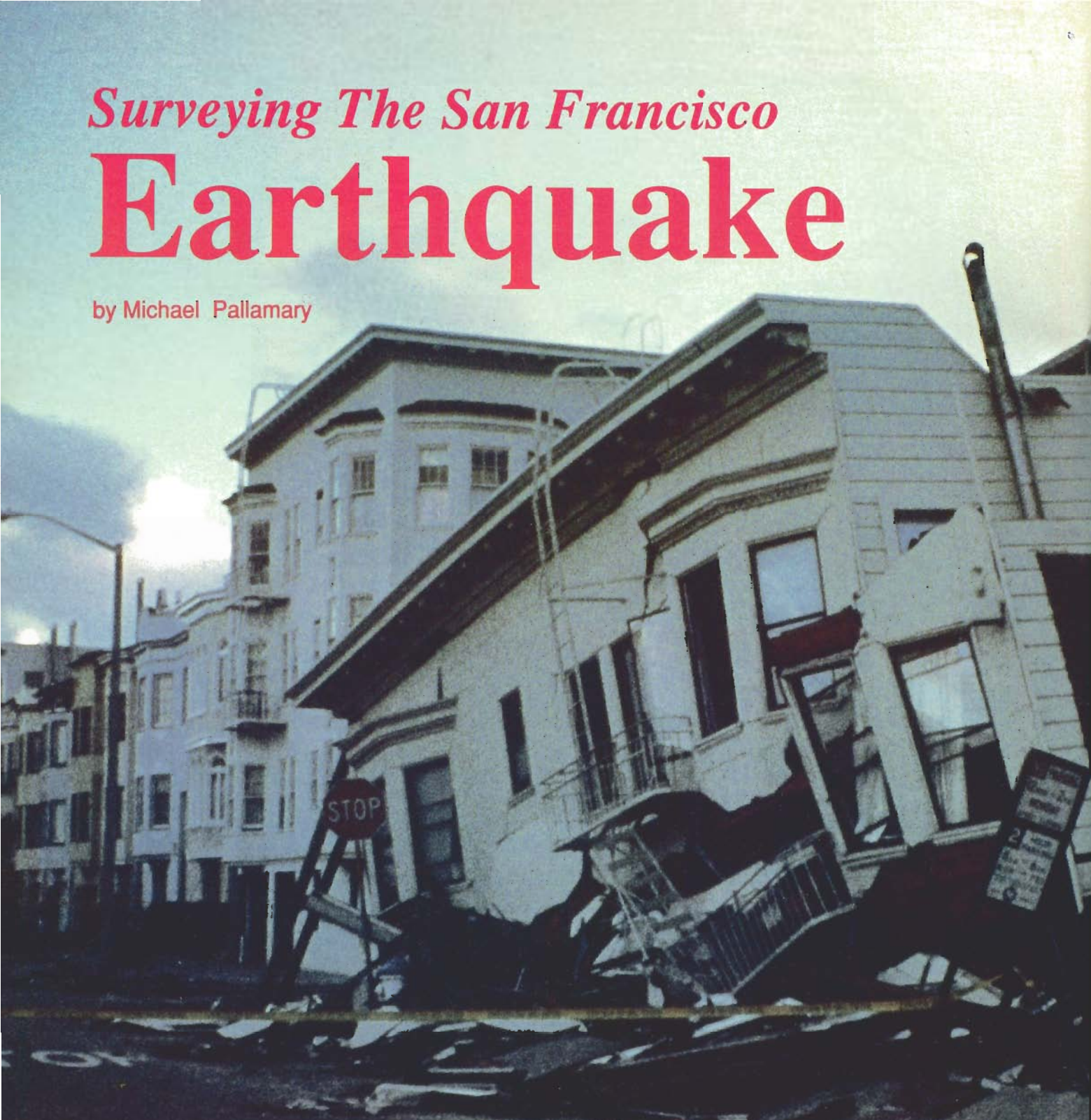
PROFESSIONAL
SURVEYOR
VOLUME 10 NUMBER 1 JANUARY/FEBRUARY 1990

Surveying The San Francisco
Earthquake

The 1990 Software Listing

Surveying The San Francisco
Earthquake

by Michael Pallamary



At 5:00 p.m., October 17, 1989, as ex-San Francisco Giant Willie Mays took to the field for a pre-game World Series interview, the stands in Candlestick Park stadium were buzzing with over 60,000 fans. Four minutes later the stadium was shaken by a tremendous earthquake that rocked the San Francisco Bay Area, collapsed a bridge and crumbled a mile-and-a-half of elevated highway like a house of cards.

In the Marina district, buildings sank to their knees as fire spewed from the combination of ruptured gas lines and severed power cables. Within minutes the city was shut down.

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Bob Gerber, California Department of Emergency Services

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When the rumbling stopped less than a minute later, a dazed and panicked city looked at the surrounding devastation and began asking crucial questions. Which roadways were open? Where were broken utility lines located? Was it safe to go home? Where were loved ones? Where should emergency vehicles go?

The answers to these and many other questions lay within the vaults and records of the cities and agencies affected by the earthquake. For some, this information was on odd-scaled maps, on conflicting scales and, worst of all, based on outdated data. Often the information lay in nearly inaccessible places. In Oakland, it was in a collapsed building, soon to be condemned and threatened by fire.

Among the first agencies to respond to the quake was the California Department of Transportation (CALTRANS), which made immediate plans to fly over the quake region to generate large scale photographs for search and rescue and to assess the damage to the state's highway system. In addition to these immediate needs, the agency was concerned with access to prime arterial roadways and alternate traffic routes.

The mapping operation was supervised by Larry Fenske, Chief of CALTRANS Geometronics Branch in Sacramento. The little-known department eventually proved to be one of the most important facets in both rescue and reconstruction operations. According to Fenske, his department's mapping functions go far beyond conventional boundary line placement and, in his opinion, "bring home the importance of the surveying profession."

Because of the obvious and well-publicized damage to Interstate 880, extraordinary demands were placed on Fenske's department. His staff, like most other Bay Area residents, were sitting at home with their families watching the World Series pre-game festivities and interviews. When the quake struck, Fenske and his key personnel knew they would be needed.

Dick Burns, CALTRANS' chief photogrammetrist, began cataloging the televised reports and news stories of the damaged sections of the state's highways. Armed with a series of AAA road maps, Burns began plotting the reported damage. Throughout the night he developed a crude flight plan so that by sunrise the next day, he was fully prepared to instruct his pilot and camera crew where to concentrate their efforts.

Bob Gerber, California Department of Emergency Services

Working on Interstate 880.

Dick Griffin, in charge of photo and map reproduction, began making immediate arrangements with the department's mapping consultant, Radman Aerial Surveys in Sacramento. When he was able to make contact, Radman and Griffin made arrangements to mobilize the flight crew the next day. The photogrammetric department at the time could be compared to a MASH unit, since every conceivable agency and rescue operation was seeking information on the now-famous collapsed highway structure and other sections of the highway system. With countless lives in jeopardy, Fenske's department could be nothing but 100 percent efficient. Not only were the collapsed structures of concern, but alternate access routes needed to be identified for large scale rescue operations.

"In Oakland, where most of the damage had occurred, the city maps were stored in a building on the verge of collapse."

"Without a doubt," said Fenske, "because of the professional commitment of Burns, Griffin and the contractor, we were able to handle the situation. They were all terrific. Everyone worked day and night and the men took the brunt of the incredible demands made upon the department." When questioned later, Fenske said there was nothing he would have done differently. "When you have dedicated individuals like these guys, you can get these things done."

That morning, the first attempts were made to fly over the devastated area. Unfortunately, security requirements stipulated that the flight be at an altitude of 4,000 feet as opposed to the desired altitude of 1,500 feet. For the first few hours, any flight activity had to be cleared with the state's Multi-Discipline Accident Investigation Team (MAIT), an association of the Highway Patrol, Highway Department and other emergency response units.

With the 4,000-foot flight in hand, a series of large-scale photos were processed immediately. Enlargements and reproductions were made and distributed to the emergency response crews. Later in the day, after the necessary clearance was obtained, a 1,500-foot flight was made. Once the photos were processed, Radman prepared a series of 50 scale maps. Like so many others, the photogrammetrist worked throughout the night to draw the maps.

Acting on behalf of the State Division of Mines and Geology, Fenske made arrangements with Beale Air Force Base for high altitude flight by a government U-2 spy plane. Once the extent of the devasta-

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tion was realized, much of the mapping was for historical purposes as well as obvious regional emergency needs.

Before the assorted mapping had been completed, state investigation teams, police agencies and major accident response teams were requesting maps and photos. Everyone needed some form of information, but most did not know exactly what they wanted, so the tendency was to ask for everything. Fenske credits his assistant, Dick Griffin, with being able to determine who needed what and how to get it to them as soon as possible. Being able to do this made the operation successful.

On Thursday the 19th, Radman returned to I-880 to take a series of oblique photos. Like the State Mines and Geology Division, the agency was interested in obtaining historical data on the area. A week later, another series of low altitude photos was taken for the purpose of mapping locations of recovered automobiles and to plot out the holes drilled through the upper level of the collapsed highway.

Once the initial maps were generated, CALTRANS engineers began their analysis of the highway's structure. While the upper level was mapped from the air, a series of detailed ground surveys was performed of the lower level to supplement those areas obscured from the aerial maps. The final set of maps, compiled at a scale of one inch to 20 feet, included one-foot contour intervals and critical spot elevations of the structure and surrounding area.

Another series of maps was distributed to the highway department's design and contracting officers so that construction contracts for demolition of the structure could be let immediately. In many cases, raw photographs were made into halftones, and specifications were drawn right on the documents. From these, the contracts were let within a few days. Another series of photos and maps were distributed to the traffic operations department to aid in devising alternate access routes throughout the area. The state's environmental agencies, as well as geophysicists, geologists and scientists, used the maps to document the effects of the quake.

Other government groups also took action within hours of the quake. The Army Corps of Engineers was mobilized to hastily bring to reality what had until then been only a vision. In the preceding year, under the direction of Maj. Warren Whithers, a team of GIS specialists from Autodesk and the Corps had begun developing a digital "intelligent" map in anticipation of a need for information about the area. The plan was being developed with the Facility Mapping Systems Company (FMS) and Autodesk, and was intended to serve as a pilot program for an emergency response database system.

The Corps' interest in the program extended from one of their primary functions, to respond to natural disasters and oversee recovery efforts. Having just dealt with Hurricane Hugo, the Corps recognized the importance of possessing maps of the area for locating crucial water and sewer lines. Equally important was the need to know where potentially dangerous gas and electric lines were located. Local efforts had included developing a "devoted" workstation to synthesize the digital mapping data. Although their one station was down when the quake struck,

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the project got underway thanks to the efforts of Autodesk, under the direction of Brad Sharp.

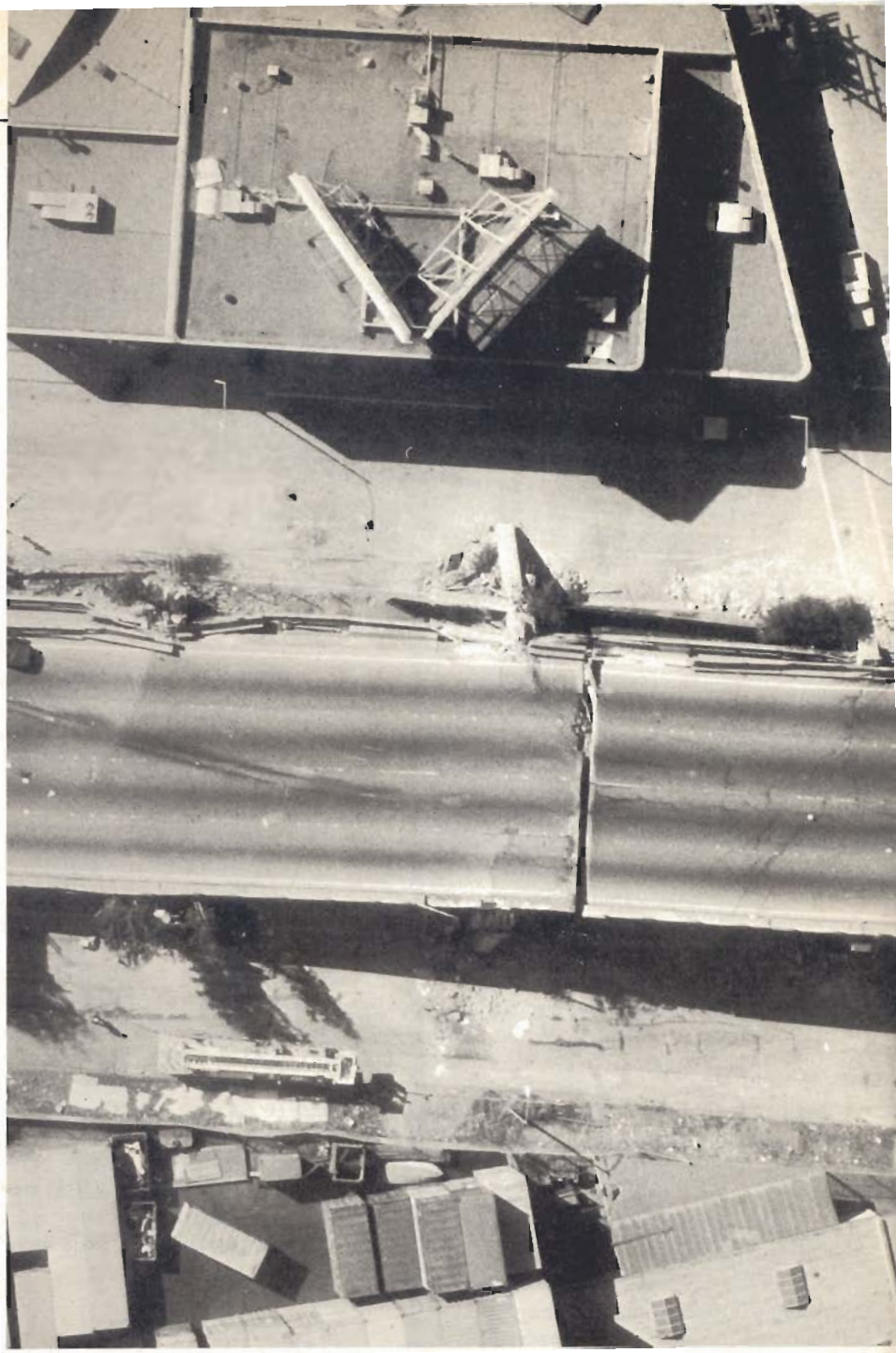
With an "intelligent" map of the Bay Area, FMS, in conjunction with the Corps of Engineers, began what would be a tireless project in Marin to figure out where the damage had occurred and who had the information needed to identify the damaged lines and city infrastructure.

According to Lynn Finley, FMS project coordinator, the most difficult problem was gathering various city and utility maps. In Oakland, the city maps were stored in a building on the verge of collapse. FMS's staff were escorted by armed police to the building to retrieve the maps. Several blocks away, a local blueprinting company began a marathon project to reproduce every available map. Once completed, the maps were whisked back to Sausalito where, in a response that would come to characterize the country's reaction to the disaster, the staff at Autodesk converted a training room into a GIS think tank on a "humanitarian basis."

The Compaq computer company donated computers to the around-the-clock operation, which commenced immediately. Twelve 386 processor machines were committed to the task; additional software and hardware upgrades were performed throughout the night.

Meanwhile, FMS employees continued scurrying around the region collecting maps and data from the municipalities affected by the quake. Once collected, the tedious process of digitizing began, using the assorted maps with their varying scales and levels of quality.

The first goal, according to Finley and Sharp, was to locate information already in digital format, since it would be helpful to have a good base map from which to build. They turned to the American Digital Cartography Company (ADC). ADC had already developed a series of AutoCAD geodetic quadrangle base maps for many of the country's populated regions. The Corps ordered 25 of the 7.5-minute digital maps, and within a few days the San Francisco, Oakland and Santa Cruz maps were delivered. The remaining regional maps were generated shortly after, using the aforementioned maps as foundations. The technical process of creating the overlays got underway.



Aerial photo of Interstate 880.

Of all the cities contacted, only Santa Cruz had begun developing a working GIS. The system was available only on a case-by-case basis and was not automated, thus making its application in an emergency difficult but workable.

DCA Engineering Software in New Hampshire flew in a team of technicians to assist in developing the topographic layers and models. As the magnitude of the quake was realized, more information was needed. The U.S. Census Bureau released its TIGER file records compiled for the 1990 census. Like so much other important information, these records were needed to assess the effect of the earthquake on the community as well as for briefing President George Bush and other government officials. Unlike the traditional utility overlays, these files included information such as railroad lines, roadways, political boundaries, street names and addresses.

Mike Bauer of ADC was responsible for overseeing the initial integration of the TIGER file overlays. Because telephone service was unavailable for two days following the quake, it was Thursday before ADC could mobilize.

Unfortunately, one of the first prob-

CALTRANS Photogrammetry Department

Inset: CALTRANS map of disaster scene taken from aerial photo.

lems to arise stemmed from the fact that the census data was based upon a DLG (Digital Line Graph) database, an older system being utilized by the government. The initial overlays, which were composed of 50 megabytes of information, were compiled within a day and a half.

Before the week had ended, South Marin, Oakland and the San Francisco Peninsula were in a digitized format. The compiled data was then "crunched" for storage and expressed to Sausalito. Within a week's time, the remaining regional base maps were delivered to the makeshift GIS headquarters, where they were incorporated into the rapidly developing digital maps.

Once the base maps were compiled into workable formats, a series of Corps icons was displayed on the electronic maps. Coded symbols identified the various levels of response each area had either needed or received. These icons included such valuable information as the location of gas leaks, water leaks, debris and other factors affecting health, safety and welfare. Although not as important as the tracking of emergency responses, other factors identified included indexing Disaster Survey Reports, road and building information. Additionally, a database was developed to monitor the status of inspections and reports necessary for insurance claims, as well as state and federal relief funds.

The use and implementation of a GIS was not uniform. At the California Office of Emergency Services, road maps were taped to the walls to guide their operations; Federal Emergency Management Agency staff members were using a similar process.

With all the coverage given to visible damage, little public attention was given to the status of the city's harbor. Beneath

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American Red Cross

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the water, there was far more physical displacement than on the surface. Once the welfare of the community was stabilized, it was the harbor that drew the attention of the Corps and their team of consultants.

Shortly after the major surface damage had been identified, DCA digitized hydrographic survey data of the city harbor. Within a few days, the subsurface damage was displayed on 3D CAD maps, and reparations commenced. In addition to immobilizing commerce and shipping, the damage threatened national security because of the restrictions on passage of navy ships. Other important concerns included the status of subsurface cables and utility lines, as well as the trans-bay Bay Area Rapid Transit (BART) lines, which miraculously escaped damage.

According to Paul Lamarouex, former NSPS director and now chief surveyor for the BART property department, "The BART Station was one of the safest places to be." Lamarouex, a South San Francisco resident, was standing on a train platform when the tremor shook the area. Subsequent inspections revealed that the system was nominally affected, and within 24 hours of the quake the bay area system was running again.

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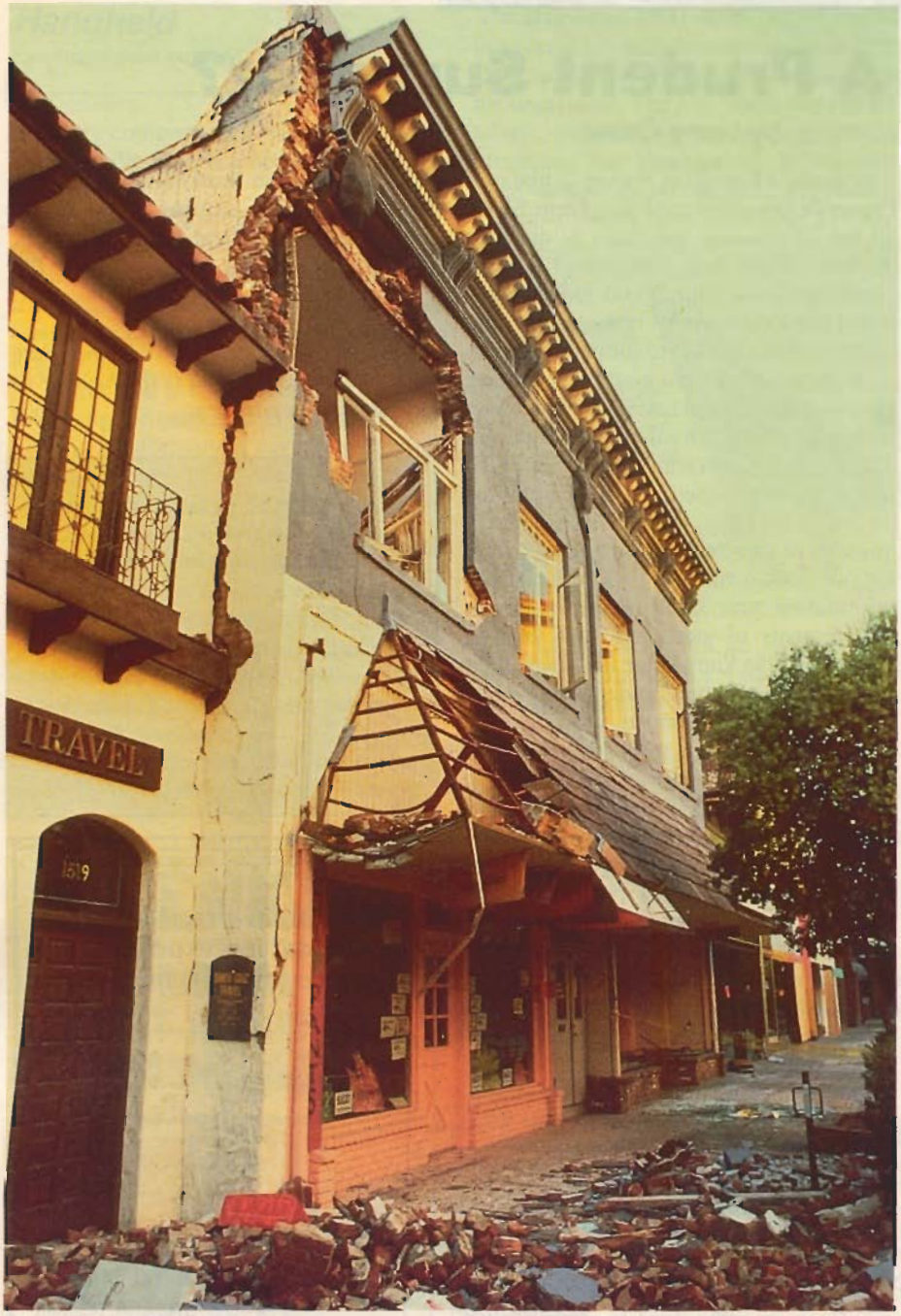

Bob Eplett, California Department of Emergency Services

Devastation in Santa Cruz.

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building damage occurred, the quake had literally shaken buildings to the ground. Within minutes, the area's gas and power lines were ruptured and a series of violent fires began. At the Pacific Gas and Electric Company's mapping headquarters, every available resource was mobilized. Larry Genardini, the company's mapping supervisor, compared the demands placed upon his department to a "nightmare," although the first few days Genardini felt like one of the "most powerful persons in the world." There was an immediate need for gas and electric maps. According to Genardini, one of the most challenging problems was to provide precisely what was needed. As expected in an emergency situation, those making the demands did not know exactly what they needed. They just knew they needed information regarding the location of the volatile utility lines. Because of the immediate need for emergency response information, the company did not have time to dispatch surveyors or engineers to locate the subsurface lines. Field inspectors and foremen were sent out with hastily reproduced maps, some color-coded to aid the field operations. Like the Oakland blueprinter, the two gas and electric company blueprint machines ran for 45 hours straight.

The disaster was an extreme test of the area's plans to investigate GIS technology. Prior to the quake, efforts were underway to develop a uniform GIS using the city of San Francisco's 200-scale base maps. Questions regarding scale and use, typical of GIS, were still to be resolved before the system could be "on-line," thus traditional methods of mapping and access were utilized. When the quake struck, there was certainly little time for utility companies and other public service offices to coordinate mapping and data resources. Each agency was compelled to respond to its own crisis.

"The disaster was an extreme test of the area's plans to investigate GIS technology."

When questioned about the application of GIS at CALTRANS, Fenske explained that his agency had discussed its use but as yet had not devoted any significant resources to the endeavor. Because the highway department work in limited strips or spots, he explained, GIS application was not as important as in cities or agencies that need a spatial approach to regional mapping. If such a program were undertaken, however, Fenske was confident his department would be interested in aiding its development.

"Overall," according to Fenske, "the whole operation was quite an experience. We had a lot of hot requests, and the effort was quite exciting. It proves to me once again that surveying is a valuable profession, and I was thankful I had a chance to help everyone."

What lies in the future for the area? According to Wayne Thatcher of the U.S. Geological Survey, the recent slippage of the Loma Prieta segment of the San Andreas Fault "has clearly increased stress"

on the rest of the fault stretching north to San Francisco.

Another member of the Geological Survey, Allan Lindh, reported there has been "a subtle but distinct" shift towards increasing quake activity. Two months before the quake struck, Lindh had predicted in the August issue of *Science* that an earthquake of 6.5 magnitude would likely strike a 20-mile section of the San Andreas fault almost exactly where the October 17 quake occurred. When asked about a historical pattern, the seismologist refused to speculate, although history has revealed a possible pattern in the sequence of quakes.

What are the lessons to be learned? Most scientists and geologists agree that San Francisco is not the only area susceptible to an earthquake. Two of the most severe quakes in the country occurred in New Madrid, Missouri, and Charleston, South Carolina. Boston and the Great Lakes regions have also been historically associated with great earthquakes. Other natural calamities will continue to plague the country, such as the recent destruction from Hurricane Hugo. Will these areas be as prepared as the Bay Area, which had only begun developing a disaster relief-based GIS?

From the great earthquake of '89 we have learned it is essential that the affected agencies communicate with each other if they intend to develop a regional GIS and respond to an emergency as efficiently as possible. Uniform mapping standards and methods of electronic storage must be adopted. The various agencies must continually review their records, both internally and with each other. The system must be "smart" enough to identify variables such as which of the damaged utility lines poses the most danger to the community. How can water pressure be maintained in the event of fires? What is the best alternate route for rescue operations? Which area is in danger of flooding? An intelligent GIS would be capable of making these decisions, instantaneously updating reports and making recommendations. As the information is updated, priorities could be reassigned and human decisions could be made.

"Little public attention was given to the status of the city's harbor. But beneath the water, unseen to human eyes, was far more physical displacement than had ever been observed on the surface."

We have also learned that the Bay Area has much to be thankful for. The response and commitment of the various individuals mentioned in this article are reasons to be proud of our profession and our friends, most of whom made many personal sacrifices in the interest of humanity. Let us learn from this lesson and continue in our efforts to serve society in a fashion commensurate with our professional stature in the community. **PS**

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