TVWS in Disaster Response:

A Breakthrough Technology for

Rapid Communications after

Typhoon Haiyan in the Philippines

Microsoft

1: Executive Summary

In the aftermath of the devastating typhoon that struck the central Philippines, the Department of Science & Technology's (DOST) ICT Office sent in a TV White Spaces (TVWS)-based network to provide an immediate on-the-ground communications network for disaster relief respondents and victims of the disaster.

The network solution that was dropped into and then deployed in Palo, a nearby municipality to the central disaster area of Tacloban, comprised a VSAT, three TVWS radios and two Wifi routers. Once the equipment was in and the locations for network nodes established, the network was able to be set up and switched on in a matter of hours. The resulting network provided immediate two-way voice and data wireless communications for anyone with a functioning device (handsets, laptops, tablets, etc.) who came within range of the network.

The initial network covered a distance of around 1km and was eventually able to extend reach by around 3-5km, providing throughput speeds of 3-5Mbps – in other words, *the network was effective from the very outset* for providing both voice communications and data transfers (messaging, picture uploads, file transfers, etc). In the weeks after the network was set up the capacity and robustness was able to easily support all users who came onto the network with sufficient bandwidth and throughput; the immediate constraints on the network were the satellite backhaul link, and the fact that by the time the network was deployed most devices had long since run out of power and therefore couldn't make use of the network. Thus, the constraints were outside the parameters of the network itself and illustrate both the potential for TVWS to be used in disaster response and the need to be prepared to deploy such solutions *immediately* in the aftermath of a disaster. In this case, if that had been done, hundreds, if not thousands, more disaster-struck people would have been able to use the network and get necessary assistance. This issue, and finding, is elaborated below.

Prior to the TVWS network being deployed, anyone who wanted to access communications had to literally walk onto a government center coordination response site to access the sat comms link – a journey that had become dangerous, challenging and long in the wake of the typhoon. The network deployment extended that reach dramatically, and did so at less than $1/10^{th}$ the cost of any alternative viable solution; it also did so rapidly when finally able to deploy, requiring almost no technical expertise, system integration or support, and provided ongoing communication throughout the later disaster relief efforts.

This paper focuses upon the fundamental need to rapidly get effective communications up and running in the wake of a disaster, and to promote the case for the use of TV White Spaces technologies as a means of rapidly and cost effectively addressing this need. The paper uses the recent catastrophic case of Typhoon Haiyan in the Philippines to look at developments in the wake of the crisis and the lessons learnt from that event to suggest the need for developing a disaster preparedness strategy – a playbook – that includes preparing TV White Spaces 'kits' for deployment in the event of such natural calamities, allowing for an effective rapid and cost-efficient solution to tackling the communications needs of first responders and disaster response teams.

2: A TV White Spaces Network for Communications following Typhoon Haiyan

The typhoon that struck the Philippines on November 8, 2013, Typhoon Haiyan (also known as Typhoon Yolanda in the Philippines), was the deadliest Philippine typhoon on record, killing at least 6,268 people, the strongest storm recorded at landfall, and unofficially the strongest typhoon ever recorded in terms of wind speed. Its impact was devastating, with about 11 million people affected, and many many left homeless.

Table 1: Effects of Typhoon Haiyan in the Philippines

Casualties			
Region	**Dead**	**Injured**	**Missing**
Calabarzon	3	4	0
Mimaropa	19	61	24
Bicol Region	6	21	0
Western Visayas	294	2,068	27
Central Visayas	74	348	5
Eastern Visayas	5,870	26,186	1,005
Zamboanga Peninsula	1	1	0
Caraga	1	0	0
Total	**6,268**	**28,689**	**1,061**

Damages		
	Amount	
	PHP	USD
Agriculture	19,559,379,136.11	431,675,497.53
Infrastructure	20,262,118,716.06	447,184,960.06
Total damages	**39,821,497,852.17**	**878,860,457.60**

Source: *National Disaster Risk Reduction and Management Council (NDRRMC) as of March 14, 2014.*

Guiuan in Eastern Samar was the point of Haiyan's first landfall. During the morning of November 8, media stations across the country were able to broadcast live the destruction of Haiyan. However, by afternoon all communications in the Visayas region had failed. Extreme damage to infrastructure throughout the region posed logistical problems that greatly slowed subsequent response and relief efforts.

In Tacloban city itself there was little communication and no mobile phone coverage. Along the east coast of Leyte numerous towns and villages were completely cut off without assistance. Large parts of Leyte and Samar were without power, a situation that continued for more than a month in some cases.

Finding a Solution

On the day after the typhoon, the ICT Office assembled a 'package' consisting of one VSAT, three TV White Spaces (TVWS) radios, and two WiFi routers to be dispatched to Tacloban for deployment as a communications solution. However, because of the weight of the package and because of the difficulty in getting flights to Tacloban, it was nine days before the team was able to reach Tacloban with their package.

The local team was provided with power sources (solar panels) and a backhaul (VSAT) but was unable to procure a location in Tacloban City where the radios could be safe-vouched. Thus it was decided to install the TVWS equipment in Palo, a municipality approximately 12 km south of Tacloban, and the location of the 'Government Center', a cluster of buildings containing the regional and provincial offices of several agencies such as the DOST and the National Economic and Development Authority (NEDA).

Once the team arrived in Palo it only took a few hours to establish the VSAT backhaul, and another couple of hours after that to fully establish the TVWS network.[1]

Three TVWS network nodes were set up in Palo, Leyte, and connected as follows:

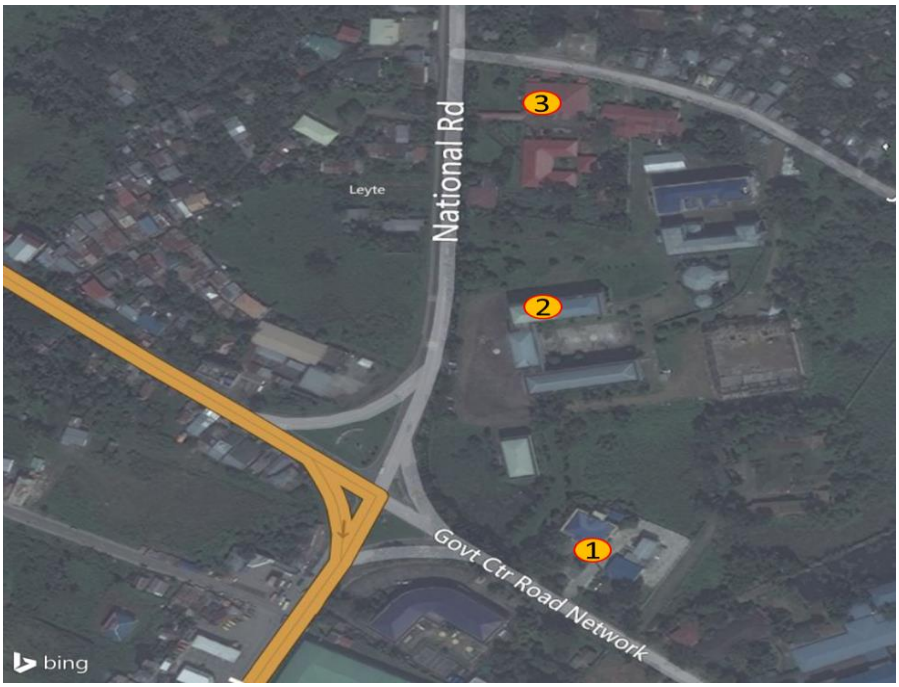
1. A base station at the DOST Regional Office (Point 1 on the diagram below) where the VSAT was located. Internet backhaul was provided via a satellite connection provided by the ITU.

[1] TV White Spaces are the gaps left to prevent interference between terrestrial TV transmitters. This prime spectrum potentially offers a number of benefits for crisis response, namely:

- Much greater range for a given transmission power, enabling vehicles and team members to stay in touch with each other more reliably;
- High capacity available on demand – to support video communications, at short notice, through a geolocational database.

2. A CPE (Point 2 below) at the Philippine Science High School Office (PSHS), approximately 500m away from Point 1. The primary users of the network were the administrative staff of PSHS.

3. Another CPE at the PSHS Campus Dormitory (Point 3 below), approximately 1km away, where the first set of users were the Bombero Unidos, a humanitarian group from Spain which sent a team of relief workers to Leyte.



In establishing the TVWS network, ICT Office tapped a number of parties to play instrumental roles, including Filipino-Singaporean firm Nityo Infotech, who had similarly set the network up in Bohol province in the wake of the October 15 earthquake, Microsoft[2], the United States Agency for International Development (USAID), and international development agency NetHope.

Science and Technology Undersecretary and ICT Office Executive Director Louis Casambre noted that the speed with which Nityo Infotech set up the TVWS system proved the huge potential of TVWS technologies as a solution to the "last mile" problem of connecting far-flung communities to the Internet. And Internet connectivity was of course vital to speeding up disaster relief and recovery efforts in both the Bohol and Haiyan events.

[2] Microsoft developed the initial TV White Spaces technologies used in 2007 and has worked to gain broad global acceptance of the technology through proposals at the ITU, through events such as the Cambridge White Space Trials, through formation of advocacy groups such as the Singapore White Spaces users Group and the Dynamic Spectrum Alliance, and through conduct of pilot deployments in countries such as Singapore, Kenya, Tanzania, Philippines and others. Further information available at: http://research.microsoft.com/en-us/projects/spectrum/pilots.aspx

The Internet connection over TVWS was used to enable communication between various NGOs, and then back to their home bases. After the disaster relief workers returned to their home countries, the Internet connection was used by the PSHS faculty to rebuild their lesson plans and instructional material in preparation for the re-opening of classes.

Lessons Learnt

1. **Connectivity needs to be established in hours or day – not weeks**

   Because of the difficulties in transporting the equipment in and then in establishing secure network sites – agencies approached by the team were reluctant to be accountable for safeguarding the equipment – it was nine days before the network was established. In contrast, after the magnitude 7.2 earthquake in Bohol, a TVWS network was established in less than a week.

   The true "first responders" are those who are at ground zero – they know who needs help, where it is most needed, and what type of assistance is most critical. Many of those on-the-ground at the time of the disaster and in the immediate aftermath still had working devices: they were taking photos and videos, recording the event, identifying prioritized medical needs, coordinating assistance. Many of these devices continued to work for extended periods after the power went out. Unfortunately, with no connectivity for days, the power in the devices eventually drained and the opportunity to utilize, respond to, and coordinate this information was lost.

   There is an outstanding opportunity for such a solution to be ready to be shipped in straight away following a disaster, including knowing the needs to securing sites for the nodes, along with solutions around getting the equipment transported onto the site.

2. **First devices up were satellite-based systems**

   Satphones are excellent tools when used by teams in the field to assess damage and the situation. They are also useful, to a limited extent, in allowing survivors to contact family members. Some NGOs asked survivors to queue up for a chance to make a 3-minute call. Satphones are also relatively easily recharged using solar panels, making them very useful in such a situation. However, satellite systems and services remain very costly and unaffordable for many countries. As such, they are at best a short-term and short-range solution. Satphones also only provide voice connectivity. The TVWS solution provides voice over IP as well as data connectivity. In addition, it is a multi-cast solution, so anyone with 'the bubble' of connectivity has the opportunity to establish linkage to the network.

   Very Small Aperture Terminals (VSATs) are good for establishing connection to the Internet, and for voice communications as well as data. However, VSATs are usable only by those within the immediate vicinity of the VSAT. In Tacloban the sole use of this solution meant that communications were almost entirely limited to those within the command center.

3. **Standard wireless connectivity can take a longer time to re-establish**

In Tacloban, many cell sites and towers were knocked out, and while some were re-established comparatively quickly, these were also typically located in the command centers. This meant that people had to walk several kilometers to get a signal. With the debris on the road, such travel could be challenging and dangerous – in some cases a 2 kilometer distance literally became a 4-hour trip. A full network re-start can take some time to re-establish. By contrast, the TVWS network can be rapidly deployed over an extended range – typically this is 4 times the range and 16 times the coverage of a comparable higher frequency solution such as 2.4GHz Wifi networks or 1800/1900 MHz 3G networks. And the TVWS network can be set up rapidly and can provide either peer-to-peer communications (as primary comms) or multi-cast distribution for an extant backhaul network such as VSAT.

Many feature phones still had battery several days after the event. Others were able to recharge their cellphones from generators or solar panels. Thus if networks could have been reestablished quickly, many people could have had communications.

4. **TVWS connectivity can be established quickly given the right conditions**

The right conditions and the right preparedness include: the necessary power source, backhaul, and secured location(s). In Tacloban, TVWS radios could have been used in a peer-to-peer network to connect teams on the ground. However this scenario was not tested as there were not enough radios available. Instead, it was decided to use the TVWS radios to distribute the backhaul from a VSAT.

3: The Importance of Communications in Disaster Response

> *"For people who are caught up in emergency situations, the need for information is often acute. Frequently, they are separated from their families, lack shelter and adequate food and are scared and confused by the events occurring around them."*
>
> – Department for International Development, UK

The United Nations International Strategy for Disaster Reduction (UNISDR) defines a disaster as a serious disruption of the functioning of a community or society involving widespread human, material, economic or environmental losses and impacts, exceeding the ability of the affected community to cope using its own resources.[3] The frequency of such events is increasing and their impact on Asia and the Pacific has been profoundly evident.

At first sight, the role of ICTs in both disaster preparedness and disaster response may not appear as highly significant as the wide range of agency planning and initiatives called for. And yet, access to reliable and effective communications networks in the immediate aftermath of a disaster can save lives and is essential to the coordination of rapid response.

According to the ITU, all countries should have an emergency communications plan, whether on its own or as part of a national emergency telecommunication plan (NETP), as this is vital in:

- Identification of communication needs in time of emergencies
- Identification of vulnerabilities, and assessment of threats
- Forging of partnerships
- Forward-planning as part of preparedness.

An NETP is critical since all other infrastructures in a modern society, e.g., water supply, electricity production, transport, banking, police, fire fighters, and ambulances, depend on telecommunications systems to function in both normal and emergency times. The role of an NETP is most evident in the support that telecommunications networks provide to society, and to public protection (police, fire fighters, medical first responders) and disaster relief organizations' needs in time of disasters or crisis. During an emergency, the ability of responding agencies to communicate is vital to the establishment of coordinated efforts to respond more effectively to disasters.

Emergency communication capacity is critical to ensuring the effectiveness and efficiency of disaster response actions, including:

- The restoration or establishment of communications (particularly wireless services)
- The rapid deployment of stand-by communication means to ensure communication among field teams and relevant headquarters

[3] UNISDR, 2009 UNISDR Terminology on Disaster Risk Reduction (Geneva, United Nations, 2009), www.unisdr.org/we/inform/terminology

- The expansion of handling capability of local cellular mobile systems to accommodate sudden increases in local and outbound traffic
- Ensuring Internet bandwidth for networking relevant information, decision supporting systems, conference and tele-health services, and news reporting

Many of these activities are usually planned and managed on the ground within a Disaster Response Coordination Center (DRCC). In general, this centre should provide strategic direction to influence the management of the response while continuously monitoring the disaster event and adjusting to changes accordingly. It is also the central information facility for the whole response phase, and should have the capability of providing an entire picture of the response and relief effort. In order to achieve this objective, the centre needs to have the capacity to obtain, process and distribute information. The effectiveness of any DRCC will be severely limited if it does not have adequate communications facilities. Information management relies on having a communication system, and any restriction in communication will limit the required collection and dissemination of necessary information.

During the immediate aftermath of a disaster, the information people need is simple: What just happened and where are their family members and friends? Over time other critical information needs emerge: the location of food and water, how to access hospitals in the area, how to prevent disease or ascertain the timeline for receiving compensation, and so on. People very quickly begin to want to know what relief, services and support are available to them. Therefore, expectation management through effective communication is vital during any emergency situation; ineffective communication will create false expectations and misunderstandings about what assistance is forthcoming and about the role of the various government and aid agencies in question.

Another important aspect of information and communication during disaster response is that information deprivation causes stress and exacerbates trauma. During the initial stage of most emergencies, information is scarce and often unreliable. Normal communication and information channels such as radio stations and mobile phone networks often become unavailable, meaning information becomes inaccessible to those most affected.

4: The Use of TVWS Technologies in Disaster Response

TVWS enjoys significantly greater range, allowing access points to be installed in areas up to several kilometers away from where VSATs are located – usually the command center. This makes it far easier to control traffic in the vicinity of the command center. In addition, TVWS antenna can be located indoors. In Tacloban there were concerns over how to secure the necessary reception antennas. The ability to locate antennas indoors in the aftermath of a disaster event is thus particularly beneficial. Furthermore, line-of-sight is not a requirement, and there is no observable channel interference to contend with. (Over recent years a great deal of effort has been put in in proof of concept trials around the world to demonstrate to various governments and interested parties that TVWS networks operate without causing interference to 'neighbouring' communications bands such as broadcast signals. This has been a very important commercial consideration requiring deep levels of technical proof; in disaster relief scenarios therefore, TVWS solutions confidently bring the additional benefits of no channel interference.)

For first-response teams, TVWS networks are easy to Install. Aligning radio antennas can be easily done; in Tacloban this took less than two hours. Power can be run effectively off solar panels, and there is relatively little effect caused by even dramatic weather conditions.

There will be a further important issue come much more into play as these network systems become more common in usage, particularly those that can be used in peer-to-peer configurations: the additional use of social media. Social media enables people to easily create and share their own news, photos, videos and other information within their networks and publically. In the past, information about populations affected by disasters have largely been collected and verified by professional responders working for authorized agencies. Now the information can be reported by the population themselves immediately. They also provide alternative avenues for social support to survivors.

Social media – such as Facebook, Twitter, Flickr, etc – is is not only an effective tool for engaging and monitoring public information during the crisis process, but also enables a shift in how the public views its role as a contributor, and can play a powerful role in managing expectations. If people in a disaster situation know that support will be coming but that it remains some way off they are provided with a light at the end of a tunnel and encouraged to both hang on and remain calm. Emergency management and crisis communication have become much more participatory.

What can be done Next Time?

According to the UN APCICT's Asian Disaster Preparedness Centre, it is recommended that the first deployment of key emergency communication systems and services to rescue sites be made within 24 hours in order to assist rescue teams with search and rescue tasks during the first 72 hours after a disaster strikes.

Ideally therefore, within a few hours after danger has passed, a helicopter or other transport vehicle can fly in and quickly deploy VSATs, TVWS radios, WiFi routers, and solar panels. These can provide connectivity for those on the ground. In addition, disaster response teams can be provided with TVWS radios to be used in a peer-to-peer networks to improve coordination on the ground.

In preparation for such an operation, several steps would need to be taken in advance:

- Mapping of suitable locations within the city that would serve as evacuation centers and command centers. Post-event, these locations would have to be reassessed to see if they would still be suitable drop sites.
- Mapping of available channels that could be used for TVWS transmissions. The regulator would have to issue permits that could be activated in times of disasters.
- Stockpiling an inventory of VSATs, TVWS radios, WiFi routers, cables and solar panels.

Rapid response VSATs (pictured below) are recommended as these are easy to transport and setup.

DOST Region 8 Office (with VSAT and solar panel) where the base station was located.

PSHS Administrative Building (the CPE antenna is the white square in the center of the photo).

About Microsoft

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