Joint Natural and technological (Natech) Disasters: Prevention and Preparedness Actions for Risk Reduction

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Outline

1. Self-Introduction
2. Definition, characteristics, gaps
3. Examples from past disasters
4. Prevention and preparedness actions for risk reduction
5. Conclusions

18-20 Apr 2011 Jpn Tsunami - C. Scawthorn - 0205 Koganechou Onagawa 38.4429; 141.4468.jpg

1. Self introduction

Multicultural background and work experience

- Work experience in three continents
- Private sector, academia, government, international
- Local, national and global perspectives

- 2003 Ph.D. Environmental Engineering, Tulane University, New Orleans, USA
- 1999 Msc. Applied Development, Tulane University, New Orleans, USA
- 1987 Chemical Engineering, Universidad del Valle, Cali, Colombia

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Building Resilience for Natural and Technological Disasters

- Improving Societal Resilience of a Territory to Natech Risks (ResTO-TerRiN)
- Natech risk perception and evacuation around JX refinery after Tohoku
- Disaster Evacuation Planning in Areas subject to Natech Risks in Osaka/Kobe
- Sustainable Management and Inheritance of Local Culture and Infrastructure
- Economic Growth Theory under Disaster Risks

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2. Definition, characteristics

What is a hazardous material?

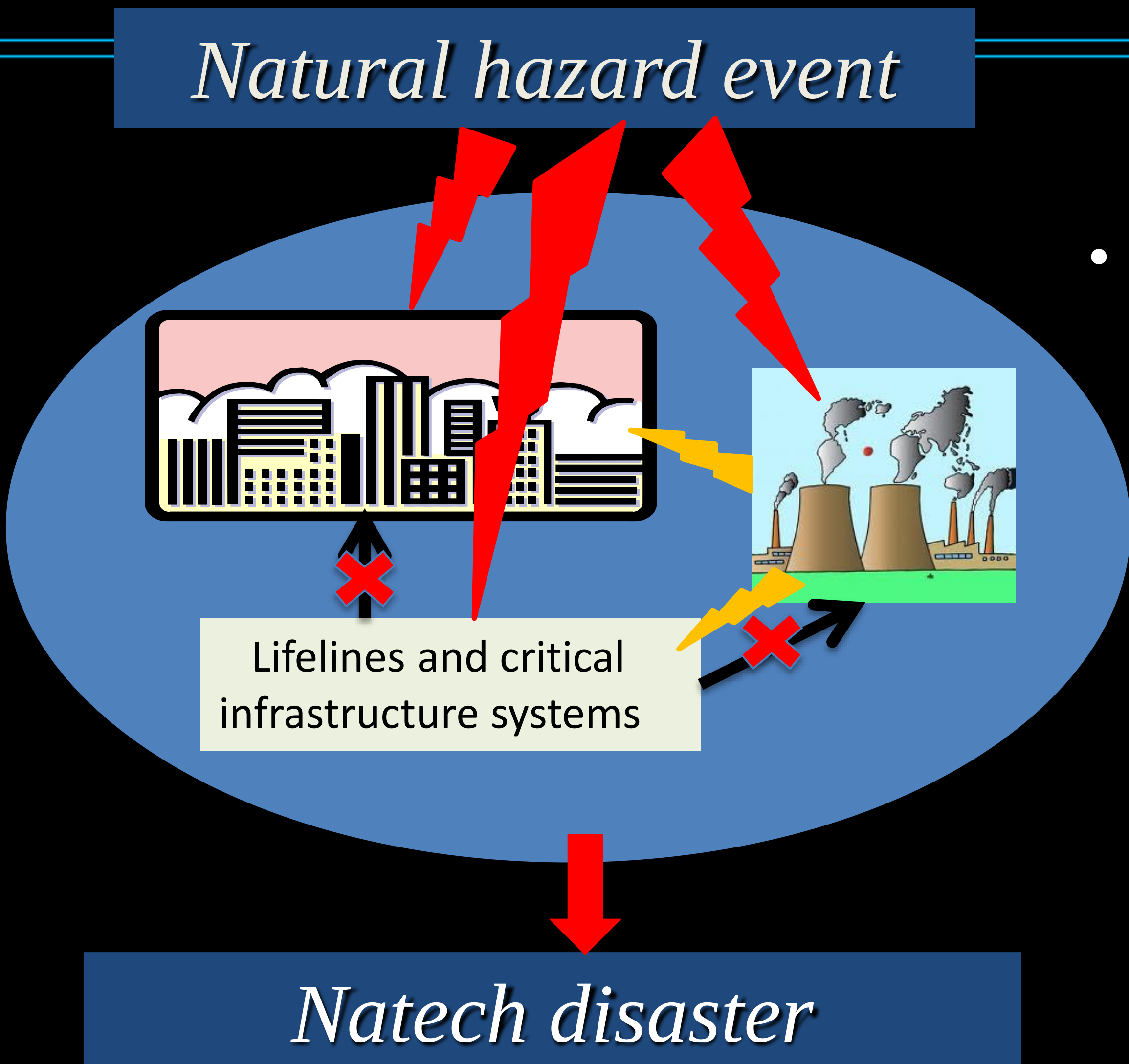
- Any chemical or mixture of chemicals having properties capable of producing negative effects to the health or safety of human beings or the environment.

- Chemicals presenting dangers that may arise from:
  - <u>Fires</u> and <u>explosions</u> (relating to flash point and boiling point)
  - <u>Toxicity</u>, <u>reactivity</u>, <u>instability</u>, or <u>corrosivity</u>.

Multiple hazmat releases more likely during natural disasters*

- Natural hazard events can trigger chemical accidents- (known as Natechs)
- Natechs accounted for about 3.6 % of chemical accidents reported to High Pressure Gas Institute (1965-2014)
- Natural hazard triggers include: typhoon (34%); flooding (32%); earthquakes (24%); others (e.g., lightning)
- Chemicals released: LPG (62%); Ammonia (15%); others (e.g., acetylene)

Implications in urban areas



Natech

- ***Na****tural disaster-triggered* ***tech****nological disaster*

  Technological disaster:

  – Releases of ***haz****ardous* ***mat****erials (hazmat)*
  – Releases from oil and gas pipelines
  – Damage to lifeline systems

- Large areas impacted
- Multiple accidents

Korfez, Kocaeli EQ, Turkey, 1999

Sendai, Tohoku EQ and tsunami, Japan, 2011

Natech disasters can be particularly problematic…..

- Likelihood of multiple and simultaneous accidents (common cause failures)
- Safety systems and protection barriers often not designed to accommodate releases triggered by, and simultaneous with natural disasters
- Simultaneous efforts required to respond to natural disaster victims and chemical accidents
- Emergency response plans may be non functional (e.g., shelter in place may not be feasible if buildings are no longer safe)

Gaps in Natech risk management

- Limited empirical data for flood, tsunami => lack of equipment vulnerability relationships for LOC
- Not factored in process safety => inadequate assumptions concerning safety/mitigation
- No agreed upon risk assessment methodologies (some for EQ, non for floods, tsunami, volcanic hazards)
- Analysis rarely includes systemic risks and cascading events beyond fence line => need for area wide risk assessment
- Large gap between agencies/organizations and disciplines
- May be overlooked in emergency planning on & off site

  => Community may not be well informed or prepared

Furthermore, generally low awareness among government officials, decision makers and industrial operators

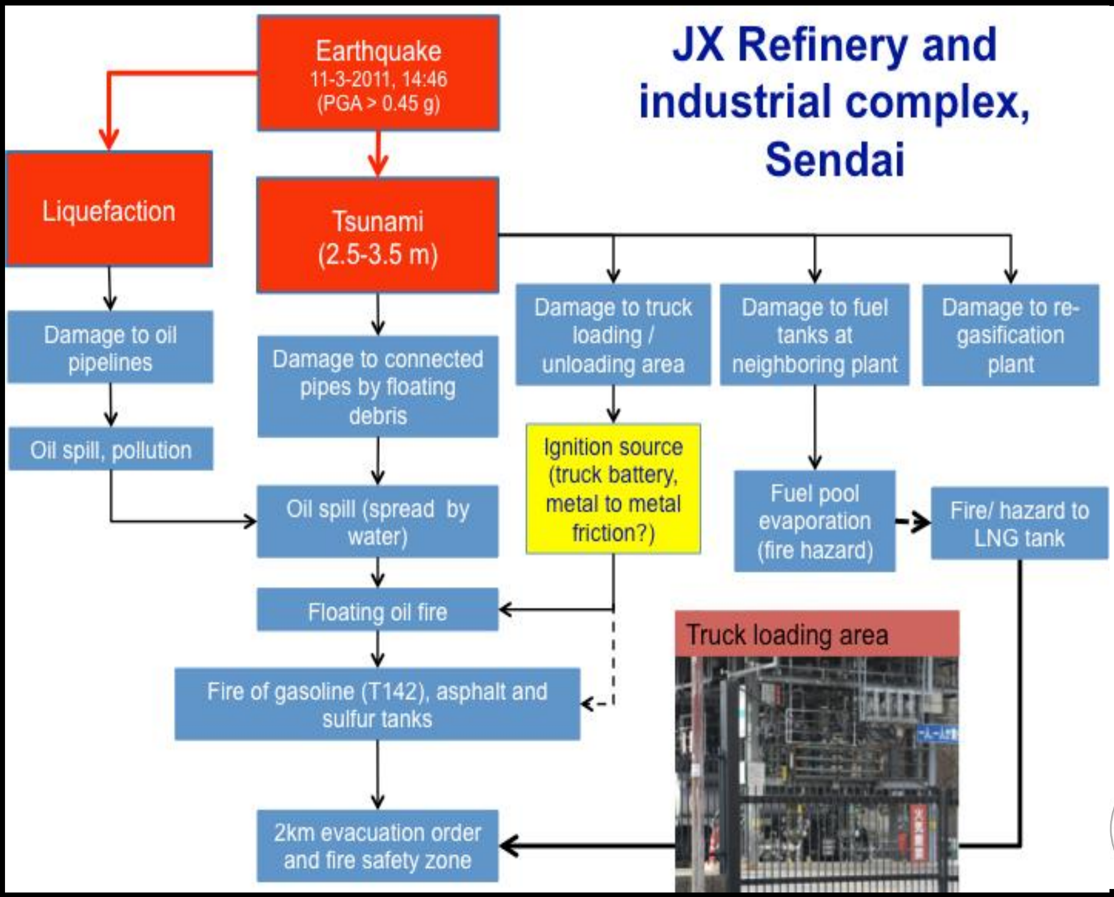
3. Examples from past disasters

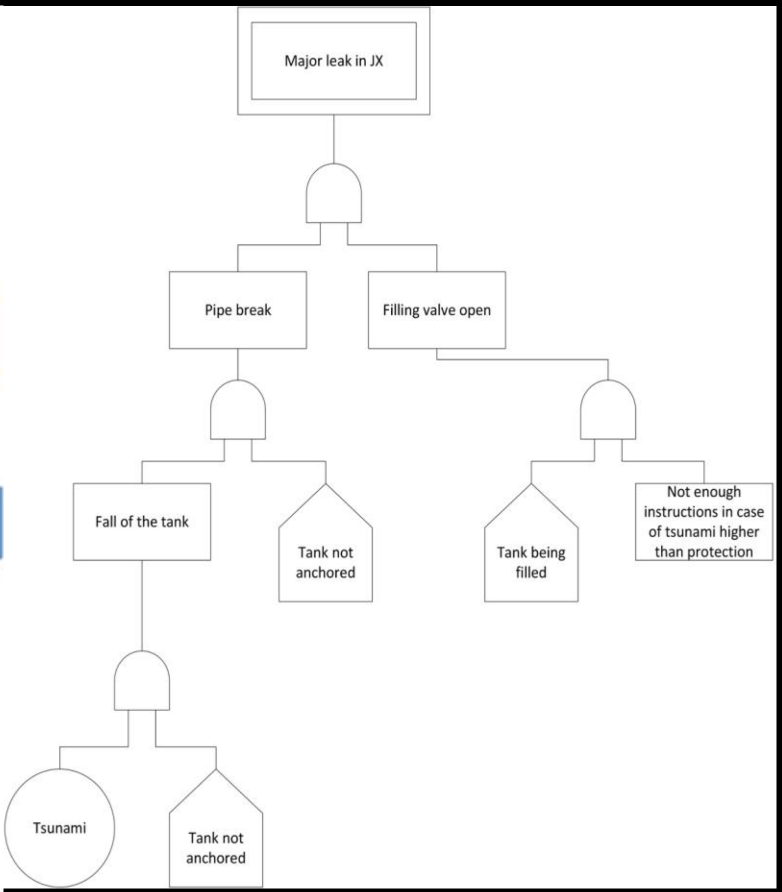
Inundation heights at JX Refinery

Tohoku Earthquake Tsunami Joint Survey Group

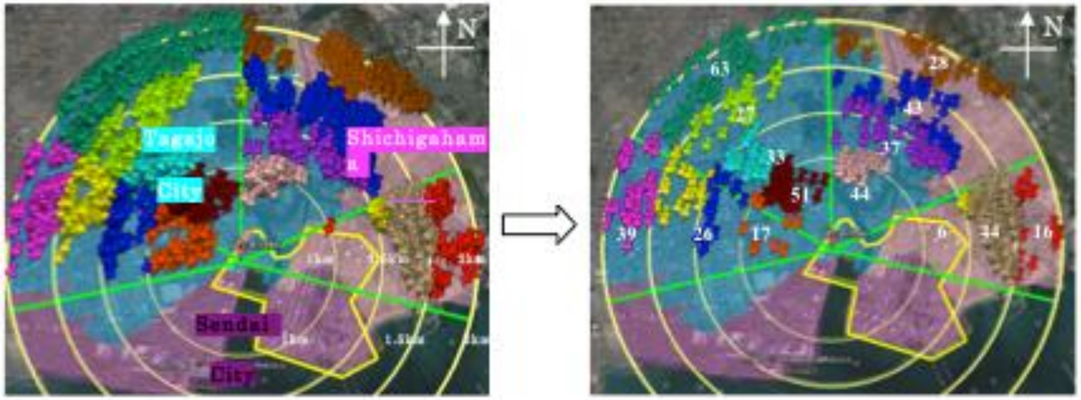
Ana Maria Cruz , 2014

Accident analysis to understand failure modes and consequences





Natech risk perception and evacuation behavior of residents living near JX refinery

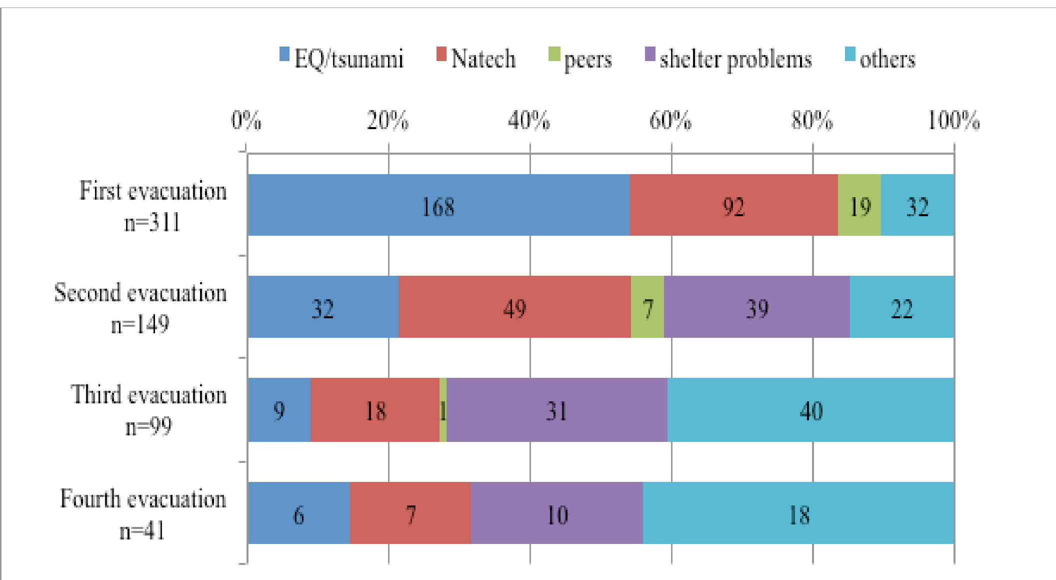


Natech risk perception of residents affected living near JX Refinery following the Great East Japan Earthquake and Tsunami of 2011. Sample distribution.

Preliminary findings:

- 63 % evacuated
- Almost half of evacuees, evacuated more than 1 time
- Regression analysis indicates decreasing risk perception with distance from accident
- Being able to see the plant due to slightly higher elevation increases risk perception

Multiple evacuations due to tsunami and Natech



- Most people do not know what to do in case of a chemical accident
- No chemical or Natech specific disaster evacuation planning

Cosmo oil refinery and Chiba industrial complex

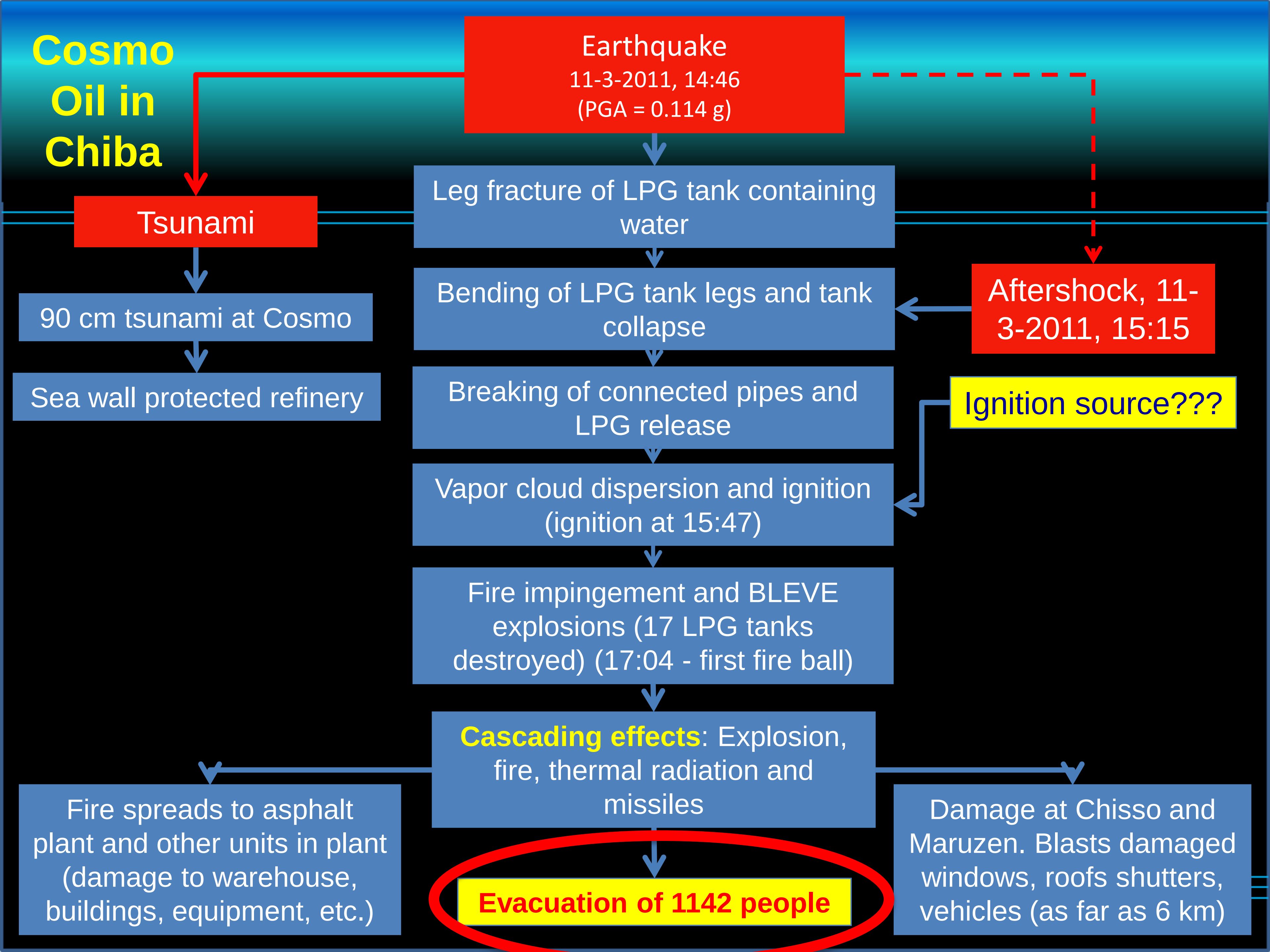
- Leg braces of LPG tank) filled with water suffers damage during Mw 9.0 EQ
- Aftershock (Mw7.0 off coast of Ibaraki) causes leg bending and tank collapse
- LPG is released, and vapor cloud explosion occurs
- Unable to reach automatic cut-off safety valve (left open and on manual for maintenance in violation of law)

Cascading and domino effects

- Fire/ explosion of all 17 LPG tanks
- Adjacent asphalt tanks damaged
- Blast, debris and heat radiation damage at Chisso
- Fire at Maruzen control room (heat radiation/ fire spread)

Cosmo oil refinery and Chiba industrial complex

- EQ damage, not tsunami
- Gas release, fire and explosion at Cosmo oil
- Damage onsite and offsite
- Glass/ window, vehicle damage to nearby buildings
- 6 injuries, 1.2 km evacuated
- Part of the facility shut down for over a year
- Crude distillation unit started on 28 April 2012


Cosmo Oil in Chiba
Earthquake
11-3-2011, 14:46
(PGA = 0.114 g)
Tsunami
90 cm tsunami at Cosmo
Sea wall protected refinery
Leg fracture of LPG tank containing water
Bending of LPG tank legs and tank collapse
Aftershock, 11-3-2011, 15:15
Breaking of connected pipes and LPG release
Ignition source???
Vapor cloud dispersion and ignition (ignition at 15:47)
Fire impingement and BLEVE explosions (17 LPG tanks destroyed) (17:04 - first fire ball)
Cascading effects: Explosion, fire, thermal radiation and missiles
Fire spreads to asphalt plant and other units in plant (damage to warehouse, buildings, equipment, etc.)
Evacuation of 1142 people
Damage at Chisso and Maruzen. Blasts damaged windows, roofs shutters, vehicles (as far as 6 km)

4. Prevention and preparedness actions for risk reduction

Industrial Risk management in Japan

Chemical accident prevention is regulated by many Laws/ Acts and their later **amendments** including:

- High Pressure Gas Safety Act (Act 204, June 7, 1951)
- Industrial Safety and Health Act (Act 56, June 8, 1972)
- The Petroleum Complex Disaster Prevention Act (Act 84 of 1975)
- Fire Service Act (Act 187, July 24, 1948)

Industrial Risk management in Japan

- Laws apply to industrial facilities that handle high pressure gases and other hazardous chemicals (e.g., toxic gases), as well as the petroleum industry
- High Pressure Gas Safety Act requires establishing maintenance programs:
  - to insure chemical accident prevention,
  - protection of workers and
  - public safety
- The Petroleum Complex Disaster Prevention Act specifically addresses potential chemical accidents during earthquakes

Industrial risk management gaps

- Law applies for new construction

=>Older facilities may not be adequately protected

- No written reports of process safety actions or other risk management information is required
- Reporting of certain chemical releases (based on chemical and quantities) is required

Risk reduction measures

- Adoption of strict seismic design codes (YES)
- Consideration of natural hazard loads in process safety analysis/ assessments (YES, partially through Fire Safety law and voluntary actions)
- Assessment of risk to nearby community (NO, not required in Japan)
- Land use controls (Only limited due to space)
- Preventive infrastructure (e.g., fire walls, improved floating roof design, anchoring of tanks, seismic sensors (YES, to some extent)
- Emergency planning and risk communication to residents (EP **=>**partially, RC **=>**NO)

What went wrong?

- Natech hazards had not been adequately considered
- Safety and mitigation measures designed to contain releases during “normal” day to day operation, may not provide adequate protection to Natechs
- Possible overconfidence in existing safety measures
- Emergency response (and resuming of operations) hampered by aftershocks, tsunami alerts, evacuation, loss of lifelines, and shortage of raw materials
- Residents not informed about chemical hazards

Lessons learned

- Natural hazards need to be an integral part of industrial risk management
- Industry and responders must work together to be prepared for chemical accidents occurring concurrently with natural hazards
- Equipment maintenance and operating procedures need to be reviewed for future Natech accident prevention
- Near miss events should be fully reviewed → can provide important lessons
- Equipment retrofitting and other measures already taken

Reinforcement of LPG tank legs after the earthquake and tsunami

Conclusions

- Natural hazards can lead to multiple and simultaneous releases and cascading events
- There is possible overconfidence in current industrial management practices and safety measures
- Natural hazards (especially extreme events), continue to pose a major threat to industry with consequences to people, the environment and socio-economic systems
- Need to adequately assess and communicate risk to residents
- Need to consider chemical accidents and Natechs in disaster preparedness and response planning


ありがとうございます
Thank you
Xie Xie
Gracias
Grazie
Merci !