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Information and communications technology as critical infrastructure for enhanced e-resilience and disaster risk management

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Note by the secretariat**

Summary

The smooth functioning of the domestic and international long-distance telecommunications infrastructure, which serves as the major supply line for the Internet, has never been so critical as it is now. In recognition of the importance of this infrastructure, new emphasis has been placed on the concept of e-resilience. Formerly based on older technologies, such as high-frequency radio links, microwave and satellite communications, the regional backbone of that infrastructure is now heavily dependent on fibre-optic technology. The Asia-Pacific information superhighway initiative is focused on promoting the resilience and performance of the network in order to facilitate seamless integration of submarine, terrestrial, microwave and other modes, including the so-called white-space spectrum.

The Internet should be considered critical infrastructure and given careful consideration in disaster management planning. In addition, the technologies concerned have become heavily embedded in a variety of other infrastructural components, such as management of the electrical grid and control systems. Therefore, an integrated approach to planning should be pursued.

The present document contains an outline of the current state of information and communications technology infrastructure as it relates to disaster management and highlights issues for consideration; it also contains recommendations for further action in order to ensure that the potential of information and communications technologies in disaster management is fully realized.

* E/ESCAP/CICT(4)/L.1.

** The late submission of the present document is due to the need to incorporate details of the deliberations on these issues by the Commission at its seventieth session from 4 to 8 August 2014.

Contents

I. Introduction

1. In the past, disaster management planning had been focused on such areas as power, water and sanitation, among others. Unfortunately, there are many instances in which communication services are not considered a priority when there is lack of access to these basic services. However, it is often access to accurate information that facilitates the restoration of the services and calms societal turmoil following a disaster. In order for information to be communicated, the underlying network must be functional. Similarly, in order to communicate accurate information, the supporting processes, such as institutions and policies, must exist. In addition, modern infrastructure often contains embedded information and communications technologies (ICTs) as part of an infrastructure control system, increasing the resilience and efficiency of the grids and networks.

2. In disaster management planning, information and communication networks may not appear to be as important as access to clean water, food and shelter, but access to relevant and timely information and communication helps promote more efficient disaster response systemically. In addition, with the

increasing interconnectedness of these infrastructure components, the risk of failure in one sector creating knock-on effects which have an impact on other systems is increased. Therefore, for disaster management, consideration must be given to bringing these infrastructure components together and planning for risk systemically.

3. In order for information to be communicated, the underlying network must function properly. Similarly, the supporting soft infrastructure, such as institutions and policies, must be available and reliable. ICT allows for documentation of needs and resources, spatial coordination, communication and facilitation of payments in the aftermath of disasters. ICT infrastructure plays different roles in different phases of the cycle.

4. Furthermore, in the publication entitled *Building Resilience to Natural Disasters and Major Economic Crises*,[1] which had been prepared as the theme study for the sixty-ninth session of the Commission in May 2013, it was found that the overlapping and interlinked nature of disaster shocks called for a more comprehensive and systemic approach to building resilience. In this regard, it called for the development of a road map to meet those needs in the region.

5. Against this backdrop, member States of ESCAP tasked the secretariat, through resolution 69/10 on promoting regional information and communications technology connectivity and building knowledge-networked societies in Asia and the Pacific, to promote the development of ICT infrastructure, including in-depth analysis of the policy and regulatory barriers that may impede efforts to synchronize the deployment of infrastructure across the region in a seamless manner. Furthermore, the secretariat was also requested, through Commission resolution 69/11, to take the lead in implementing the Asia-Pacific Plan of Action for Applications of Space Technology and Geographic Information Systems for Disaster Risk Reduction and Sustainable Development, 2012-2017 (Asia-Pacific Plan of Action) at the regional level, to harmonize and enhance existing regional initiatives, to pool expertise and resources at the regional and subregional levels and to act as a clearing house for good practices and lessons. The secretariat was also requested to organize a ministerial conference to evaluate the progress made in implementing resolution 69/11 as it related to space and geographic information system (GIS) applications in Asia and the Pacific.

6. Information and communications technology, usually understood as electronically mediated communication, storage and manipulation, allows for the necessary actions related to relief and recovery to be done in ways that are qualitatively superior to the alternatives:

(a) **Documentation of needs and resources.** The enhanced information-processing and visualization capabilities of modern computing hardware and software can, by themselves, enable better documentation of the needs that have to be met, which, when combined with GIS, further enhances these capabilities;

(b) **Spatial coordination.** ICTs allow for synchronous and asynchronous communication, enabling greater coordination of spatially separated actors. This is especially important when a disaster has a geographically wide scope (a tsunami or a cyclone/typhoon versus a localized landslide) and when physical transportation systems may have been degraded or even destroyed in the disaster. Even with localized disasters, ICT enables the

[1] United Nations publication, Sales No. E.13.II.F.3.

coordination of assistance from unaffected areas. When buildings have collapsed and roads have buckled, spatial coordination is difficult;

(c) **Publication.** ICT can also give a voice to the people affected, especially in terms of empowering them in their interactions with the relevant authorities, be they governmental or non-governmental bodies;

(d) **Facilitation of payments**. This particular function has not thus far been implemented in a disaster situation because payment disbursement through mobile telephones is a relatively new phenomenon. However, it does have potential benefits, as e-transactions through mobile telephones have become relatively ubiquitous in several countries.

II. Enhanced network resilience

7. The Internet is a robust virtual infrastructure comprising tens of thousands of communicating nodes; it has come to be relied upon across the world. In some cases, segments of this infrastructure, which keeps Internet traffic flowing worldwide, can be quite fragile, notably submarine cables and terrestrial fibre networks.

8. These networks have seen significant growth in use over time, requiring additional investment and expansion of this critical infrastructure. As a result, ESCAP members and associate members have experienced differing trends in the responsiveness of their networks. As measured by the latency experienced by users on the network, most countries have demonstrated reductions in latency, which implies improved user experiences and higher speeds of data transit. This trend is not universal however, with some countries experiencing slower data transit speeds, implying a need to address network performance over time (see table 1).

Table 1
Network latency experienced by users in selected countries

Country	**2010**	**2011**	**2012**	**2013**	**Percentage change**
Singapore	124.74	85.80	77.23	79.29	-36.43
Viet Nam	140.52	87.22	100.87	98.87	-29.64
China	133.15	114.28	150.95	102.64	-22.91
Iran (Islamic Republic of)	419.06	N/A	384.08	352.20	-15.96
Indonesia	172.95	151.14	143.31	149.07	-13.81
Philippines	160.53	138.65	148.25	150.51	-6.24
Russian Federation	78.58	80.46	69.90	73.95	-5.89
United Kingdom of Great Britain and Northern Ireland	69.92	64.24	62.63	66.28	-5.20
New Zealand	71.65	68.14	69.74	70.19	-2.04
Republic of Korea	42.72	45.61	44.46	43.48	1.77
France	85.42	83.35	85.36	95.04	11.26
Malaysia	101.88	93.57	98.70	114.14	12.04
United States of America	67.38	67.31	70.50	76.89	14.10
Australia	63.40	66.17	76.51	75.65	19.32
Netherlands	45.22	49.90	50.51	67.62	49.52
Turkey	78.85	76.72	87.42	123.25	56.31

Source: Speedtest.net (retrieved June 2014) and analysis by ESCAP.

9. These critical pieces of infrastructure are often at risk. On average, a submarine cable snaps once every three days whereas a terrestrial cable gets severed once every 30 minutes somewhere in the world. The global economy suffers an annual loss of US$ 26.5 billion due to such disruptions.[2] These events make it clear that those countries which deploy a diversity of connectivity across seas as well as over land are better positioned to survive shocks to their communications and control infrastructures.

10. Providing robust, diverse and resilient connectivity in the Pacific subregion is particularly challenging from a technical perspective. Low population densities in Pacific island countries and territories and difficult terrain make the use of fibre-optic technology cost prohibitive in many cases. Wireless technologies, such as satellite connectivity, have had drawbacks, including high cost, high latency and low capacity. However, improvements in available satellite services offer new options for consideration. For example, the use of satellites in closer orbit to the surface of the Earth (approximately 8,000 km) offers the possibility of significantly improved communications capacities over more distant satellite options, such as those in geosynchronous orbit (approximately 35,000 km). These more modern, higher-capacity satellites have the potential to deliver significant enhancements in latency throughout, as well as cost savings. In recognition of this potential, Governments of some countries in the region have pre-purchased capacity on such satellite networks in anticipation of the reaping the benefits of greater network diversity, resilience and performance.

11. With this in mind, disaster planning should foster a systemic response that includes training and human capacity-building for key national stakeholders, such as ICT regulators, policymakers, legislators and cyber security experts in charge of protecting global and national critical infrastructures. In addition, cooperation between government and the private sector is necessary in order to properly manage backbone infrastructure, including such aspects as resilience, industrial control systems, identity management, Internet root name server administration and spam regulation. Trainings and capacity-building activities should also address non-State actors, such as non-governmental organizations, academia and the technical community.

A. The need to shorten time and resource requirements to restore critical systems

12. In order to promote resilience, it is advantageous to design, from the beginning, critical infrastructure with disaster management in mind. By so doing, the capacity to restore systems to functionality is enhanced. By contrast, retrofitting such capabilities into existing systems can be unnecessarily expensive and time-consuming.

13. The Information Communication Council of Japan, after analysing the causes of service interruption in the wake of a catastrophe, proposed the following technical standards with the aim of strengthening the resilience of the communication infrastructure:[3]

2 Data taken from infographic entitled "You've been cut, so what?" Available from www.ciena.com/resources/posters.

3 Hiroyasu Hayashi, "ICT strategy for recovery of Japan", 12th Asia-Pacific Telecommunity Policy and Regulatory Forum, May 2012. Available from www.apt.int/sites/default/files/2012/05/INP-13_ICT_Strategy_for_Recovery_of_Japan_PRF_Japan_rev.pdf.

(a) Increase the capacity of batteries and fuel for facilities that cover government buildings;

(b) Identify important base transceiver stations and provide backup circuits for those facilities. (Approximately 1,900 base transceiver stations, covering about 65 per cent of the population of Japan, are being equipped with electricity generators and/or 24-hour batteries as mechanisms to secure the telecommunication needs of the local government.);

(c) Identify important switching facilities of the core network and ensure that they are geographically well-distributed;

(d) Adhere to restriction-control guidelines to manage network traffic and congestion;

(e) Use a voice message delivery service that has the ability to avoid network congestion due to voice calls. (Other carriers are planning on starting the same service, which would enable operators to send messages to each other.);

(f) During emergency situations, direct maximum resources to basic communication services needed for carrying out rescue operations and confirming the safety of others, while reducing the priority for servicing other bandwidth-intensive video services.[4]

B. International standards and recommendations to be followed after disasters

14. The International Telecommunication Union (ITU) has also defined a number of standards and recommendations to be followed in times of disaster. One such standard is the International Emergency Preference Scheme (IEPS), which ensures that calls made by those involved in directing and coordinating relief operations get preferential treatment on public networks. IEPS is also operational for Internet protocol networks, cable networks and next-generation networks. Standards for emergency alert delivery have also been defined.[5]

15. ITU considers it vital to ensure that women are also engaged in disaster response programmes, because in many communities, women often are the primary communicators and primary caregivers and are more likely to heed warnings and plan for disasters. It is imperative therefore that Governments and disaster relief agencies involve women in their disaster preparedness programmes.[6]

[4] Hideo Tomioka, “Maintaining communications capabilities during major natural disasters and other emergency situations”, Ministry of Internal Affairs and Communication, 16 March 2012. Available from www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/Telecommunications_Policy_Division_MIC.pdf.

[5] International Telecommunication Union, “Handbook on emergency telecommunications – Appendices”, October 2005. Available from www.itu.int/ITU-D/emergencytelecoms/doc/handbook/pdf/Emergency_Telecom-e_appendices.pdf.

[6] International Telecommunication Union, “Emergency telecommunications: engendering prevention and response”, in *Handbook on Disaster Communications* (Geneva, ITU, 2001). Available from www.itu.int/ITU-D/gender/documents/emertelegenderfinal.pdf.

Box

Catalysing digital connectivity in rural areas: white-space spectrum management in the Philippines

The term “TV White Spaces” (TVWS) refers to unutilized television frequencies in the VHF (very high frequency) and UHF (ultra high frequency) bands.

In 2010 the United States Federal Communications Commission approved the use of TVWS for data communications. In the Philippines, the Information and Communications Technology Office of the Department of Science and Technology has been promoting the deployment of this new wireless data communications standard. TVWS has been found to be an ideal wireless data delivery medium for the Philippines, as it has long-distance propagation characteristics, and its signals have the ability to travel over water and hills and through thick foliage. Furthermore, the medium has proven to be a relatively inexpensive way of bringing high-speed Internet to underserved or unconnected areas and thus can play an important role in bridging the digital divide pending further roll-out of fibre-optic infrastructure. More importantly, it has the potential to act as a catalyst to increase demand and thus provide greater incentives for private sector investment in underserved areas.

Consequently, work is under way to utilize TVWS to support government initiatives requiring data connectivity, such as sensors used by Project NOAH for disaster mitigation, as well as a range of other applications related to education currently being developed by the Philippines Information and Communications Technology Office for the country’s Department of Education through the Cloud Top Project and the initiatives being taken by the University of the Philippines’ “TeleHealth Center”.

Source: www.icto.dost.gov.ph/index.php/news-events/current-news/91-government-announces-tv-white-space-plans.

III. Information and communications technologies as critical infrastructure

A. ICT as a critical component of other infrastructure

16. The enhanced information-processing and visualization capabilities of modern hardware and software can, on their own, enable better documentation of the needs that have to be met, ranging from registries of the missing and injured, to medicines and food for the affected. ICTs enable coordination of spatially separated actors, especially when a disaster has a geographically wide scope and when physical transportation systems may have been degraded. ICTs can also give voice to the people affected, in terms of empowering people and authorities to communicate. Payment through mobile telephones has great potential in disaster relief processes.

17. If the above-mentioned functions are to be performed, it is necessary that ICT infrastructures survive the disaster. The many disasters experienced in the Asia-Pacific region in recent years have yielded insights that can contribute to ensuring greater e-resilience.

18. Following the 26 December 2004 tsunami in the Indian Ocean, the operators and the Communications Authority of Maldives took key steps to safeguard their communication networks in the event of another natural disaster. As a disaster mitigation step, two mobile network operators, Dhiraagu and Wataniya, have changed their network topologies from a series type to a ring, for the purpose of increasing resilience. In addition, two very small aperture terminals (VSATs) have been installed for emergency communications in strategic locations (Vilimalé and South Gan Island), which were selected based

on geographic dispersion of the two islands and population density. Other measures taken include the interconnection of the country's two submarine cables, one owned by the incumbent Dhiraagu and the other by a consortium that includes Wataniya and Focus Infocom, an Internet service provider. These measures will reduce the risk of completely losing connectivity with the international community. National roaming and priority calling that are activated with the official announcement of a disaster are other initiatives that have been taken by the operators in Maldives.

19. Currently, most backhaul traffic in Asia transits via international bandwidth hubs, such as Hong Kong, China; Mumbai, India; Singapore; and Tokyo. Cross-border terrestrial links between countries either are missing or, where they exist, are of low capacity, and do not form a coherent network. These links are often built by incumbent carriers; therefore, they are designed to route cross-border traffic onto their submarine networks, which limits realization of their full potential. If a regional network can be created by filling the gaps in the existing links, thus opening access to all operators, the result would be seamless regional integration, price declines and improved quality.

20. Redundancy and resilience should be explicitly considered when promoting the sharing of telecommunications infrastructure. Specifically, rules regarding critical infrastructure and essential facilities, such as undersea cable stations, should be formulated taking into account the need to reduce disaster risk. Especially in small island countries where there are few suitable sites, disaster management planners should earmark locations that are the least vulnerable to disasters and ensure that they are made available to ICT infrastructure operators.

21. In addition, a proactive approach to leveraging ICT for e-resilience should encourage private sector suppliers to diversify locations of critical infrastructure and deploy multiple technologies, for example, by ensuring that backup satellite connectivity is maintained even after fibre connectivity is widely deployed. Reliance on undersea cables should be balanced by utilization of terrestrial cables where possible and vice versa. Diversity of cable routes, which promotes a resilient infrastructure, should also be a policy objective. As such, encouraging terrestrial cable systems that run alongside the Asian Highway and the Trans-Asian Railway networks is an important consideration for utilizing ICT for improving resilience to disasters.

22. This is due to the fact that Asia experiences severe undersea earthquakes. For example, on 26 December 2006 the Hengchun earthquake off Taiwan Province of China devastated the Internet, voice and data services in China, India, the Philippines and Singapore. There were 21 faults in 9 submarine cables, and it took 11 cable repair ships 49 days to fix the damage.

23. Typhoon Morakot, followed by an earthquake in Taiwan Province of China on 7 August 2009, severed 10 submarine cables. Up to 90 per cent of the voice and data traffic was adversely affected across China, India, Japan and various countries in South-East Asia. On 4 March 2010, another earthquake in Taiwan Province of China snapped the SEA-ME-WE 3, APCN2, CUCN, FLAG and FNAL submarine cables.

24. On 11 March 2011, Japan was struck by a devastating earthquake followed by a catastrophic tsunami. Although two major submarine cables were severed, the country's Internet system remained functional because lessons had been learned from previous earthquakes, and Japan had been comprehensively bolstering its transmission network. As part of these efforts, Japan created a

dense network of domestic and international connectivity using a diverse set of technologies. This enabled the country's network traffic to adapt to the catastrophe and maintain service, even in the face of a chaotic situation.

25. In considering these scenarios, new applications of fibre-optic infrastructure have been identified. For example, by installing environmental monitoring sensors as part of the cable systems themselves, applications are possible, such as early warning of tsunamis. This form of environmentally sensitive "green cable" can add a very important dimension to the multisectoral value of the communications infrastructure. Projects to deliver this functionality are in the early stages of planning.

26. Wireline and wireless access networks pose different challenges in terms of ensuring resilience. Post-disaster analysis of wireline networks after the 2011 Tohoku earthquake and tsunami in Japan and Typhoon Haiyan in the Philippines showed that aerial cables were susceptible to greater damage than buried cables. As a result, experts have promoted the use of ducts and buried cables. Post-disaster analysis of wireless networks has pointed to the criticality of power supply to base transceiver stations (BTSs). Provision of battery and generator backup to a large number of BTSs is costly. Supplying fuel to BTSs in the aftermath of a disaster is difficult when roads are damaged or blocked. As with any form of redundancy, increased capacity of backup power throughout a mobile network can be cost prohibitive. Therefore, selected strategically located BTSs, such as those that are situated close to government buildings and hospitals, may be equipped with enhanced backup capacity.

27. Even if the physical elements, such as towers and wires, survive the disaster, the networks may fail due to congestion. The end result, in the short term, is no different from failure caused by physical damage. Sudden spikes of traffic in circuit-switched networks can cause the networks to crash, although it is possible to restore the network relatively quickly. In packet-switched networks, the result may be degraded but performance is still operative.[7]

B. Infrastructure investments in the ESCAP region

28. ESCAP members and associate members have been making significant investments in improving their packet-switched networks. As a result, this infrastructure has demonstrated increased reliability and responsiveness. As measured by data obtained from user-initiated connection speed tests, the percentage of information packets lost has declined significantly over the last three years (table 2). This indicates both the usefulness of these networks in providing reliable communication services and the importance of safeguarding this critical infrastructure.

[7] Congestion and how it can be dealt with are discussed in detail in Rohan Samarajiva and Nuwan Waidyanatha, "Two complementary mobile technologies for disaster warning", *Info*, vol. 11, No. 2 (2009), pp. 58-65.

Table 2
Percentage of data packets lost in transmission

Country	2010	2011	2012	2013	Percentage reduction
China	4.62	2.56	1.88	1.27	72
United Kingdom of Great Britain and Northern Ireland	3.12	3.06	1.29	0.96	69
New Zealand	4.90	3.58	2.05	1.57	68
Malaysia	3.26	1.64	0.96	1.06	68
Australia	3.00	3.28	1.72	1.14	62
Republic of Korea	1.76	1.08	0.65	0.70	60
United States of America	3.25	3.66	2.47	1.44	56
Turkey	6.87	5.40	4.42	3.22	53
Singapore	3.60	3.08	1.96	1.86	48
France	2.61	2.17	1.83	1.39	47
Indonesia	2.15	1.48	1.09	1.20	44
Viet Nam	1.80	1.60	1.12	1.03	43
Philippines	1.93	1.79	1.13	1.21	37
Netherlands	2.37	2.14	2.30	1.56	34
Iran (Islamic Republic of)	1.86	N/A	2.40	1.24	33
Russian Federation	1.54	1.15	1.19	1.30	16
Average:	3.04	2.51	1.78	1.38	51

Source: Speedtest.net (retrieved June 2014) and analysis by ESCAP.

29. Public networks are likely to be highly unreliable for critical first-responder communications, especially in the early hours after a disaster. The consequences of this congestion for first responders are extremely serious. Therefore, it is customary to give them forms of connectivity that are more resilient to congestion. For example, first responders may be provided with subscriptions to terrestrial trunked radio (TETRA) networks, which are not interconnected with public networks and are designed to accommodate the expected volume of peak-use scenarios by first responders. As a result, however, these networks are more costly per user. The handsets also tend to be more expensive and bulkier than normal mobile handsets. However, certain features, such as the broadcasting function of existing cellular networks, which is more resistant to congestion because it is a one-to-many communication system that reaches all handsets within range of a base station, may be used to supplement first-responder communication through dedicated private networks. Cell broadcasting offers more than 60,000 virtual channels. Therefore, certain designated and not publicly available virtual channels can be used to alert first responders to immediately initiate use of their TETRA units, for example.[8]

[8] Natasha Udu-gama, “Mobile cell broadcasting for commercial use and public warning in the Maldives”, May 2009. Available from http://lirneasia.net/wp-content/uploads/2009/07/CB_Maldives_FINAL_2009_041.pdf.

30. The Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations governs the availability of ICT infrastructure during disaster relief operations. These provisions assist in facilitating the travel of emergency service personnel and their related telecommunications gear. During the critical early response periods, this approach holds the promise of reducing bottlenecks and enhancing responsiveness to disasters.

31. If there is no physical damage to network elements, the problems caused by congestion will gradually subside as the general users modify their communication behaviour. Regulators cannot insist on networks being built to eliminate congestion altogether, although it is possible to develop standards for redundancy levels and recovery procedures in consultation with service providers that are best informed on the subject and have to implement the rules in difficult circumstances.[9]

32. To enhance communications infrastructure, national highways provide convenient rights of way to deploy optic-fibre transmission backbone segments. At the regional level, the Asian Highway serves as a meshed transcontinental road network. Therefore, a parallel meshed dense wavelength division multiplexing fibre network with a capacity of 100 Gbps offers a compelling option for redundancy to the Asian submarine cable networks. It will greatly reduce the risks of outage from accidents, sabotage or natural disasters.

33. Installing fibre optic cables along the Asian Highway would reduce the isolation experienced by landlocked countries. Of the 32 member countries through which the Asian Highway passes, 10 are landlocked developing countries (table 3). Among them, Uzbekistan, for example, is a double-landlocked economy. The growth rates in international bandwidth traffic, as illustrated in the table below, emphasize the need to proactively plan infrastructure upgrades which would enable continued growth. Without undertaking such measures as peering, cable investments and increased efficiency in Internet exchange points, bottlenecks will develop quickly, which would contribute to a deepening of the digital divide among these countries.

34. Asian submarine cable networks encounter five major geographic bottlenecks. Too many submarine cables passing through a narrow maritime passage makes them vulnerable to accidents followed by mass outage, as discussed above. Such choke points are:

(a) The Luzon Strait between the Philippines and Taiwan Province of China;

(b) The Strait of Malacca between Indonesia and Malaysia;

(c) The Strait of Hormuz between the Islamic Republic of Iran and the United Arab Emirates;

(d) The Suez Canal in Egypt as well as the Red Sea region;

(e) The Strait of Sicily in the Italian maritime zone.

[9] P.S. Anderson and G. Gow, "A general framework for mitigation-oriented planning assessments of mobile telecommunications lifelines", *Natural Hazards*, vol. 28 (2004), pp. 305-318.

Table 3
International Internet bandwidth consumption by landlocked developing countries sharing the Asian Highway

Country (alphabetically)	Annual bandwidth consumption (Mbps) 2008	2009	2010	2011	2012	Annual growth rate (%) 2008	2009	2010	2011	2012
Afghanistan	245	265	912	1 897	3 147	29	8	244	108	66
Bhutan	75	116	330	485	640	150	55	184	47	32
Kazakhstan	3 752	11 123	36 967	74 368	122 566	155	196	232	101	65
Kyrgyzstan	524	1 019	1 335	2 005	5 129	32	94	31	50	156
Lao People's Democratic Republic	481	756	1 616	2 682	4 190	48	57	114	66	56
Mongolia	2 169	3 621	6 372	11 180	17 280	1 199	67	76	75	55
Nepal	199	1 085	1 775	4 865	7 960	135	447	64	174	64
Tajikistan	129	179	235	595	3 108	90	39	31	153	422
Turkmenistan	344	54	69	290	400	1 047	-84	28	320	38
Uzbekistan	498	1 085	1 332	5 066	12 595	108	118	23	280	149

Source: TeleGeography, Q2, 2013.

35. On 19 February 2013, a consortium involving Hong Kong, China; Japan; Malaysia; the Philippines; and Singapore commissioned the Asia Submarine-cable Express system bypassing Luzon Strait.

36. Carriers have also started bypassing the increasingly risky Suez Canal route to Europe. Asia historically has more international Internet capacity connected to Canada and the United States of America than to any other such area. However, this proportion is falling steadily as Asian carriers become less dependent on the United States for connectivity.

37. In 2013, nearly 40 per cent of Asia's 19.9 Tbps of international Internet bandwidth was connected to the United States and Canada, down from 48 per cent in 2009. Likewise, both intra-Asian and Eurasian capacity grew at 44 per cent and 42 per cent, respectively, in 2013.

C. Need for mesh architecture and enhanced interconnectedness (peering) to provide redundancy

38. In liberalized environments, multiple suppliers and technologies exist. Even long-held assumptions, such as the technical and economic infeasibility of building multiple undersea cable stations, have had to be re-examined in the new competitive environment.[10] Competitive markets provide inherent redundancy, which is created by the existence of multiple, competing networks. Even if one network were to fail, it is unlikely that all networks in a specific locality would fail at the same time. Solutions such as permitting the customers of one operator

[10] Office of the Communications Authority, Hong Kong, China, "Landing of submarine cables in Hong Kong", 1 August 2013. Available from www.ofca.gov.hk/en/industry_focus/telecommunications/facility_based/infrastructures/submarine_cables/index.html.

to roam on the networks of competitors for the duration of "a state of exception" resulting from a disaster are available only in diverse markets. Local roaming has been tested and is ready for implementation in the event of a disaster by the two mobile network operators in the Maldives. Additionally, crews travelling across post-disaster terrain to repair one network can coordinate their activities by using mobile telephones from another functioning network. Where multiple undersea cable and satellite paths controlled by different companies exist, various kinds of formal and informal swap and barter arrangements can be made to ensure redundancy and business continuity.

39. In addition, the potentially vulnerable element itself can be made less critical by the use of ring architecture, whereby a single break can be worked around, albeit at a degraded network speed. Multiple breaks, however, can result in network failure. Therefore, ring architecture is not ideal when network availability is critical. It is now becoming more common to shift to even more robust mesh architectures, in which multiple, simultaneous breaks can be worked around. In a mesh network topology, all nodes are connected to every other node, thereby increasing redundancy and cost, the latter being its main disadvantage. With cost and complexity in mind, hybrid ring-mesh architectures may prove to be a more viable option.

40. Among the remaining concerns is the vulnerability of the towers, which can be toppled, flooded or otherwise damaged. The solutions are selecting robust locations and building adequate redundancy into the network so that communication can continue even if some towers fail. The specialized networks may use higher power levels and frequencies that cover greater distances and so may rely on a less dense network of towers, but they too are vulnerable. As a broadcast technology, high-frequency (HF) transmission is accessible by anyone who is tuned in to the frequency; however, the trade-off is significantly lower bandwidth, although it is sufficient for transmitting text. A more pertinent characteristic to consider is signal propagation; the atmosphere alters the propagation of signals in general. HF signals are more prone to react to such propagation characteristics, but the effect can be overcome by using equipment that will automatically tune in to the best available channel. Regional collaboration on standardizing the use of high frequencies is desirable for its optimum use as a mode of emergency communication.

41. It is not possible to make these critical infrastructure elements completely secure, although it is important to strive for high levels of robustness in design and operation. Therefore, network design has to incorporate redundancy. For example, the design may enable power to be drawn from more than one electrical substation. Battery backup is common, although generators may also be placed in the location, along with adequate supplies of fuel.

42. Provision of information-sharing between government and private sector stakeholders during times of crisis is often part of cybersecurity plans. From a disaster management perspective, it is important to create mechanisms for response and information-sharing with cybersecurity stakeholders well before disruptive events occur. In the case of ICT infrastructures, these risks also include increased vulnerability to cybercrime and electronic attacks. Coordination between national computer emergency response teams and disaster management planners should take a holistic view of these risks, and incorporate response to cyberattacks as another form of disruptive event.

IV. Emerging applications

A. Social media for disaster management

43. With rapidly expanding usage rates, social media applications have attained a central role in the online experience of users around the globe. In many ways, user behaviour has shifted from the browsing of web pages to sites and applications which are focused on enabling people to interact with each other and provide critical, real-time location information. As such, these technologies represent an important vector for the dissemination of information. During times of crisis, social media can act as an effective broadcast mechanism, as well as a catalyst for enabling citizen-level responses.

44. Tsunami activity, most recently in Japan on a large scale, has resulted in extensive use of text message-based social media, such as Twitter. In addition, Google Crisis Response is a team that helped create Google Person Finder, which provides a message board-style approach to keeping people informed. This was particularly useful in asynchronous, bandwidth-constrained areas, such as are commonly experienced in the aftermath of a disruptive event. Further, in Japan, after an earthquake, a new application (Line) was created which makes further use of packet-switched networks. The application experienced rapid uptake, underscoring the value of social media applications and their transformative effect on communication. Because these systems are less resource-intensive than competing technologies, they offer a compelling option which should be carefully considered in disaster management.

45. In addition, the Government of the Philippines has taken proactive steps to utilize social media for information dissemination and coordination. As a country with a high penetration of social media applications, such as Facebook, these types of platforms hold great promise in facilitating the spread of information, including during times of crisis. The National Disaster Risk Reduction and Management Council of the Philippines has made use of social media applications to keep citizens informed about government responses and to obtain citizen-level information on disaster impacts. In this regard, the Presidential Communications Development and Strategic Planning Office has issued a set of instructions for the use of official hashtags (a word or phrase preceded by the symbol "#" used in social network services) in order to promote clarity and ensure a unified approach.

46. Advanced preparation is necessary in order to take full advantage of these tools, making social media an important part of e-resilience planning and disaster management. Among the best practices which have emerged in this area, the prearranged use of specific tags and communication channels for disaster management is an important step. By creating official channels of communication and disseminating this information to the public and disaster response agencies, appropriate channels will already be in place in advance, thus reducing an area of potential confusion in a post-disaster environment.

47. Many disaster management agencies have pursued the creation of applications for so-called smartphones and mobile devices to provide a clear and secure communications mechanism for coordination with the public. These solutions leverage the mobility and resilience of portable devices, with the efficiencies of communication which can be seen with social media. While more expensive to develop than making use of existing technology, these approaches offer a compelling option which should be carefully considered.

B. Facilitation of payments

48. During the relief phase, resources flow into the disaster-affected area. Initially, they take the form of actual goods. As time passes and recovery begins, the mix changes in favour of money. In fact, disaster professionals advocate the practice of discontinuing the importation of supplies and re-engaging local sources by giving disaster survivors the wherewithal to purchase necessities so that economic revival can begin.[11]

49. It is not a simple matter for government to disburse money to citizens while minimizing the risk of fraud. In conditions where people are still living in temporary accommodation, keeping cash is likely to be a problem. The increasing presence of mobile money and payment mechanisms may be used to provide solutions to both problems.[12] It is not difficult to establish a unique relationship between a citizen and a "mobile wallet" associated with a specific telephone number. Once the money is in the mobile wallet all that is required are local vendors who will accept mobile payments and a few cash-out locations to disburse cash to those who might require small quantities of old-fashioned money.

50. The Government may face some difficulty if the mobile payment system is limited to one company and not all beneficiaries are subscribed to that company. It may be necessary to make at least temporary arrangements within the disaster-affected area for some kind of interconnection, perhaps even based on proxy numbers, to be made possible in the payment space.

51. The robustness of the system comprises two parts. The robustness of the underlying mobile network has already been discussed; the security of the payment system is the second part. This is an issue that must be addressed, but not necessarily in the context of post-disaster relief and recovery actions.

V. Upcoming work of the secretariat

52. At its seventieth session, the Commission recognized the importance of ICTs as critical infrastructure for coordination of disaster response. In this regard, and particularly for developing countries with limited access to satellite-based systems, a robust, interoperable and priority-sensitive emergency communications infrastructure should be an integral part of disaster management planning and response. While ICTs were a critical component of infrastructure in their own right, they were also integrated into the infrastructure control system of other vital sectors, such as energy, health care and law enforcement. As such, e-resilience considerations should be mainstreamed into a holistic approach to disaster planning.

53. In support of the efforts of member countries to identify opportunities for network enhancement and infrastructure improvement, ESCAP will improve the existing maps of the terrestrial fibre-optic network to add a holistic picture, including Internet exchange points, and other critical infrastructure pieces, such as Internet root domain servers and new terrestrial connections. This information

[11] United Nations Development Programme and Department of Humanitarian Affairs, *Disaster Economics: Disaster Management Training Programme*, 2nd ed., 1994. Available from www.pacificdisaster.net/pdnadmin/data/original/dmtp_17_disaster_economics_8.pdf.

[12] Matt Daggett, "Mobile money in Haiti: a new support for disaster relief and development programs", 9 March 2011. Available from www.ssireview.org/blog/entry/mobile_money_in_haiti_a_new_support_for_disaster_relief_and_development_pro/.

will help in identifying aspects of the communications infrastructure that could benefit from additional capacity or cooperative activity, such as enhancement of peering agreements.

54. This will include an analysis of good practices to systematically coordinate fibre-optic lay-out with work on transport infrastructure, including cost-benefit analysis at the country level, in order to take ground-level situations into account. ESCAP will also undertake to further improve other metrics to complete assessment of investment opportunities, including such aspects as existing and planned regional networks, quality of service and availability of local language content. In addition, in follow-up to subregional approaches to currently available data, the research activities will, as a first step in in-depth analysis, include examination of the gap between the current state and future needs for international connectivity and backbone networks in the region covered by the Association of Southeast Asian Nations, by collecting new data and measuring Internet traffic flows. The results will incorporate presentation to telecommunications carriers in the industry for further feedback.

55. In order to maximize the impact of these activities, ESCAP will also continue to disseminate this and related research on the Asia-Pacific Gateway for Disaster Risk Reduction and Development. Development and enhancement of substantive material on this portal will continue aimed at including updated information in the related databases, enhanced online services, facilitation of satellite imagery and enhanced support for collaborative and user-generated content. By building these capacities, the Gateway will continue to deliver relevant and timely value added analysis of ICT infrastructure and related disaster management themes.

56. The use of ICT in disaster management planning is an important matter in the region. In recognition of this need, ESCAP is in the process of undertaking studies documenting lessons learned and good practices on the national and regional integration of ICT in disaster planning. In support of the Framework for Action on ICT for Development in the Pacific and through subregional and national partnerships, initially Bangladesh and the Philippines, ESCAP is drawing on the results of these studies to provide members and associate members with recommendations for the future.

VI. Issues for consideration by the Committee

57. The Committee may wish to consider the above-mentioned issues and provide the secretariat with guidance on future work in the areas described below.

58. The secretariat could promote the concept of a diverse and resilient pan-Asia-Pacific optical fibre network which incorporates robust terrestrial and submarine connectivity. Such a network would enable member States to improve international backhaul, including lowering costs and enhancing reliability. The terrestrial components of this network could make use of the existing Asian Highway, Trans-Asian Railway and electrical grid rights of way, while the integration of existing and new terrestrial and undersea cable segments into regional networks should also be promoted. Towards this end, the Committee may wish to consider recommending that the working groups on the Asian Highway and the Trans-Asian Railway work on including these priorities in the resulting intergovernmental approach.

59. The secretariat could also raise awareness about the usefulness of the Tampere Convention for enhancing resilience during disasters and promote

ratification of this treaty among the member States concerned. In addition to raising awareness among government decision makers concerning the possibilities of requesting help through the Tampere Convention, especially those from countries which are vulnerable to earthquakes and tsunamis, and from small island countries and territories.

60. The secretariat may be requested to continue to promote and enhance its analytical work on ICT as a critical infrastructure for e-resilience through in-depth, ground-level, subregional studies, as well as online modalities, such as the previously mentioned Asia-Pacific Gateway.

VII. Conclusions

61. ICTs have become a vital component of national infrastructure both as a means of communication and as embedded devices in other systems, such as power, water, transport, health care and law enforcement. As such, disaster management planners should give specific consideration to ICT communications as a critical infrastructure. In order for these technologies to deliver increased efficiencies and enhanced resilience, it must be planned from the beginning for networks to support disaster resilient applications and systems. Improving network interconnectedness in backbone infrastructure, including such concepts as peering and redundancy through meshed terrestrial networks, will greatly improve the capacities of these assets to provide enhanced disaster management. The Asia-Pacific information superhighway is significant in this regard as it represents an opportunity to integrate and enhance these networks. Member countries should carefully consider the endorsement of the optional protocol for this Asian integrated transport network in order to facilitate development of this system.