Study of Space-Based Applications in the Pacific region to Enhance ICT connectivity for Disaster Risk Management and Socio-Economic Development

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April 2011

Contents

Acronyms and Abbreviations

APAA	Active Phased Array Antenna
ALOS	Advanced Land Observing Satellite
APRSAF	Asia-Pacific Regional Space Agency Forum
AusAID	Australian Agency for International Development
Beidou	Chinese word for "Big Dipper"
BGAN	Broadband Global Area Network
C Band	Is a pair of satellite radio frequency bands with the up-link at 6 GHz and the down-link at 4 GHz
BSS	Broadcasting Satellite Service
CITIC	Formerly the China International Trust and Investment Company
dbw	logarithmic ration of power referenced to 1 watt
DMSS	Disaster Management Satellite System
DRM	Disaster Risk Management
DTH	"Direct to Home" the signal is strong enough for a receiving station on the Earth to communicate directly using a relatively small antenna.
eirp	Equivalent Isotropic Radiated Power
EESS	Earth Exploration Satellite Service
FSS	Fixed Service Satellite
GPRS	General Packet Radio Service
GMDSS	Global Maritime Distress and Safety Services
GNSS	Global Navigation Satellite System (generic name for GPS type services)
GPS	Global Positioning System
GSPS	Global Satellite Phone Service
Inmarsat	International Maritime Satellite Organization
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITU	The International Telecommunication Union
ITU-R	ITU-Radiocommunications Sector
JPL	Jet Propulsion Laboratory
Ka Band	Satellite radio frequency band of 18-33 GHz with uplink frequencies between 27.5GHz and 31Ghz and downlink frequencies between 18.3 and 18.8Ghz and between 19.7 and 20.2Ghz, (for bands mentioned in the text)
KIZUNA	Known as WINDS – Japanese designed Active Phased Array Antenna Satellite
Ku Band	A pair of satellite radio frequency bands with the up-link at 14 GHz and the down-link at 11/12 GHz (11/12/14 GHz)
L Band	L band refers to four bands of the electromagnetic spectrum: 40 to 60 GHz (NATO), 1 to 2 GHz (IEEE), 1565 nm to 1625 nm (optical), and around 3.5 micrometres (infrared astronomy). L band covers 950 MHz to 1450 MHz
LAN	local area networks
LEO	low-Earth orbiting
LORAN	long range navigation
MOSAIC	Mobile System for Accurate ICBM Control
MPDS	Mobile packet data service
MSS	Mobile Satellite Systems (Services)
NASA	The US National Aeronautics and Space Administration
NCPF	New Caledonia - Polynesia Française (French Polynesia)
RNSS	Radio Navigation Satellite Service
PacRICS	Pacific Rural Internet Connectivity System
Pac Rim West	Pac Rim West a pair 560Mb/s optical submarine cable, which linked Australia to the world
PIFS	Pacific Island Forum Secretariat
PMSC	Personal Mobile Satellite Communications
PPDR	Public Protection and Disaster Relief
PNT	Positioning Navigating and Timing

PSTN	Public Switched Telephone Network
QZSS	Quasi-zenith Satellite System
SIDS	Small Island Developing States
SPC	Secretariat of the Pacific Community
Tampere Convention	Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations. A multilateral treaty for provision and availability of communications equipment during DRM operations.
USDOD	Department of Defence
WB	World Bank
Web-GIS	Web based Geographic Information Services
Wifi	Wireless Fidelity, trade name for a wireless broadband delivery system
WINDS	Also KIZUNA – Japanese designed Active Phased Array Antenna Satellite

Tables

Figures

Appendices

Executive Summary

This paper looks at connectivity in the Pacific, cable options, and satellite development and shows that apart from the communications satellites that play an important role in the monitoring of the earth's resources, there are a number of specialist satellites carrying out earth resource measurements called Earth Exploration Satellites (EESS) and those used in determining locations called Radio Navigation Satellites (RNSS). This study reports on the potential of space-based ICT connectivity for socio-economic development, in particular Disaster Risk Management (DRM), among the Pacific countries, particularly the smaller island states. It identifies policy and regulatory changes, which may be necessary for the full utilization of such space-based applications.

It begins by clarifying current (including near future) ground, submarine and space communications infrastructure, which will soon be available in the region. Then there will be a discussion of how satellite technologies can contribute disaster risk management in the Pacific nations. It further proposes a worthwhile project to ensure that the Earth Resource data gathered by satellite becomes available to the parties that need forecasting and coping with national catastrophes including natural disasters.

A lot of work has gone on over the last few years, terrestrial services requirements for Public Protection and Disaster Relief (PPDR) within the aegis of the International Telecommunications Union (ITU) and the Regional Telecommunications groupings like the APT. But, there has been little work done on how satellite technology can help. Many of the communities in our Asian-Pacific Region are remote and satellites can play a major role in alleviating the distance barrier.

Internationally communications in support of disaster relief are covered by the Tampere Convention. The Tampere Convention has been available for states to accede to for over a decade and while the terrestrial component has received a lot of attention in the ITU Radiocommunications Sector (ITU-R) the satellite component has been restricted to Mobile Satellite Systems (MSS) operations under Working Party 4C of the ITU-R. This work has identified networks but not much more than that. Our work should progress the international frameworks under this accord.

We know that low and medium density traffic in PPDR can be handled now by the existing MSS constellations. But what about the emerging high speed data capability? Has it got a role and if so how could it be met? How do terrestrial and submarine options compare with satellites as a means of getting high speed broadband to remote locations?

Numerous attempts have been tried to find terrestrial high-density data transfer solutions with limited success in areas where the populations are sparse and remote like the Pacific Islands. This paper examines the option of a quantum leap to a satellite solution for all countries in the region based on an international cooperation framework. Although current options are dependent upon the generosity of the government and people of Japan sustainable solutions are possible.

Consideration of all options paves the way for consideration of high-speed broadband options. One conclusion is that the most immediate use of high speed satellite internet would be itinerant capacity. There are dangers in the sudden introduction of a government supported innovation, offering the latest technology, into a small rapidly developing market. If high-speed satellite broadband deploys initially to support events such as major sporting fixtures or for events such as the Pacific Forum Meetings, it will not only meet a demand sudden short-term increase in capacity, it will familiarise providers with the new technology, provide on the spot operator training and pave the way for more extensive deployment as equipment upgrade cycles com around.

Success of high volume itinerant providers, particular in the recovery phase of a major disaster, will depend upon the rapid arrival of the appropriate reception equipment and the availability of appropriate secondary interconnections. It will be to the advantage of all concerned if they are already familiar with the equipment.

However, there is greater potential to allow access by disaster recovering teams to a huge variety of backup services including telephony, data and expert advice like medical and engineering.

Telecommunications in general is proving to be a useful tool to address social and economic development through empowerment of the poor. Access to reasonably priced telecommunications in a disaster situation is but another manifestation of the liberation process underway. Whatever the future has in store it is probably opportune for the nations of the region to meet and discuss how they can best harness this new technology to give relief to their people in times of need.

1. Background

1. This study is to report on the potential of space-based ICT connectivity for socio-economic development and Disaster Risk Management (DRM), among the Pacific countries, particularly the smaller island states. It will identify policy and regulatory changes, which may be necessary for the full utilization of such space-based applications. It will begin by clarifying current (and near future) ground, submarine and space communications infrastructure, available in the region.

2. We also discuss the current-status and necessary changes in the local space-based ICT human and institutional capacity development and retention to achieve the necessary changes Then there will be a discussion of how satellite technologies can best contribute disaster risk management in the Pacific nations. It will conclude by looking at enhanced regional cooperation in the Pacific as a way forward to sustain and expand the initiatives.

3. From a telecommunications infrastructure perspective, the Asia Pacific Region countries fall into two broad categories: On the one hand are the rapidly emerging "tiger" economies and heavily populated countries of North and East Asia (China, Indonesia, Japan, Malaysia, Philippines, Singapore, Thailand and Vietnam). These countries generally have well developed ICT infrastructure including satellite capability, although Vietnam in particular is starting from a low base.

4. On the other hand are the slower developing or less intensively populated countries such as Cambodia, Laos and Myanmar and the nations of the South Pacific. In these nations, smaller populations or lower incomes and smaller economies mean that these nations have seen rapid improvement in their ICT infrastructure, but do not have the critical mass required to develop their own satellite capability. Much of the discussion will focus on brining services to these communities.

1.1 ICT and Development

5. Throughout the developing World, millions of people have gained enormous benefits from the wide availability of modern telecommunications, particularly cellular telephones, but increasingly broadband internet. Cheap and convenient mobile telephone calls have greatly cut the cost of communications by leaping the technology of fixed lines and at a very low outlay, have turned people with no service at all into mobile subscribers.

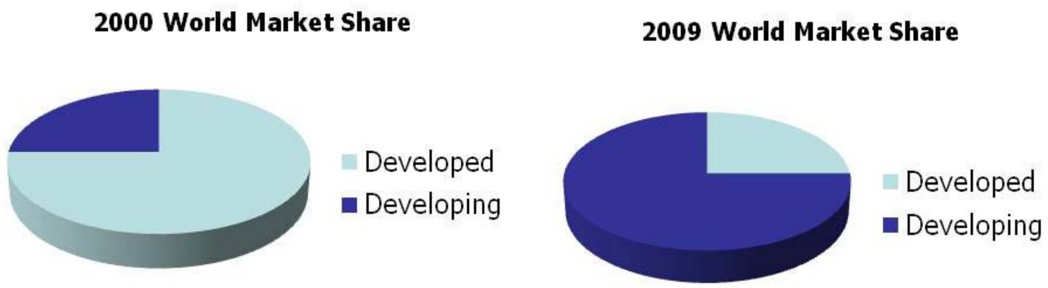
6. In 2000, developing countries accounted for one quarter of the 700 million mobile telephones in operation. Figure 1 shows how from 2000 to 2009 the share of the world market for telephones in operation has move to the point where 75 percent of the total, are in developing countries[1].

7. It is estimated[2], by 2009 at least 3.6 billion people own at least one subscriber identity module (SIM) card; in developing countries, many others have access to one. It is not possible to know precisely how many people have access to mobile phones today, but the growth in subscribers is enormous. In the year, to March 2009, India increased subscribers by 128 million, China by 89 million and across

[1] Carl-Henric Svanberg of Ericson *quoted in Mobile Marvels,* The Economist, 2009-09-26, Supplement pages 1 and 2
[2] ibid

Africa, there were 96 million new subscribers. In one month, November 2009, India increased its total subscribers by 17.5 million[3].

Figure 1: Communications for the Poor



Source: The Economist 2009-09-26

8. The mobile telephone sector has played its part in meeting many development objectives. Telecommunications first came to the Pacific in the 1970s and today most islands have both Public Switched Telephone Network (PSTN) telephone networks as well as access to cellular mobile services.

1.2 Digital Divide

9. The October 2009 UNESCAP Sub-Regional Workshops on Strengthening ICT Policies and Applications to Achieve MDGS and WSIS goals in Asia and Oceania received further evidence[4] of the magnitude of changes underway and the distance the Pacific must travel[5]. Nineteen out of fifty-one countries showed fixed telephone lines are on the decline, with negative growth in 2008, indicating accelerated transition to mobile and broadband. Some LDCs recorded some of the highest growth rates. Mobile technologies are expanding rapidly, especially in Landlocked Developing Countries LLDC with over 100 percent growth between 2003 and 2008.

10. Small Island Developing States (SIDS) generally show slower growth than the rest. The share of mobile out of all telephone lines is higher among LDC (95.1percent), LLDC (84.9 percent) and SIDS (76.9 percent) than in industrialized countries, reflecting the reality for many developing countries where there were no phones until mobiles arrived. The average share of mobile lines for the UNESCAP member countries is 75.4 percent

11. Consistent with the findings of the World Bank studies, in respect of the Internet in general and broadband Internet in particular, there is large divide among the developed countries and the rest. The lowest Internet subscriber proportion is in South and South-West Asia with 8.6 per 100 populations, but this has the highest average consolidated growth rate of 27.8 percent. The highest percentage of 44.2, is found in the Pacific (including Australia and New Zealand), with negative growth of approximately - 0.4 percent[6]. The UNESCAP average in 2008 is 17.4 percent and

[3] ibid
[4] *A regional overview: the current status on ICT access and emerging issues, Information and Communications Technology and Disaster Risk Reduction Division (IDD) UNESCAP Secretariat*, Atsuko Okuda, Presentation
[5] *Telecommunications Regulation - Competition - ICT Access* in the Asia Pacific Region, David Butcher, February 2010
[6] Largely due to fast broadband / wi-fi with large numbers of people using a single internet connection

the LDC average is 0.6. The most serious digital divide between rich and poor remains the uptake of broadband usage. There is a correlation between the decline in fixed telephone lines and growth in broadband subscription. Some countries are catching up rapidly with the leaders. However, the UNESCAP average is 3.9 per 100 populations. For the South and South-West of the UNESCAP region growth is rapid at (99.1 percent), but remains a low proportion at only (0.67) of the population. The SIDS are the lowest users of the internet, because of constrained bandwidth.

1.3 Poverty Reduction

12. In addition to its successes in encouraging Direct Foreign Investment (DFI), service expansion and national budget contributions (in many Asian and African countries the largest single source of government revenue), the mobile telephone sector has directly addressed poverty reduction by providing direct and indirect employment for thousands of people of which significant number are women. These mobile ICT services

- reduce the cost of doing business, making it easier for the poor to make a living,
- mobile calls substitute for cross town journeys, saving jams, time and money,
- information empowers the poor, improves their bargaining and incomes,
- provide secure methods of money transfer and payment, and
- generate employment opportunities (e.g. nearly 700,000 in Bangladesh)

13. As a result, successes in telecommunications and development are closely linked:

- a study by Leonard Waverman of the London Business School shows that an extra 10 telephones per 100 people increase GDP by .6 percent[7], and
- a study by Qiang and Rissotto of the World Bank shows that a 10 percent increase in mobile phone penetration increases GDP by .8 percent[8].

14. This solid evidence now shows that telecommunications services cut poverty in many of the World's least developed countries. Mobile phones have brought modern communications to the poor in many least developed countries, such as islands in the Pacific. Huge increases in investment, connectivity and subscribers have helped governments meet their targets for poverty reduction and development. Ongoing development of telecommunications will also be vital for future development programmes.

15. In summary, these studies show that telecommunications have a strong positive influence on development. Mobile telephones have led the way, not only because of the convenience of the technology (and falling prices), but because of the lack of alternatives. Mobile phones have been popular because they have allowed a significant reduction in the cost of communications.

16. There is now evidence that the Internet can play a similar or greater development role. The Internet not only requires greater literacy, it is a tool for encouraging people to become literate and may provide training opportunities. However, the LDC and LLDC are not benefitting from the Internet to the same extent as the developed countries. This is partly because many LLDCs and LDCs have only

[7] *Mobile Marvels*, Op. Cit page 7

[8] *Mobile Marvels*, ibid. page 7

recently acquired telephones for the first time. Largely it is because the higher cost of computers, rollout of facilities, the infrastructure needed and the availability of fast broadband internat.

1.4 Satellites

17. In October 1945, Arthur C. Clarke described the fundamentals behind the deployment of artificial satellites in geostationary orbits to relay radio signals. Clarke, was the first to link together ideas developed by others into a description of what we are familiar with today.

18. The first artificial satellite was the Soviet Sputnik 1, launched on 4 October 1957. Shortly after the launch of Sputnik, the Americans launched Project SCORE in 1958[9]. The US National Aeronautics and Space Administration (NASA) launched an Echo satellite in 1960 a passive reflector for radio communications. Courier 1B launched in 1960 and was the world's first active repeater communications satellite. Telstar[10] was the first active, direct relay communications satellite. Launched by NASA on 10 July 1962, Telstar and carried commercial traffic.

19. In the 1960s, the technology had not yet evolved to provide light-weight, high capacity equipment. For that reason, early satellites were limited in power and the original communications satellites used large earth stations, with massive dishes to communicate. As the technology improved so the size of the dish needed has reduced to where now small, portable earth stations are in everyday use and be easily erected in an emergency.

20. In general, communications satellites use microwave frequencies. Satellites using these frequencies need a clear path uninterrupted line of sight between satellite and earth station to function. They also require frequency coordination within the target country so that interference to existing services does not occur when emergencies happen and satellite solutions are used. Not all satellite technologies are the same. The next section clarifies some of the differences.

1.4.1 Geostationary Satellites

21. There are two generic types of communications satellites, geostationary and non-geostationary. Geostationary orbits are synchronised with the rotation of the earth so that they appear to be stationery in the sky. The class of satellite, synchronised with the rotation of the Earth is called *geosynchronous* – or synchronised with Earth.

22. All geostationary satellites are geosynchronous. They orbit Earth around the equator at some 35,000 kilometres above the surface of the planet. In this unique synchronised orbit, they appear to be stationary from the earth's surface, because they are circling the earth at the same rate as it is spinning. This allows the use of small fixed earth stations, similar to those used to receive satellite television in homes. Today the majority of satellites that transmit telecommunications and broadcasting are geostationary in nature. Figure 2 illustrates how the geostationary principle operates.

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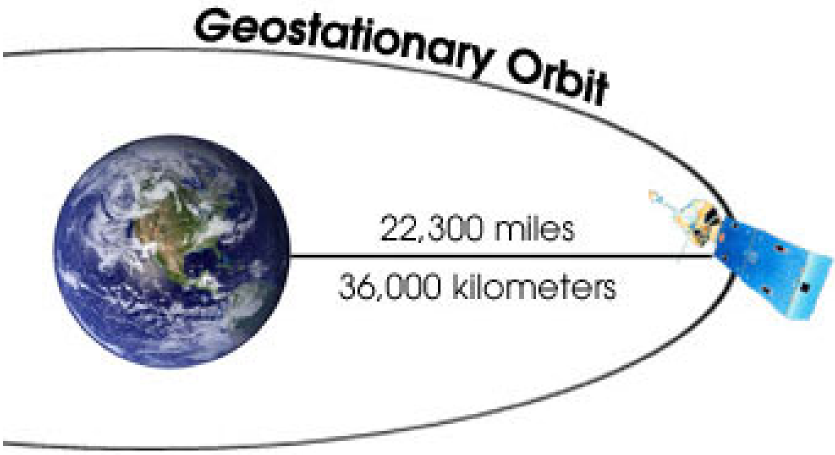
[9] On 18 December 1958, SCORE (Signal Communication by Orbiting Relay Equipment) was to test the feasibility of transmitting messages through the upper atmosphere from one ground station to one or more other ground stations. TSee http://patterson.narmc.amedd.army.mil/Pages/pscore.aspx

[10] The first two Telstar satellites were experimental and nearly identical, successfully relayed through space the first television pictures, telephone calls, fax images and provided the first live transatlantic television feed. Telstar 2 was launched May 7, 1963.

Figure 2: Geostationary Satellite



23. The geostationary orbit is useful for communications because ground based antennas, which must point towards the satellite, can operate without the need for expensive equipment to track the satellite's motion. For applications that require a large number of ground antennas (such Sky TV distribution), the savings made by dispensing with tracking equipment can more than justify the extra cost and onboard complexity of lifting a satellite into the relatively high geostationary orbit.

1.4.2 Non-geostationary

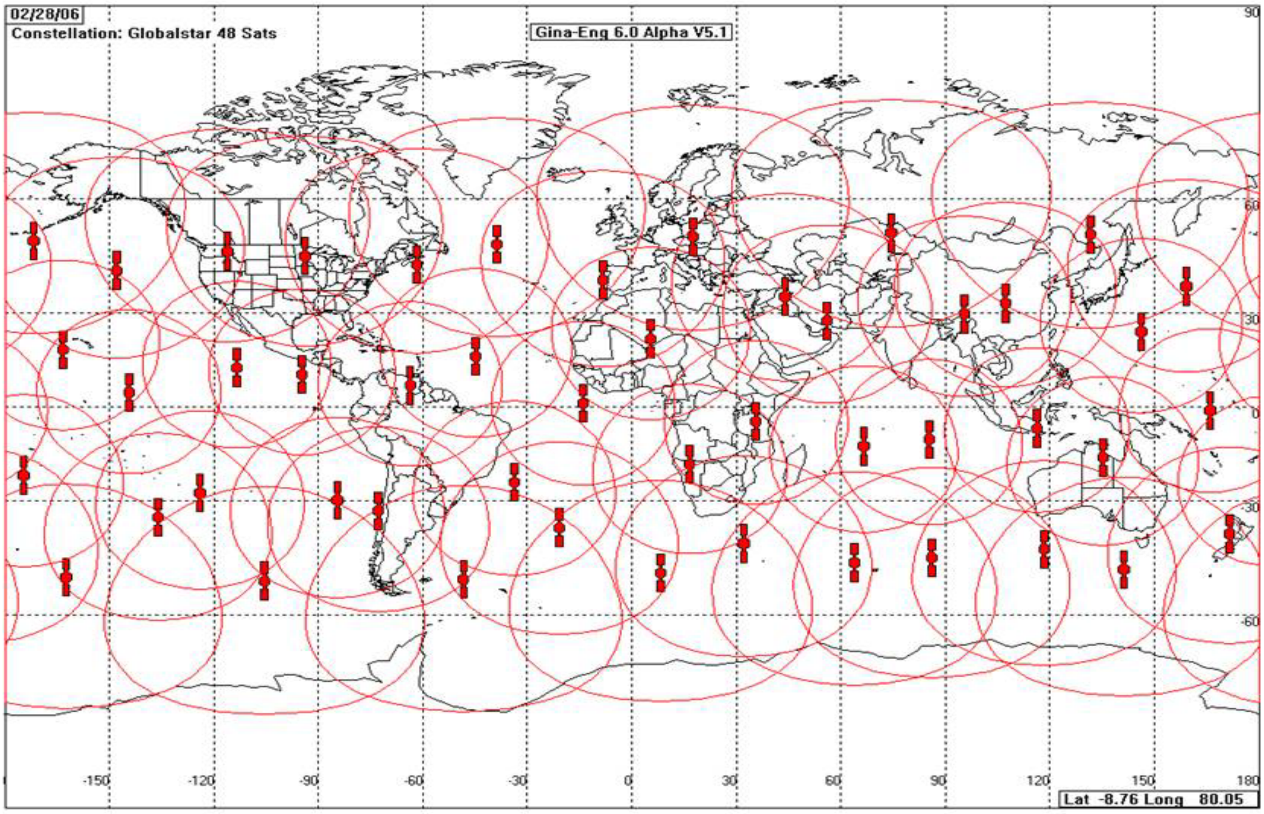
24. Apart from the geostationary communications satellites, others orbit at lower levels and from the surface of the earth, appear to be moving. A Low Earth Orbit (LEO) satellite is typically in a circular orbit about 400 kilometres above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes.

25. Because of their low altitude, these satellites are only visible from within a radius of roughly 1000 kilometres from the sub-satellite point. In addition, satellites in low earth orbit change their position relative to the ground position quickly. If the mission requires uninterrupted connectivity, even localised applications require a large number of satellites.

26. Low earth orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to the relatively close proximity to the earth, do not require as high signal strength (signal strength falls off as the square of the distance from the source, so the effect of the signal strength fall of is dramatic). There is a trade off between the number of satellites and their cost. In addition, there are important differences in the onboard and ground equipment needed to support the two types of missions.

27. A group of satellites, where each is working in concert with the others, is a *satellite constellation* (see Figure 3). To provide continuous coverage from a point on earth requires a constellation of LEO satellites synchronised so that one or more is in line of sight to the point at any one time. This allows continuous coverage provided by non-geostationary satellites as in the Global Star network illustrated in Figure 3. Discontinuous coverage using a LEO satellite capable of storing data received while passing over one part of Earth and transmitting it later while passing over another part. An example is the CASCADE system of Canada's CASSIOPE communications satellite. Another system using this store and forward method is Orbcomm.

Figure 3: Global Star Satellite Constellation



Source: See for example: http://en.wikipedia.org/wiki/Globalstar

1.4.3 Molniya Satellites

28. Geostationary satellites operate above the equator, therefore, they are not always suitable for providing services at high latitudes. At high latitudes, a geostationary satellite will appear low on the horizon and will no longer be visible at latitudes greater than 70°. This affects connectivity and in cases of simple earth stations like the handheld Iridium phone, causes interference from signals reflecting off the ground and into the ground antenna. "Multipath interference" is the name for this phenomenon. The Molniya orbit is similar to the QZSS orbits and aims to keep the satellite visible at a high elevation angle in locations that are in medium and high latitudes.

29. The Molniya orbit is highly inclined, guaranteeing line of sight over selected high latitude positions. The first of Molniya series launched on in April 1965 for experimental transmission of TV signal from a Moscow uplink station to downlink stations located in Siberia and the Russian Far East at Norilsk, Khabarovsk, Magadan and Vladivostok. In November of 1967, Soviet engineers created a national TV satellite television, called Orbita based on Molniya satellites.

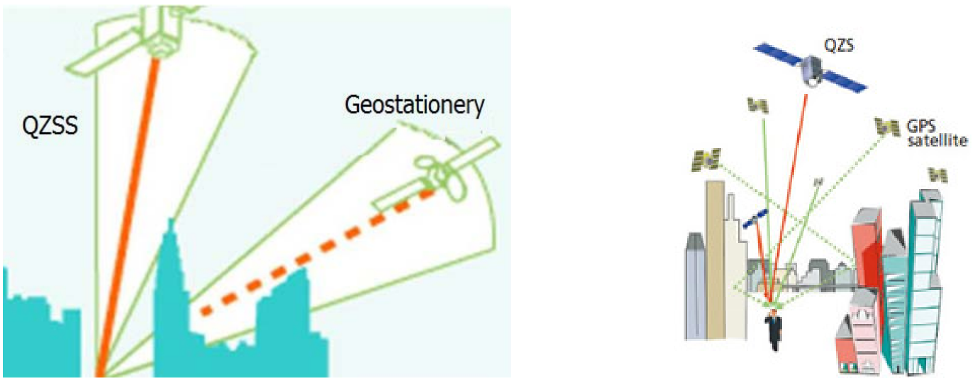
30. The Molniya orbit allows the satellite to spend the great majority of its time over the far northern latitudes, during which its ground footprint moves only slightly. Molniya satellites typically provide telephony and TV services over Russia and mobile radio systems since cars travelling through urban areas need access to satellites at high elevation in order to secure good connectivity. In the high-rise environment direct transmissions from a geo-stationary satellite to street level, are not possible.

1.4.4 Tundra Orbit

31. Tundra orbit is a type of highly elliptical geosynchronous orbit with a high inclination (usually near 63.4°) and an orbital period of one sidereal day (almost 24 hours). These are conceptually similar to Molniya orbits, which have the same inclination but half the period (about 12 hours). A satellite placed in this orbit spends most of its time over a chosen area of the Earth, a phenomenon known as apogee (or highest point) dwell. The ground track of a satellite in a tundra orbit is a closed "figure-eight" lemniscate[11].

32. The only current user of tundra orbits is Sirius Satellite Radio[12], which operates a constellation of three satellites. The RAAN[13] and mean anomaly of each satellite is offset by 120 degrees so that when one satellite moves out of position, another has passed apogee and is ready to take over. Tundra and Molniya orbits provide high latitude users with higher elevation angles than a geostationary orbit. Neither the Tundra nor Molniya orbits are geostationary because that is possible only over the equator, so both orbits are elliptical to reduce the time that the satellite is away from its service area.

Figure 4: QZSS Satellite – Campared with Geostationery



Source: http://www.jaxa.jp/projects/sat/qzss/index_e.html

1.4.5 QZSS

33. A special case of non-geostationary satellite is QZSS, which uses three satellites in a highly elliptical orbit. The apogee for such a satellite is very high. The satellite as it climbs steeply to the peak apogee, travels through the apogee and descends back to earth appears to be a point in space, which is almost stable from the point on the earth directly beneath the apogee.

34. Figure 4, left, compares operation of the QZSS with a geostationary satellite. The illustration on the right shows in more detail the advantages of the QZSS concentrated beam. The QZSS satellite is visible in the apparent almost stationary

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[11] In algebraic geometry, lemniscate refers to any of several figure-eight or ∞ shaped curves

[12] Sirius Satellite Radio is a satellite radio (SDARS) service operating in the USA and Canada. Launched in July 2002 Sirius provides 69 streams (channels) of music and 65 of sports, news and entertainment to 20 million subscribers by 2010. http://finance.yahoo.com/news/SIRIUS-XM-Achieves.

[13] Right Ascension of Ascending Node (R.A.A.N.) also called "Longitude of Ascending Node". With the earth spinning, it is not possible to use the common latitude/longitude coordinate system. Astronomers use a "right ascension/declination coordinate system", which does not spin with the earth. Right ascension means an angle measured in the equatorial plane from a reference point in the sky where right ascension is zero, called the vernal equinox. http://www.amsat.org/amsat/keps/kepmodel.html

position for some 8 hours so three such satellites can give 24-hour coverage. A QZSS network can give street level service in high rise environments in temperate latitudes, because it is literally directly overhead whereas a geostationary satellite signal from above the equator would arrive in a slant path at locations in the temperate latitudes.

Figure 5: QZSS Orbit

35. The QZSS quasi-geostationary orbit is highly elliptical and has a small loop while it is over the target to minimize the satellite-earth path distance variation when the satellite is above the target area. Figure 5 illustrates this orbit.

1.5 ITU in Satellite Regulation

36. The International Telecommunication Union (ITU) is the agency of the United Nations, which regulates international information and communication technology issues. It coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve IT infrastructure in the developing world and establishes worldwide standards.

37. The ITU's main achievement is to create regulations, standards and codes of practice that are widely respected, thereby facilitating inter-operability of infrastructure and equipment, all of which are vital in DRM situations. In particular, the ITU Radiocommunications Bureau provides the forum for the international coordination of satellite activity through Articles 9 and 11 of the ITU Radio Regulations. This is a three-step process. (1) A country makes known its general intention to position a satellite through an Advanced Publication notice, (2) technical details follow the notice in a Request for Coordination notice, (3) finally when all affected countries reach agreement, ITU receives notification. These cover most of the situations encountered in bringing connectivity to the Pacific.

38. When a proposed network has gone through all three steps, it gets provisional entry into the International Frequency List. After launch verification, ITU confirms the entry and it enters the databases. All future satellites must respect those in the list and avoid interference. Any initiative for additional satellite usage throughout the Pacific Region will require agreement of the countries in the Region for the satellite service to operate into their territory even in times of disasters or emergencies.

1.6 Communications for Disasters

39. The original use of satellite networks was to span great distances. In recent years, they increasingly provide domestic services like satellite DTH TV and broadband services. The potential applications are many and varied and satellites play an important and increasing role in our everyday ICT activities. However, applications,

like terrestrial services are replicable only at prohibitive cost and restoration can take time. Likewise, there are applications like high-density mobile phone networks best served by terrestrial networks to their towers.

40. In a normal situation, where there is no disaster to cope with, by far the majority of communications is via terrestrial networks with satellites providing some support in remote areas and for specialised uses. After a disaster, the big advantage of satellite communications is that they are out of the immediate problem area and located in orbit above the weather, no matter how severe.

41. Experience has shown that even in the most developed areas of the world when disasters strike shortages of essential medicines and supplies occur. Nations can only hold so much stock and it is essential to place orders quickly to secure urgent supplies. Furthermore, countries often need wide-ranging help as quickly as possible as demonstrated recently in both Christchurch and SENDAI.

42. The Internet is a very useful platform to transmit disaster information and stimulate help, with attached photos and video clips. It also is time independent. The internet can carry messages when the other party is not about or asleep and it is there for them when they arrive at their place of business. SMS messages also have these attributes, but their capacity is very limited. It follows that the rapid restoration of some Internet is critical in getting help and restoring normality.

43. If both terrestrial fixed lines and terrestrial mobile communications are out of action, rapid restoration Direct to Home (DTH) provision of Broadband will be the remaining option. Services in everyday use provide the most reliable services in the end as they generally work when needed. The major mobile satellite constellations can provide (at a cost) communications from anywhere to anywhere else. The user can access the Iridium[14] and Inmarsat[15] constellation, by a hand held phone anywhere on the planet including at the Poles. However, for more substantial satellite services coordination is required and satellites can play a role in restoring public communications network access to the outside world.

44. In earthquakes, civil disturbances, typhoons and similar situations, the terrestrial networks, which carry the bulk of the normal traffic, invariably are affected and are often put out of service. An earthquake can easily sever the power to a mobile phone base station or even worse collapse the tower. It may also cut terrestrial cables for backhaul telecommunications. The private networks that support most agencies like fire brigades, ambulances, police and civil disaster agencies have base stations that are also often affected by the disaster itself e.g.; in cases of floods, earth quakes, hurricanes or fire.

45. There are at least five communications phases in a disaster with somewhat different immediate needs. Any disaster management system has at least five phases and for each there are different information flows and infrastructure required. These are set out in Table 1. Satellites physically remote in space remain operational even though the associated earth stations maybe damaged. This can reduce the scale of essential restoration and allow for the rapid restoration of some services. Of course, satellite networks cannot replicate many of the services supplied by terrestrial networks, but capacity can often exist to allow for essential messages.

[14] See Paragraph 3.2
[15] Formerly the International Maritime Satellite Organisation

Table 1: Disaster Phases Information Flows and Infrastructure

Phases	Information Flow	Infrastructure
Ongoing Regular Monitoring	weather warning, e.g. storm build up, earth movement etc	terrestrial and satellite communications. earth exploration sensors and positioning, navigation and timing (PNT), internet access to remotely gathered information
Disaster Warning	letting people know to prepare for a specific event or disaster.	broadcasting, mobile phone sms and warning systems like klaxons
Immediate Aftermath	to know what happened and how bad	terrestrial and satellite communications (if working) otherwise MSS and PNT
Remedial Action	the call for help	probably MSS
Restoration	personal communications. the restoration of services	temporary restored networks satellite communications resumption of normal service

46. It is in DRM situations that satellites show what they can achieve. Even before the recent earthquakes in New Zealand and Japan, the floods in Pakistan and Australia, the Indian Ocean Tsunami, there were also major earthquakes in China, India and Pakistan[16]. The UNESCAP's region's population is close to 3 billion and the region was teh location of more than 50 percent of the global fatalities associated with such disasters. Disasters, calamities such as flooding, earthquakes, wildfires, high winds and landslides are responsible for many deaths, destruction and economic losses in the region.

1.7 Tampere Convention

47. The Tampere Convention is the agreement reached by the first Intergovernmental Conference on Emergency Telecommunications held in Tampere Finland in 1998 under the auspices of the UN Office for Humanitarian Affairs and the International Telecommunications Union. 60 states have acceded to the Convention. In Appendix 2 we reproduce Article 3. This commits state parties to cooperate among themselves and with non-official entities and intergovernmental organizations, in the use telecommunication resources for disaster mitigation and relief. It also relates to the sharing of information about natural hazards, health hazards and disasters among the parties and the dissemination of information.

48. Any work by UNESCAP on disaster mitigation and recovery needs to have regard to the provisions of the convention and the resources available under its auspices. However, the first tool in a disaster is access to personal mobile communications. We will now examine what is actually available in the Asia Pacific Region and then look at some options.

[16] See https://sentinel.tksc.jaxa.jp/sentinel2/MB_HTML/About/About.htm

2. Pacific Region - Cables

2.1 Pacific Options

49. A World Bank (WB) study completed in 2009[17] looked at options for a Pacific region, telecommunications, backbone. It focused on the similarities and differences between the various Pacific Islands. The similarities include:

- isolation from the rest of the world and located relatively far from each other,
- populations that are dispersed internally, often in remote "outer islands",
- societies bound by tribal links, and customary collective, land ownership,
- telecommunications market that are relatively small, and
- high cost of developing infrastructure, particularly in more remote islands.

50. However, the WB study[18] also identified ways in which the various Islands differ strongly:

- population sizes range from 20,000 to one million Papua New Guinea (PNG) with six million people is an exception. Significant internal features with origins in the mountainous topography, separating small communities and more than 400 languages ensures that in important ways it resembles smaller nations),
- per capita income levels vary significantly,
- some telecommunications markets are monopolistic others are competitive,
- distance to main telecom peering points vary from one country to another.

51. What the World Bank study also noted is that they all have in common, **a rapidly growing demand for international connectivity to break down their isolation from the world** in a context where demand for broadband Internet is accelerating worldwide.

2.2 Cable Facilities

52. We have noted that the Asia Pacific Region contains developed and developing countries; those with the critical mass have their own satellite or broadband capability and those without. For regular communications infrastructure the WB study took this further and divided the Pacific nations into three groups:

- high demand countries for which a submarine cable solution is already by far the most economical solution for normal telecommunications. Fiji, French Polynesia, New-Caledonia and PNG fall into this category,
- medium demand countries for which solutions like submarine cables, have in some cases been put in place, as growing demand for international connectivity, their proximity to economical links and cheaper technologies have combined to facilitate new developments. This list includes Timor-Leste, Samoa, Solomon Islands, Vanuatu, Tonga and American Samoa, and

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[17] *Regional telecoms backbone network assessment and implementation options study*, The World Bank, January 2009
[18] Ibid.

- low demand countries for which satellite will remain the most economical option for international connectivity for many years to come. These are Cook islands, Niue, Wallis and Futuna and the islands of the Northern Pacific, Palau, Marshall, Kiribati and Federated States of Micronesia.

53. Until now, satellite communication links have been the main provider of telecommunications capacity (bandwidth) at high prices. Most of the Pacific population cannot afford high prices. The first question is how to address future demands adequately and affordably.

Figure 6: Existing Cables in the South Pacific

Source: ITU Background Note, Senior Officers Meeting for Pacific ICT Ministerial Forum: Tonga, Feb 17-18, 2009 Page 11

54. Currently there are major cables across the Ocean addressing the many demands from commercial consumers. The position as of 2009 is illustrated in Figure 6. However, even where the main islands are connected by a submarine cable system, there are scattered populations, which will need to remain connected by satellite because of technical and economic obstacles to direct connection. All systems reliant on a single technology and a single connection are vulnerable to failure of a single point of failure (SPOF), or a part of the system, which will take the whole system down if it stops working properly. A secured system has no SPOF. A secured system has redundancy.

2.3 High Demand Countries

55. As of February 2009, the existing and planned cables in the South Pacific Region included[19]:

[19] ITU Background Note, ibid Page 12

- APNG-2: cable between Sydney and PNG (Port Moresby), actually a second hand cable (formerly Pac Rim West) with capacity of 1 Gbps,
- Pipe project: approx 6,900 km fibre cable connecting Sydney to Guam with PNG en route, with capacity of 1.92 Tbps, entered service in late 2009,
- AJC: Australia – Japan cable (with a landing point in Guam) was installed in 2001 with a capacity of 320 Gbits,
- Telstra: cable between Sydney and Hawaii, 9,000 km, 2 pair of fibre, initial capacity of 64 Gbps, went live in October 2008.
- Gondwana-1: cable between Sydney and Noumea. 2,150 km, 1 pair of fibre. Initial capacity of 20 Gbps entered service September 2008.
- Southern Cross: loop Sydney – Fiji – Hawaii and Auckland, had an initial system capacity 680 Gbps, initially in 1999 each cable had a bandwidth capacity of 120 gigabit/s, doubled in an upgrade in 2008 with a further upgrade to 860 gigabit/s at the end of 2008 and yet a further in 2010..
- Tasman-2: cable installed in 1992, a link between Sydney and Auckland, current system capacity is 1 Gbps
- Honotua cable between French Polynesia (Tahiti) and Hawaii 4,650 km. The contract signed in 2008, landed in March 2010).

56. May 2009 saw the launch of the ASH Submarine Cable, connecting Samoa to the international fibre optic cable between American Samoa, Samoa and Hawaii connecting Samoa to the existing global infrastructure providing more than 40 times the current capacity used in both Samoa and American Samoa, albeit not secured.

57. Submarine cable projects already underway may meet the immediate needs of the "high demand" countries. The New Caledonia connection to Sydney via the Gondwana cable may need improvement and securing. French Polynesia's Honotua will also need an alternative path. PNG's connection is by APNG-2 (a reconditioned PACRIM-West cable[20]) and may gain connected by the new Sydney-Guam, PPC-1 (Pipe Networks) cable.

2.4 Medium Demand Countries

58. For the "medium demand" Pacific Island countries, the WB Regional telecoms backbone network assessment Report puts forward three options to meet demand for increased international connectivity:

- Point-to-point submarine cables: those would simply help to connect a Pacific country to the nearest place where there is cheaper bandwidth to be bought (called a *backhauling point*). ASH is an example,
- Subregional submarine cables: those connect several Pacific Island countries together to a backhauling point,
- Regional or trans-pacific submarine cables: those would not only connect Pacific Island countries to a backhauling point but also potentially carry trans-pacific

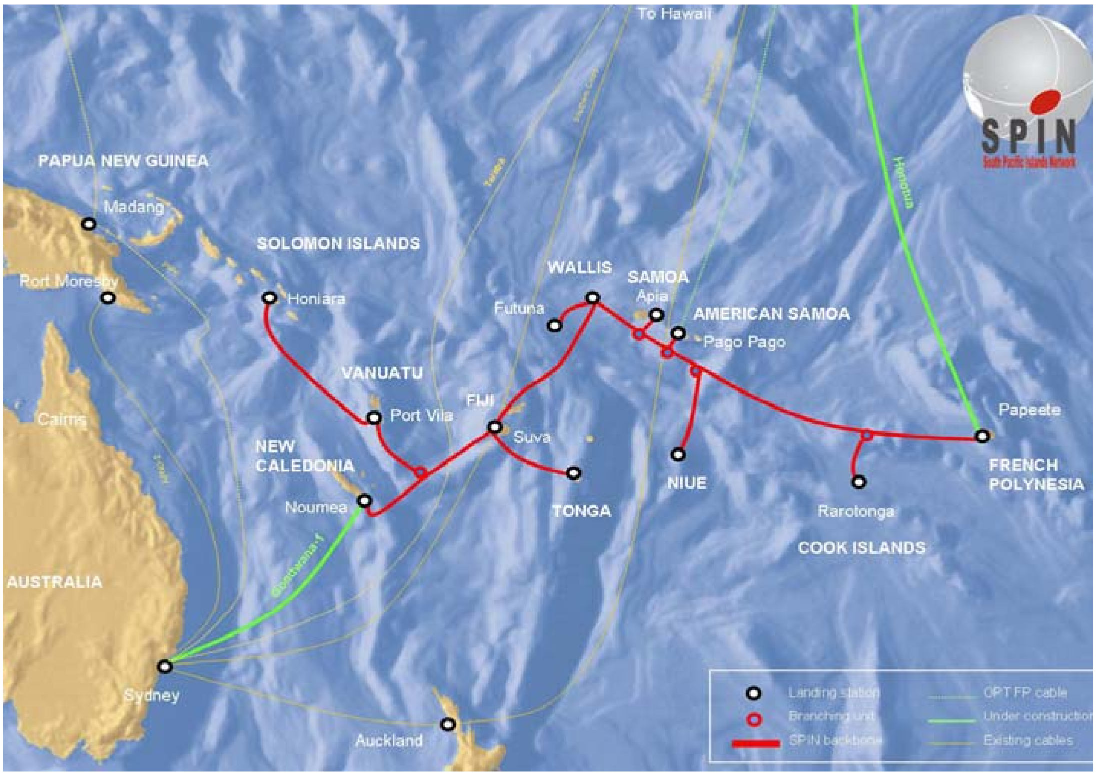
[20] PacRimWest - a pair 560Mb/s optical submarine cable, which linked Australia to the world, along with Tasman2 (Australia to New Zealand) and Pacrim East (New Zealand to Hawaii). Constructed in 1994, Pacrim West came into service on 31 January 1995 connecting Australia and Guam. It was withdrawn from service in 2005. Design of both cables were for voice, fax and video traffic for television networks, with limited requirement for data.

traffic allowing for a better return on investment (ROI). An example is the (South Pacific Islands Network) SPIN proposal.

59. SPIN is an initiative proposed by SPIN Ltd., based in New Caledonia for a Trans-Pacific submarine cable. The project proposal followed on from the Office des Postes et Telecommunications (OPT) of New Caledonia signing a Euro 42 million contract with Alcatel-Lucent in October 2006 for the GONDWANA-1 submarine cable network connecting Noumea and Sydney. OPT of French Polynesia subsequently awarded a Euro 72.2 million contract to Alcatel-Lucent for a new, high speed submarine cable network (Honotua), linking Tahiti to Hawaii.

60. SPIN aims to take advantage of high international capacity of GONDWANA-1 and Honotua to supplement the link between Noumea (New Caledonia) and Tahiti (French Polynesia) thereby connecting South Pacific Island Countries and their territories (*i.e. New Caledonia, Solomon Islands, Vanuatu, Fiji, Tonga, Samoa, American Samoa, Niue, Cook Islands, French Polynesia*) en route between Sydney and Hawaii.

Figure 7: Proposed SPIN Network



Source: Source: ITU Background Note, Senior Officers Meeting for Pacific ICT Ministerial Forum Tonga, Feb 17-18, 2009 Page 11

61. Spin is a variant of the so-called New Caledonia – French Polynesia (NCFP) proposal discussed in the WB Report. The NCPF (New Caledonia Polynesia Francais) plan is a submarine cable linking New-Caledonia to French Polynesia and potentially serving Vanuatu, Solomon Islands, Fiji, Tonga, Samoa and American Samoa on the way. The infrastructure would also serve additional "low demand" countries on the way.

62. As can be seen from paragraph 2.3 above, some aspects of this initiative may have been overtaken by events, such as the ASH cable and the Honotua. In addition, cost is a major obstacle. The NCFP, would need capital expenditure in the region of

US$252 million (2009 estimates) if all 11 countries join. Even a stripped down version would still cost more than US$ 100 million. However, a direct link across the Pacific would substantially advance connectivity and security.

63. Sub-regional or Regional collaboration between countries allow the cost of investments to be shared. Each Pacific Island country will have to assess the benefits to itself of Sub-regional or Regional options and their ability to contribute to construction costs. In addition, the cost of augmenting the links on the network may need support from outside. Money was raised for the Pipe project connecting Sydney to Guam. However, our conclusion is: given the economic downturn in 2008-2009, in the immediate future, the prospects of raising US$ 200 million from the private sector or even from donor governments for a Cross-Pacific link comparable to NCPF are not good. This should not deter ongoing work to develop a consistent regional approach may pay great dividends for the region.

64. The next section looks at what is currently available in the Pacific for Satellite based telephony.

3. Pacific Region - PMSC

3.1 Personal Mobile Satellite Communications

65. There are several telephony options provided by Personal Mobile Satellite Communications (PMSC) systems available for general commercial use and for DRM in the Pacific Region. Many networks operate from handheld earth stations. We will now briefly examine the most widely available networks.

3.2 Iridium

66. The Iridium[21] satellite constellation is a large group of satellites that provide voice and data coverage to satellite phones, pagers and integrated transceivers over Earth's entire surface. Iridium Communications Inc. owns and operates the constellation and sells equipment and access to its services. Its 66 active satellites in orbit complete its constellation and additional spare satellites remain in-orbit to serve in case of failure. Satellites are in low Earth orbit at a height of approximately 485 mi (781 km) and inclination of 86.4°. Figure 8 illustrates the constellation of Iridium satellites and the kinds of handsets required to access the network.

Figure 8: The Iridium Constellataion and Handsets

Source: http://www.iridium.com/

67. Satellites communicate with neighbouring satellites via Ka band[22] inter-satellite links. Each satellite can have four inter-satellite links: two to neighbours fore and aft in the same orbital plane, and two to satellites in neighbouring planes to either side. The satellites orbit from pole to pole with an orbit of roughly 100 minutes. The Iridium constellation of LEO cross-linked satellites provides voice and data services for areas not served by terrestrial communication networks.

68. June 2001, saw the successful restart of Iridium[23] data and Internet satellite services. Iridium Communications claims to be the only mobile satellite service

[21] http://www.iridium.com/

[22] frequency band of 26.5–40 GHz with uplink frequencies between 27.5GHz and 31Ghz and downlink frequencies between 18.3 and 18.8Ghz and between 19.7 and 20.2Ghz see http://www.tech-faq.com/ka-band.html

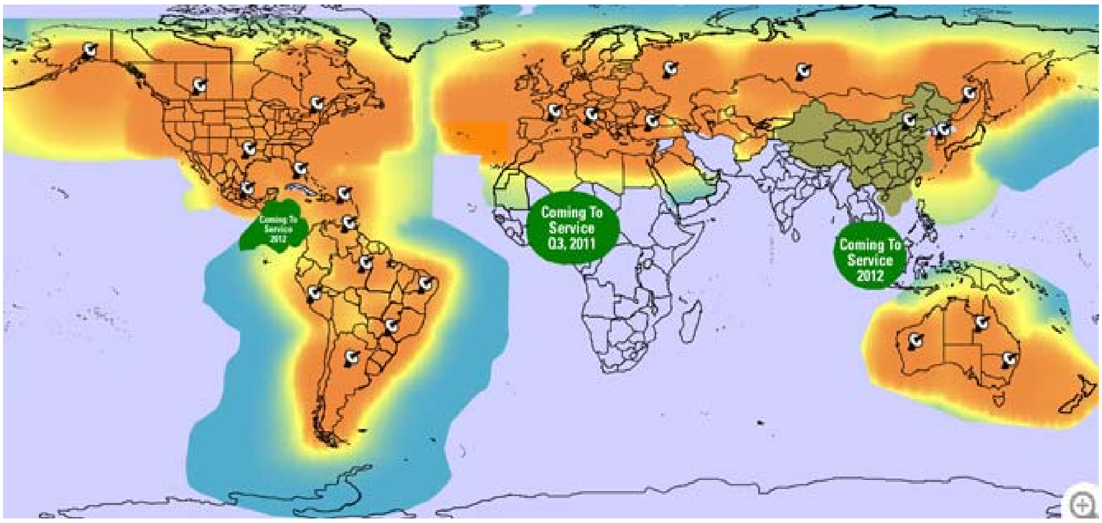
[23] The Iridium service launched on 1 November 1998 and was supported by the Motorola Company but went into Chapter 11 bankruptcy nine months later caused by costs of service too high for most potential users, compounded by clunky technology and mismanagement.

company offering coverage over the entire globe. It serves commercial markets through a worldwide network of distributors, and provides services to the U.S. Department of Defence and other U.S. and international government agencies. Iridium handsets closely resemble a mobile phone, so they are very useful in an emergency when all other options have failed. Global coverage means that its services are available everywhere, including the Pacific.

3.3 Global Star

69. The Globalstar project 1991, launched as joint venture of Loral Corporation and Qualcomm. Globalstar received a U.S. spectrum allocation in January 1995, and negotiated with various other sovereign nations for rights to use the same radio frequencies in their countries.

Figure 9: Global Star Voice Coverage



Source: http://www.globalstar.com/en/index.php?cid=101&sidenav=85

70. In 1999, the system began limited commercial service and full commercial service in February 2000 with its 48 satellites and 4 spares in North America, Europe and Brazil. Initial prices were $1.79/minute. In 2002, Globalstar like Iridium spent two years in Chapter 11 bankruptcy protection[24]. An illustration of its voice coverage is in Figure 9. This will expand to Africa in 2011 and SE Asia in 2012. SE Asian coverage extends to PNG, but coverage for the Pacific is not yet on the agenda.

3.4 Thuraya

71. Thuraya, the Arabic name of the Pleiades[25], is a regional satellite phone provider[26]. It covers most of Europe, the Middle East, North, Central and East Africa, Asia and Australia. Based in the United Arab Emirates, it distributes its products and service to its subscribers through authorized service providers. Its shareholders are a

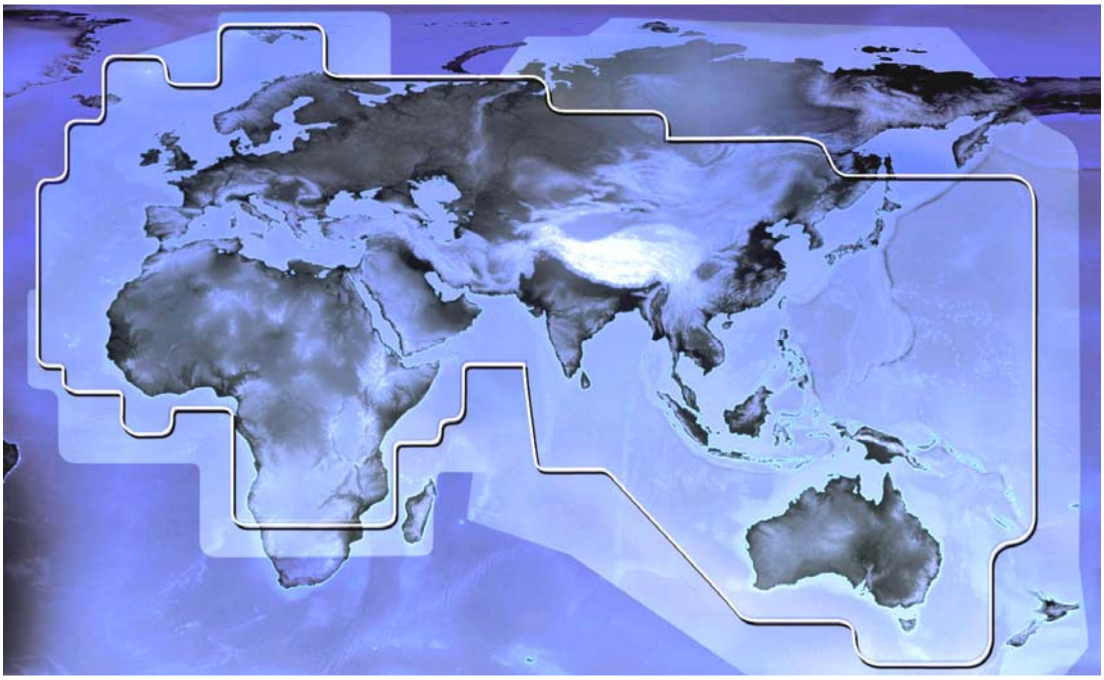
[24] http://en.wikipedia.org/wiki/Globalstar

[25] In astronomy, the Pleiades, or Seven Sisters (Messier object 45), is an open star cluster containing middle-aged hot B-type stars located in the constellation of Taurus. It is among the nearest star clusters to Earth and is the cluster most obvious to the naked eye in the night sky. Pleiades has several meanings in different cultures and traditions. http://en.wikipedia.org/wiki/Pleiades_(star_cluster)

[26] http://www.thuraya.com

mixture of Middle Eastern and North African telecommunications companies (including Etisalat[27]) and investment companies.

Figure 10: Thuraya Coverage Map



Source: http://www.thuraya.com

72. In 2000, the first Thuraya satellite, Thuraya-1, was launched by the Sea Launch Consortium from the Pacific Ocean. In 2008, Thuraya-3 satellite further expanded the coverage footprint of Thuraya's network covers Asia and Australia (but not New Zealand – see Figure 10). Only Pacific Islands West of New Zealand including PNG are covered, Samoa is not. 2009 saw Thuraya introduce the Thuraya XT, a satellite handset complying with Internet Protocol (IP) IP54/IK03 standards of durability (splash water resistant, dust and shock proof).

3.5 Inmarsat

73. Inmarsat plc is a British based satellite telecommunications company[28]. It provides mobile satellite communications services for use on land, at sea, and in the air worldwide (see Figure 11). The company offers voice and broadband data services, which support safety communications, as well as office applications, such as email, Internet, secure VPN access and videoconferencing.

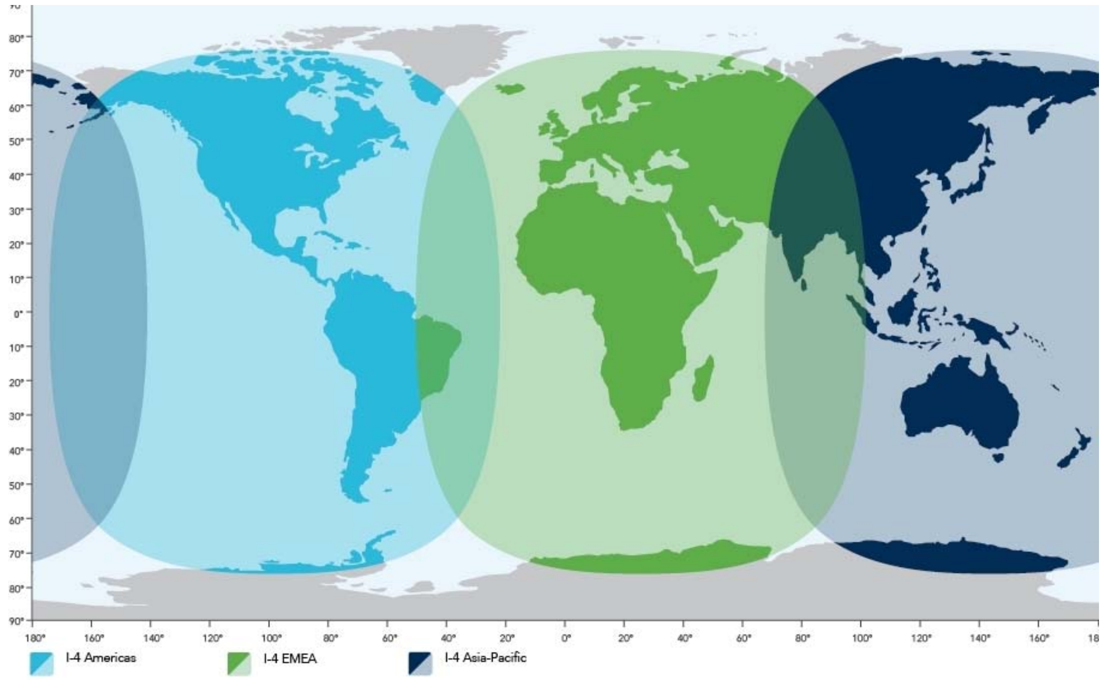
74. The company founded in 1979 as the International Maritime Satellite Organization (Inmarsat), a not-for-profit international organization, for the International Maritime Organization (IMO), a United Nations body, to establish a satellite communications network for the maritime community. Aside from its commercial services, Inmarsat still provides Global Maritime Distress and Safety Services (GMDSS) to ships and aircraft at no charge, as a public service.

[27] Etisalat operates in 18 countries across Asia, the Middle East and Africa, servicing over 100m customers out of a total population of approximately 1.9bn people. http://etisalat.ae/

[28] http://investing.businessweek.com/research/stocks/snapshot/snapshot.asp?ticker=ISAT:LN

75. When the organisation converted into a private company in 1999, the business split into two parts: The bulk of the organisation converted into the commercial company, Inmarsat Plc, and a small group became a regulatory body, IMSO. Currently, its services include traditional voice calls, low-level data tracking systems, and high-speed Internet and other data services as well as distress and safety services. The most recent of these provides GPRS[29]-type services at 492 kbit/s via the Broadband Global Area Network (BGAN)[30] IP satellite modem (the size of a notebook computer)[31]. Other services include mobile Integrated Services Digital Network (ISDN) services used by the media for live reporting on world events via videophone.

Figure 11: Imarsat Coverage Map - Expected not guaranteed



Source: http://www.inmarsat.com

76. The price of a call via Inmarsat is fixed at the same rate for any location in the world where the service is used, and is at a level comparable, and in many cases favourable, to international roaming costs, or hotel phone calls. Newer Inmarsat services use an IP technology that features an always-on capability where the users pay for the data they send and receive, rather than the length of time they are connected. This applies specifically to BGAN and Mobile Packet Data Services (MPDS).

77. The satellites are transponders designed for digital emissions that receive digital signals, reform the pulses and then retransmit them to ground stations. The major ground stations maintain usage and billing data and function as gateways to the public switched telephone network and the Internet. Each Inmarsat satellite is equipped with a global beam, 19 regional spot beams and over 200 narrow spot

29 General packet radio service (GPRS), a packet oriented mobile data service on the 2G and 3G cellular systems, Global System for Mobile communications (GSM). In 2G systems, GPRS provides data rates of 56-114 kbit/second. 2G cellular technology combined with GPRS is sometimes described as 2.5G, a technology between the second (2G) and third (3G) generations of mobile telephony.

30 http://www.inmarsat.com/Services/Land/BGAN/Terminals/default.aspx

31 see paragraph 77

beams. Three Inmarsat I-4 satellites offer Narrow beams. Narrow beams, are much smaller than global or regional beams, but are far more numerous and hence offer the same global coverage. By focussing the power into spot beams these beams allow yet smaller antennas and much higher data rates. They form the backbone of Inmarsat's handheld Global Satellite Phone Service (GSPS) and BGAN.

78. The above are the principal Inmarsat services reviewed for mobile emergency use in the ITU-R Study Group Working Party 4C. Under the ITU Radio Regulations if an earth station is in a fixed location, then the fixed satellites are used and there are many networks today including both international and domestic satellite networks such as Intelsat and Optus. The choice of the network to support emergency and disaster operations will be critical but it is important to know where the communications traffic originates. Most emergency and disaster communications needs are to detinations within the affected country, but for example, a shipping or aircraft disaster could require multinational locations.

79. In general, the international traffic requirement in a disaster is small compared to the national needs. Within the ITU, the major disaster relief studies look at the terrestrial frequency bands set aside, which indicates that in general the bulk of disaster messaging is within the country involved. The selection and organisation of frequency bands is a case for international help especially specialist help to small nations.

3.6 Frequency Band

80. The frequency band is a critical choice when looking at a suitable satellite network for DRM. The required size of earth station depends upon the frequency band employed. Lower frequencies require bigger dishes for similar performance. Commonly used bands for geostationary satellites are:

- C Band (which comprises a pair of satellite radio frequency bands with the up-link at 6 GHz and the down-link at 4 GHz),
- Ka Band (frequency band of 18-33 GHz with uplink frequencies between 27.5GHz and 31Ghz and downlink frequencies between 18.3 and 18.8Ghz and between 19.7 and 20.2Ghz),
- Ku Band (refers to "K-under", the band directly below the K-band. In radar applications, 10.95-14.5 GHz in IEEE Standard 521-2002) used for satellite communications for fixed and broadcast services and specific applications such as vehicle speed detection. Ku satellites are also used for backhauls and particularly from remote locations back to a television network's studio for editing and broadcasting. Band segments vary by ITU set geographical regions.
- L band (L band refers to four different bands of the electromagnetic spectrum: 40 to 60 GHz (NATO), 1 to 2 GHz (IEEE), 1565 nm to 1625 nm (optical), and around 3.5 micrometers (infrared astronomy). L band covers 950 MHz to 1450 MHz)[32]. For this paper L band is taken as per the IEEE definition
- DTH ("Direct to Home" - the signal from the satellite is strong enough for a receiving station on the surface of the Earth to communicate with the satellite directly using a small antenna).

81. The complete set of frequency bands is set out in Appendix 1. Lower frequencies, perform better in heavy rain. Observations during very heavy rain in Vancouver, for

[32] http://www.tech-faq.com/ka-band.html

example, showed that where the C Band was out for 3 minutes, the Ka band for was out of action for 12 minutes and the Ka band for some 18 Minutes. These differences can be very important in a disaster situation. Similarly, the convenience of the respective technologies is a matter than needs consideration. A 2.7 m diameter dish at C Band (4/6 GHz) will perform like a 1.2 M dish at Ku band (11/12/14 GHz) or a 45 cm dish at Ka band (20/30 GHz).

82. To connect many countries over a global beam the lower frequencies are better. Higher frequencies work for spot beams where the energy is concentrated over a small part of the planet. WINDS and the original QZSS discussed later (section 9.1) both have spot beans to concentrate the energy on the surface of the planet (the original QZSS had communication equipment with spot beams, but current operating QZSS has no communication equipment).

83. A complication is that different authors have used different frequency boundaries for letter designation of the microwave bands. The complete set of frequency Bands and three sets of boundaries of those are shown in Appendix 1[33]. The next issue to look at is the related but different services that allow precision identification of earth bound locations.

[33] From Reference Data for Radio Engineers, V Edition, Howard W. Sams & Co., Inc., Indianapolis, 1970. The columns headed "US Navy" from US Navy Submarine Communications Spectrum at http://mintaka.spawar.navy.mil/ftp/pmw173/APX-C.pdf. RSGB means Radio Society of Great Britain at http://www.rsgb.org.uk/society/uwinfo/uwfaq6.htm.

4. Pacific Region PNT (RNSS)

4.1 Global Navigation Satellite Services

84. Before we can identify a way forward, we need to examine the Positioning, Navigating and Timing (PNT) infrastructure in place today. At the ITU these services are also referred to as Radio Navigation Satellite Services (RNSS) or the Global Navigation Satellite System (GNSS). These have revolutionised many aspects of our lives. Most of the applications that are vital are so unobtrusive that most people do not recognize what is going on. Currently, there are four global navigation satellite service networks, set out in Table 1.

Table 2: Global Navigation Services Satellites (GNSS)

Name of Networks	Ownership
GPS Constellation	USA
Glonass Network	Russia
Compass Network	China
Galileo	EU

85. These various services are supplemented by many regional and national initiatives, particularly those used for Tsunami, Fire, Land and weather monitoring.

Figure 12: Satellite of the GPS Constellation

4.2 GPS Constellation

86. Figure 12 illustrates a GPS[34] Satellite of the GPS Constellation. Apart from position fixing GPS is extremely important as a time and frequency standard. GPS provides the exacting conditions required for the higher generation mobile phones as it provides the frequency reference that the phones need to operate. GPS is also extremely important as a time and frequency standard. GPS also provides the conditions and frequency reference that higher generation mobile phones need.

[34] Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites.

87. GPS stem from ground-based radio navigation systems, developed in the early 1940s and used during World War II. To achieve accuracy requirements, GPS uses principles of general relativity to correct the satellites' atomic clocks. In 1956, Friedwardt Winterberg[35] proposed a test of general relativity using accurate atomic clocks placed in orbit in artificial satellites.

Figure 13: GPS Unit Giving Directions

88. When the Soviet Union launched the first man-made satellite, Sputnik in 1957 U.S. scientists discovered that, because of the Doppler effect, the frequency of the signal being transmitted by Sputnik was higher as the satellite approached, and lower as it continued away from them. They realized that because they knew their exact location on the globe, they could pinpoint where the satellite was along its orbit by measuring the Doppler distortion.

89. The Cold War arms race and the threat of nuclear weapons triggered the United States to allocate the dollars required to develop the GPS system, to allow precise navigation of missiles, particularly those submarine launched. After the 1983 shooting down of Korean Air Lines Flight 007, carrying 269 people, in the vicinity of Sakhalin and Moneron Islands, President Reagan issued a directive making GPS freely available for civilian use, once it was sufficiently developed, as a common good. Initially, the authorities reserved the highest quality signal for military use, and the signal for civilian use was degraded. President Clinton ordered the precision of civilian GPS from to increase from 100 meters to 20 meters when the US military gained the ability to deny GPS service to potential adversaries on a regional basis.

90. The US Government owns and operates GPS as a national resource. Department of Defence (USDOD) is the steward of GPS. USDOD is required by law to "maintain a Standard Positioning Service (as defined in the Federal Radio Navigation Plan and the standard positioning service signal specification) that will be available on a continuous, worldwide basis," and "develop measures to prevent hostile use of GPS and its augmentations without unduly disrupting or degrading civilian uses."

4.3 GLONASS

91. In the days of the USSR, the Russians developed GLONASS[36] to provide real-time position and velocity determination, initially for use by the Soviet military for navigation and ballistic missile targeting. It was the Soviet Union's second

[35] Friedwardt Winterberg (born in 1929) is a German-American theoretical physicist and research professor at the University of Nevada, Reno. He is known, among other accomplishments, for his proposal to put accurate atomic clocks on Earth-orbiting satellites in order to directly test General Relativity his fusion activism. (See http://en.wikipedia.org/wiki/Friedwardt_Winterberg)

[36] See http://en.wikipedia.org/wiki/GLONASS

generation, improving on the Tsiklon system, which required one to two hours of signal processing to calculate a location with high accuracy. By contrast, once a GLONASS receiver is tracking the satellite signals, a position fix is available instantly. It is stated that at peak efficiency the system's standard positioning and timing service provide horizontal positioning accuracy within 57–70 meters, vertical positioning within 70 meters.

92. An operational GLONASS constellation consists of 24 satellites. The three orbital planes' ascending nodes are apart 120° with each plane containing eight equally spaced satellites. The orbits are roughly circular, with an inclination of about 64.8°, and orbit the Earth at an altitude of 19,100 km (11,868 miles). The satellites cross the equator one at a time, instead of three at once in each orbital period (a period of 11 hours and 15 minutes). The overall arrangement is such that, if the constellation is fully populated, a minimum of five satellites are in view from any given point at any given time.

93. GLONASS is complementary to the United States' GPS. Development began in 1976, with a goal of global coverage by 1991. The constellation was complete by 1995, but fell into disrepair with the collapse of the Russian economy. In 2003, Russia committed to restoring the system and by 2010 achieved 100 percent coverage of the Russia's territory. Currently 20 satellites are operational, while four other satellites are in orbit for maintenance and two more are spare. The constellation needs 24 satellites to provide continuous global coverage.

4.4 COMPASS Network

94. Before the construction of the Compass navigation system, China sent four experimental navigation satellites into orbit from 2000 to 2007 to form the experimental Beidou (Big Dipper)[37] system. In 2008, the Chinese government decided to expand Beidou to cover the entire planet, like GPS, Galileo and Glonass. The original system only covered East Asia, not even all of China mainly the coast and Taiwan. The system could only handle a few hundred thousand users, but that would have been sufficient for the Chinese military involved in any major operation.

95. Compass has more than 40,000 registered clients, mainly from the fields of water conservancy projects, marine fishery, transport, meteorology, surveying and mapping and disaster relief. Compass aims to provide positioning and navigation services to China and the Asia-Pacific region by 2012. China will expand Compass into a global network, requiring at least 30 satellites, by 2020.

96. Compass has one unique advantage - sending text messages. When the May 12 earthquake devastated southwest China's Sichuan Province in 2008, the system helped the army navigate in the disaster area and offered message communication services in areas with all other communications destroyed. Compass is not yet as convenient as GPS, and it costs four to five times more. Compass technologists have held talks with counterparts from GPS to negotiate on future cooperation between the two systems and there is a willingness to cooperate.

97. The Chinese Compass network plans to incorporate the best features of the GLONASS and Galileo systems, as well as items planned for the next generation GPS satellites. However, like the GPS and other systems there have been few successful examples of making money from such systems. Moreover, there are problems between Beidou, Galileo and Glonass, over who should use what frequencies first.

[37] http://www.gpsdaily.com/reports/China_Compass_Finds_Route_To_Rival_GPS_999.html

Since GPS got into service first, no one is contesting the frequencies GPS uses. The government expects the Compass system, jointly developed by state-owned aerospace and electronics departments, to rival GPS in world coverage after it is completed.

4.5 Galileo

98. In early 2010 a German/UK consortium was awarded a contract by the European Commission in Brussels to supply the first operational spacecraft for Europe's Galileo[38] satellite-navigation system, an EU version of the US GPS, but with significant improvements. The promoters, hope that Gelileo's technology that is more advanced will give users quicker, more reliable fixes, and enable them to locate their positions with an error of one metre compared with the current GPS error of several metres. The Galileo system will offer five services:

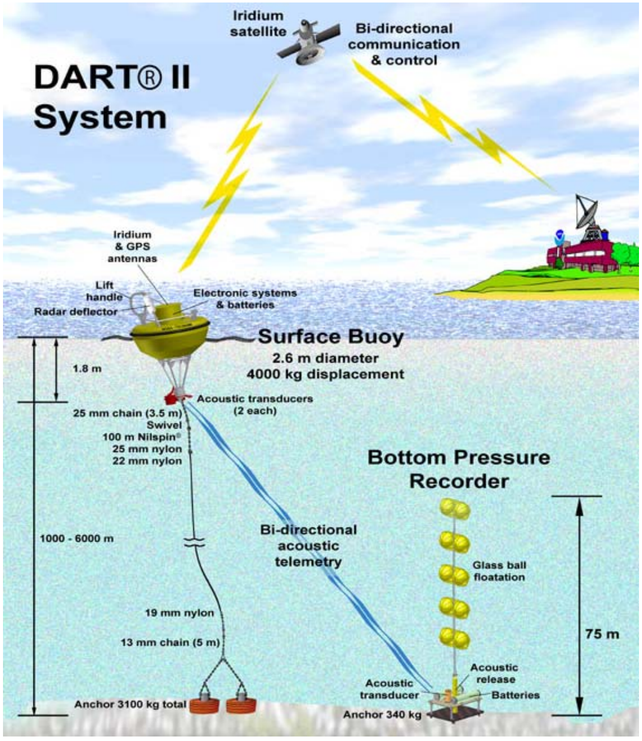
- OPEN ACCESS NAVIGATION 'Free to air' for the mass market; simple timing and positioning down to 1m
- COMMERCIAL NAVIGATION Encrypted, high accuracy, guaranteed fee paying service
- SAFETY OF LIFE NAVIGATION Open service; For applications where guaranteed accuracy is essential and integrity messages will warn of errors
- PUBLIC REGULATED NAVIGATION Encrypted; Continuous availability even in time of crisis;
- SEARCH AND RESCUE System will pick up distress beacon locations and it will be feasible to send feedback, confirming help is on its way

99. Galileo should have been operational by early 2010, but had to overcome technical, commercial and political obstacles. The venture came close to abandonment in 2007 when the public-private business model set up to build and run the system collapsed. EU member-states have to fund the entire project from the public purse. What should have cost European taxpayers no more than €1.8 billion euros will now probably cost them in excess of €5 billion. Galileo should now become operational in early 2014. The EU's continued commitment to the project despite budget and management failings stems from the belief that huge returns to the European economy will accrue. The Galileo constellation will find markets as satellite navigation becomes ubiquitous in consumer devices such as mobile phones.

[38] http://news.bbc.co.uk/2/hi/8442090.stm

4.6 Application - Tsunami Warning

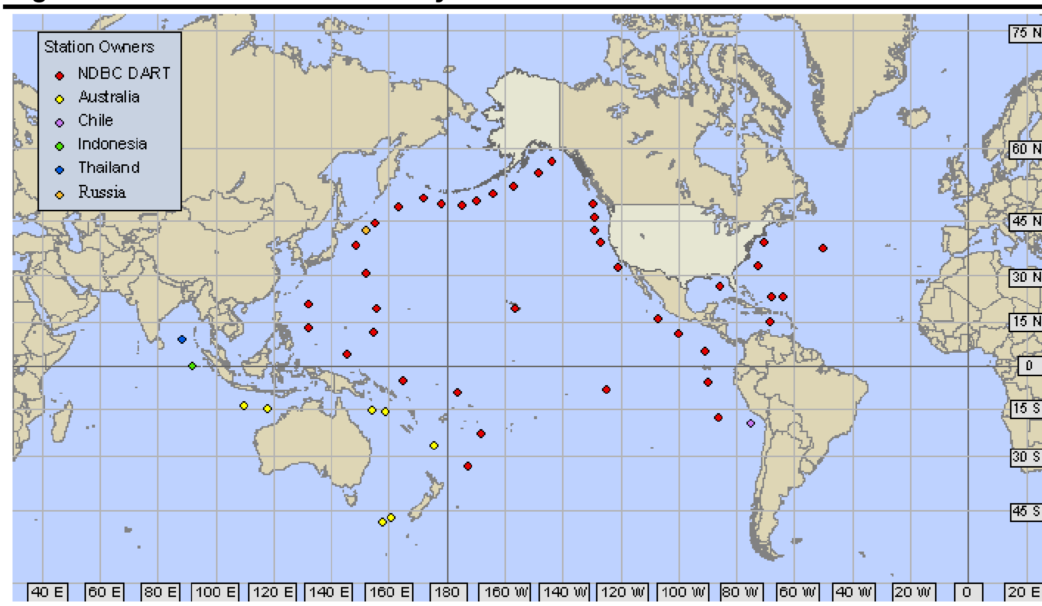
Figure 14: DART Buoy System



Source: http://nctr.pmel.noaa.gov/Dart/index.html,
http://nctr.pmel.noaa.gov/Dart/index.html

100. Following the 2004 Boxing Day Tsunami work began on ocean buoys that will give advanced warning when a tsunami is on its way. Traditionally tsunami warning centres monitored waves and Earth movements with optical imaging. Buoys with bio-directional acoustic telemetry can now provide life saving information.

Figure 15: Location of Dart Buoys



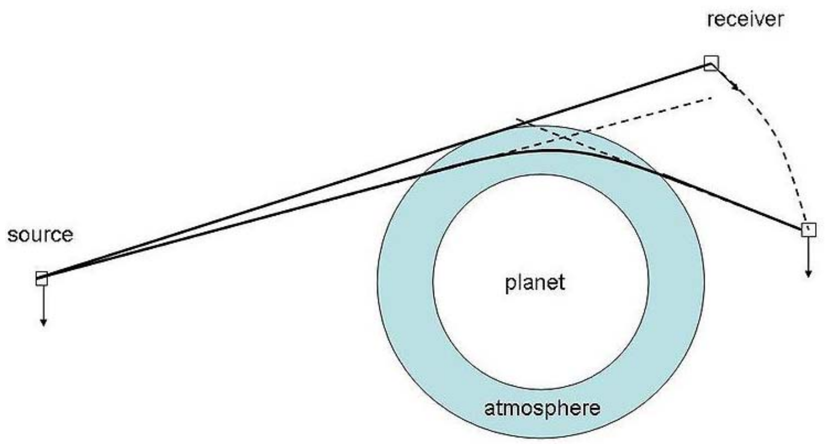
Source: http://www.ndbc.noaa.gov/dart.shtml

101. Figure 14 shows how the DART system works. Figure 15 illustrates the proposed locations for the principal Deep-ocean Assessment and Reporting of Tsunamis (DART) Buoys. DART Buoys anchor to the ocean floor, which detects rapidly changes in sea level. Normally, it reports-back every 6 hours to the Tsunami Warning Centres through the Iridium satellite constellation. DART systems deployed near areas with a history of tsunamis, are to ensure measurement of waves as they develop towards threatened coastal communities.

102. DART buoys also acquire data critical to real-time forecasts. The National Oceanic and Atmospheric Administration (NOAA)'s National Data Buoy Centre (NDBC) manage the tsunameter technology and operational responsibility for the US Pacific. NDBC provides free open access to all real-time tsunami data[39].

4.7 Application - Radio occultation

Figure 16: Radio Occultation



103. Radio occultation (RO) is a remote sensing technique used for measuring the properties of a planetary atmosphere. It relies on the detection of a change in a radio signal as it passes through the planet's atmosphere i.e. as it is occulted by the atmosphere. In 1987, researchers at the US Jet Propulsion Laboratory (JPL) recognized the potential for using the GPS satellites to make Radio Occultation measurements of the Earth's atmosphere[40].

104. Electromagnetic radiation passing through the atmosphere is refracted. The magnitude of the refraction depends on the gradient of refractivity normal to the path. This depends on the gradients of density and the extent of water vapour. Bending can be calculated using the Doppler movement of the signal given the geometry of the emitter and receiver. The atmosphere's temperature, pressure and water vapour can be derived; hence radio occultation data has applications in meteorology.

105. Current radio occultation missions rely on radio signals from GPS (Global Positioning System) satellites, the technique is then known as GPSRO. The GPS signals are received on low earth orbit (LEO) satellites.

[39] See http://nctr.pmel.noaa.gov/Dart/dart_pb1.html
[40] See http://www.atmo.arizona.edu/~kursinsk/GPS_RO_overview.htm

4.8 Application – Forest Fire and Steep Slope Degradation

106. Early and reliable detection are important controls of both wildfire and steep slope degradation. Aerial photography and infrared scanning were the tools of the 1950s and 1960s. Visual analysis of photographs and hand delivery to control authorities were reflected the limitations of technologies of the era. The first examples of satellite fire analyses were hand-drawn on maps at remote sites and sent by courier to the fire manager. In the Yellowstone fires of 1988, delivery of satellite-based fire information was cut to approximately four hours by moving the control centre forward[41].

107. Limitations of hotlines, sensors, fire lookouts and aerial patrols remain, so electronic systems have been adopted to overcome operator error and technology imposed constraints[42]. Satellite based systems may be semi-or-fully-automated and can be adapted based on the risk area, degree of human presence and other factors revealed by GIS data. A multiple systems approach can merge satellite data, aerial imagery, and personnel position via GPS into a near-real-time information system for the authorities.

108. Satellite and aerial monitoring provide a wider view than any other options and may be sufficient for routine monitor of very large, low risk areas. They can also be used more intensively in high risk areas at times when high-risk factors combine with risky climatic or other conditions. These more modern and sophisticated systems employ GPS and satellite cameras to identify and target wildfires or major land slips.

109. One of the first satellite-mounted sensors Envisat[43] has an advanced scanning radiometer that can measure infrared radiation emitted by fires, identifying hot spots greater than 39 °C. However, satellites in geostationary orbits may become disabled and satellites in polar orbits are limited by their short window of observation time. Cloud cover and image resolution and may also limit the effectiveness of satellite imagery. Recent advances in technology have improved performance and currently the Asia Pacific Region is covered by satellites from Japan (ALOS and WINDS), Indian (IRS), Thailand (THEOS), Taiwan (FORMOSAT) and Korea (KOMPSAT). These are coordinated by the Sentinel Asia system (discussed in more detail in paragraph 6.3 below).

4.9 Application - Weather Forecasting

110. Geostationary weather satellites orbit the Earth above the equator at altitudes of 35,880 km (22,300 miles). Because the are geostationary they appear to remain stationary with respect to the rotating Earth and record and transmit images of the entire hemisphere continuously with their visible-light and infrared sensors. Newspapers and broadcasters use the geostationary photos and videos in their daily weather presentation as single images or made into movie loops.

111. The United States has two satellites in operation, GOES-12, located over the Amazon River to provides U.S. weather information and GOES-11 over the eastern Pacific Ocean. Russia's Elektro-L 1 operates over the Indian Ocean. The Japan's

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[41] A comprehensive review of fire fighting can be seen at: http://en.wikipedia.org/wiki/Wildfire

[42] See for example: http://www.libelium.com/libeliumworld/articles/101031032811

[43] Earth observation satellite, to study atmospheres, ozone, oceanography, ocean temperature and color, wind, hydrology (humidity, floods), agriculture and arboriculture, natural hazards, monitoring of maritime traffic, atmospheric dispersion modeling (pollution), cartography and snow and ice.

MTSAT-1R is over the mid Pacific. India's INSAT also carries instruments for meteorological purposes.

112. Polar orbiting weather satellites circle the Earth at a typical altitude of 850 km (530 miles) in a north to south (or vice versa) path, passing over the poles in their continuous flight. Polar satellites are in sun-synchronous orbits, which means they are able to observe any place on Earth and will view every location twice each day. Polar orbiting satellites gain better resolution images than geostationary due their closeness to the Earth.

4.10 Application – Web-GIS

113. "Web mapping" describes the process of designing, implementing, generating and delivering maps on the World Wide Web. Web mapping primarily deals with technological issues such as the type and capability of Earth Observation satellites. Web cartography by contrast studies the use of web maps, evaluation and optimization of techniques and the usability of web maps. Web based Geographic Information Service (Web-GIS[44]) is similar to web mapping but emphasises analysis and processing of project specific geodata. Web GIS and web mapping are often used synonymously, even if they do not describe exactly the same activity.

114. The boundary between web maps and web GIS is unclear: web maps are often a presentation media in Web-GIS and Web Maps are increasingly gaining the analytical capabilities of WEB-GIS. If the mobile web maps also display context and location sensitive information, such as points of interest, the term Location-based services is frequently used. While the origin of many maps today is satellite observation, aerial photography is still used, particularly where there is extensive cloud cover.

115. All of the options discussed above are increasingly dependent on collection and interpretation of masses of data. The next section will discuss how this data can be transmitted quickly enough to take remedial action to save lives.

[44] See for example: http://www.webgis.com/

5. Pacific - Internet via Satellite

116. We have previously looked at satellite options that offer PMSC. However, with convergence most of the satellites service providers who equipment was designed to offer PMSC now offer satellite internet and vice versa. We will now look at services that began with a focus on data transmission.

5.1 BGAN

117. The BGAN network spun off from Imarsat. It offers a global Satellite Internet Network with telephony using Inmarsat portable terminals and using three geostationary I-4 satellites to provide almost global coverage. Terminals in remote locations, are normally used to connect a laptop computer to broadband Internet. As long as line-of-sight to the satellite exists, the terminal can be used almost anywhere. Unlike other satellite Internet services, which require bulky and heavy satellite dishes to connect, a BGAN terminal is about laptop size; easily carried.

118. Downlink speeds of high-end BGAN terminals approach 492 Kbit/s and upload speeds 300–400 Kbit/s[45]. As with all geosynchronous satellite connections, latency is an issue. Common latency is 1–1.5 seconds round trip for the Background IP service. It is slightly better for the streaming services at 800 ms – 1 second. Latency is due to the distance travelled before a packet can reach the Internet Server. Users frequently have accelerators to improve performance.

119. BGAN is currently the fastest GLOBAL data link available via a portable terminal. Anyone can set it up and it has good voice calling quality. It works on the L band[46], avoiding rain fade and other issues of larger satellite systems. The process of connecting a BGAN terminal to the satellite is simple. A user would be outside, and have a general idea of the satellite's direction (with a compass if necessary). Turning slowly by hand, gives an indication the satellite's location. Following a touch on a button, the terminal auto-negotiates with the satellite and connects. The average pointing time for a BGAN unit is under a minute with an experienced user and a good signal.

120. Each I-4 satellite provides around 200 narrow spot beams. In August 2010, Imarsat contracted Boeing to build a new constellation of satellites the Inmarsat-5s. They will form the backbone of the Inmarsat *Global Xpress* network, delivering mobile broadband speeds o*f up to 50 meg*abits per second. BGAN is being used in the world today for disaster response, telemedicine, business continuity, military use and recreational use. In 2010, *Inmarsat won an* Award for its BGAN service.

5.2 Asia Sat

121. Asia Sa*tellite Teleco*mmunications Co. Ltd. (commonly AsiaSat) is a commercial operator of communication satellites. AsiaSat is based in Hong Kong with two major shareholders, CITIC[47] and General Electric. Its earliest satellite stranded in the wrong orbit. A 1984 Space Shuttle mission retrieved it and sold it to AsiaSat. It

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[45] For the specifications see http://en.wikipedia.org/wiki/Broadband_Global_Area_Network, and http://bgansatellite.com/

[46] L band refers to four different bands of the electromagnetic spectrum: 40 to 60 GHz (NATO), 1 to 2 GHz (IEEE), 1565 nm to 1625 nm (optical), and around 3.5 micrometres (infrared astronomy). See for example: (http://en.wikipedia.org/wiki/L_band)

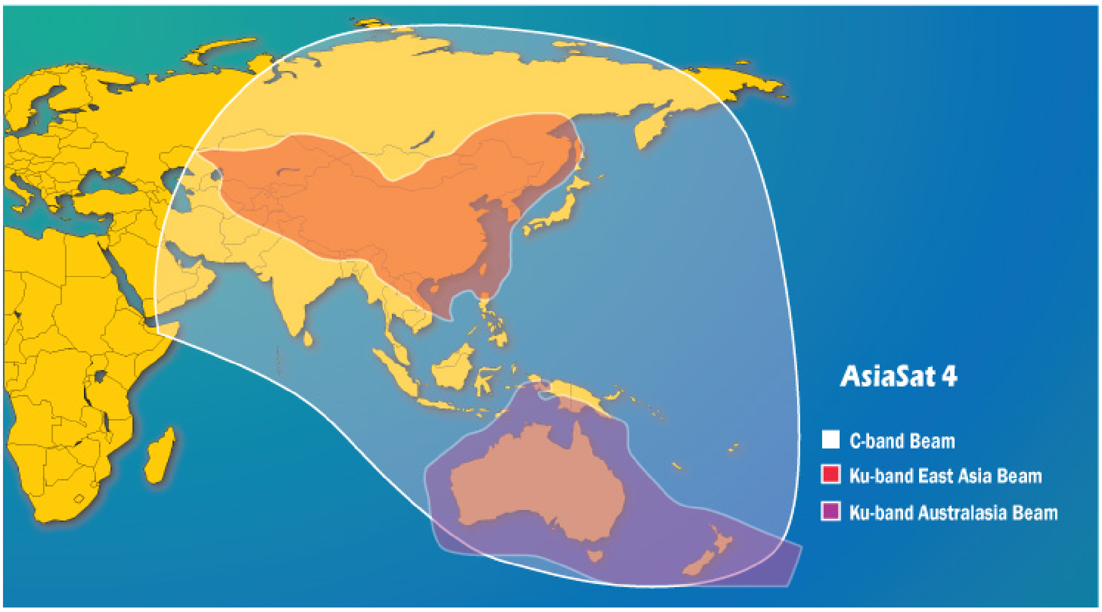
[47] The CITIC Group, formerly the China International Trust and Investment Company, is a state-owned investment company of the People's Republic of China.

entered service after re-launch on a Chinese Long March 3 booster in 1990. The next satellite was an AsiaSat Lockheed Martin Astro Space Satellite launched in 1995. A further launch is planned in 2011 of AsiaSat 5C Space Systems/Loral at 100.2 degrees.

122. AsiaSat satellites are used by European and international broadcasters as well as channel providers. It can offer full-time, part-time or infrequent use. Its main feature is a Multiple Channels per Carrier (MCPC) offering with distribution platforms provided by AsiaSat from its own earth station in Hong Kong or through worldwide partners. The aim of a MCPC platform is a shared platform to allow clients to enjoy cost effective solution for channel and content distribution. Services include space segment, fibre links, signal turnaround and uplinking services in C or Ku-bands.

123. It also features back up Services, to establish short-term network for disaster recovery when telecom carrier's primary terrestrial network is being damaged by natural disaster or other catastrophic event. In cases when AsiaSat's customers encounter emergency, AsiaSat's capacity across the fleet and its facilities can provide support as customers' service back up. This is very useful for DRM purposes but the only drawback is that not all areas can 'see' the satellite Asiasat 3s as it is low on the horizon[48]. Figure 17 illustrates the West Pacific orientated footprint, which also covers Australia, New Zealand and the Western Pacific to Central Asia.

Figure 17: Asia-sat footprint



Source: Asiasat.com

5.3 Thaicom - IPSTAR

124. Thaicom 4, also known as IPSTAR[49], is a broadband satellite built by Space Systems/Loral (SS/L) for Shin Satellite (Thailand). Designed for high-speed, 2-way broadband communication over an IP platform it aims to play a core role in the convergence of information and communication technologies, with its 45 Gbit/s bandwidth capacity. It can provide high-capacity ground network with affordable

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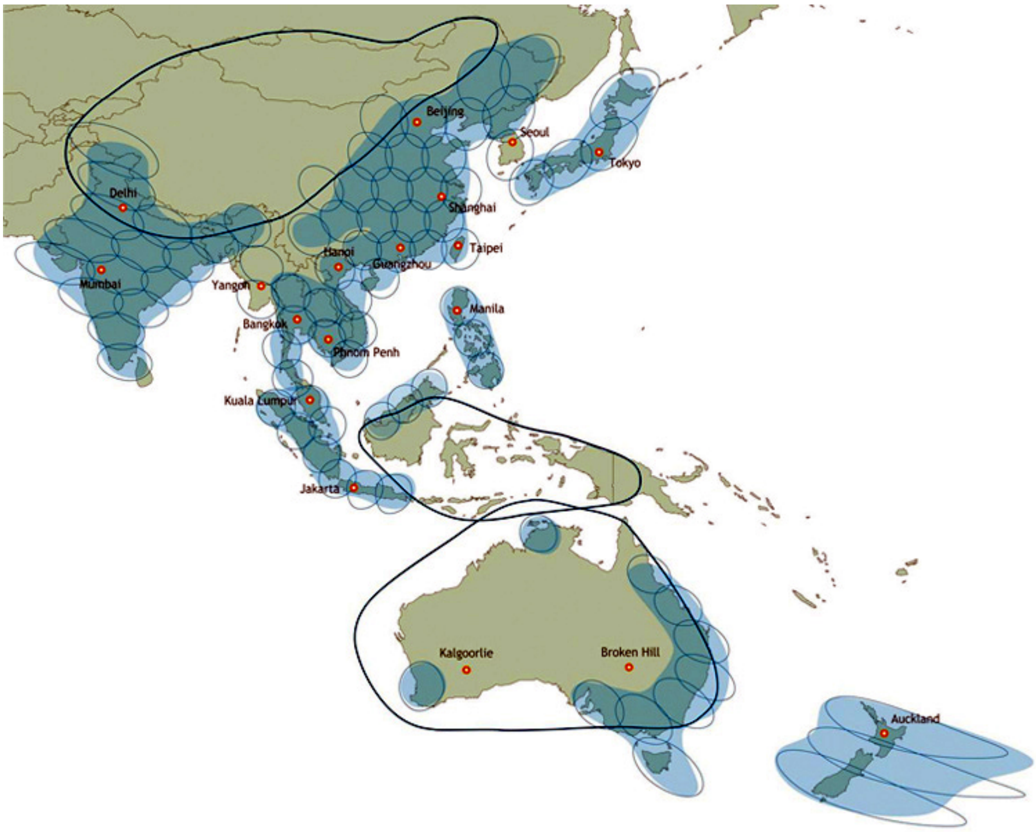
48 See for example: http://www.freetv.co.nz/webapps/site/61418/52840/shopping/shopping-view-plus.html?pid=254345

49 See http://www.ipstar.com/ and Wikipedia http://en.wikipedia.org/wiki/Thaicom_4

bandwidth, allowing rapid deployment and flexible service locations within its footprint. IPSTAR is composed of a gateway earth station communicating over the satellite to provide broadband packet-switched communications to many small terminals with network star configuration. IPSTAR's power allocation optimizes the use of power among beams and allocates a power reserve of 20 percent for allocation to beams affected by rain fade, thus maintaining the link. IPSTAR has coverage over most of South East Asia and Western Oceania, including those set out in Figure 18.

Figure 18: IPSTAR Coverage



Source: http://www.ipstar.com

125. A wide-band data link from the gateway to the user terminal employs Orthogonal Frequency Division Multiplexing (OFDM) with a Time Division Multiplex (TDM) overlay. In the terminal-to-gateway direction (or return link), narrow-band channels employ the same transmission methods. These operate in different multiple-access modes based on bandwidth-usage. Multiple narrowly focused spot beams and frequency reuse allows IPSTAR to maximise available frequency. It increases bandwidth by a factor of twenty compared to traditional Ku-band satellites translates into greater efficiency. Despite the costs associated with spot beam technology, the overall cost per circuit is considerably lower as compared to other current technology.

Figure 19: Ipstar Dish and Satellite Terminal

Ipstar Dish   Ipstar Terminal

Source: http://en.wikipedia.org/wiki/Thaicom_4 and http://www.ipstar.com

126. Traditional satellite technology utilizes a broad single beam to cover entire continents and regions. IPSTAR has multiple narrowly focused spot beams. IPSTAR increases bandwidth by a factor of twenty compared to traditional Ku-band satellites. Despite the higher costs associated with spot beam technology, the overall cost per circuit is considerably lower compared to shaped beam technology. IPSTAR's power allocation optimizes the use of power among beams and allocates a power reserve of 20 percent to beams affected by rain fade to maintain links. Its principal drawback is lack of coverage of the Pacific Islands.

Figure 20: PacRICS Option

Source: http://pacrics.net/index.php?option=com_frontpage&Itemid=1

5.4 PacRICS

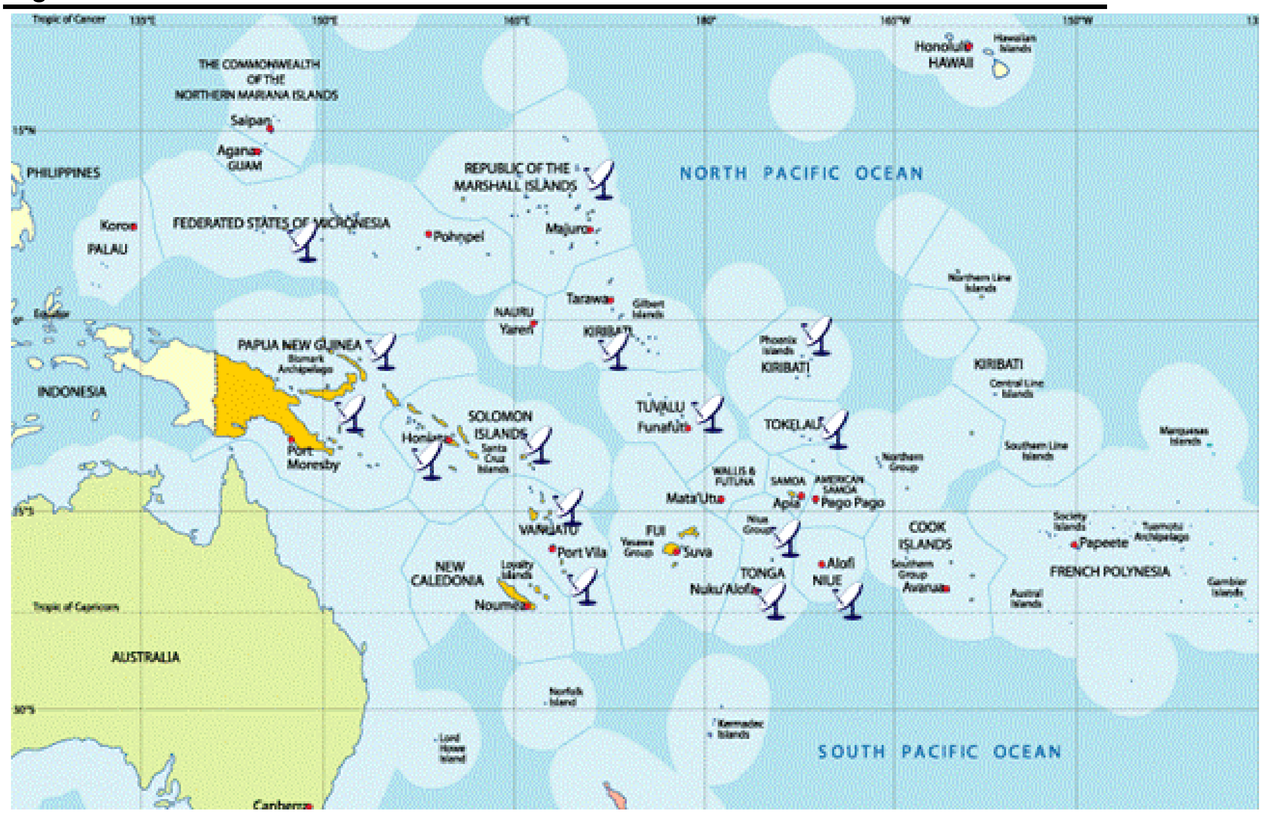
127. PacRICS (Pacific Rural Internet Connectivity System) is a low cost Internet access system for rural and remote areas, using the Intelsat satellite platform, to bring them reliable broadband connection. Designed to provide 2-way Internet connectivity to all Pacific Island Countries, it can handle VOIP and other high quality

uses. The RICS connects directly to the US backbone via Hawaii and provides high performance and low latency. The RICS (second generation) is based on the SHIRON DVB-S2 ACM Intersky platform, utilizing the latest modulation techniques to ensure reliability, availability and throughput. Antennae can be compact or large depending on the requirements of the client (see Figure 20)

128. Under the Pacific Plan digital strategy, SPC (Secretariat of the Pacific Community) and PIFS (Pacific Island Forum Secretariat) worked together on developing a system to provide cheap, fast, and reliable internet connectivity to any rural and remote area in the Pacific region and securing funding. A design process commissioned by the Australian Agency for International Development (AusAID) agreed with the concept and gave some AU$2 million to set up the system.

129. The funds have paid for a dedicated 'Pacific hub' in the AMC-23 satellite for the lifetime of the satellite and two years of bandwidth initially. The system was launched during the 38th PIF meeting (October 2007) in Nuku'alofa, Tonga. The Gilat Dual Outbound VSAT Hub is installed in Honolulu, Hawaii. It offers full South Pacific Coverage via two separate beams on GE-23 satellite. The system offers speeds of 256 Kbits/second down and 64 Kbits/second up. Speed is also dependent on the size of antenna and the number of parties sharing the connection.

Figure 21: Pilot Sites for PacRICS



130. In many countries of the South Pacific, this is the principal financially feasible service on offer. Figure 21 illustrates the existing pilot sites around the Pacific. These use commercial satellites on a fully commercial basis. They anticipate moving to an Imarsat satellite offering 50 mbpts service[50].

[50] Interview with the PacRICS office in Sydney, 11 March 2011

6. Pacific - Connectivity

6.1 Current Satellite Coverage

131. There are very few places on earth between the polar circles without some commercial satellite access. The Mobile Satellite Services Iridium and Inmarsat cover nearly all the earth. Globalstar and Asiasat have more limited coverage but it is expanding. Iridium has coverage right to the Poles. In respect of PNT, there will soon be three options for worldwide satellite Radio navigation, but the GPS network is the most readily available. Its ground segment equipment is readily available and relatively cheap. The total inventory of Satellites available in the Asia Pacific Region was recently summarised as in Table 3.

Table 3: Invetory of Satellites from the Asia Pacific Region

Country	Communica-tion	Earth Observation	Meteorology	Navigation	Tsunami	Total
Australia	10					10
China	49	25	12	12	2	100
India	31	18	10		1	60
Japan	63	6	2	1		72
Korea	4	1	1		1	7
Russian Federation	121	31	62	10		224
Thailand	5	1				6
Tonga	5					5
Turkey	6					6

Source: ESCAP Contributions to Enhanced ICT Connectivity in Pacific Island Developing Economies, Dr. Xuan Zengpei, Director, Information and Communications Technology and Disaster Risk Reduction Division (IDD), United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Special ICT Ministerial Forum, Noumea, New Caledonia, 11 April 2011

132. The medium demand countries with growing needs for international connectivity and their proximity to economical submarine links, these are becoming the preferred choice for general business. However, low demand countries will continue to depend on satellites for international connectivity for many years to come.

133. This is why emerging broadband satellite communication options have the potential backbone to ensure connectivity to the dispersed islands of Pacific region. It is beyond the scope of this study to undertake a complete technical evaluation and audit of all satellites, their capabilities and their potential for enhancing ICT Connectivity in Pacific Island Developing Economies. However, there are number of issues that can suggest the options for deployment and the best way to enhance connectivity in the medium term (3-5 years).

134. In the North West Pacific there are many communications satellite systems carrying all types of telecommunications and broadcasting. Approximately 57 percent of satellite resources (of total 697 satellites launched so far) are communication satellites[51]. The ASEAN area has a number of choices where it comes to communications satellites ranging from older C band technology to the latest direct to home (DTH) broadband satellites like IPStar. As we have identified, most of the existing commercial satellites (offering services on the market) are privately owned.

[51] *ESCAP Contributions to Enhanced ICT Connectivity in Pacific Island Developing Economies*, Dr. Xuan Zengpei, UNESCAP Special ICT Ministerial Forum, Noumea, New Caledonia, 11 April 2011

135. The Pacific Islands have less choice, but extensive Intelsat services provide much of the telecommunications infrastructure and options such as PacRICS currently fill a gap with a cost effective solution that is now run as a commercial operation.

136. Earth Observation and Navigation Satellites are useful for mapping and developing disaster risk assessments. Earth resources satellites cover all countries but generally, these cannot be accessed in the smaller countries because of lack of ground infrastructure. They are largely publicly owned and some, like Inmarsat have their origins in a not-for-profit international organization or are owned by one nation and offered free-to-air to anyone in the World. We will now look at some of the regional institutional developments affecting connectivity.

6.2 APRSAF

137. Asia-Pacific Regional Space Agency Forum (APRSAF), set up in 1993, was to enhance the development of each country's space program and to exchange views toward future cooperation in space activities in the Asia-Pacific region. In particular it has a mandate[52] to:

1. Promote International cooperation with disaster management by Remote Sensing and Web-GIS technologies in the Asia-Pacific region.
2. Collaborates with Space Agencies and Disaster Management Agencies in order to improve the effectiveness of their activities.
3. Provide satellite data and images of disaster affected areas on the website upon request from the member countries.
4. It's overall aims is to:
    - Improve safety in society by ICT and space technology
    - Improve speed and accuracy of disaster preparedness and early warning
    - Minimize the number of victims and social/economic losses

138. About ten countries in the region now operate satellite-data reception facilities, some of which also have their own earth observing spacecraft, or are planning to launch new systems in the near future. These agencies have traditionally provided satellite imagery after disasters to their own relevant country agencies, and in some cases posted it on their own websites.

139. Many of the causes and impacts of natural disasters, including droughts, are observable in real-time (or quasi real time) from space by earth observing satellites. Such data can be sent rapidly to affected communities and local emergency agencies as early-warning before the disaster occurs, or as post-disaster maps to assist in recovery operations.

6.3 Sentinel Asia

140. Sentinel Asia is a voluntary initiative led by APRSAF to support disaster management activity in the Asia-Pacific region by applying the WEB-GIS and space based technology, such as earth observation satellites data. Its main activities comprise emergency observation by earth observation satellites in case of major disasters. It was proposed in 2004 by APRSAF to promote the use of real-time internet dissemination methods and Web-GIS mapping tools. After the 2004 Indian Ocean

[52] See Xuan Zengpei, op. cit, 11 April 2011

tsunami disaster, the technical concept for Sentinel Asia was finalized at a meeting in May 2005 in Kuala Lumpur. A stepwise approach for implementation of this dissemination system was proposed by the APRSAF Earth Observation Working Group, where:

- STEP 1: Implementation of the Sentinel Asia data dissemination system and associated Nodes, to show the value of the standard internet dissemination systems (February 2006 - December 2007)
- STEP 2: Expansion of the dissemination backbone with new Satellite Communication Systems (2008 - 2012)
- STEP 3: Establishment of a comprehensive DMSS[53] (2013 and onwards)

141. The Sentinel backbone system utilizes the WINDS satellite. This initiative is to be closely coordinated with similar initiatives elsewhere in the world. Currently participating satellites include the Advanced Land Observing Satellite (ALOS[54] JAXA - Japan), IRS (Indian Space Research Organisation), THEOS (Geo-Informatics and Space Technology Development Agency Thailand), KOMPSAT (Korean Aerospace Research Institute) and others. ALOS, IRS, THEOS and KOMPSAT accept observation requests for major disasters in the Asia-Pacific region from Asian Disaster Recovery Centre member organizations.

142. Besides emergency observation of disasters, a top priority the Sentinel Asia Project emphasize implementation of satellite-data production systems for wildfire, flooding and glacier lake outburst flood information with other applications to be implemented subsequently. Capacity building for technical and emergency-response agencies users of the Sentinel Asia system will be undertaken, by organisations including UNESCAP in Bangkok.

143. Currently available operational publicly owned and available technical resources in the Pacific include:
   1. Sentinel Asia
   2. Wideband Inter-Networking Test and Demonstration Satellite (WINDS)
   3. Environment and Disaster Management Constellation of China
   4. Multi - Global Navigation Satellite System (multi - GNSS)

144. The problem confronting UNESCAP and other agencies dedicated to development in the UNESCAP region is to find ways of taking advantage of the satellite based technologies available without undermining the organisations promoting commercial developments in the region.

145. For the Asia Pacific Region, the problem with Sentinel is that it focuses on the developed countries of the region: India, Japan, Korea and Thailand. Most of the contributors to Sentinel are publicly owned satellites with governmental functions. UNESCAP and similar regional bodies in Bangkok have to act as proxies, looking after the small countries in the region it covers. However, the Sentinel experience has provided useful lessons even for the very different needs of the Pacific. These will be discussed in the context of the Way Forward in Section 10 below.

[53] Disaster Management Satellite System

[54] ALOS (DAICHI in Japanese) launched by Japan Aerospace Exploration Agency in January 2006 is 3.5m wide x 4.5m long x 6.5m high. With a Solar Battery Paddle extended it is 22m x 3m wide, gross weight is approximately 4 tons, which is one of the largest among Land Observing Satellites.

7. Pacific - Human - Institutional Capacity

7.1 Training and Capacity Building

146. One of the problems with all disaster relief is the balancing of training and capacity building. It is realised that most people that train for actions in time of disasters often never or seldom use their training. For this reason, training can lose momentum if staff training is too superficial. On the other hand, sophisticated technologies like satellite technologies require a high degree of familiarity with the equipment and the operational protocols if it is work efficiently when needed.

147. Equipment left in cupboards for emergency use only, available in emergency supplies and donated by neighbouring countries keen to assist might not work when needed for many reasons that can include deterioration of batteries, omission of essential motherboards, penetration by vermin or dust and even theft of critical components. Humans are similar, if they go for long periods without using equipment, they will need to refresh their memory. While this may not take as long as training someone who has never used the gear, it will still take time as anyone who goes from the latest tablet after using a 10-year-old PC will attest.

7.2 Benefit of Familiarity

148. The recent earthquake emergency in Christchurch and the earthquake and Tsunami in Japan that followed soon after, has shown once again, the most useful communications in the time of an emergency are those that as closely as possible resemble those in everyday use. With any piece of new equipment from handheld controls on the domestic television, controls on the electric or gas cooking equipment to standard mobile telephones, at least three months of regular use are required before even a regular owner feels confident that they know their way around and can begin to realise its potential.

149. If training courses are used, the time required reduces substantially, but even with the benefit of training, day or weeks may elapse before the operator feels confident to use it. Training needs to be current. All modern equipment, these days, is subject to constant upgrading. The life of a PC is about three year maximum and during that time, there will be multiple upgrades, patches and often-new features added.

150. Training people to use satellite ground equipment is probably easier today than 20 years ago, but the gap between first use and competent use remains a period of days, a week or even months. This implies the need for regular training and experience, but this has to balance against the demands of regular work and the cost of any specialised training. In the case of the spot beam satellites, for example, the beams have to be re-orientated to reach the coverage areas and this may involve organization and cost. The balance is between a situation where the critical staff know what to do on the one hand and affordable current training on the other.

7.3 Economising

151. Costs will reduce dramatically, if the operation of base stations is multi-purpose. If the satellite has day-to-day use, in addition to emergency capability then commercial users (such as internet providers and telecom companies) can be

charged for the services they receive and the cost of training spread over the DRM applications and the commercial applications.

152. This means that in a DRM situation, the equipment will be available rapidly, or if destroyed by the disaster, when replaced will need minimal familiarisation to be fully effective. Multiple-use is particularly important because it is not possible to predict where a disaster will take place.[55] As it is likely that any use of a satellite like WINDS to meet the high data rate itinerant needs of counties following a major disaster will require some special training it is proposed that countries could use the satellite for other high profile events thus increase the exposure to the technology.

153. With satellite technology, training usually incurs considerable cost. Asia Pacific regional training exercises are probably better value than each member state carrying out its own training. It would be useful though for the training to rotate through the countries so that each country in turn gets the benefit that comes from holding the courses. This calls for an agreement of the involved member states and some central office coordination. The benefit is a growing, regional pool of people who understand the region to be called on if the disaster incapacitated the local experts.

154. In respect of minimising human resource risks, appropriate infrastructure therefore will have the following characteristics:

- relatively simple training that requires minimal specialist knowledge by the operator in a DRM emergency,
- choice of equipment that is multiple use and available for prior familiarity, and with which a large number of operators can be comfortable using in an emergency,
- commercial and DRM uses to recover some of the locally incurred costs
- equipment that has a relatively short time between first use and competent use,
- regional agreements of rotation of training and hosting training courses to maximise the developmental impact, and
- agreement to cover other high data rate itinerant requirements to broadcasting of special cultural and sporting events

7.4 Ending the Digital Divide

155. The initial impact of telecommunications services of all kinds are that they make markets more efficient, reduce transaction costs and increase productivity.[56] These are all areas where developing countries have greater need than the developed. Mobile telephones also have the effect of allowing citizens to report human rights violations as they did during the post-election violence in Kenya and during the current crisis in Tunisia.

[55] Similar to the soldiers' complaint that "battles always take place on the junction of two maps!" (i.e. mapmakers cannot anticipate where a battle will occur and it is difficult to consult two adjoining maps especially while moving),

[56] Markets were more efficient in the Kerala Study by reducing the waste of unsold fish. Transaction costs are reduced because a few cents on a telephone call could substitute for a journey across a crowded city or a walk to the next village. They increased productivity, because the user would have time saved to redeploy to farming or income earning. Instead of taking three days off work to take a message to the next village, the subscriber can make a call for a few cents.

156. The potential of satellite communications for both voice calls and the internet is even greater. In countries, where the local media have low credibility they can arm citizens with the information they need to effect reforms. With better technologies available, portable and lightweight equipment that can be carried in a backpack, power packs and better batteries that can be solar recharged the distance barrier to communications can be greater reduced.

7.5 User Focus

157. The internet has an even greater impact where available, but because mobile telephones are widely available their total impact on the population is greater. Householders expect to receive internet services using relatively small dishes. This is technically possible if the data rate remains modest. To achieve the maximum allowable power, satellites concentrate their power like the reflector on torch to create a narrow "spot" beam that just covers the area where the service is sought. For example, a satellite may have a beam that covers just Singapore and a receiver may require only an antenna to receive signals aimed at Singapore.

158. Spot beam coverage is essential for direct to home internet services. In essence, if internet services are required using modest sized dishes, spot beams will be required. In Canada and the USA, 60 cm dishes are available to provide direct to home internet services. These services use the Ka satellite band, which is very high in frequency and badly affected by heavy rainfall. Even in the temperate climates, outages occur with rain but the relatively high rainfall over much of SE Asia would be detrimental to the use of Ka band for high quality signals.

159. Even in the lower Ku band rain fading occurs, but is not so severe, but the dish size requirement is over 1 metre in many cases. Despite this, many countries use the Ku band for DTH broadband. Very small aperture terminal systems (VSAT) current provides services in the Pacific and is an example of a reliable service provided over relatively "thin" connection, which may or may not suffer from weather interference, depending on the dish size.

160. In terms of development, applications for satellites will probably have used initially for carrying telephone calls to local exchanges making voice and data communications available. With these facilities established, demand for the internet is not far away. The impact of the internet is potentially critical in bringing information into the village. It expands horizons and shows that there are new ways of doing things. It makes both local and international news and information available. High-speed satellites will allow remote areas to receive news and feature broadcasts with an impact potentially greater than the impact of brining television programs into the living room in Europe and America in the 1950s.

161. It may not be possible to for every family to have their own satellite dish. However, many villages will afford a communal dish and with an adequate power source can offer telephone, internet and even television services to rural areas. The important requirements for satellites to contribute to ending the digital divide include:

- sufficiently powerful satellite transmitters to allow signals to be received by very small dishes for Local Area Networks (LANs),
- financial packages to allow communities to purchase/lease equipment, and
- content, for remote communities that they will find useful in their everyday lives.

7.6 Regulation

7.6.1 Economic Regulation

162. Regulation of telecommunications has been transformed in recent years. Traditional regulation focused on consumer protection in an environment where people believed telecommunications was inevitably a natural monopoly. Whether the sector was state owned or privately owned, the focus of regulation was to prevent the natural monopoly provider from using market power the monopoly conferred to extract monopoly rentals from final consumers.

163. With the wide spread introduction of competition the focus shifted to regulation of competition as an independent referee on the one hand and the power available to prevent the abuse of significant market power, on the other. Recently, a further development has been the fostering of facilities sharing to bring down costs and to make better use of expensive infrastructure.

164. Where there is significant support from governments to develop cables, satellites or even universal access to telecommunications, fair competition will require open access to infrastructure. It will not only ensure access, it will foster vigorous competition in terms of both prices and quality of service to attract customers. The biggest barrier to reduced costs is lack of competition. Most Pacific Islands have telecommunications markets that remain uncompetitive. The most significant barriers to additional competition are the small consumer base and the need to construct new facilities.

165. One approach would be to agree that all enterprises with significant government participation should operate their services and networks as separate business groups the incentives change dramatically. Instead of keep out competition to protect its service providing arm, the managers of the network will have an incentive to expand bandwidth to accommodate as much traffic as it can attract. Many service companies using the facilities will be virtual operators with no facilities. This will stimulate competition without the expense of additional investment in networks.

166. There is no need to make it compulsory for private operators to follow. However, there could be regulatory changes in most countries to require the sharing of facilities. There could be regulatory requirements to account for services and infrastructure separately as part of a renewed focus on cost reduction to keep prices as low as possible. There are now many lessons from both India and parts of Africa that can be adapted in the UNESCAP region[57]. The principal task is to ensure that regulatory capacity keeps pace with the rapid developments taking place in India and Africa in particular.

7.6.2 Technical Regulation

167. Article 21 of the ITU Radio Regulations determines the power that a communications satellite can radiate towards the surface of the Earth. This power maximum is a compromise to allow other services to frequency share without resorting to detailed coordination. The ITU members agree to amend the Radio Regulations from time to time to reflect new technologies and the demise of the older. For example, the switch of broadcast television services to digital

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[57] These are discussed extensively in *Mobile Marvels,* The Economist, 2009-09-26

broadcasting that use a much narrower bandwidth will have major implications for the development of new services[58].

168. The availability of 2.4 GHz spectrum in the 1990s unleashed a wave of technological innovation. The new spectrum rapidly becoming available is anticipated to allow much higher data transfer rates than have been available in the past. Many commercial and home WiFi applications are now in use in this band providing direct wireless connection to computers.

[58] See Technology Quarterly, The Economist, 11 December 2010, Page 14

8. Pacific - DRM - Infrastructure, Policies and Regulations

8.1 Infrastructure

169. Most geostationary satellite systems, including those in the Pacific are of the "bent pipe" variety. Bent Pipe means that the satellites retransmit what they receive without engaging in any data processing. For most satellite operators the uncertainty of future needs encourages the bent pipe approach, which is of course very flexible, in particular, it is possible to update the standards and protocols without changing the satellite.

170. Even the large IPSTAR is of the bent pipe variety. This approach allows for ready upgrade by modifying the emission from the terrestrial stations. Many satellite networks have transitioned from analogue to digital emissions using the same satellite network. Processing is highly desirable in the case of systems designed for weak signals, however can make the space craft obsolete with technology changes. It is notable that the QZSS satellite discussed later originally contained processing capability, but this was removed in the later versions.

171. The non geostationary satellites supporting mobile services have some processing. For example, the Iridium satellite receives the signals from the hand phone and relays the signals through inter satellite links through the constellation to a central gateway. Use of on board processing to boost the limitation of mobile earth station is common, but the processing is generally regeneration to improve the weak signal characteristics and network switching to get the call to the right down link and on to the PSTN.

172. The high growth in DTH TV services including HDTV and now 3D TV is forcing satellite growth and there is pressure on the frequency resource to meet the needs. WINDS type of satellite exploiting the Ka band is one of the few areas where growth can be accommodated however, the high incidence of rainfall attenuation means that some capacity is lost in error correction. Development work on high order digital compression continues partially driven by the need to get a higher throughput from the existing satellite frequency bands.

173. It is likely that this situation will continue for the years to come as more networks convert to HDTV for their DTH services. In the future, the very high bandwidths needed to deliver HDTV etc can arrive only through fibre or satellite. The public has been very eager to have large numbers of high data rate services for entertainment. The spin off can be harnessed to benefit everyone especially in adverse times.

174. Much of the Broadband infrastructure is shared with other telecommunications applications. For example, an optical fibre connecting two towns will contain both internet and other data streams. It may also contain the TV program and other high data rate applications.

175. In many places, in emerging economies all types of wiring has been installed, in a way to meet the need of the day rather than follow best practice procedures. As a result, when there is an emergency, infrastructure sometimes fails leaving the community without power or telephone let alone internet.

8.2 Policies

176. Adoption of good standards of practice along with the necessary capacity building of staff can help a lot in adverse times. It is clear too, that each area of Government and body corporate needs to take into account the possibility of disaster when designing their own ICT infrastructure. In the major overhaul of Government that took place in the 1980's in New Zealand the responsibility for all such operational matters were devolved to the Heads of the Ministries and Departments

177. The effect of this was to make the immediate line control officer accountable for ensuring that the ICT keeps working when there is a disaster. This is an important element as while centralised policy platforms may seem useful, they only work when the person responsible is the person who can do something about it!

178. In the Pacific Islands, for example hurricanes happen from time to time so one would expect each agency to be prepared or at least have a plan. In a similar ways, legislation and regulations are in place in most countries and it is likely that officials have discussed all issues thoroughly.

179. Governments should review ICT rescue and restoration policies to ensure that they have a plan to deal with emergencies. Measures should be taken to ensure Fire Brigade, Police and Ambulance Services communications are ready to work together during disaster relief operations. It would be appropriate for UNESCAP to help develop an online library of rules and regulations, based on those already in place but at various locations around the Pacific.

180. The essential ingredient of successful disaster rescue, recovery and reconstruction is preparation. Building codes and warning systems may be beyond the resources of many regional countries, but this does not prevent them from reviewing the resources they have and putting in place a plan to make the best possible use of what is available and to receive and deploy resources from outside.

8.2.1 Preventative Measures

181. A useful case study is the building industry. Recently, there was a force 7.1 earthquake in Christchurch New Zealand, followed by a less intense but closer to the surface shake a few weeks later. New Zealand has very strict building codes in recognition of the prevalence of earthquakes in the country. In the first Christchurch case, not a single life was lost, while in many countries much smaller earthquakes result in many thousands of deaths. An aftershock in Christchurch caused a number of buildings to collapse with a death toll that will rise over 200 with a relatively small number of buildings having collapsed though many were extensively damaged and will have to be replaced. Mostly deaths were in buildings constructed before the current building codes came into force.

182. The lesson is that excellence in employing best practice pays real dividends in times of disaster. Governments need to be sure that their respective authorities use best practice methods, have the powers and skills required in the construction of their IT infrastructure. In many cases, as in Christchurch this can be done only in new projects. As resource allow, countries need to re-examine their infrastructure in light of the effects of possible disasters and to improve it where appropriate. Measures, for example like those in Thailand, that ensure power and telephone lines along beach-fronts are now run underground was as an outcome of the Phuket disaster. Once planning takes place, all future construction can comply.

183. We have within the Asia Pacific area now some decades of experience at overcoming disasters and their effects on ICT. There is plenty of information available to operating companies and the like including a number of international Agencies like the ITU and APT. There must be a large body of information available to guide the members of the region. UNESCAP could take the lead in ensuring information is in an electronic library and made available universally which may help individual policy practitioners in drafting suitable advice. Nearly all problems and issues arising from disasters have already been faced somewhere in the region, though too often they are lessons buried in the files.

8.2.2 Spectrum and Licensing

184. In paragraph 69 above, we noted how Globalstar obtained U.S. spectrum allocation and negotiated with various other sovereign nations for rights to use the same radio frequencies in their countries. The need to obtain operating rights can have a major influence on the development of Satellite infrastructure and technology and on responses to DRM emergencies.

185. Every country has the right manage the spectrum within its own territory as it sees fit, but to avoid cross border interference all countries apply the provisions of the ITU Radio Regulations in carrying out their management of the radio frequency spectrum. Most countries today have very heavy spectrum usage below about 25 GHz. Any regional policy and regulatory agreement would have to address this matter.

186. Because of the difficulties and relatively high cost of making of radio equipment coupled with the poor propagation of radio waves in the higher frequency bands above about 25 GHz in most countries, spectrum usage is not as high as in the lower bands. Each country is at a different stage of their radio-communications development so if regional coordination is to work, all parties would need to be consulted.

187. The need for international agreement does not stop countries using the frequencies in the meantime, but rather that when an emergency comes they should be prepared with, some possible earth station locations already sorted out that would avoid interference to the existing services. At these frequencies, the beams are very narrow rays so frequency sharing is not as difficult as with the lower frequencies.

188. The Tampere Agreement[59] did not cover this sort of arrangement so a discussion to ascertain frequency bands and arrange the other aspects like licensing, inter country coordination, operations and training could be very useful

8.2.3 Supportive Regulatory Framework

189. In the 2008 UNESCAP Review of Pacific Connectivity[60] it was noted that many laws and policies in the Pacific predate the impact of the internet, mobile telephony and broadband on the telecommunications sector. At that time not only were some operators and regulators still combined, the prevailing mode of operation was still to treat the sector as a natural monopoly. Over the ensuing three years there have been many changes with several additional countries creating telecommunications regulators and the introduction of competition particular from mobile operators.

[59] See Appendix 2 for the operative clause

[60] *Enhancing Pacific Connectivity*, USESCAP, 2008, Page 21 (accessed from http://www.unescap.org/icstd/research/ap-connectivity.asp)

190. However, many of the operators are still deploying regulations and depending on regulatory models that were characteristic of the 1990s rather than the 21st Century. The innovative methods used in Africa and India to reduce costs and foster competition without duplication of infrastructure have largely passed the region by, exception in New Zealand and Australia where the introduction of Ultra Fast Broadband is forcing the respective countries to face up to the impact of mobile broadband applications on the finances of mobile operators and the need to ensure that infrastructure that is constructed with government involvement is open to all service providers. This leads to the potential to create competition in all, but tiniest of markets by requiring all infrastructure providers to operate on an open access basis with competition primarily at the level of services.

191. There is no doubt that the regulatory position has improved substantially in recent years, but there is a task ahead to ensure that the lessons now being learned in Africa and Asia about providing services to subscribers on low incomes are adapted and applied in all parts of the Asia Pacific Region.

8.3 Internet Access

192. Technically, there is no doubt that accessing mobile satellite service like the Inmarsat though BGAN or the Iridium NEXT network has the potential to give internet access. They could not though carry the traffic of a nation or even a city. Other satellite options need to be explored. Essential elements in the Ku band for example are powers in the satellite typically greater than 50 dBw eirp[61] along with sensitive satellite receivers with a sensitivity of G/T about 4 dB or better. These figures require spot beam antennas on the satellite to concentrate the beams to just the coverage area on earth which cannot generally be bigger than 2-3000 km².

193. Unfortunately, disasters happen everywhere but many countries do not have access to satellites with spot beam coverage especially that can be re-orientated to cover the disaster area. It is highly probable that a disaster situation will occur where coverage is slight. There is very little Ku band coverage of the Pacific Islands, for example. The global and hemi global beams used to provide satellite services in many countries require big dishes to provide such services and these can be expensive and difficult to restore, relocate and install.

8.4 Further Work

194. Further detailed work is required to examine the earth resource data[62] available in the region and investigate any barriers to making it available over the internet. This may need an international accord of some sort along with an awareness campaign to ensure that the maximum amount of earth data especially that underlying disasters is available everywhere it is needed. In the next section, we will look in more detail at two new technologies with the potential to provide high speed internet access in both a normal situation and a DRM crisis.

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[61] dbw relates to the logarithmic ration of power compared to 1 watt. Equivalent isotropicly (i.e. everywhere at once) radiated power (EIRP) or, alternatively, Effective isotropicly radiated power is the amount of power in radio communication systems that a theoretical isotropic antenna (which evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum antenna gain. EIRP can take into account the losses in transmission line and connectors and includes the gain of the antenna.

[62] e.g. data to understand movement in tectonic plates etc, to help identify disaster prone regions

9. Potential of WINDS and QZSS

9.1 KIZUNA - WINDS

195. We will now look in more detail at the two new offerings from Japan that have the potential to address some of the gaps in the current infrastructure: KIZUNA (WINDS) and QZSS. JAXA and the Japanese National Institute of Information and Communications Technology jointly developed WINDS as part of the e-Japan Priority Policy Program of the Japanese government's IT strategy. WINDS was launched in February 2008 from the Tanegashima Space Centre to establish the world's most advanced, high speed information and telecommunications network.

196. Other satellites, like IPSTAR show a pattern that looks a bit like a honeycomb of spot beams. The WINDS system has two dish antennae on the satellite with one pointed at Japan and the other that can be steered in a large area of South East Asia. WINDS also offers and Active Phased Array Antenna (APAA) that can link two points in the global beam area by pointing at one area then pointing at the other with a very quick transition. The WINDS APAA offers hope to be able to cover two points in the Asia Pacific area like Sydney and Suva. It has used spot beams to Japan, Thailand and Mongolia to carry out their experiments.

Table 4: Major Characteristics of KIZUNA - WINDS

International Designation Code	2008-007A
Launch Date	17:55, February 23, 2008 (JST)
Launch Vehicle	H-IIA Launch Vehicle No.14
Location	Tanegashima Space Centre
Shape	Box-shaped structure with 3m in depth x 2m in width x 8m in height (including a tower)
Weight	Approx. 2700kg (at the beginning of mission life)
Orbiter	Geostationary Earth Orbit (GEO) (East Longitude 143degrees tentative)
Altitude	Approx. 36,000km
Inclination	0 degrees
Period	Approx. 24 hours
Attitude Control	Three-axis stabilization

197. WINDS's speed and capacity is much higher than anything achieved previously. WINDS satellite communication system aims for a maximum speed of 155Mbps (receiving) / 6Mbps (transmitting) for households with 45-centimetre aperture antennas (the same size as existing Communications Satellite antennas) and ultra-high speed 1.2 Gbps communication for offices with five-meter antennas. The WINDS craft has a design life of 5 years. In addition to establishing a domestic ultra high-speed Internet network, the project also aimed to construct ultra high-speed international Internet access, especially with Asian Pacific countries and regions that enjoy close relation with Japan. Details are provided in Table 4.

198. In respect of the Asia Pacific Region, the coverage of the WINDS APAA its coverage of the Asia Pacific Region is very good. Figure 22[63] shows coverage from the Sakhalin peninsula (North of Japan) to the North Island of New Zealand. Christchurch, the site of the recent earthquake would not be covered, nor would

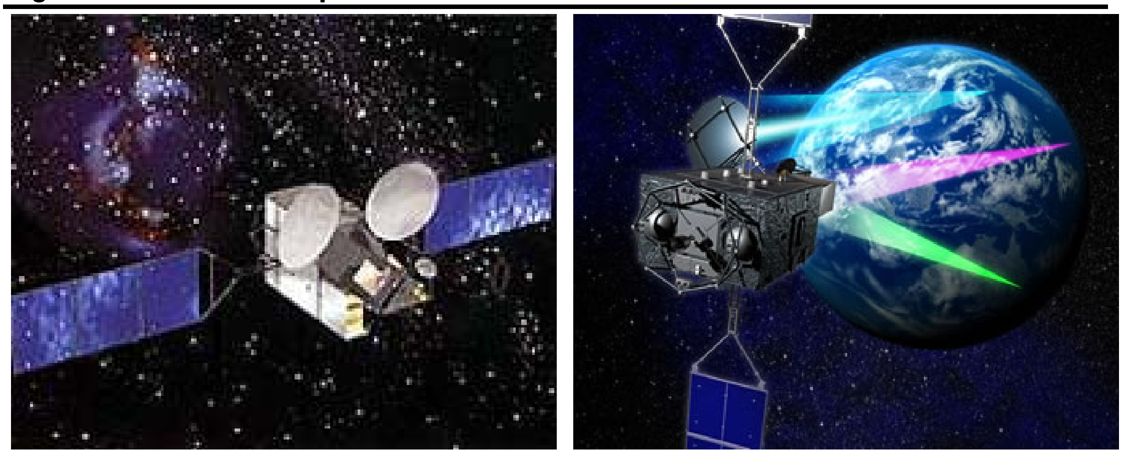
[63] *Sentinel in Asia*, Japan Aerospace eXploration Agency (JAXA), September 2010 Slide 10

much of the Eastern Pacific including some of French Polynesia. However, the vast bulk of the East Asia Pacific Region is covered.

Figure 22: Active Phased Array Antenna - Coverage

199. WINDS's technology recognises that satellite communications are far-reaching, multicasting and disaster-resistant. The objective is that ultra-fast satellite-based Internet-based communications aims to remove the so-called digital divide by providing high-speed Internet service in areas where the terrestrial and submarine infrastructure is poor. This will make possible advances in telemedicine, which will bring high-quality medical treatment to remote areas, and in distance education, connecting students and teachers separated by great distances.

Figure 23: WINDS in Operation



Source: In Operation Project Topics, 20-10-2010
http://www.jaxa.jp/projects/sat/winds/index_e.html

200. In Figure 23 above, the picture on the left shows the two antennas that focus the energy into a tight beam. In the picture on the right, one beam points at Japan and another at Thailand. The "box" on the underneath of the craft is the APAA.

9.1.1 Aerial Photo Trial 5

201. To test the usefulness of the WINDS the JAXA and the Japanese National Institute of Information and Communications Technology agency tested its capabilities in a

number of trials. The 5th and 8th trials were the most pertinent to this report. In the first case, an aerial image of an emergency communications disaster site was transmitted to the Geographical Survey Institute (GSI) was tried. The trials were a great success in that it promptly transmitted high-resolution (250MB) digital aerial photos of the disaster to the GSI. By using WINDS, the transmission time shortened considerably, and distribution of the images faster. As a result, it would be easy for the authorities to grasp the disaster situation. Based on this result, the Japanese GSI will consider the introduction of this accelerated operation system for emergency aerial photos.

9.1.2 WINDS utilization in SENTINEL Asia Trial 8

202. The purpose of this test was to transmit disaster related information disseminate to the disaster management agencies in the Region by using WINDS's high-speed data. WINDS transmitted an Advanced Land Observing Satellite (ALOS) observation image to the Philippine Institute of Volcanology and Seismology.

9.1.3 Advantages of WINDS

203. The principal advantage of WINDS is its enormous digital capacity to enable the recovery of banking, insurance and other data intensive infrastructure following the conclusion of rescue of the injured, recovery of victims and removal of debris and those to the restoration of essential infrastructure services. WINDS also has the great advantage of rapid refocusing from one receiver to another. This enables the satellite to service more than one location at the same time by leaping from one to the other. In this respect, it has many advantages over similar satellites.

9.1.4 Disadvantages of WINDS

204. WINDS would have limited application in the immediate aftermath of a disaster when the emphasis is on location and rescue of the trapped and injured rather than the restoration of normality. In addition, the immediate availability of WINDS in an emergency will depend upon whether there is capacity available at the time of the occurrence of the emergency. For example, WINDS has the ability to connect Bangkok and Tokyo simultaneously. Should two disasters occur in the footprint of a single WINDS the full capacity of the satellite may not be available to assist. In this case, its advantages over the commercial satellites will reduce.

9.2 QZSS – Watching Japan

205. During 2010, JAXA conducted the initial functional verification of the First Quasi-zenith Satellite "MICHIBIKI." Tests included performance trials of its attitude control systems. The MICHIBIKI launched on 11 September 2010 from the Tanegashima Space Centre. On 19 October, transmission began.

206. Initial trials ensured the signal does not interfere with conventional satellite positioning services such as the GPS service. It then began checking interference of other positioning signals transmitted from the MICHIBIKI in the same way. For at least three months after launch it was planned that, initial functional verification of the onboard devices would take place with organizations responsible for technical verification. Figure 24 is an illustration of how the QZSS would appear in space

Figure 24: Quasi-zenith Satellite System (QZSS) watching Japan

207. As mobile phones equipped with car navigation or GPS have become widespread, positioning information using satellites is increasingly important in all our lives. To specify a location, we need to receive signals from at least four satellites. However, in some urban or mountainous areas, positioning signals from four satellites are often hampered by skyscrapers or mountains, and that has often caused significant errors.

Table 5: Major Characteristics - QZSS

International Designation Code	2010-045A
Launch Date	20:17, September 11, 2010 (JST)
Launch Vehicle	H-IIA Launch Vehicle No.18
Location	Tanegashima Space Centre
Shape	2 box shape with wing-type solar array paddles 2.9m in depth x 3.1m in width x 6.2m in height (Length between the tips of the paddles: 25.3m)
Weight	Approx. 4000kg
Orbiter	Quasi-Zenith Orbit
Altitude	Approx. 32000 - 40000km
Inclination	Approx. 40 degrees
Period	23 hours 56 minutes

208. The QZSS, by contrast consists of a multiple number of satellites that fly in the orbit passing sequentially through the near zenith over Japan. Each satellite is over Japan for eight hours so 3 are required for a 24 hour service. By sharing almost the same positioning signals for transmission with the currently operated GPS as well as the new GPS, which is under development in the U.S., the system will enables the QZSS team to expand the areas and time duration of the positioning service provision in mountainous and urban regions in Japan. Its major characteristics are set out in Table 5.

209. There is scope for QZSS to be deployed to assist the work of regional bodies. UNESCAP, for example has recently highlighted the need for satellite-based PNT technologies in the West Oceania and Typhoon-prone area. Currently, the focus has been on early warning of steep slopes landslips caused by forests degradation, Tsunami warnings by buoy, weather prediction, radio occultation observation, atmosphere research, and other technical validation to improve DRM. UNESCAP is currently investigating the deployment of such satellites for socio-economic development, disaster management, support of disaster recovery activities,

mitigation and prevention using satellite observations and communications using GIS[64].

210. Similarly, the RED *RESCUE* PROJECT (REal-time disaster REsponse using Small-Capacity data from the UniversE), [65] is specifically investigating the use of QZSS in its response to disaster situations. The work that has been undertaken by the NTT Data Corporation aims to establish systematic and reliable communications with the affected area in the immediate aftermath of a major disaster such as that at Sendai and Fukushima. It is not known if this system was in operation during the course of the immediate rescue and nuclear emergency response, but would have been very useful it was.

211. Furthermore, the QZSS aims at improving positioning accuracy of one meter to the centimetre level compared to the conventional GPS error of tens of meters by transmitting support signals to augment the GPS data. The first quasi-zenith satellite "MICHIBIKI" carries out technical and application verification of the satellite as the first phase, then the verification results will be evaluated for moving to the second phase in which the QZ system verification will be performed with three QZ satellites.

9.2.1 Future improvement of QZSS

212. People familiar with car navigation may feel that the current system has enough functionality. However, satellite positioning is also important for mapping, construction work, monitoring services for children and senior citizens, observing tsunami, detecting earthquakes, volcanic eruptions, weather forecasting and other fields, particularly those associated with DRM. QZSS will improve positioning data with an error of within one meter in all these areas. In some cased GPSD can receive MICHIBIKI signals by improving software. JAXA and related organizations are now promoting receiver manufacturers to cope with MICHIBIKI signal reception.

9.2.2 Advantages QZSS

213. A QZSS network is of unique utility to the target country as it penetrates to street level. No other type of satellite can match the attributes of a QZSS in the temperate latitudes for penetration and bandwidth. Disasters are generally handled at street level by vehicles like ambulances, fire brigades etc. If these need rapid positioning, for example other satellite types could not handle them as they would lack penetration and bandwidth. MICHIBIKI has very impressive performance under optimal conditions.

9.2.3 Disadvantages QZSS

214. QZSS has excellent performance, but the downside of this performance is that the very high frequencies used can suffer serious loss of performance in rainy conditions close to Earth, as described in paragraph 81 above. Furthermore, QZSS is only of use above the territory to which it relates. A network designed for Japan for example is not of much use to Vietnam. There is no doubt if there in major disaster

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[64] See for example: "*Potential applications of GNSS in Socio-economic development*", Xuan Zenpei, IDD/ESCAP at the opening session of the first Asia Oceania Regional Workshop on GNSS, Bangkok, 25-26 January 2010

[65] "Real-time Disaster Response using Positioning Information and Wide-area Small-Capacity Data", Tesuya Kusuda and etc., NTT Data Corporation, Second Asia Oceania Regional Workshop on GNSS workshop, Melbourne, 21-22 November 2010

like that in Sendai Japan on 11 March 2011, it will be very useful indeed, but unless more satellites become available, effectively one set for each country, the use will be limited to Japan.

215. Secondly, as there are few QZSS in service, in countries rescuers responding in a DMR have to rely on ground transport communications, a temporary radio link or on one of the communications services with coverage probably Iridium, Thuraya or Inmarsat. Re-activating ground communications after an emergency can take time, which could mean the difference between life and death of the victims. Unless there is a QZSS already in use, people are trained to use it and have the right reception equipment it will be more effective in the short term to use services with which people are more familiar. QZSS, if available to carry communications can undoubtedly make a major contribution in restoring data intensive transmissions.

216. A third point is that while QZSS is relatively inexpensive when spread over the population of Japan, it would be uneconomic to have similar coverage over the Solomon Islands, for example. The QZSS undoubtedly will direct signals to locations where GPS or other signal reception may be limited or distorted. The number of satellites available will limit QZSS's operations. It needs at least three geostationary satellites in the right place at the right time. It is difficult to predict the location of disasters and unlikely to be economic to locate three new satellites at short notice.

9.3 Potential

217. It is not clear how the Pacific countries would use the WINDS satellite capacity in the immediate aftermath of a disaster. Within 10-14 days, it is possible there will be a need for massive amounts of bandwidth as banking, insurance, travel and numerous other services get up and running again. Functionality will depend upon the rapid arrival of the appropriate ground terminal equipment and the availability of appropriate interconnections. There is also a danger of inclement weather causing deterioration in performance.

218. THURAYA and IRIDIUM currently have handheld terminal equipment that is very useful in the immediate aftermath of a disaster. Currently, WINDS has much better transmission capacity, but requires a portable dish and an earth station, which although portable in a briefcase, needs to be setup by a trained operator. As was noted in paragraphs 228 below the PITA has already committed to BGAN, which while of a much earlier design and much less technically advanced has the advantage of being there, relatively cheap and familiar to the local operators.

219. Both WINDS and QZSS are heavily dependent upon the generosity of the government and people of Japan. There is no reason to suggest that this generosity will reduce. In respect of WINDS and QZSS as well as the various cable options across the Pacific the advice of the "Enhancing Pacific Connectivity" report is pertinent. It notes that "if a proposal calls for large direct government investments, or of government commitments to build and maintain infrastructure, that proposal should be looked at with caution".[66]

220. The fact that commercial options providing similar if much lower capacity services are already present in many of the locations covered by WINDS means that provided they are well managed options such as INTELSAT-BGAN, THURYA and IRIDIUM have the prospect of immediate ongoing sustainability irrespective of

[66] *Enhancing Pacific Connectivity*, USESCAP, 2008, Page 69 (accessed from http://www.unescap.org/icstd/research/ap-connectivity.asp)

official funding. Some of these initiatives are by international business, but others are small local businesses struggling to develop a clientele. Organic development that occurs in response to the needs of the local community is probably a sounder strategy than grafting the latest technology onto an immature market. In this context organic development means the natural process of suppliers responding to the needs of their clients, as opposed to the idea "build and he will come"[67] or demand will respond to supply of a new technology.

221. Through most of the Pacific, the pattern has been a mixture of government initiatives, recycling refurbished equipment and private initiatives on a commercial, unsubsidised basis. This combination of efforts is delivering a steady stream of improvements in services available. Accordingly, there should be caution in delivering a product so advanced, compared with local immediate needs, that it crowds out private initiatives in favour of a "Rolls Royce" technology that will require ongoing external support. We will suggest an appropriate role for WINDS in the context of sustainable solutions for the Pacific.

222. The future of the Pacific lies in a mixture of private and public innovative solutions for a region that has been dependent on aid and government jobs. Whatever the future has in store it is probably opportune for the nations of the region to meet and discuss how they can best harness this new technology to give relief to their people in times of need. The next section looks at some options and offers suggestions on how the advanced technology WINDS and QZSS offer can be deployed in a role that builds on what is there enabling an orderly transition to more advanced technologies.

[67] In the Hollywood sports drama fantasy Field of Dreams, while walking through his cornfield, the hero Ray hears a voice whisper, "If you build it, he will come" (often misquoted as "If you build it, they will come"), and sees a vision of a baseball field. Watched by disbelieving neighbors, Ray plows under his corn and builds the field. Eventually, players do come!

10. Pacific - Regional Cooperation

10.1 PIFS

223. The Pacific Islands Forum founded in 1971 is inclusive of the Forum's Oceania-spanning membership of both north and South Pacific island countries, Australia and New Zealand. The Forum's mission is "to work in support of Forum member governments, to enhance the economic and social well-being of the people of the South Pacific by fostering cooperation between governments and between international agencies, and by representing the interests of Forum members in ways agreed by the Forum".

224. The Forum recognises ICT as a powerful tool for development in the region. It has also recognised numerous barriers to the successful implementation of better digital communications including, the limited and unequal access to communications technology, high costs of equipment and services, insufficient telecommunications bandwidth, low investment in networks and the outdated and absence of sufficient regulatory frameworks at the national level.

225. The Pacific Regional Digital Strategy is the action plan for the Forum Secretariat in pursuing ICT development in the region stemming from 2006. Priorities are to:

- improve access to communications technology
- reduce the cost of providing ICTs
- establish a higher bandwidth to the global ICT 'backbone'
- remove inappropriate regulatory environments in order to foster higher levels of investment, and
- strengthen ICT skills in the region

226. In accordance with the plan, the Forum Secretariat and the Pacific Islands Telecommunications Association (PITA)[68] undertook a comprehensive data collection exercise: the Pacific ICT Survey 2002. This planning process has produced many options for better handling the development of telecommunications in the Pacific and its efforts have seen significant improvements in the region, driven by national governments and private initiatives; sometimes a mixture of both. The PacRICS discussed earlier was one such initiative when some seed money led to the establishment of self-sustaining business based on access to the INMARSAT system.

10.2 International Agreements

227. Useful planning has begun already. In a 2009 presentation, [69] PITA laid out the disaster response problems for the Telecommunications Sector in the South Pacific. It pointed out the high risk of disruption by natural phenomena, such as earth quakes either directly or indirectly via tsunami, cyclones or typhoons, lightning strikes and volcanic activity; with both terrestrial and satellite infrastructure threatened. A 2005 Working Group undertook the responsibility of preparing a response. It looked at a solution for the Pacific to mitigate service disruption from

[68] http://www.forumsec.org.fj/pages.cfm/economic-governance/economic-growth-work-programme/ict-2/

[69] *Regional Emergency & Disaster, Communications System*, Pacific Islands, Telecommunications Association, PITA, 2009, presentation

natural phenomena and failures of satellite or terrestrial infrastructure. It aimed at fully integrated service restoration solution that:

- addresses both domestic and international services,
- covers loss of terrestrial and / or satellite backbone services,
- supports essential services (Telephony & IP) during an emergency,
- uses standard building blocks for transmission, switching and customer access to interface with or to replace existing network infrastructure
- may be activated automatically or with a minimal level of expertise,
- can achieve critical backbone service restoration within about 24 hours, and
- is cost effective to implement.

228. In outline the PITA Emergency/Disaster Recovery Plans

- use Inmarsat BGAN terminals and/or satellite phones for initial emergency communications,
- purchase a 2.4m SCPC VSAT terminals to re-establish satellite link for rapid deployment from a secure depot,
- purchase multiple 1.2m VSAT terminals that can be deployed in country,
- use a donated switch to provide call switching in the event of failure of an international gateway switch.

229. Progress to date has been significant:

- satellite phones are deployed in all the Islands and are used to establish initial communications after a disaster hits,
- 2.4m VSAT antenna, peripheral equipment and generator are stored ready for deployment,
- gateway switch donated by Redcom USA ltd.

230. The budget is very modest with cost effective solutions favoured:

- VSAT antenna training is provided by Telecom NZ at little or no cost except travel and accommodation,
- BGAN terminals are $10,000 each and the aim of one terminal per PI nation is achievable,
- Multiplex equipment for deployment with the 2.4m antenna cost about US$8,000 each.

231. This seems to us to be appreciable progress in a difficult area. The South Pacific is littered with well intentioned buildings and infrastructure that function poorly or not at all, basically because they are over specified for the level of demand and the capacity of the host community to pay. Accordingly we suggest that sustainable solutions to problems identified should progress along the same lines. All regional activities and discussions should focus on building on what is there and finding cost effective and sustainable ways of accessing the latest technologies while ensuring that efficient existing suppliers can continue to develop and thrive.

11. Conclusions

11.1 Possible Contribution

232. Currently the Island nations FSS[70] requirements (telephony and internet traffic) are largely met using external satellite operators mainly Intelsat, but they also use the MSS networks mainly Iridium and Inmarsat for their larger maritime vessels. In an emergency, the first responses tend to depend on Iridium, Inmarsat and Thuraya as the disaster may damage local networks. Recently, Thuraya in particular offers handheld services very similar to the standard mobile phone. Any first responder can operate this equipment with a few minutes familiarisation. These satisfy most needs in the first hours after a disaster. The issue is what comes after the immediate emergency rescue phase. This is where WINDS can be very useful.

233. In our view, there is sufficient difference between the partners in nature for the Pacific Islands and territories to have their own agreements and understandings covering the best use of WINDS and similar technologies. It will not be sufficient to roll-over into the Pacific the arrangements for countries around the Indian Ocean. In the unlikely event that the Pacific region commits to a new system based on the WINDS technology, a governance framework will be required, similar to that employed to manage the capability of SENTINEL, but meeting local requirements. As a minimum the following steps will be required:

- first task would have to be a study to identify suitable frequencies and orbit locations along with of course and indication of the support of most nations of the Region.
- next, would be an international agreement covering the financing and the national obligations of each participating nation.
- each nation will need to take responsibility for its role under the ITU Radio Regulations Article 9 and 11 to allow for the spot beams to focus on their country in times of emergency. We must assume, that domestic legislation would either limit use of the frequency bands within the country or set up a system of clearance/priority in times of disaster,
- thirdly there would be an agreement among the affected parties for financing of the satellite and the launching of the necessary satellite delivery vehicle.

234. There is room in this outline for a nation not to participate and provided all comply with Article 21 of the ITU Radio Regulations, non-participation by a neighbour should not hamper its use by its neighbouring states. As Sentinel Asia utilizes the existing WINDS satellite this initiative could be closely coordinated with similar initiatives elsewhere in the world. In particular, decision makers should pay close attention of the work under the auspices of the Tampere Convention and the ITU.

11.2 Sustainable Solutions

235. Sustainable solutions are those that make commercial as well as technical success and the issue will be to resolve ongoing international response that will work, are practical and cost effective in the long term. We cannot see an early realisation of a dedicated satellite for the Pacific because, satellite networks require large populations to be economic. Of the 16 members of the Pacific Forum, 3 members

[70] Fixed Service Satellite (FSS); the classification for geostationary satellites used for DTH broadcast TV feeds, radio networks, as well as for telephony and data communications.

have about relatively large populations: Australia 21.88 million, New Zealand 4.32 Million and PNG 5.19 Million. The other 13 members have total population 1.69 Million from Island states like Niue with a population 1354 to Fiji with a population of some 849,218.

236. The high costs involved in the design build and launch of satellites require ongoing revenue streams that will give a return to the investor. The economies of the South Pacific are small and cannot sustain the required capital costs, hence, no country in the South Pacific has yet developed a national satellite. No one state has the resources to meet the need, but together they may do. Australia had a domestic satellite network (OPTUS), but sold the network to Singapore Telecom. Telstra, Australia's largest telecommunications provider has no satellite of its own. New Zealand has a fledgling program called NZLSAT, but has not announced any long-term plans. PNG has recently filed a satellite network with the ITU but the objectives of the filing are not clear. It has been filed for a BSS[71] network with global beams covering Asia and the Pacific. The filing is for a change in the PNG allotments under Appendix 30 and 30A in the Radio Regulations.

11.3 UNESCAP's role

237. Given this situation, the way to organise things in the Pacific is through collaborative arrangements. As proposed earlier a meeting should be called under the auspices of UN ESCAP that would involve the Forum Members and the members of PITA to examine how the Pacific Nations can harness newer satellite technologies like the WINDS, to assist nations in recovering from disasters and meet other itinerant needs for sudden increases in data capacity. It will:

- identify the capacity of the existing and planned infrastructure to meet high data rate itinerant needs in support of disaster relief and other events,
- assess the need for supplementary itinerant satellite services infrastructure,
- model high data itinerant systems' operations and identify possible networks,
- agree on a framework for high data rate itinerant satellite, to meet the needs of the South Pacific nations
- discuss financial arrangements and formulate a suitable financial framework,
- decide whether an existing organization (PIF or PITA) can host this activity or should a new organization be created.
- agree on where itinerant earth stations should be held and the arrangements for transport to the area of need,
- study the operational barriers that could exist and how they can be over-come,
- discuss capacity building to ensure the programme is successful, and
- discuss how best to ensure that countries get earth resources reports that they need especially Tsunami warnings and Metrological storm data.

238. For this meeting to be a success a small pilot group under ESCAP could work together and draft a suitable text, for circulation well before the meeting to provide a basis for the discussions. If high-speed satellite broadband deploys initially to support events such as major sporting fixtures or for events such as the Pacific Forum Meetings, it will not only meet a demand sudden short-term increase in

[71] Each country has an allotment for Broadcasting Satellite Services applications under Appendix 30 and 30A of the ITU Radio Regulations

capacity, it will familiarise providers with the new technology, provide on the spot operator training and pave the way for more extensive deployment as equipment upgrade cycles com around.

11.4 Recognise DRM

239. Currently, most Pacific international telecommunications traffic utilises rented capacity mainly on Intelsat. In respect of emergency uses, after the first days of response to a major emergency, like that in Christchurch or Sendai, there may be an opportunity for further itinerant high capacity services, such as WINDS. WINDS satellites could meet the needs of service restoration after a major emergency. The earth stations in place may be damaged or destroyed and even if intact are designed to meet only day to day needs and are small in size.

240. Furthermore, in November 2004 and January 2005 there was an unexpected complete failure of the Intelsat communications satellites IA-7 and IS-804 satellites[72]. This suggests that a single satellite or a single cable is not an enduring solution for any nation, particularly Pacific States that have few options and are in a region subject to earthquake and unusually dependent upon space based options. This realisation opens up a way for WINDS to become an integral part of the Pacific Satellite landscape especially for itinerant high data rate requirements.

241. WINDS is well placed to play an important role in the Pacific, initially to meet infrequent high capacity itinerant needs[73], but with growing traffic volumes, falling costs and enhanced competition, developing into major provider option. Whether it is a satellite failure, a failure of a submarine cable or to where a nation requires extra high capacity to cover special events like Pacific Island Forum meetings or sporting and cultural events, WINDS is designed to meet sudden and unexpected itinerant demands for large increases in capacity. The Forum, for example, meets annually and the meeting venue circulates among the member states in turn. This means that the least equipped states need access to significantly enhanced high data services for the duration of the event.

242. For training and capacity building, the application of the WINDS technology should broaden from disaster relief to include itinerant usage. This will ensure that all parties are familiar with the technology when the disaster happens. All these issues need discussion so that the implications for the efforts of all the concerned nations gain consideration. Our recommendations aim to encourage Island countries to engineer their land and submarine cables and earth stations, cost effectively, to meet the day-to-day growth in demand. This would allow them to plan capacity to meet natural growth. It will also assure them of ongoing services when nations have special high data rate requirements. Facilities such as those provided by WINDS, can serve them well on special or emergency occasions, without the extra cost of over-engineering their earth stations to meet rare levels of demand. Familiarity with the technology will allow the local people to assess, when they are considering new equipment, whether they need ongoing capacity of the kind WINDS can offer.

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[72] Op. cit *Enhancing Pacific Connectivity*, USESCAP, 2008, Page 32

[73] Itinerant need refers to peak or exceptional demands that can be met by a temporary solution.

12. Recommendations

12.1 Summary of Recommendations

12.1.1 Cross Pacific Cable

Recommendation	Elaboration
There should be ongoing cooperation and work to develop a consistent approach regional cooperation aimed at the eventual construction of a Cross-Pacific cable system that will pay great dividends for the region.	Our conclusion is, given the economic downturn in 2008-2009; the immediate budget constraints facing donor governments, the prospects of raising US$ 200 million from the private sector or even from donor governments for a trans-pacific link comparable to NCPF are not great.

12.1.2 Plans and Preparations

Recommendation	Elaboration
Governments should review ICT rescue and restoration policies to ensure that they have a plan to deal with emergencies. Measures should be taken to ensure Fire Brigade, Police and Ambulance Services communications are ready to work together during disaster relief operations UNESCAP can play a role in developing an online library of rules and regulations, based on those already but at various locations around the Pacific.	The essential ingredient of successful disaster rescue, recovery and reconstruction is preparation. Building codes and warning systems may be beyond the resources of many regional countries, but this does not prevent them from reviewing the resources they have and putting in place a plan to make the best possible use of what is available and to receive and deploy resources from outside.

12.1.3 WINDS

Recommendation	Elaboration
Sustainable deployment of WINDS a satellite with its high-speed data transfer capability should focus on DRM emergency recovery conditions. Use of the WINDS satellite to provide high data rate itinerant services where the national infrastructure cannot, should also be pursued.	In an area within the steering range of the WINDS movable antenna, relaying high bandwidths is possible. Its phased array can be steered anywhere in the visible earth from the satellite. It can connect two widely spread regions using beam hopping where it points at one area then at the other very quickly. It is light and portable.

12.1.4 QZSS

Recommendation	Elaboration
QZSS should be used to meet peak demand or disaster relief data services in countries where it is already available or will deploy in future.	The need to have at least three quazi -geostationary satellites in the right place at the right time will limit widespread use of QZSS in DRM. It is difficult to predict the location of disasters and unlikely to be economic to locate three new satellites at short notice.

12.1.5 Standards of Practice

Recommendation	Elaboration
All Pacific nations should, as a high priority, ensure all officials and IT professionals are fully conversant with best standards of practice, along with the necessary capacity building of staff, to prepare them for adverse times.	Employing best practice pays real dividends in times of disaster. People need to be conversant with all equipment and procedures. This is related to using equipment with which they are familiar and trained in emergency procedures

12.1.6 Disaster in Design

Recommendation	Elaboration
Each arm of every government and body corporate should be warned to take into account the possibility of disaster when designing their own ICT infrastructure.	Governments need to be sure that their respective authorities have the powers and skills to ensure best practice methods are used in the establishment of their infrastructure.

12.1.7 Sentinel

Recommendation	Elaboration
Given the complexity of the steps required to promote an alternative and the problems of reaching international agreements consideration of the SENTINEL option should continue.	SENTINEL is in place and performing a vital function; it offers lessons for the Pacific. SENTINEL, largely applies in the Western Pacific and the Asian mainland so a new approach may be required for the Pacific

12.1.8 Regional Meeting

Recommendation	Elaboration
UNESCAP should seek to call a meeting of all interested parties, including the PFS and the PITA to discuss progress with implementation of the regional strategy and how advantage can be taken of the new WINDS including access to spectrum and regulatory reform.	UNESCAP can play a seminal role in bringing the parties together and ensuring that all the options are considered. In particular the need for additional IT capacity in the Pacific following disasters and for major regional events that are beyond the capacity of host nations to provide.

12.1.9 Preparation for Meeting

Recommendation	Elaboration
In the light of the recommendation in paragraph 12.1.8 above, UNESCAP should set up a group to discuss the outline of an agreement designed to take forward the cause of ICT connectivity using the latest technologies	If a regional meeting is agreed, then it may convene at short-notice so it is essential there is a document to table at the meeting. It should be specifically charged with ensuring that all the latest technologies are considered.

13. Appendixes

Appendix 1: Frequency Bands

Complete Set of Frequency Bands

Band	Range of Band
L band	1 to 2 GHz
S band	2 to 4 GHz
C band	4 to 8 GHz
X band	8 to 12 GHz
K_u band	10.95-14.5 GHz
K band	18 to 26.5 GHz
K_a band	26.5 to 40 GHz
Q band	30 to 50 GHz
U band	40 to 60 GHz
V band	50 to 75 GHz
D band	110 to 170 GHz

Source: http://en.wikipedia.org/wiki/Ku_band

Frequency Boundaries in Common Use

<table>
<tr><th colspan="3"></th><th colspan="6">FREQUENCY (MHz)</th></tr>
<tr><th colspan="3">DESIGNATION</th><th colspan="2">Reference. Data for Radio Engineers.</th><th colspan="2">US Navy</th><th colspan="2">RSGB</th></tr>
<tr><td colspan="3">I</td><td colspan="2"></td><td colspan="2">100 - 150</td><td colspan="2"></td></tr>
<tr><td colspan="3">G</td><td colspan="2"></td><td colspan="2">150 - 225</td><td colspan="2"></td></tr>
<tr><td colspan="3">P</td><td colspan="2">225 - 390</td><td colspan="2">225 - 390</td><td colspan="2"></td></tr>
<tr><td colspan="3">L</td><td colspan="2">390 - 1,550</td><td colspan="2">390 - 1,550</td><td colspan="2">1,000 - 2,000</td></tr>
<tr><td colspan="3">S</td><td colspan="2">1,550 - 5,200</td><td colspan="2">1,550 - 3,900</td><td colspan="2">2,000 - 4,000</td></tr>
<tr><td colspan="3">C</td><td colspan="2">3,900 - 6,200</td><td colspan="2">3,900 - 6,200</td><td colspan="2">4,000 - 8,000</td></tr>
<tr><td colspan="3">X</td><td colspan="2">5,200 - 10,900</td><td colspan="2">6,200 - 10,900</td><td colspan="2">8,000 - 12,000</td></tr>
<tr><td rowspan="2">K</td><td>K_u</td><td></td><td rowspan="2">10,900 - 36,000</td><td>15,350 - 17,250</td><td rowspan="2">10,900 - 36,000</td><td>15,250 - 17,250</td><td rowspan="2">18,000 - 26,500</td><td>12,000 - 18,000</td></tr>
<tr><td>K_a</td><td></td><td>33,000 - 36,000</td><td>33,000 - 36,000</td><td>26,500 - 40,000</td></tr>
<tr><td colspan="3">Q</td><td colspan="2">36,000 - 46,000</td><td colspan="2">36,000 - 46,000</td><td colspan="2">33,000 - 50,000</td></tr>
<tr><td colspan="3">U</td><td colspan="2"></td><td colspan="2"></td><td colspan="2">40,000 - 60,000</td></tr>
<tr><td colspan="3">V</td><td colspan="2">46,000 - 56,000</td><td colspan="2">46,000 - 56,000</td><td colspan="2"></td></tr>
<tr><td colspan="3">W</td><td colspan="2">56,000 - 100,000</td><td colspan="2">56,000 - 100,000</td><td colspan="2"></td></tr>
</table>

Source: http://www.jneuhaus.com/fccindex/letter.html.

Appendix 2: Tampere Convention Article 3

1. The States Parties shall cooperate among themselves and with non-state entities and intergovernmental organizations, in accordance with the provisions of this Convention, to facilitate the use of telecommunication resources for disaster mitigation and relief.

2. Such use may include, but is not limited to:

a) the deployment of terrestrial and satellite telecommunication equipment to predict, monitor and provide information concerning natural hazards, health hazards and disasters;

b) the sharing of information about natural hazards, health hazards and disasters among the States Parties and with other States, nonstarter entities and intergovernmental organizations, and the dissemination of such information to the public, particularly to at risk communities;

c) the provision of prompt telecommunication assistance to mitigate the impact of a disaster; and

d) the installation and operation of reliable, flexible telecommunication resources to be used by humanitarian relief and assistance organizations.

243. This does not have the high-speed availability of the spot beams but is sufficient for most applications. The logical outcome of the SENTINEL process could be for a WINDS type of satellite to have a steerable beam that could be brought to focus on a wider area than at the moment. This would then allow small, highly portable “fly-in” earth stations to provide immediate, very high-speed data, rate reliable communications at the disaster scene, including internet.