Mexico City Seismic Alert System

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INTRODUCTION

The Seismic Alert System (SAS) for Mexico City has been operating as an experimental evaluation project since August, 1991. The aim of this project is to mitigate the effects of earthquakes generated in the Guerrero Gap. There is an advantage of 60 sec average for an early warning before a quake that occurs on the Guerrero coast strikes Mexico City, 320 km away. The system is designed to broadcast a universal alert for earthquakes in Guerrero above the threshold $M > 6$, and a limited alert for earthquakes with $M \geq 5$. The warning radio receivers are installed in elementary schools, commercial radio stations, offices of Civil and Mexican government agencies, universities, public services, and housing complexes. The civil authorities have backed up the project by increasing the preparedness of the people, to ensure that if an earthquake occurs people are ready to get through it safely and respond effectively, even in the case of a false alert.

The Michoacan earthquake of September 19, 1985 caused many deaths and severely damaged many buildings in Mexico City. On the other hand, the San Marcos and Guerrero gaps have the highest seismic risk in the Pacific Coast (Anderson et al., 1987, 1989a, 1989b), and if the major earthquake ($M > 7$) expected in these gaps takes place, the damage in Mexico City would be similar to that in the Michoacan earthquake (Anderson et al., 1993), because the seismic waves are enormously amplified at lake bed sites and even at hill zone sites (Ordaz et al., 1992).

The idea of an earthquake warning system was proposed as early as 1868 by Cooper (Nakamura et al., 1988), and the UrEDAS warning system has been in service in Japan for more than 20 years (Nakamura and Saito, 1982). A model for a seismic computerized alert network (SCAN) (Heaton, 1985) was proposed to process this information automatically and initiate safeguard actions. More recently, an Earthquake Warning System has been installed in Taiwan (Lee et al., 1995a). Additionally, systems for rapid disaster response in the cities have been proposed and implemented. The Caltech-USGS Broadcast of Earthquakes (CUBE) sends to the emergency operation centers in California information about epicenter and magnitude and a map of the areas most likely to have sustained the worst damage.

In Mexico, the Engineering Institute of the National University of Mexico (UNAM) operates the Seismotelemetric Information System of Mexico (SISMEX) (Prince et al., 1973), an analog real time radio telemetry system where recordings of the remote events typically are made in the central installation on campus before the ground shaking arrives. SISMEX was developed by the UNAM in a joint project with the United Nations Educational, Scientific and Cultural Organization (UNESCO, Paris) in 1968–70. This telemetry network was designed for strong motion recording. The system started to operate in 1970 and has been operating continuously to date. The experience gained in the design, installation, operation and maintenance of SISMEX has been used in the implementation of the Mexico City early warning Seismic Alert System.

MEXICO CITY SEISMIC ALERT SYSTEM

The Seismic Alert System for Mexico City has been operating as an experimental project since August, 1991. The aim of this project is to mitigate the effects of earthquakes generated in the Guerrero Gap. The velocity difference between seismic and radio waves gives an advantage of 60 sec average for an early warning before an earthquake strikes Mexico City.

The Seismic Alert System (SAS) was designed in 1989 (Espinosa Aranda et al., 1989a). The system consists of four parts: the Seismic Detection System, a Dual Telecommunications System, a Central Control System, and a Radio Warning System for users.

When an earthquake is detected by the field stations, warning messages are sent from the remote sites on the coast.
of Guerrero to the central control system in Mexico City, where they are processed and evaluated, and if it is determined that the event is $M_1 (M \geq 6)$ or $M_2 (6 > M \geq 5)$, an encoded signal is broadcast to trigger the alerting radio receiver, which warns the community.

**Seismic Detection System**

The Seismic Detection System consists of 12 digital strong motion field stations distributed at approximately 25-km intervals along the Guerrero Coast. The source area covered is all the coast of the Guerrero state (Figure 1). The field station consists of sensors, a data acquisition board, a standard commercial IBM PC-compatible Laptop microcomputer, and a VHF radio transmitting system. The sensors are silicon piezoresistive triaxial accelerometers. The microcontroller based acquisition board samples 10 bit data at a 100 Hz sampling rate. The Laptop microcomputer does the data processing and stores the data in a standard 3.5" floppy disk. The VHF radio transmits the information of earthquakes detected to a Central Radio Relay Station located near Acapulco.

Each SAS field station makes the local event detection and analysis to estimate its energy and growth rate on the site, and then the information is sent to the central control system, where it is compared with a function constructed from historical records to determine the magnitude of the event detected. If any other station sends an equivalent message corresponding to the same event, then the early warning alert is issued. This method has redundancy because there are several stations that can back up each other in case one station fails; experience has demonstrated that in a major earthquake several stations detect the event one after the other. The communication system sends information only when an event happens.

Each field station detects any seismic event of interest for focal distances less than 100 km. Thus, the area covered by the system or window of acquisition is approximately 450 km long and 200 km wide. This fact has been considered in
designing the seismic trigger algorithm for the SAS. The seismic signal detector is of the Short Term Average/Long Term Average Ratio (STA/LTA) type. Each field station senses in real time the P and S phases of the seismic wave arrival, and the algorithm uses the average square input as a characteristic function for detection and energy magnitude evaluation. If the function exceeds a given threshold, then a P phase has been detected, and a second threshold is used to detect the S phase arrival (Espinosa Aranda et al., 1989b). The algorithm was tuned up with earthquakes M > 5. Data of the Guerrero Network (Anderson et al., 1989b) were used to calibrate the trigger algorithm. After detection and energy level evaluation with the first arrival of a signal, the field station determines if a message is to be sent to the Central Station in Mexico City. Once this message is sent, it is not reevaluated by the field station.

**Dual Telecommunications System**

The communication system is based on one VHF Central Radio Relay Station near Acapulco and three UHF Radio Relay Stations distributed along the route to Mexico City. To improve reliability, the SAS was designed to be redundant with two independent communication paths, sending the duplicated data through different radio frequencies. Additionally, every twelve hours each field station generates and transmits its own signal code to validate that it is operating and to verify the communication link.

**Central Control System**

The central control system is also a redundant dual system. Each subsystem includes a 486 IBM PC-compatible computer, a radio receiver, and a radio transmitter. The central control system is located at the facilities of the Centro de Instrumentacion y Registro Sismico (CIRES) in Mexico City. The messages received from the field stations in Guerrero are processed and are considered valid only if an earthquake is detected by two or more stations.

In order to generate an early warning signal to the public, two thresholds are defined: M_1 (M ≥ 6) and M_2 (6 > M ≥ 5). When an earthquake M_1 or M_2 is determined, a warning message is automatically broadcast by the UHF radio transmitter located in the central control station. In case of ambiguity between two stations with messages M_1 and M_2 from two stations, the message with greater magnitude is the one that is broadcast.

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### TABLE 1

**Summary of Earthquakes Detected in the Capture Zone**

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>M_1</th>
<th>M_2</th>
<th>M &lt; 5</th>
<th>Event</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>M ≥ 6</td>
<td></td>
<td></td>
<td></td>
<td>Not</td>
<td>Confirmed</td>
</tr>
<tr>
<td>M ≥ 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6.7</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6.3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5.8</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5.6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5.2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>5.1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>10</td>
<td>16</td>
<td>31</td>
<td>64</td>
</tr>
</tbody>
</table>

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### TABLE 2

**Time Advantages of Early Messages Issued as M_1**

<table>
<thead>
<tr>
<th>Event</th>
<th>Magnitude</th>
<th>Early Warning Time (Anticipating time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov 9, 1992</td>
<td>4.8</td>
<td>–</td>
</tr>
<tr>
<td>May 14, 1993</td>
<td>5.8</td>
<td>65 sec</td>
</tr>
<tr>
<td>May 14, 1993</td>
<td>6.0</td>
<td>73.5 sec</td>
</tr>
<tr>
<td>May 15, 1993</td>
<td>4.8</td>
<td>58 sec</td>
</tr>
<tr>
<td>Oct 24, 1993</td>
<td>6.7</td>
<td>58 sec*</td>
</tr>
<tr>
<td>Sep 14, 1995</td>
<td>7.3</td>
<td>72 sec</td>
</tr>
<tr>
<td>Sep 15, 1993</td>
<td>5.0</td>
<td>70 sec</td>
</tr>
</tbody>
</table>

*evaluated as M_1, but issued as a supervision message.

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### TABLE 3

**Time Advantages of Early Messages Issued as M_2**

<table>
<thead>
<tr>
<th>Event</th>
<th>Magnitude</th>
<th>Early Warning Time (Anticipating time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 31, 1993</td>
<td>5.1</td>
<td>46 sec</td>
</tr>
<tr>
<td>Sep 10, 1993</td>
<td>4.9</td>
<td>70 sec</td>
</tr>
<tr>
<td>May 22, 1994</td>
<td>5.6</td>
<td>30 sec</td>
</tr>
<tr>
<td>Oct 29, 1994</td>
<td>5.1</td>
<td>58 sec</td>
</tr>
<tr>
<td>Dec 10, 1994</td>
<td>6.3</td>
<td>34 sec</td>
</tr>
</tbody>
</table>
There are two warning signals that can be issued to the public:

- a general alert that is issued to all the public when the event satisfies the $M_1$ threshold. This triggers commercial radio stations, CIRES radio receivers, and digital receivers.
- a restricted warning that is issued when the event is $M_1$ and triggers all CIRES radio receivers installed except those corresponding to the commercial radio stations.

Additionally, there are radio supervisory signals that are sent periodically by the central control station to the CIRES radio receivers that allow users to verify that their system is functioning properly.

**Radio Warning System**

When an early warning is issued by the central control system radio transmitter, the general public has three possible ways to receive this message. In other words, there are three different types of radio receivers: those made by CIRES, the standard commercial AM/FM radio receivers, and digital receivers.

The custom radio receivers supplied by CIRES are currently installed in 31 elementary schools, 25 commercial radio stations, the offices of the XXXVI District of the Mexican army, the offices of the Mexican Power Generation Company (Comision Federal de Electricidad), the Mexico City subway transportation system (METRO), an office of the Mexico city government (Secretaria General de Obras), the Civil Disaster Management office (Proteccion Civil), the Central Agency for Disaster Prevention (CENAPRED), the police department of the state of Mexico (Direccion General de Seguridad Publica, Policia y Transito), the law enforcement task force (Procuraduria General de Justicia) and some universities like the UNAM and the Monterrey Institute of Technology; all of them contribute in funding the project. Also, there are 11 strong motion accelerometers from CIRES installed in Mexico City, which are triggered remotely with the early warning. This remote trigger of accelerographs is done with the early warning in Mexico City. The trigger of earthquakes detected within the area of the acquisition window or capture zone are: 7 as $M \geq 6$, 10 $M \geq 5$, 16 $M < 5$, and 31 EVENTS NOT CONFIRMED as shown in Table 1. The last column shows the type of early warning issued, which could be $M_1$, $M_2$ or no warning.

The early warning times for earthquakes in the $M_1$ and $M_2$ categories are given in Tables 2 and 3. The detection of earthquakes $M_1$ has given time advantages ranging from 58 to 73.5 sec as shown in Table 2. The first four $M_1$ messages in Table 2 were issued to all users except the AM/FM radio commercial stations, which were connected in August 1, 1993, also the first and fourth events were overestimated due to erroneous site factors, which were later corrected.

The anticipation times in Tables 2 and 3 were calculated using the records of the Guerrero field stations and a record triggered by the early warning in Mexico City. The trigger of the Mexico City accelerometers is done with the early warning signal. The anticipation time of the event of November 9, 1992 was not calculated because we had no record in Mexico City of this event with which to compare. Table 3, with earthquakes in category $M_2$, has fewer events because we do not have records in Mexico City to calculate the advantage time. The time advantages range from 30 to 70 sec.

Figures 2, 3, 4 and 5 illustrate the system performance for the events of May 14, 1993, October 29, 1994, December 10, 1994 and September 14, 1995. Figure 2 shows records for an $M_2$ alert on October 29, 1994. The map shows the location of the stations triggered. Below that, in real time, the figure shows the earthquake records gathered by the field stations, the time when the alert was on, and one of the earthquake accelerograms registered in Mexico City. For the two events on May 14, 1993, M 5.8 and M 6.2, two early warnings were issued, with advantages of 34 and 73.5 sec (Figure 3). The overhead time of the communication channel is typically 1 sec. Figure 4 shows the information for the $M_1$ alert on Dec 10, 1994, and figure 5 shows the information for the successful $M_2$ warning on Sep 14, 1995.
CENTRO DE INSTRUMENTACION Y REGISTRO SISMICO, AC
SEISMIC ALERT SYSTEM

EVENT RECORDED ON OCTOBER 29, 1994, IN GUERRERO, OT=10:44:08.6, M = 5.1 °Richter

Alert Seismic Function in Mexico City

ACCELERATION RECORD PENJAMO #5

(1) Pre-Alert Time = 10:44:21

ACCELERATION RECORD JARDIN #6

(2) Alert Confirmation Time = 10:44:23

ACCELERATION RECORD PLAZA INN

(3) OTA = 10:44:25

Seismic Alert Signal
range 5°< M <6°

(4) Anticipate time AT = 58 sec

(5) Wave P arrival = 10:44:51

(6) Wave S arrival = 10:45:23

Figure 2 Time diagram of Early Warning advantage in Mexico City, May 14, 1993.
CENTRO DE INSTRUMENTACION Y REGISTRO SISMICO, AC
SEISMIC ALERT SYSTEM

EVENT RECORDED ON MAY 14, 1993, IN GUERRERO, OT = 21:09:39, M = 6.0° Richter

1st Latitude 16.43° N, Longitude 98.71° W
2nd, Latitude 16.04° N, Longitude 98.70° W

ACCELERATION RECORD HUEHUETAN #12
(1) T Alert 1 = 21:10:09
(2) T Alert 2 = 21:12:49

ACCELERATION RECORD MARQUELIA #11

Alert Seismic Function in Mexico City

ACCELERATION RECORD TLATELOLCO
(3) Ts = 21:11:14
(4) Ts = 21:14:2.5
(5) Ts = 21:11:00

OT = Origin Time 21:09:39, Geofísica, UNAM
1,2: Seismic Alerts
3: Acceleration "Tlatelolco" initial
4,5: Wave S arrival
AT = Anticipate Time = Ts - T Alert

Figure 3 Time diagram of Early Warning advantage in Mexico City, October 29, 1994.
CENTRO DE INSTRUMENTACION Y REGISTRO SISMICO, AC
SEISMIC ALERT SYSTEM

EVENT RECORDED ON DECEMBER 10, 1994, IN GUERRERO, OT=10:17:40.9, M =6.3 °Richter

- Recorder stations
- Epicenter: Latitude 18.02° N, Longitude 101.56° W

ACCELERATION RECORD TETITLAN #3

(1) Pre-Alert Time = 10:18:19

ACCELERATION RECORD EL VEINTE #2

(2) Alert Confirmation Time = 10:18:21

Alert Seismic Function in Mexico City

(3) OTA=10:18:23

Seismic Alert Signal
range 5° < M < 6°

ACCELERATION RECORD PLAZA INN

(4) Anticipate Time

AT = 34 sec

(5) Wave P arrival = 10:18:29
(6) Wave S arrival = 10:18:57

OT = Origin Time = 10:17:40.9, SSN, Geofisica, UNAM
M = Magnitude ° Richter, SSN, Geofisica, UNAM
(3) OTA = Operation Time Alert
(4) AT = Wave S arrival - OTA

Figure 4 Time diagram of Early Warning advantage in Mexico City, December 10, 1994.
CENTRO DE INSTRUMENTACION Y REGISTRO SISMICO, AC
SEISMIC ALERT SYSTEM

EVENT recorded on September 14, 1995, in Guerrero, OT = 08:04:35.8, M = 7.3° Richter

Epicenter: Latitude 17.00° N, Longitude 99.00° W

ACCELERATION RECORD MARQUELIA #11

1) Pre-Alert Time = 08:04:42

ACCELERATION RECORD HUEHUETAN #12

2) Alert Confirmation Time = 08:04:46

Alert Seismic Function in Mexico City

3) OTA = 08:04:47

Seismic Alert Signal
range M > 6°

4) Anticipation Time

ACCELERATION RECORD CIRES, AC.

AT = 72 sec

5) Wave P arrival = 08:05:29
6) Wave S arrival = 08:05:59

OT = Origin Time = 08:04:35.8, SSN, Geofisica, UNAM
M = Magnitude 7.3° Richter, SSN, Geofisica, UNAM
(3) OTA = Operation Time Alert
(4) AT = Wave S arrival - OTA

Figure 5 Time diagram of Early Warning advantage in Mexico City, September 14, 1995.
**Incidents of System Problems**

During more than 45 months of operation of the early warning system, three problems have occurred. The first incident was a missed alarm during the October 24, 1993 1:52 local time M 6.7 earthquake. The event was detected and evaluated correctly by the field stations, but the early warning message issued was of supervision instead of alert, due to a software error in the microcomputer of the Central Control System. As a result the AM/FM commercial radio stations did not send any message to the public. This error was corrected within the next eight hours.

The second was a false alarm broadcast to the public on November 16, 1993, 19:20 local time. A battery failure in the supply system of one of the field stations generated noise in the accelerometers' output, which was detected as an earthquake by the STA/LTA detector. Due to this false warning, the Central Control System sent a message to the AM/FM stations, which was received by the public listening to the radio stations.

In the third incident, on May 31, 1995, an M 4.6 earthquake struck along the Guerrero and Oaxaca coast at 6:49:47 local time, and a restricted early warning M1 was issued by CIRES. The signal was received in one commercial radio station where a wrong CIRES receiver, set to receive warnings M1 and M2, was installed due to a human error. Although no warning was intended to be issued to the public, at that moment one of the most popular programs of news and reports in the city was on the air, and the chief reporter announced that a big earthquake was about to strike Mexico City. This caused some panic and anger, but no person was hurt or injured because of the false alarm.

An M 7.3 earthquake on Sep 14, 1995 at 8:04:30, local time, was detected by the Seismic Alert System as M > 6. Six stations detected the event; the first one was Marquelia (station 11) at 8:04:43, and the second one was Huehuetan (station 12) at 8:04:47, which confirmed the event. The M1 message was issued to 42 AM/FM commercial radio stations, 30 elementary schools, the housing complex of El Rosario, and all other places where it is connected. The subway system used the early warning for stopping the trains 50 sec before the main shock. Three radio stations reported that the receivers didn't work because they were not connected yet. There were no casualties in Mexico City from this earthquake, but there were some minor injuries and minor damage in buildings. Four persons were killed and additional people were injured in the state of Guerrero where houses collapsed. The earthquake was felt by the people in the states of Guerrero, Oaxaca, Puebla, Veracruz, Tlaxcala, Jalisco and the state of Mexico.

**PERFORMANCE**

The system has been completed in parts. The first part, including communications from the accelerometer sensors to the Central Control System, was finished and put into operation in August, 1991. This part did not have redundancy at that time. The second part, including the alerting CIRES radio receivers, started operation in January, 1993. The third part incorporated the redundancy and was completed in December 1993.

An earlier attempt to calculate the reliability of the system was made using the data derived from September, 1991 to July, 1993 (Jimenez et al., 1993). Evaluation is somewhat ambiguous, since there have been changes in hardware and software throughout the operation, both to correct bugs and to improve the system.

Figure 6 shows a histogram of component failures (72 total) from August, 1991 to August, 1995. The common type of failures are due to power supplies, frequency shift in radios, radio interference, software errors, vandalism and mechanical failures due to hurricanes. The receivers installed for the general public were not considered in this calculation because their use and how they are connected is not under control of CIRES.

**Availability of the system and the histogram of failures**

Since the start of operation, the system has accumulated 72 failures. Of these, 68 were minor and only four affected the whole system. During those 48 months the system has been out of operation 136 hours for preventive and corrective maintenance purposes giving the factors of availability (A) and unavailability (U):

\[
U = \frac{136}{29930} = 0.00454393 \tag{1}
\]

\[
A = 1 - U = 0.995456 \tag{2}
\]

We consider this an acceptable level of availability, but obviously we seek to improve it.

**DISASTER PREVENTION AND THE EARLY WARNING SYSTEM**

The civil government authorities who sponsored the project have made considerable efforts to increase the preparedness of the people, to ensure that if an earthquake occurs, people are ready to get through it safely and to respond to it effectively. This effort is covered mainly by means of the Civil Disaster Management office from the Mexican government (*Proteccion Civil*), although volunteer groups, government agencies and individual citizens are also involved.

Some of the programs that have been implemented are:

- *Proteccion Civil* have carried out a campaign for earthquake exercises of building evacuation in Mexico City. This campaign has been completed in some cases with the aid of the restricted early warning signal in public buildings, government offices, universities and hospitals.
There is a program for issuing the early warning alert each two months for exercise purposes.

City authorities printed and mailed 1,500,000 booklets to the population of Mexico City. This pamphlet describes briefly the early warning alert.

A permanent program for earthquake exercises of evacuation for children is sponsored by the Secretariat of Public Education and is carried out in elementary schools.

Radio spots are transmitted during the day by the commercial radio stations, reminding the people what to do if an earthquake strikes.

A campaign trains volunteers as emergency managers.

Also the community and several volunteer groups have become involved in the earthquake disaster prevention program, and some have asked for the installation of Cieres radio receivers. As an example, a program for providing the early warning alert to the housing complex of El Rosario with 200,000 inhabitants was started. This community is considered the biggest of its kind in Latin America. The first part of this program was completed May 31, 1995 and covers approximately 10,000 people. The system employs a Cieres radio receiver with accessories to voice an alert message on 32 high-power loudspeakers installed in the center of the complex. This project was carried out in cooperation with the municipal authority officials, the community representatives and the Civil Disaster Management Office (Proteccion Civil).

**DISCUSSION**

Improving earthquake magnitude determination is one of the most important tasks that is being carried out. Considerable effort has been expended to enhance the detection algorithm by analyzing the existing data base of earthquakes in order to improve the detection and magnitude estimation of an incoming earthquake. Also improvements in hardware are planned to enhance the system architecture, making it more flexible.

The failure histogram (Figure 6) shows that failures have diminished to a rate of one per four months. In order to detect an earthquake that lasts a few seconds, the system should have better factors of availability and reliability, but the cost could be very expensive.

Extensive work is being done to enhance the security of the system hardware and software and to improve human performance. This includes writing system procedural, administrative, physical, personnel, and communications security controls.

The radio communication system has had frequent problems with interference and noise due to the high degree of use of the radio spectrum in Mexico City, the most populous city in the world. Unfortunately, the radio link has been the best way to reach the field stations that are normally located in places otherwise not accessible. The use of fiber optics is not feasible due to the limited infrastructure of the Mexican communications system. Although there is a program to introduce fiber optics to link the more important cities in Mexico, the majority of the medium and small cities in our country cannot access it.

Another problem is the limited coverage of seismically active areas that are of potential risk to Mexico City. At present the Seismic Detection System is only covering the Guerrero Gap, but there are other seismic risk areas along the Pacific Coast of Michoacan and Oaxaca, not covered by the current system, that can affect Mexico City. Also at present, the warning system only covers the Mexico City population.
The use of the new Mexican satellite *Solidaridad I* could become a solution of several of these problems. The messages could be transmitted via satellite from the field stations to the Central Control System in Mexico City, improving reliability in communications, reducing the number of relay stations and the intrinsic noise of operation. Also, it would be feasible to cover more seismic and volcanic risk areas, extending the use of the seismic early warning signals to more highly populated Mexican cities.

The experience gained in the interaction with the community and their response to the early warnings has been very valuable. Contrary to some expectations, on November 16, 1993, when a false alarm was issued to an estimated radio audience of 2,000,000 people in rush hour (19:20 local time) in a city of 20 million people, common sense prevailed. Before that, an argument used against disseminating the early warning to the general public was that many people could die because of situations of panic in public places. Although some people were already trained for disaster situations when the false alarm triggered, the majority of the public was not. However, on November 16, nobody was injured or killed because of panic.

Although there were efforts to distribute 1,500,000 pamphlets in a 20,000,000 people city, many people were not reached by the information. There are many persons who had been through the traumatic experience of the 1985 Michoacan earthquake, but there are still many more people who ignore or do not know what to do when the early warning sounds and would not do anything to prevent or minimize the disaster.

**CONCLUSION**

The most important objective of the Mexico City sponsoring authorities and CIRES is to improve reliability of the early warning seismic system. Carrying out a campaign of information about the concepts underlying the SAS and understanding their strong points and limitations with a continuous program to train people will hopefully mitigate in the near future the undesirable but unavoidable effects of a severe earthquake. The government attitude is that of maintaining the early warning Alert System as a public service operating with a nonprofit organization such as CIRES.

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