated
- Traffic control officers in place
- Potential for austere conditions evaluated
- Hospital disaster staffing plan implemented
- Staff registration site established
- Staff communications plan initiated
- Security established for staff arrival and departure
- CURE Center command structure confirmed

COMMUNICATIONS

- Establish internal communication links
- Establish site security and support links
- Communications to patient arrival area established
- Communications to reception area in place
- Communication devices to escort personnel
- Establish external communication links

TECHNOLOGY

- Registration devices allocated
- Tracking system initiated for on site patients
- Identification badges readied for scanning
- Medical equipment deployed to treatment areas
- AEGIS employed by the communications team to link with real time regional assessments
- Staff credentialing data system initiated
- AEGIS updated with CURE Center icon when activation complete

ENVIRONMENT

- Signage and barriers placed
- Identify specific and unique resources needed
- Helicopter landing zone cleared and secure
- Power and water supply confirmed
- Sewage facilities and systems confirmed
- Equipment and supplies to patient arrival area
- Equipment and supplies to reception area

FIGURE 22 — *Entry and Reception areas for the Critical Care Function of the CURE Center*

PATIENT RECEPTION AREA

VISITOR MAIN ENTRY

RECEPTION/ CHECK-IN

VISITOR WAITING

PATIENT ENTRY
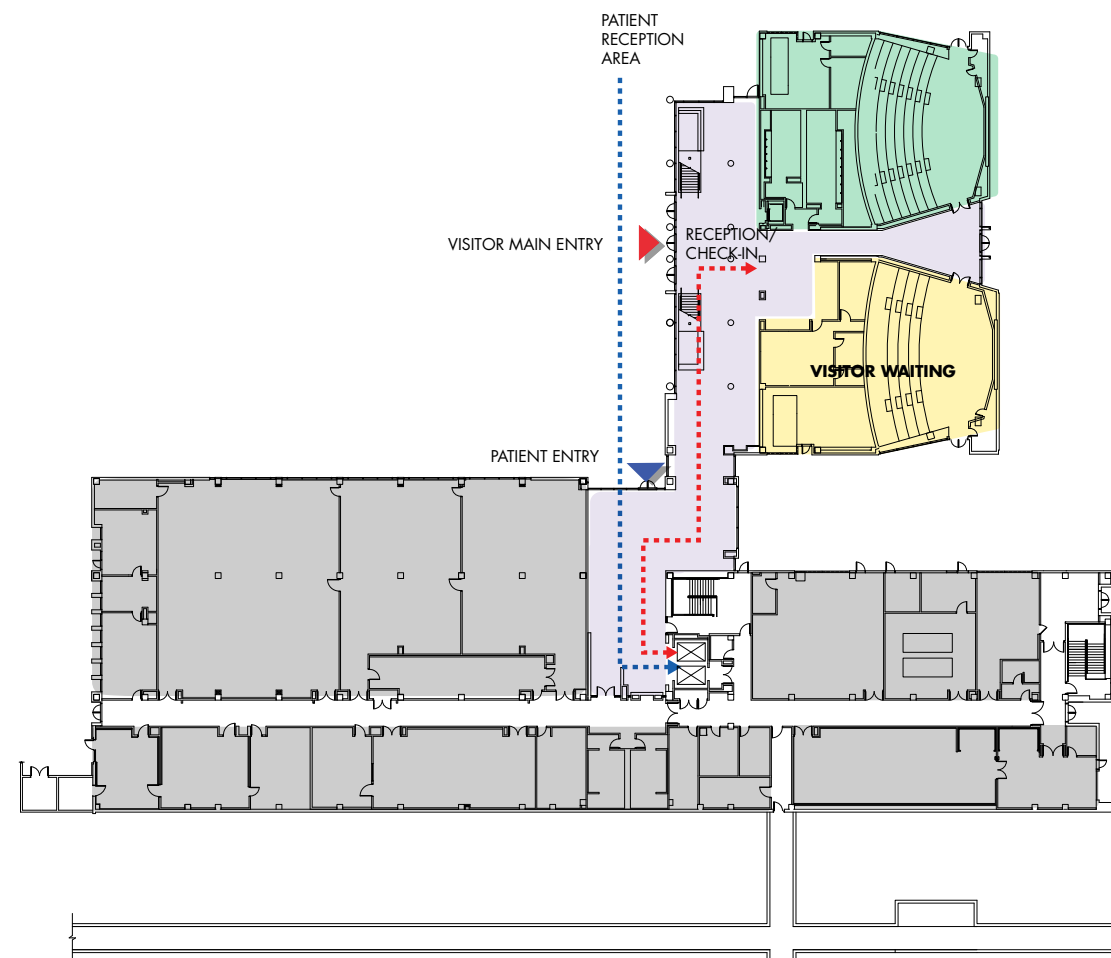
CENTENNIAL COMPLEX UTILIZATION

Ground Floor Response

When the emergency transport personnel arrive, CURE Center team members will accompany them into the CURE Center and to the critical care treatment area on the fourth floor. From the Patient Reception Area, ramped walkways and a direct route facilitate ingress into the facility (Figure 22). Elevators located off the Main Entry have controlled access, allowing them to bypass other floors and go directly to the critical care treatment area. Patient registration will occur in the treatment area, where medical staff can immediately begin their assessment.

Family and visitors will go through the Main Entry where they will be greeted and logged in. Reception desk staff will be able to contact the critical care treatment area prior to allowing visitors. Family members may wait in the Visitor Waiting Area if necessary. Additional comfort can be provided in this area, such as counselors and chaplains for family members, social workers to help with living arrangements as needed, and nutritional support with snacks and beverages. Those requesting admittance to the treatment area will require escort or staff identification. Security personnel will be available to the Reception Area and the elevators.

SCENARIO B: CRITICAL CARE FUNCTION

CENTENNIAL COMPLEX UTILIZATION

Critical Care Treatment Area

The patient population for the critical care treatment area will be identified at the time of activation. It is anticipated these patients will be stabilized ICU patients from hospital ICUs, thereby making additional ICU beds available for incoming critical patients at their sites. The CURE Center will be available for pediatric or adult patients if both needs are identified early in activation, in order to properly staff and equip the space. The circumstances for which the critical care function of the CURE Center may be needed include all disasters for which local or regional critical care resources could be overwhelmed. This might occur in natural disasters, as well as accidental or intentional disasters.

Planning for the LLU CURE Center conceives of critical care functions occurring in a large area divided into two parts (Figures 23 and 24). Each half has a centrally located space for monitoring and communications. Each half is made up of two modules, and each module consists of seven to ten beds. This plan allows for rapid deployment of up to a forty bed critical care treatment area, in a space originally designed for education and classrooms. Spaces allocated for individual treatment approximate current hospital requirements for space. The CURE Project Team, however, comprehends the possibility of a disaster of historic proportions, which may necessitate functioning under more austere and crowded conditions.

Ideally, patient care will be managed by healthcare teams which include:
- 1 physician medical director
- 1 to 2 physicians per module
- 1 charge nurse
- 3 nurses per module
- 2 patient care technicians per module
- 1 secretary per module
- 1 pharmacist
- 2 respiratory therapists
- 1 radiology technician
- 2 housekeeping staff
- 1 cardiac monitoring technician

Staffing will be determined by the CURE Center Commander in conjunction with LLUMC EOC and will depend on available resources. The necessity to maintain standards of care versus the realities of possible austere conditions will be assessed regularly. Ideally, the critical care treatment area will be staffed with intensive care trained physicians and a medical director. Telemedicine capability in the CURE Center will provide a means of obtaining consultations from medical specialists, whether those consultants are nearby or far away.

FIGURE 23 — Critical Care Treatment Area
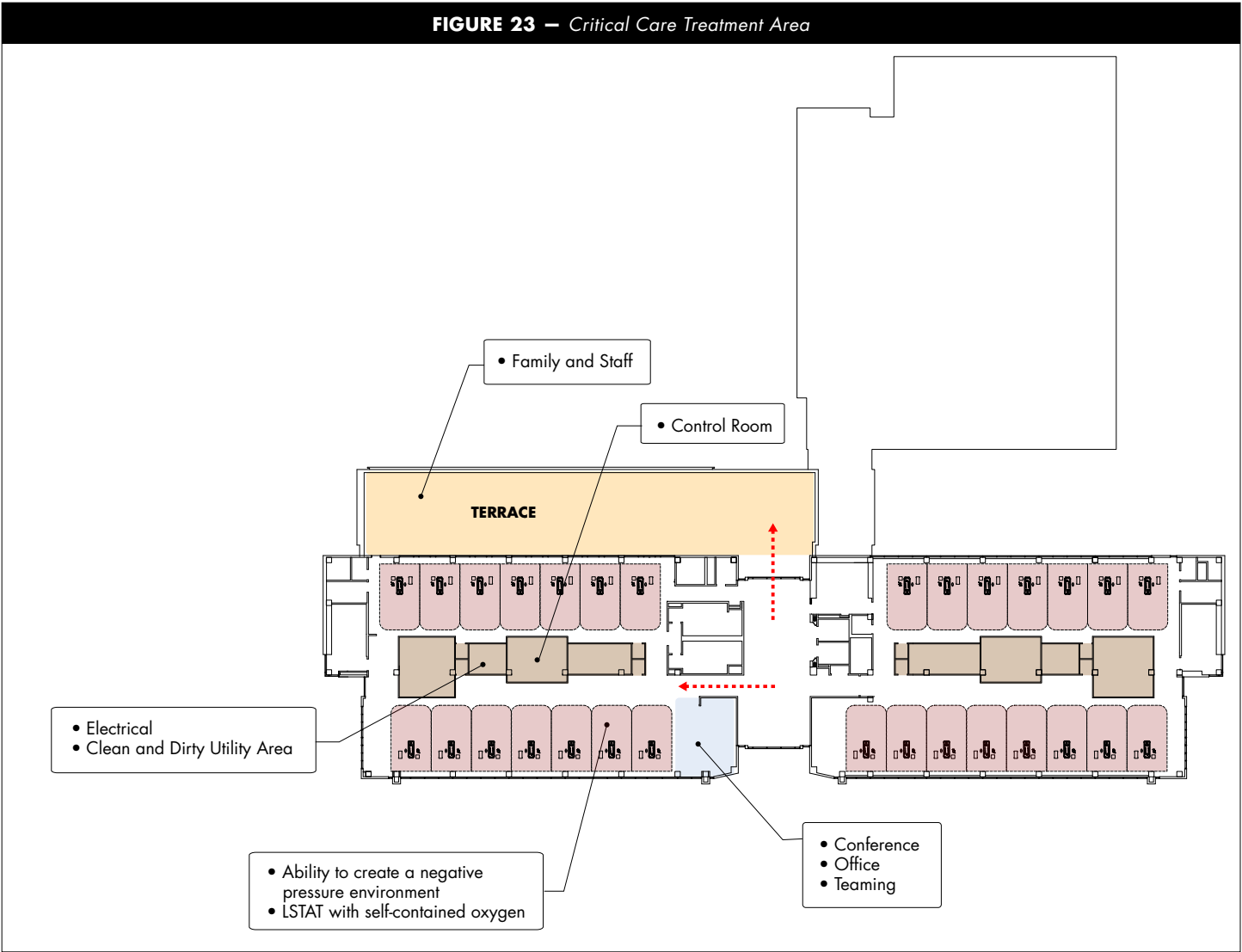
OPERATIONS
- Process initiated for documentation of staff arrival and departure
- Ambulance staging pattern established and secured
- Healthcare teams deployed to assigned areas
- Pharmaceutical and equipment checklist completed
- Prepare temporary morgue
- Prepare media site and identify spokespersons
- Credentialing process established for volunteer staff
- Deactivation team initiates deactivation planning process

COMMUNICATIONS
- Confirm redundancy of communication networks
- Support patient transport communications as needed
- Update Incident Command
- Update EOC(s)
- Interfacility communications established
- Monitor systems and network status
- Resolve communication requests from staff
- Continuous status updates through AEGIS

TECHNOLOGY
- Electronic patient records initiated
- Computer data retrieval system confirmed
- Initiate simulation technology to model current disaster and estimate casualties
- Assess need for collaborative resources, such as the Mobile Telemedicine Vehicle
- Telemedicine links established for ultrasound and X-ray
- Utilize syndromic surveillance analysis and update Incident Command
- Assess continuous dynamic AEGIS data and adapt response as indicated

ENVIRONMENT
- Equipment deployed and tested in place
- Isolation resources established
- Nutritional and laundry supplies available
- Mobile critical care beds in place
- Modular work stations in place for staff
- Patient evaluation initiated
- Staff respite areas available for staff on third floor
- Social services available
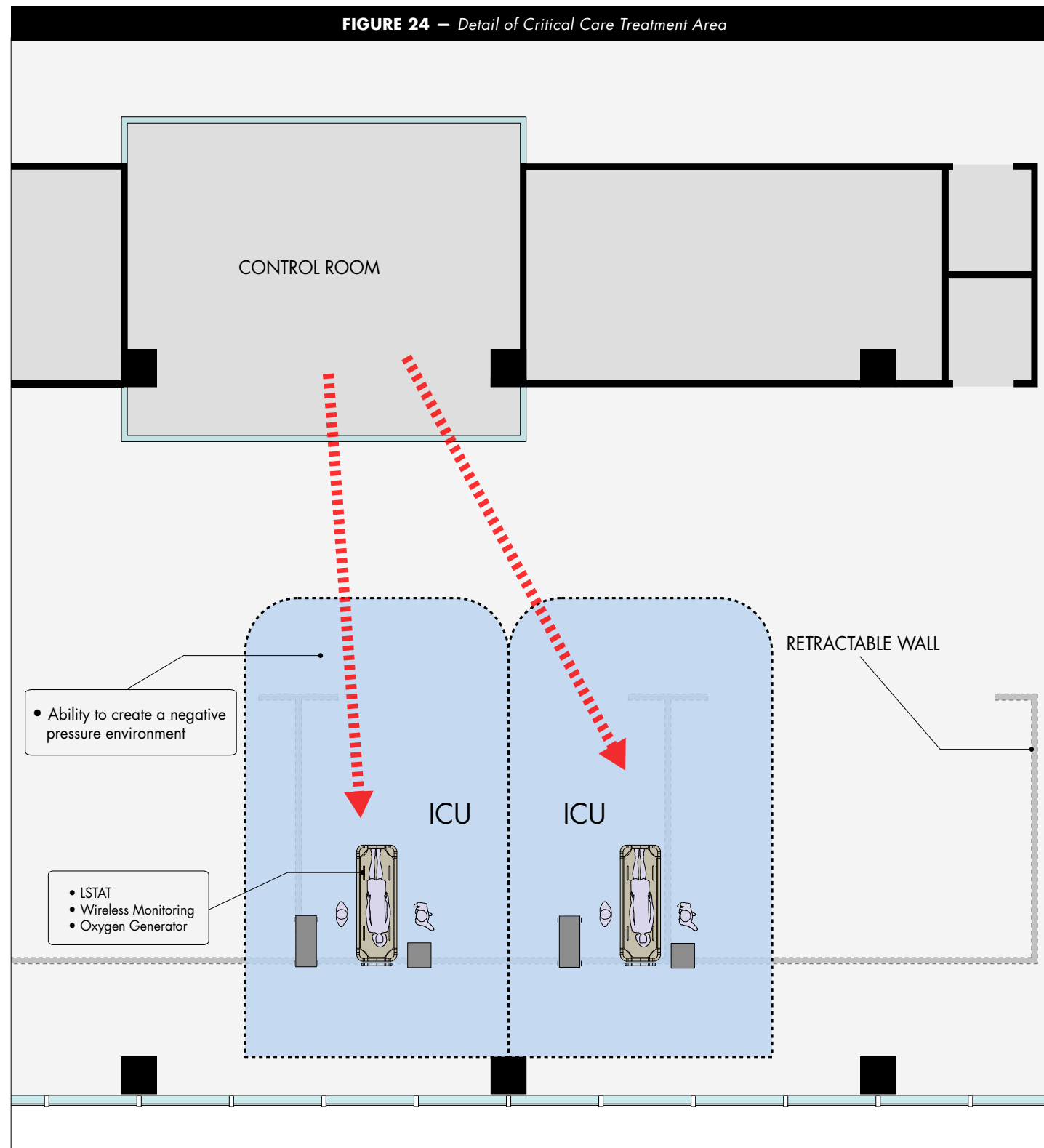
FIGURE 24 — *Detail of Critical Care Treatment Area*

CONTROL ROOM

RETRACTABLE WALL

• Ability to create a negative pressure environment

ICU   ICU

• LSTAT
• Wireless Monitoring
• Oxygen Generator

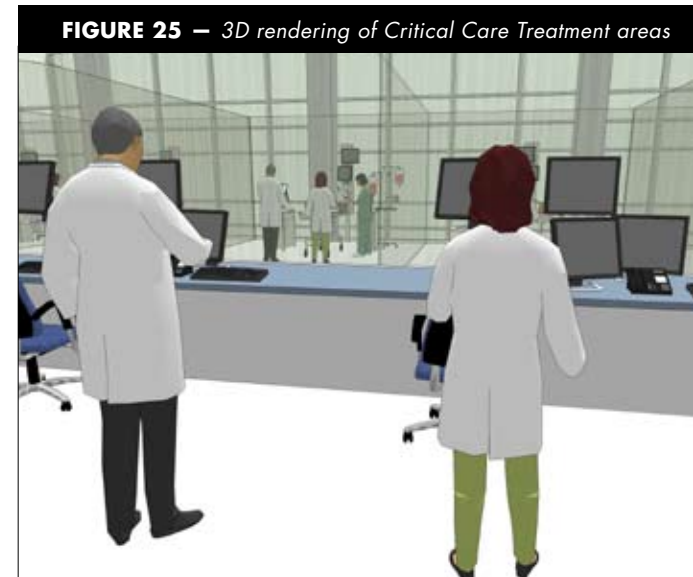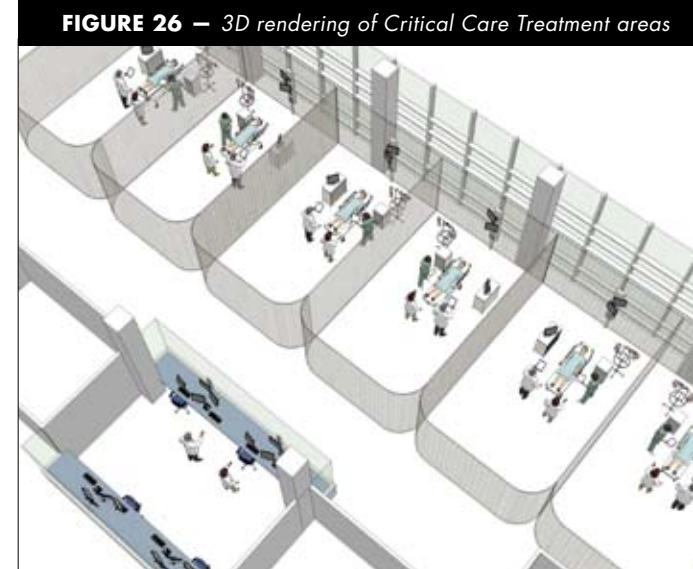**FIGURE 25 —** *3D rendering of Critical Care Treatment areas*

FIGURE 26 — *3D rendering of Critical Care Treatment areas*

Specific resources and capabilities desirable for patient care include:
• Monitoring: cardiac, blood pressure, pulse oximetry, capnometers, intracranial pressure, central venous and arterial lines
• Oxygen source
• Suction
• Ventilators
• Intravenous lines: central and peripheral
• Intravenous infusion pumps
• Medications
• Medical supplies, including those unique to specialties such as orthopedics and ophthalmology
• Crash cart with code medications
• Intubation equipment and supplies
• Appropriate patient restraints
• Laboratory point of care testing
• Radiographic availability
• Isolation support
• Biohazard detection

When reviewing needs for pharmaceuticals, equipment, and supplies, there are advantages in combining existing technologies for patient care where possible. As one example, the patient bed utilized in the CURE Center will be itself a potential limiting step with ease of patient movement and patient care. A patient bed that can be easily set up, moved, and which will provide critical care monitoring is a definite advantage.

Pharmaceutical caches with the capability of caring for 50 patients are pre-assembled and enable stabilizing care to be initiated without separate ordering and subsequent delay in pharmacy response. A pharmacist on site will be invaluable for resolution of any issues arising with procuring medications for individual patients.

Similarly, supply caches will be pre-assembled with medical materials such as wound care supplies, suture packs, syringes, needles, etc. It is anticipated that technicians will help set up these medical supplies as well as assess continuing supply needs.

TECHNOLOGY APPLICATIONS

When anticipating the needs for patient care in this unique critical care setting, combining necessary components would be helpful. Technologies such as patient monitoring, oxygen, ventilation capability, suctioning, infusion pumps, and bedside testing are all necessary to provide adequate critical care. The CURE Project Team has explored many different types of medical technologies that could potentially be integrated into the CURE Center. The following are examples of some of the technologies investigated and/or utilized.

Iomedex Mobile Incident Response Information System (MobileIRIS)

The MobileIRIS is a wireless patient tracking system enabling first responders to track movements of casualties through triage and treatment using bar codes. This system also provides local healthcare organizations with a common database from which to share information and access patients' electronic health records. A system such as MobileIRIS may be utilized in the CURE Center to demonstrate how a data management system can enhance the processes of communications, safety, and patient tracking during mass casualty incidents. Familiarity with wireless tracking systems could be enhanced by using them during training of military and civilian disaster responders.

Battlefield Medical Information System Telemedicine-Joint (BMIST-J)

BMIST-J is an application developed by the United States Army Medical Research and Materiel Command (USAMRMC) and the Telemedicine and Advanced Technology Research Center (TATRC). Initially designed to be used by Special Forces medics, it is a point of care handheld assistant, enabling medics and front line providers to record, store, retrieve and transmit the essential elements of patient encounters in an operational setting. This information can then be synchronized with host computers and data transmitted to a server for surveillance analysis with storage and retrieval capabilities. Reference materials, diagnostic and treatment decision aids, and logistic support software can also be included, facilitating patient care, skill retention training, and mission planning. It can function as a stand alone system, though its ability to share information into a networked system can provide data for readiness, medical history, consultation, evacuation, and other medical planning.

Life Support for Trauma and Transport (LSTAT)

The LSTAT is a portable intensive care system providing the resources necessary for resuscitation and stabilization of a patient at the site of injury. Integrated into the system is a ventilator with oxygen, intravenous infusion pumps, suction, and physiological monitoring devices. Additional patient care devices include a defibrillator and blood chemistry analyzer. Patient and system information can be monitored wirelessly from a handheld tablet, as well as downloaded to off-site systems. These medical technologies, integrated into a NATO litter, provide an efficient use of technology and space for the CURE Center.

Charlie's Horse Medical Emergency Response Deployment Systems

Charlie's Horse deployment systems are used in a variety of settings to provide optimal patient management from triage through resuscitative surgical interventions. The products are modular and expandable, multitask oriented, and portable. Ergonomically designed so that a single person is able to move large components, these systems allow rapid deployment of CURE Center equipment while reducing the manpower needed.

Telemedicine

During incidents of natural, accidental, or intentional disasters, the CURE Center will utilize telemedicine capabilities to collaborate with a variety of telemedicine consults, ultimately creating a dynamic telemedicine network. The use of this technology will allow CURE Center staff to carry out the following functions:

- Guidance for triage and transport decisions in the field, in support of the Incident Commander. This type of direction will facilitate the process of getting patients to their intended destinations while avoiding unnecessary transport.
- Medical direction and oversight for off-site and alternative care centers.
- Specialized medical expertise (infectious disease, emergency medicine, radiology, mental health, dermatology, neurology, etc.) to remote locations.
- Provide "just in time" training specific to those responding to an incident.

To illustrate how the CURE Center would integrate such an advanced telecommunications system, imagine a hub and spokes system. To facilitate this integration, the CURE Center command center anticipates being equipped with an interactive management tool, the Advanced Emergency Geographic Information System (AEGIS). Using one aspect of this multidimensional tool, the CURE Center will function as the hub and connect with spokes to multiple locations, providing an invaluable communications framework during and after a disaster. The spokes of the system are the real time telemedicine consults that the CURE Center could collaborate with at any given time. As an example, the CURE Center has access to the Mobile Telemedicine Vehicle (MTV) for consultation use. The MTV is a state-of-the-art all terrain vehicle developed by Loma Linda University Medical Center. The MTV allows the expertise of a tertiary care center to be available anytime, anywhere during an emergency or disaster. The MTV is telemedicine and x-ray capable, is equipped with satellite and wireless technology, has UHF, VHF, HAM, and 800 MHZ radio communications, and a VOIP phone system. Other potential telemedicine sites include the emergency telemedicine command center at Loma Linda University Medical Center and Children's Hospital, military bases, rural hospitals, nursing homes, prisons, and additional remote telemedicine sites within the CURE Center itself.

In addition to the advanced telecommunications system, the Centennial Complex is equipped with multiple teleconferencing and videoconferencing platforms that allow for linkages around the world. This is a unique feature that dynamically supports CURE Center telecommunication operations.

Simulation and Modeling Technologies

CURE Centers can use simulation and modeling technologies both in the planning stages of a CURE Center and for continual evaluation. Modeling programs such as HAZUS, a risk assessment software tool from the Federal Emergency Management Agency, and FluSurge, another software tool from the Centers for Disease Control and Prevention, have been significant assets to the LLU CURE Project Team. Use of these programs during the development phase allowed the CURE Center team to evaluate unusual and worst case scenarios as well as more likely events to aid in planning. When the planning phase is completed, developing various scenarios and modeling them will allow virtual deployments of the CURE Center and its assets. Likewise, completion of the AEGIS Disaster Management Tool and its included simulations will permit similar virtual deployments. Additionally, these AEGIS simulations are anticipated to offer users valuable experience in managing different types of disasters.

Beyond virtual deployments, community and hospital disaster drills that exercise CURE Center personnel and assets will provide valuable feedback on CURE Center systems as well as individual technologies. These drills may include volunteer victims as well as patient simulators. The LLU CURE Project Team has purchased from Medical Information Technologies, Inc., portable patient simulators and disaster training modules. These provide realistic patient encounters for first responders, military personnel, Emergency Department personnel, and other individuals who will be involved in a disaster and CURE Center response. Collaboration with the LLU Medical Simulation Center will provide these opportunities during drills and on an ongoing basis between these events. Future goals include the development of a mobile simulation platform for even greater disaster training opportunities.

TECHNOLOGY APPLICATIONS

PowerFilm Solar Technology

Power from solar energy can be used for many needs, such as lighting, ventilation, field communication radios, satellite phones, battery recharging, laptops, and GPS units. Innovative applications of solar energy are available from PowerFilm, Inc., and can be combined with an inverter to provide 110 volt AC. One such innovation is the lightweight and flexible PowerFilm solar power shade, which not only provides a Kilowatt of power but also provides a canopy of protection from the sun, capable of reducing the solar heat load by up to 80-90%. The solar power shade integrates PowerFilm solar panels directly into rugged PVC-coated fabric. Such a system can be rapidly deployed and quickly provide solar electric power generation, even in remote locations.

Advanced Emergency Geographic Information System (AEGIS)

AEGIS is the first integrated emergency system incorporating both static and dynamic information into one user-friendly highly sophisticated interactive map. Static information includes a variety of typical maps, hospital locations with hospital capabilities, Fire/EMS/police stations, major venues, and numerous additional overlay options. Dynamic information includes hospital diversion status, real time traffic information, live highway video feeds, current weather conditions, and real time major incident locations from Emergency Dispatch. Dynamic visualization of emergency resources in real time will include fire apparatus ambulances, as well as rescue helicopter and air ambulance locations, whether on the ground or in the air.

This is an effective EMS management tool that immediately helps with everyday decisions on dispatch and disposition of patients. Beyond its capabilities for routine EMS operations, AEGIS is being enhanced and converted into a disaster management tool.

It is the opinion of the LLU CURE Project Team that what works best in a disaster is what works best on a daily basis. Personnel are most familiar and most accomplished with routine operations. Therefore, it was the intent of the CURE Project Team to create an EMS management tool for everyday use that would also serve as a disaster management tool. Instead of dusting off a manual describing unfamiliar systems and processes during a disaster, AEGIS will adapt seamlessly to whatever situation is at hand. Many small disasters, such as multiple casualty incidents, occur frequently. An AEGIS EMS and disaster management tool will be a system all users can be familiar with from daily usage, and comfortably utilize in any disaster, large or small.

Since communities cannot predict whether they will be burdened by natural, accidental, or intentional disasters, one management tool must be able to handle all possibilities. Predictive tools that are currently available for wildfire activities, toxic plume behavior, hazardous material incidents, flooding, and earthquakes, are being incorporated into AEGIS for immediate use by Emergency Managers. Additionally, AEGIS will be able to handle multiple incidents. During an extended disaster such as a wildfire or flood, there is a possibility of other emergency incidents occurring, such as hazardous material events, multi-vehicle accidents, or train wrecks. Resources and drawdown levels affected by local incidents could impact management decisions at more remote sites. This information would be readily available via AEGIS.

The AEGIS disaster management tool incorporates the principles of Incident Command Structure so managers will see, at a glance, who the Incident Commander is and who is responsible for operations, planning, finance, and logistics. Like Incident Command Structure, AEGIS will be scaleable and will expand to meet the requirements for managing a large regional disaster or shrink to meet the requirements for routine EMS activity. Managers will be able to see the extent of the disaster and adjacent threatened structures or communities. It will facilitate allocation and deployment of resources by identifying mutual aid agreements, recognizing asset locations, and serving as a tool to alert individuals or even communities. For example, as a disaster develops, AEGIS will alert critical managers and responders so they become aware of the situation and aware of the need for their services. AEGIS will be able to alert an entire community through mass reverse 911 calling if a disaster, such as a hazardous materials incident, requires evacuation of the area. It may also serve as a means by which responders communicate with each other. Personnel in critical locations will be identified and given specific instructions, and personnel or assets in other locations will be redeployed to more strategic positions. Commanders will be able to update each other at specific intervals for dissemination of action plans or other critical information.

Most importantly, AEGIS will create a unique level of situational awareness which has not been available before. The spatial representation of the disaster, the wealth of information for decision support contained in the data layers, an understanding of adjacent critical structures, and the understanding of resources available with current asset allocations, all will allow managers to make well informed decisions in real time. Moreover, since AEGIS will be available on any number of portable devices, managers, field commanders, and personnel will all have access to this information. Via these mobile devices, field responders can provide accurate, timely, on-scene information to the system. Those involved in disaster response will be able to communicate action plans, alerts, assignments, Incident Command roles, and other critical spatial and temporal information.

Additionally, AEGIS will include quality improvement and public information components. Incident events and management decisions will be recorded and catalogued for further analysis. Reports will be generated to describe incident conditions, resource allocation decisions, manpower allocation, injuries, property damage, and incident costs as appropriate. Access to this information provides an opportunity to examine critical decision making and determine what contributes to efficient and effective decisions. Incident reports permit participants to analyze, refine, and improve disaster response activities, both in real time and in anticipation of future incidents. Information officers will be able to use the tool as a portal for information requests. AEGIS will be able to quickly generate reports and summaries both for use in action plan development and for general distribution to the public.

The CURE Project Team imagines that AEGIS will have broad application. It will be of value to those in an Emergency Operations Center, and it will be of value to those at the scene of the disaster. It will also be of value to those working in a CURE Center. If everyone involved understands the areas of need, the resources available, and the moment-to-moment changes in the event, well informed decisions can be made by managers. AEGIS should serve to maximize the effectiveness of a CURE Center.

TECHNOLOGY APPLICATIONS

Advanced Emergency Geographic Information System (AEGIS)

System Oriented Architecture will permit multiple public safety-related data layers to be combined in AEGIS. Once AEGIS is fully operational, these data layers may be accessed by disaster managers at an Emergency Operations Center or at a CURE Center. They may also be accessed by responders at the scene of the incident. Figure 27 illustrates some of the multiple sources of communication that can cross through the architecture of AEGIS, as well as a few of the multiple means by which AEGIS technology and its real time situational awareness can be accessed.

FIGURE 27 – *The Overview*
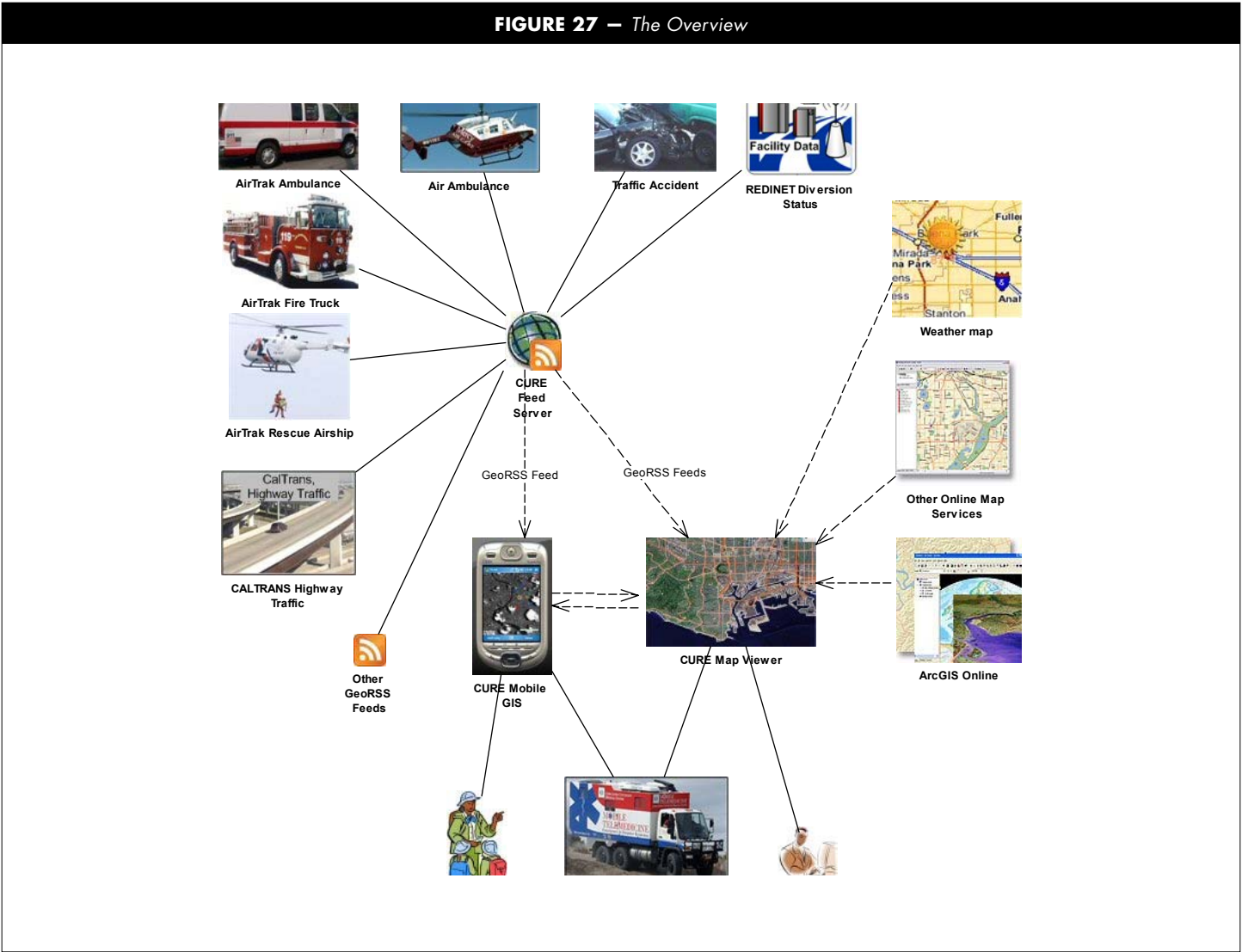
FIGURE 28 — *The AEGIS*
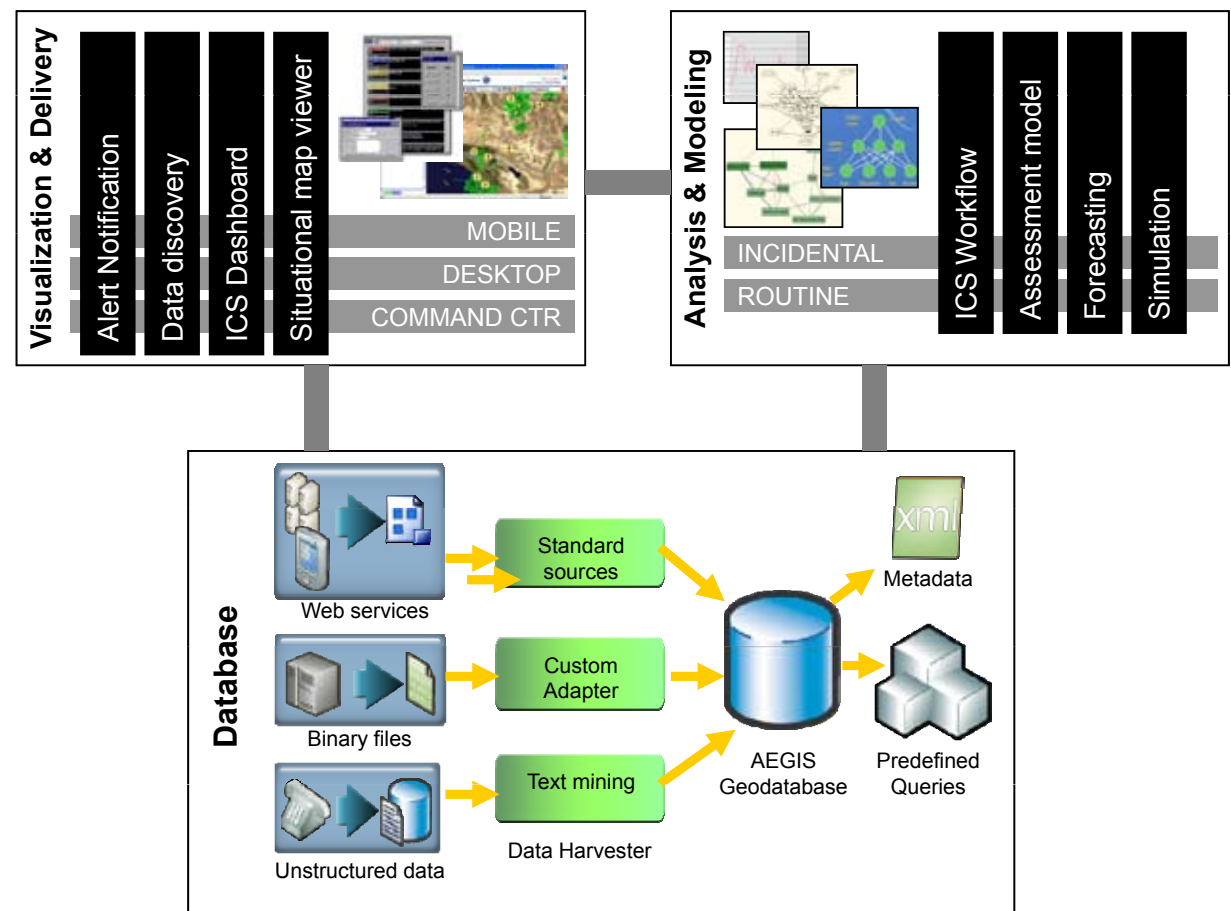
A broad outline of the detail supporting the System Oriented Architecture of AEGIS is presented in Figure 28. The many disaster management tools in AEGIS draw upon this architecture, some of which is specific for the management of disasters. However, all of the tools may be used during simulation exercises or field drills, and the day to day use of AEGIS for EMS operations will provide an ongoing opportunity for all providers in the system to become comfortable with its use. Thus, AEGIS will bring together the resources necessary to facilitate efficient decision-making under rapidly changing conditions. This efficiency is obviously valuable during disaster circumstances.

POST-EVENT ACTIVITIES

CURE Center activities are a temporary solution to provide for the immediate need for patient care surge capacity in the hours or days following a major disaster. Planning for the conclusion of CURE Center activities should be initiated early in its deployment. As soon as all patients can be discharged or transported to acute care facilities, the Centennial Complex can start to resume its previous functions. Priorities for shutting down CURE Center operations should be set by the CURE Center Commander.

Closure of the CURE Center requires the following:
- Cleaning, restoration, and removal of CURE Center equipment from the site or stowing it in on site storage areas
- Restocking of supplies and medications
- Reconditioning of the structure, making it safe for a return to everyday activities, and evaluating for hazardous materials if indicated
- Preparation of final briefings for media
- Reporting of final patient numbers, conditions, and locations to Incident Command, anticipated to be a function of AEGIS
- Notification of families regarding patient transfer destinations
- Provision of stress management and debriefings for staff
- Monitoring of the health status of staff exposed to infectious patients and provision of appropriate medical and mental health follow up, as needed
- Recognition and appreciation extended to personnel (staff and volunteers) who helped during the incident
- Specific evaluation of the role of the Medical Simulation Center during the incident with the intent of improving future operations
- Preparation of a summary report, including a synopsis of the incident and actions taken, actions that went well, areas for improvement, recommendations for future responses and corrective actions needed
- Submission of any other required administrative or regulatory reports

CURE Center team leaders will oversee the conclusion of deployment activities for their areas of responsibility. Final closure will occur only after the CURE Center Commander and the Facility Manager have had an opportunity to walk through the structure with the appropriate local officials, and determine together that normal operations of the Centennial Complex may resume.

FIGURE 29 — *Classic Management Cycle for Disasters*
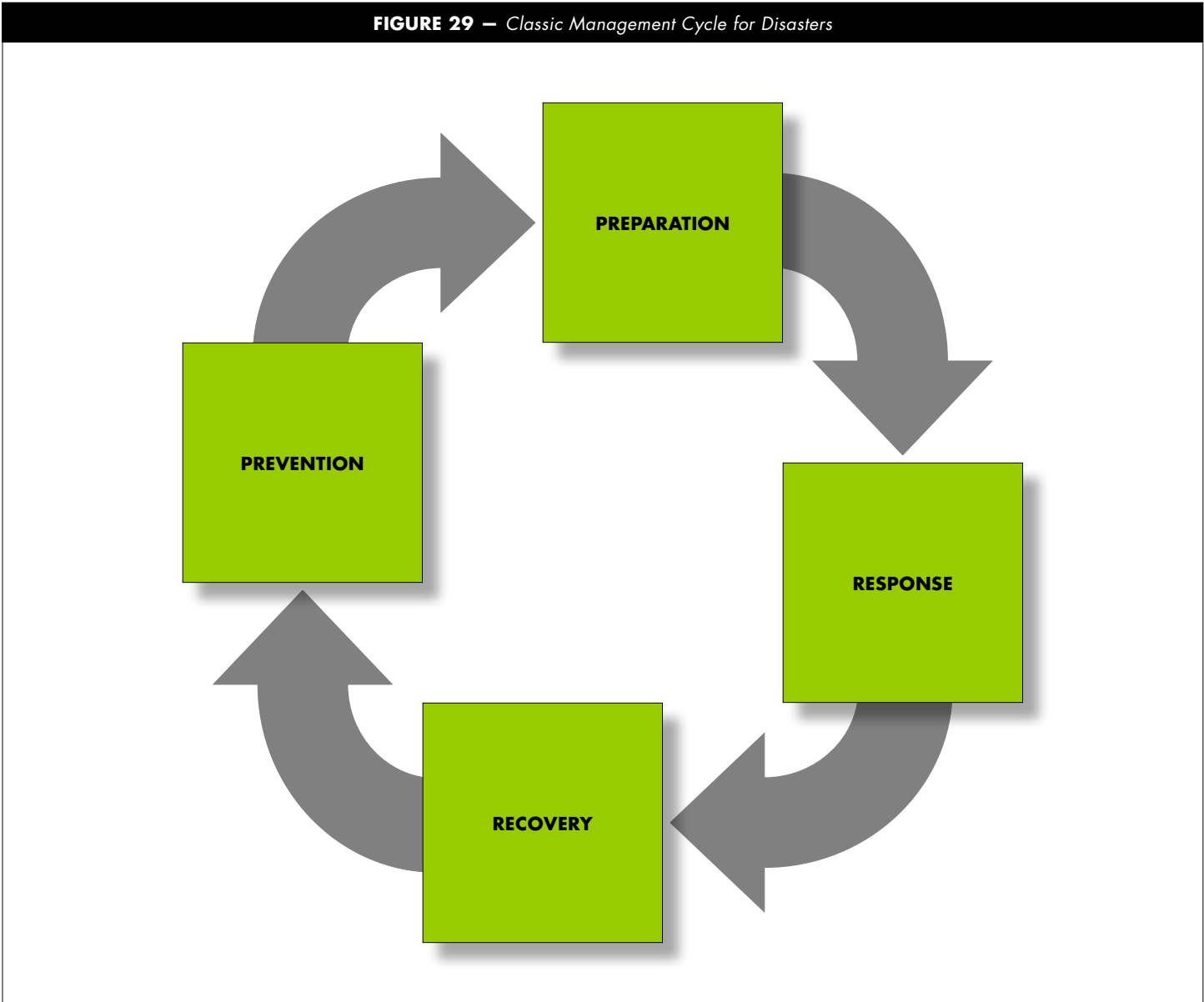
Where does the journey of the CURE Project Team end?

In a very logical sense, it ends at the beginning. And starts all over again.

In your community. And in every community.

The management approach to disasters is frequently conceived of as a circle which never stops turning. In this classic presentation (Figure 29), the cycle includes actions of preparing, responding, recovering, and preventing. In any given community, the cycle can be impacted at any point by a disaster event. The cycle can also be impacted by a new program of preparation or prevention. The CURE Project Team holds a hope that every community will impact the cycle by preparing.

It is important to comprehend that this circle of preparing, responding, recovering, and preventing is turning, even if our own community is not prepared. If failing to prepare is the default choice of a community, the cycle moves inexorably towards requiring a response as its first action step. Sadly but predictably, if no preparation for a response has been planned, recovery will be its own disaster.

Thus, our collective journey in dealing with disasters must of necessity continue to start all over again. By preparing, again. Then, again.

Every community must make, in its own context and for its own potential circumstances, plans for the inevitable though unclear challenges. The scene in front of all of us is undeniably murky and undeniably unforgiving.
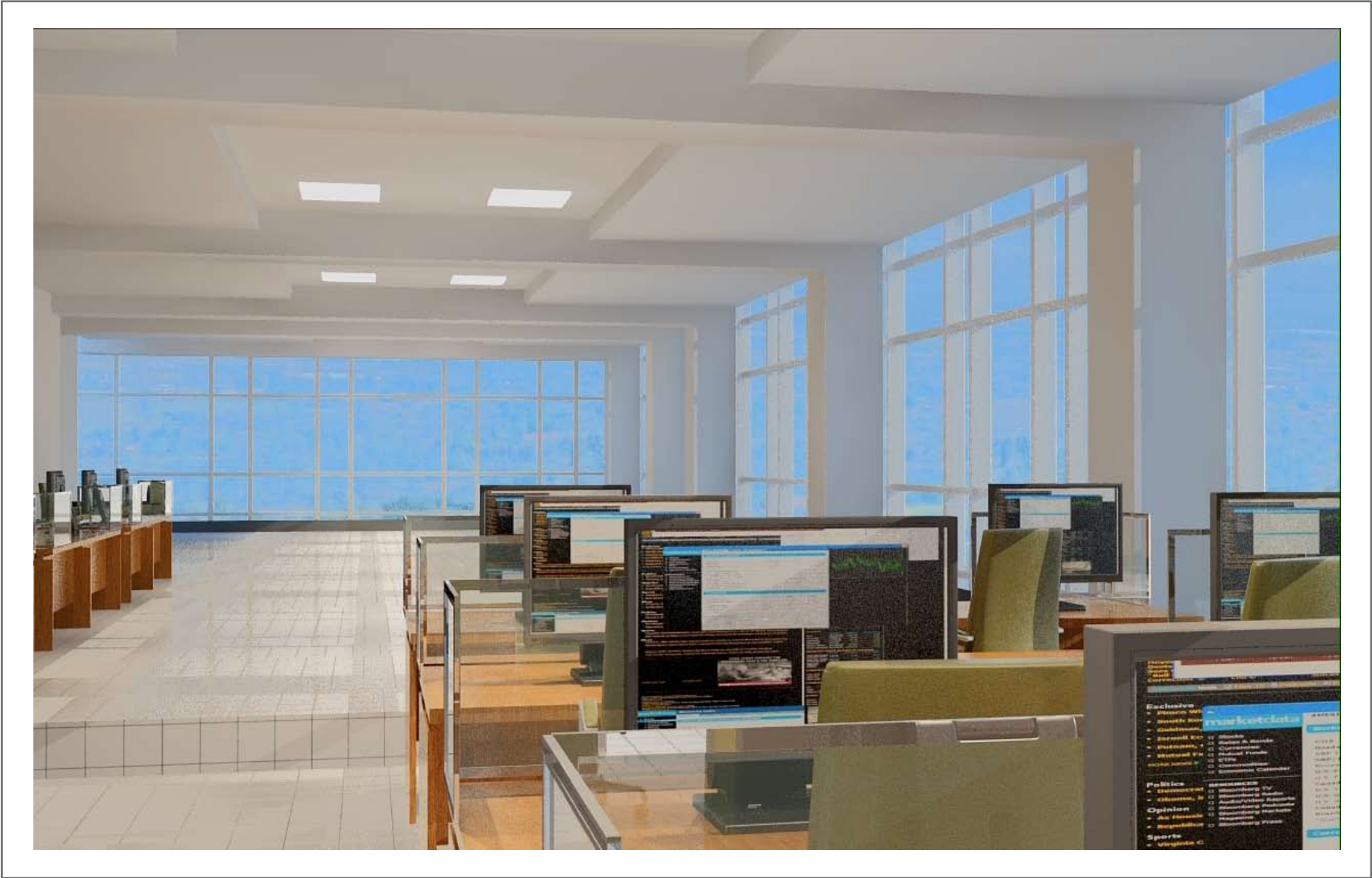
The journey of the CURE Project Team begins—again—every time a community starts the process of dealing with its own destiny in a way that confronts disaster, and takes catastrophe on. By taking catastrophe on, new CURE Center teams may be born. The concept of promoting preparedness for a response will of course enhance recovery and reduce tragedies. All can join the inescapable future but only if we allow ourselves the luxury of looking at the past and resolving to do better.

When disaster strikes, as it surely will, going home is not an option. The CURE Project Team at Loma Linda University looks forward to preparing, over and over again, with our own community, and with any other communities interested in sharing experiences and working together.

PHOTO CREDITS

Appendix C

Appendix D – AEGIS CHAPTER

Chapter 11

Making Sense Out of Chaos: Improving Prehospital and Disaster Response

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Introduction

Communities nationwide are at risk for disasters, pandemics, and terrorist incidents. Successfully responding to these incidents requires coordinating input and effort from a multitude of sources, and providing up-to-the-minute information as the situation evolves. The prehospital and disaster medical response system is a unique environment that presents several challenges to the healthcare system. Public safety, fire services, emergency medical services, hospitals, public health, and local government agencies all respond to these incidents. While the purpose of their missions may be linked, they each require unique data and tool sets for optimal response in a coordinated manner. This coordination requires current information which must be communicated to the individual responders as well as those on whom they depend for direction, within and between organizations, and in real-time (Meissner et al. 2002). Even public safety agencies accustomed to working shoulder-to-shoulder are unable (and sometimes unwilling) to share information due to multiple systems, multiple interfaces, and multiple data streams that provide

each agency's information, not to mention a need for security to protect that information. Since many emergency resources are not available on a single network, interactions among agencies often occur on a personal/phone/fax basis. The resulting interaction is therefore limited in scope and slow in response time, in contrast to the heightened need for information access in an emergency situation (Tanasescu et al. 2006). Cutter noted that there is a disconnect between the researchers of Geographic Information Sciences and the local responder or emergency manager. Whereas the researcher is interested in spatial data acquisition and integration, dynamic representation of physical and human processes, and cognition of geographic information, among other things, the responder wants to know what data need to be collected, who has it, how can I get it, and will my computer talk to yours? (Cutter 2003).

For a GIS to be successful in this environment, it must be interoperable, portable, accessible, and independent of infrastructure that may be damaged during the disaster. Applications must also be flexible for quick adaptation as the situation changes (Meissner et al. 2002). Designing information systems that span these operational limitations and provide pertinent information to managers and responders from these disparate disciplines is required to make sense out of chaos.

Situation Awareness

For years we have been struggling to make data portable and accessible. And we have been successful. We now have data at our fingertips. Too much data.

More data does not equal better information. Technology has created a snowstorm of facts and figures that can be so overwhelming as to be useless. Studies have shown that as a decision-maker's information load (defined as data to be processed per unit of time) is increased, the decision-maker tends to 'simplify' the information to

make sense of it, as well as attend to fewer data dimensions during the process (Wright 1974). Wright describes these simplification tactics as including restricting attention to certain portions of the data, excluding from consideration data about less relevant dimensions, even though they may have been considered in less taxing situations, or by focusing attention on data in certain regions of each dimension.

Providers need only that data that is relevant to their situation. They need only that data that helps them manage an incident. Decision support tools can filter and distill the data so that the user can have the right information at the right time. In critical public safety operations, providers do not need to be wading through tables, moving from application to application, or dealing with multiple databases. They want data presented in a way they can use quickly and easily.

A first responder who is multitasking at an incident needs to reserve their cognitive skills for the task at hand. Decision support tools have the potential to allow data processing for the first responder so that useful, filtered information is made available in a manner that meets their needs and allows them to concentrate their attention on more critical problems. Decision support tools may tell a provider about the status of a nearby hospital, may tell them the quickest route between two locations, may include site-specific material safety data sheets for hazardous materials, or may provide an overview of an incident.

Well-designed decision support tools can provide enhanced situation awareness for the public safety sector. The concept of "situation awareness" (also referred to a situational awareness) has been developed and tested in the airline industry. A formal definition has been provided by Endsley (1988): "The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future." A less formal definition is that situation awareness simply means knowing what is going on around you. Nevertheless, three elements are crucial; perceiving what is happening, understanding what it means, and being able to use this information to

predict what is going to happen next.

Jones and Endsley (1995) have looked at pilot and air traffic controller errors in order to characterize examples where situation awareness was inadequate. More than 80% of errors had to do with perception. In other words, the information was not detected, not monitored, or not even available. Understanding what is going on around you in time and space is exactly what a GIS excels at. A GIS can provide situation awareness for responders in the public safety sector, such as emergency medical services, hospitals, fire, law enforcement, public health, and military.

GIS and EMS Management

A GIS has the potential to "get the right resources to the right place at the right time." Imagine that a 911 call is placed. Once the dispatcher receives the call, he or she notifies the appropriate agency as quickly as possible so they can respond to the emergency. In the event of a medical incident, ambulances arrive to the scene, provide an assessment and emergency treatment, then make arrangements for the patient to be transported to definitive care. Contact with a base station that routes ambulance traffic to receiving hospitals alerts the emergency department of the impending arrival. An Emergency Management System (EMS) GIS could improve patient outcomes by making these processes more efficient.

EMS Case Study: A Schoolyard Accident

Emergency personnel often have to make educated guesses regarding numerous decisions that might significantly impact patient mortality and other important outcomes. For instance, several years ago, while running on the playground at her elementary school in Hesperia,

California, an 8-year-old girl suddenly chased a ball into the middle of the local street. With the sound of screeching brakes and a thud, numerous teachers and students suddenly looked up just in time to see the girl thrown over the hood of a car and then lie limply on the sidewalk. Immediately, "911" was called by the teachers. A fire engine and ambulance were dispatched to the scene.

Upon arrival, the first paramedic recognized that due to the severity of her injuries, this child would be best served at a pediatric trauma center rather than the local community hospital. The local community hospital was about 10-15 minutes away by ground ambulance, but the pediatric trauma center was about 20-90 minutes by ground ambulance, depending on traffic conditions. The paramedic knew that if a helicopter was close by, it could pick up his patient and fly over the rush hour traffic and get to the pediatric hospital in about 20 minutes. The paramedic also knew that current weather conditions could prevent a helicopter from flying through the mountains to get to the pediatric trauma center in the valley. He also knew that the local community hospitals might be on "ED Diversion" status due to the full utilization of their resources. Unfortunately, the paramedic was forced to make "educated guesses" regarding helicopter proximity and availability, hospital diversion status, traffic conditions, and weather conditions because there was no way to have all this information immediately available in order to make an ideal decision.

The paramedic guessed that there would be bad traffic since it was Friday afternoon and requested a helicopter to transport the girl to the hospital. Unfortunately, the closest available helicopter was 30 minutes away and took nearly an hour to land on the scene due to poor weather conditions in the mountain pass. En route the child's heart stopped and she was unable to be resuscitated at the hospital. It was later determined that the highway was wide open and that the ground ambulance may have been able to get the child to the desperately needed care within about 20 minutes. If the paramedic had been able to have the right information in real-time the outcome might have been

different for this little girl. Numerous similar scenarios like the one above have been taking place for many years because of the lack of real-time situation awareness for public safety personnel.

Now, imagine a system that answers these questions <u>at a glance</u>:

- Where is the closest airship and landing zone to the patient?
- What is the current weather in the area?
- What are traffic conditions on the possible routes available to ground crews?
- Which hospitals are available and what resources do they have?

The development of just such a system, the Advanced Emermgency Geographic Information System (AEGIS), described later in the chapter, began with these seemingly obvious questions. However, nowhere in EMS was there a single tool that could provide this information. Based on a "user needs" assessment, rather than a "top-down" approach, customization of a GIS provides the best tool for real-time decision support (Zerger 2003). Much of the information is available, but access to multiple systems is required. Although custodianship of the various data can provide a barrier to integrating the required information, emphasizing the communal benefit to the various entities resulted in successful collaborating with the principals of these other systems to bring all this information together for the first time.

GIS and Disaster Management

Elaborate disaster plans that collect dust on a shelf except for biannual drills are rarely of use when needed. For first responders, a major constraint to utilizing GIS is providing an understandable user interface and willingness to adopt new technologies (Cutter 2003). Inexperience with a system precludes them from using it to aid

decision-making to its full potential (Zerger and Smith 2003). A clearly accepted rule of human work is that "practice makes perfect." Better performance can be readily expected if disaster responders are assigned tasks they already carry out on a routine basis. Even in times of low stress and excellent information availability, the individual who is familiar with his or her tasks is much more likely to perform at high levels. In disaster situations, where the level of stress and distractions makes it difficult to focus on the details of what needs to be done, a clearly defined and understood role significantly contributes to the probability of highly effective performance among rescuers and health care personnel (Bissell 1996).

With this in mind, what works best in a disaster is what people are good at. And what they are good at is what they do on a daily basis. By adding additional features to the same tool that serves on a daily basis for EMS operations so that it can also be used for episodic disaster management, the advantage is that the public safety community would already be familiar with the system; additional training would not be required. Since many EMS systems experience disaster-like conditions (ambulance diversion, multiple casualty incidents, road closures, severe weather conditions, etc.) on a weekly or even daily basis, having the same system for both EMS and disaster management makes sense. A hybrid EMS/disaster management GIS will be able to adapt as needed to meet any conditions along this continuum.

A Disaster Case Study: Esperanza Fire, 2006

On October 26, 2006, Santa Ana winds were blowing across southern California. These winds are seasonal, occurring mostly during the fall. The wind blows from the northeast to the southwest. They are strong with gusts in excess of 75 miles per hour at times. Conditions begin with high pressure systems; as the air drops to lower altitude it picks up speed, increases in temperature, and loses humidity. The result is dry, hot, and windy conditions that increase the risk of seasonal

wildfires. Arsonists also seem to appear during these weather patterns. At approximately 1:00 AM, an arsonist set a blaze at the foot of the San Bernardino Mountains near Cabazon.

Six fire engines were assigned to structure protection in the mountain community of Twin Pines at 1:43 AM. There was some difficulty reaching the structures because of fleeing residents blocking the narrow, winding dirt road that provided access to the area. They were finally able to set up their engines around several structures atop the ridge. Around 5:45 AM, Engine 57 prepared to defend the "octagon house" which was at the end of an unnamed drainage that ran several miles down hill to a point near the origin of the fire. This drainage ran from the northeast to the southwest, in perfect alignment with the ongoing Santa Ana winds. The other five engines were staged at nearby structures. They were able to communicate amongst each other using a tactical frequency not assigned to the fire. At that point they expressed concern about the fact that one of their exit routes had been cut off by the advancing fire.

At about 6:45 AM the engine crews noted that the fire was moving up toward them very rapidly, and they began to set back fires. Around 7:00 AM the firefighters took refuge in their engines and waited until the fire front passed through at about 7:15 AM. After the front had passed, they were no longer able to contact Engine 57. Shortly thereafter they were able to make their way to the Octagon House. (Fig. 1) There they found the five-man crew of Engine 57, victims of a burnover. Three crewmembers were dead at the scene. Two firefighters were transported to a nearby burn center where they later died of their injuries.

The Esperanza Fire Accident Investigation Factual Report (Anon. 2007) noted several <u>contributing</u> factors that facilitated the accident. The alignment of the unnamed creek drainage with the Santa Ana winds combined with the high fuel load and low moisture content created dangerous conditions. Span of control was exceeded in a complex environment. There were also communication problems. The

engines were using a tactical frequency not assigned to the fire and their objectives were not clear. Finally, a contingency map from 2002 describes some of the structures they were defending as being "non-defensible". They also identified one <u>causal</u> factor "that if corrected, eliminated, or avoided would have prevented the fatality". That causal factor was felt to be a loss of situation awareness.

Figure 1: The Octagon House after the Esperanza Fire. Engine 57 is in the lower right corner. (AP Photo/ Reed Saxon).

Certainly data was available. The unified incident command system organizational chart was published. Fire perimeters were created. Fire frequencies and historic fire perimeters were known. Fire threat and fuel rank was described. The contingency map showing the non-defensible structures was available. The problem was that these various pieces of data were not immediately available to the incident commanders, or at least were not available in a form that made them

accessible in a practical time frame. Assembling disparate data so that critical information is available to a commander enables them to focus their cognitive skills on the demands of managing a complex wildfire rather than expending time and energy locating, reading, and interpreting data. It is exactly this type of situation awareness that a disaster GIS should provide, not only for incident commanders, but also for individual responders on a handheld smart-phone or other portable device (Fig. 2).
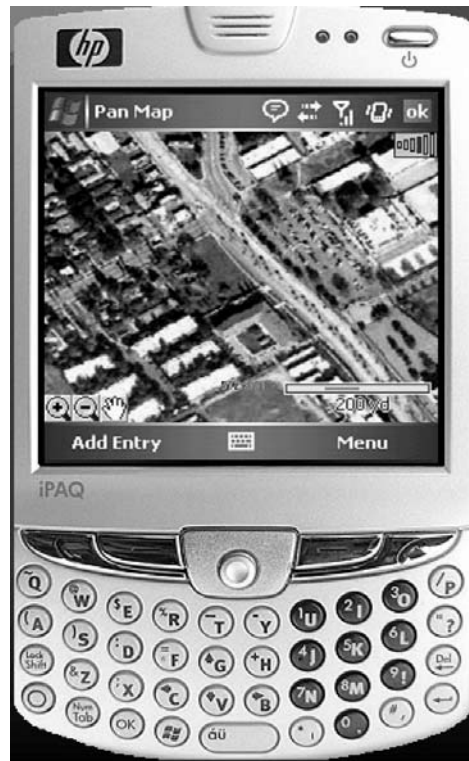

Figure 2: AEGIS displayed on a handheld mobile device.
Now imagine a system that answers these questions <u>at a glance</u>:

- What is the location and extent of the disaster?
- How many are injured, and what is the extent of their injuries?
- Who is the Incident Commander?
- Where are personnel and resources currently deployed?

If at its most basic level situation awareness is knowing what is going on around you, then a GIS can effortlessly provide this. Being able to see a fire perimeter in time and space and appreciate its relationship to a community or its relationship to public safety personnel can also be easily accomplished (Figure 3). Additional information may be added such as the locations of schools, staging areas, traffic conditions, weather, camera inputs, etc.

Figure 3: Fire perimeter mapped showing proximity to structures and location of resources

Making Sense Out of Chaos: One Solution

GIS can be, and has been, used in all phases of the disaster cycle: preparedness, response, recovery, and mitigation. Risk assessment and preparedness efforts can be enhanced by use of tools such as FEMA's HAZUS (http://www.fema.gov/plan/prevent/hazus/) and National Oceanic and Atmospheric Administration's (NOAA) weather forecasting (http://www.nws.noaa.gov/). GIS is particularly useful for integrating modeling results in time and space, and for assessing exposure (Von Braun 1993) And national databases, such as HSIP-Gold (NSGIC 2006) providing information about vital infrastructure and available to government entities, can aid in hazard vulnerability identification as well as resource capabilities for a given area.

However, real-time disaster applications of GIS have very specific requirements, which are significantly different from long-term decision making for disaster planning (Zerger and Smith 2003). To understand how a GIS can be used during crisis situations, we can examine one solution – the Advanced Emergency Geographic Information System (AEGIS).

AEGIS

The Advanced Emergency Geographic Information System (AEGIS) was designed to address many of the inadequacies seen in our daily EMS operations. Loma Linda University Medical Center is the only Level I trauma center and pediatric hospital in a vast area of Southern California, about 25% of the state. This region is geographically diverse, including urban and rural communities, desert, lake, and mountain terrain (including the highest and lowest points in the continental United States, Mount Whitney at 14,505 ft. and Death Valley at -282 ft.), and extremes in temperatures. The resources available also vary a great deal from locale to locale, and as a result emergency services are parochial and fragmented. As a tertiary referral center and a base station for ambulance runs, our Mobile Intensive Care Nurses (MICNs) take about 3,000 ambulance calls

every month. As medical providers in the field, the authors understood the challenges faced not only by paramedics, but also by emergency dispatchers and the nurses in the radio room trying to route ambulances for the best patient care. As part of a Department of Defense sponsored project focused on getting medical care to the site of injury, we worked to develop a system we felt would provide a solution to many of the barriers encountered in the prehospital setting.

First, it was understood that the system must be available to all who would need to use it for emergency management. This meant a web-accessible system that could be accessed securely from any number of locations. Second, the information would need to be able to transmit a great deal of information in an easily understood interface, making a visual system most desirable (i.e. the old adage "a picture is worth a thousand words.") And, it was apparent that many of the challenges were geographic in nature. This led us to consider GIS as the only viable platform on which to base such a system.

We also realized that "old" information would be useless in the dynamic setting of emergencies and disasters and sought to include 'real-time' information necessary for efficient operations. Most of this information was already accessible in a variety of forms. For example, information regarding hospital diversion status and other alerts is transmitted in tabular form to all local hospitals and updated frequently via radio and phone communications. One can look at current traffic conditions from live streaming cameras as well as determine highway speeds from sensors located along the freeways. Current incidents being worked by the California Highway Patrol are also available on the web, showing where incidents are located and their status. This information can be used to avoid certain areas as well as to estimate how long resources may be deployed to an incident. However, none of this information was available without having to access multiple resources.

Working with ESRI, Redlands, California, we were able to develop a GIS that incorporates both static and dynamic information in a

single, user-designed, user-friendly interactive map. Static
information includes a variety of maps with the location and attributes
of key facilities and resources, including hospitals, Fire/EMS/Police
stations, major venues, schools, airports, and numerous additional
overlay options that can be toggled on or off by the operator (Fig 4).

 Dynamic information includes color-coded hospital diversion
status, real time traffic information, current weather conditions, and
updated major incident information and location from Emergency
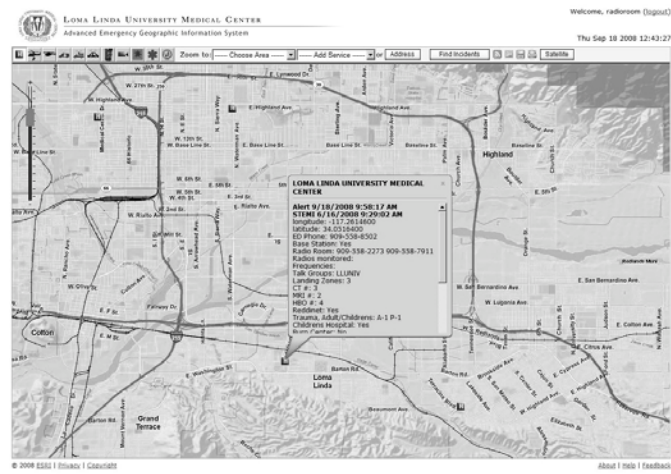Dispatch. (Figs. 5, 6).

Figure 4: Map showing location of hospital, fire and sheriff
stations

Figure 5: Current traffic conditions from speed sensors and highway web cams

One feature we felt would be helpful to users of the system would be the ability to know where ground and air assets were located. Several incidents, including the one in our schoolyard case study, had shown that having this information might have prompted a different resource to be dispatched to an accident, resulting in a shorter response time and subsequent arrival of the patient to definitive care. Through the use of Automatic Vehicle Locators (AVLs), AEGIS is able to visualize fire apparatus, air transport helicopters, and other support vehicles in real time (Figures 7 & 8). Along the same idea, GPS-enabled phones and other personal devices could show the location of key personnel and other resources. Now emergency managers, as well as responders, have an up-to-date awareness of where their resources are in relation to the incident, and in relation to others who are or will be deployed.
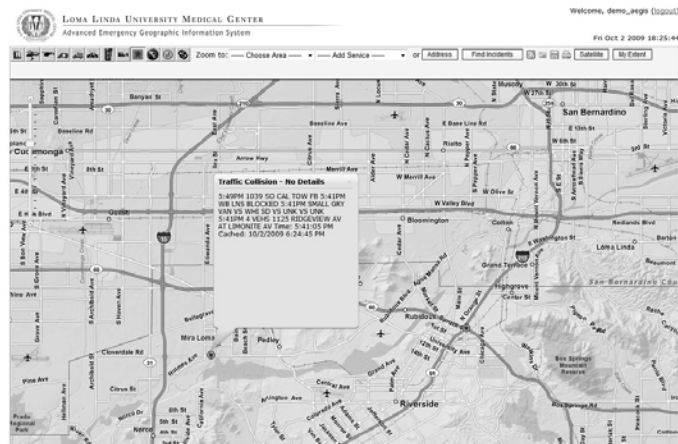
Figure 6: Active incidents from Highway Patrol, updated every minute
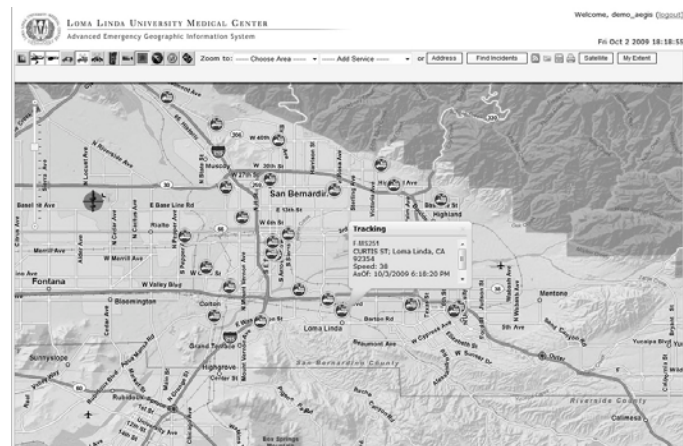
Figure 7: Real-time tracking of ground assets

AEGIS began as a means to improve prehospital operations. As the system has evolved, we saw the advantages of using it for disaster operations as well. The system is scalable and can expand to meet the requirements for managing a large regional disaster, or shrink to meet the requirement for routine EMS activity. It is designed to allow secure access to a variety of information sources. For example, information regarding mutual aid agreements cached in the system beforehand can facilitate requisition and deployment of resources. Critical information, such as that needed during the Esperanza Fire, can be included as attributes of structures and locales so that it is available quickly and visually to the Incident Commander. Through the inclusion of community contacts, 'reverse 911' systems, automatic paging and phone tree activations, AEGIS can alert individuals or communities with updated information, requests, and directives.

Figure 8: Location, direction and airspeed of medical transport helicopter

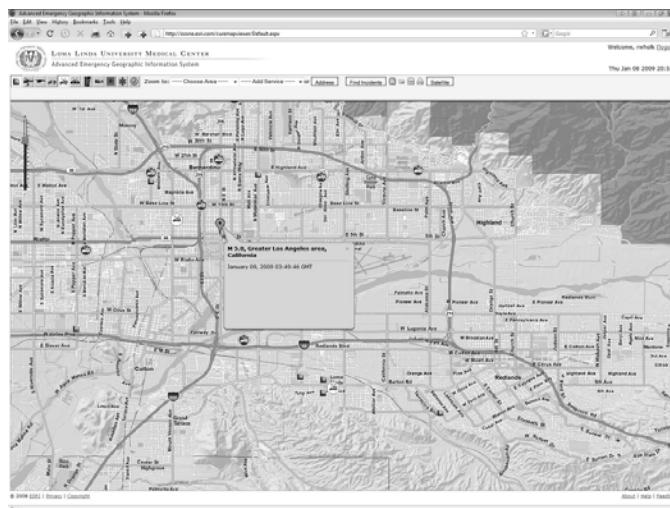We also understood that some disasters would require use of available predictive tools that describe wildfire activities, toxic plume behavior, hazardous material incidents, flooding, and earthquakes. These can be integrated into the system for immediate use by emergency managers. Additionally, any geospatial information that is needed by a particular agency, jurisdiction, or responder can be incorporated via RSS feed, resulting in a customizable map specific to the user's needs and/or incident. Conversely, information displayed on the AEGIS system can be exported to other mapping systems via RSS feed, making it universally available. This idea of being "technology agnostic," which we feel allows integration of data from multiple disparate sources into a common interface, has been paramount in the development of the system.

As we began to see that the system could be used in emergency incidents of all types and sizes, we felt that some additional attributes would make it even more effective. By incorporating the fundamentals of the Incident Command System, emergency managers could see at a glance who the incident commander is, and who is responsible for operations, planning, finance, and logistics. Personnel in critical positions or locations can be identified and given specific instructions, and personnel or assets in other locations can be redeployed to more strategic positions. This is accomplished by allowing interoperable communications among a variety of devices via test messaging to an individual or group participating through the system.

It was also critical to provide the system to portable devices so that everyone working on the incident, whether remotely or in the field, will have access to the information. Field responders can provide accurate, timely, on-scene information to the system with 'on the fly' editing of the map, adding incident-specific information such as roadblocks, photographs, location of command posts, and incident perimeters. Information published to the map is available to all authorized viewers instantly and simultaneously. From web or mesh

access points, field responders can access all pertinent data, update scene specifics, or communicate with other responders. It also allows mobile users to run sophisticated analysis provided by a remote server using the field data input. This increases their ability to perform their duties expediently and safely, and convey timely information through to their command structure and to others who require an understanding of the nature of their response.

Additionally, AEGIS can handle multiple incidents. During an extended disaster, such as a wildfire or flood, there is a possibility of other emergency incidents occurring, such as hazardous material events, multi-vehicle accidents, or train wrecks. Resources and drawdown levels affected by local incidents could impact management decisions at more remote sites. This information would be readily available to the incident manager.

AEGIS was first deployed to the Esperanza Fire. While its use in that incident was mostly as a communications device, the authors were able to demonstrate its features to many emergency responders, including incident command personnel, who provided positive feedback and suggestions. Through its deployments during numerous drills and exercises, as well as its daily use in the emergency department, AEGIS continues to undergo this iterative evaluation process by those who will potentially use the system.

AEGIS is an example of a GIS that can overcome the barriers that occur during a disaster, allowing an integrated, efficient, and secure response by establishing a common operating platform for all agencies involved in the response. Improved situation awareness enhances planning and increases personnel safety. The spatial representation of the incident, the extensive scope of information for decision support contained in the data layers, visualization of adjacent critical structures, and the understanding of resources available with current asset allocations, will allow managers to make well informed decisions, decrease uncertainty, and improve time to action. Understanding the operational conditions at all levels and across

agencies is necessary for prompt response, proper allocation of resources, and responder safety. This information can be provided seamlessly to all authorized users via web-enabled desktop or mobile computing devices.

Summary

Disasters often require immediate action with very little information. Systems that allow Emergency Managers to access real-time information, receive updates instantly, communicate with field responders and other personnel, and provide decision support, can be invaluable in making those decisions. A successful GIS-based EMS and disaster management system will also be flexible, portable, and interoperable. A system that can be used on a daily basis avoids a barrier to its use during emergency incidents and aids the user in critical decision-making. Communications should occur instantly among users of the system, circumventing the barriers often seen when various agencies, jurisdictions, and technologies are involved in the response. Those using the system should have access to the information that they require to manage the incident, but it should also safeguard sensitive information. We describe one example of an EMS/disaster management tool that can bring together a variety of information resources into a single access point.

Acknowledgements

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CURE Center Project Expert Symposium
Bioterrorism and Public Health Emergencies

Background:

- Traditional disaster planning has concentrated on focal events. However, emerging infectious diseases or bioterrorism incidents will require hospitals to address prolonged periods of intense demand for services. [1]
- Public health emergencies are different from other disasters in that they are not as easily recognized, more insidious in onset, require specialized laboratory and epidemiological investigations and equipment. [2]
- HRSA recommendations include that 100% of hospitals have the capacity to maintain at least on suspected highly infectious disease case in negative pressure isolation, and that regional assets can support the initial evaluation and treatment of at least 10 adult and pediatric patients within 3 hours post-event. [3]
- The 2003 Severe Acute Respiratory Syndrome (SARS) epidemic in Singapore resulted in the screening of 11,461 people in emergency departments in a two and a half month period. [4]
- During the 2003 SARS outbreak in Toronto, the Hospital for Sick Children (HSC) noted emergency visits were decreased from baseline, but hospital admission rates increased significantly. [5]
- Most hospitals have adopted "just-in-time" supply methods for equipment and supplies, due to financial constraints, and would quickly develop shortages in critical supplies during a public health emergency. [1]

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Goals	What is Needed	Activities and Recommendations from Panel
Determine strategies to protect staff		Advisement: Level of PPE required, quantity, need for decontamination, training
Describe ways CURE Center can augment community response specifically in biological events	Consider isolation and quarantine	
Determine what	List of resources	

university/hospital/local resources are immediately available to identify infectious agents		
Provide epidemic detection	Biosurveillance and bio-agent detection Guidelines for the clinical recognition of and public health management plans for potential biological agents Ideal characteristics of a syndromic surveillance system: • Does not rely on physician reporting. • Data already collected routinely. • Immediately computerized. • Population-based. • Categorized by syndrome.	Recommendations on strategies

Breakout Session II- M. Proctor, E. Hsu, T. Williams, T. Thomas

A unique factor of biologic event is that no threat assessment is possible. Anything can happen anywhere?

An initial approach suggested is ask several questions:

- #1 CAN ANYTHING BE DONE?

  - A – YES
    - Immediate response?
    - Delayed response?
      - Importance of decision to distribute vaccine as well as strategy for distribution.

It is important to develop measures of evaluation (MOE) in response to biologic agent/epidemic. How do we evaluate our response.

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How do we affect infectivity rate?

Countermeasures – biologic perspectives
- Strategy to obtain countermeasures (antibiotics, antivirals, vaccines)
  - Develop strategy – Who gets it?
  - Plans to obtain - Where do you get it?
  - Plans for staff countermeasures – you and your family protected
- Prioritization – Who gets it?
  - #1 Staff
  - People who affect the hospital
- Quantity of countermeasures
  - If you have plans to obtain countermeasures for 1000 be sure to plan for quantities for staff and family members(what do you do if you need 800 just for staff and their families)?
- Need protocol for:
  - who gets what?
  - How much?
  - For how long?

DO YOU FORCE PROTECTION?
- This raises some very interesting ethics for protocols in epidemics.
- Should you or can you force staff to come in?
- Which staff members would be exempt?

Strategy for Bio events
- Think completely different than for a standard trauma-based critical event where surge capacity is crowing more patients into a room, hallways, lobbies etc
- In bio-events, higher the densities of patients may increase the problem.
- Humanitarian relief data suggests that there is a critical density (cubic feet per patient) in refugee camps that people get ill.
- This takes us back to the cohort isolation in the 1920s.
- Can disease be contained in a facility?   . . .Depends
  - E.g. Influenza – not realistic
  - Hanta – probably all ill people get to the hospital

Triage hospital
- Is it possible to designate a quarantine hospital?
  - ??Should it be the first hospital an epidemic is identified.
  - Should a specialized facility be designated?
  - CURE – Would it be effective to name a facility like CURE as a quarantine area? Over time this may be effective since CURE is not set as a revenue generator? Many hospitals do not wish to be designated as the bio hospital since it would keep patients from coming in, stop elective procedures . . .

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Biosensors

- Problem with testing is what to do with the results
- E.g. Biosensors in some areas in Texas consistently read high for tularemia (Many rabbits in Texas).
- What do we do with results of positive senses? False positive senses

WORKER SAFETY

- Need for protocols
    - Do we need to set up negative pressure rooms, should they be permanent or temporary
    - Decontamination decision
        - Discussed dry decontamination – new protocols state that majority removed with disrobing to underwear
        - Israel discontinued all mobile decontamination since it is set up at hospitals.
        - Recent recommendations suggest that no catchment is necessary for run-off (except for radiologic).
        - Recent suggestion that there is a need level C decontamination (only need level A for industrial incidents).
    - Over pressurization of buildings may be a good idea. Good window and doors. Over pressure increases airflow. (Hospital in Tel Aviv pressured at 20 cm H2O).

ACTIVATION

- A key component of the CURE plan should be to explicitly determine what the activation procedure is.
    - Certainly, activation for an epidemic may differ from other critical events. (3rd case or trigger case)
        - Contagious vs. non contagious
    - What is the trigger point to alert everyone?
    - One suggestion: look at number of evacuees - 5000 activate half the system, 15,000 activate the entire system
    - WHO ACTIVATE?
        - Probably better for the decision by committee, not by one person.
        - Tiered activation for a bio-event – Phase I, II, III, IV
- Tracking/surveillance
    - ICD-9 diagnosis codes can't pinpoint test case but can identify large groups or unusual peaks. (some track on GIS)
    - Signs of disruption such as kids at school or OTC medications being sold out.
- Identify trigger spots that determine partial vs. full activation
    - Such as number of casualties or %population in a defined area
    - Scenario-based
    - Multi-modal activation

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STAFF

- Enormous needs

Fundamental decision – Where do you put the patients?
- Alternative care sites – which patients should go here? The advantage is to off-load bulk of patients onto acute care sites
    - Utilize facility to de-bulk main site. Need to provide them with supplies.
- Another strategy would be for the primary site to take care of the critical patients.

MISCELLANEOUS

- Floor track, one site has a 24" build-up for the floor to run all lines in
- Struggling with mechanical ventilation strategy
    - 40 beds put in flow meters?
    - Cohort 20 ventilators
    - Might be easier to divide 10 critical beds in each department
- Equipment
    - Ventilator decision, flow meters, monitors
    - Do you need to monitor patients?
    - Perhaps capnometer, pulse ox,
    - Exchanger
    - Portable vs. mainstream
        - General feeling was to have as much equipment as possible be portable.
- Communications
    - Hastily formed networks(HFN)
    - 9 piece puzzle

Appendix E

CURE PROJECT – Surge Capacity

BACKGROUND

"Our American health care system exists very close to the margin." Nearly every city, nationwide, experiences hospital diversions, closures and a decreasing number of beds. Additional issues of nursing shortages and "just in time" supplies seriously challenge the health care system's flexibility. Recent disasters and potential critical events have highlighted the necessity of surge capacity. They have compelled the medical system to find rapid, efficient, cost-effective, and manageable solutions for the inevitable surge needs placed on an already overtaxed health care system. [tadmor]

Many definitions exist for surge capacity and the concept has continued to evolve over recent years. Surge capacity for hospitals has been defined as components necessary to care for a sudden, unexpected increase in patient volume that exceeds current capacity. [hicks] Essential components of surge capacity include staffing, equipment and supplies, and structure (physical structure and management infrastructure).

Surge capacity is a complex issue. Appropriate management of high-consequence critical events encompasses hospitals, systems, jurisdictions and multiple disciplines. When reduced to the simplest of terms, our ultimate goal in a critical event is to increase the capacity for patient care. The goal of the current CURE project is to discover flexible, innovative, and expandable solutions for emergency care in a critical event in order to provide surge capacity.

DEFINITIONS		
Medical Surge Capacity		
	Ability of obtaining additional resources when needed during an emergency."	CDC
	"Healthcare systems ability to rapidly expand beyond normal services to meet the increased demand for qualified personnel medical care, and public health in the event of bioterrorism or other large–scale public health emergencies or disasters.	[ARHQ]
	Maximum number of persons that the health care system can evaluate or treat on sudden demand.	NA Corp
Daily surge	"the ability to respond to a sudden, unexpected surge in demand using only the daily operating resources of the hospital	asplin
Disaster surge		
Sustainability	Ability of local health care system to tolerate an extreme event until significant outside	mileti

assistance arrives.

COMPONENTS OF SURGE CAPACITY		
MEDICAL SURGE CAPACITY PATIENT CARE	HRSA/JCAHO recommend that a community be able to provide triage, treatment, medication, transportation above the daily staffed bed capacity as follows: 500 cases/million for acute infectious diseases	
	50 cases/million for toxic agents (chemical agents, botulinum), burn, trauma, radiation-induced injury. [1]	
	Other sources recommend 20-30% surge capacity [2].	
	[San Bernardino and Riverside Counties have an estimated total population of 3.8 million (US Census Bureau 2005 estimates)]	
STAFF		
EQUIPMENT & SUPPLIES	HHS recommend medications to treat 25% of the population, in case of BT/Pandemic.[3]	
	IDSA (Infectious Diseases Society of America) recommends 25-40%. [4]	
	AHA recommends 24-hour supply of most common drugs and a standardized formulary. [5]	
	JCAHO recommends 48-72 hours stand-alone capability for medications and supplies. [6] The National Center for Disaster Preparedness recommends 48 hour supply of pediatric equipment and medications for the average daily number of patients plus 100 additional patients. [7]	
STRUCTURE		
MANAGEMENT		

Equipment

Examples from the literature
Forrest General Hospital, Mississippi treated 500 patients (normal = 230) the day after Hurricane Katrina
-The Rhode Island Nightclub fire sent 40 seriously injured patients to Kent County Hospital, the area's second largest hospital. The largest hospital (Rhode Island Hospital) has 12 ICU capable beds in the ED. [8]

-Some hospitals affected by Hurricane Katrina were without access to outside resources for 72 hours or longer.
Anecdotal data from 2 hospital systems after the Pentagon attack September 11, 2001 found that bed capacity could be increased by 10-20% in the first few hours. [hick]

Goals:

- **Determine level of care to provide**

- **How long should the Center be self-sustaining?**

- **Describe initial equipment/supplies needed based on above determinants.**
- **Describe services needed to sustain independent operations.**

- **Provide personnel to CURE Center independent of hospital**

- **Determine CURE Center needs for special populations**

Needs:
- Need "all hazards" approach
- Plan to operate independently from main hospital
- General categories of medical equipment list
- General categories of non-medical equipment list (e.g. fuel, water, food, waste disposal)
- List services (medical and non-medical)
- Strategies to increase staffing
- Credentialing of volunteers
- Describe methods for "just-in-time" training
- Describe support services needed for additional staffing
- Describe populations at risk
- Determine care to be provided by CURE Center to these populations

Summary:

- Principles
  - When dealing with surge capacity a basic approach to the philosophy of care should be addressed:
    What assumptions are you making?
    Should you assume that the standard of care will be maintained?
    Should you assume that anything goes?

    → There are d rawbacks with either assu mption; however, in a resource-rich environment like the US it is a rare critical event that resources are completely overwhelmed. Even in a catastrophic event like Hurricane Katrina the <u>amount</u> of resources technically were not the m ain lim iting f actor in re sponse

particularly in a geographically speci   fic event (rest of the country not affected).

→ The scrutiny that responses are under make the issue of "anything goes care" somewhat problematic.

→ Diminished Care

- There may be diminished standards of care during a disaster. There needs to be adequate education and communication to ally public perception.
- When standards of care are altered, predesignated decision criteria should be established with education, training and drills planned.
- Dr Cantrill encouraged care providers to use a systems point of view to determine what or where the rate limiting step(s) is(are).
- Redlands has specific plans to control the surge to the hospital that includes road blocks and alternative care sites. The purpose is to limit ingress to the hospital
- Dr. Cantrill noted that the vast majority of patients will self-present or have family/friend transport to hospital

- Decide - Where do we raise the bar for di   saster response?   Congress decides – but how do we get to the private sector?
- Key points- W e need to con centrate on sufficiency of care   rela ted to specif ic hazard vu lnerability analysis. One sugges tion m ade was to look at th e specific case-specific scen arios designated by DHS   with m odels for each. T   here was varying opinions around the table as to what the value of these scenarios are.

- All-hazards approach
  → The concept of an " *all-hazards approach"* was discussed. W hile this term has been un iversally accep ted there are som e concerns. All hazards are not the same - in fact a hurricane is a radi cally different actor th an an earthq uake and an epidemic even more different.
  → In reality what we may be trying to say is there are commonalities in response. The common ground in all of these types of incidents is logistics.
  → The key to any approach is a focused,   relevant hazards an alysis. It is essential to develop a specific m enu of risks for a geographic area, prioritize this list and develop an swers to prep aredness and response to each of these risks.
- Scalability
  → Alternative site care facilities, particularly the CURE Center, should be scaleable. This brings with it the notion of modules or units that could be sequentially put into service.
  → In addition activation of the CURE Center should be event or situation dependent with predetermined set- or trigger-points to determine activation. This trigger might be patient numbers or some other measure of critical mass.

Challenges to surge capacity
- There is no data to h elp determ ine the am ount of surge each hosp ital should be prepared for.

- When HRSA recomm ended num bers were being developed data from NDMS, national traum a system data bases, an d m ass casualty sy stems from other countries were evaluated res ulting in a prelim inary recommendation that regional su rge capacity should acco mmodate 100-300 cases per 1 million population. This was later expanded to 500 cases per 1 million. The exact methodology used in not clear.[schultz]
- Example, Israel (PH)
  - Top-down approach with centralized decision making
  - Resources are not abundant so the approach is to avoid redundant resources (no re-inventing the wheel).
  - Command and control are centrali zed and re gularly practiced. The military has no m edical infrastructure so civilian m edical care regularly interfaces with the m ilitary. In the s ame sense, military resources are used in a critical event (comm and and control on a national level, air transport regular care).
  - Clear division of labor – exam ple of response to recent refugees after war this fall.
  - All hospita ls are re latively large. Since na tional m edical care is delivered by 4 HMOs there a re not sm aller co mmunity hospita ls competing.
  - Israel requ ires that a ll hospita ls ha ve the ability to surge 20% within 1 hour, and 60% within 24 hours.

- Control/Command (MP)
  - Two items that were es sential to hospital response in Katr ina were that Gov Blanco suspended JC AHO as well as the licensure requirements . . .
- It was discu ssed as to wh at to do in the large event where the majority of patients respond to the closest hospital. After 9/11 m ore than 500 patients surges to St. Vincent's Hospital wh ile th e m ajority of othe r Manhattan hospitals were not particularly busy. One suggestion that has been used in Israel is to go on *"Triage Hospital Mode."* This would m ean that the entire hospital only conducts triage. Only ABC and em ergency surgeries are done. Adm itted patien ts are sent el sewhere as well as surgery cas es that can wait. The goal is no admissions to the triage hospital,

- Historically, in the US it was intende d that the public health care providers would provide care in such situations. However, there have been no federal providers - public health hospitals or cadre of public health care workers since the 1960's

- Preparing an alternate care site
  - Five key issues for an alternative site care facility:
    - Command and control of the resources and physical plant.
    - Documentation of care.
    - Reduced standards of care.
    - Exit strategy.

- O$_2$
  - o Example: Dr Cantrill stated that there are currently 3 cache levels in Colorado:
    - Level 1 Cache – 50 beds in a single trailer containing basic equipment to augment the hospital it is attached to.
    - Level II Cache – preparation for 500 beds/ 1,000,000 population as Regional Alternative Sites. There are 7 locations across the state.
    - Level III Cache – Comprehensive Alternative Care Site where the level of care is equivalent to a hospital.

  - o DHHS has Public Health Contingency Stations that are structurally independent federal medical stations.
  - o The Denver Convention Center was set up in 6 hours as a 100-bed facility in response to Hurricane Katrina.
  - o Private and public hospitals
    - o need for joint medical asset visibility and that in Denver the MMRS serves this function
    - o there needs to be a shift in philosophy that allows for public/private transfer of personnel and resources
  - o Evacuation -Need an overall plan
    - o Requires planning of input and output of area.
    - o Significant problem in New Orleans when airport was designated as the evacuation site.
    - o While it was set up as a way station, there was not a clear plan for out-put. (There was an additional 11,000 evacuees outside th e airport). It worked a bit like the ga me of Tetris where patients coming in initially could be handled but as the "gam e" got faster, it was im possible to keep up.

- ***Estimate minimum number and acuity of patients to prepare for – level of care***
  - 500 per m illion recomm ended by HRSA. In this area w ould need to provide 1,500 – 2,000. Are we considering that th e CURE Center m ay need to provide surge for large incidents in nearby counties, e.g. Lo s Angeles? This would require a much larger capacity.

  - Must have a contingency if LLUM C is in the m iddle of the disaster. Would the CURE Center be able to provide care for hospital inpatients?

  - The CURE Center should be able to provide the highest level of care for patients that m ay need to be evacuated from LLUM C or other hospitals (e.g. an earthquake in LA that requires evacuation of patients.)

  - How would the CURE Center leverage the expertise of the hospital to Casualty Collection Points. Is this a valid role for the Center?

How long should be self –sustaining?

- ◆ To develop strategies to cope with medical surge capacity necessary during a sudden impact disaster Stratton et al explored characteristics of initial demands for medical care that have occurred.
- ◆ Characteristics after sudden impact disasters evaluated were:
    - → **Length of time a community must sustain itself prior to outside assistance**
        - • Earliest arrival was 24 hours with a range of 24 to 96 hours. [Stratton]
            - ◆ Disaster medical assistance team (DMAT) arrived within 4 days for Hurricanes Iniki and Andrew. DMAT teams responded to Northridge earthquake within 24 hours (within state) and 48 hours for out of state teams. After the World Trade Center DMAT arrived within 72 hours.
            - ◆ After Hurricane Katrina reached land Charity and Tulane Hospitals functioned in austere mode without outside relief. Outside aid and patient evacuation to external hospital were not initiated until 72 to 96 hours.

    - → **Time interval between disaster impact to peak in health care demand**
        - • Peak demand in emergency departments occurring within 24 hours.
        - • This is difficult to evaluate in a critical event that requires evacuation such as Hurricane Katrina.
        - • After the World Trade Center explosions in 2001, injured patient arrivals to ED peaked 2 to 3 hours after the event. Within in 12 hours 71% of 723 survivors of WTC attacks sought and received care.
        - • Murrah Federal Building bombing in Oklahoma City the median time from the blast to ED arrive was 91 minutes. Non ambulance arrivals peaked at 2 hours.
        - • After the Northridge earthquake the peak demand for quake-related emergency care at 95 patients per hour during the first 24 hours which decreased to 25 patients per hour within 48 hours.
    - → **Types of injuries and illnesses to expect**
        - • 84-90% of health care demand was for conditions that were managed on an ambulatory basis.[Stratton]
    - → **Access points for health care delivery immediately post impact**
        - • Emergency departments were the access point for care

        - o *Review likely hazards to area and potential for focal, time-limited (point-in-time) vs. prolonged events to make estimate.*
        - o *Review likely hazards to area and potential for focal, time-limited (point-in-time) vs. prolonged events to make estimate.*

- ▪ Make recommendations on **_supplies needed_** with regard to space and servicing limitations.
    - o The CURE plan m ust determ ine what serv ices are esse ntial and e stablish contracts with these services prior to a disaster occurring.
    - o
- ▪ **_Personnel_**

- o A major challenge f or the CURE Center (a nd all healthcare facilities) will be to m aintain staf fing when the work ers f eel that the ir f amilies or se lves are threatened. Plan must address these issues.
- o Personnel—CURE should work with other agencies to establish standardized definitions of personnel types

- ***Special needs population***

  - • Special needs groups were defined dur ing Katrina as those that the Red Cross shelters would not take in - this included post-partum women.

    - o Elderly
      Significant needs for this growing segm ent of the population. Often this group of patients n eed m edications filled, blood pressures checked, blood sugars checked, and medication lists and doses. Israel has voluntary m obile team s set up with in entire community (community is mapped out). This would be a valuable data obtained from the Arc–GIS - m apping out comm unity needs of elderly citizen s as well as h aving the inf ormation av ailable to prehospital community.

    - o Exacerbation of chronic disease
      Who needs to be treated in-patient?
      Who can be treated out patient?
      Dialysis is also a significant problem.

    - o Mentally ill
      Suggestions for treating m entally ill patients in pre-designated Stress Management Centers.
      This significantly decreased load on the EDs.
      After the rec ent missile crisis in Israel 20% of total visits wer e due to stress-related symptoms.
      Stress Management Centers are set up separate from hospitals.

    - ▪ Every are a/location (HMO joined) is defined into specific care areas . (Israel)
      - o Based on population density.
      - o This is im portant inform ation si nce these special populations m ay have evacuation difficulties.

An addition al problem addressed in patient den se situa tions is m edical records . Physical m edical records ar e im possible to locate. Se veral suggestions include plastic cards. Bar codes. . . It wa s suggested that sm all chips with m edical information could be placed subcutaneously since this is an effective way to keep track of cattle!!! Another suggestion is an on-line clinical data depository.

- • Ehren Ngo mentioned that special needs populations may have difficulty getting to a hospital

Standardizing or quantifying disaster surge is problematic. There are significant difficulty in identifying standards and metrics in disaster research. Outcome measures are even more challenging. It has been suggested that if metrics for the varying components of surge such as severity, acuity, duration, magnitude and event type, it may then be possible to measure the "speed and adequacy of response to the fluctuation in surge as an outcome measure. There are no scientifically derived, universally accepted standards of hospital surge capacity and objective measure defining hospital surge capacity are lacking. [kaji]

"Measuring capacity in terms of numbers of victims is tempting because it is quantifiable but capacity changes on a minute-to-minute basis. The key concept is whether hospital resources are exceeded at a given point in time and, if so, what procedures can be implemented to expand and enhance patient care capacity. [Schultz]

Necessary investigations: Evidence-based benchmark for hospital surge capacity immediately following an event and the maximal hospital surge capacity given time to augment resources, length of time necessary for hospital to reach the point where they can provide maximal surge capacity. Schultz]

PREPARING FOR BIOTERRORISM AND PUBLIC HEALTH EMERGENCIES

- Traditional disaster planning has concentrated on focal events. However, emerging infectious diseases or bioterrorism incidents will require hospitals to address prolonged periods of intense demand for services. [1]
- Public health emergencies are different from other disasters in that they are not as easily recognized, more insidious in onset, require specialized laboratory and epidemiological investigations and equipment. [2]
- HRSA recommendations include that 100% of hospitals have the capacity to maintain at least on suspected highly infectious disease case in negative pressure isolation, and that regional assets can support the initial evaluation and treatment of at least 10 adult and pediatric patients within 3 hours post-event. [3]
- The 2003 Severe Acute Respiratory Syndrome (SARS) epidemic in Singapore resulted in the screening of 11,461 people in emergency departments in a two and a half month period. [4]
- During the 2003 SARS outbreak in Toronto, the Hospital for Sick Children (HSC) noted emergency visits were decreased from baseline, but hospital admission rates increased significantly. [5]
- Most hospitals have adopted "just-in-time" supply methods for equipment and supplies, due to financial constraints, and would quickly develop shortages in critical supplies during a public health emergency. [1]

Goals:

Determine strategies to protect staff

Describe ways CURE Center can augment community response specifically in biological events
Determine what university/hospital/local resources are immediately available to identify infectious agents
Provide epidemic detection

Needs:
- Consider isolation and quarantine
- List of resources
- Biosurveillance and bio-agent detection.
- Guidelines for the clinical recognition of and public health management plans for potential biological agents.
- Ideal characteristics of a syndromic surveillance system:
    - Does not rely on physician reporting.
    - Data already collected routinely.
    - Immediately computerized.
    - Population-based.
    - Categorized by syndrome.

Summary
Advisement: Level of PPE required, quantity, need for decontamination, training
Recommendations on strategies

ESSENTIAL COMMUNICATIONS & TECHNOLOGIES
Comm
- Disasters generate high demand at a time when services, infrastructure, and resources may be least available.
- Telecommunication capabilities in the US are among the most advanced in the world, but are dependent on electricity, are characterized by above ground lines and towers that can be adversely affected by weather, and buried lines susceptible to flood waters.
- Mobile phone and long-distance communication experienced almost complete disruption after Katrina. Over 60% of networks were still down three weeks later. [1]
- In the aftermath of Hurricane Katrina, satellite communications were overwhelmed, did not work inside buildings and only 50% of the time from outside. The only phones that were functional were "old-fashioned" direct lines. As a result of the communications breakdown, no city-wide command and control could be established. [2]

Tech
-Telemedicine, via the Space Bridge Project, was successfully used after the 1988 earthquake in Armenia. [1]

-An extensive network and videoconferencing infrastructure is already in place to support telehealth throughout the US. According to the American Telemedicine Association (ATA), over 200 telehealth networks within the US are linked to more than 3,500 clinical facilities. [2]

-Telemedicine can be used to improve triage; direct medical transport decision making, including patient and resource allocation; allow consultation with experts in diagnosis and management of bioterrorism/infectious agent exposure; deliver remote guidance of procedures; improve interfacility or interagency collaboration, provide teleconsultation (e.g. psychological consults, other specialized care) and access to long term follow-up; and provide training.

-Technologies currently being researched and developed include robotics capable of remote sensing of contaminated areas, patient retrieval and evacuation, remote trauma patient monitoring and treatment, radio frequency (RF) devices for identification and access to personal medical records, advanced medical imaging, including high resolution 3-Dimensional devices. [3, 4]

<u>*Goals:*</u>
- Describe plan for communications within the CURE Center to HCWs
- Establish a communications plan between the CURE Center and LLUMC administration
- Establish a secure and redundant communications system that insures connectivity between the CURE Center/LLUMC and state and local health departments, emergency medical services, emergency management agencies, and public safety agencies
- Determine feasibility of communications with Incident Command

Tech
- Determine essential medical technologies to be integrated into the CURE Center
- Describe specialized equipment needed
- Describe other available technologies that should be incorporated into CURE system
- Provide well-defined protocols and procedural guidelines for use of telemedicine and other technologies in disasters
-

<u>*Needs:*</u>
- Ability to contact workers and keep updated during an event
- Access to key administrators
- System interoperability
- Need for prepositioning of resources
- What is the appropriate level of redundancy needed?
- Field systems should be mobile, able to operate without AC power

Tech
- Monitoring capabilities, laboratory, diagnostics, etc.
- Needs to function independently

- ▪ Must be reliable, rugged, low maintenance
- ▪ Utilize alternative energy sources
- ▪ Determine amounts of equipment
  - o Fixed vs. portable
- ▪ Describe functions necessary for CURE Center to address (e.g. isolation, decontamination, morgue, etc.) with recommendations on devices
- ▪ Technologies to consider: (not comprehensive)
  - o Telemedicine
  - o Geographic Information Systems
  - o Patient tracking device
  - o Robotics
  - o Electronic medical records
  - o Security devices
- ▪ Describe security and safety plans specific to a CURE Center (as separate from the main facility)
- ▪ Determine patient and work flow requirements
- ▪ Methods to ensure appropriate training and use of new technologies, especially telemedicine

Summary
Specific Systems
Recommendations on strategies

Questions to consider:
- • What emerging technologies have the best applications to disasters and are affordable?
- • What technologies can be shared or integrated into existing operations?
- • What is the best approach to pre-positioning assets?
- • How can we track a patient and access their medical history?
- • Should hospitals have more than just radio contact with EOCs?
- • How can current plans for public health surveillance be developed?
How can you secure the facility during an incident?

STRATEGIES FOR INTEGRATING INTO THE COMMUNITY

The Emergency Care system should be coordinated, regionalized, and accountable, with the various components of the system (from
 911 dispatch to hospital care) able to deliver seamless care. [1]
Community preparedness requires a system-level response, but many hospitals describe lack of community-wide planning for several key issues, including surge capacity.

Goals:
- ▪ The CURE Center should be integrated into the current response system
- ▪ CURE Center response should be flexible/scalable
- ▪ CURE Center response should be clearly defined
- ▪ Determine how is the CURE Center is activated

- Discuss what levels of preparation are essential vs. desired

Needs:
- Review the current plan and identify where the CURE Center can be deployed/utilized
- Identify essential partners for sustained community-based disaster response
- Describe ways to increase interactions between the various entities
- List the barriers to integrating the Center into the current system
- Tiered response
- Describe specific roles and responsibilities of the CURE Center
- Describe mechanisms for activation
- Describe minimal response

Summary
HOSPITAL recommendations

LOCAL recommendations (regional, county, municipalities, emergency management agencies, local hospitals, public health, law enforcement)

ICS—ensure compatibility, interactivity

COMMUNICATIONS—to be discussed separately

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Background:

– HRSA/JCAHO recommend community able to provide triage, treatment, medication, transportation above the daily staffed bed capacity as follows:

500 cases/million for acute infectious diseases

50 cases/million for toxic agents (chemical agents, botulinum), burn, trauma, radiation-induced injury. [1]

– San Bernardino and Riverside Counties have an estimated total population of 3.8 million (US Census Bureau 2005 estimates)

– Other sources recommend 20-30% surge capacity [2].

– HHS recommend medications to treat 25% of the population, in case of BT/Pandemic.[3] IDSA (Infectious Diseases Society of America) recommends 25-40%. [4]

– AHA recommends 24-hour supply of most common drugs and a standardized formulary[5.]

– JCAHO recommends 48-72 hours stand-alone capability for medications and supplies. [6]

– The National Center for Disaster Preparedness recommends 48 hour supply of pediatric equipment and medications for the average daily number of patients plus 100 additional patients. [7]

– Forrest General Hospital, Mississippi treated 500 patients (normal = 230) the day after Hurricane Katrina

– The Rhode Island Nightclub fire sent 40 seriously injured patients to Kent County Hospital, the area's second largest hospital. The largest hospital (Rhode Island Hospital) has 12 ICU capable beds in the ED. [8]

– Some hospitals affected by Hurricane Katrina were without access to outside resources for 72 hours or longer.

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Goal	What is Needed	Activities for Panel
Determine level of care to provide	Need "all hazards" approach	Estimate minimum number and acuity of patients to prepare for.
How long should the Center be self-sustaining?	Plan to operate independently from main hospital	Review likely hazards to area and potential for focal, time-limited (point-in-time) vs. prolonged events to make estimate.
Describe initial equipment/supplies needed based on above determinants.	General categories of medical equipment list General categories of non-medical equipment list (e.g. fuel, water, food, waste disposal)	Make recommendations on supplies needed with regard to space and servicing limitations.
Describe services needed to sustain independent operations.	List services (medical and non-medical)	
Provide personnel to CURE Center independent of hospital	Strategies to increase staffing Credentialing of volunteers Describe methods for "just-in-time" training Describe support services needed for additional staffing	

Determine CURE Center needs for special populations	Describe populations at risk Determine care to be provided by CURE Center to these populations	

Breakout Session – M. Proctor, E. Hsu, T. Williams, T. Thomas

When dealing with surge capacity a basic approach to the philosophy of care should be addressed:

What assumptions are you making?

Should you assume that the standard of care will be maintained?
Should you assume that anything goes?

- There are drawbacks with either assumption; however, in a resource-rich environment like the US it is a rare critical event that resources are completely overwhelmed. Even in a catastrophic event like Hurricane Katrina the amount of resources technically were not the main limiting factor in response particularly in a geographically specific event (rest of the country not affected).
- The scrutiny that responses are under make the issue of "anything goes care" somewhat problematic.

Challenges to surge capacity
- No data to decide on amount of surge each hospital should be prepared for.
- Example, Israel (PH)
  o Top-down approach with centralized decision making
  o Resources are not abundant so the approach is to avoid redundant resources (no re-inventing the wheel).
  o Command and control are centralized and regularly practiced. The military has no medical infrastructure so civilian medical care regularly interfaces with the military. In the same sense, military resources are used in a critical event (command and control on a national level, air transport regular care).
  o Clear division of labor – example of response to recent refugees after war this fall.
  o All hospitals are relatively large. Since national medical care is delivered by 4 HMOs there are not smaller community hospitals competing.
  o Israel requires that all hospitals have the ability to surge 20% within 1 hour, and 60% within 24 hours.
- Control/Command (MP)

- o Two items that were essential to hospital response in Katrina were that Gov Blanco suspended JCAHO as well as the licensure requirements . . .
- It was discussed as to what to do in the large event where the majority of patients respond to the closest hospital. After 9/11 more than 500 patients surges to St. Vincent's Hospital while the majority of other Manhattan hospitals were not particularly busy. One suggestion that has been used in Israel is to go on *"Triage Hospital Mode."* This would mean that the entire hospital only conducts triage. Only ABC and emergency surgeries are done. Admitted patients are sent elsewhere as well as surgery cases who can wait. The goal is no admissions to the triage hospital,
- Historically, in the US it was intended that the public health care providers would provide care in such situations. However, there have been no federal providers - public health hospitals or cadre of public health care workers since the 1960's.

All-hazards approach

- The concept of an "*all-hazards approach"* was discussed. While this term has been universally accepted there are some concerns with this. All hazards are not the same - in fact a hurricane is a radically different actor than an earthquake and an epidemic even more different.
- In reality what we may be trying to say is there are commonalities in response. The common ground in all of these types of incidents is logistics.
- The key to any approach is a focused, relevant hazards analysis. It is essential to develop a specific menu of risks for a geographic area, prioritize this list and develop answers to preparedness and response to each of these risks.

Decide - Where do we raise the bar for disaster response? Congress decides – but how do we get to the private sector?

Special needs population

- Special needs groups were defined during Katrina as those that the Red Cross shelters would not take in - this included post-partum women.
  - o Elderly
    Significant needs for this growing segment of the population. Often this group of patients need medications filled, blood pressures checked, blood sugars checked, and medication lists and doses. Israel has voluntary mobile teams set up within entire community (community is mapped out). This would be a valuable data obtained from the Arc –Gis - mapping out community needs of elderly citizens as well as having the information available to prehospital community.

    o Exacerbation of chronic disease
       Who needs to be treated in-patient?
       Who can be treated out patient?
       Dialysis is also a significant problem.

    o Mentally ill
       Suggestions for treating mentally ill patients in pre-designated
       Stress Management Centers.
       This significantly decreased load on the EDs.
       After the recent missile crisis in Israel 20% of total visits due to
       stress-related symptoms.
       Stress Management Centers are set up separate from hospitals.

Every area/location (HMO joined) is defined into specific care areas. (Israel)
- Based on population density.
- This is important information since these special population may have evacuation difficulties.

Evacuation
- Need an overall plan
- Requires planning of input and output of area.
- Significant problem in New Orleans when airport was designated as the evacuation site.
- While it was set up as a way station, there was not a clear plan for out-put. (There was an additional 11,000 evacuees outside the airport). It worked a bit like the game of Tetris where patients coming in initially could be handled but as the "game" got faster, it was impossible to keep up.

An additional problem addressed in patient dense situations is medical records. Physical medical records are impossible to locate. Several suggestions include plastic cards. Bar codes. . .   It was suggested that small chips with medical information could be placed subcutaneously since this is an effective way to keep track of cattle!!! Another suggestions is an on-line clinical data depository.

Key points- We need to concentrate on sufficiency of care related to specific hazard vulnerability analysis. One suggestion made was to look at the specific case-specific scenarios designated by DHS with models for each. There was varying opinions around the table as to what the value of these scenarios are.

GIS in Emergency and Disaster Response

One glance on the wall of most departments or a quick look at a station scrap book and many would ask how they ever did their jobs with the equipment they had to use. It is readily apparent, whether it be for fire suppression or medical aid, the response apparatus and the gear that was used was archaic at best and relatively unusable by today's standards. Since that time, service areas have increased, populations have grown, patients are older and the complexity of the job, whatever it is, has gotten significantly more difficult. Today, we respond in greater numbers with larger and more efficient equipment and navigate through maize of roads often around uncertain obstacles and other traffic. Our bags are full of just about every tool we need to make our jobs easier and safer to perform. Or are they?

After-Action reports following a rash of recent wildland fires, hospital evacuations, school bus crashes, campus shootings and a never ending sting of natural and manmade disasters indicate that there is more that can be done to improve our response, provide the tools to keep us safe and manage resources for the best overall outcomes. While we have come a long way, providing up-to-the moment information to assist command staff and event responders to make educated decisions and complete their jobs successfully is one of the many challenges we are facing today. One tool, currently under development at Loma Linda University Center for Prehospital Care, Education and Research (CPCER) under a Federal grant managed by the Telemedicine & Advanced Technology Research Center (TATRC), promises to provide that higher level of understanding necessary to answer this challenge.

Advanced Emergency Graphical Information System
AEGIS (Advanced Emergency Graphical Informational System) is a collaborative effort between the CPCER, developers at ESRI in Redlands, CA, private business and a host of Fire, EMS and Law Enforcement agencies throughout California and beyond. It collectively combines numerous spatial and temporal elements with an easily understood graphical information system (GIS) into layers that can be accessed together or separately. AEGIS allows users to view a variety of pertinent information in one location, identify and interpret trends and threats and analyze the information presented eventually leading to informed decisions. It has applications for Law Enforcement, Fire and EMS response, hospitals, public health, dispatch, and emergency and disaster planners from all disciplines.

AEGIS is a unique kind of database in that it displays emergency information geographically or in a map view. In its present form, AEGIS provides the user with spatial awareness of the location of resources using tracking technologies, local weather and road conditions, hospital status and capabilities, and the locations of schools, hospitals, and airports. It can track the movement of fire apparatus, air transport helicopters and other support vehicles. AEGIS can also be used to support further analysis of trends such as pandemic disease, the proximity of fires to structures, and threats to infrastructure. Additionally, AEGIS can be customized to include any geospatial information that is needed by a particular agency or jurisdiction.

Field Flexibility and Access
One particular advantage of AEGIS is that it can be accessed by any authorized user using an internet connected device such as a Windows enabled computer or cell phone. Further, the application is

optimized depending on the device so down time is minimized allowing personnel to spend more of their time providing a service rather than referencing their computer.

The user's sign in profile provides a level of security and the information considered important for their level of response. It is envisioned that the level of information would be determined by each agency and be specific to the type of agency, the type of event, the intended use of the information, and the user's job requirements. This any-or-all capability would allow the user to access only pertinent information avoiding possible information overload and delays in making informed decisions.

Interactive Layers
An interactive layer is currently being developed. This will enable field personnel to identify incident locations, evacuation centers, causality collection points, helipads, and fire camps. Responders will also be able to interact with others using geo-coded messages, photographs and video showing images and notes directly from the scene. Other information such as 3 dimension building plans, locations of underground pipes, or hazards can be added to compliment the scene by ancillary staff or participants in other locations. Everything is immediately disseminated to all authorized responders thereby providing a higher level of understanding in seconds rather than in the usual minutes or hours it would take to transmit, catalogue and store information using more traditional means.

More than CAD
AEGIS differs from more common CAD interfaces by providing information from sources and resources outside the agency CAD system. In this way, a more complete picture of an event including other agency assets and response apparatus can be viewed.

Hospital Availability
Resources at hospitals are becoming increasingly impacted by the number of patients, their acuity and staffing. The trickledown effect is longer bed delays and hospital diversion. Hospital status, providing up-to-the moment capability, capacity, and diversion status is available to field responders eliminating the delays in patient transport waiting for hospital response and direction in major incidents. Getting the patient to the right hospital the first time is a challenge and tools such as hospital status and capability, bed delays, and availability of extended services will help medical control make informed decisions.

Provisions are available within AEGIS that could provide transport and patient information directly to the receiving hospital. This would help to redirect the impact of lengthily reporting of less critical patients by reducing on air time and allowing for the medical management of more critical patients. The receiving hospital would also have more time to prepare for patients while they are in route and insure that resources are available when they arrive.

Public Health
In the future, Public Health could view regular EMS call data and the movement of patients in major incidents. This will be particularly helpful rejoining families during and following major events or evacuations. Regular call analysis can help in providing syndromic surveillance and the analysis tools built into AEGIS will help Public Health identify potential pandemics and bio-hazards before they reach epidemic proportions.

Just a few other ideas…

Network Resiliency and Redundancy
Todd….this is your specialty

The CURE Connection
Uses for disaster triage…Karla? Lea?

How GIS Is Changing Loma Linda University Medical Center's View of the World

By Ruthita Fike, MA

Chief Executive Officer, Loma Linda University Medical Center

Geography is more than just a place on a map with distinctive topographic features. It fundamentally influences and connects our many cultures, societies, and ways of life.

GIS helps Loma Linda University Medical Center and Loma Linda University fulfill a mission to improve health care delivery, refine research initiatives, and educate the next generation of health care professionals.

Geography also plays a critical role in improving health care. At Southern California's Loma Linda University Medical Center (LLUMC), we're embracing the emerging discipline of health geoinformatics, which uses innovative scientific and geospatial technology to investigate health issues.

A multifaceted collaboration involving the use of geographic information system (GIS) technology is changing how LLUMC and the associated health sciences university, Loma Linda University (LLU), relate to the world. And because of the almost limitless possibilities of GIS, we have been able to create a better future for those whose lives we touch.

Our long-term collaboration with ESRI, the GIS software company headquartered in nearby Redlands, has had far-reaching outcomes at every level of our organization. It's helping us fulfill our mission to improve health care delivery, refine research initiatives, and educate the next generation of health care professionals. We are teaching them health geoinformatics. They will learn how to collect, analyze, and share information to provide optimal solutions to critical public health issues around the globe such as public health emergency response.

Because of our work with GIS, we see the world differently. We are living proof that better information makes for better business decisions.

The Medical Center's Heritage and Mission

LLUMC is an academic medical center, one of only 125 in the United States. We are strategically located in what's known as the Inland Empire, one of the fastest-growing regions in the country. With nearly four million residents, the Inland Empire is larger than 24 of the 50 states.

Loma Linda University was founded in 1905 as a Seventh-Day Adventist educational health sciences institution. By 2006, it had grown to 3,400 students in the schools of medicine, dentistry, and pharmacy and departments of nursing, public health, allied health, science, and technology. Through Adventist Health International, Loma Linda provides assistance in governance, accounting, and fund-raising for 32 hospitals and 52 clinics in 13 countries. For instance, Loma Linda University has been managing Wazir Akbar Khan Hospital in Kabul, Afghanistan, since 2005, through a U.S. AID grant and at the request of the Afghanistan government. LLU also manages Gimbie Adventist Hospital in Ethiopia and is a consultant to the Chinese government at Sir Run Run Shaw Hospital in Hangzhou.

We are proud of our community and our heritage as well as our students, faculty, and alumni. We're also very proud of the fact that the founder of ESRI, Mr. Jack Dangermond, was born at LLUMC. For a short time, our campus housed ESRI's offices before their world headquarters were developed in Redlands, just a few miles from the LLU campus. So the roots of our partnership are deep, and we are grateful for them.

We comprise four hospitals: the University Hospital; Children's Hospital; the East Campus hospital, which provides rehabilitation, orthopaedic, and neurosciences services; and the Behavioral Medicine Center. About 750 physicians partner with us in delivering care. Our 7,000 employees skillfully handle hundreds of thousands of patient visits per year.

Nearly 600 medical residents and fellows are training at Loma Linda at any given time. Research at Loma Linda has led to a number of medical breakthroughs and clinical firsts including

- The Judkins technique of coronary arteriography, a forerunner of angioplasty.
- Pioneering work in endoscopic surgery.
- The first infant heart transplant program.
- Development of the world's first hospital-based proton treatment center. The center provides highly precise proton radiation treatments for 125 patients each day with a variety of cancers and other diseases, and it also does research into the use of proton radiation to treat additional forms of cancer and other diseases.

GIS Applications at Loma Linda

There are several areas that demonstrate the value of increasing geographic literacy in our organization. GIS technology has added an entirely new dimension to the clinical, academic, and research programs at Loma Linda University on many levels. We are applying GIS to real-life scenarios that are making a difference in thousands of lives.

Clinical

Loma Linda University Medical Center's Web-based Advanced Emergency Geographic Information System (AEGIS) receives continuous data feeds and photos that show, for example, in close to real time, where air ambulances have been dispatched and which freeways are congested. A Mobile Intensive Care Nurse working on a computer will be able to see that information displayed on a digital map on a 40-inch LCD monitor.

LLUMC operates the only Level I trauma center in a vast geographic region. We are also situated in one of the most earthquake-prone areas in the country. As the largest hospital in the region, we have a social responsibility to be prepared to respond to emergencies of every type.

In emergency response, every second counts. Linking emergency resources with victims is fundamentally a geographic challenge. A big part of that challenge is the fragmentation of emergency services and lack of a central communications clearinghouse. Loma Linda wanted to build a system that could be accessed by the community, allowing all emergency resources to be fully coordinated.

In 2005, Loma Linda approached ESRI about collaborating in the Discoveries project, which is a congressionally sponsored partnership with the U.S. Department of Defense. The goal was to develop a Web-based situational awareness geographic information system for use in emergency medical services. Such a system would monitor and map the location and status of emergencies, locate victims and emergency response personnel, and track other factors that can impact emergency response. The result of this collaboration is the Advanced Emergency Geographic Information System (AEGIS).

Using GIS, AEGIS graphically maps the real-time location of an emergency and its victims as well as emergency response assets. It maps where ambulances, rescue helicopters, and other emergency

vehicles are and the locations of all fire departments, rescue workers, and law enforcement officers. By glancing at the screen, emergency personnel can determine which hospital emergency rooms in San Bernardino and Riverside counties can accept more ambulances and which ones are at capacity. AEGIS overlays traffic congestion and accidents on freeways to plot the fastest routes to area trauma centers. In many cases, this reduces response and transport time from a half-hour or more to just minutes at a time when minutes mean lives saved. All emergency responders in Southern California can access AEGIS via the Web or by using a basic cell phone or an in-vehicle unit, so there is literally coverage everywhere.

A specially equipped mobile telemedicine command center serves in the field as the hub of rescue efforts.

Academic

At Loma Linda, we have come to appreciate how GIS technology can be used to improve health and quality of life. In public health, for example, it provides a means to collect and analyze information on how natural resources, the environment, and human diseases interact. As a health sciences university, we recognize that geoinformatics can help us provide future health professionals with a valuable tool to understand the impact of our environment on human health.

Health geoinformatics is a relatively new discipline that uses a combination of GIS technologies to investigate health issues. In this area, it has helped by mapping the adolescent pregnancy rates for each high school attendance area in southwest San Bernardino County. This makes it possible to identify which areas may need additional resources to address teen pregnancy.

GIS can also increase efficiency in public health services. Local public health agencies are often organized geographically. It is possible that a home or business on one side of a street can be in one agency's service area, while the building across the street belongs in another service area. GIS eliminates confusion. When an agency receives a complaint-say an environmental complaint-the street address is processed through a GIS program that standardizes the address in conformance with U.S. Postal Service standards. It even corrects spelling errors and verifies the existence of the address. The complaint is then automatically assigned to the appropriate service area, which eliminates possible confusion over jurisdiction.

Another example: Say a non-English-speaking, foreign-born person entering the United States is identified as having tuberculosis (TB) as well as a severe heart problem that requires medication. A TB outreach worker can use a GIS health care access map to identify the nearest cardiologist who speaks

the same language as the patient. At the same time, using GIS technology, the TB outreach worker can also produce a public transportation map, printed both in English and in the patient's language, that shows the patient how to travel to the physician's office for treatment.

In partnership with ESRI, Loma Linda University has greatly advanced the field of health geoinformatics. This partnership has resulted in three health geoinformatics firsts:

1. The school's faculty designed and taught the first graduate-level GIS course offered at an American school of public health.
2. LLU launched the country's first health geographics bachelor's degree. Today, undergraduate students can pursue a Bachelor of Science in Public Health (B.S.P.H.) in Health Geographics and Biomedical Data Management. Other tracks offered are GIS for Environmental Health, GIS for Global Health and Development, and Spatial Epidemiology.
3. The university created an M.B.A. in Health Administration and a graduate-level Certificate in Health Geoinformatics.

Loma Linda continues to explore new public health applications of GIS technology. We are using what we know to help create solutions to the biggest public health issues confronting humanity.

Research

Besides using GIS to better manage emergencies, LLUMC can also dispatch its new state-of-the-art Mobile Telemedicine Vehicle (MTV) to the scene. The MTV can relay medical information such as patient x-rays, vital statistics, and live video to the medical center.

Loma Linda faculty members are actively engaged in numerous funded research projects that apply geoinformatics methods to solving health issues. One of these projects is using geospatial tools for investigating the health effects of air pollution in California. Many of you may know that Southern California has the dubious distinction of having the worst air quality in the nation. The Loma Linda University Adventist Health and Smog (AHSMOG) study began in 1977 as a way to evaluate the effects of long-term exposure to air pollutants on the health of nonsmoking adults.

We have found through the study that women exposed to high levels of particulate air pollution have a significantly increased risk of fatal heart attacks compared to their counterparts who live in less polluted areas. This finding has subsequently been replicated in other air pollution studies. Other findings from the AHSMOG study have indicated that long-term exposure to air pollution is related to chronic obstructive pulmonary disease, decreased lung function, asthma, lung cancer, and death. To date, 27 peer-reviewed articles have been published on this study in the scientific literature.

The result has been the identification of critical indicators that are helping to shape public health policy at the national level. The AHSMOG study has weighed significantly in the criteria by which federal and state air pollution standards are set.

Additional Collaborations

In addition to AHSMOG, Loma Linda has launched many other GIS-related research projects and initiatives:

- A kidney transplantation study is determining geographic variation and factors related to kidney transplant access in California.
- The African American Health Initiative in San Bernardino County is creating an inventory of all health service providers who offer prevention and treatment programs to African-Americans for hypertension, heart disease, HIV/AIDS, and prostate and breast cancers. GIS was used to select the areas that needed prevention and treatment services for these diseases among the African-American population in the county.
- LLU is funded by the U.S. Centers for Disease Control and Prevention as a Center for Public Health Preparedness and also as a Regional Academic Center of Excellence in Environmental Health. As such, it is building the preparedness and response capacity of the region's Native American Tribes and California's 2,500 registered environmental health specialists. It is working to enhance the environmental health workforce capacity in an eight-state region from Texas to Hawaii. GIS was used to determine the distribution of registered environmental health specialists throughout the region.
- Loma Linda University is one of 21 colleges and universities in the United States sharing learning resources to increase the fundamental understanding of how GIS can be applied to earth system principles.
- Through the Partnership for Quality Medical Donations (PQMD), Loma Linda is working to link donors worldwide with resource-poor communities. The goal is to ensure more efficient and effective distribution of medical donations such as pharmaceuticals, supplies, and equipment.

Loma Linda is using GIS to assist PQMD members in identifying local resources, assessing the condition of the resources, allocating them, and improving logistics and networking in the areas receiving the medical product donations.

How GIS Has Changed Our View of the World

We are affirming over and over that "place matters" when it comes to one's health. Geography and the features that distinguish it—be it air or water pollution or proximity to nuclear power plants—can have a significant effect on quality of life.

GIS helps us redeploy, reposition, and manage our assets more effectively in a timelier manner. The Discoveries project, and the resulting AEGIS system, is a prime example of how bringing personnel, equipment, and information technology together can save lives. San Bernardino is the first and only county in the nation to apply this model of GIS technology to emergency management.

GIS technology is helping us do better work in the traditional areas of health care management including facilities, infection control, and quality improvement. By applying GIS principles to public health, we have brought an unprecedented level of scientific exploration to public policy decision making. Loma Linda graduates are taking health geoinformatics principles to communities around the world and helping change our global view of public health.

GIS has given Loma Linda a powerful new tool as we work to improve health worldwide. GIS has certainly changed our world view. But even more important, it is changing how the world approaches health and wellness. We value our partnership with ESRI in achieving this goal and are very grateful that GIS is helping us fulfill our mission of enhancing and saving lives in our local community and, indeed, around the world.

About the Author

Ms. Ruthita J. Fike, MA, currently serves as the Chief Executive Officer (CEO)/Administrator for Loma Linda University Medical Center, Loma Linda University Children's Hospital, Loma Linda University East Campus Hospital, and Loma Linda University Behavioral Medicine Center. As CEO and administrator of Loma Linda University Medical Center, Ms. Fike oversees the day-to-day operations of the institution, which includes four hospitals, 6,000 employees, 800 faculty members, and an annual operating budget of more than $800 million.

Ms. Fike is also responsible for Loma Linda University Medical Center's international activities in the People's Republic of China and serves as the liaison administrator to Sir Run Run Shaw Hospital in Hangzhou, China.

Ms. Fike formerly served as executive vice president of operations and support services for Centura Health in Englewood, Colorado; CEO of Porter Adventist Hospital, Denver, Colorado; CEO of Littleton Adventist Hospital, Littleton, Colorado; and CEO and senior vice president of Shawnee Mission Medical Center, Shawnee Mission, Kansas.

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Hospital Implements High-Tech Emergency Response System

Location-based mapping system helps public safety officials, hospitals, and emergency responders more quickly and efficiently get aid to people in trouble.
By Marianne Kolbasuk McGee
InformationWeek
June 25, 2008 03:30 PM

GPS-enabled cell phones and other mobile location-tracking technologies used for Enhanced 911 capabilities are helping emergency response workers find people in trouble.

The deployment of a geographic information system and mobile applications in southern California is enabling emergency response personnel to more quickly and efficiently deploy rescue teams based on near real-time data about traffic conditions, the location of nearby ambulances and helicopters, and other factors, such as bed availability at area hospitals.

And soon, field personnel will be able to use mobile devices, including cell phones and laptop computers, to securely send rescue teams additional information -- such as on-the-fly map drawings showing where a triage area has been set up in a crisis -- so that other mobile emergency workers know exactly where to go.
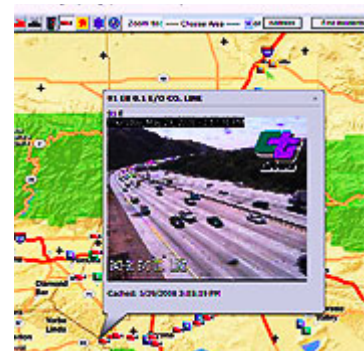
The Advanced Emergency Geographical Information Systems (AEGIS) at Loma Linda University Medical Center in Loma Linda, Calif. is a Web-based hospital situational awareness system that monitors and maps the location and status of emergency resources, including area hospitals, ambulances, and rescue helicopters.

Currently, Loma Linda University Medical Center's AEGIS system is being used for emergency medical response in a vast geographic region of Southern California covering 25% of the state. The next phases of the system's development will provide functionality for all public safety organizations -- including police and fire departments, and even the U.S. military -- in multiple counties to manage all sorts of disasters.

The rollout by Loma Linda University Medical Center has been several years in the making with the help of funding from a U.S. Department of Defense telemedicine grant and technology from GIS vendor ESRI. The AEGIS deployment is also serving as a model disaster-response management system not only for other communities in the United States, but also for the U.S. military, said Dr. Steve Corbett, chief medical informatics officer of Loma Linda University Adventists Health Sciences Center.

Loma Linda University Medical Center Emergency Mapping System
(click for image gallery)

Loma Linda University Medical Center includes a trauma center and pediatric hospital that handles about 3,000 ambulance runs in the region each month, said Corbett. Currently, LLUMC is the only level-one trauma center serving several counties in southern California, including Inyo, Mono, Riverside, and San Bernardino County, where LLUMC is located.

Loma Linda University Medical Center uses AEGIS for emergency response dispatch, transport, and destination decisions. For instance, if a freeway accident involves multiple victims, emergency managers can view real-time data on a Web-based map to see which ambulances or helicopters are in the area, and click onto icons of area hospitals to see if they're accepting casualties or if they're currently overloaded with patients.

The system collects data from a variety of sources, including the state highway patrol, highway video cameras, and road sensors that can update emergency managers about how fast traffic is moving on a road, all information that can help responders make better decisions about where and how to route victims, said Corbett.

"We created this as a medical emergency management system, but it's turning into a disaster management system that's interactive and also being rolled out for use by EMS, police, fire, public health officials," said Corbett. "The true potential is disaster management for all public safety," he said. "It's built to fit anywhere," he said.

New functionality will allow secure role-based interaction by authorized mobile users in the field. "Someone at the scene could draw [on the system's map] a staging area for ambulances -- here's the disaster area where we have more victims for triage," he said. In addition, response workers "from miles away could also interact by sending text messages via the map" to provide context of the local situation, he said.

Bringing 9/11, Katrina Experience To Bear

June 25, 2008 03:30 PM

Loma Linda University Medical Center has the second-largest bay station in the county, said Corbett. The use of the system is being expanded in to neighboring counties, including Los Angeles County and Santa Clara County. San Bernardino is "enormous but sparsely populated, GIS helps us determine what's the nearest facility based on a patient's needs," say Corbett.

In the next phase of development, scheduled to roll out in August, the additional AEGIS functionality will enable the system's use by all regional public safety organizations for disaster management, said Ed Carubis, principal consultant and senior program manager of ESRI professional services.

"The real-time situational awareness applications [of AEGIS] accomplish their mission through multiple location services," said Carubis, who, before joining ESRI, was a CIO for the New York City Department of Health and was involved in the post-9/11 development of a bio-surveillance system to collaborate with hospitals, emergency workers, and the Centers for Disease Control to monitor the outbreak of disease.

"It doesn't take much for a large casualty event to bring hospitals to capacity, hospitals don't have a lot of extra beds," Carubis said. "There needs to be a regional approach for response of care in wider areas to make those decisions," he said. "As horrific as 9/11 was, it had a small footprint" compared to the sort of havoc that occurs in other disasters, like Hurricane Katrina, which covered a multistate region, he said.

AEGIS uses location-based technologies, including automatic vehicle location, which is a set of capabilities consisting of GPS mounted on vehicles like ambulances, fire trucks, police cars, and helicopters, said Anak Agung, ESRI senior consultant. The vehicles transmit their data through "wired or wireless, cell phone network, direct satellite communication, Wi-Fi, and a Web service that processes the location data transmitted by vehicles, and serves the locational data to other users," including ArcGIS Mobile users, he said.

ArcGIS Mobile, a part of ESRI's ArcGIS server, is the GIS technology that enables mobile users working on laptop, tablet PC, PDA, and mobile phone to be connected with enterprise GIS, said Agung. "It allows users to synchronize data they input from the fields and share data from other users at nearly real time," he said. It also allows mobile users "to run sophisticated analysis provided by a server using the field data input," he said.

"For example, based on the current location of a mobile user, one can ask the server to analyze drive time and to report back from the server the multi-rings polygon indicating drive times, and find out other mobile users within each polygon," he said.

This information helps emergency response managers and public safety officials make better informed decisions, such as choosing the routes and destinations for helping critically injured patients and other victims of an emergency or disaster. Input from users in the field will also allow emergency responders, for instance, to alert other responders en-route in a disaster that there are fallen trees or debris blocking a road leading to a crisis area.

When not being used to manage real emergencies, AEGIS can also provide simulation training, not only for new users, but also as a cost-effective means for hospitals and regions to participate in disaster preparedness, Carubis said.

The system is also built to help emergency response and public safety officials handle more routine situations. "You don't want a system only for mass casualties, you want to use it on a day-to-day basis," which also helps prepares responders when a large crisis does occur. "You want this to be second nature," Carubis said.

Appendix I

By Rod Brouhard <http://www.emsresponder.com/publication/bio.jsp?id=219&pubId=2>

A prehospital crew working on a shooting victim radios the control facility for an available trauma center. Looking at a map of available centers, the mobile intensive care nurse at the control facility sees the crew is only a few miles from the nearest one. But what if they can't get there?

ESRI, a Redlands, CA, company that develops mapping software <http://www.emsresponder.com/print/EMS-Product-News/Using-Geographic-Information-To-Aid-Patient-Care/2$7381> applications, is working with Loma Linda University Medical Center to develop the Advanced Emergency Geographic Information System (AEGIS). Lea Lynch, MD, an attending physician in the LLUMC emergency department, says the system is already being used in the ED.

"If there is a collision in between you and the closest hospital," says Lynch, "it may make more sense for you to go to the next-closest hospital." With AEGIS, she explains, an ambulance can be rerouted based on live traffic information, saving valuable time. "AEGIS shows specialties and up-to-date diversion status information for each hospital," Lynch says.

It also shows weather and traffic information. The California Highway Patrol and California Department of Transportation (Caltrans) provide data feeds to the public via the Internet. CHP offers accident information, and Caltrans provides video from cameras monitoring freeway traffic. "What we do is harvest those feeds," says Anak Agung, a senior consultant with ESRI.

Agung says AEGIS takes feeds showing ambulance and helicopter availability, traffic, and weather and hospital status, and portrays that data graphically using icons on a map. When a user needs to check highway traffic or look at hospital resources, he or she simply clicks on its icon. Users can pick which icons to display on the map, like adding layers over a base picture.

Currently, AEGIS only works with a map viewer developed by ESRI. Eventually, says Agung, it will be usable on many common viewers. "The system will be a subscription service," he explains. "Users will have very little software to install." Information will be sent over the Internet to clients through GeoRSS, an emerging standard for encoding location as part of an RSS feed, disseminating it out to users for viewing on whatever map they like.

Most viewers, says Agung, process geographical information in similar ways. GeoRSS feeds can be laid directly onto any map. The next generation of AEGIS, he explains, will be able to run on laptops <http://www.emsresponder.com/print/EMS-Product-News/Using-Geographic-Information-To-Aid-Patient-Care/2$7381> and tablet PCs. Eventually, even mobile phones will be able to communicate with AEGIS.

According to Lynch, the system has been well received. "We have all that information coming in," she says. "The daily use is to make the best patient care decisions based on available information." But, she says, the applications for AEGIS are just beginning. "This second phase we envision as not only an EMS tool but a disaster tool."

"Interoperability has been a key process we've tried to build into this," says Ron Holk, operations coordinator for Loma Linda's Center for Prehospital Care, Education and Research. "We wanted to develop a good, workable situational awareness piece that an incident commander can use in the field during a disaster. If an IC wants to know what's happening at the far edge of an incident, he has to know the cell phone number of the person he's calling. With AEGIS, he can click the white truck on the map and send that person a text message. The IC doesn't even have to know who's in the white truck."

The future of projects like AEGIS touches on ideas that seemed science fiction just a few years ago. "You in the field won't have to tell us a whole lot, because we can see it," says Lynch. "All the info you would tell us from the scene could be plotted on the map—number of patients, resources, etc."

A single database like AEGIS can be used to manage electronic health records or flag concerns. "We'll be implementing some stuff for biosurveillance so we can see things develop in real time," adds Lynch.

It stands to reason that even with such futuristic applications of AEGIS, those working with the system will find new and innovative ways to use it.

Rod Brouhard is a paramedic for American Medical Response in Modesto, CA, and former director of the EMS program at Modesto Junior College.