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HOKKAIDO Eastern Iburi Earthquake 2018 – Telecommunications and Transportations Lifeline Performance

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Abstract

This paper examines the performance of Telecommunications, and Transportations lifelines in the M_w 7.0 Hokkaido Eastern Iburi Earthquake of September 2018.

Telecommunications. This section includes both landline and wireless systems. Power outage caused long duration service disruptions in many communities of Hokkaido Prefecture. NTT East the major service provider in the area deployed resources from Honshu to support the local recovery teams. The resources include power generation trucks, portable generation units, and Cellular on Wheel.

Transportations. This section includes airport, port and harbor, and road/rail network in the earthquake impacted areas. Significant impact due to power outage was observed. Reliability of back up power at Chitose International Airport needs to be carefully examined to avoid shut down in future events. Ports and Harbors sustained damage due to ground deformation and liquefaction. The ports were able to continue to operate to allow relief supplies to Hokkaido.

The paper summarized with discussion of available techniques to reduce service interruption in telecommunications as well as the special transportations recovery team from MLIT TEC-Force.

Keywords: telecommunications, transportations, preparedness, response, recovery

1. Introduction

The two key impacts of the 06 September 2018 Hokkaido Iburi East Earthquake are landslides and electric power outage to lifelines. Although the landslides did damage a few electric power transmission towers, the power blackout resulted from unforeseen mishandling of network control and power plant equipment damage was a significant lesson of this earthquake. This paper will not discuss the power blackout, but highlight the power outage impact to both telecommunication and transportation lifelines.

This earthquake is one of the most extensive landslides events in Japan's earthquake record. The landslide covered an estimated 400 sq. km. One of the impacts of many landslides was the spread of the flow that destroyed the rice and vegetable fields. The financial impact to agricultural sector of the prefecture was very significant. Figure 1 shows this special characteristic of one of the many landslides in this earthquake.

Roads and utility poles were routed along the foothills in this rural area. Many sections of the rural roads were covered by landslide debris, which also destroyed the utility poles in their path. The results are that both power and telecommunication services were disrupted. The loss of these services caused difficulties in emergency and rescue services.

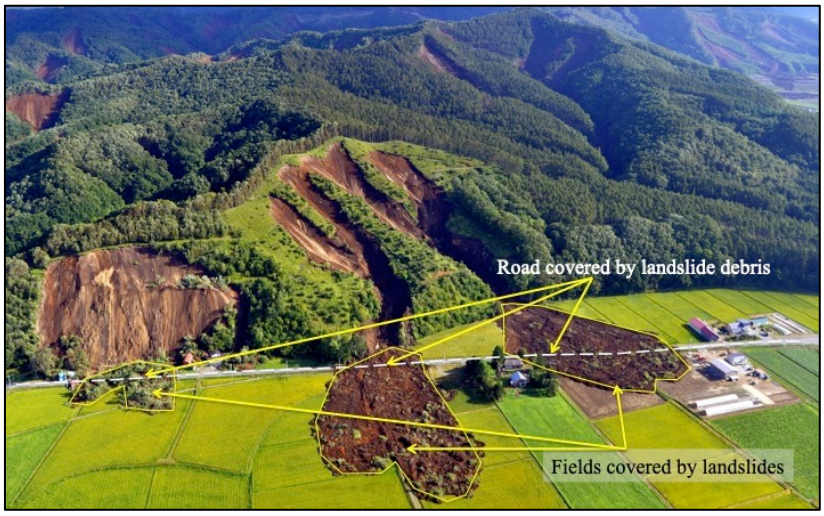

Fig. 1 – Spread of debris from the landslides covering the rice fields and other vegetable fields.

2. Telecommunications

The service providers in Hokkaido are the same as in Honshu and Kyushu. NTT East basically dominates both landlines and cellular services. The other competitors are KDDI and Softbank. The term services in telecommunications represent both voice and data. Technology advancement has changed the landscape of hardware and software, which is being driven by demand. Any telecommunications services disruptions have a wider effect to the community. This is a service that most people take it for granted. Therefore it is vital to have a more robust system to reduce or hopefully eliminate services disruptions after a large earthquake.

Telecommunications is the only lifeline that connects all the populated spaces on earth. That is this network has the greatest probability of locating in a natural hazard location. So dealing with hazards is a normal operation of any service providers. The only difference is how and what are being done in the operation processes. NTT learned many lessons from post earthquake service disruptions. As observed, the network progressively has performed better after each event. Unfortunately each earthquake has its characteristic on lifelines and the result is that new lessons are learned. Hokkaido earthquake proved to be a unique one for telecommunications with a blackout to 2.95 million customers, basically a whole island blackout for a day with progressive power restoration to all customers up to 35 hours after the blackout.

All the NTT Exchange Offices within Hokkaido did not sustain any service interruption damages; however there were minor superficial surface cracks within a few buildings in Sapporo City were observed. The major set back was due to long duration of power outage, which caused the backup battery reserve exhausted in some Exchange Offices. Even with additional mobile power generation units from NTT Honshu could not satisfy every Exchange Offices and Cell Sites within Hokkaido. Figure 2 shows the impact of power outage to NTT telecom services. This is 2 days after the main shock. A number of counties is still out of service

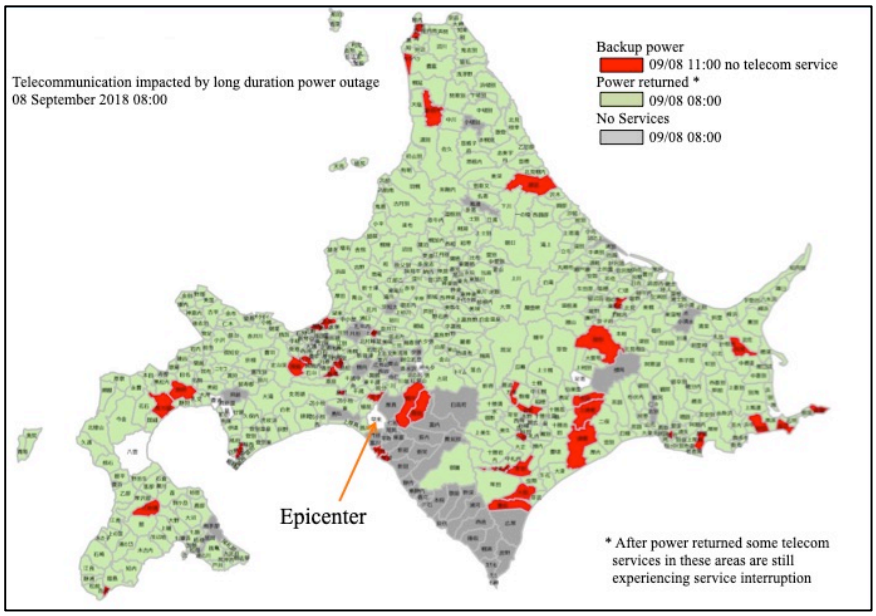

Fig. 2 – NTT power outage map 08 September 2018. (NTT East)

Figure 3 shows NTT landlines disruption due to power outage. On the first date after the main shock the landline disruptions were due to severed lines by landslides. Staring on the 7th of September to peaking on 8th of September disruptions were due to backup power running out in Exchange Offices. As power returning to Hokkaido, the number of landlines affected was greatly reduced by mid-day on the 8th of September. Basically all landlines were back to normal on the 11th of September, six days after the earthquake.

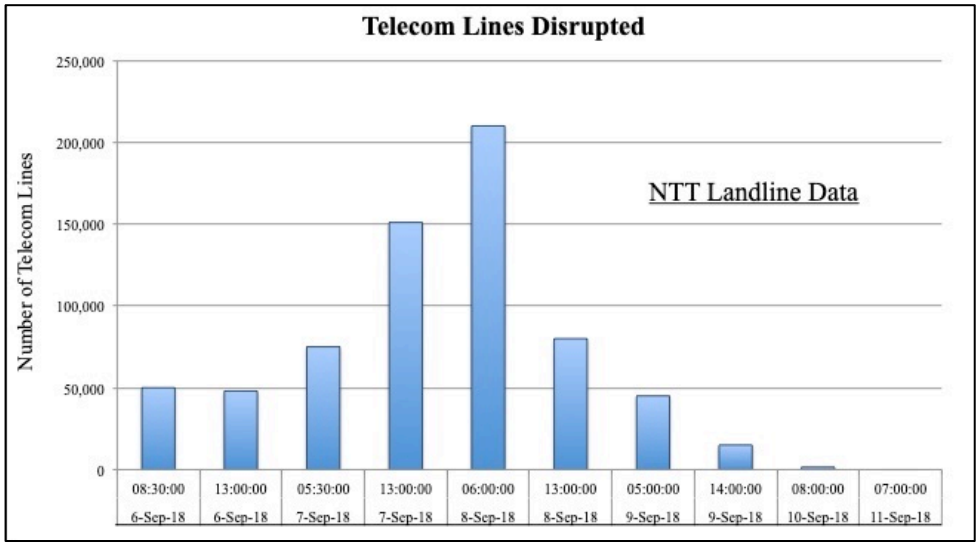

Fig. 3 – NTT landline disruption during the power outage period

The physical damage experienced by the telecom network was mainly caused by landslides that destroyed transmission and distribution lines. Figure 3 shows one of the many sites with landslides taking out utility poles carrying both telecom lines and power lines. There are many cell sites within the earthquake-impacted area; there was no damage to any cell sites due to landslides as the cell sites are quite far from the foothills. One pair of cell sites (one owned by DoCoMo and one owned by KDDI) is situated between two major landslides, Figure 4. The problems experienced by these cell sites were power outage and severed cable connections to exchange offices. Insert in Figure 4 shows the mobile satellite (the white vehicle with a parabolic antenna on the roof) was used to connect the cell sites to exchange offices and the mobile power generator.

Fig. 3 – Damaged transmission and distribution telecom cables.

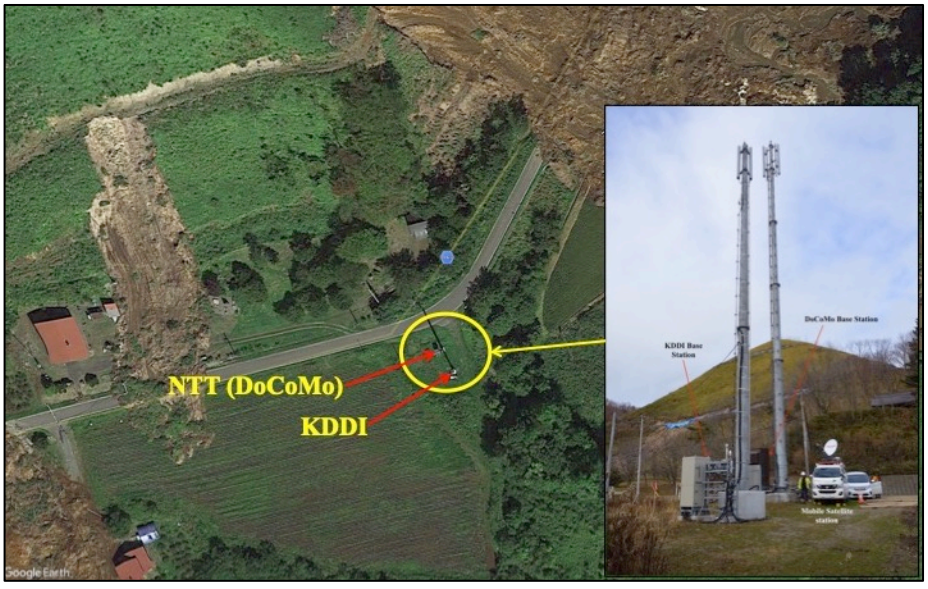

Fig. 4 – Two Cell Sites spared by landslides. Mobile Satellite link used to connect the cell sites to exchanges. (Aerial Google Earth)

There was one remote exchange destroyed by a landslide near Tomisato. Figure 5 shows the aerial view of the site prior to the earthquake, while Figure 6 shows the destruction in the same area. This location is where the newly constructed water purification plant was destroyed by landslide. To the surprise of most geotechnical people, this remote was about 130 m from the foothill on a relatively flat slope. NTT was quick

to install a temporary DLC[1] with optical fiber access, Figure 7. This shows NTT is following a strategic network enhancement process to build a more resilient network.

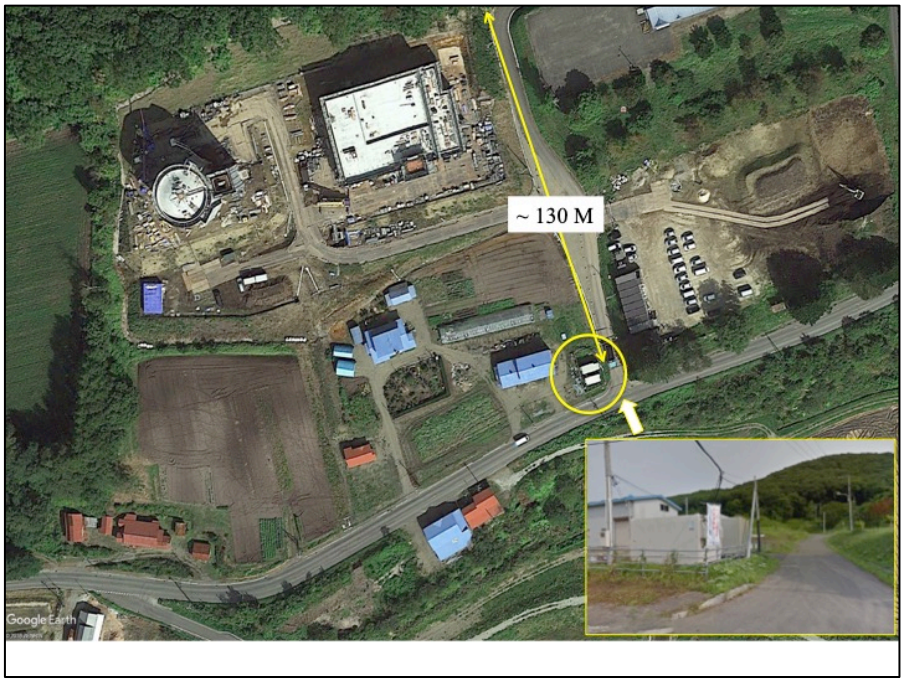

Fig. 5 – The aerial view of the location of the NTT remote before the earthquake. (Aerial Google Earth)

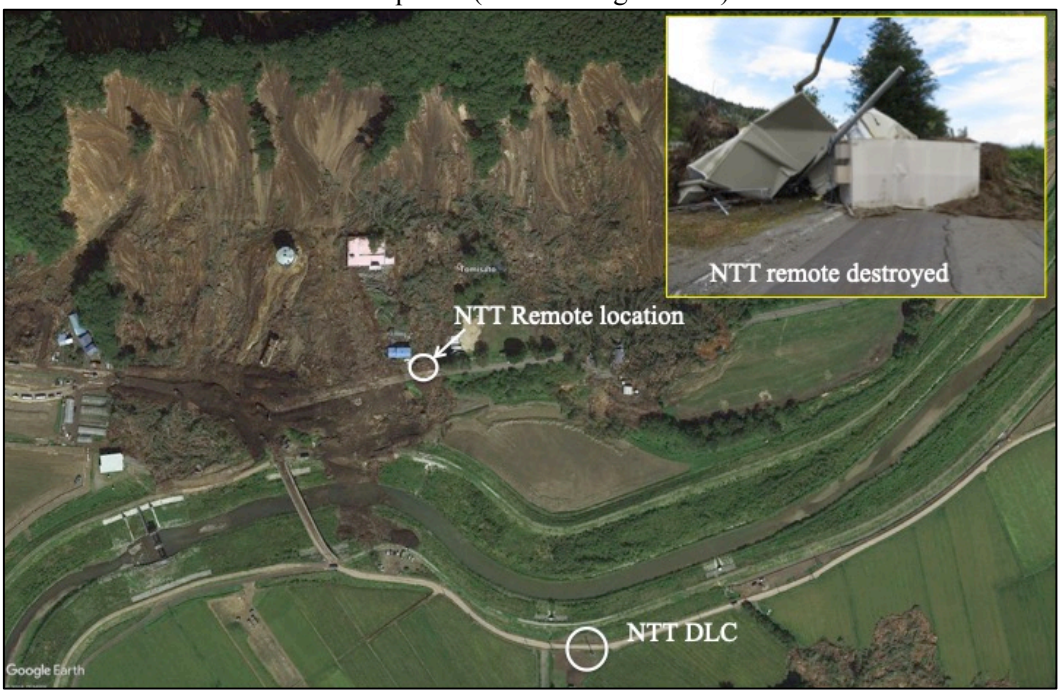

Fig. 6 – The view of the post earthquake destruction, insert from NTT East. (Google Earth).

[1] DLC – Digital Loop Carrier

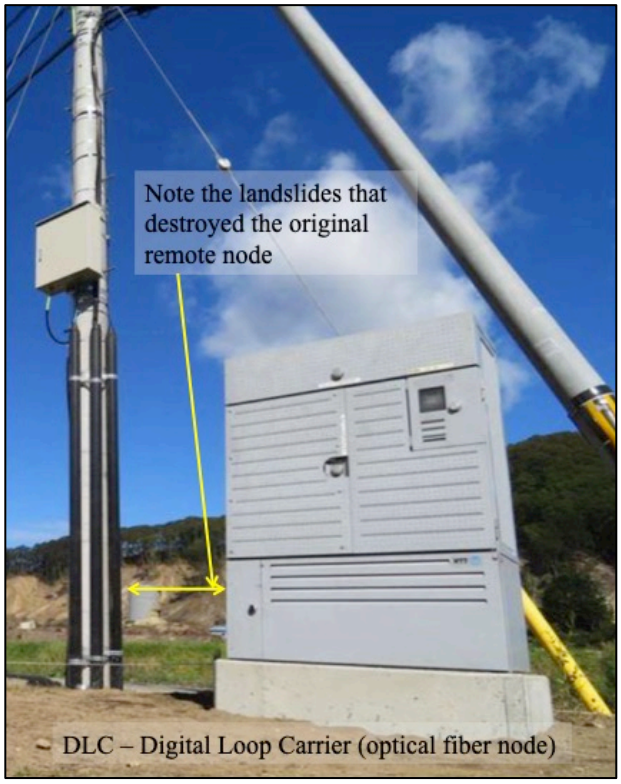

Fig. 7 – New DLC (NTT East)

The only non-landslide related damage was an optical fiber cable at a high-speed way (toll free section of the toll way) joint at the abutment (42.9143^0, 141.9213^0) near Kawabata Hydro Power Station, Figure 8. This transmission link does not belong to NTT. There was no report of the impact due to this failure. The repair might have been completed before the power return to the island.

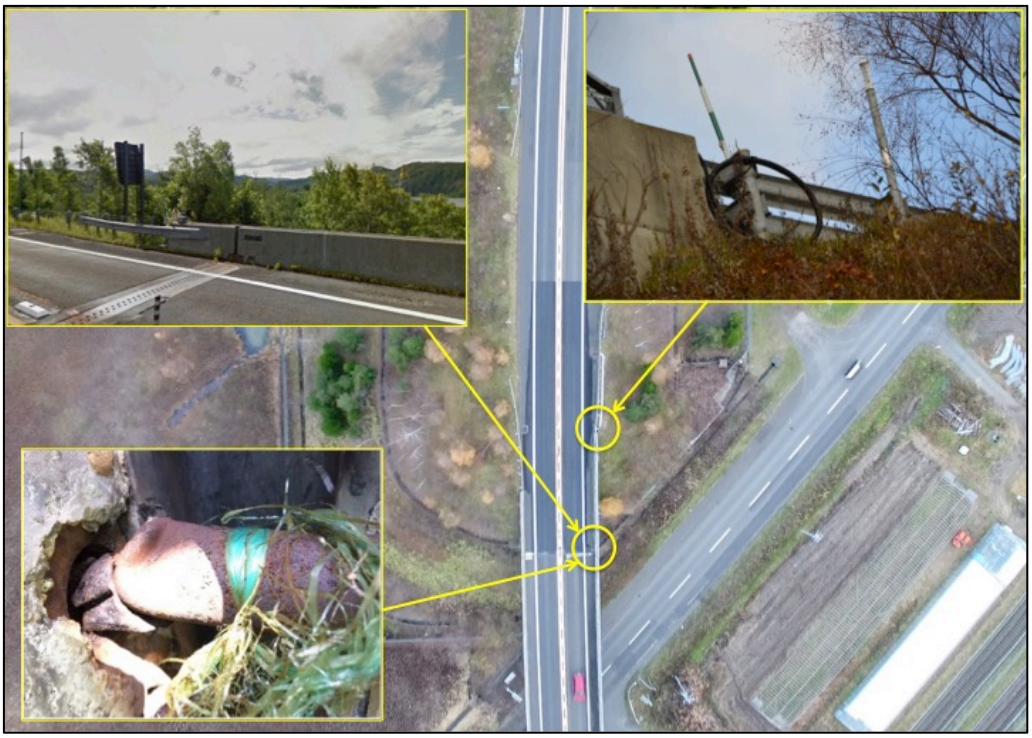

Fig. 8 – Optical fiber cable failure at the expansion joint of this bridge. (Aerial by Mr. Masataka Shiga)

HEPCO[2] telecommunication system sustained damage in a few loactions. The private telecom network problems after the earthquake are listed below. HEPCO provided the information and claimed there was no impact to recovery of power due to these set backs. Temporary fixes were quickly completed to allow continuous function of the network.

1. Micro-wave Link

On 06 September 2018 misalignment of the antenna and reflector at Tomakomai Branch Power Department to Hobetsu Radio Station and Hobetsu Radio Station to Iwatoshi Radio Station occurred due to strong ground shaking. Helicopter was used to inspect all the reflectors at Hobetsu Radio Station. All parabolic antennae were re-aligned by 20 September 2018.

2. Optical Fiber Link

On 06 September 2018 due to landslides cable was severed and part of the optical loop was not connected. As it is a loop configuration, the signal path automatically switches to prevent interruption. This occurred between Tomakomai Branch Power Department and Atsuma Substation.

3. Transport Link

On 06 September 2018 right after the earthquake the power line used for telecom transmission was severed due to collapse of a tower of the Iwachishi Line. This occurred between Hayagi Substation and Hobetsu Substation. Optical fiber cable was used to establish telecom transmission by 12 September 2018.

4. Equipment Coupling

On 06 September 2018 at Atsuma Substation telecom equipment coupling device base was tilted and the metal part of the support of an external line trap was deformed. There were 2 coupling units affected. Inspection was completed on 10 September 2018 and the plan was to have this corrected in December 2018. This failure did not affect telecom transmission.

5. Equipment Power Supply

On 06 September 2018 at Tomakomai Branch Power Department and a few other locations rectifiers units failure occurred at various places. As a temporary correction, defective parts were removed and the rectifiers returned to service. There were 9 rectifier units that failed due to strong shaking.

In addition, some power stations and offices experienced battery banks running out of reserve energy causing telecom equipment not operating. Study will be carried out to identify corrective actions.

3. Transportations

This section will provide information relating to disruption to roads, rail, air and sea transportations. Again landslides covering roads, which resulted in longer recovery time, mainly caused the disruption, Figure 9.

[2] HEPCO – Hokkaido Electric Power Company

Fig. 9 – Rural roads in the landslides area. (Base photo from Guardian Media Group)

3.1 Roads and Bridges

Due to power outage the tollgates were momentarily closed and access to the highway was also closed for damage assessments. The highway was opened after detours were set up. The damage to the high-speed toll way was minor. Figures 10 and 11 showed the damage caused by the earthquake on national roads.

Fig. 10 – Surface compression failure (MLIT)

Fig. 11 – Surface compression close to the overpass (MLIT)

There were a few roads in Sapporo city with surface cracks, liquefaction and subsidence.

The only known bridge damage was Doto Expressway at intersection of Route 274, Figure 8. This site is close to the entrance of Kawabata (川端) Hydro Power Station. It was evident that liquefaction occurred at the abutment area.

There were several rural roads damaged by lateral spread and surface cracks. MLIT TEC-Force teams were on site putting together plans for recovery. Figure 12 shows a MLIT TEC-Force team working at the road failure site.

Fig. 12 – MLIT TEC-Force preparing details for recovery work. (MLIT)

3.2 Railway

JR (Japan Rail) Hokkaido is the primary operator of the railway network in Hokkaido. A few remote railway lines only operate during tourist seasons. Operation of the rail systems such as light rail and subway were affected by power blackout. There was a twisted railway tracks due to ground deformation on Hidaka (日高) Main Line between Hamataura (浜田浦) Station and Mukawa (鵡川) Station, Figure 13.

Shinkansen was not affected as the terminal station at the time of earthquake was at Hakodate.

Fig. 13 – Twisted railway tracks (JR Hokkaido)

3.3 Airport

There are 9 airports (3 domestic and 6 international) in Hokkaido main-island; the largest airport is the Chitose International Airport, which is only 15 km from the epicenter. There was no structural damage to the terminals. Fallen suspended ceiling tiles and broken water pipes were reported. Power outage impacted the operation of the airport and many flights (both inbound and outbound) were cancelled. The backup power was not working and it took a day to restore the backup generator.

The airport was closed for both domestic and international flights for 1.5 days. Only domestic flights with relief supply were allowed during closure. Many travellers were stranded at the terminal overnight, as the railway connecting the airport to Sapporo city was not operating. Road closure impacted airport bus services. After backup generator was back on line some flights were allowed, as the power gradually return to the

terminals more flights both inbound and outbound were returning to normal. It was high tourist traffic time for Hokkaido.

3.4 Seaport

There was no reported pier damage and all ports were open, Figure 14. The ports were critical in supporting local community with necessary supplies, such as water.

Fig. 14 – Container port shows no damage and operating.

One of the container ports had liquefaction, Figure 15.

Fig. 15 – Liquefaction at a container storage area at the port (MLIT)

Ferries between Honshu and Hokkaido were operating but with a modified schedule for a few days. There was no damage to any ferry terminals.

4. Discussions and Conclusions

Electric power demonstrated to be critical to all other lifelines again. The black out hopefully will not happen again in future earthquakes. The lesson of black out must be carefully analyzed and develop a process to eliminate black out. This earthquake strengthens the need to have good and reliable backup power for lifeline service providers.

For telecommunication networks, there are many ways to reduce power consumption after an earthquake that knocks power, so that essential services can operate longer with backup power. The customers can also help to avoid impacting emergency services calls by not using the network during the early hours after a damaging earthquake. NTT established the 171 messaging service that allows customers to obtain information of relatives affected by the earthquake without loading the network in the earthquake-impacted areas. However, with the long duration black out the whole island telecom service interruption was very severe.

The effectiveness of MLIT TEC unit demonstrated the importance of emergency recovery planning. The continuous effort to build a specialized team is an essential of the operation so that when the need arises the skill members can be formed to react quickly.

5. Acknowledgements

The long list of acquaintances and new friends who helped in obtaining the relevant information to put this paper together are recorded in acknowledgement section of Reference [1], to them I like to thank their kind support and patience accommodating the requests during the four days visiting sites in Hokkaido. However, I like to express my special appreciation to Prof Konagai and his two students (Mr. Masataka Shiga and Dr. (Ms.) Mayumi Alessandra Nakata) who handled all the logistics and establsihing information collection meetings. PGE[3] and GE Engineering Systems support is much appreciated. JSCE also played a key role in this investigation with kind supports from the members.

6. References

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[2] NTT East web site dealing with telecom issues relating to Hokkaido Earthquake.

[3] Power Point Presentation on NTT by Professor Takanobu Suzuki of Toyo University, Tokyo, Japan.

[4] Power Point Presentation of transportation by Professor Yoshihisa Maruyama of Chiba University, Tokyo, Japan.

[5] Presentations by management of MLIT Hokkaido at Sapporo, Hokkaido, Japan.

[3] PGE – Pacific Gas and Electric Company

