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# TRANSPORTATION PROBLEMS AND NEEDS IN THE AFTERMATH OF THE 1985 MEXICO CITY EARTHQUAKE

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1987

Quick Response Research Report #10

Institute of Behavioral Science #6 • (303) 492-6818

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## ACKNOWLEDGMENTS

This work has been produced through a grant from the Earthquake Hazard Mitigation Program of the National Science Foundation. In addition, the authors wish to acknowledge the support of the Natural Hazards Research and Applications Information Center at the University of Colorado, Boulder in sponsoring our trip to San Salvador following the earthquake of October 10, 1986, from which valuable lessons and data have been obtained. We also wish to thank a number of students who have rendered great assistance in our field data collection efforts. These are Francisco Torres Verdin of the National Autonomous University of Mexico, Lev Malakhoff of Virginia Tech, and Luis Garcia, Lucila Perez, Edmundo Del Castillo, Raul Perez, Jorge Lopez, Fernando Rodriguez, Mario Marquez, and Pascual Reyes of the Autonomous Metropolitan University.

Thanks are also due a number of Mexico government officials who have participated in our interviews and have assisted us in the data collection task. They include: General Ramirez Garrido-Abreu, General Coronado, Engineers Colin Arcos, Bazan De La Pena, Conrado Rodriguez, Gustavo Escobar, Luis Pommerencke, Gerardo Garcia Lara, Francisco Norena, General Baravo Magana, Mr. Isaac Osorio Corpi, and Lic. Rebeca Lopez. The assistance of Dr. Victor Torres-Verdin has also been extremely valuable to us in the conduct of our research in Mexico.

# ABSTRACT

A description of the state of the transportation network and services in the immediate aftermath of the Mexico City earthquake is provided. The goal has been to identify the major problems faced in the management of the transportation system pertaining to the overall emergency response and restoration of normalcy. The type of transportation-related decisions faced and the consequent actions taken are documented. The documentation is based on interviews conducted with response agencies officials in Mexico and a review of the pertinent literature. In addition, official documents have been obtained from various Mexican government agencies, and are supplemented by an eyewitness account of the unfolding of the events following the earthquake and the roles played by the transportation system.

Five transportation-related areas have been addressed, namely: 1) the street and highway network, 2) traffic devices and control, 3) mass transit, 4) emergency vehicles, and 5) crowd management and shelters. The major problems faced in each area have been identified and the subsequent actions taken are documented. Based on these findings, the future needs in management of the transportation system in the aftermath of a major urban disaster have been outlined.

## I. INTRODUCTION & SCOPE

Mexico City lies in a basin approximately 1,500 square kilometers surrounded by high volcanoes. It is the home of 17 million people, with over two million buildings. At 7:19 a.m. on September 19, 1985, for almost 90 seconds, this largest human settlement in the world was shaken by a powerful earthquake (8.1 on the Richter Scale). In fact, some researchers (Ref. 1) have concluded, based on collected data, that on the morning of September 19, Mexico City experienced not one but two equally powerful earthquakes only 27 seconds apart. Consequently, the September 1985 earthquakes left in their wake an emergency condition rarely paralleled in human experience.

The extensive destruction caused by the September earthquakes is well documented. Table 1 lists an estimate of the damage sustained by the city as a result of the earthquakes. Not included in Table 1 are the number of lives lost; estimates vary widely from 4,596 to over 20,000 people. Table 2 summarizes the resources available and deployed during the early days following the disaster.

In terms of response and rescue, the efforts and achievements of both the government and volunteer workers are highly commendable. Their achievements in rescue operations and in restoring order are better appreciated when one compares the magnitude of the disaster (Table 1) to the resources available (Table 2). Although the emergency crew of the various city organizations were in the middle of a shift change when the first earthquake occurred at 7:19 in the morning, both shifts engaged tirelessly in the rescue and emergency operations, often unaware of the

Table 1. Impact of the Earthquake on the City Infrastructure

| Infrastructure | Damage Estimate | Reference |
|---|---|---|
| Buildings | 957 Destroyed<br>4,771 Damaged | 2 |
| Electric Power | 38% Reduction in Distribution capacity | 2 |
| | Power Failure in 1/3 of the City | 2 |
| Water | 27% Cutback in Normal Supply | 3 |
| Drainage | Damage Negligible | 2 |
| Solid Waste | $1.2x10^6$ $m^3$ of Debris<br>(Discarded over 2 months) | 2 |
| LP Gas | 35% of Storage Plants Damaged | 2 |
| Telephone | Local - 5% of Lines Disrupted<br>Domestic Long Distance - 70% of Lines Disrupted<br>International - All Service Disrupted | 2 |
| CBD Roads | 70% Reduction in Capacity | 4 |
| Subway | No Serious Damage<br>Slight Damage to Line No. 5<br>Only Temporary Service Suspensions for Inspections | 5 |

Table 2. Resources Deployed in the Immediate Aftermath of the Earthquake

| Item | Quantity | Reference |
|---|---|---|
| Trained Volunteers | 35,000 | 2 |
| Untrained Volunteers | 15,000 | 2 |
| Fire Fighters | 800 | 2 |
| Fire Vehicles | 125 | 2 |
| Fire Stations | 7 | 6 |
| Ambulance Stations | 20 | 6 |
| Refugee Camps | 171 | 2 |
| Police Personnel | 15,300 | 7 |
| Police Auto Patrols | 1,090 | 7 |
| Motorcycles | 450 | 7 |
| Tow Trucks | 105 | 7 |
| Police Jeeps | 150 | 7 |
| Police Vans | 31 | 7 |
| Police Helicopters | 10 | 7 |
| Heavy Machinery | 850 | 3 |
| Light Machinery | 1,500 | 3 |

fate of their own families. To add to the danger, the rescue operations had to be carried out under a highly restrictive transportation network. Immediately after the earthquake, the traffic control system became inoperational; therefore, the status of the various street links in the city center was unknown to the emergency crew. As the morning-rush traffic, unaware of the magnitude of the disaster, began pouring into the city center, the transportation logistics problems became more apparent. Consequently, the management and restoration of the transportation system was recognized as an integral and vital part of the emergency operations.

The objectives of this report are to describe the state of the transportation services in the immediate aftermath of the earthquakes and to discuss the roles played by the transportation system in the unfolding of the events following the earthquakes. The overall goal is to identify the major problems faced in the management of the transportation system pertaining to the overall emergency operations and efforts to restore normalcy and extract lessons from this experience. The type of transportation-related decisions faced in the aftermath of the September earthquakes and the consequent actions taken are also documented herein. The documentation is based on interviews conducted in Mexico, a review of the pertinent literature, and official documents obtained from various Mexican government agencies, and is supplemented by an eyewitness account by one of the authors, Dr. A. Martinez-Marquez. Five transportation-related areas are discussed, namely: 1) the street and highway network, 2) traffic devices and control, 3) mass transit, 4) emergency vehicles, and 5) crowd management and shelters.

## II. AN EYE-WITNESS ACCOUNT OF THE EVENTS

Based on interviews held with a number of witnesses, this account is intended to shed light on some of the many and yet varied experiences recorded during the September 19, 1985 Mexico City Earthquake. In narrative style, some of the critical situations experienced by many are described herein by an observer involved in Traffic Management at the time of the earthquake. As a witness, Dr. Martinez-Marquez reflects on items which warrant further consideration in earthquake mitigation planning.

"It was about 0718 hours of that September 19, 1985 day when I arrived at the parking lot near the office, to attend some usual things dealing with the Mexico City computerized Traffic Control System I was in charge of, when I experienced a strange sensation as if the car was moving and the floor was somehow shaking. Within my visual scope the surrounding buildings were subjected to an oscillatory motion barely perceivable, when I realized that an earthquake was in progress. My digital wrist watch was displaying 0719 hours.

After experiencing such shaking of the ground, I nearly ran into my office. Two young people, responsible for the operation of the Traffic Control System, were trying to start the computer on. They were depicting some panic in their faces but were more worried about the computer not working properly. I did try to help, but we just could not get the computer running. I entered into my office, grabbed my camera, and went out to see what the situation was outside. It was approximately 0735 hours.

From Plaza de Tlaxcoaque, near the Police Headquarters building, I started to walk along 20 de Noviembre Ave. Northbound, noticing amazement and surprise on most people's faces, as well as some buildings which had at least partially fallen down. That first experience was also shaking, though emotionally now. In my path, I was able to take a picture of a visibly leaning building from the intersection of Fray S. Teresa de Mier and San Antonio Abad Avenue. Later on, the building, belonging to 'Conjunto Pino Suarez,' completely fell down to its basement. Some people had gotten the impression that the cause was the vibration generated by a Police helicopter which was flying around. However, such a building, my understanding suggests, was under a collapsing process which could not be stopped by any means. The vibration generated by the helicopter acted as a very small perturbation on a rather unstable structure.

I decided to walk along 20 de Noviembre Avenue and, at the intersection with Jose M. Izazaga, I turned left and continued taking photographs of mainly the general aspects of the streets but also of structural details and the visibly excessive loading which several damaged buildings were carrying, a loading which appeared to be well beyond the design load specified by 'Reglamento de las Construcciones del D. F.' (The Mexico City Building-Code Standards). An example of such loading consisted of fabric rolls piled up in more than six rows reaching a height of at least 1.50 meters (5 feet) above the steel platforms sustaining them. In general the mode of failure of these buildings resembled that of a house of cards.

There were people leaving the I. la Catolica Metro station displaying horror in their faces, mainly because there was nothing to do under those unbelievable circumstances. As I was walking along J. Ma. Izazaga Ave., hearing screams of despair, possibly from people trapped, my feeling of frustration increased mainly because one does not know what to do. Such feelings of despair and frustration tend to disappear one feels relieved when hearing the sounds of ambulances and Police patrols arriving at the site. They altogether seem to know WHAT and HOW to do under those unthinkable conditions.

A number of people were putting wide band stripes of fabric around the damaged buildings and small houses, as well as apartment buildings, in the area. Such fabric had been taken from a collapsed building housing cloth manufacturing companies which had used some of the floors to stockpile rolls of fabric regardless of the amount of loading they would impose on the structure. Surrounding the damaged buildings by stripes of fabric was, perhaps, meant to emphasize the excessive loads which had contributed to the collapse of the building.

I continued along Eje Central until I was able to look at a collapsed building which had miraculously withstood the July 28, 1957 earthquake. The building housed a very popular restaurant (La Copa de Leche) where many people used to have a rather early breakfast. Being an occasional visitor to that place myself, where my wife and I had first met, my feelings were mixed between wanting to help the people trapped inside or somehow bringing up the whole building. It was some consolation, however, to see on my right the Latin-American Tower still in place. Such a tower, a Mexico-U.S. Engineering design, has been a leitmotif for study and admiration to Civil Engineering in Mexico.

Coming from the Allende Metro Station, I saw a young man in his early twenties carrying books under his right arm and some dust covering his face, with no expression at all. I was prompted to ask him if he needed help but got no response. The whole experience had been so shocking that no one could ever express it in words. It would be absurd to expect any person to be so articulate as to find in his/her vocabulary the needed words. That young man reminded me of one of my sons who should have been traveling from home to work by Metro at the time of the earthquake, and whose whereabouts I did not yet know.

Looking westward, at the intersection of Benito Juarez and Eje Central (Lazaro Cardenas Ave.) one could not help but notice the collapsed 'Hotel Regis' on Benito Juarez Ave. and the many people who were merely watching in helplessness. Northwards, I noticed several more damaged and collapsed buildings. I decided to return to the office by way of Madero Street.

Glimpses of the things I saw back in 1957, while in the Military Service, began to emerge in my mind as traffic conditions were worsening on the streets. There was no power, and the traffic signals were not functioning. Drivers were passing other drivers to get ahead by pressing their cars' horns. Few people were aware that a major earthquake had occurred since they were used to frequent but light earth tremors. Meanwhile, continuous honking was in progress and no traffic police were at hand. They were possibly preparing to be sent out from their own respective Sectors (or Coordinating Areas) or perhaps traveling to their respective posts. I continued walking along 20 de Noviembre St. back to my office , encountering people of all walks of life walking in despair.

In the meantime, the arrival of police patrols and ambulances had begun. To state it bluntly, all those units particularly of the police were doing everything within their power to help people understand the gravity of the overall problem.

As I was walking back, a police helicopter was flying around the area when a heavy noise was heard from a building at the 'Pino Suarez' Metro station followed by a rush of people away from the station. The building was made of boxed steel columns and trussed beams supporting reinforced concrete slabs. Fortunately, when the collapse occurred, the Metro station was not functioning; otherwise, the victims toll would have risen. Possibly the vibration induced by the flying helicopter accelerated the inevitable collapse of the unstable structure already dangerously leaning southwards. The steel-framed structure was bent like a large cantilever beam before its actual collapse. By about 10:00 o'clock, I started a trip westbound along Fray Servando T. de Mier, this time by car, to more closely examine the prevailing traffic situation. It was very difficult to move due to people standing by, just observing the damaged buildings. The traffic signals were out of order so that policemen had to regulate traffic circulation at the intersections. Near the crossing of 5 de Febrero with Fray Servando T. de Mier, several buildings had totally collapsed. In particular a building with flat slab structure showed only the columns standing, whereas the roofs had stacked up on top of one another. On the northwest corner of that intersection, one building had collapsed at the top floors. The nearby one had collapsed on the front while the back of it was still standing, showing the inside of each floor.

Between Lazaro Cardenas and Cuauhtemoc Ave., traveling was nearly impossible due to the many collapsed buildings, including a portion of the 'Televisa' Complex (a television station), and a steel trussed tower which had fallen over Dr. Rio de la Loza Ave. (continuation of Fray S. T. de Mier Ave., westwards). Very few cars were allowed to enter this section of the roadway. At the intersection with Cuauhtemoc Ave. the building on the southeast corner, housing several radio broadcasting stations ('Radio Formula') had also collapsed at the top floors.

Along Chapultepec Ave. a secondary school building had collapsed, killing a number of teenagers. The nearby apartment building, failing at the top, had completely tilted around, showing the top of the roof as a 'facade' looking southward."

We tried to enter the Colonia Juarez Area (toward the north from Chapultepec Ave.) where traffic encountered a number of 'cul-de-sacs' created by a few damaged buildings and the non-existence of detour signs. This situation led into an atypical grid lock, affecting the surrounding roadways of Reforma Ave. and Insurgentes Ave. We decided to leave that area and travel along Insurgentes Ave. Southbound, since a number of collapsed buildings had been reported along the section between Chapultepec Ave. and Alvaro Obregon Ave. through the Police Radio channels. Such a section was immediately cordoned off by the police force and the transit and other traffic were detoured around this zone which extended a few blocks ahead to the south.

In returning to the office along Alvaro Obregon Ave., we stopped the car near Cuauhtemoc Ave. and walked north for a few blocks noting the roofs of the building housing the Secretaria de Industria y Comercio (Ministry of Industry and Commerce), had collapsed. Within our vision there were a number of other buildings partially destroyed. Near the intersection of Cuauhtemoc and Chapultepec Aves. many people were walking in the nearby street which was closed to all traffic. This was due to the fact that the Metro line running along Cuauhtemoc St. was out of service.

Back in the office, the following assessment of the general situation was made:

a) the Computerized Traffic Control System's Central Computer experienced damage at the disk drive units level, though the CPU was functioning properly;

b) communication between the supervisory computer and the equipment on the street was completely lost, so that it was not possible to identify the current status of neither the local controllers nor the subarea computers;

c) the rest of the traffic signals, mainly the electromechanical type, experienced minor damage though several signal posts had collapsed or were covered with construction debris;

d) the Traffic Roadway Network was severely damaged in its capacity since many isolated links could not be used by vehicles. There were many other streets which were also closed by the initiative of the neighborhood residents who later claimed that some buildings were so damaged that they might fall down at any moment;

e) by means of the Police Radio System, a number of reports had been gathered on the damaged or collapsed buildings, and an inventory of places where victims rescue operations were needed. However, we desperately felt the need for a roadway inventory, including:

i) the number of lanes available after discounting those needed for activities such as heavy machinery demolition activity or victims rescue operations;

ii) the streets closed which could be opened to traffic within 24 hours or so; and

iii) finding alternative routes to avoid traffic circulation around severely damaged areas.

# III. TRANSPORTATION PROBLEMS

## A. STREET AND HIGHWAY NETWORK - PROBLEMS FACED

Upon the occurrence of the September 19, 1985 earthquake approximately 70% of the normal capacity of the Mexico City central transportation network was lost (Ref. 4). The loss of the street capacity in the central region was not due to structural damages to the streets alone. In fact, the latter was the least of the contributing elements.

The network capacity was mainly reduced due to blockages caused by structures collapsing into the streets and compounded by debris from collapsed structures stored in the streets as search, rescue, demolition, and clean-up progressed. Also contributing to the loss in capacity were the cordons used to minimize the threat from near-collapse structures and to facilitate rescue operations and heavy machinery assembly. In addition, at least one source (Ref. 8) identified the gathering of crowd (volunteers, relatives of victims, and on-lookers) as another element in the closure and capacity reduction of streets. Finally, a number of massive gridlocks in the hours following the 7:19 earthquake had effectively shut down many street links.

Most of these problems were concentrated in the central region of Mexico City shown in Figure 1. This is a zone whose primary streets are under the control and monitor of the Mexico City computerized traffic control system since 1982. Figures 2 also shows the distribution of the capacity reductions on a street-by-street basis within the affected network shown. The extent of disturbances within the area shown includes:

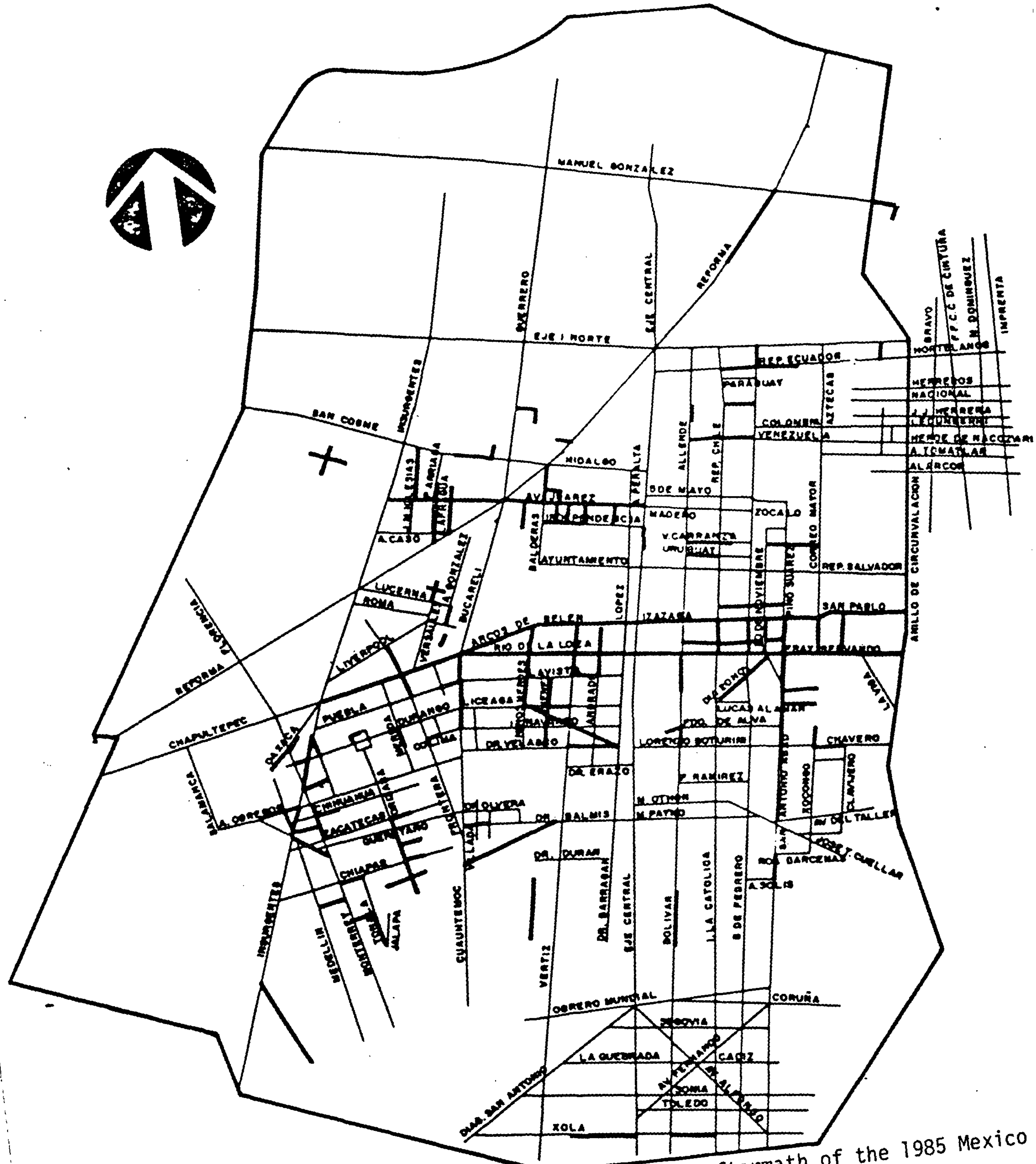


Figure 1. The map of severly damaged regions in the aftermath of the 1985 Mexico City earthquakes.

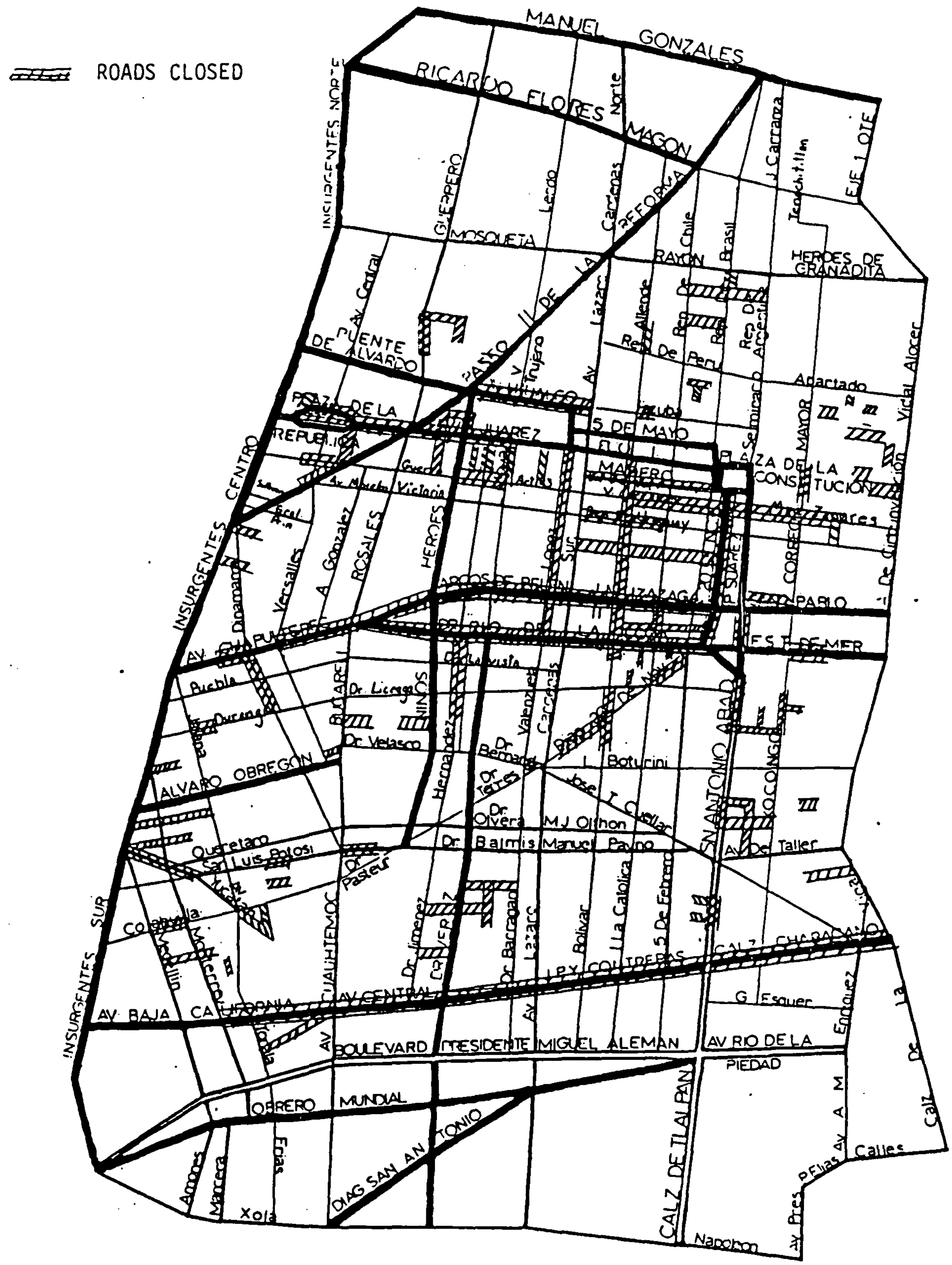


Figure 2. Location of streets closed to through traffic in the aftermath of the September 1985 Mexico City earthquake.

| | | |
|---|---|---|
| i) | Access-Controlled Freeways | 10.7 kms. |
| ii) | Two-Way Avenues | 19.0 kms. |
| iii) | Ejes Viales* | 68.9 kms. |

## B. TRAFFIC DEVICES AND CONTROL - PROBLEMS FACED

The Mexico City computerized traffic control center has been in operation since November 1982. In this center, the status of each signal is displayed on a board map. When the signal indication for the main street is green, a green light is displayed on the board. When the main street has a red indication, the green light on the board is off. The red light on the board is only lit when a signal has failed. The amber lights on the board show the location of inductive loop detectors in the city network.

In the aftermath of the September earthquake, this entire system was rendered inoperational. Although the CPU of the central computer was functional, the disk drive units were damaged. Worse yet, the communication between the central computer and the street hardware was also lost, hence any rapid assessment of the operational status of local or master controllers was practically impossible.

The main cause of the communication loss was the failure of the ducts housing the signal cables. These concrete ducts had sheared at the joints as a result of the earthquake. It is believed that PVC ducts may have been more appropriate since they are considerably less susceptible to shear forces. The failure of the power ducts also caused the

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* Ejes Viales are one-way streets with 5 or more lanes with one possible transit counter-flow lane.

malfunctioning of street hardware such as signal controllers and loop detectors. For example, of approximately 634 loop detectors in the city network, only ten were operational.

A secondary board at the traffic control center assesses the degree of congestion on various critical intersection approaches by measuring the loop occupancy time. A steady yellow light on the board indicates an intermediate level of congestion. This board was also not operational due to the loop malfunctions mentioned earlier.

Meanwhile, many traffic signals were not functional due to widespread power failures. Not knowing the extent of the disaster, major lock-ups began to form at the intersections as the peak-hour traffic began to enter the city center as usual. The traffic conditions were further aggravated by vehicles entering the normally through-links which had become cul-de-sacs due to collapsed structures, debris, etc. Consequently, few hours after the first earthquake, major grid-locks formed in the city center, seriously interfering with the search and rescue operations.

The formation of such grid-locks identifies three other problems faced, namely, 1) the effective dissemination of information to the public, 2) the lack of quickly implementable diversion and detour plans, and 3) the lack of enforcement. With proper dissemination of information in the initial hours after the earthquake, many vehicular trips destined for the city center could have either been cancelled or aborted. Such an effective information dissemination ability is, of course, conditioned upon an equally effective and quick means of surveying the conditions in the area. It is possible that the extent of damages were initially perceived to be relatively light and consequently such an information campaign was not deemed necessary. Nonetheless, in the days following the earthquake the information provided by radio on detours was not specific enough to identify closed streets and alternate routes. The public was simply advised to avoid certain general areas.

An obstacle in implementing a quick traffic diversion and detour strategy was the lack of availability of a sufficient number of traffic signs of the kind needed to carry out an operation of such magnitude. Consequently, drivers would very often find themselves in streets whose circulation direction had been reversed or which led into a "cul-de-sac" condition. In addition, special traffic signs were needed to warn vehicular and pedestrian traffic of some of the extra-ordinary conditions which prevailed, such as the near-collapse structures or demolition and rescue work in progress. Finally, the enforcement of such a great number of diversions, detours, and cordons was also problematic. This was particularly the case in the initial hours after the first earthquake when many of the needed cordons and detours were set up by volunteers and neighborhood residents themselves, who lacked an official enforcement authority.

In the days which followed, the primary goal was to restore traffic services to normal as quicly as possible. As such, efforts were made to reduce the number and size of cordon areas and to devise network-wide diversion strategies to facilitate and gradually improve on accessibility. The decision was reached after many interorganizational debates between the traffic division of the Police and the transportation division (CGT) of the office of Mayor. In connection with this goal, priorities were needed to be established for the clean-up and opening of closed streets. The lack of a systematic street clean-up strategy was also a problem confronted in traffic management.

## C. MASS TRANSIT - PROBLEMS FACED

The mass transit system in Mexico City is composed of four major modes: buses, trolley buses, trams and the Metro. Together, these modes of transportation provide over 56% of the total daily travel by all modes in Mexico City, as shown in Table 3.

Table 3. The Breakdown of Daily Person-Trips by Modes Within the Mexico City Metropolitan Region.

| Mode | Daily Person-Trips | Percent |
|---|---|---|
| Surface Transit (bus,trolley,tram) | 10,085,554 | 33.3 |
| Metro | 6,916,628 | 22.9 |
| Walk* | 6,480,244 | 21.4 |
| Car | 4,530,414 | 15.0 |
| Jitney | 1,951,851 | 6.4 |
| Taxi | 164,327 | 0.5 |
| Other Means | 143,928 | 0.5 |
| Total | 30,272,933 | |

This would amount to approximately 17 million person-trips a day. In addition, two para-transit modes, namely jitneys and taxis, supply 6.4% and 0.5%, respectively of the total daily trips.

As expected, the streets in the city center are heavily utilized as transit and para-transit routes. Figures 3a and 3b show the concentration of bus and trolley routes within the city center. In addition, all metro lines also converge at the city center (Fig. 3c). Consequently,

* Trips longer than 5 minutes or approximately 400 meters.

Bus Routes

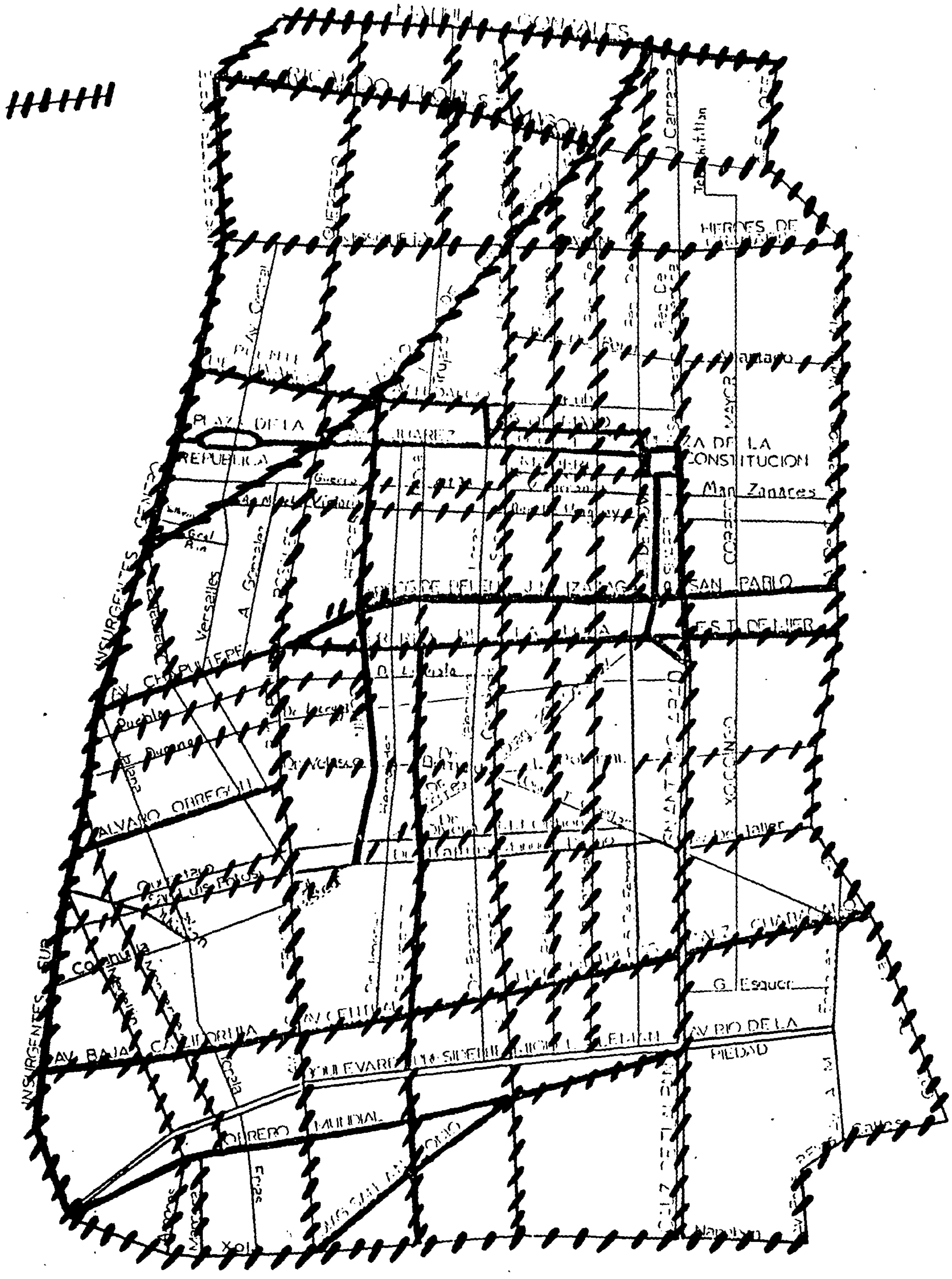



Figure 3a. Bus routes in the Mexico City study network.

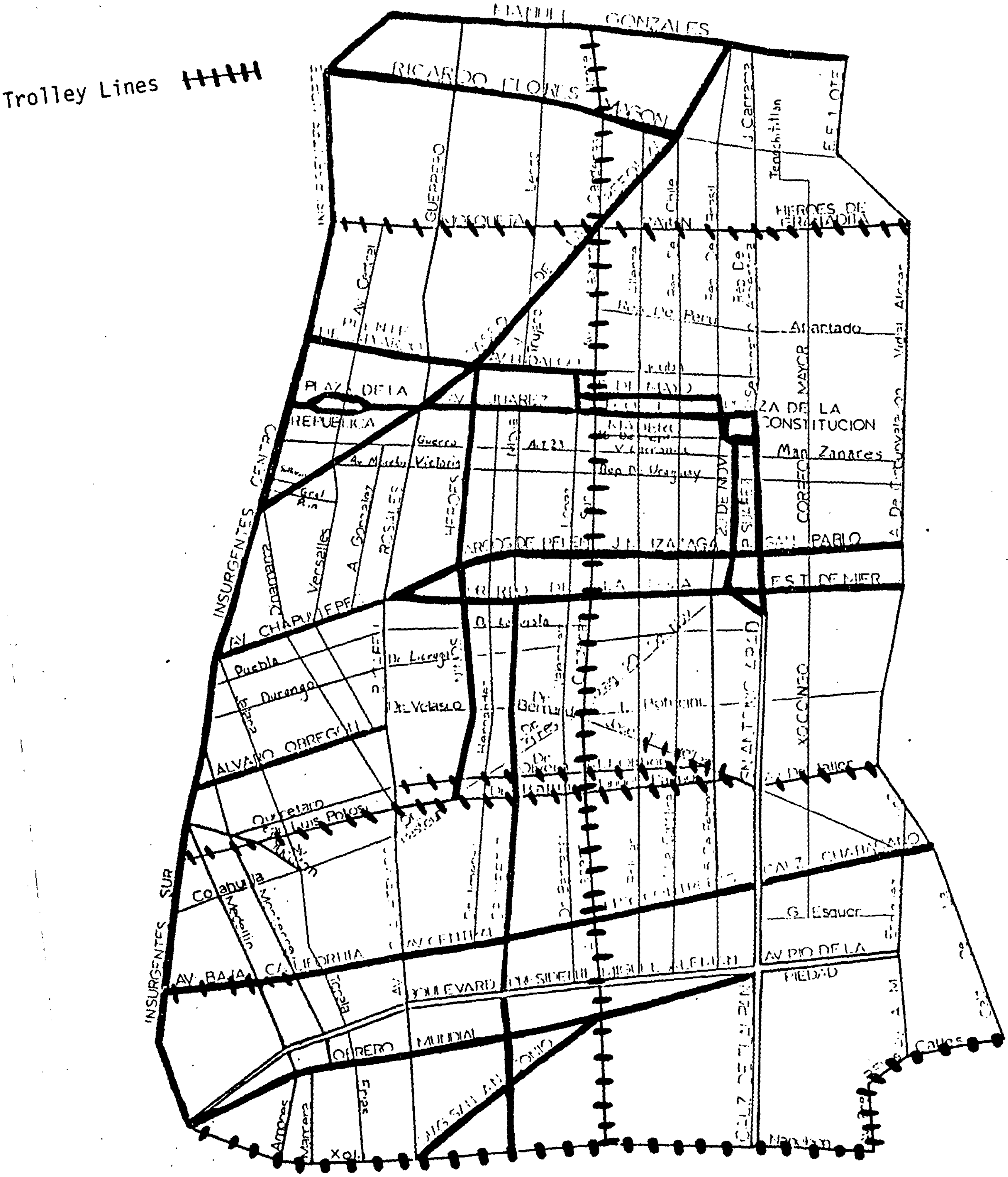



Figure 3b. Trolley lines in the Mexico City study network.

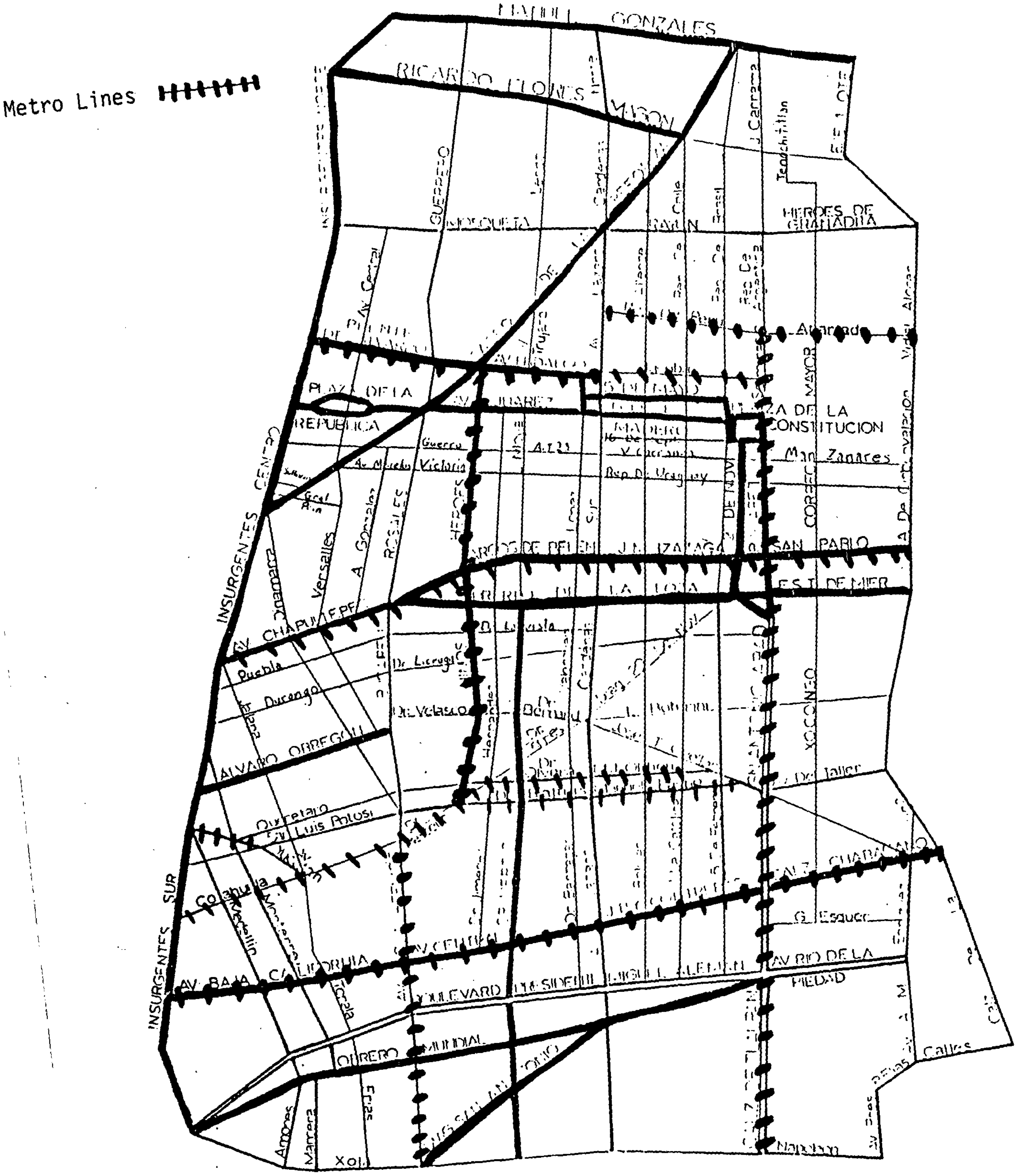



Figure 3c. Metro lines through the Mexico City study area.

the earthquake damages to the central city street network caused major disruptions in the surface transit operations.

The metro lines, carrying an estimated 297,000 passengers at the time of the earthquake, were only momentarily shut down for inspection. However, the surface transit modes had to undergo route and schedule changes due to street closures described earlier. Such changes required an effective dissemination of the relevant information to the public. The route changes and detours also had to consider important changes in travel needs and patterns produced by the earthquake itself. These changes included the travel needs to shelters, relief centers, first-aid stations, and trips made to incident nodes and information centers in search of missing relatives.

In light of these additional trip purposes, problems arose regarding setting up make-shift stations and acquiring additional buses to accommodate the increased ridership demand. Additional buses were also in demand to transport excess passengers along those segments of metro lines which were temporarily out of service. However, since some transit buses were used to transport victims and relief supplies the supply of buses was smaller than usual.

In short, it was soon acknowledged that the restoration of mass transit services to an acceptable level was an essential step in expediting the return to normalcy in the aftermath of the earthquake in Mexico City. To this end, major transit problems faced included:

- Route and schedule changes
- Service to special trip generators
- Dissemination of transit-related information

- o Inspection of Metro lines
- o Alternative service to shut-down Metro lines
- o Short supply of buses due to alternate uses

## D. EMERGENCY VEHICLES - PROBLEMS FACED

Two major problems existed in the emergency response operations. First, there were an insufficient number of emergency units. Second, the emergency vehicles had to be dispatched under highly uncertain conditions. In addition, there were problems experienced due to disruptions in communication systems and lack of coordination among emergency response agencies.

The emergency response resources and facilities in Mexico City are extremely limited compared to other cities of comparable size. For example, while there are 76 fire stations and 8,000 firemen in London, Mexico City has only 7 fire stations and 800 firefighters, who operate 125 fire engines and work in two 12-hour shifts. The 125 fire engines accompanied by only 20 ambulances. Figure 4 shows the location of the fire stations and ambulances in Mexico City. It must be noted that the location of the ambulances are not fixed but rather are distributed according to demand variations with the time of day and day of week. They are usually stationed near small police modules.

Despite such limited resources, following the 1985 earthquake, the Mexico City fire brigade was forced to engage in activities as diverse as removing crushed walls, quenching fires, preventing gas leakages, and supplying water to medical facilities. Within the first 24-hour period after the earthquake, the fire brigade responded to 193 cases of fire and 236 cases of gas leakage (Ref. 2). In the three days after the earthquake, 351 cases of fire were reported; Figure 5 shows the loca-

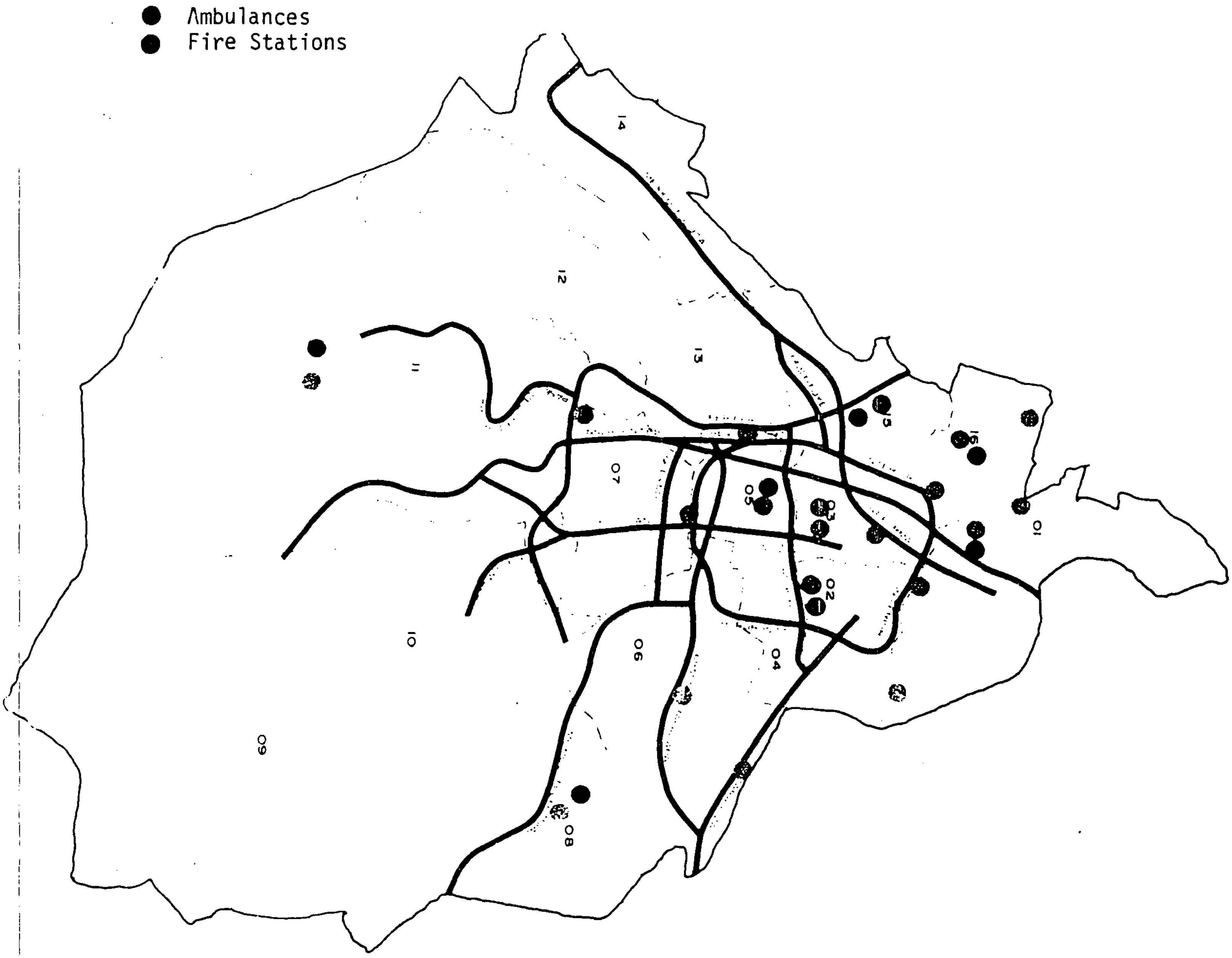



Figure 4. Location of fire stations and ambulances in Mexico City.

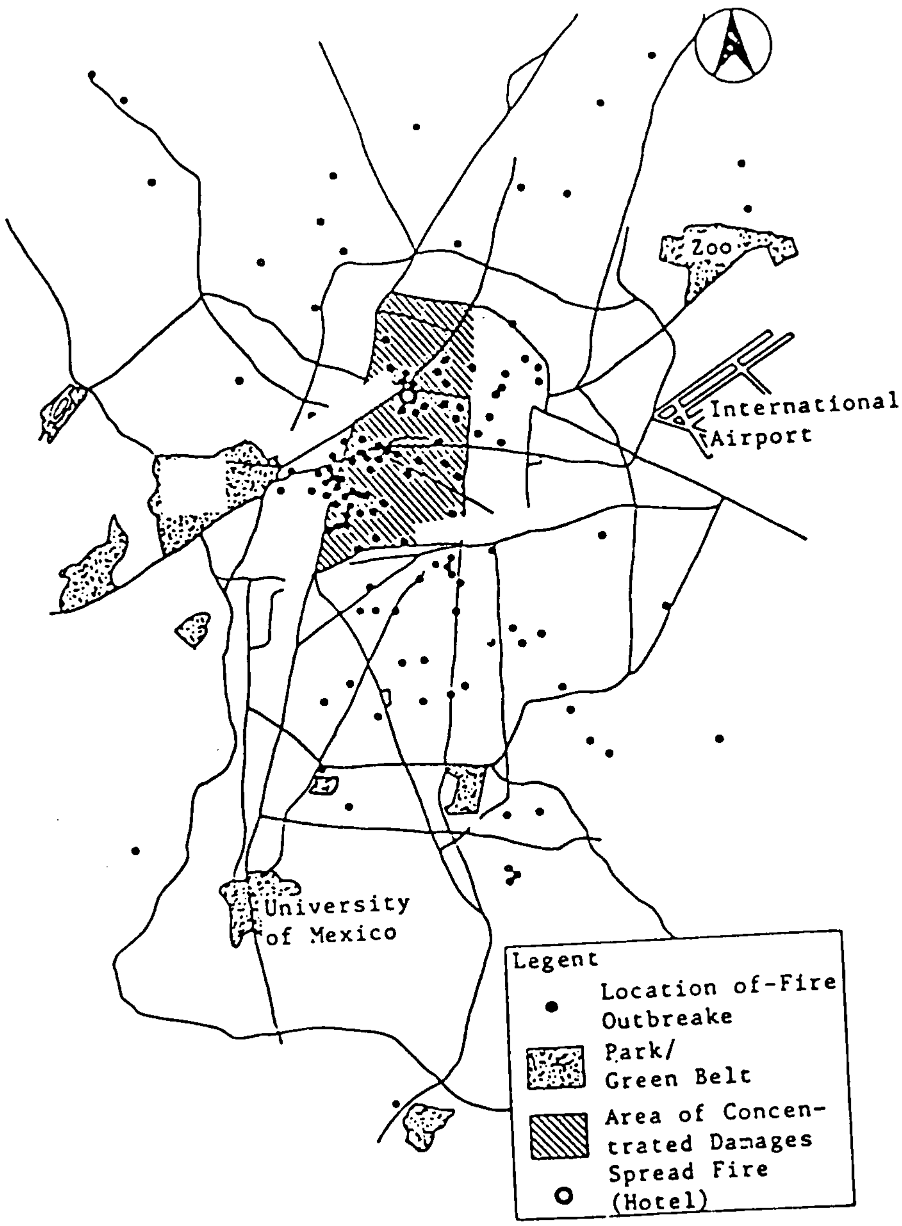



Figure 5. Location of fire outbreaks in the three days following the September 19, 1985 Mexico City earthquake (Ref.2).

tion of the major fire outbreaks.

A second problem was in dispatching emergency vehicles under unknown route conditions. Emergency units such as ambulances, rescue teams, and fire vehicles had to make numerous attempts and diversions, usually by trial and error, in order to access areas where secondary and local streets were closed. This was particularly the case within the "Colonia Juarez" and "Colonia Roma" zones. Figure 6 exemplifies the vehicle dispatch problem through showing the spatial distribution of the critical facilities which were potential origins or destinations of emergency vehicles.

The dispatch of emergency units was further complicated due to disruptions in communication lines. For example, the logistics division of the police had lost their telephone connection to their radio dispatch center (Ref. 9). Furthermore, the Metropolitan police had lost their entire system of communication with the exception of hand radios (Ref. 8). However, through the four channels available on these hand radios, they were able to communicate with ambulances and fire divisions.

Finally, there was a general lack of coordination among the various response agencies. For example, the Army, the police, and mayor's office launched independent condition surveys to assess the accessibility of the streets, only to discover their redundancy in the meetings which followed. Furthermore, in the first 72 hours after the earthquake, the ambulances and fire engines took whatever routes were available by trial and error, independent of each other. In addition, they were not pro-

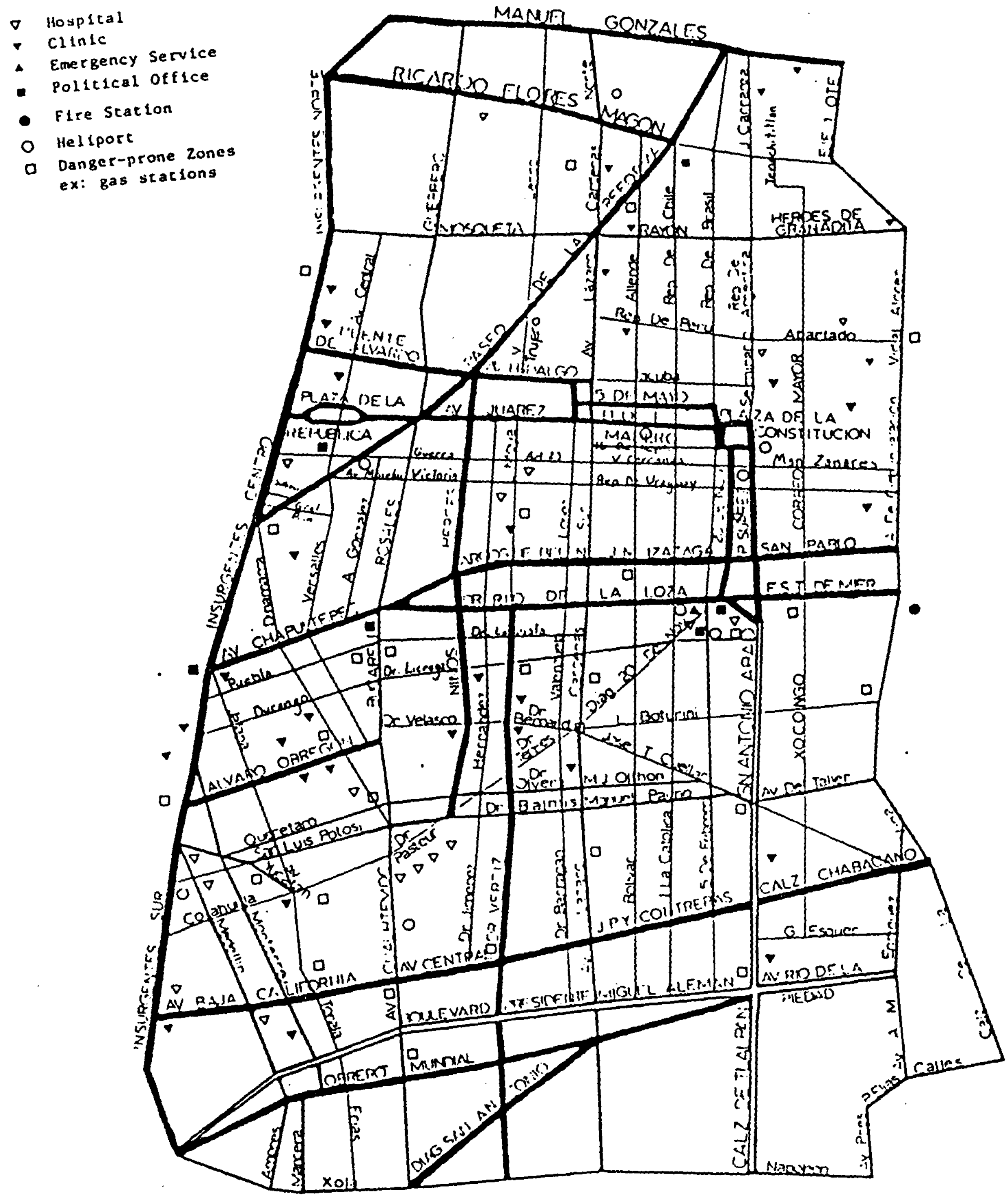



Figure 6. Location of critical buildinds in the Mexico City study area.

vided, nor sought input, regarding the street conditions from the agencies which had conducted condition surveys. It should be emphasized that, in time, the problems stemming from the lack of coordination were identified and actions were taken to rectify them, as discussed in the chapter which follows.

## E. CROWD MANAGEMENT AND SHELTERS - PROBLEMS FACED

According to General V. Coronado, Head of the Mexican Metropolitan Police, there were four different crowd types assembled in the vicinity of incident points, each type posing unique problems and requiring special responses. The four types were: victims, victims' relatives, on-lookers, and volunteers.

i) Victims

Victims who did not need immediate medical attention needed to be transported to shelters. However, their evacuation to shelters was not always an easy task since such victims were concerned about looters and remained to guard their possessions. In addition, due to a 1950 rent-freeze ordinance, the residential rents had been frozen at the low rates in effect at the time. Consequently, many victims were reluctant to evacuate their heavily damaged places of residence for fear of losing their low-rent privilege once their buildings were renovated.

ii) Victims' Relatives

Relatives of trapped victims would also gather near the incident points. The control of the emotionally-charged relatives was especially difficult, and usually beyond the police capability (Ref. 8).

iii) On-Lookers

The crowd of on-lookers would often be absorbed into the volunteer force or would otherwise be dispersed. This was particularly the case after the second day when volunteers were registered and given identification tags. It was therefore easy to distinguish on-lookers from volunteers and require their dispersion.

iv) Volunteers

Volunteers played a vital role in search and rescue operations. Approximately 50,000 volunteers a day participated in the rescue activities. All government officials interviewed had consensus on the importance of actions taken by volunteer individuals and groups. The only major problem with the volunteers was the unequal spatial distribution of such forces. The main conflict was in controlling the excess volunteer crowd at certain incident points.

# IV. TRANSPORTATION ACTIONS TAKEN

## A. STREET AND HIGHWAY NETWORK - ACTIONS TAKEN

Actions taken regarding the roadway network in the severely damaged city center included those aimed at rapidly surveying the conditions of the various street links, setting up cordons, and disseminating information to the public. Other actions related to traffic control, public transit, and emergency vehicles will be discussed in separate sections.

i) Survey of Conditions

Under the auspices of the Secretary General of Police and Traffic, the "Disaster Work Headquarters" was set up to gather data regarding the status of the network street links and to monitor their conditions with time. The main objective was to rapidly evaluate the degree of utility of each link on the network for traffic circulation. The initial inventory started on Thursday, September 19 at about 1300 hours and was completed by Friday, September 20 at noon. The data were primarily collected through patrol vehicles and ten police helicopters, all in radio communication with the logistics headquarters (Ref. 9). Helicopters were very useful in surveying the accessibility of the area; however, it was difficult to assess the conditions of secondary streets from above.

The incoming information was then emptied onto a city map by the traffic team. Once the map was completed, it was estimated that the roadway network capacity within the damaged zone was reduced to nearly 30% of the normal capacity. Unfortunately, the initiative was not taken to quickly publicize the efforts in progress and to furnish such a map and data base to other agencies involved in emergency response operations.

As such, organizations such as the Office of the Mayor or the Public Works Department engaged in their own independent condition surveys. The Transportation Division of the Mayor's Office (D.D.F.), for example, dispatched twenty observers, on foot, to collect data regarding the network conditions (Ref. 10). Each observer was assigned a pre-designated path to walk and survey. The data was then returned to the office and emptied onto a map. The information was updated in a similar fashion on a daily basis. Mr. Pommerencke, the engineer in charge of this operation, highly recommended this method of information gathering.

ii) Cordoned Areas

Certain areas were cordoned primarily to facilitate the disaster relief activities. Other reasons for cordoning off areas included public protection from near-collapse structures, restoration of utility services, and prevention of looting. A total of 54 cordons were set up within the disaster zone, the largest being about 10 blocks by 10 blocks. The Army, Police, and the National Guard were the main organizations in charge of enforcing and establishing cordoned areas. In addition, some areas were initially cordoned by volunteers first to arrive in certain disaster sites. Table 4 summarizes the location of these 54 cordoned areas along with the authority in charge and the reason behind the action.

Table 4. Cordoned-Off Areas in the Immediate Aftermath of the September 1985 Earthquakes (Ref. 11)

| Cordon | Authority | Reason |
|---|---|---|
| 1. Luis Moya & Juarez | Army | Collapsed Bldgs |
| 2. Dr. Mora St. | Army | Collapsed Bldgs |
| 3. Balderas & Hidalgo | Army | Collapsed Bldgs |
| 4. Hidalgo & Veracruz | None | Collapsed Bldgs |
| 5. Valerio Trujano & Hidalgo | Army | Collapsed Bldgs |
| 6. Central Lazaro Cardenas & Hidalgo | None | Collapsed Bldgs |
| 7. Lazaro Cardenas & Cuba | Army | Collapsed Bldgs |
| 8. Pedro Moreno & Riva Palacio | None | Collapsed Bldgs |
| 9. Heroes St., Mina & Violeto | None | Collapsed Bldgs |
| 10. Lerdo & Magnolia | None | Collapsed Bldgs |
| 11. Victoria between Lazaro Cardenas & Lopez | Police and Nat'l Guard | Collapsed Bldgs |
| 12. Moctezuma & Guerrero | None | Damaged Neighborhoods |
| 13. Zaragoza & Alvarado Bridge | Police | Collapsed Bldgs |
| 14. Bucareli Ave., Abrahan Gonzales & Lucerna | Police | Collapsed Bldgs |
| 15. Turin, Versalles, Chapultepec Ave. & Berlin | 20 Volunteers | Collapsed Bldgs |
| 16. Napoles St., Chapultepec Ave., Dinamarca & Londres | Police | Collapsed Bldgs |
| 17. Paseo de La Reforma & Insurgentes, Berlin & Hamburgo | Police | Collapsed Bldgs |
| 18. Juarez & Lopez | Nat'l Guard & Volunteers | Collapsed Bldgs |
| 19. Juarez & Reforma | Army | Collapsed Bldgs |
| 20. Cuauhtemac Ave., Dr. Norma, Dr. Pauster & Central Ave. | Nat'l Guard | Collapsed Bldgs |
| 21. Dr. Norma, Dr. Pauster & Cauchemco | Nat'l Guard | Rescue Operations |
| 22. San Antonio Abad #231 & 5 de Febrero, Roa Barcenas & Rafael Delgado | Nat'l Guard | Rescue Operations |
| 23. Netzahualcoyotl, 20 de Noviembre & 5 de Febrero | Nat'l Guard | Collapsed Bldgs |
| 24. Flamenco, 20 de Noviembre & Pino Suarez | Nat'l Guard | Collapsed Bldgs |
| 25. Izazago, 20 de Noviembre & 5 de Febrero | Police | Collapsed Bldgs |
| 26. Regina, 20 de Noviembre & Pino Suarez | Nat'l Guard | Collapsed Bldgs |
| 27. Mesones, Pino Suarez & Correo Mayor | Police | Collapsed Bldgs |

Table 4 Continued

| | | |
|---|---|---|
| 28. Isabel La Catolica, Venustiano Carranza & 20 de Noviembre | Nat'l Guard | Collapsed Bldgs |
| 29. Fray Servando, Bolivar & Eje Central | Nat'l Guard & Police | Zonal Damages |
| 30. Dr. Liceaga, Lazaro Cardenas & Dr. Barragan | Police | Zonal Damages |
| 31. Augustin Delgado, Xocongo & Lorenzo Boturini | Police & Volunteers | To Survey Damages |
| 32. Fray Servando, San Antonio Abad & Chimalpopoca | Police & Volunteers | To Survey Damages |
| 33. Xocongo, Chimalpopoca, Fray Servando & Clavijero | 10 Volunteers | To Survey Damages |
| 34. San Cosme, Serapio Rendon, Antonio Caso, Migual Schultz, Alfonso Herrera, Edison & Insurgentes | Neighborhood Residents | To protect residents involved in emergency operations 35. |
| 35. Paseo de La Reforma, Rio Tamesis to Rio Marine | None | Near-Collapse Bldgs |
| 36. Chapultepec, Oaxaca & Glorieta de Insurgentes | None | Near-Collapse Bldgs |
| 37. Puebla, Oaxaca, Monterrey & Chapultepec | None | Near-Collapse Bldgs |
| 38. Oaxaca, Tabasco & Colima | None | Near-Collapse Bldgs |
| 39. Oaxaca #54 | Nat'l Guard | Near-Collapse Bldgs |
| 40. Tamaulipas, Nuevo Leon & Cadereita | Nat'l Guard | Near-Collapse Bldgs |
| 41. Alvaro Obregon & Nuevo Leon | Construction Crew | Near-Collapse Bldgs |
| 42. Monterrey & Oaxaca Up to Chapultepec | Police | Zonal Damages |
| 43. Dr. Balmis, Dr. Lucio & Cuauhtemoc | Neighborhood Residents | Near-Collapse Bldgs |
| 44. Dr. Pasteur, Dr. Lucio & Cuauhtemoc | Police | Collapsed General Hospital Complex |
| 45. Dr. Andrade, Dr. Marquez & Dr. Arco | None | Truck Traffic Complex Carrying Debris |
| 46. Calle Sol #66, Lerdo, Galeana & Camelia | Neighborhood Residents | Near-Collapse Bldgs |
| 47. Calle Cdo. de Camelia #5 & Lerdo | Neighborhood Residents | Near-Collapse Bldgs |
| 48. Chapultepec #385, Medellin & Monterrey | None | Near-Collpase Bldgs |
| 49. Xola, Castilla, Andalucia & & Correspondencia | Nat'l Guard | Collapsed Bldgs |
| 50. San Antonio Abad, Roa Barcenas & Juana A. Mateos | Nat'l Guard | Collapsed Bldgs |

Table 4 Continued

| | | |
|---|---|---|
| 51. Dr. Barragan, Universidad, Casas Grandes & Morena | Police | Partial Collapse of the Radio Sta. |
| 52. Dr. Vertiz #800, Mitla & Universidad | Fed. Hgwy Patrol | Partial Collapse of the Communications Bldg |
| 53. Xola, Universidad, Lazaro Cardenas & Cumbres de Acultzingo | Police | Partial Collapse of the Communications Bldg |
| 54. Mosqueta, Lerdo & Galeana | None | Collapsed Bldgs |

iii) Information Dissemination

The inter-organizational dissemination of information occurred in the daily coordination meetings. During the days following the quake, a coordination meeting was held every morning (7 to 8:30 a.m.) at the Police and Traffic Headquarters. Representatives of various organizations such as the Army, Public Works, and Office of the Mayor were present. In these meetings information regarding the status of the street network was exchanged. Mainly, the information gathered by the Police and the military would be exchanged and analyzed, hence providing an additional resource-allocation decision tool to participating organizations. Interestingly, in these meetings the traditional conflicts and rivalries among various groups were set aside and all groups appeared to have a deeply concerned spirit of cooperation in the face of the disaster.

The Army also solicited information from the Police Command Post and the Transportation Division of the City Hall (Coordinacion General del Transporte, CGT, de Departamento Distrito Federal) on an as-needed basis. The City Mayor and the Public Works Department also acquired information from the Office of Police and Traffic as well as the Transportation Division (CGT).

The dissemination of information to the public was mainly through the newspapers and government radio and television; air time in commercial radio and television was not easily available. Police patrols were also furnished with the latest information on the status of the network and would provide those to the public upon request.

Both the Traffic Office of the Police and the Transportation Division (CGT) published in the newspapers, maps showing the network conditions. The main objective on the first day was to discourage the public from traveling to the severely damaged zones. Television appearances were made by police and CGT representatives. On Friday, September 20, for example, Dr. Martinez-Marquez as the representative of Police and Traffic, advised the public in a 20-minute television interview, to refrain from traveling to the damaged zones unless absolutely necessary. On Sunday, September 22, a representative of Police and Traffic was interviewed by a commercial television to inform the public of the status of the roadway system. Similar appearances were made by the Mr. Dominguez-Pommerencke representing the CGT. The public was informed that by Monday, September 23, travel activities could resume. That same night, a general report was also presented, describing the prevailing conditions along the main travel corridors affected by the earthquakes. Meanwhile, the public was again urged to avoid the heavily damaged zones so that the rescue operations could continue. They were also urged on behalf of the Secretary General of Police and Traffic to use their private vehicles only when absolutely necessary. "There are still many people fighting for survival under the rubbles," the Secretary General exclaimed, "They surely deserve a chance."

## B. TRAFFIC DEVICES AND CONTROL-ACTIONS TAKEN

Major traffic problems encountered in the immediate aftermath of the earthquake included:

1. Formation of wide-spread grid-locks due to:

- o Lack of rapid information dissemination
- o Absence of quick diversion strategies
- o Initial lack of enforcement

2. Loss of power to traffic signals
3. Failure of communication lines of the central signal system
4. Need for special warning and diversion signs
5. Absence of a systematic clean-up strategy

Due to the enormous magnitude of these problems and limited resources, most actions taken to alleviate them have been rather limited in scope. Regarding the dissemination of roadway information to the public, actions were taken not immediately after but in the days which followed the earthquake. The consequence was the formation of extensive grid-locks in the central area in the initial hours following the earthquake which hampered the rescue operations. Many of the grid-locks were removed by "flushing out" the vehicles trapped in cul-de-sacs using police escorts. The operations were, however, time consuming and resource intensive, and thus further justified the need for a rapid information dissemination campaign aimed at preventing such problems.

The information dissemination in the days which followed was mostly through preparing drawings of the re-designed traffic network which were published in the newspapers and shown on the commercial and government television channels. These drawings were based on inventories of the damaged areas performed by the Police, the Public Works, and the Office of the Mayor (CGT). The police used their helicopters and the ground patrol reports to make a first-hand assessment of the conditions. The Public Works Secretariat also made a quick and reliable assessment of the street conditions through the Army's support in the form of motorcyclists sent out on reconnaissance missions. Such inventory activities emphasized damaged buildings and their effects on the street links. The transportation division (CGT) of the Office of Mayor also performed their own survey of the conditions in the days following the earthquake by dispatching on-foot personnel to the field. The main objective of the newspaper and television information bulletins issued by CGT was to discourage any travel to or through the damaged areas.

The initial inventories assembled at the Police and Traffic Secretariat showed that the overall roadway capacity in the central zone was reduced to 30%; but there was a possibility of immediate re-opening of several streets so as to increase the available capacity to 50%. Such capacity retrieval forced a number of unexpected obstacles including the simultaneous activities which lacked coordination and the interest of some government agencies to keep certain streets cordoned off. The network re-design, however, was carried out by the Police and Traffic Secretariat with the objective of keeping the cordons to a minimum and providing diversions around the blocked areas.

A specific outcome of such a re-design process was the identification, on a section-by-section basis, of a capacity deficit for mobility from north to south near the "Zocalo" area. Consequently, it became necessary to reverse the traffic circulation on some north-south streets. Even some avenues with medians had to be converted to one-way streets to make up for the capacity deficit in the southerly direction.

Regarding enforcement, the police force was not at all adequate to control traffic and enforce the set up cordons and diversions. As such, the Army and volunteers greatly assisted the Police, particularly in the enforcement of cordoned areas. Most of the Police efforts were directed at managing the traffic at intersections with failed signals. In the hours after the disaster, traffic control at intersections was restored to an acceptable level of service through a wide-spread presence of the police force. A balanced assignment of priorities by the Police at intersections with failed signalization helped prevent further grid-locks and expedite rescue activities.

The massive police involvement in traffic control was maintained for the first two days until signal operations at critical intersections were restored and diversion strategies were devised and implemented. By Friday, September 20th, a first draft of traffic diversion plans were prepared by the Traffic Division and submitted to the Police Operations Division for its implementation. The agreed upon diversion plans included the following features:

a) Minimize the number of lane closures along vital street links.

b) Identify roadway links which could be opened by simply removing small amount of debris and artificial obstacles placed by neighborhood residents to close those links.

c) Identify those sections of avenues that could be used for two-way circulation on an alternating one-way basis.

d) Identify those streets on which the traffic direction could be reversed with minimal perturbations and effort in order to further facilitate the rescue and demolition operations.

e) Identify sections which could be used in the reversible mode to favor a dominating direction at different periods of the day.

f) Prepare drawings of the re-designed traffic network for dissemination to the public through newspapers and television stations.

g) Assess the need for traffic signing along main travel corridors affected by diversion plans.

The implementation of these plans on Saturday, September 21 required design and manufacturing of a number of special signs (Fig. 7). These signs included:

a) Wooden barricades with mounted reflectorized metalic sheets and supported by 1.5-inch steel angle sections.

b) A two-way sign for originally one-way streets, framed in a red circle on a navy blue background. The sign showed two arrows, a white arrow for the originial direction of the street and an opposing red arrow to warn drivers of the existence of on-coming traffic.

c) A sign to prohibit drivers from entering a roadway section where demolition activities were in progress.

d) A sign to warn pedestrians of demolition activities.

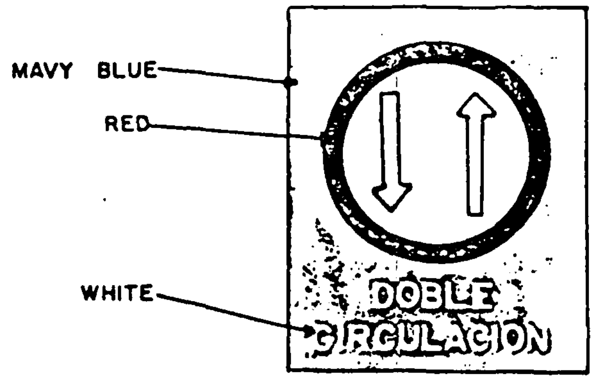
The massive demolition and clean-up activities also brought about the need to establish locations outside the most affected region where the structural debris could be deposited. Paths were designated and signed to be taken by trucks transporting the debris to the deposit sites. The main objective was to speed up the clean-up process so that the debris was not piled up in the streets, thus hampering the vehicular mobility.

## C. MASS TRANSIT-ACTIONS TAKEN

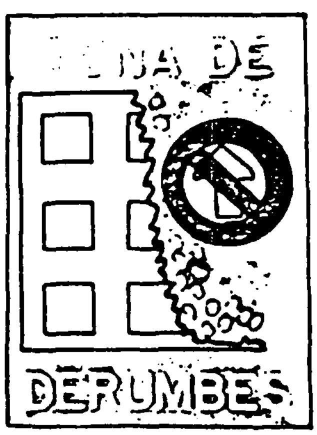
Modifying a transit route was not merely a problem of finding detours around the disaster zones but also a problem of properly informing the users. Given that in Mexico City, transit services are supplied by the City Government (RUTA 100), the Transportation Coordination division (CGT) of the Mayors Office was able to take direct actions to:

a) Back up the Metro by allocating more buses to transport

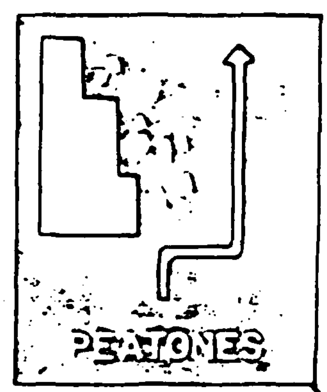

(1) Chevron sign to indicate Detour




(2) One-way Street converted into two-way




(3) Sign for collapsed buildings or being demolished combined with do-not-enter sign




(4) Sign for pedestrians to walk around the zone affected by a damaged building.

Figure 7. Special signs used in Mexico City after the September 1985 earthquake (Ref. 4).

passengers along those segments of any Metro line which was temporarily out of service.

b) Allocate buses to provide limited assistance to victims in carrying their more appreciated belongings.

c) Modify the surface routes according to a daily assessment of further roadway openings after debris removal.

d) Use the newspapers to keep the public informed of any major changes in routes, bus stations, and service frequencies.

In spite of the reduced mobility of people in the first three days, the earthquake brought about major travel pattern changes. Shelters, medical centers, relief and supply centers, and information centers had become major special "Trip Generators." Due to the size of the Mexico City region and the volume of transit passengers handled, it was not possible to greatly modify the transit routes or implement special routes as a response to these travel pattern changes. Consequently, most such transit riders had to find their way around the transit network to their destinations by trial and error.

## D. EMDRGENCY VEHICLES - ACTIONS TAKEN

In the aftermath of the earthquake, it was necessary to mobilize scarce medical resources to widely scattered location in the city. Sporadic fires had also broken out in many locations (Fig. 5). Emergency response agencies, generally understaffed and underequipped, had to make the most efficient use of their resources.

An essential element in efficient use of resources was the time savings which could be realized through selection of the best dispatch routes. The street network conditions, however, changed very rapidly. There was no established mechanism to keep track of these changes. Therefore, the incident points were simply reached by taking routes that were usually taken and modifying them as the need arose. The various information bulletins on the street conditions assembled by the reports from the ground Police patrols and the ten Police helicopters provided some insight into the major street links to be avoided. But such information was not continually updated nor systematically available.

The newly formed organization, SIPROR (Sistema de Proteccion Civil y Rescate) could take up the vital function of roadway condition information inventory and its dissemination to all emergency response agencies. SIPROR was conceived in 1984 as a division of the Police and Traffic Secretariat. Its function was to coordinate emergency response operations in the face of major disasters. But at the time of the 1985 earthquake, SIPROR was organizationally not yet prepared to assume such a role. In addition, as a new group it was not well recognized by other government agencies. Thus, at the time of the earthquake, the role of SIPROR was simply to keep an inventory of supplies such as the amount of water available for the fire department, the number of vehicles in use, the location of ambulances, etc.

Since the earthquake, however, a major emphasis has been placed on developing SIPROR as the focal point in coordinating the emergency response to disasters. Its functions could include a computerized inventory of resources and supplies available, the most updated survey of street conditions, the location of incidents and the type of emergency services needed at each location, receiving and disseminating information from and to the various organizations engaged in emergency response, set-up of shelters and relief posts, and management of relief supplies and other resources sent from other countries, to mention a few.

## E. CROWD MANAGEMENT AND SHELTERS - ACTIONS TAKEN

Initially after the earthquake, the protection of neighborhoods from looting was primarily handled by residents themselves. They usually lived in nearby tents and guarded their residences. On the second day, the Police and Army became actively involved in guarding the damaged areas and preventing looting and riots. At this time a volunteer registration scheme was devised. Badges were distributed to registered volunteers primarily in order to take effective action in dispersing the on-lookers.

Immediately after the disaster, 171 shelters were set up by the City and staffed by volunteers. The refugees were transported to these shelters by buses as well as in volunteered vehicles. Free gasoline was provided to the volunteer vehicles, which also had to be registered. The Ministry of Commerce and Industry distributed basic foodstuffs such as corn, milk, bread, flour, beans, rice, and cooking oil to the shelters. Water, however, was in short supply. Even four weeks after the earthquake, water tanks were still providing only 1 liter of water per person per day as compared to the average pre-earthquake water consumption of 50 liters per capita per day. Long queues were formed for water. The water shortages created a charged atmosphere which at times led to riots. Containing the tense conditions would have been much more difficult had it not been for a wide distribution of water tankers and water plastic bags throughout the city. The water supplies were continuously refurbished by the water supplies arriving from the U.S.

Information dissemination about the victims and their whereabouts was handled mainly by radio and television stations. Both the commercial and government-owned television channels were used extensively in exchanging messages between victims and their relatives and friends. The television Channel 11, belonging to the National Polytechnic Institute of Mexico, provided a continuous broadcast facilitating message exchanging.

Other mass media were also actively involved. "Radio Universidad," a radio station belonging to the National Autonomous University, broadcast information on the roadway traffic conditions, particularly along most heavily traveled corridors. The newspapers published a list of victims rescued and the place they could be reached.

## V. FUTURE NEEDS

In regard to the survey of street conditions in Mexico City, the need existed for a central data base accessible to all agencies involved in emergency response. Many times, similar surveys were conducted and duplicated by two or more organizations under conditions which demanded the best utilization of time and other resources. In addition, the accumulated data needed to be incorporated onto a city map which was quickly reproduced and modified as conditions changed. Critical decisions also needed to be made on cordoning areas, diverting traffic, clean-up of streets, and management of transit resources.

Such capabilities would, of course, be more feasible with a main-frame computer facility. Since main-frame facilities were not available for 72 hours following the September 19 earthquake, a battery-operated micro-computer is therefore recommended. The micro- computer facility would have graphical network editing capabilities and be stationed at a central command post. All information regarding the conditions of the street networks would be communicated to the command center. The computerized map of the network could then be modified based on incoming data. The latest graphical documentation of the network conditions can then be made available to all interested parties in the form of a hard-copy map or by telecommunication links. Figure 8 shows a schematic diagram of the proposed command center.

A micro-computer graphical network editing software has been developed for Mexico City and is currently being tested and modified. In addition to network editing capabilities, such a software could also have features which could make it useful as a traffic management tool in de-

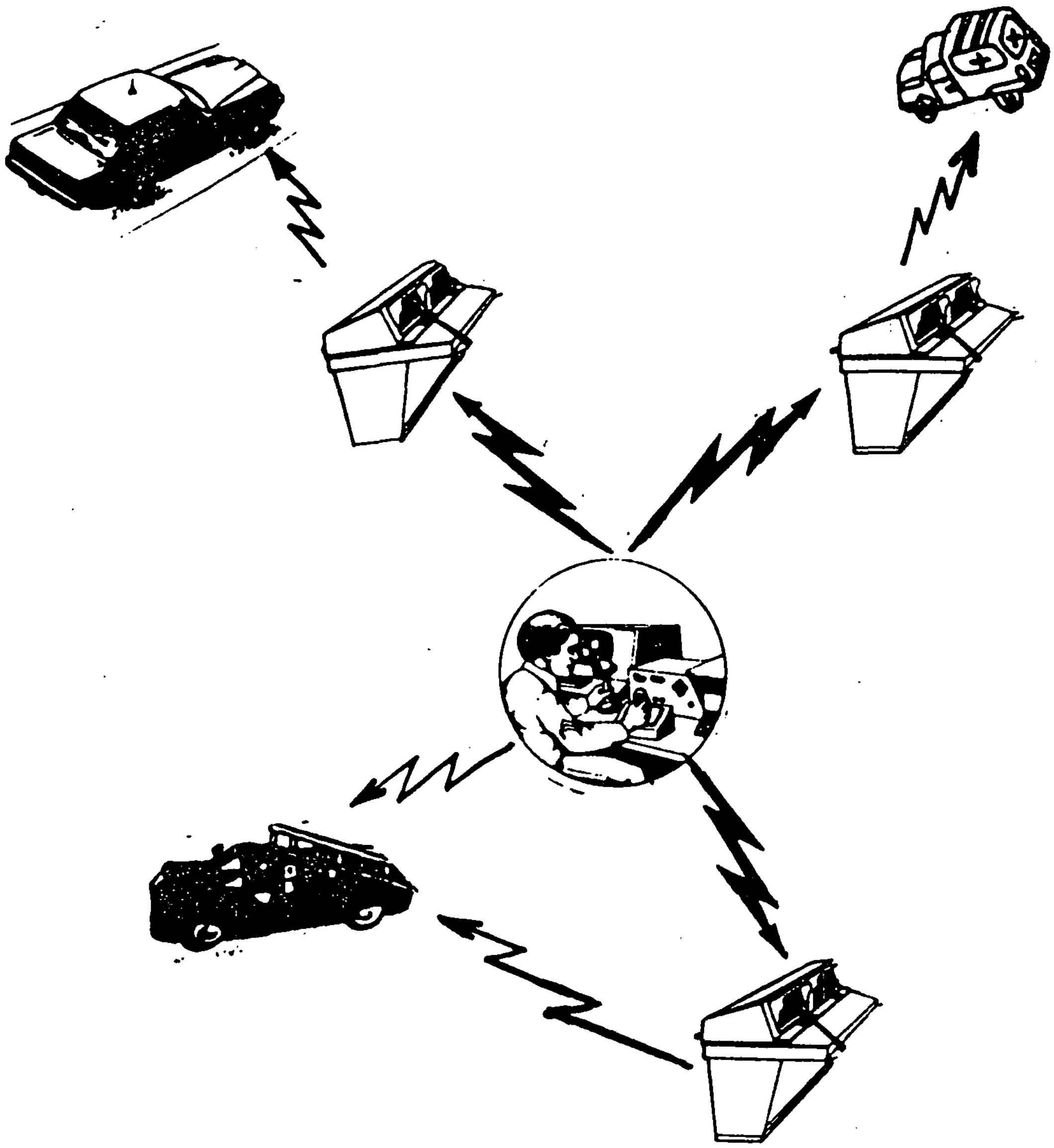


Figure 8. A schematic diagram of the proposed transportation emergency management headquarters.

cisions such as establishing cordon areas and simulating alternative traffic diversion strategies around these areas as well as assessing the need for quantities and types of special traffic control devices. The software can also be used in dispatching emergency vehicles. A shortest path algorithm could be developed to identify the shortest path from any origin to any destination in a network based on the latest network conditions. Furthermore, a transit module could be developed to be used as a decision tool in managing the transit resources, particularly transit vehicles, in light of the diversity of demands for such resources. A prioritization scheme for street clean-up could also be developed by developing priority indices for each closed street link which are a function of reasons behind the link closure, the relative importance of the link in accessing critical response facilities, and the degree of utility of the link in serving traffic and surface transit routes. The command center may also furnish information on the street conditions to the public through a hot-line telephone number.

In short, such a command center could effectively fulfill a number of needs identified regarding the transportation network. Namely, it would

i. promote more efficient use of resoures
ii. provide wide access to information on network conditions to all interested parties
iii. promote further inter-organizational cooperation; and
iv. provide a real-time microcomputer-based transportation decision tool.

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