An international scientific organization dedicated to the reduction of disaster risk in complex metropolises

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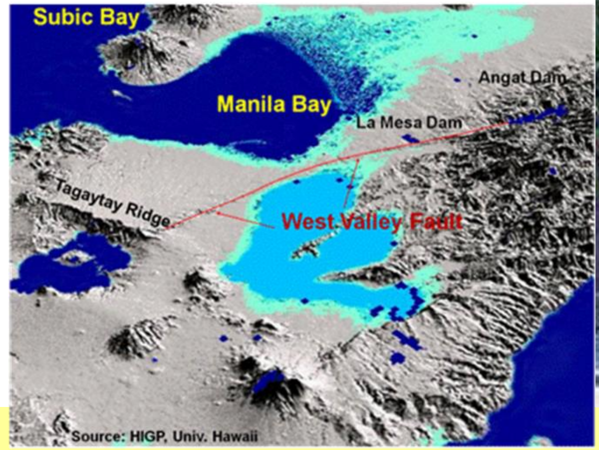

Earthquake Risk Considerations of Mobile Communication Systems

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19 June 2013

EMI

An International Scientific Organization with the Mission

To advance the knowledge, policy, and practice of Urban Disaster Risk Reduction in megacities and fast growing metropolises

Operating Globally

Organized as a not-for-profit organization in the Philippines

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20 city partners

East Asia: Kobe, MMDA, Shanghai, Seoul, Tianjin, Jakarta

South & Central Asia: Mumbai, Dhaka, Kathmandu, Tashkent, Beijing

Americas: Bogota, Los Angeles, Mexico, Quito, Lima

Euro-Mediterranean: Naples, Istanbul, Tehran, Cairo

Philippines:

PHIVOlLS, MMDA, OCD,

Quezon City

Marikina

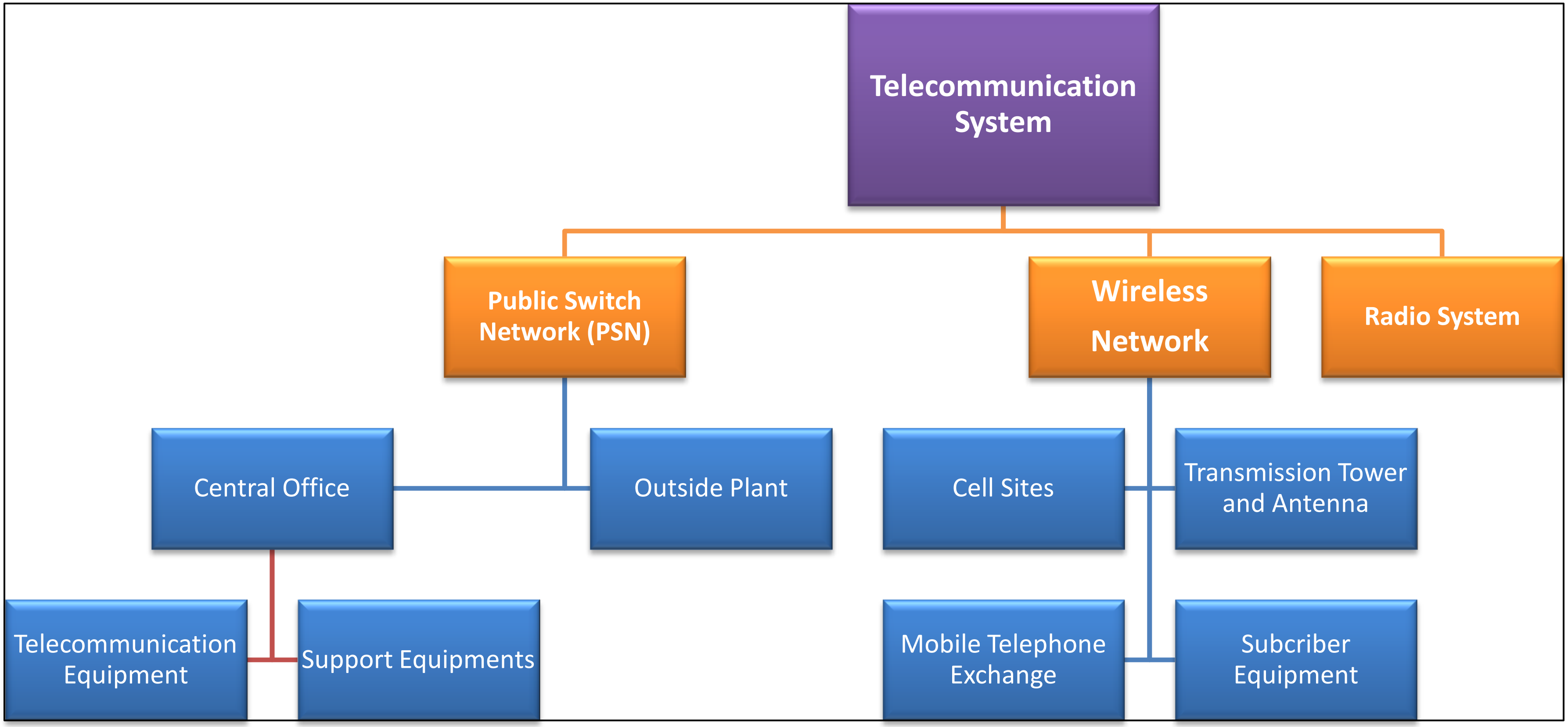
Pasig

Makati

Content

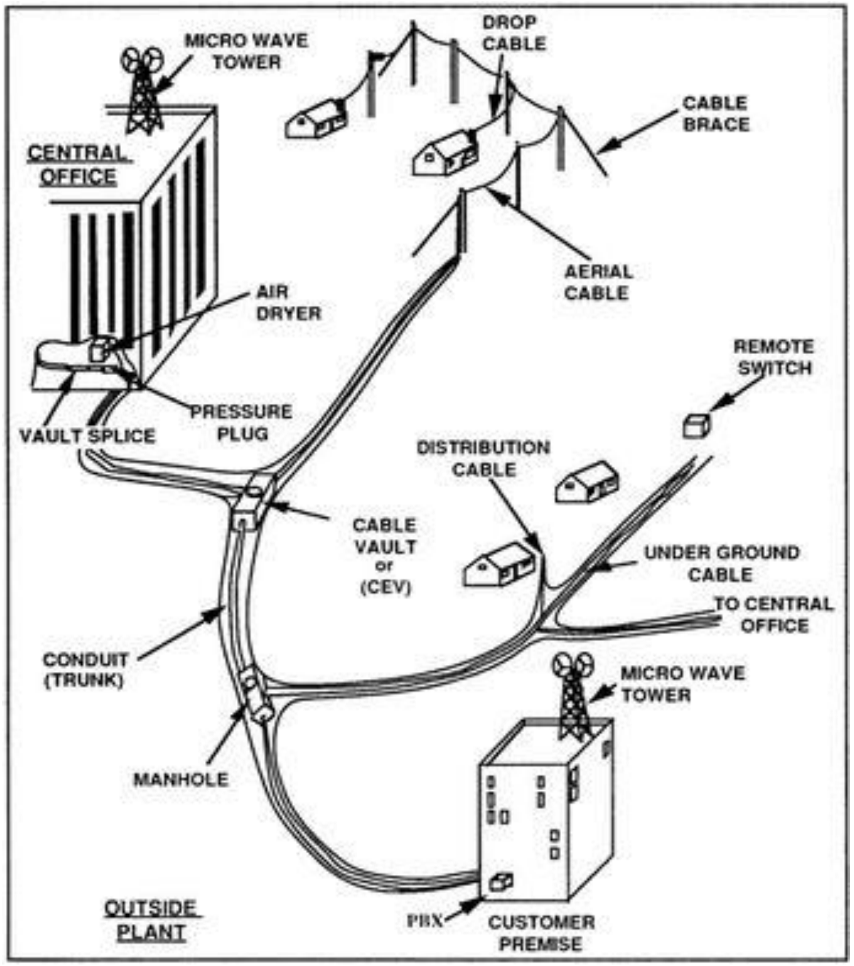
Description of a Telecom System

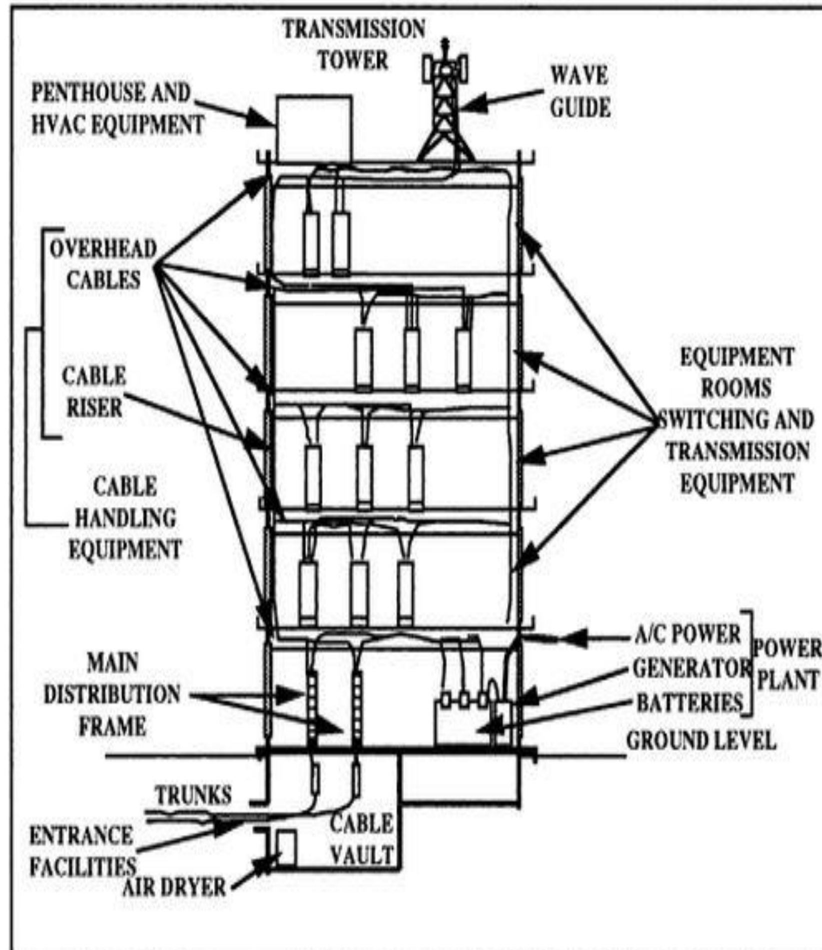
Communication system comprises of three types of communication networks: a) public switch network b) wireless networks and c) radio system



Component chart for telecommunication system Bibliography: Anshel J. Schiff (1998). *Guide to Post – Earthquake Investiation of Lifeline: American Society of Civil Engineers*

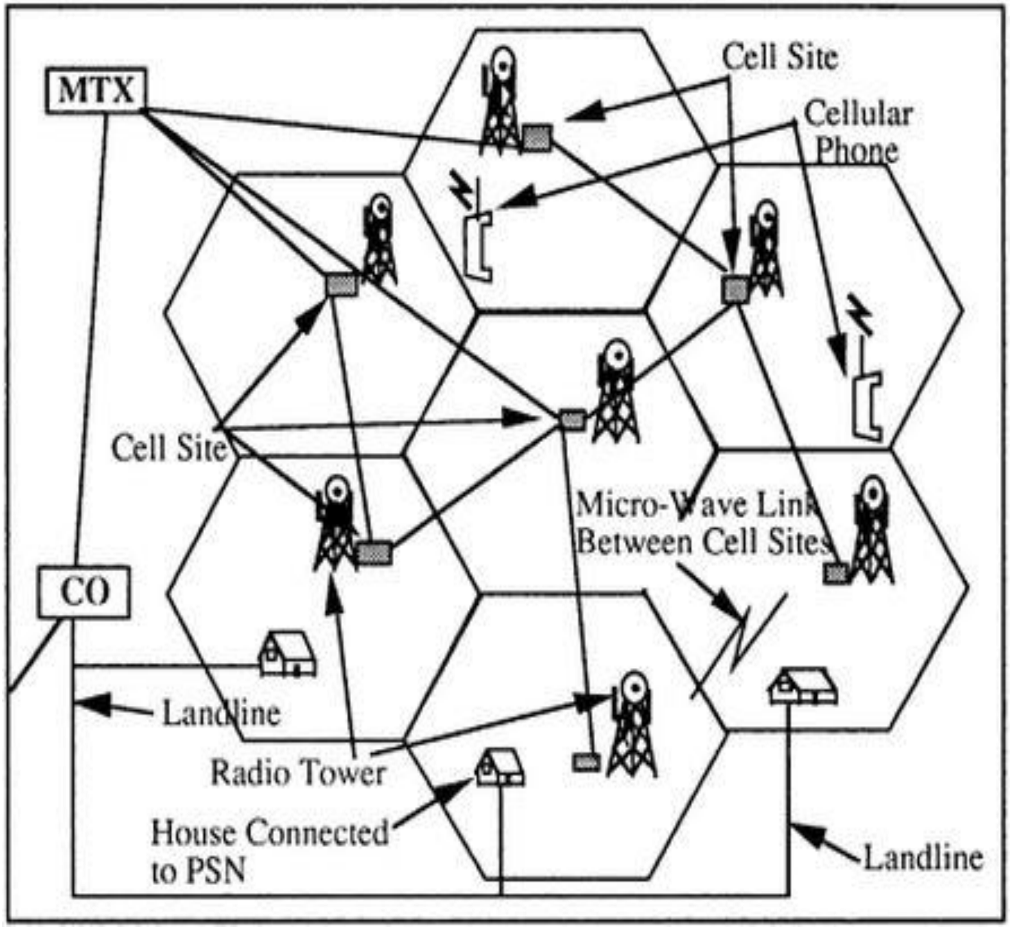
Description of a Telecom Systems: Public Switch Network





Schematic diagram of a central office showing telecommunication and its support facilities

Description of a Telecom System – Wireless Network



The major elements of the wireless network are as follows:

- Cell sites
- Transmission tower and antenna
- Mobile telephone exchange
- Subscriber equipment

Description of a Telecom System: Radio System Network

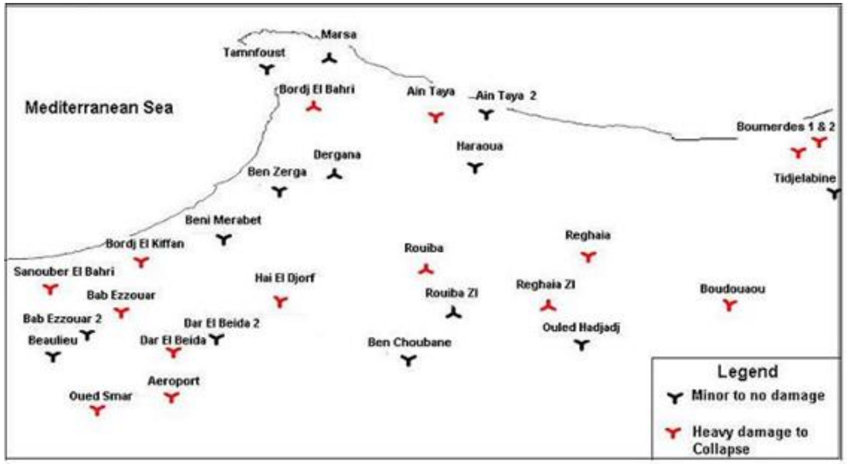
Radio system, considered here are those system typically used by police, fire, rescue services and other commercial organization.

It is consists of base station, repeaters and users who may have transceivers mounted in vehicles or hand held units.

PART 2

Vulnerability of Mobile Telecom Systems

Experience from Past Earthquakes:
21 May 2003 M7.0 Boumerdes, Algeria Earthquake

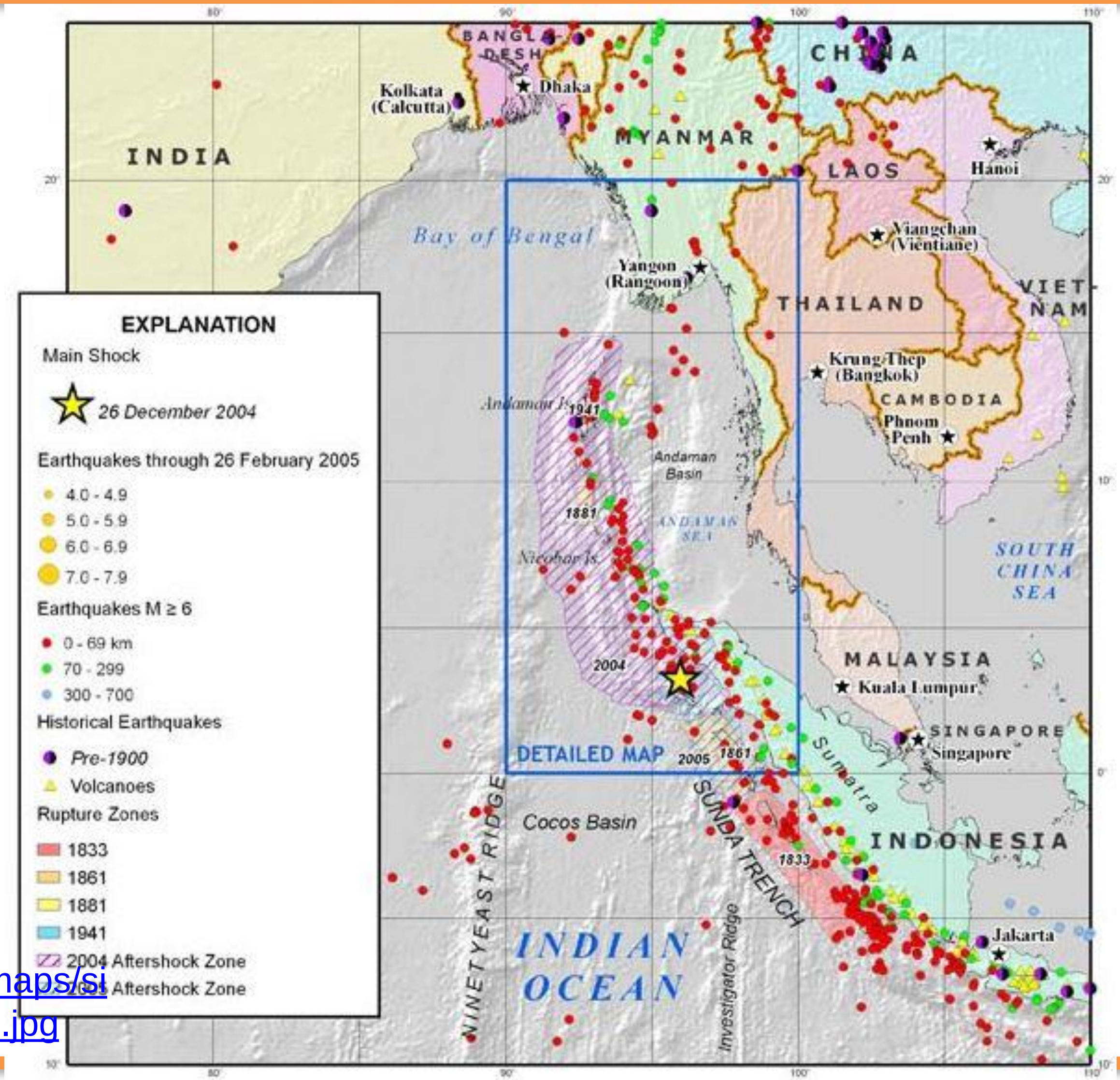


Antenna Damage Eastern Part of the Capital City Algiers

Collapse of the Central Office Building in the epicentral area

Extensive Damage to another CO Building

Experience in Past Earthquakes: 26 Dec 2004
M9.0+ Sumatra-Andaman Islands Earthquake &Tsunami



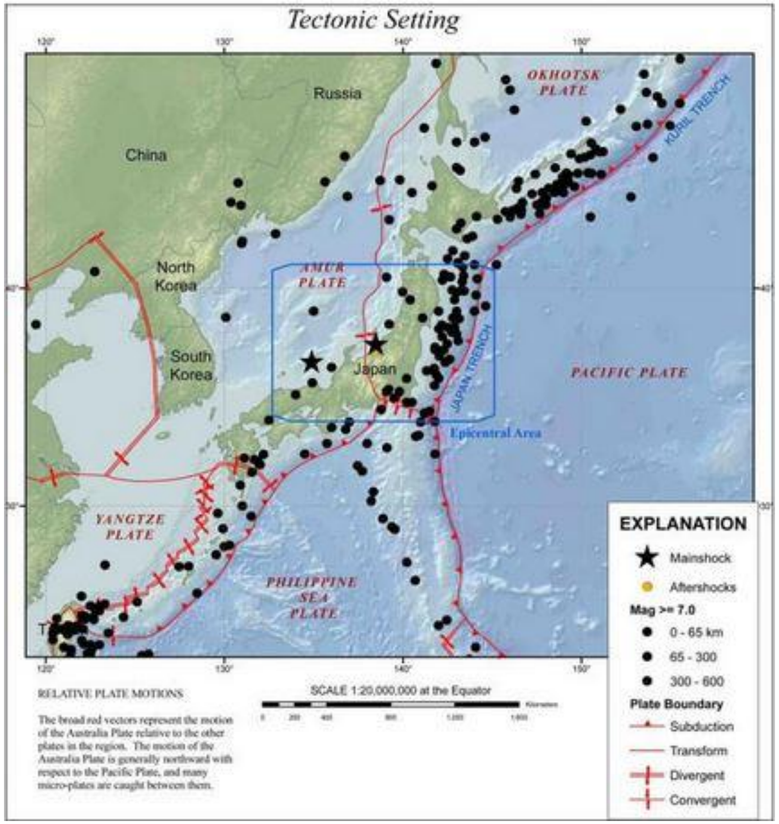
Source: ftp://hazards.cr.usgs.gov/maps/sigeqs/20041226/20041226.jpg

Experience in Past Earthquakes: 26 Dec 2004
M9.0+ Sumatra-Andaman Islands Earthquake &Tsunami

On December 26th 2004, an earthquake of 9.0 -9.3 magnitude hit the Sumatra and Andaman Islands. Depending on the region, there were tremendous number of injuries, casualties, property damage and destruction to lifeline.

Tsunami crippled telecommunication system by damaging poles, towers and local switching equipment.

Experience in Past Earthquakes:16 July 16, 2007 Kashizawaki, Japan M 6.7 Earthquake



Source: Alex K. Tang and Anshel J. Schiff (2010). *Kashizawaki Japan Earthquake of July 16 , 2007: Lifeline Performance.* Virginia: American Society of Engineers

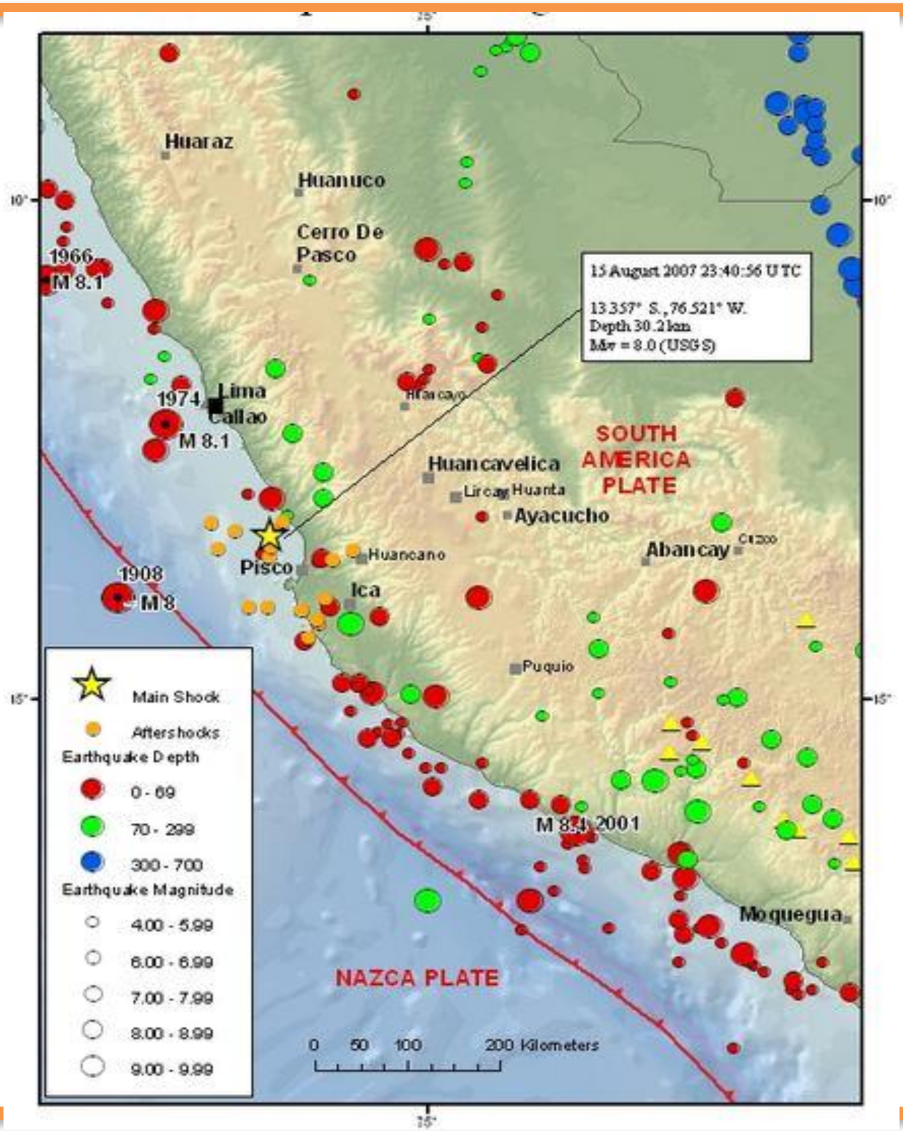
Experience in Past Earthquakes:16 July 16, 2007 Kashizawaki, Japan M 6.7 Earthquake

Hit a mostly rural area.

The damage at the site was confined to the outside of central office building such as manhole with broken conduit and broken concrete pole.

The transmission and distribution system experienced extensive damage due to liquefaction.

Experience in Past Earthquakes: 15 Aug 2007 M8.0 Peru Earthquake



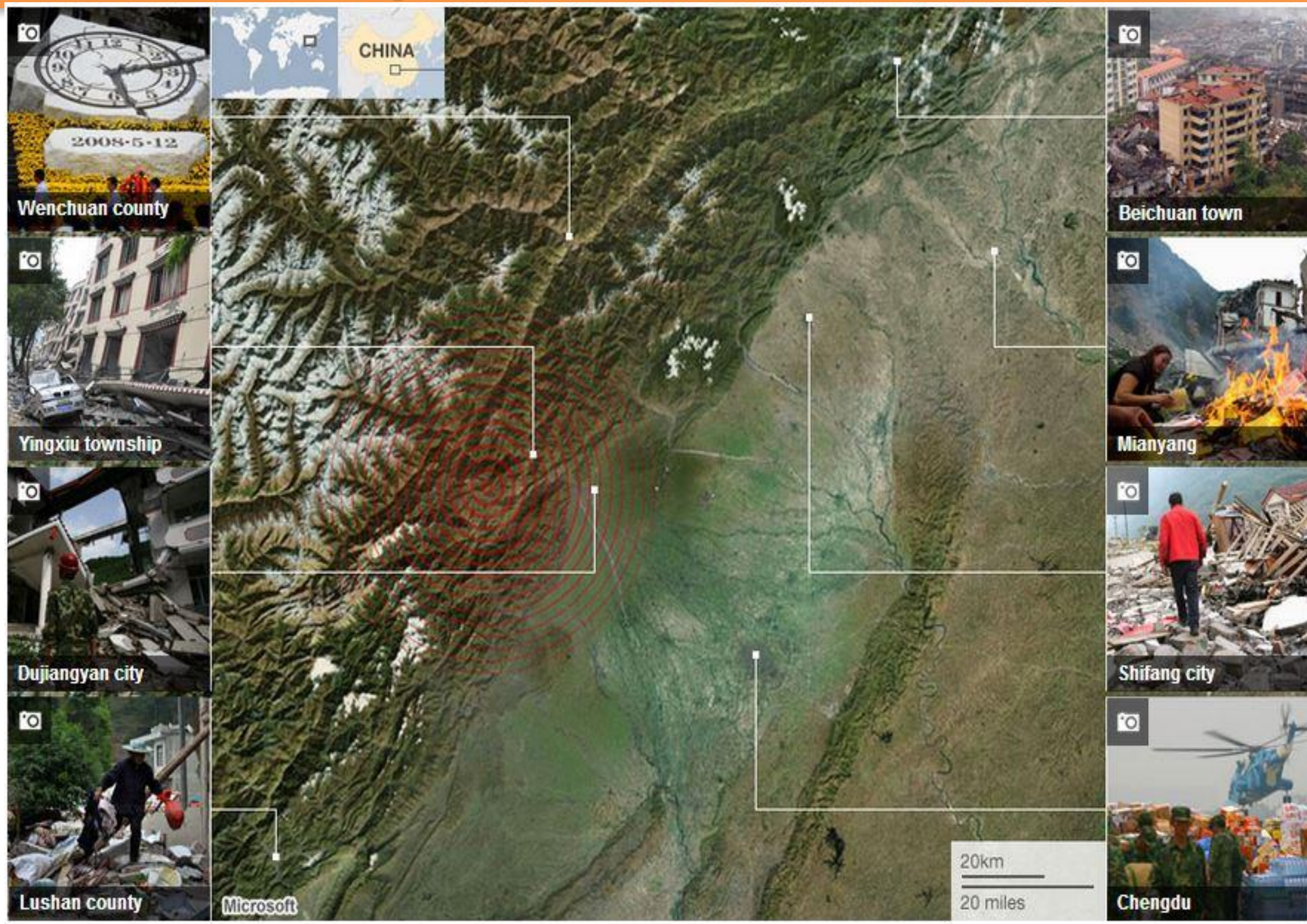
[Source: ftp://hazards.cr.usgs.gov/maps/sigeqs/20070815/mainpage.jpg](ftp://hazards.cr.usgs.gov/maps/sigeqs/20070815/mainpage.jpg)

Experience in Past Earthquakes: 15 Aug 2007 M8.0 Peru Earthquake

Both landline and cellular network performed poorly in first few days after earthquake, due to:

- Damages to transmission and distribution system.
- Damage of trunk lines, central office and their support facilities.
- Power outrage

Experience in Past Earthquakes: 12 May 2008 Sichuan, China Earthquake



[Source: http://www.bbc.co.uk/news/science-environment-22398684](http://www.bbc.co.uk/news/science-environment-22398684)

Experience in Past Earthquakes: 12 May 2008 Sichuan, China Earthquake

- In the most damaged areas, all telecommunications systems were severely damaged and operations affected.
- Satellite communication was used in the quake relief work including co-ordination, of communication reconstruction, live new coverage, and temporary communication vehicle.

Experience in Past Earthquakes: 12 Jan 2010 M7.0 Haiti Earthquake

- 7.0 Magnitude Quake struck near Port au Prince
- 3,500,000 people were affected by the quake
- 220,000 people estimated to have died 300,000+ people were injured
- Over 188,383 houses were badly damaged and 105,000 were destroyed by the earthquake (293,383 in total),
- 1.5m people became homeless
- After the quake there were 19 million cubic metres of rubble and debris in Port au Prince – enough to fill a line of shipping containers stretching end to end from London to Beirut.
- 25% of civil servants in Port au Prince died
- 60% of Government and administrative buildings, 80% of schools in Port-au-Prince and 60% of schools were destroyed or damaged
- Over 600,000 people left their home area in Port-au-Prince and mostly stayed with host families

12 Jan 2010 M7.0 Haiti Earthquake

There was considerable damage to communications infrastructure. The public telephone system was not available

Haiti's largest cellular provider Digicel suffered damage to its network. It was operational by 14 January, but the volume of calls overwhelmed its capacity and most calls could not be connected.

Comcel's Haiti's facilities were not severely damaged, but its mobile phone service was temporarily shut down on 12 January. By 14 January the company had re-established 70% of its services

Service on the spur connection to the BDSNi cable system which provided Haiti with its only direct fibre-optic connectivity to the outside world, was disrupted, with the terminal in Port-au-Prince being completely destroyed.

Experience in Past Earthquakes: 22 Feb 2011 M6.3 Christchurch Earthquake

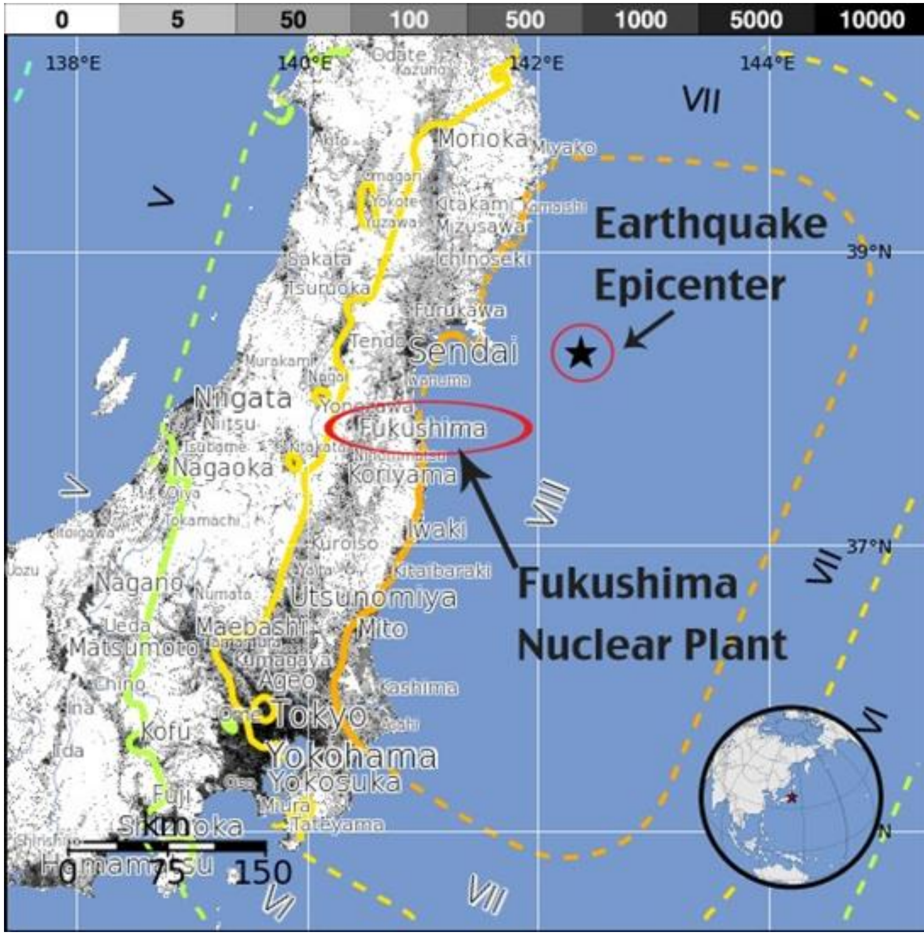
- Cellular performance suffered for some hours due to extreme congestion
- Batteries ran down after a few hours were a problem
- Some cell towers and other assets were damaged
- Cordless PSTN phones ceased to work where electricity failed.
- Some microwave dishes were misaligned
- Many PSTN copper and lead-covered cables were damaged.
- Fibre held up well.
- Main nodes /exchanges (where back-up electricity supplies are available) held up well.
- Radio services held up well. Radio

Experience in Past Earthquakes: 22 Feb 2011 M6.3 Christchurch Earthquake

In the following hours and days:

- Cellular performance temporarily declined where electricity was unavailable as batteries at cell sites depleted
- Cellular performance then improved to usable, and then to near-normal levels as generators and mobile sites were deployed (around 200 mobile generators were used)
- Generator re-fuelling presented major logistical challenges due to road conditions and congestion. Petroleum was generally available for generators and vehicles.

Experience in Past Earthquakes: March 11, 2011 Great East Japan EQ



Experience in Past Earthquakes: March 11, 2011 Great East Japan EQ

Damage to Communications Systems

Wireless facility, Iwate Prefecture

18	Central offices destroyed
23	Central offices submerged
1,000	Buildings without power
6,300	km aerial cable destroyed
65,000	Telephone poles destroyed

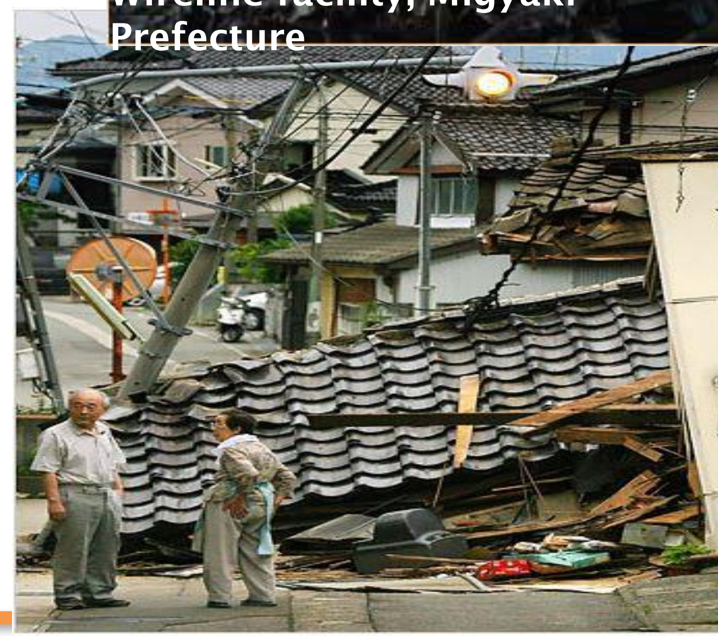
Wireline facility, Migyaki Prefecture

Experience in Past Earthquakes: March 11, 2011 Great East Japan EQ

Despite the devastation and the destruction, the recovery was amazing fast due to detailed preparations and high awareness

Vulnerability Components: Buildings, Equipment, Servers, Conduits and Cables


Wireline facility, Migyaki Prefecture



External Lifeline Vulnerabilities: Transportation, Power, Water, Fuel

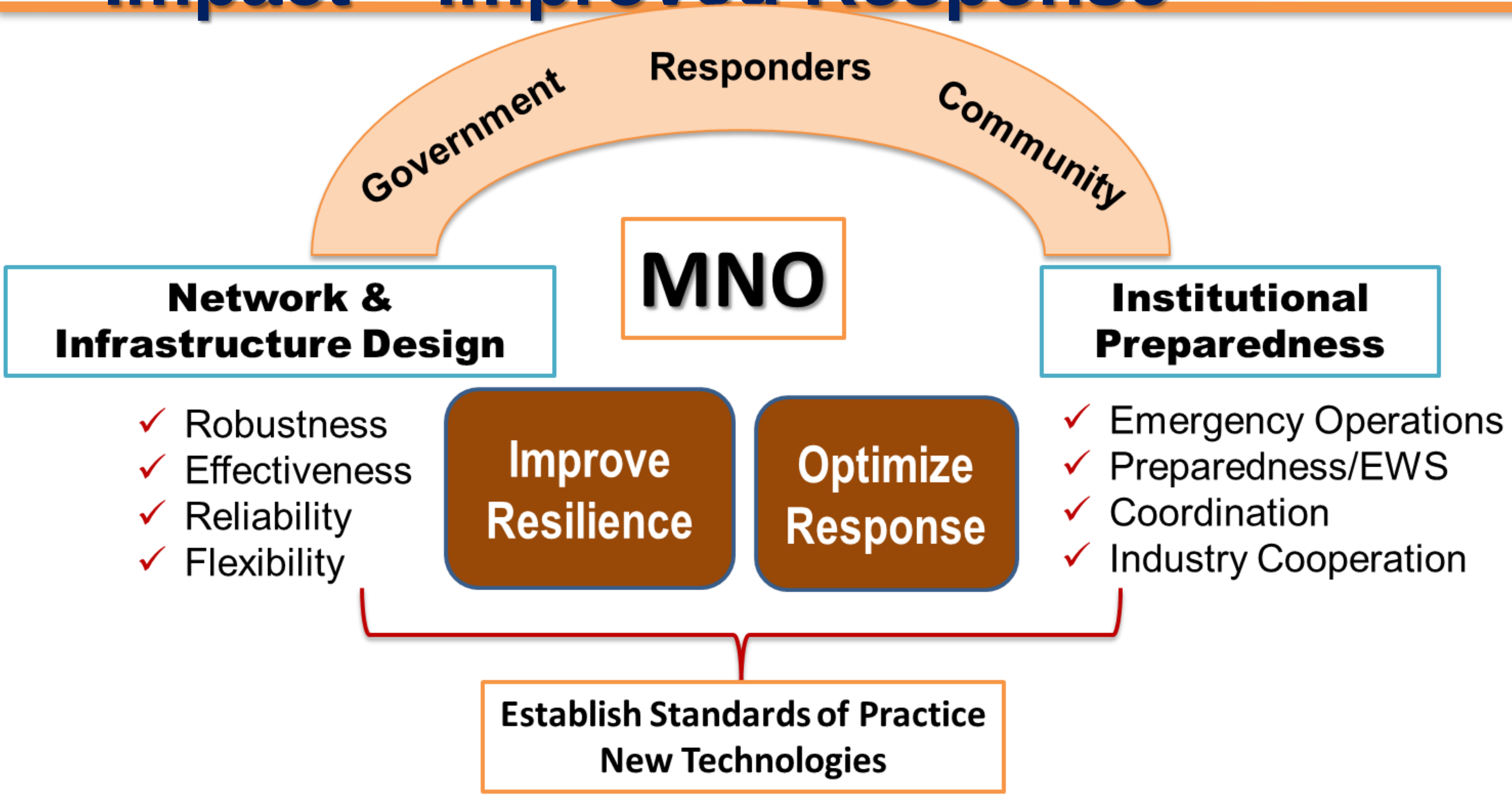
PART 3

Improving Earthquake Resilience of Mobile Telecom Systems

MNO Challenges

- Reducing Congestion
- Knowledge gathering; reporting; alerts and warnings
- Institutional capacity to manage the response
- Coordination/cooperation between MNOs, government and humanitarian stakeholders.
- Infrastructural and technical challenges in network resilience and restoration
- Reliance on other lifelines (Transport; Power, Water, Fuel)

MNO Performance Objective: Less Impact – Improved Response



Reducing Vulnerability: Building Design

- Building Code's intent is to protect Life Safety
- Communication buildings are critical facilities and should be designed to remain operational after a major EQ
- Entails additional special requirements for both building and equipment design

Central Office Building damaged by Tsunami

Reducing Vulnerability: Building Design

Bracing to the steel structure to resist lateral forces
Introduction of Passive Energy Systems such as BRBF's

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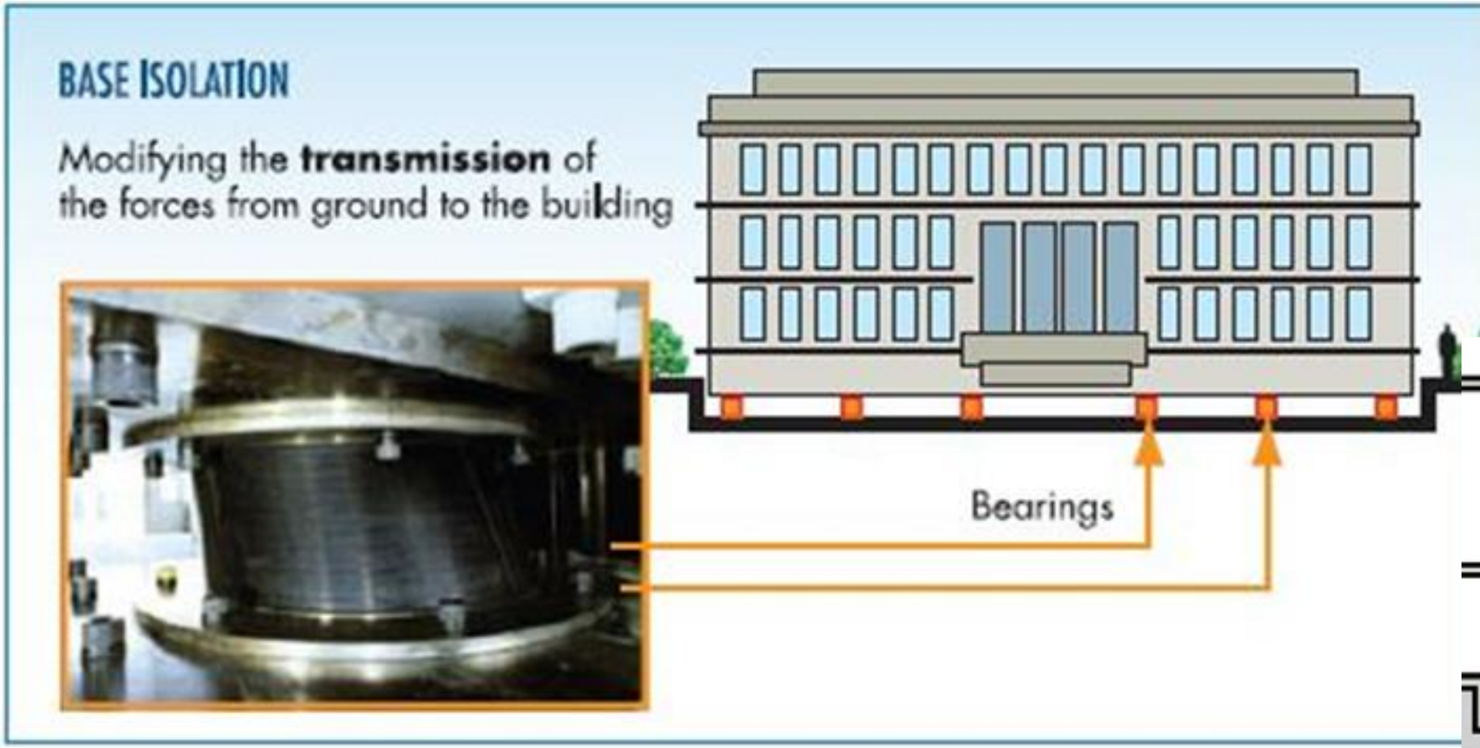
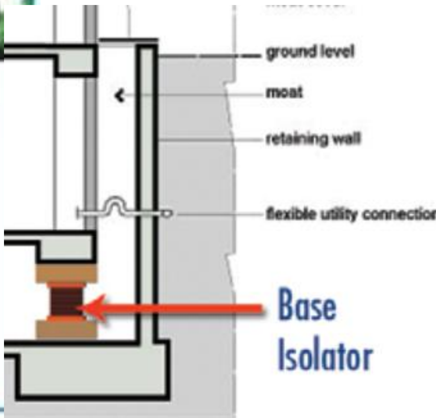
Reducing Vulnerability: Building Design





Base Isolation technology is designed to keep building and Equipment Operational after a major earthquake

Reducing Vulnerability: NEBS Equipment Standards

- **NEBS (Network Equipment-Building System)** is the most common set of safety, spatial and environmental design guidelines applied to telecommunications equipment in the United States.
- NEBS was developed by Bell Labs in the 1970s to standardize equipment that would be installed in a central office.
- It is an industry requirement, but not a legal requirement (i.e., Standard but not Code)
- Telcordia (Erricson) now manages the NEBS specifications.

Reducing Vulnerability: NEBS Equipment Standards

- Bell Laboratories developed the Network Equipment Building Standard (NEBS) for Regional Bell Operating Companies (RBOC) in response to a disastrous fire that completely destroyed an entire Central Office.
- The resulting investigation revealed that the telecommunications equipment caused the rapid spread of the fire.
- NEBS has been embraced and adopted by military, government and public agencies, and commercial enterprises worldwide.
- NEBS is also recognized by financial risk assessors, municipalities and regulatory agencies

NEBS-3 For EQ Safety

- **"NEBS Level 3"** has strict specifications for fire suppression, thermal margin testing, vibration resistance (earthquakes), airflow patterns, acoustic limits, failover and partial operational requirements, RF emissions and tolerances, and testing/certification requirements

Reducing Vulnerability: Conduits and Cables

Severe movement of the abutment has separated the conduit damaging the cables inside

Dedicated structure for the cable conduits crossing a river

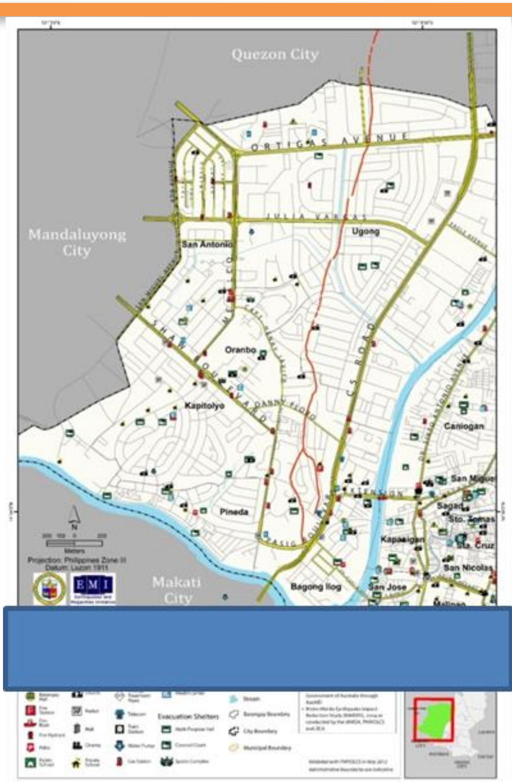
Resilience Parameters: Summary

- Designing buildings and facilities to higher standards: Using technologies such as Base Isolation or Passive Energy Dissipation Systems
- Adopting most recent design practices in antenna and tower design
- Adopting the NBES 3 standards for equipment design
- Providing for redundancy to secure communications in the event of a disaster.
- Designing resilient network topologies

Understanding Earthquake Hazards

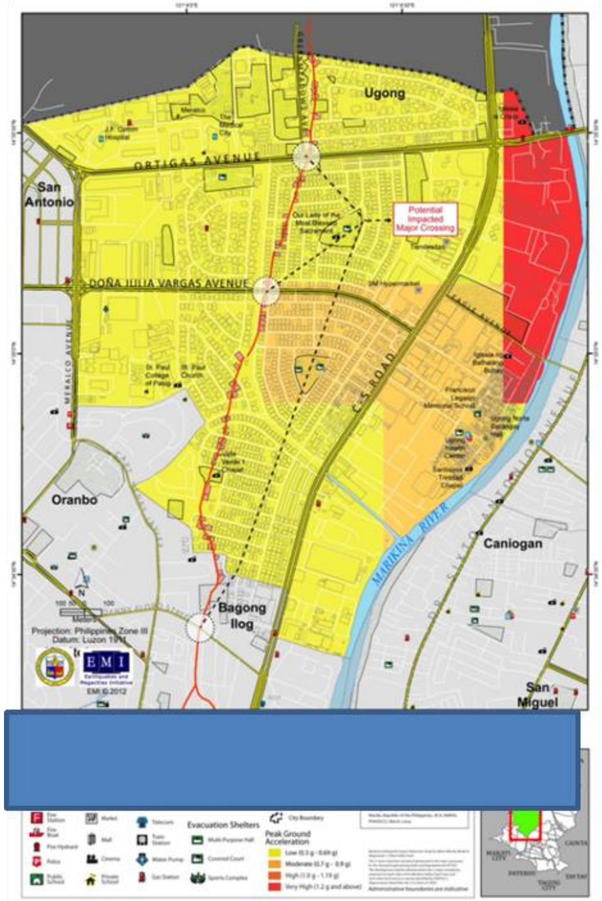
- Surface Fault Rupturing
- Earthquake Shaking
- Soil Failure: Liquefaction and Landslide
- Fire Following
- Tsunamis

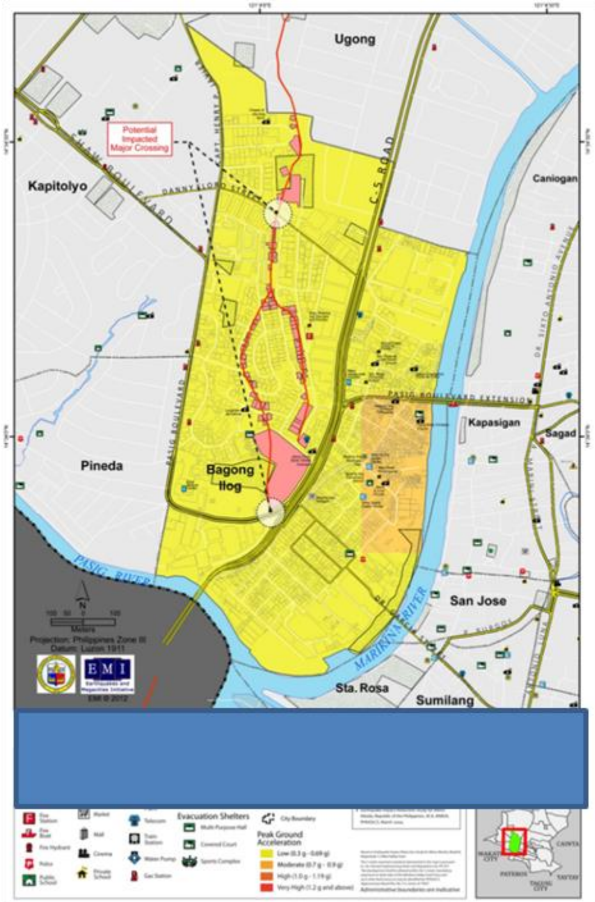
Understanding hazards: Surface Fault Rupturing



Map showing surface rupture potential with essential facilities in Western Pasig City (***Source: EMI, 2012 – original data sources recognized in the map)***

Understanding hazards: Surface Fault Rupturing

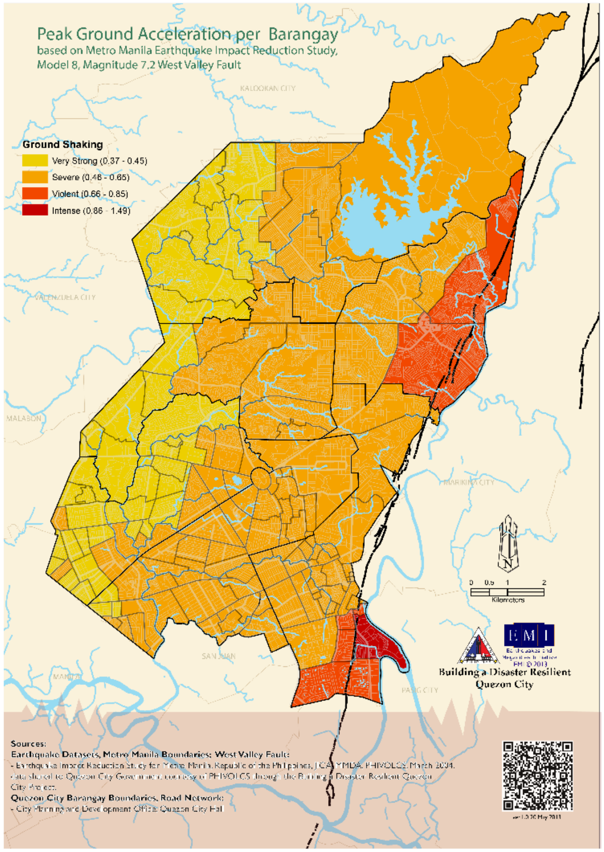


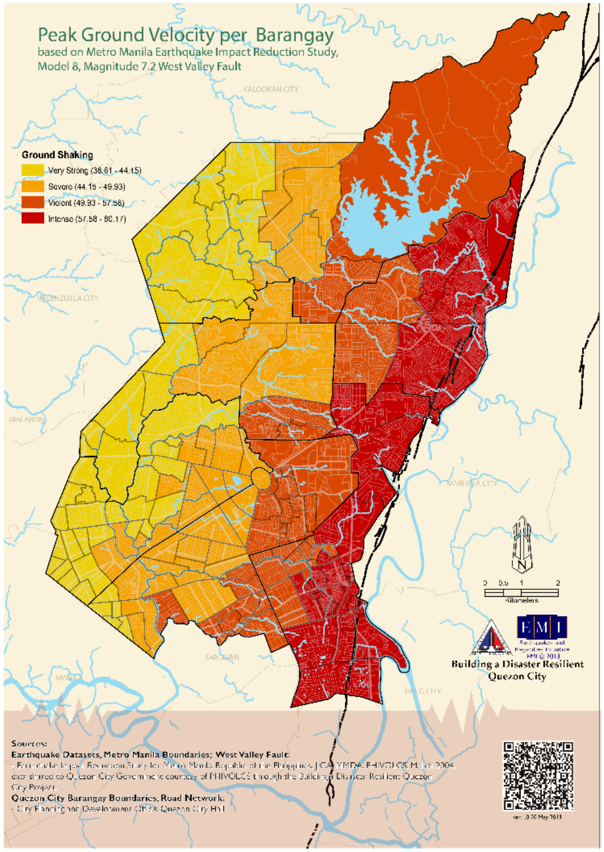


Fault Crossings and identification of Structures at Risk

(Source: EMI, 2012 – original data sources recognized in the map)

Understanding hazards: Ground Shaing

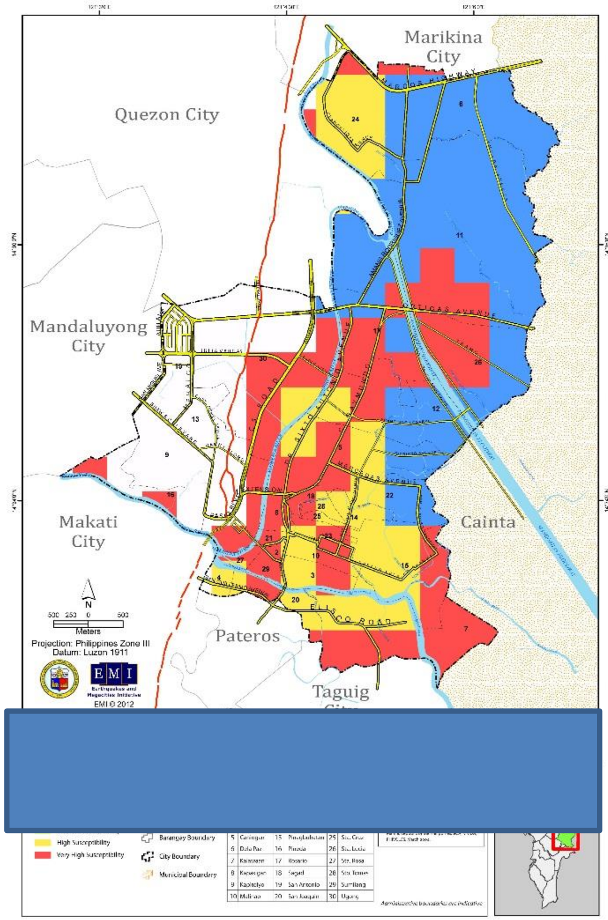




Map showing Ground motion hazard in Quezon City from M7.2 EQ

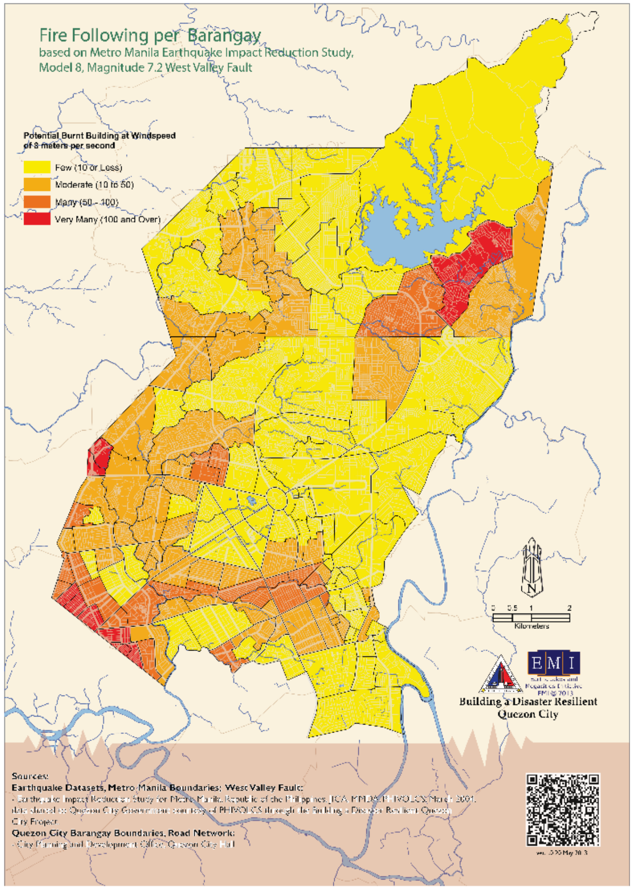
(Source: EMI, 2013 – original data sources recognized in the map)

Understanding hazards: Liquefaction Potential



Maps showing Liquefaction Potential hazard in Pasig City and Luzon
(Source: EMI, 2012 – PHIVOLCS; original data sources recognized in the maps)

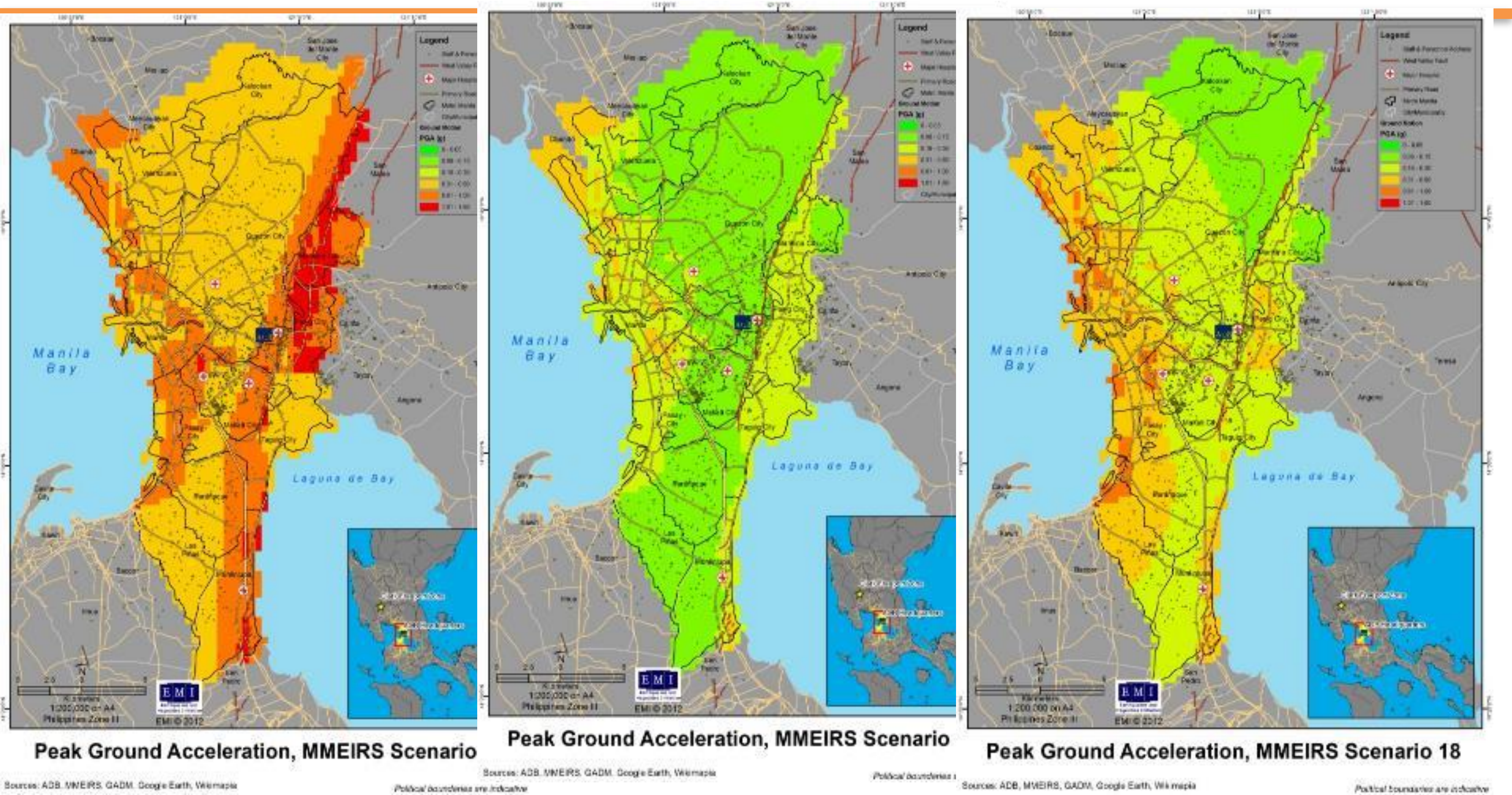
Understanding hazards: Fire Following



Maps Showing Fire Following Hazards for Pasig City and Quezon City

(Source: EMI, 2011-2012 – original data sources recognized in the map)

Understanding hazards

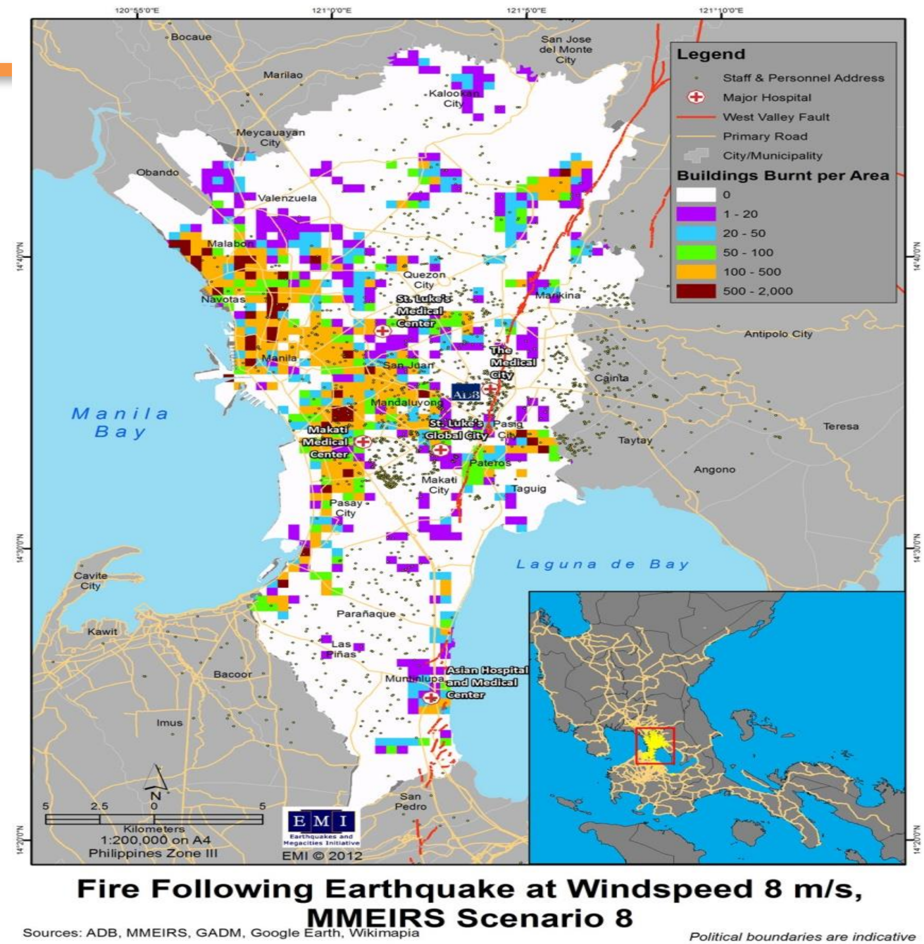


Comparison of intensity distribution between the three scenarios expressed in terms of peak ground acceleration (pga). Source: MMEIRS Study (2004)

Understanding hazards

Fire following could be a major issue in high density neighborhoods because of mixed usage of buildings, lack of fire code enforcement, and risk of conflagration.

Fire fighting capability is limited



Map showing major hospital locations and fire following M7.2 earthquake – Source MMEIRS Study 2004

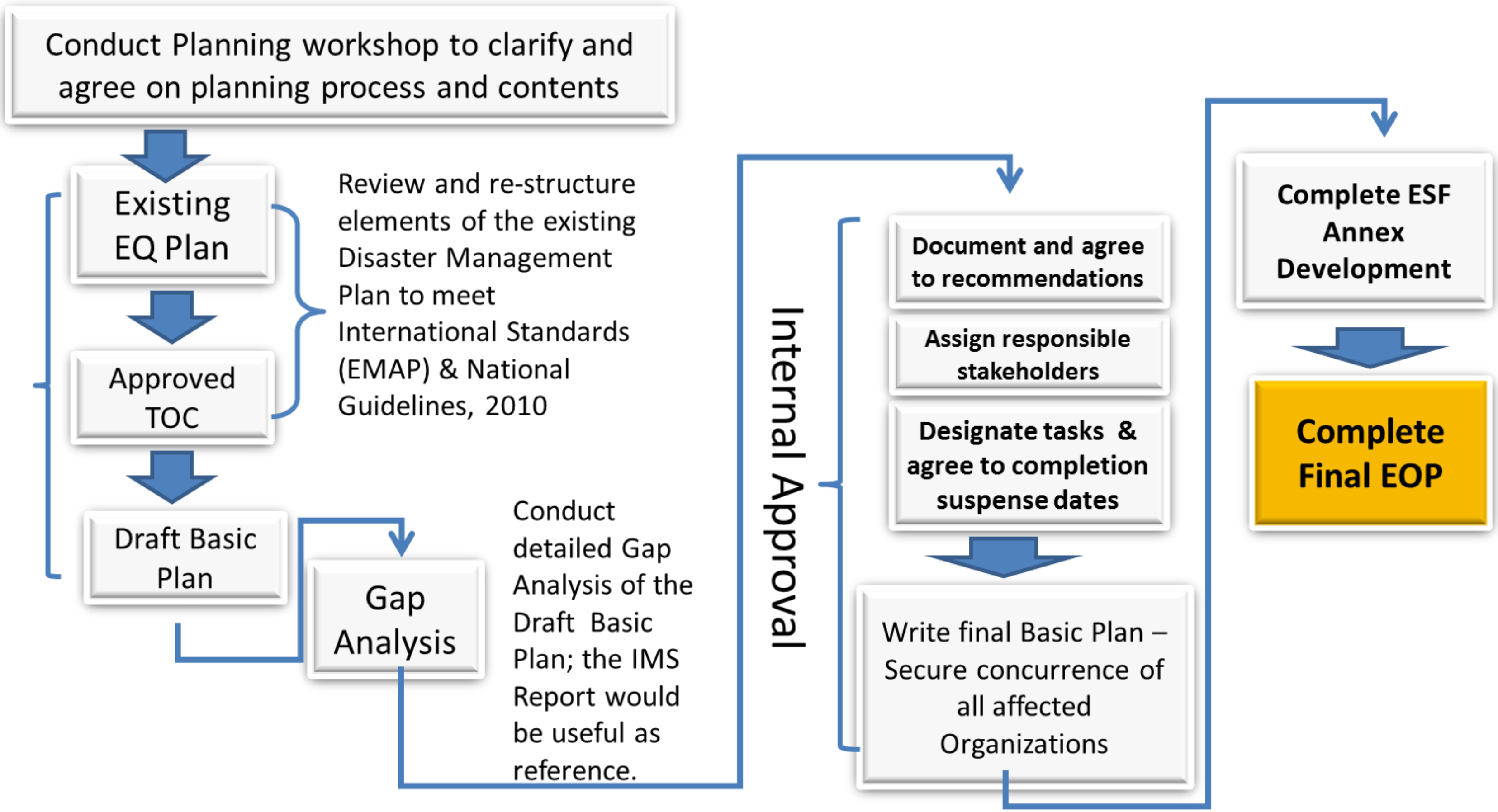
PART 4
Improving Preparedness

Improving Preparedness: Institution

- Elaborating a vision that defines roles and responsibility
- Undertaking Impact Analysis:
  - Understanding hazards, vulnerabilities and capacities;
  - Impact on Human and Physical Assets
  - Mobility Study
  - Business Continuity
- Taking a holistic Approach to Disaster Planning: *Mainstreaming DRR in Business Units*

Improving Preparedness: Institution

Prepare, Test and Practice the Corporate EOP

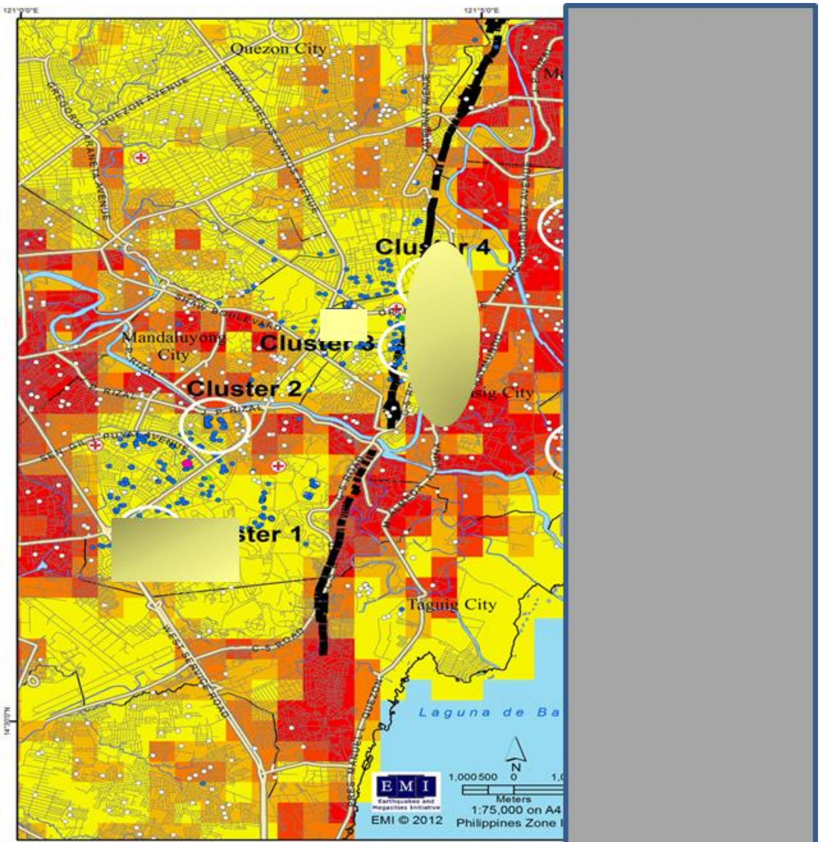


(*Source: EMI, 2011 Confidential*)

Improving Preparedness:
Business Continuity

Staff Exposure and Mobility Study: Develop Work-hours scenario and Off-Work Hours scenario

Distribution of staff by category together with the distribution of heavily damaged buildings



Proposed Cluster Locations for Determining Safe Havens

Sources: ADB, MMEIRS, GADM, Google Earth, Wikimapia

Political boundaries are indicative

(***Source: EMI, 2011 Confidential***

Improving Preparedness: Maintaining Connectivity

- Rapid Repair & Restoration
- Free Public Phones
- Mobile Phone Charging Stations
- Disaster Message Boards

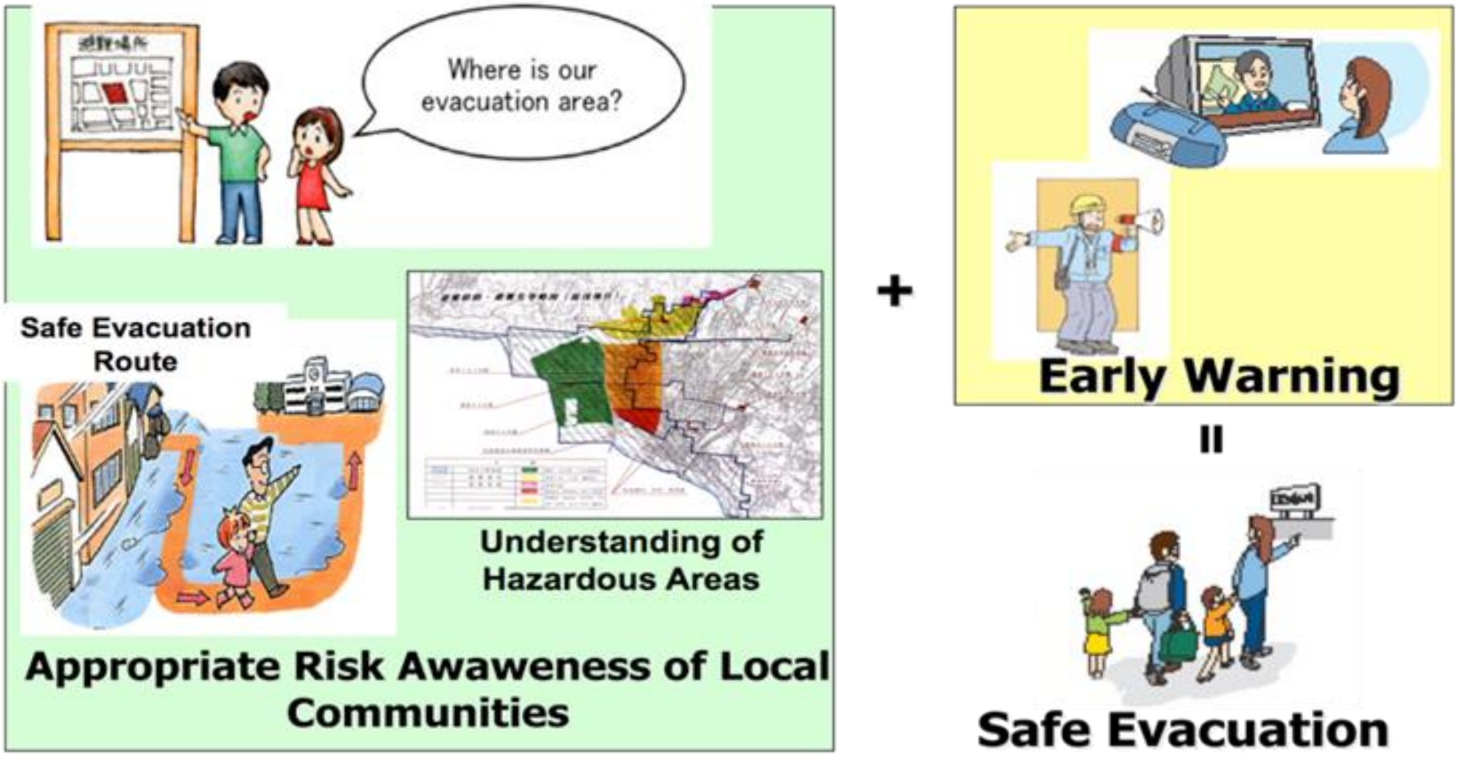
Andrew@AndrewBurtonPhoto.com

Andrew@AndrewBurtonPhoto.com

Preparedness: Community and Industry Initiatives

Earl Warning System will improve efficiency, save lives and property and industry-government-community collaboration

Community-Based Disaster Risk Reduction



Conclusions

- Mobile Networks are critical facilities but also inherently vulnerable to earthquakes
- MNO's have a significant challenge to respond to expectations while keeping their systems efficient and cost-effective
- Preparation for EQ is more challenging but Science and knowledge can help build Network Resilience - EPRI's Example
- Preparedness can improve response and save assets
- Collaboration between MNO's is crucial (Refer to GSMA Blueprint)
- Collaboration with Lifeline Operators and Government (Lifeline Council??)

Salamat Po!

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