Hurricane Sandy Effects on Communication Systems

(Preliminary Report)

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This report presents a preliminary summary of findings yield by damage assessments conducted from November 2 to November 5 and from November 22 to November 23, 2012 in the area affected by Hurricane Sandy and shown in Fig. 1. These damage assessments were funded in part by the National Science Foundation under award # ECCS 0845828

Hurricane Sandy made landfall as an extra-tropical cyclone (cold core) with maximum sustained winds of about 80 to 90 mph, equivalent to that of low-intensity Category 1 hurricane according to the Saffir Simpson Scale. However, Sandy's unprecedented large size generated a storm surge found in more intense hurricanes according to the Saffir Simpson Scale with observed heights of 14 ft in The Battery, NY and Kings Point, NY. These high storm surge levels flooded and damaged some areas in Lower Manhattan, New Jersey's barrier islands, and narrow coastal strips of New Jersey's Atlantic Coast, Staten Island, Long Island, and Long Island Sound and shorelines along the Hudson and Hackensack rivers.

Although communication networks did not experienced outages as extensive as those observed with Hurricane Katrina, issues similar to those observed with Hurricane Ike still happened. However, due to the higher population and network elements density in area affected by Hurricane Sandy and its large storm size, the effects of this storm on communication systems were more noticeable than those observed with Hurricane Ike. Reports issued by Verizon indicate that 300 (wireline) central offices were affected. However, information collected during the damage assessment indicates that the majority of them were affected by power outages and did not loose service. Unlike Katrina, there is no indication of outages at central office caused by engine fuel starvation originated in diesel procurement and delivery issues. Still, two key central offices in Lower Manhattan flooded and at least some of their operations, if not all, were interrupted when flooding damaged power backup equipment including onsite diesel generators and fuel pumps in their basements or first floor. One of these facilities in Lower Manhattan is Verizon's main building located at 140 West Street. As Figs 2 to 4 show, water was still being pumped out of this site on November 3. Figures 3 to 5 also show a large containerized mobile diesel generator used to power part of this building. Flooding also affected the main cable entrance facility and likely damaged cable pressurization equipment used to prevent multi-pair copper cables to corrode due to moisture or water entering the cable. Evidence of the likely damage to the cable pressurization equipment is found in Fig. 6 showing emergency cable pressurization equipment units. Even when water did not damaged cable pressurization equipment, air pumps for cables would not have worked due to lack of power at the site. With the main entrance facility flooded and without pressurized air, water entered the cables. Although there are procedures to dry the cables of water and moisture, these methods are not perfect. Hence, higher failure rates can be expected in these cables. This same problem was experienced in New Orleans after Katrina. At that time, Bellsouth used the opportunity to modernize their cable plant and installed more fiber optic cables connected to digital loop carrier (DLC) remote terminals (RTs). However, since RTs require local power and in many instances it is complicated to provide long term backup power at these sites, the chances of some subscribers to loose service during long power outages is higher than with a traditional wireline telephony architecture with a centralized power plant. In the Gulf Coast, some of the vulnerability reduction approaches seen for DLC RTs include placing them on elevated platforms that are equipped with a permanent natural gas generator. However, use of elevated platforms and natural gas generators may not be possible in Manhattan due to practical reasons related with the significant architecture differences between both areas.

Figures 7 and 8 shows the other central office that flooded in Lower Manhattan, this one located at 104 Broad Street. These two photos show mobile diesel generators on both sides of the building and two diesel trucks on the Water Street side. The damage assessment was able to identify two other central offices that may also likely flooded and had damage to power back up equipment: one in the Rockaway Peninsula (Figs. 9 and 10) and in Long Beach (Fig. 11). All these four central offices likely experienced some loss of service.

Although Verizon attempted to prevent these sites from flooding by using sandbags, this solution was not very effective. Flooding damage and loss of service could have been prevented in a number of other ways. One solution is to place onsite diesel generators and other power plant components on higher floors. This was the design that likely prevented the central office at Lavallette (north of Seaside Heights) in Fig. 12 to have its diesel generator damaged even when the storm surge flooded the streets around the building. Another solution shown in Figs. 13 and 14 in Kamaishi and Unosumai, Japan, is to use watertight doors at the building and flood gates around it. Although in some locations in Japan this design did not prevented damage from the tsunami because of its tremendous magnitude, watertight doors and flood gates in Kamaishi reduced the damage at this location and it would have prevented flood waters to enter the aforementioned buildings affected by Sandy. All other visited central offices in the affected area did not show flood damage, mostly because significant flood waters did not reach the site and sandbags protected the building from the limited potential flood waters that reached the building (Fig. 15). The only other central office that requires a special mention is the one in Fig. 16 in Garden City. This central office has seven 200 kW fuel cells that can power the facility when fueled by natural gas. When this site was visited on November 3, there was still no commercial power on, yet this site showed no signs of being out of service suggesting that the fuel cells or other onsite generation mean where operating adequately.

Wireless communication networks also presented issues, with reports indicating that an average of about 25 % of the base stations in the affected area lost service—some network operators informed of a lower percentage of base stations out of service. During the damage assessment on November 3 to 5, wireless communications coverage in the western half of the Rockaway Peninsula was almost non-existent (Fig. 17) Cellular coverage also showed issues along the New Jersey coastline. The cause of loss of service in almost all of these affected base stations was lack of power. During the damage assessment it was possible to observe that the majority of base stations in cities and towns in the affected area were placed on buildings roofs and had no permanent gensets. Some of these cell sites (Fig. 18) have standard power sockets at the ground level and with easy access so a portable diesel generator can be transported to the site and be easily connected. However, many sites (e.g. Fig. 19) did not have any pre-prepared way of connecting a generator at ground level so a cable had to be run from the roof to the street where the portable genset is located. In practice, placing these generators in service may take considerable time because it requires locating the building owner or administrator in order to coordinate building access. This may have been the reason why in some sites, gensets were not deployed until a few days after the storm (Fig. 20). Like in all previous hurricanes, genset deployment was not coordinated among network operators leading to the inefficient logistical approach of having multiple gensets in several cell sites (Fig. 21).

In order to provide coverage in some areas network operators deployed cell on trucks (COLTs), such as those in Figs. 22 to 24, and cell on wheels (COWs) such as that in Fig. 25. Several of the COLTs have satellite links (Figs. 22 to 24). Although most of these COLTs and COWs were deployed shortly after the hurricane passed, at least one was deployed on Nov. 3 (Fig. 24). Use of COLTs and COWs is comparable to what was observed in damage assessments after past hurricanes but one difference was the increased used of satellite links.

One important issue in the operation of communication networks after Sandy that was also associated to the extensive power outages caused by the storm was the need for charging stations for cell phones and other personal communication devices. That is, Hurricane Sandy's aftermath highlighted an increasing vulnerability of communication networks as their architectures are more distributed and more relying on power from an electric grid, particularly at the end user level. In order to address this need both Verizon and AT&T provided charging stations where people could charge their phones (Figs. 26 and 27). However, it is unclear how many people were unable to communicate due to difficulties in charging the batteries. Private organizations also provided charging stations, in some cases powered by renewable energy, such as the one in Fig. 17.

Powering distributed network elements and users communication devices is also an important issue for cable TV (CATV) operators, who often also offer phone services routed through the Internet. In order, to power their distributed network elements, CATV operators used in some cases small camping off the shelf gensets placed on their equipment cabinets on top of poles (Fig. 28). Besides the obvious safety issues (high winds affected the disaster during a northeastern about a week after Hurricane Sandy made landfall), it is likely that these poles had not been calculated to support the extra load. The photovoltaic (PV) modules on poles shown in Fig. 28 suggest a missed opportunity in many towns in New Jersey to power these CATV network elements using solar power because these PV modules have grid-tied inverters that cannot operate when the main electric grid is not in service.

Internet use has also become a critical need both for everyday life and during disasters. In many cases, Internet is also currently used to transmit telephony services, too. Several data centers experienced issues and loss of service during Hurricane Sandy. A few of them, such as those in 75 Broad Street, 33 Whitehall Street, 325 Hudson Street, and 121 Varick Street reported flooding and damage to generators and fuel pumps that led to loss of service. Partial loss of service due to a generator malfunction was reported at the data center in 111 8th Avenue (Fig. 29). Several private data center lost service due to engine fuel starvation caused by difficulties in diesel procuring and delivering. No loss of service despite limited flooding was reported in the data centers at 25 Broadway and 32 Avenue of the Americas. Loss of service was also avoided in the important data center located at 60 Hudson Street (Figs. 30 and 31). One of its diesel generators was still operating when the site was visited on November 3. It is unknown why this site had two relatively small portable diesel generators outside and with cables running into the interior of the building.

Wireline telephony outside plant equipment was also affected by flooding and power outages or direct damage. Reports from Verizon indicate that up to 600 DLC RTs or other digital wireline communications equipment both in vaults and in cabinets (Fig. 32) were affected by Hurricane Sandy; some due to flooding and most due to power outages. In some specific few limited areas fires also caused damage to the outside plant infrastructure (Fig. 33). Flooding also affected manholes (Figs 34 and 35) particularly in lower Manhattan. Although poles were damaged, loss of poles was limited even in the areas affected by the storm surge where the damage to homes was most severe. In some of these areas it was usually possible to observe that the pole closest to the shore had been damaged (Figs. 36 and 37) other by houses floating away (Fig. 36) or by other debris caused by the intense waves. Still, in many cases with significant damage to homes, damage to poles and telephony lines was light or non-existent (Fig. 38).

Broadcasting networks (radio and TV) also experienced service affecting issues during Hurricane Sandy. One example is shown in Fig. 39 where the site with the transmission towers was flooded and the huts with the transmission equipment were damaged.

There are no information of damage to a few intercontinental cable landings on New Jersey's coast.

Suggested additional reading:

- A. Kwasinski, V. Krishnamurthy, J. Song, and R. Sharma, "Availability Evaluation of Micro-Grids for Resistant Power Supply During Natural Disasters," in press IEEE Transactions on Smart Grid.
- A. Kwasinski, "Technology Planning for Electric Power Supply in Critical Events Considering a Bulk Grid, Backup Power Plants, and Micro-Grids," IEEE Systems Journal, vol. 4, no. 2, pp. 167-178, June 2010.
- A. Kwasinski, W. W. Weaver, P. L. Chapman, and P. T. Krein, "Telecommunications Power Plant Damage Assessment for Hurricane Katrina - Site Survey and Follow-Up Results," IEEE Systems Journal, vol. 3, no. 3, pp. 277-287, September 2009.
- A. Kwasinski, "Effects of Notable Natural Disasters from 2005 to 2011 on Telecommunications Infrastructure: Lessons from On-Site Damage Assessments," INTELEC 2011, 9 pages, Amsterdam, Netherlands, October, 2011.
- A. Kwasinski, "U.S. Gulf Coast Telecommunications Power Infrastructure Evolution since Hurricane Katrina," International Telecommunication Energy Special Conference, 2009, 6 pages, Vienna, Austria, May 10-13, 2009.

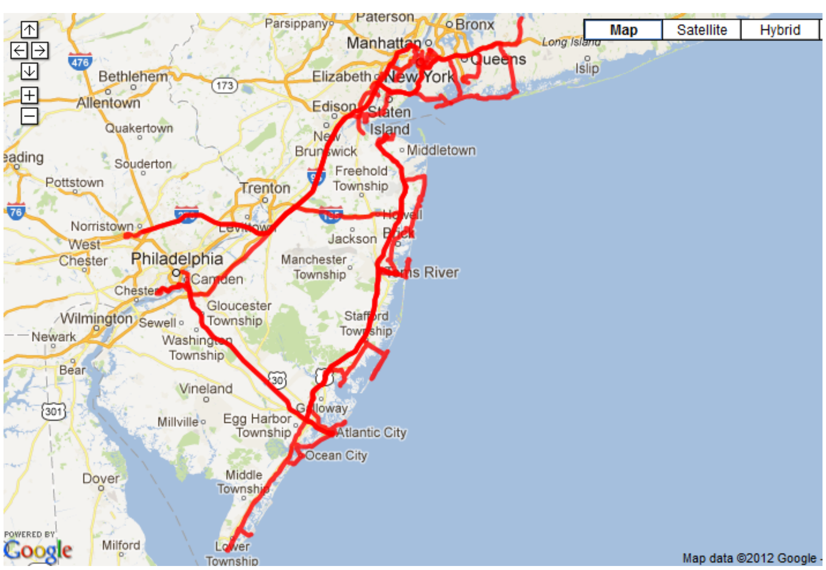

Fig. 1. Damage assessments tracks. Background map: © Google

Fig. 2. Water being pump out through the main entrance of Verizon's central office at 140 West Street.

Fig. 3. Water being pumped out and a diesel generator running at the entrance on Barclay Street for Verizon's main central office in Manhattan.

Fig. 4. Barclay Street flooded from water being pump out of Verizon's central office at 140 West Street.

Fig. 5, Another view of Barclay Street showing a COLT parked next to Verizon's central office at 140 West Street.

Fig. 6. Emergency cable pressurization units at 140 West Street. The image on the right shows the pressurized air injection nozzle.

Fig. 7 Pearl Street side of Verizon’s central office at 104 Broad Street.

Fig. 8. Water Street side of Verizon’s central office at 104 Broad Street.

Fig. 9. Verizon’s central office at Rockaway Beach.

Fig. 10. Another view of Verizon’s central office at Rockaway Beach showing a large portable genset behind the waste liquids vacuum pump.

Fig. 11. Verizon’s central office in Long Beach.

Fig. 12. Verizon's central office in Lavallatte. Notice the genset located on the second floor.

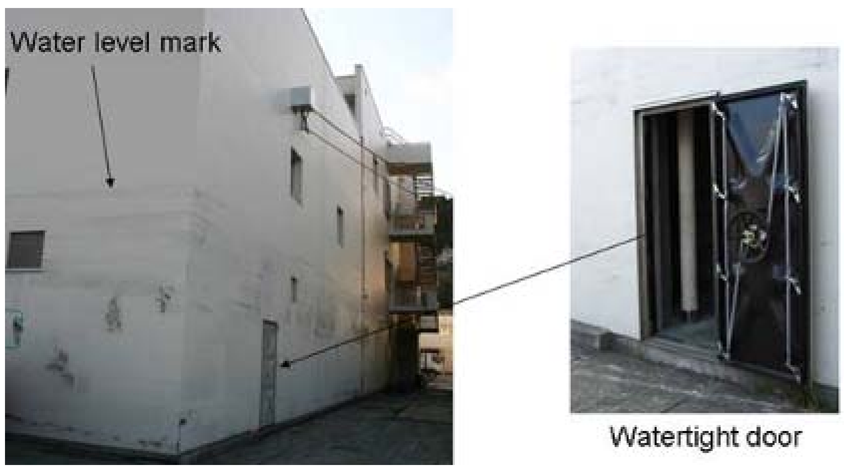

Fig. 13. Watertight door in Kamaishi, Japan.

Fig. 14. Flood gate in Unosumai central office, Japan.

Fig. 15. Verizon’s central offices in Brigantine (Left) and Wildwood (Right). Notice in both cases the sandbags at the doors.

Fig. 16. Fuel cells at Verizon’s central office in Garden City.

Fig. 17. A person talking on a satellite phone standing on top of a truck with solar panels to provide electricity to people in the Rockaway Peninsula.

Fig. 18 A rooftop cell site in Ausbury Park powered by a genset at street level. Notice the standard connector for the genset.

Fig. 19. A rooftop cell site in the Rockaway Peninsula.

Fig. 20. Another cell site in the Rockaway Peninsula

Fig. 21 A cell site with multiple genset (3 portable and one permanent) at the intersection of I 95 and I 195 in New Jersey.

Fig. 22. A COLT in front of the Freedom Tower in New York City (Left) and a Colt in the Rockaway Peninsula.

Fig. 23. A COLT near Seasigh Heights, NJ.

Fig. 24. Two COLTs in Long Beach. The one in the back is still being installed.

Fig. 25 A COW along the Garden State Parkway.

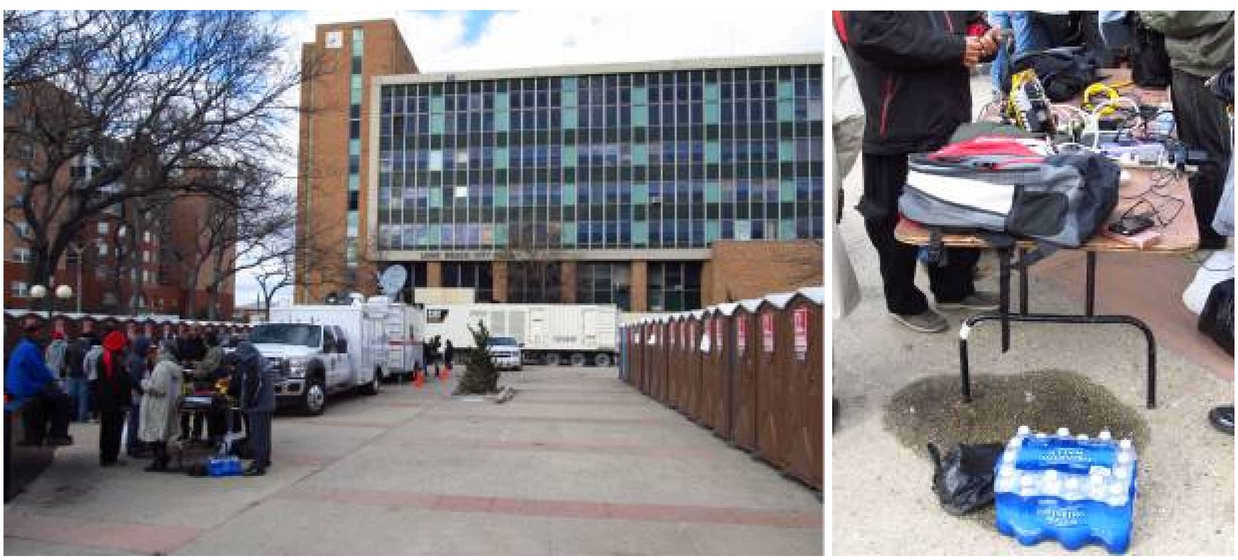

Fig. 26. COLTs and a charging station in Long Beach.

Fig. 27. An emergency communications truck in Rockaway Peninsula

Fig. 28. CATV equipment in Bayonne, NJ.

Fig. 29. Data center building at 111 8th Avenue.

Fig. 30. Data center at 60 Hudson Street. Notice the dielsel generator exhaust on the photo on the right.

Fig. 31. Two views of the 60 Hudson Street data center showing additional small gensets in the area and a truck with diesel to replenish the fuel tanks at this site.

Fig. 32. A vault (left) and a DLC RT cabinet (right) in the Rockaway Peninsula.

Fig. 33. Damage from a fire affecting communications infrastructure.

Fig. 34. A Verizon's truck working next to manhole.

Fig. 35. A manhole still with water.

Fig. 36. A severed telecom cable hanging from the pole on the right.

Fig. 37. Damage to the pole nearest the sea in Ortley Beach


Fig. 38. Important damage to dwellings in Union Beach but little damage to poles.

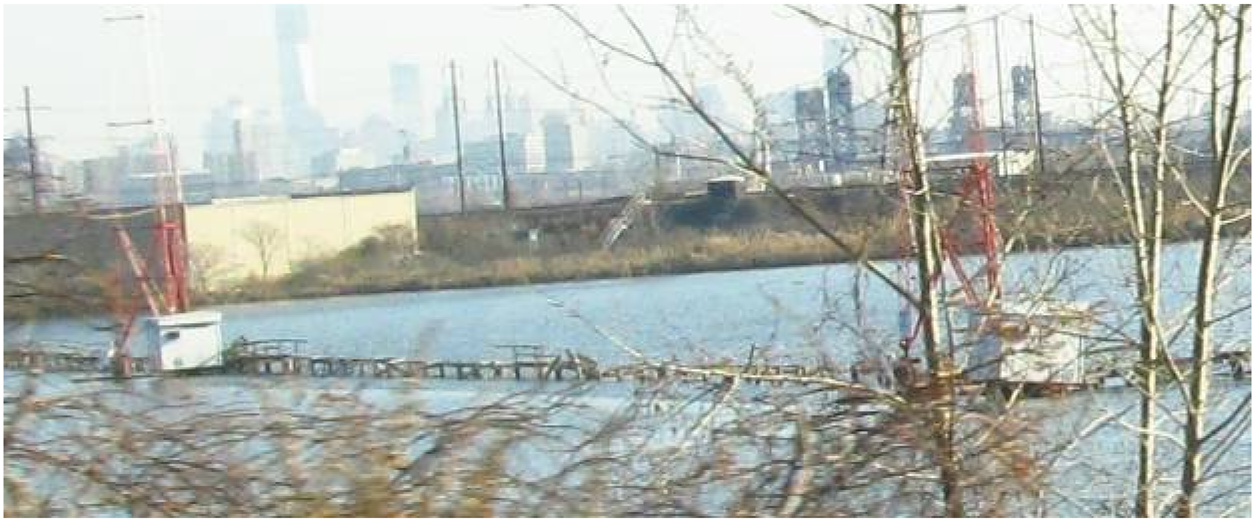

Fig. 39. Transmission towers for WEPN, damaged by Sandy.