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Effects of Notable Natural Disasters from 2005 to 2011 on Telecommunications Infrastructure:

Lessons from on-site Damage Assessments

Overview

- Introduction
- Analysis methodology
- Case studies
  - 2005: Hurricane Katrina
  - 2008: Hurricanes Gustav and Ike
  - 2010: Mw 8.8 Maule Region, Chile Earthquake and Tsunami
  - 2011: Feb. 22, Christchurch, New Zealand, Earthquake
  - 2011: Mw 9.0 Great Tohoku Region, Japan, Earthquake and Tsunami.
- Conclusions

Introduction

- Importance of communications during and after a disaster:
  - Emergency services
  - Social
  - Interdependent infrastructures
- Study typically follows two approaches
  - Anecdotal: More common but more unreliable, too. It also considers government inquiries.
  - Scientific: Relies on hard data from damage assessments coupled with outage data and other quantifiable information.

Methodology Approach

- Scientific approach

- Based on damage assessments and quantifiable data.
- Questions explored during damage assessment:
    - What infrastructure elements failed and what did not fail? Why?
    - In the cases when the infrastructure element under observation failed and/or was damaged, how was operation restored?
  - The set #1 of questions aims at learning primarily how to achieve higher MUTs, whereas the set #2 of questions targets at identifying ways of reducing the MDT.
- Failure modes:
  - Lack of onsite genset and battery exhaustion
  - Genset failure (e.g. fuel starvation).
  - Power plant damage but communications equipment (e.g. switch fabric) undamaged.
  - Communications site damage.
  - Other failures in communications infrastructure.

Hurricane Katrina

- Power outages a significant cause of communications failures

- 2.5 Million PSTN lines lost service.
- Storm surge destroyed 9 central offices and flooded 6 other COs. 5 of the 9 destroyed COs were restored with digital loop carrier (DLC) systems.
- 18 central offices lost service due to engine fuel starvation.

Hurricane Katrina

- Power outages a significant cause of communications failures

- Most of the cell sites and existing DLCs failed due to power-related issues. Only a small percentage were damaged (e.g. water immersion or collapsed tower).
- Inconsistent building practices for cell sites. In a same site some base stations above flood plane and the others below the flood plane.
- Damaged base stations restored with COWs or COLTs.
- Power restored to most undamaged base stations and DLCs with portable gensets. Some cell sites had multiple gensets deployed.

Hurricane Gustav

- Lessons from Katrina served to reduce communication outages

- Power outage was more extensive than that caused by Katrina. Yet, communication outages were small.
- No CO was damaged because the storm surge was not as strong as Katrina's.
- Damage assessment identified a CO with genset issues.
- PSTN outages were reduced because many DLCs had been located on platforms and equipped with permanent gensets since Katrina.

Hurricane Ike

- Power issues in distributed network elements were a significant cause of com. outages.

- Cat. 2 hurricane but the storm surge is comparable with a cat. 4 storm.
- 340,000 PSTN outages.
- 12 COs lost service. One of those destroyed by the storm surge. One other may have been damaged by storm surge waters but the remaining lost service due to power issues.
- Service restored to the damaged CO with a switch on wheels.

Hurricane Ike

- Power issues in distributed network elements were a significant cause of com. outages.

- Power issues the most important cause of outages in distributed network elements.
- Only 3% of the more than 1,000 DLCs that lost service were destroyed.
- Few cell sites were damaged.
- COWs and COLTs were used to restore service or to improve network coverage.

2010 Chile's Earthquake

- Power issues was an important cause of communication systems outages

- Shaking was not particularly intense but, still, power outages lasted in important areas more than 2 weeks.
- 3 COs were affected by the tsunami.
- One CO lost service due to high temperatures when the air conditioner stop working after the genset failed.

2010 Chile's Earthquake

- Power issues was an important cause of communication systems outages

•Almost all cell sites and most small remote switches lacked permanent gensets.

- Shaking damaged batteries, antennas and other base stations equipment.

2011 Christchurch, NZ

- The second highest peak ground acceleration ever recorded caused by an earthquake
- Extensive soil liquefaction led to many buried power lines failures.
- Extensive use of micro and nano-cells imply many sites where gensets were needed. Hence, genset deployment was prioritized.
- Only a few cell sites were destroyed. They were restored with COWs
- Cordoned-out areas in city downtown affected services restoration.

2011 Japan's Earthquake

- Most severe damage was caused by the tsunami

- Shaking damage was little. Tsunami damage was extensive on the coast.
- Power outages were extensive both on the coast and inland. Power issues and restoration of all services were affected by Fukushima Daiichi nuclear power plant incident. Coal fired power plants were also damaged by the tsunami and other nuclear power plants went offline.
- There were significant transportation issues specially during the first month due to limited availability of gasoline, damaged roads in coastal areas and more traffic (e.g. the army deployed more than 100,000 troops in the area).

2011 Japan's Earthquake

- Most severe damage was caused by the tsunami

- PSTN outages peaked at 1.5 Million 2 days after the earthquake.
- 26 COs were destroyed by the tsunami. Some were restored with DLCs or shelters with switching equipment.
- COs were well constructed. In some towns the CO is one of the few buildings still standing. Watertight doors reduced damages.
- Power issues affected many COs both on the coast and inland. Small COs require portable generators to keep operation. Deployment of these generators and refueling was complicated by road conditions and limited gas

2011 Japan's Earthquake

- Most severe damage was caused by the tsunami

- Cells out of service peaked 6,720 on March 12th.
- Many cell sites in coastal areas were destroyed. Service was restored with COWs or by increasing coverage of neighboring undamaged cells. Also, small microcells linked with satellites were used.
- Power issues affected most of the cell sites that lost service. Few cell sites had permanent gensets.
- The microgrid in Sendai performed well and did not lost service.

Conclusions and Recommendations

- Independently performed damage assessments provide an objective view of the effects of natural disasters on communication systems.
- Two basic sets of questions are studied during damage assessments. One addresses MUT, the other MDT.
- Distributed generation (microgrids) may address power issues during disasters. Power issues is one of the most common causes of outages during disasters.
- Renewable sources do not have lifelines but they also have large footprints.
- Damage assessments identified higher failure rate than in the past. The reason still need to be determined (system planning and design vulnerabilities, such as increased use of distributed network elements or another reason?)