EARTHQUAKE EARLY WARNING and RAPID LOSS INFORMATION GENERATION IN ISTANBUL

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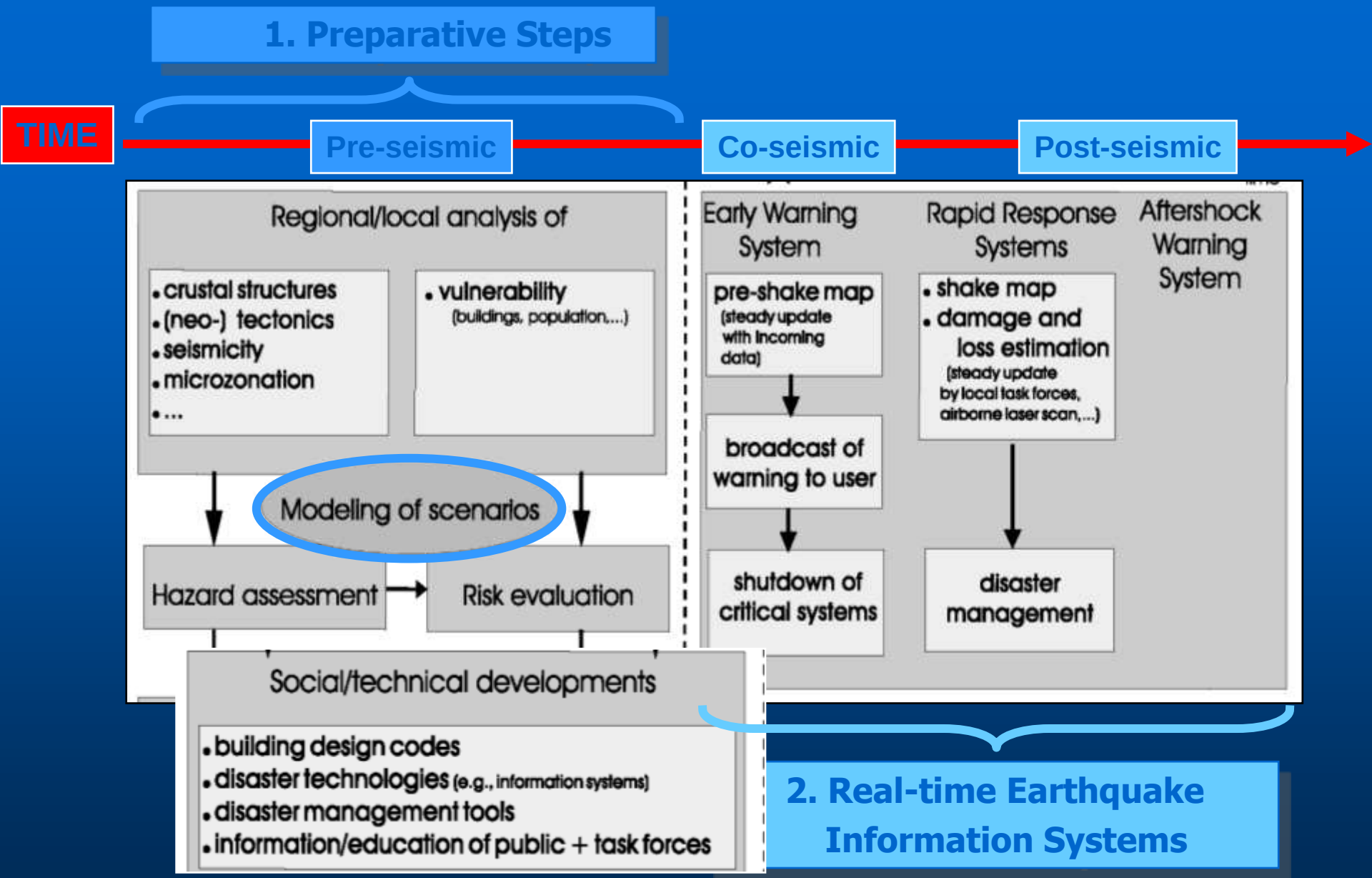


After Böse (2006)

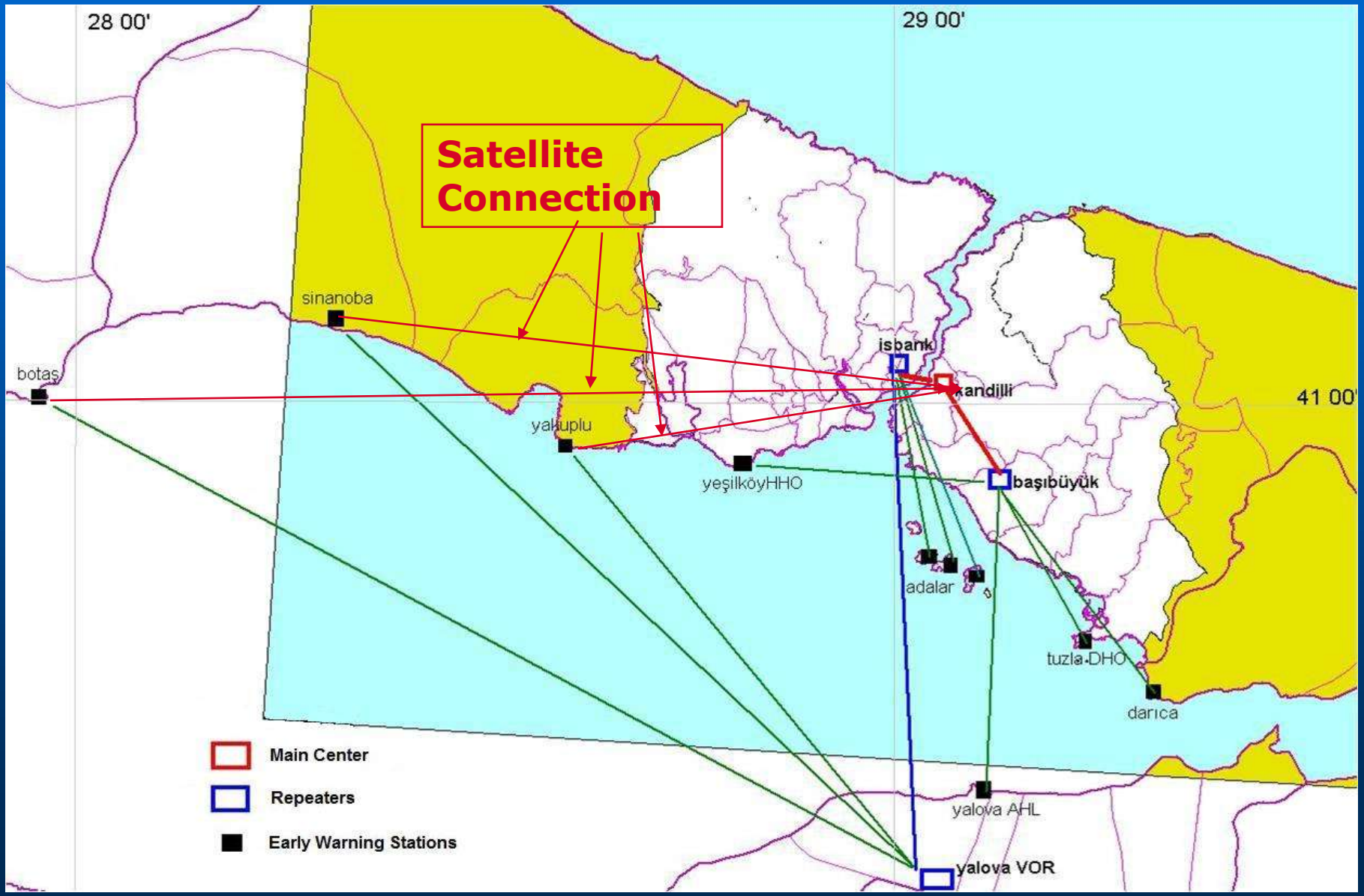
ISTANBUL EARTHQUAKE EARLY WARNING SYSTEM

The Early Warning part of the I-NET 10+2 strong motion stations were located as close as possible to the Great Marmara Fault zone in “on-line” mode.

Data Transmission is provided with Spread Spectrum Radio Modem and Satellite.

The continuous on-line data from these stations is used to provide real time warning for emerging potentially disastrous earthquakes.

DISTRIBUTION OF EARLY WARNING STATIONS and RADIO-MODEM TRANSMISSION



REAL-TIME STRUCTURAL DAMAGE RELATED PARAMETERS

Many researchers have investigated the relationships between the earthquake damage and the ground motion parameters such as peak ground motion amplitudes, spectral amplitudes at selected periods.

Arias Intensity, Cumulative Absolute Velocity and Housner's Spectrum Intensity.

$$PGA = max\left|a(t)\right| \quad where \quad \left|a(t)\right| = \sqrt{a_x^2(t) + a_y^2(t) + a_z^2(t)}$$

$$I_{aX} = \frac{2\pi}{g}\int_0^t [a_X(t)]^2 dt,$$

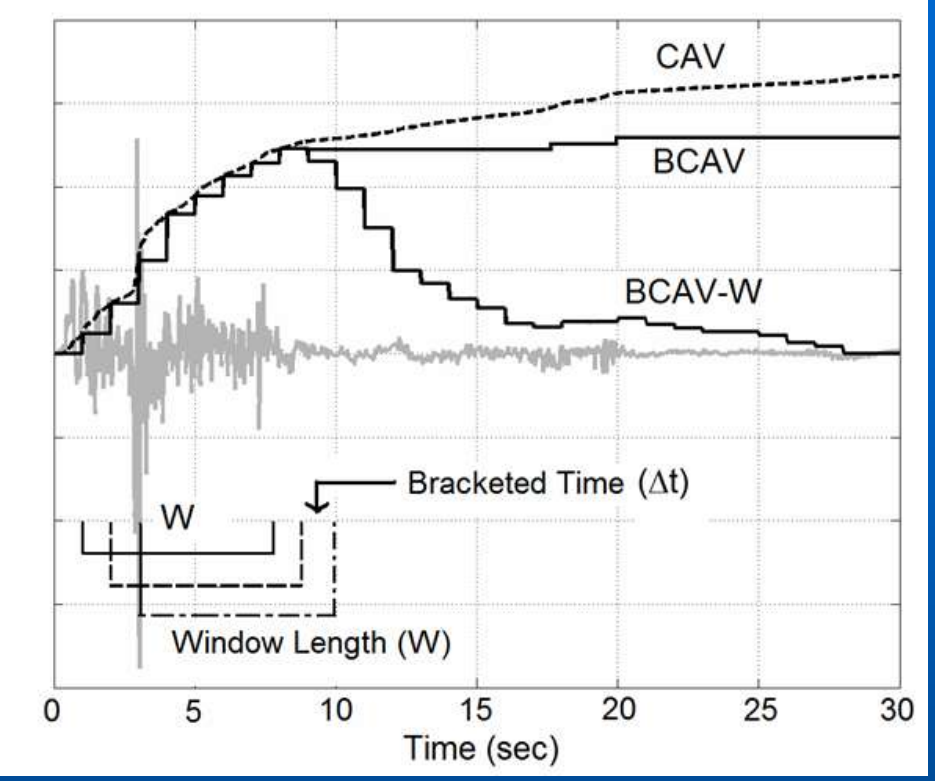
$$SI = \frac{1}{2.4}\int_{0.1}^{2.5} S_v(T,\ \xi)dT.$$

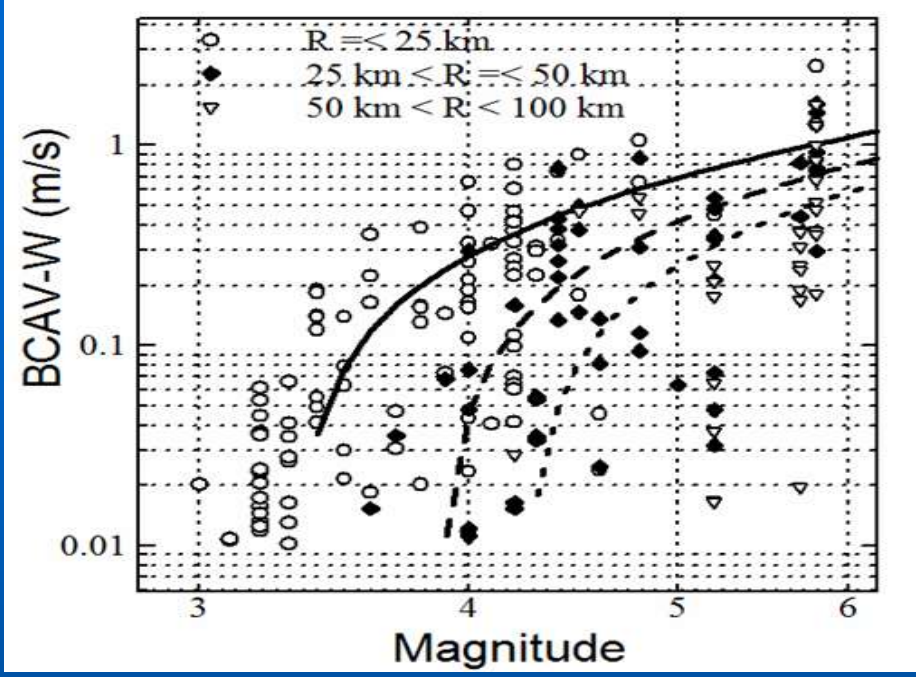
$$\mathrm{CAV} = \int_0^t |a(t)|\, dt,$$

$$BCAV = \sum \int_{t_i}^{t_i+\Delta t} \left|a(t)\right| dt \quad where\ \Delta t = 1\,sec,\ max\left|a(t)\right| > 0.025\,g$$

Nakamura (2004) defined the so-called "Destructive Intensity, DI", represented by the logarithm of the absolute value of the inner product of the acceleration and a velocity vectors:

DI = log (|Σ(*a*.*v*)|), MMI=(11/7)*DI + 4.27

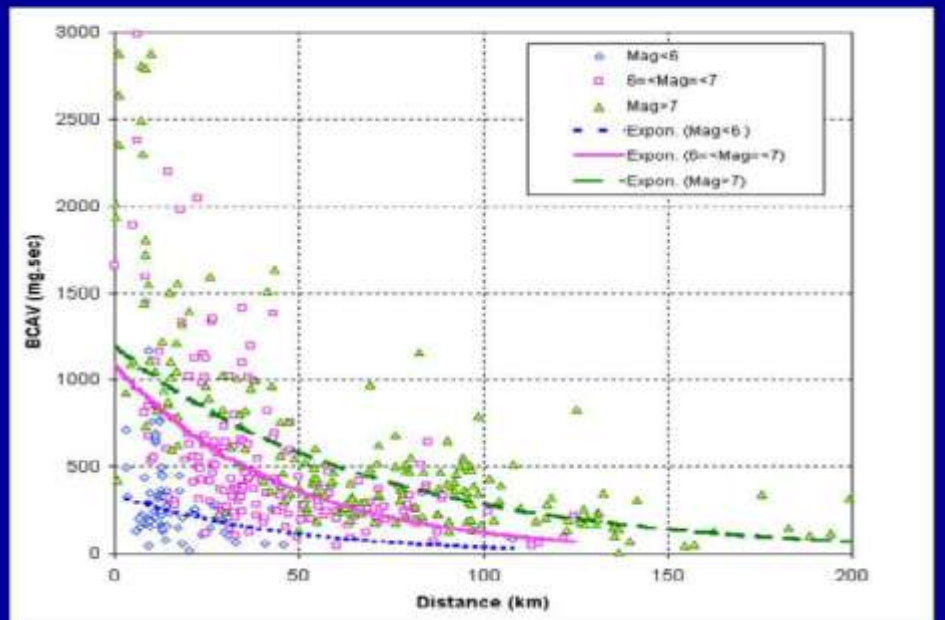


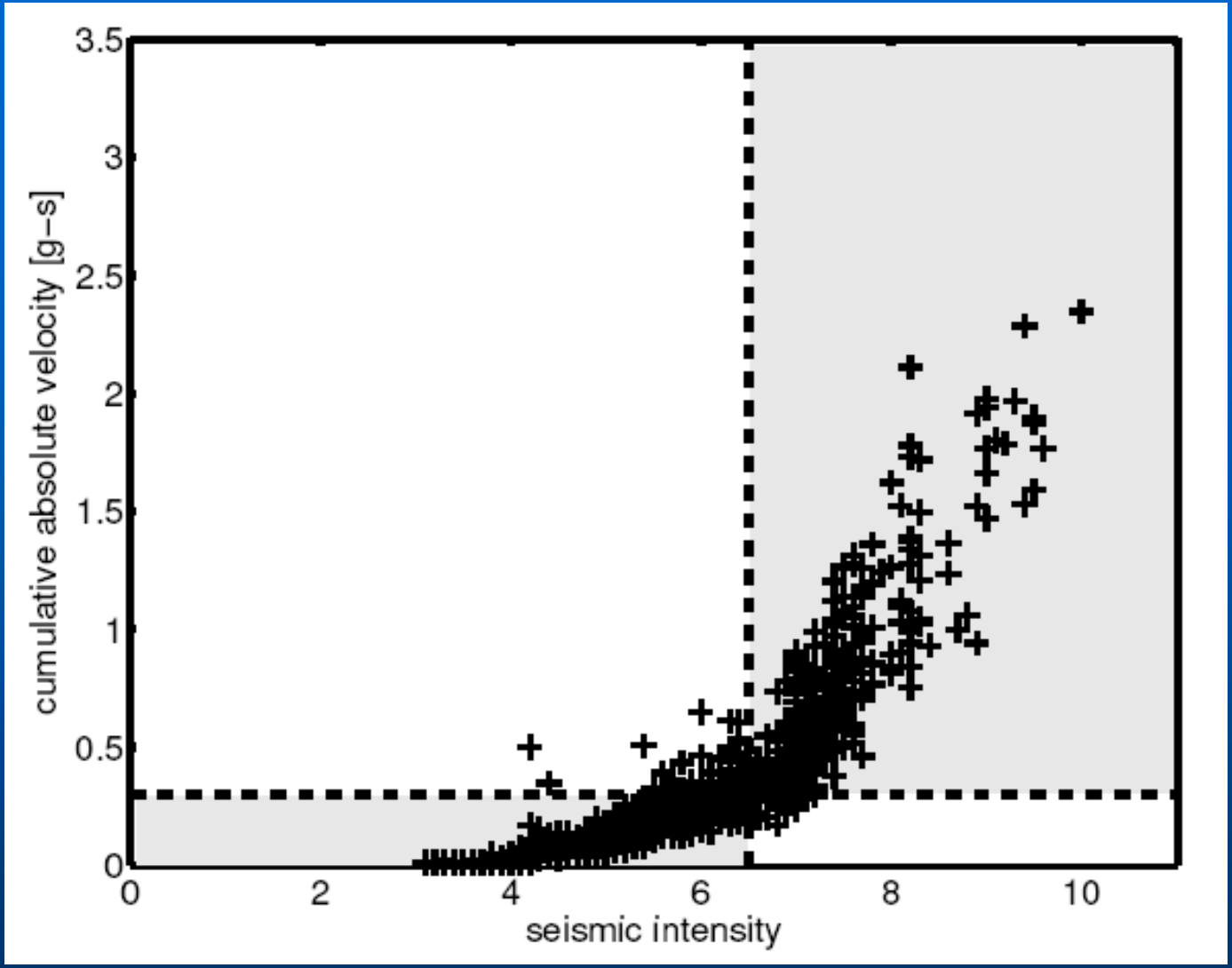


BCAV – Window Length=1s

BCAV – W (Window Length=8s)

BCAV-W16 versus epicentral distance for different magnitude ranges (hard soil)





Correlation between CAV and computed seismic intensity

(Computed Seismic Intensities are obtained from the FAS of simulated accelerograms using Sokolov (2002))

Considering the complexity of fault rupture and the short fault distances involved, a simple and robust Early Warning algorithm, based on the exceedance of specified threshold time domain amplitude levels (band-pass filtered accelerations and the cumulative absolute velocity) is implemented.

The early warning information (consisting three alarm levels) will be (are) communicated to the appropriate servo shut-down systems of the recipient facilities, which will automatically decide proper action based on the alarm level.

Depending on the location of the earthquake (initiation of fault rupture) and the recipient facility the alarm time can be as high as about 8s.

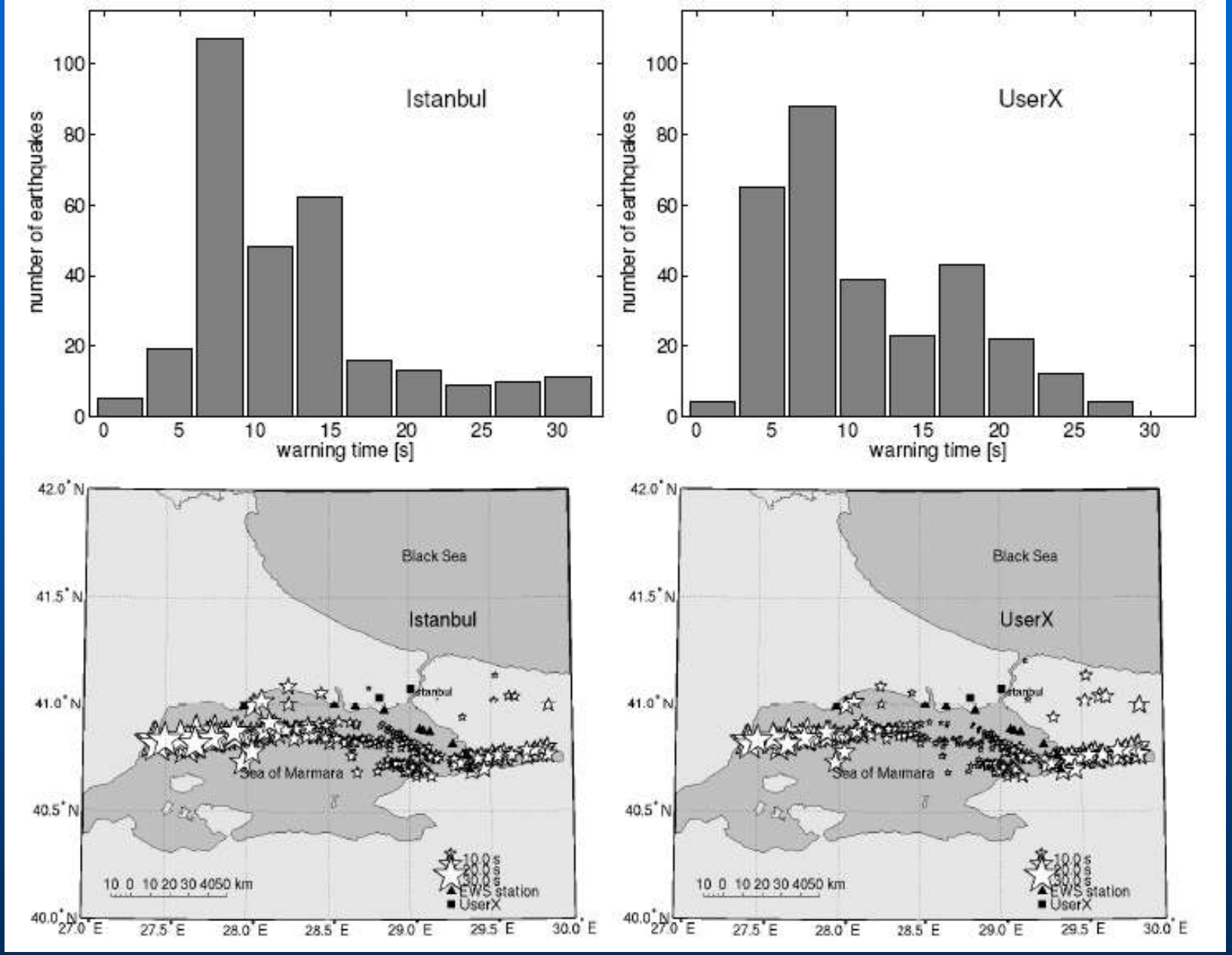
EW BASED ON EXCEEDANCE OF FILTERED PGA TRESHOLD – *CURRENLY APPLIED PROCEDURE*

- All online acceleration data from all stations will be low-pass filtered at selectable frequencies of 12 and 25 Hz.
- When any acceleration (on any channel) in a given station exceeds a selectable first threshold value (20 mg) it will be considered a vote
- Whenever we have 3 (selectable) station votes within a selectable time interval of (5s) after the first vote it will be declared the first alarm.
- After the first alarm, whenever we have 3 (selectable) votes for the second acceleration threshold value (50 mg) within selectable time interval of (5s) after the first vote it will be declared the second alarm.
- After the second alarm, whenever we have 3 (selectable) votes for the third acceleration threshold value (100 mg) within selectable time intervals of (5s) after the second vote it will be declared the third alarm.

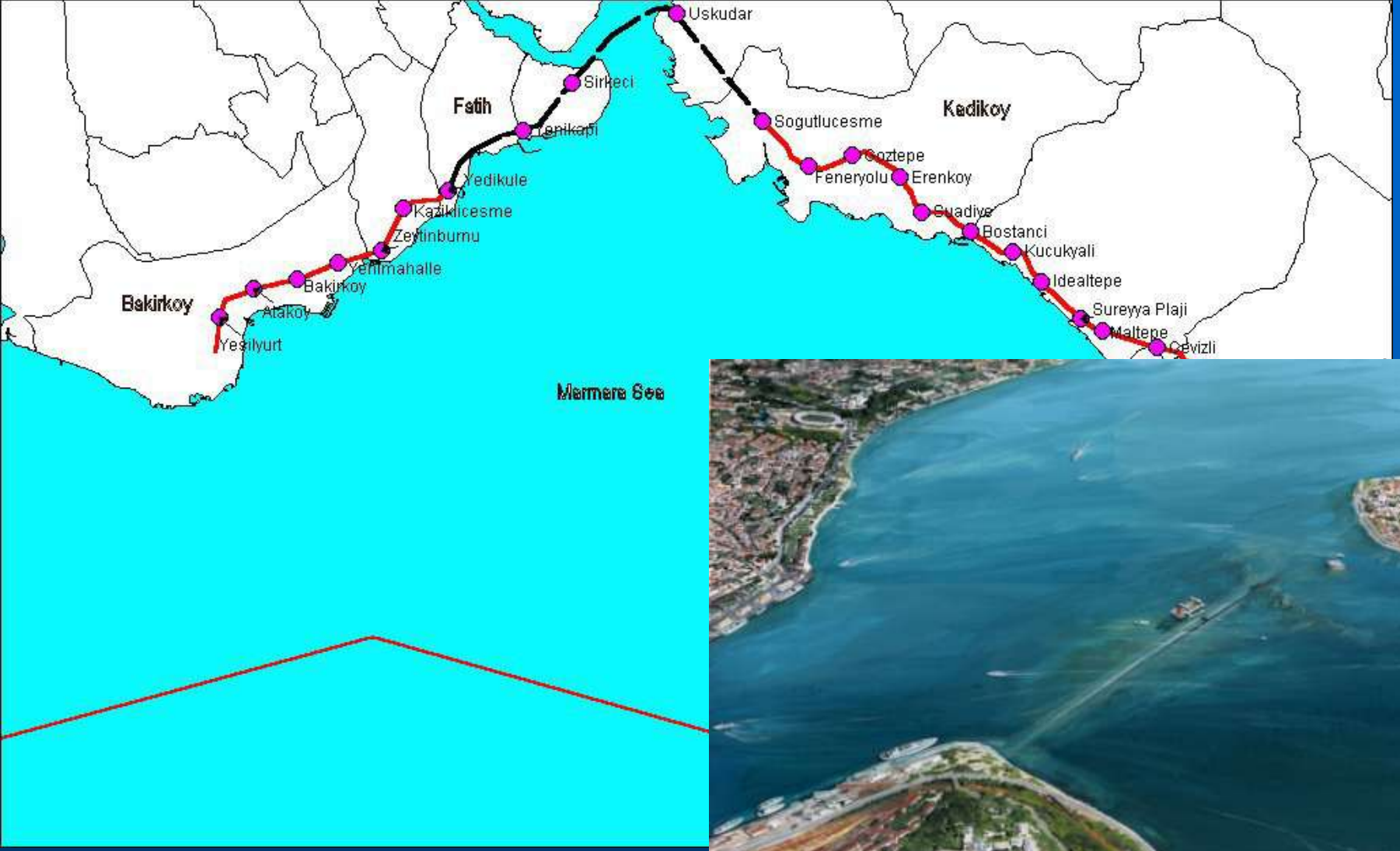
EW BASED ON CUMULATIVE ABSOLUTE VELOCITY (CAV) – *ALTERNATE PROCEDURE*

CAV (t) = Integral from 0 to t [abs (a).dt] (g-sec)

- The CAV from acceleration data are computed for only those 1s intervals where PGA is greater than 3mg. When any CAV (on any channel) in a given station exceeds a selectable first threshold CAV value (20 mg.s) it will be considered a vote.
- Whenever we have 3 (selectable) votes for the first threshold CAV value within selectable time interval of (5s) after the first vote it will be declared the first alarm.
- After the first alarm, whenever we have 3 (selectable) votes for the second threshold CAV value (40 mg.s) within selectable time intervals of (5s) after the first vote it will be declared the second alarm.
- After the second alarm, whenever we have 3 (selectable) votes for the third CAV threshold value (70 mg.s) within selectable time intervals of (5s) after the second vote it will be declared the third alarm.

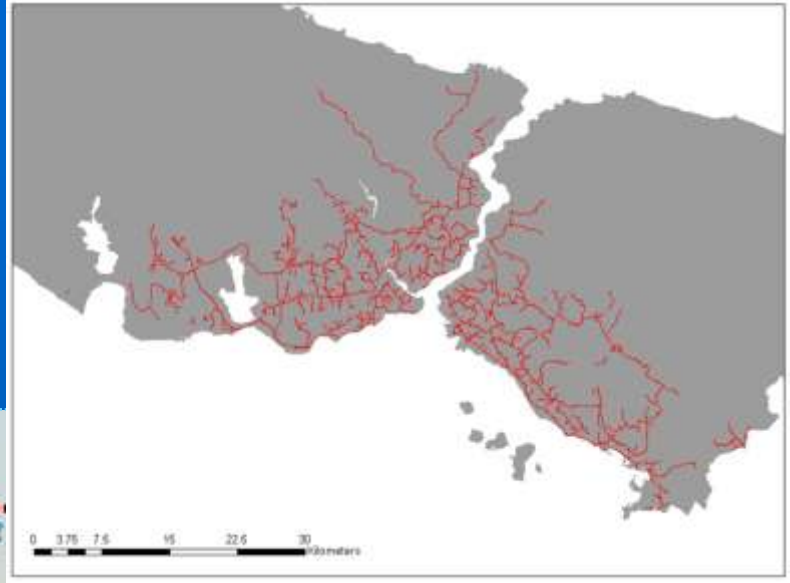


Early Warning times from 280 simulated earthquakes



EEW
FAST TRAIN AND TUBE TUNNEL

IGDAŞ Service Network Earthquake Monıtorıng



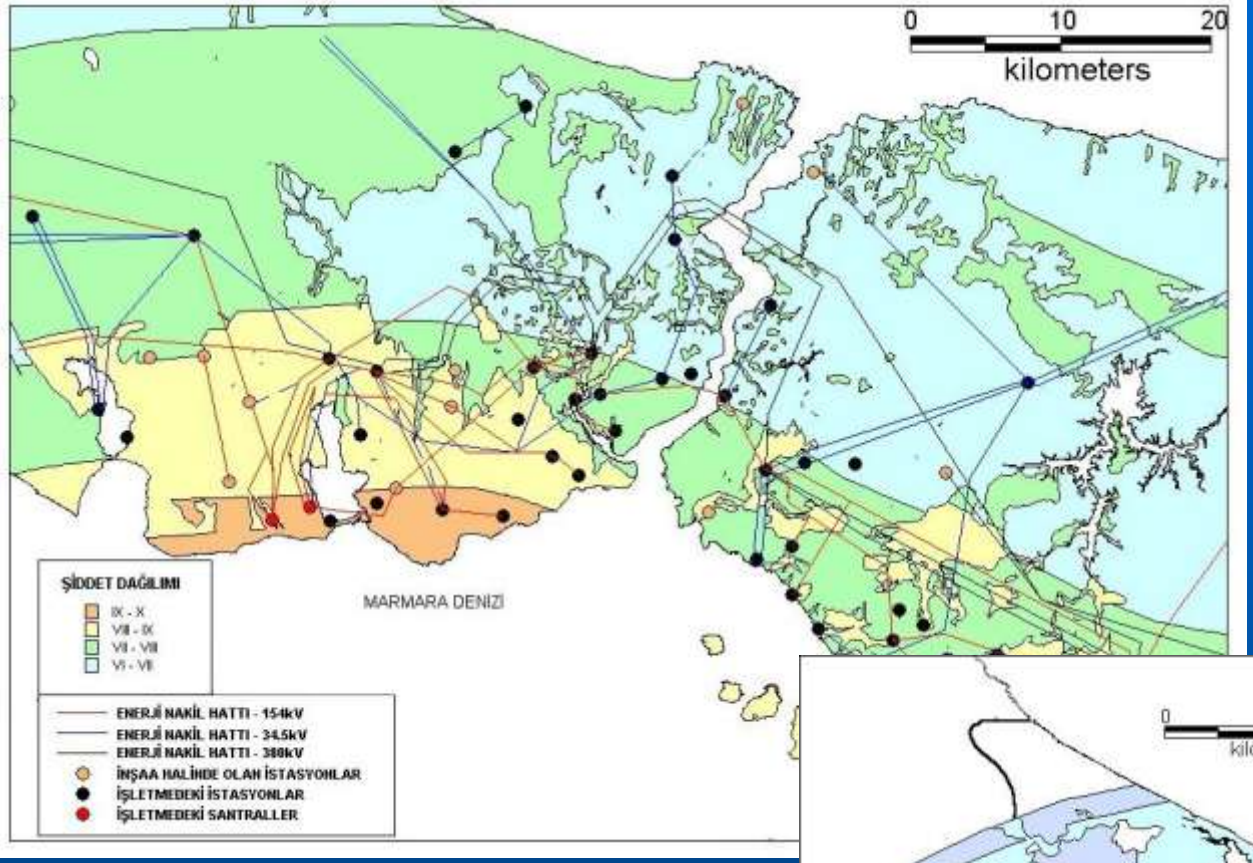
FACILITY SPECIFIC EEW SYSTEMS

İŞ-KULE

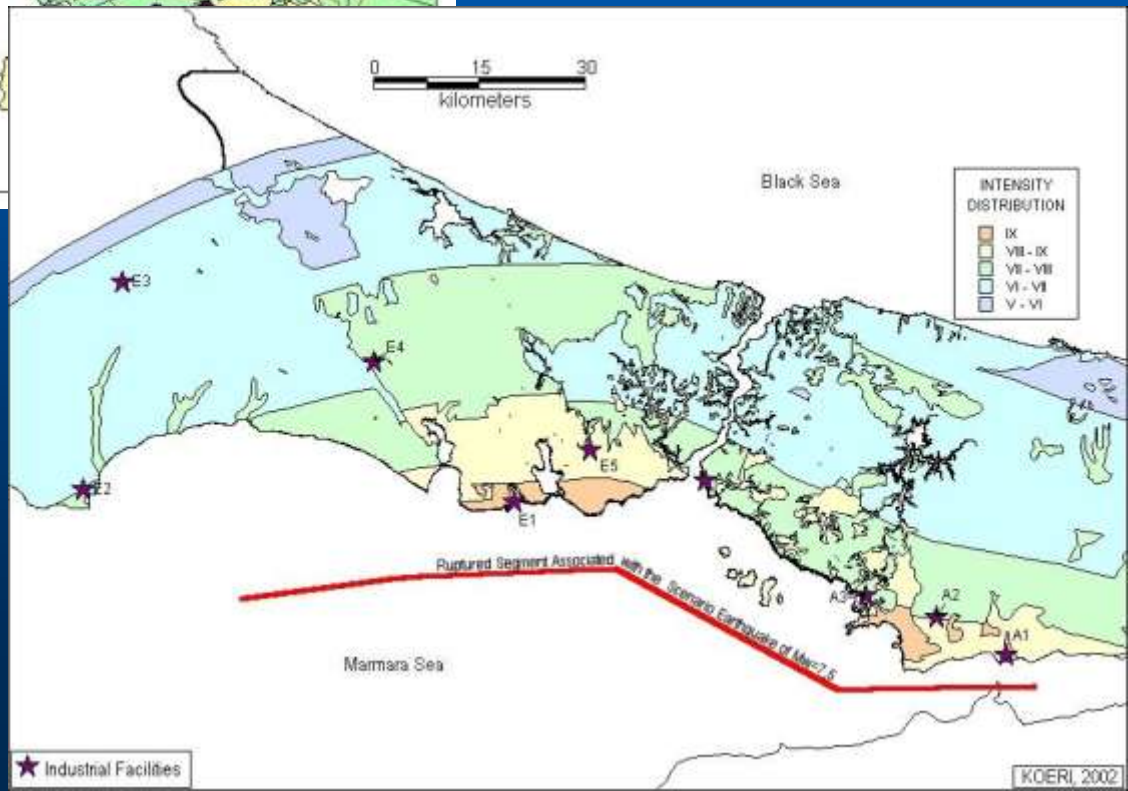
ENRON-TRAKYA ELEKTRIK

Potential Uses of EW in Istanbul

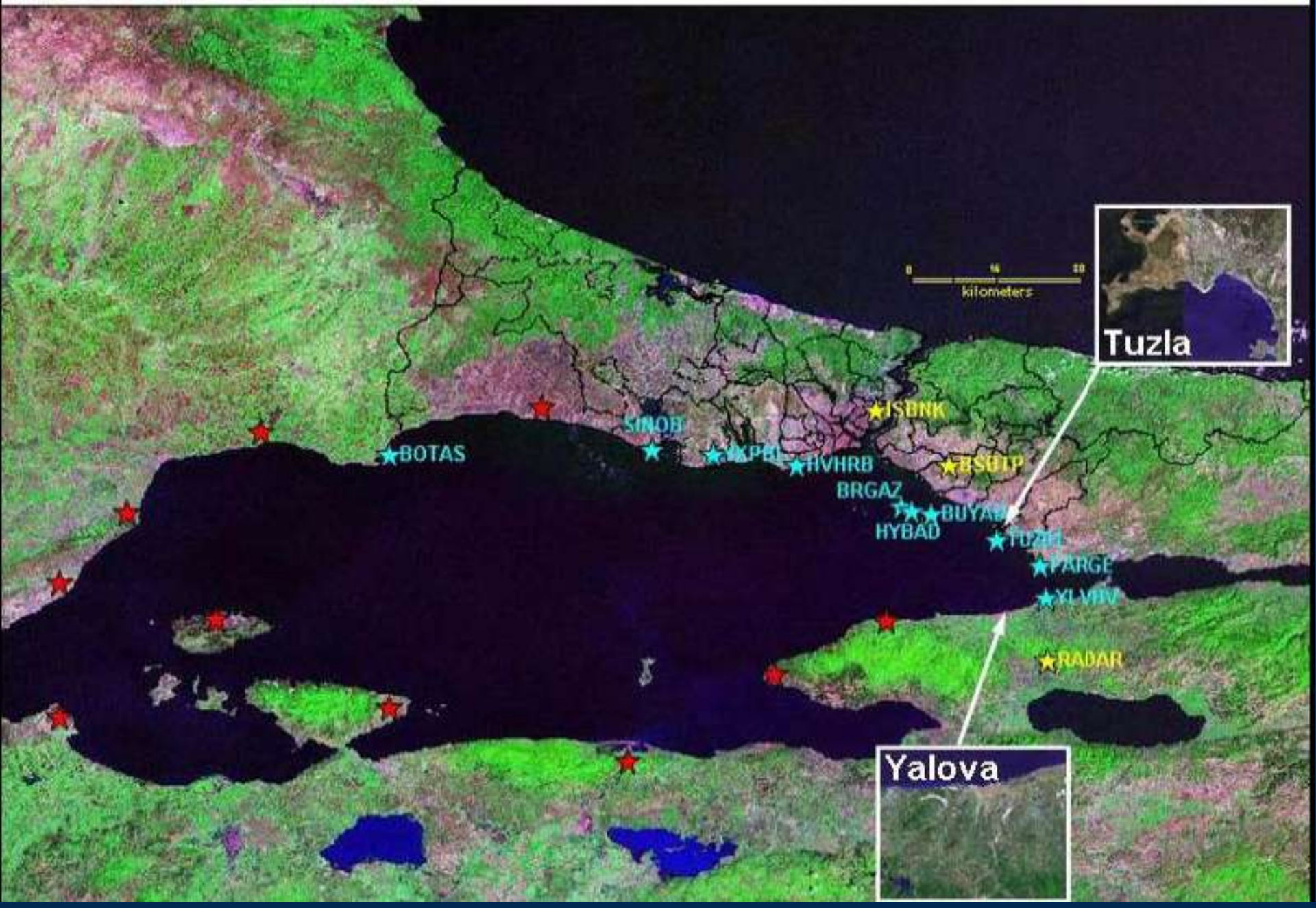
ELECTRIC POWER DISTRIBUTION SYSTEM



HEAVY INDUSTRY



EXPANSION OF THE ISTANBUL EARTHQUAKE EARLY WARNING SYSTEM



EARTHQUAKE RAPID RESPONSE (INFORMATION) SYSTEMS: SHAKE- and LOSS-MAPS

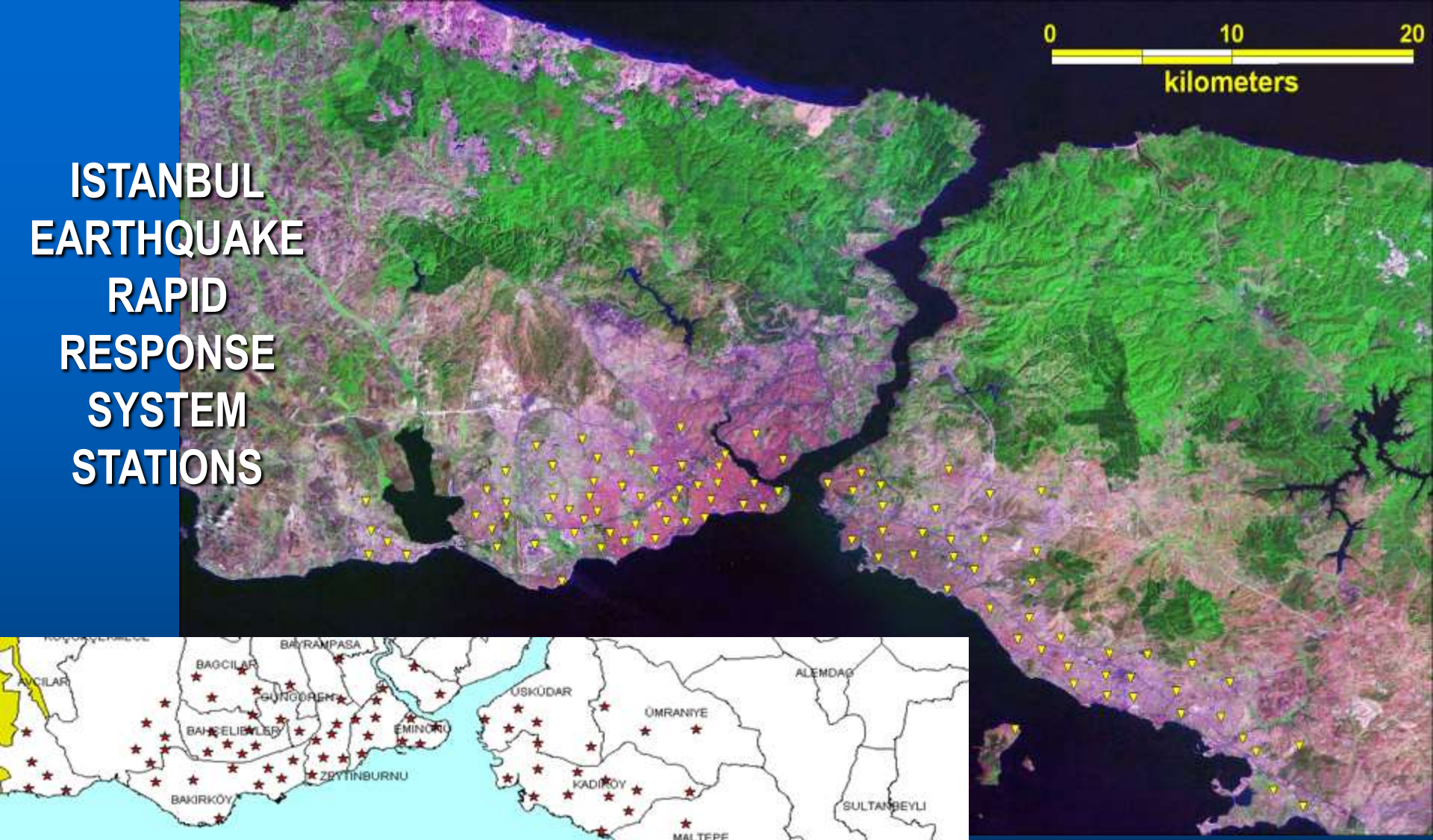
The assessments of the distribution of strong ground motion (Shake Maps), building damage and casualties (LossMaps) can be made within a short time after an earthquake. Earthquake ground motion measurement and data processing systems designed to provide this information are called Rapid Response Systems.

DIRECT AND INDIRECT APPROACHES

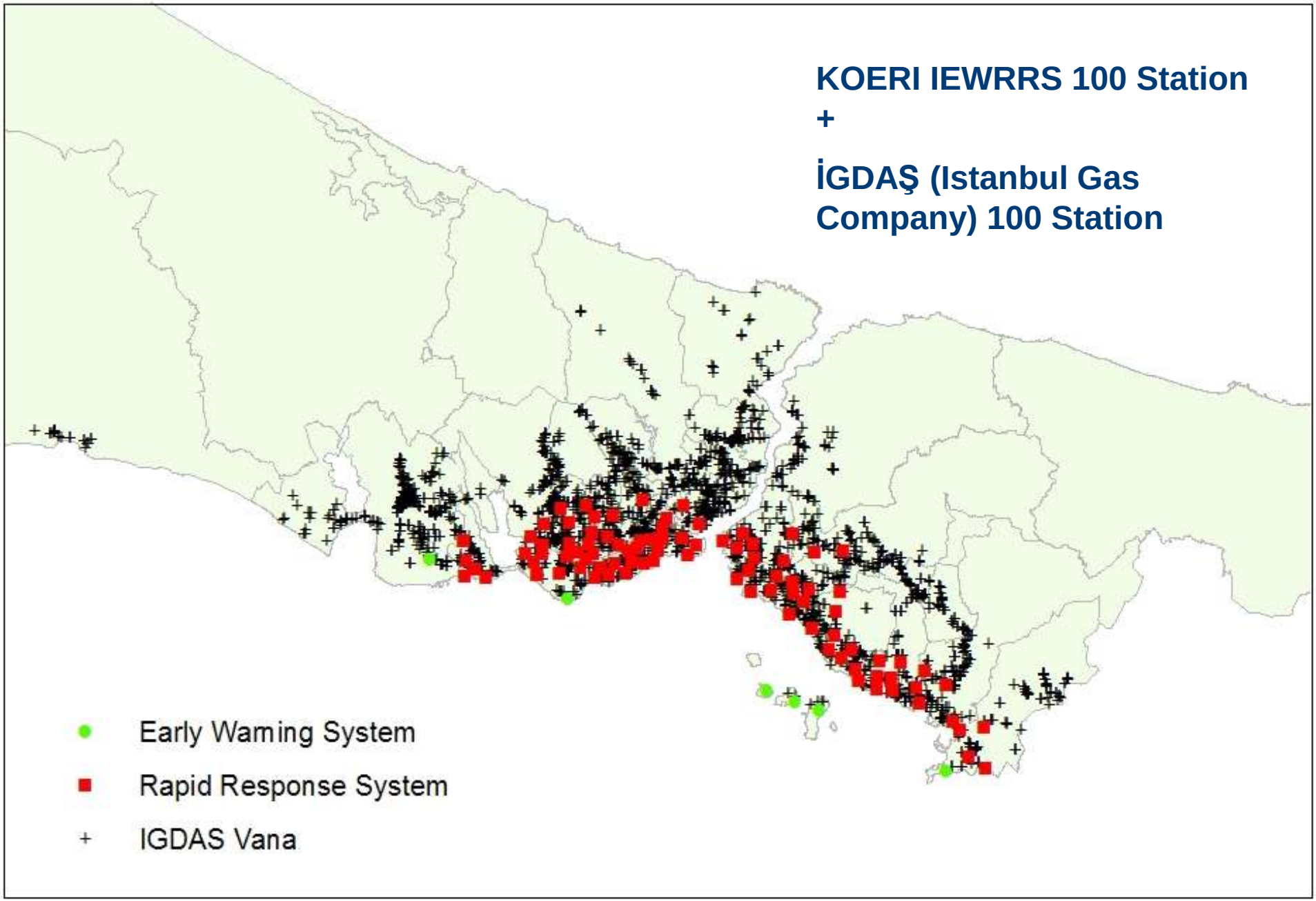
The DIRECT approach use the direct engineering parameters such as peak ground acceleration (PGA), peak ground velocity (PGV), spectra displacements (SD) maps to compute the potential damage.

The INDIRECT approach uses the seismic source parameters (hypocenter, magnitude, intensity) in order to compute the ground shaking and potential damage.

ISTANBUL EARTHQUAKE RAPID RESPONSE SYSTEM STATIONS



Expansion by the end of 2009

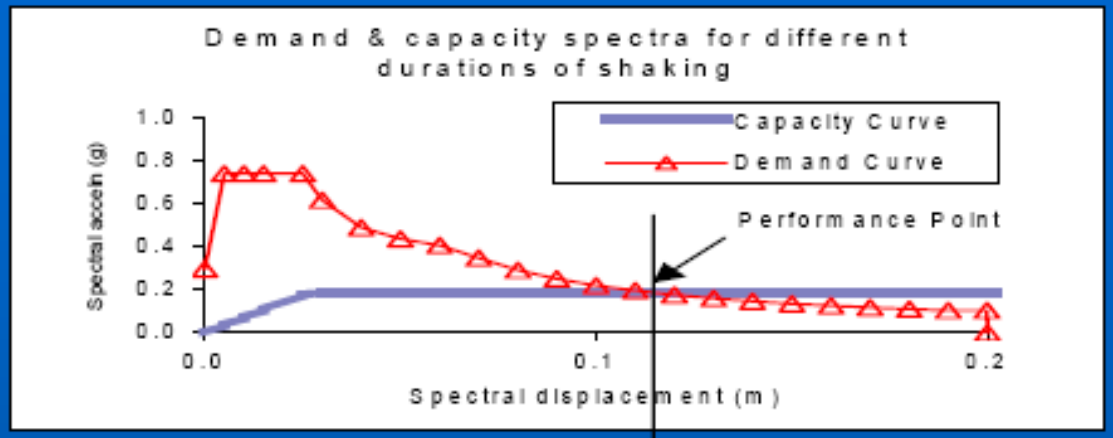


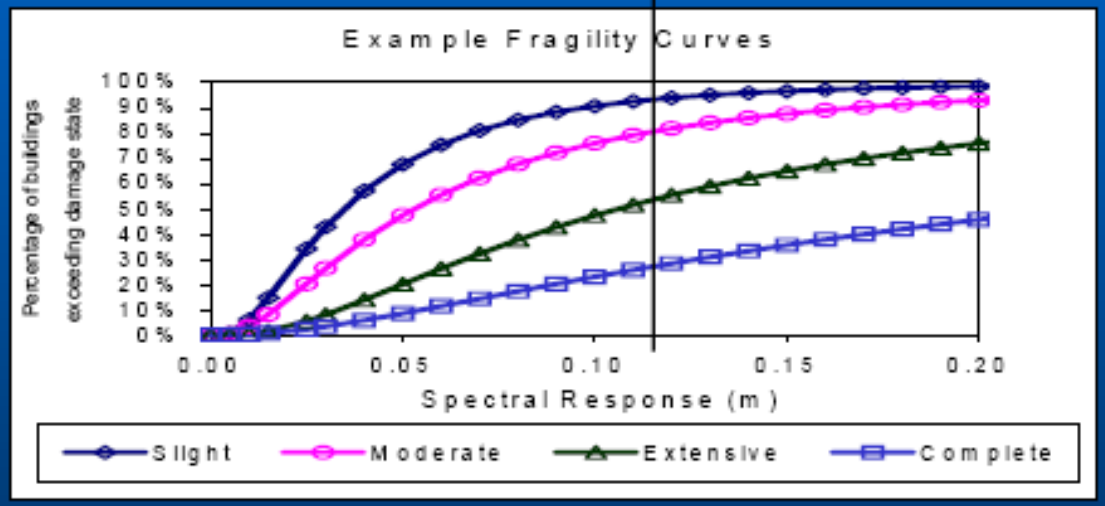
After triggered by an earthquake, each station processes the streaming three-channel strong motion data to yield the Spectral accelerations at specific periods, 12Hz filtered PGA and PGV and sends these parameters in the form of SMS messages at every 20s directly to the main data center through the AVEA - GSM communication system by using several base stations, microwave system and landlines.

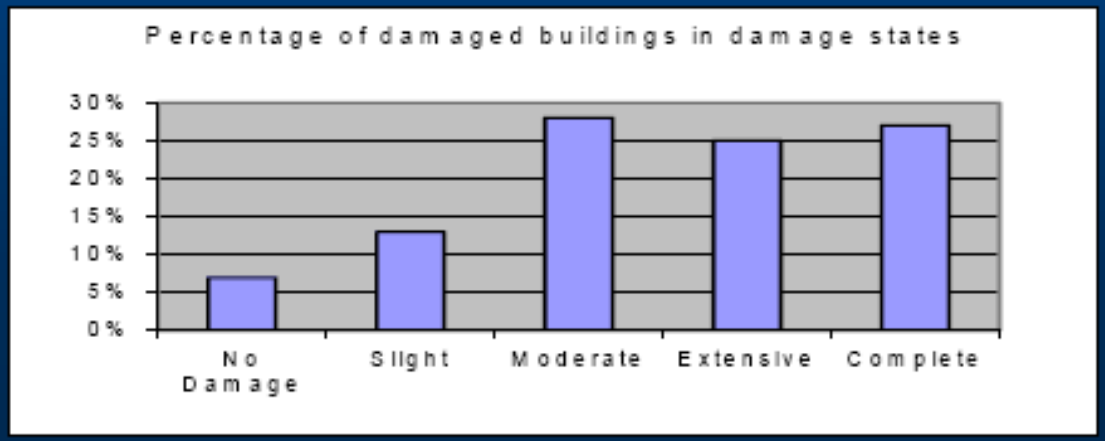
Spectral displacements obtained from the SMS messages sent from stations are interpolated to determine the spectral displacement values at the center of each geo-cell (0.01° x 0.01°).

The seismic demand at the center of each geo-cell is computed using these spectral displacements.

Using the capacities of the buildings (24 types) in each geo-cell the building damage is computed by using the spectral-displacement based fragility curves (Capacity Spectrum Procedure).





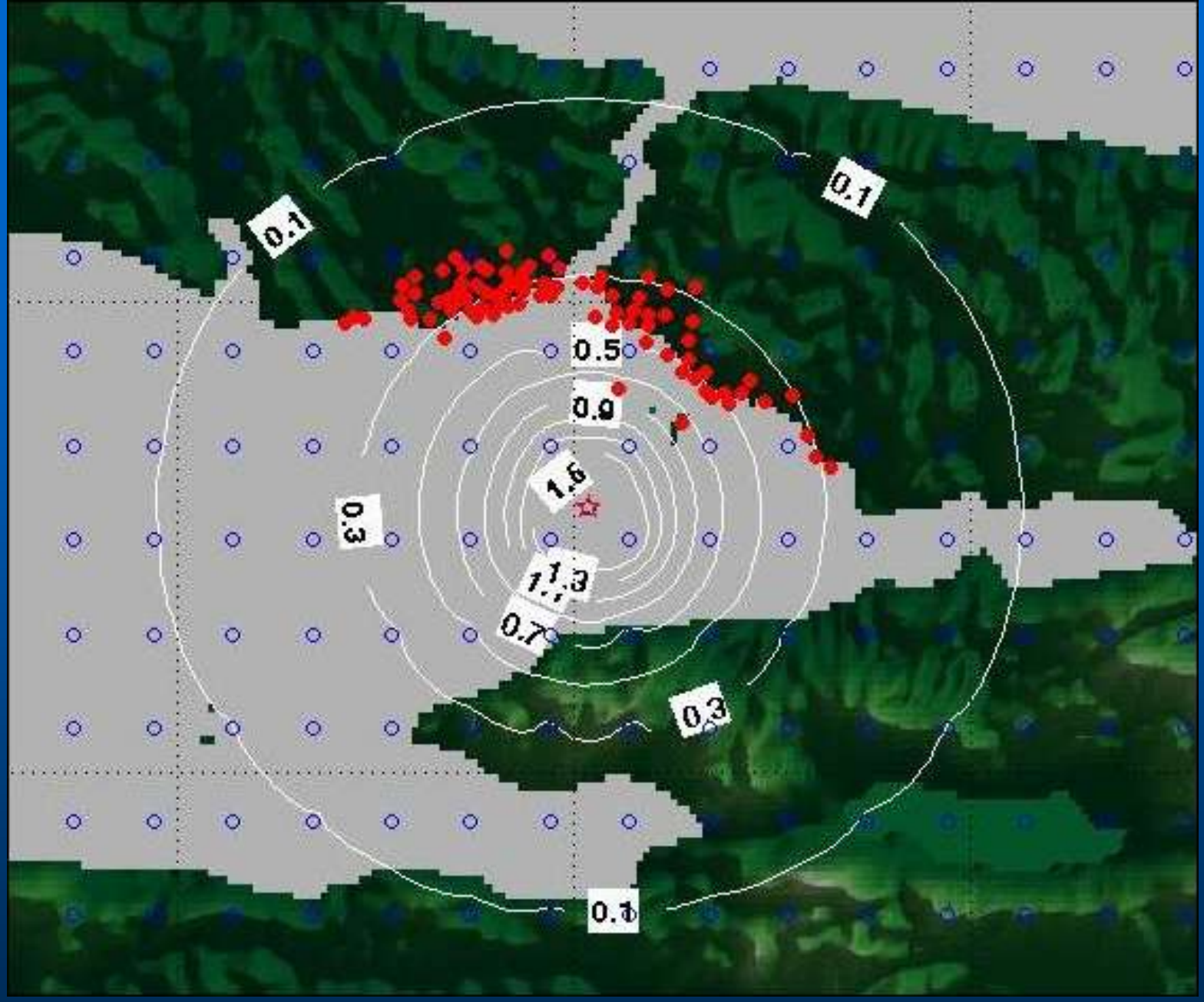


Capacity Spectrum-type Building Damage Assessment

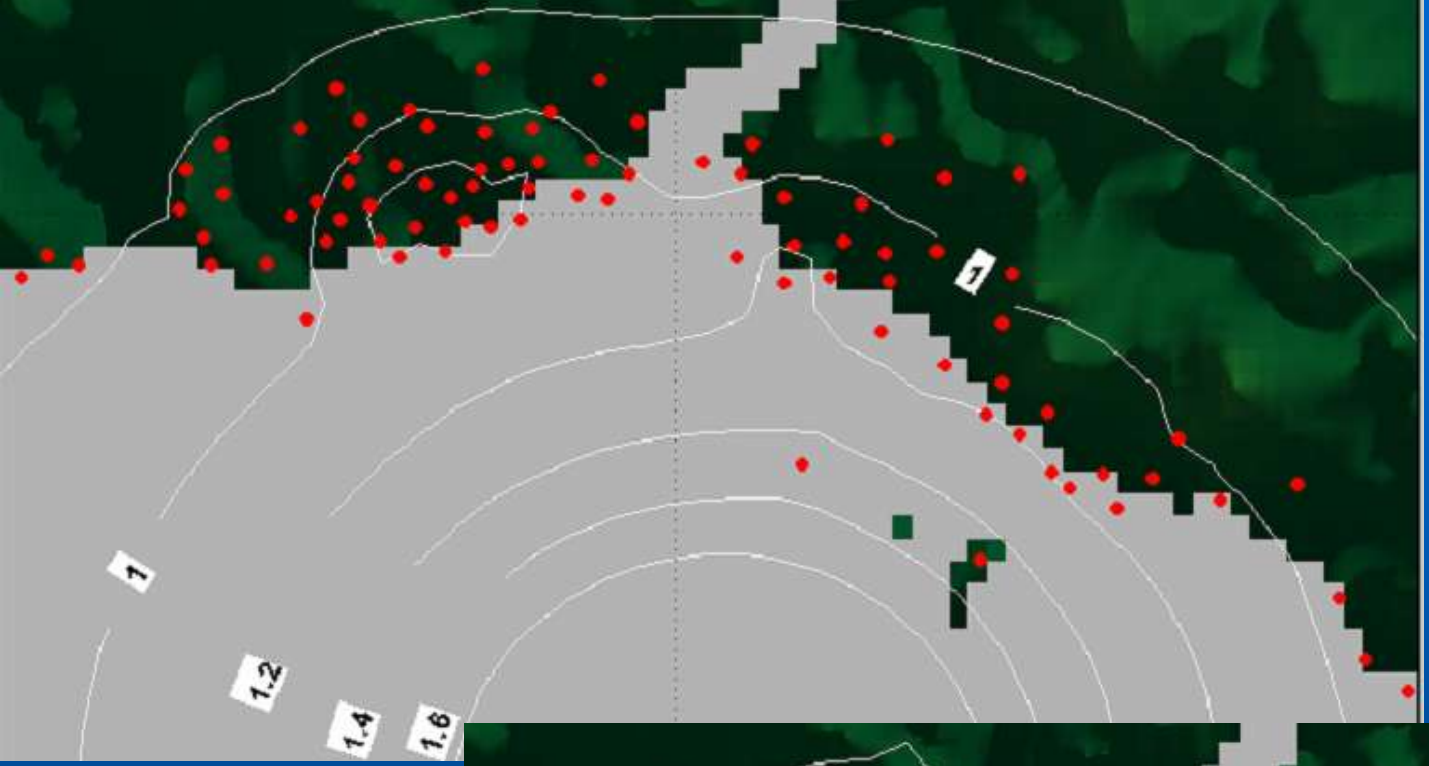
Location of earthquakes recorded by the system

Information on recorded Earthquakes

Event	Date	Time	Latt-N	Long-E	Depth(km)	MD	ML	Region	Number of Stations recorded
1	19.09.2003	00:51:08	40.850	29.287	8.2	3.1	3.2	GUZELYALI (ISTANBUL)	16
2	16.05.2004	03:30:48	40.696	29.322	11.0	4.2	4.3	YALOVA	73
3	16.05.2004	21:07:48	40.699	29.317	9.2	3.3	3.4	YALOVA REGION	5
4	24.06.2004	13:28:54	40.868	29.268	16.7	3.2	3.2	GUZELYALI (ISTANBUL)	14
5	29.09.2004	15:42:07	40.780	29.020	12.4	...	4.0	MARMARA SEA	86
6	20.10.2006	21:15:24	40.264	27.984	12.9	5.2	...	KUS LAKE	43
7	24.10.2006	17:00:21	40.424	28.995	14.3	5.2	...	GEMLIK BAY (MARMARA SEA)	47
8	19.12.2006	21:15:37	40.391	28.321	11.1	4.2	...	BAYRAMDERE (MARMARA SEA)	5
9	12.03.2008	20:53:37	40.621	29.011	11.2	...	4.8	CINARCIK (YALOVA)	54

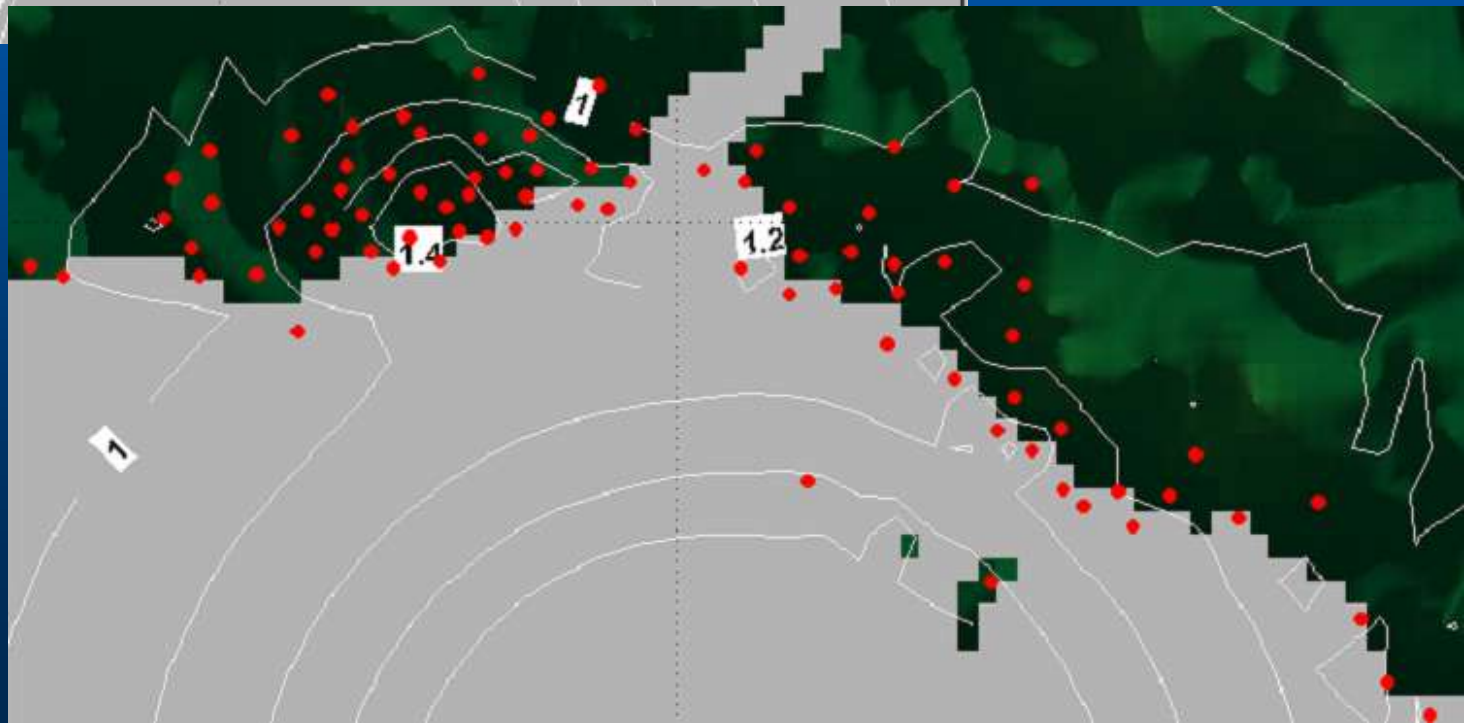


Sept. 29, 2004 Marmara Sea Earthquake (M4) ShakeMap (Cambell and Bozorognia, 2008) with no consideration of instrumental data and site response

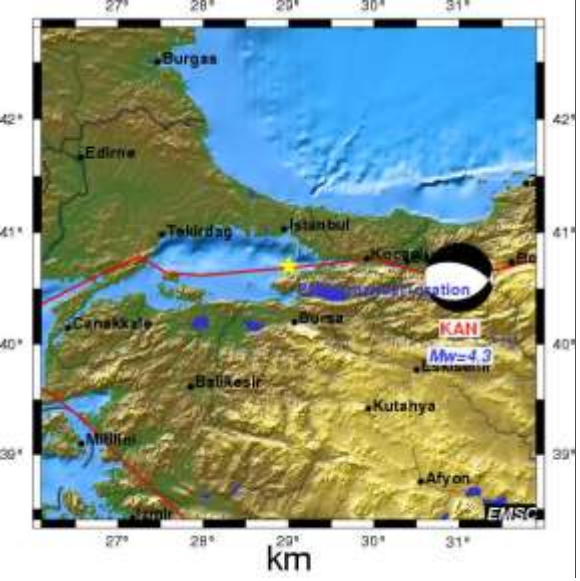


Empirical Data Incorporated

(Bias adjustment at surface)



Empirical Data and Site Response Incorporated

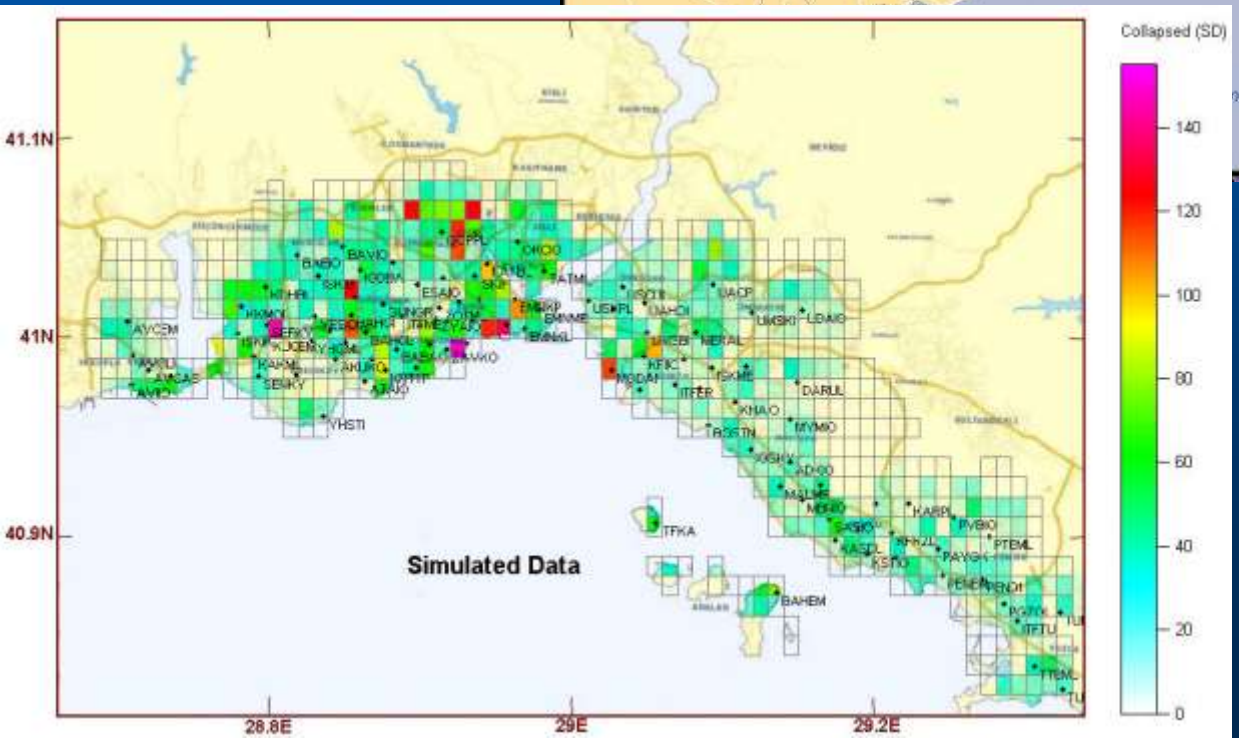


March 12 2008 Earthquake

Shake and Loss Map

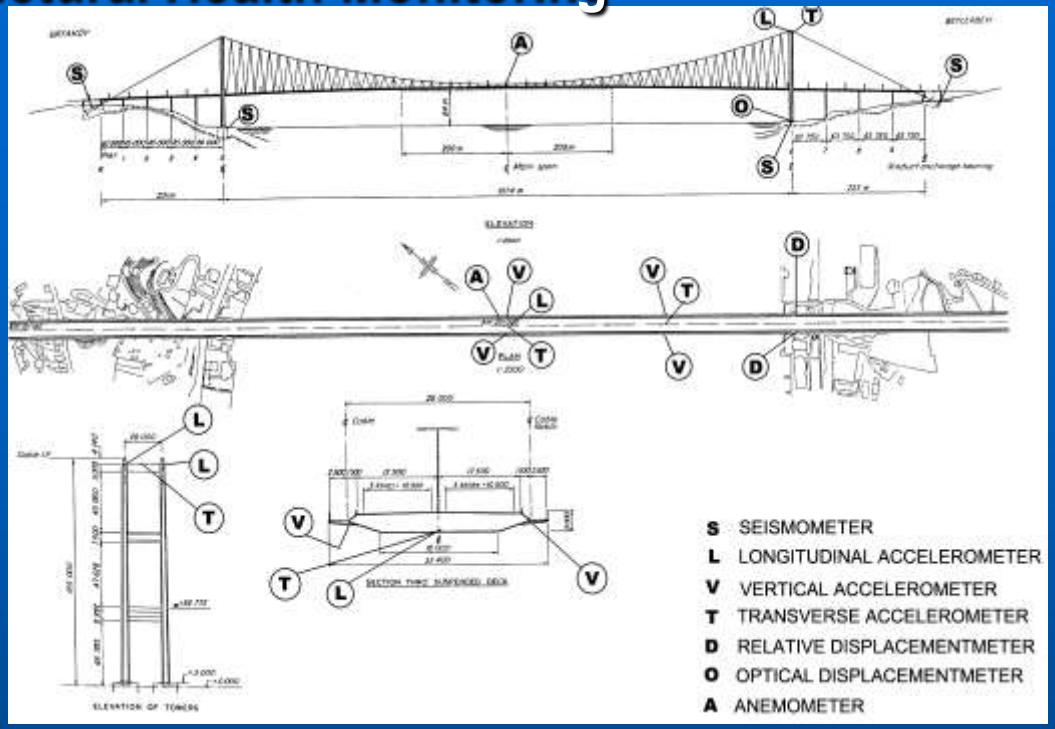
Communication of Rapid Response Message (Damage Maps)

(Mobile phones and PDA's)



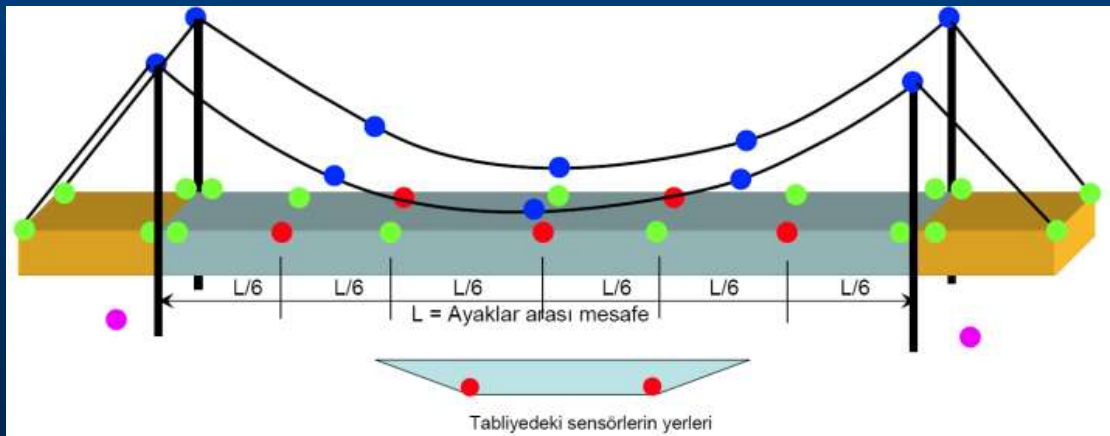
NUMBER OF COLLAPSED BUILDINGS PER CELL (Simulated from random data and communicated to end users every day at 10am)

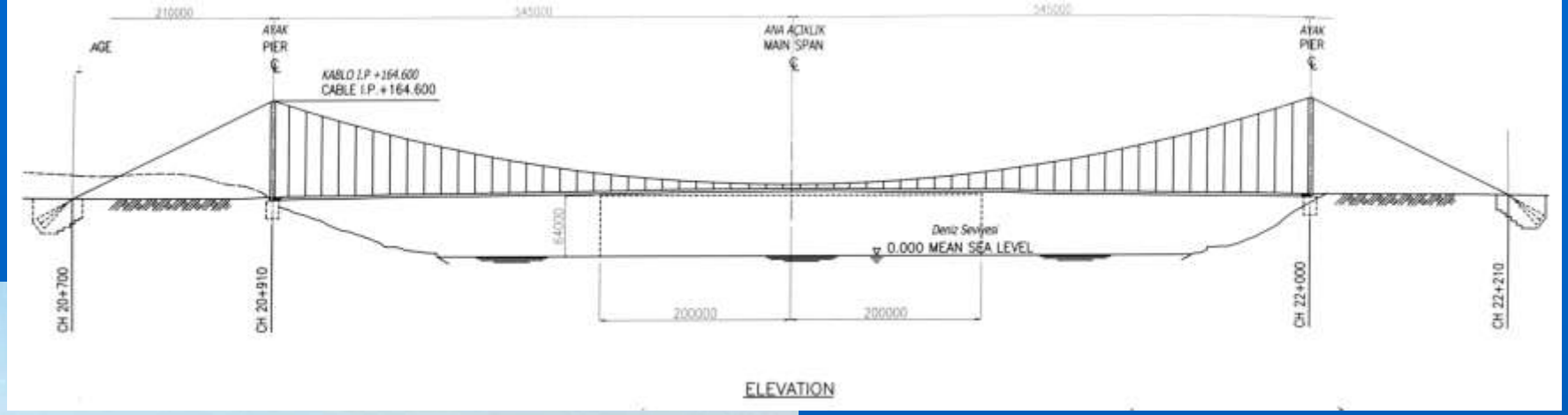
Structural Health Monitoring



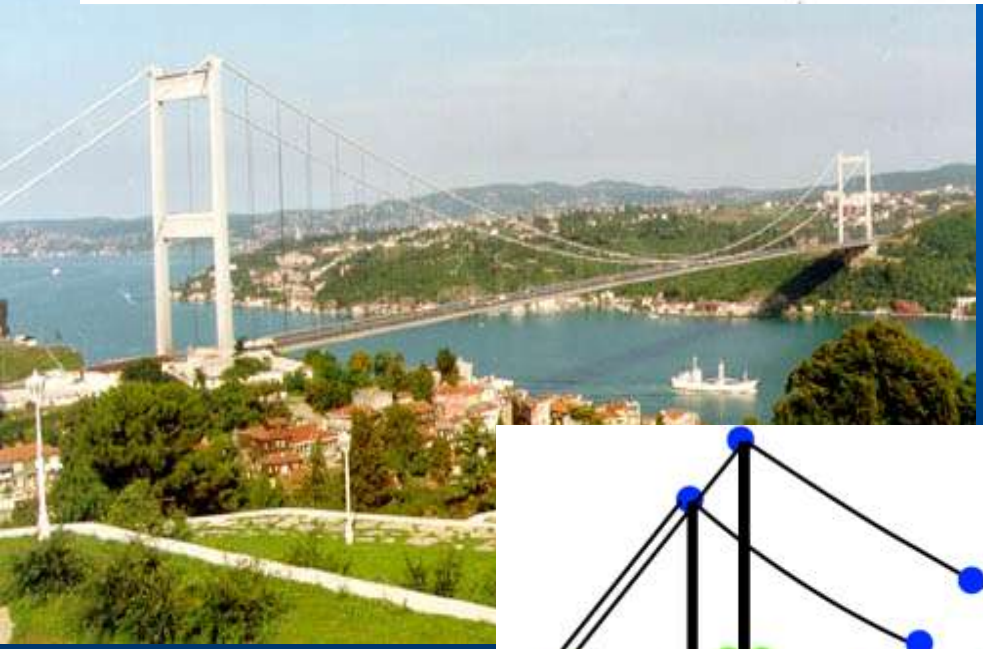
BOĞAZİÇİ BRIDGE

FATIH BRIDGE

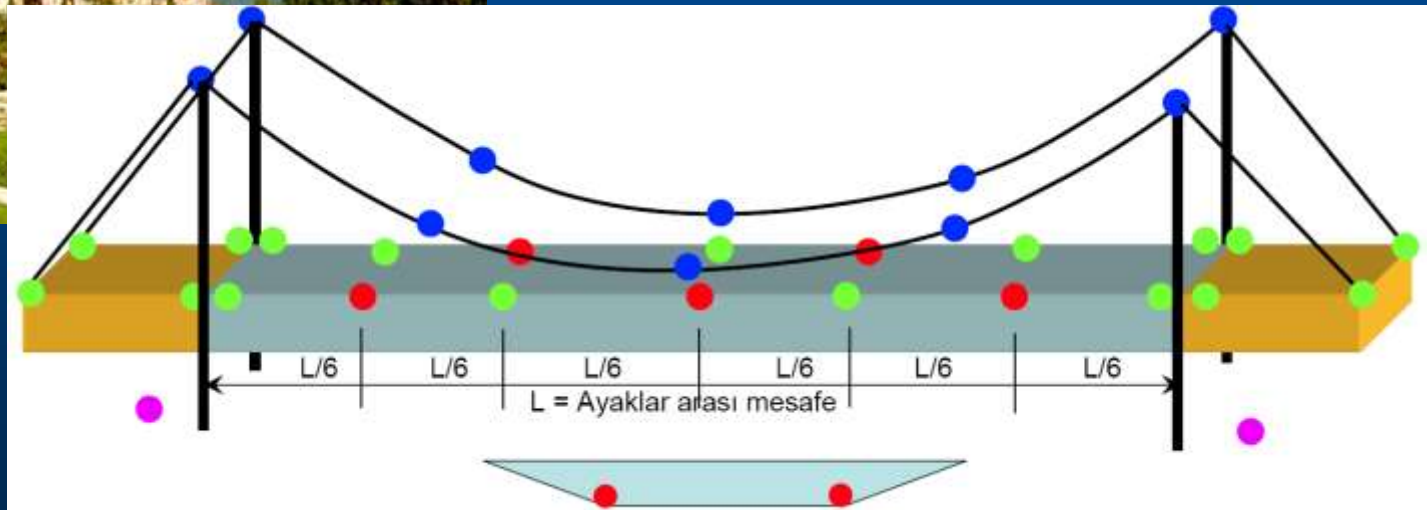




ELEVATION



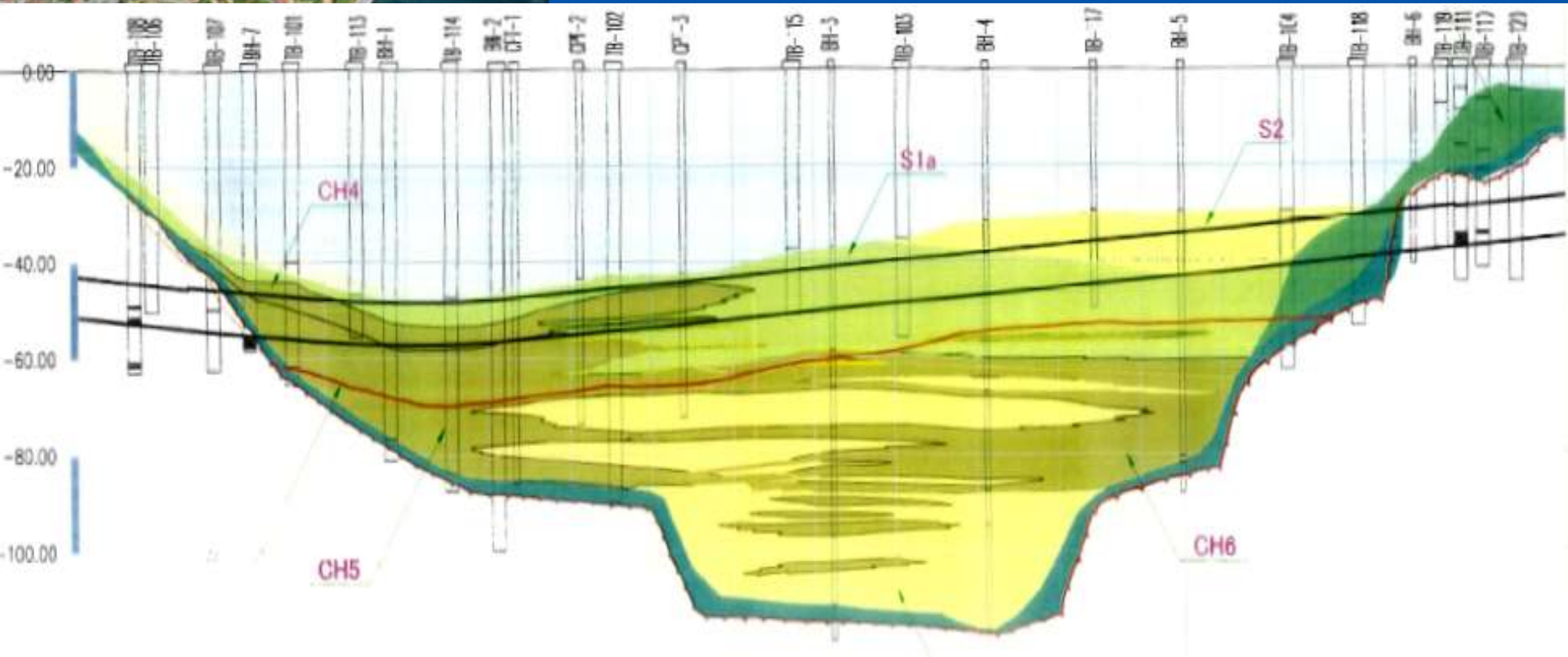
FATIH BRIDGE



Tabliyedeki sensörlerin yerleri

Structural Health Monitoring

- Tube Tunnel



THANK YOU