United Nations A/AC.105/860

General Assembly

Distr.: General
9 February 2006

Original: English

Committee on the Peaceful Uses of Outer Space

Report of the United Nations/European Space Agency/Argentina Workshop on the Use of Space Technology for Human Health for the benefit of the countries in Latin America

(Córdoba, Argentina, 19-23 September 2005)

Contents

V.06-50966 (E) 030406 040406

I. Introduction

A. Background and objectives

1. In its resolution entitled "The Space Millennium: Vienna Declaration on Space and Human Development",[1] the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) recommended that activities of the United Nations Programme on Space Applications promote collaborative participation among Member States at both the regional and international levels by emphasizing the development of knowledge and skills in developing countries and countries with economies in transition.

2. At its forty-seventh session, in 2004, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposiums and conferences planned for 2005.[2] Subsequently, the General Assembly endorsed the United Nations Programme on Space Applications for 2005 in its resolution 59/116 of 10 December 2004.

3. Pursuant to resolution 59/116 and in accordance with the recommendation of UNISPACE III, the United Nations/European Space Agency/Argentina Workshop on the Use of Space Technology for Human Health for the benefit of the countries in Latin America, organized in cooperation with and hosted by the National Commission on Space Activities (CONAE) of Argentina was held in Córdoba, Argentina, from 19 to 23 September 2005. The Workshop was the first in a new series of activities devoted to tele-health/tele-epidemiology issues.

B. Programme

4. Opening statements were made by representatives of the Office for Outer Space Affairs, CONAE and the European Space Agency (ESA).

5. A keynote address was given by a representative of the Pan American Health Organization (PAHO), the regional office of the World Health Organization (WHO). A total of 37 presentations were made during the thematic sessions. Two round table discussion sessions and observation and recommendation sessions were organized, as well as a technical visit. All sponsored participants made presentations on the status of the use of tele-health/landscape epidemiology programmes for sustainable development in their respective countries.

6. The discussion sessions were an opportunity for deliberations on the structured discussion topics, with the aim of defining follow-up activities for the region. Participants were divided into working groups in the areas of tele-health and landscape epidemiology and each working group submitted project proposals for further consideration and selection for financing by interested sponsors.

C. Attendance

7. Some 150 participants from the following countries attended the Workshop: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, France, Germany, Guatemala, Italy, Mexico, Paraguay, Peru, Spain, United States of

America, Uruguay and Venezuela (Bolivarian Republic of). International organizations represented were as follows: Office for Outer Space Affairs, United Nations Educational, Scientific and Cultural Organization (UNESCO), PAHO, American Telemedicine Association, ESA and Latin American and Caribbean Chapter (ATALACC).

8. Funds allocated by the United Nations and the sponsors—the Office for Outer Space Affairs, the Government of Argentina and ESA—were used to defray the cost of logistics, air travel, accommodation and daily subsistence allowance for 15 participants.

9. The hosting institution, the Mario Gulich Institute for Higher Space Studies, created by agreement between CONAE and the National University of Córdoba, is a decentralized organization initially specializing in offering graduate workshops and courses in basic space technology, applications, space technology and engineering, tele-education and project management.

10. Since 1998, CONAE has been providing space information collected by several sensors on-board Earth observation satellites. More than 200 projects at the municipal, provincial or national levels receive free images through a "fast-track" channel prepared to supply archived and actualized data files to people working actively on prevention or early warning, during a crisis or in the mitigation of the effects of a natural or technological disaster.

11. An agreement between CONAE and the Ministry of Health of Argentina was signed in order to develop those fields and use their results in the national programme of disease vector prevention. Since the first meeting on applications of space information to human health in 2001, the Mario Gulich Institute for Higher Space Studies has become a forum and the focus of a network for different aspects of landscape epidemiology.

II. Summary of presentations

12. The representative of PAHO reported that the "know-do" gap in health sciences, that is, the difference between what was known and what was done in public health through policies and programmes, remained unacceptably wide and seriously hampered equitable access to health services and knowledge throughout the Americas. The gap resulted in part from insufficient resources, but also from knowledge that remained inadequately accessible and shared among policymakers and public health practitioners. It was from that perspective that PAHO saw knowledge management as a key instrument in addressing the "know-do" gap, seeking to bring the right knowledge to the right people at the right time.

13. In its resolution WHA58.28 of 25 May 2005, entitled "eHealth", the fifty-eighth World Health Assembly had recognized that electronic (e) health was a cost-effective use of information and communication technologies in support of public health, and encouraged the formulation of e-health policies and strategies by Member States and the secretariat of WHO, including the establishment of centres of excellence and support to national electronic public health information systems. This was important in view of the potential of information and communication technologies for a more equitable access to health knowledge and services.

14. In that context of needs and institutional mandate, the PAHO knowledge management model was centred on capacity development of people and organizations for enacting processes of knowledge development, sharing and application, facilitated by technologies appropriate to knowledge management. The model allowed PAHO to broker authoritative public health knowledge to professional and public communities and showed the Organization as a facilitator of expertise and resources for knowledge management in public health.

15. It was therefore in that conceptual knowledge management framework that PAHO perceived its e-health activities, which included building the capacity of people and organizations for e-health programmes, the identification of lessons learned and of good practices and the development of a relevant taxonomy. In relation to knowledge-sharing, activities included encouragement of communities of practice and public discussions, exchanges and formal learning programmes through both real and virtual channels. Applications, in turn, included the WHO-led Global Observatory for eHealth, which had a country focus of reliable, up-to-date information on related policies and activities. It also provided for tools in disease surveillance, telemedicine applications (consultations, diagnostics, therapy, radiology, epidemiology, etc.), health management, as well as e-learning for health.

16. PAHO believed that its model situated e-health more clearly in the context of the public health situation and needs, enabling better communication of the objectives and processes of e-health. It also provided for a more comprehensive mapping of current assets, needs and the gap that remained between both, thus facilitating the development of a strategy to fill the gap by all e-health stakeholders.

17. Information communication technology had reached a sufficient degree of maturity for it to be possible to envisage setting up a virtual hospital in a patient's home, obtaining real-time tele-consulting and diagnosis from a remote location and transmitting clinical data and multimedia medical content from one location to a large number of widely scattered locations.

18. In order to improve the adoption and effectiveness of telemedicine, advanced information communication technology infrastructures were needed that would guarantee access, availability and quality of service in the required locations. Satellite communications, accessible from virtually any location and capable of instantly activating communication channels adapted to specific needs, could prove an important factor driving the development of telemedicine.

19. With the use of state-of-the-art space technology services, tele-health/telemedicine was receiving worldwide attention. It consisted of computer and telecommunication, including satellite communication, technologies to bring medical experts into virtual contact with patients in remote and rural areas, thus avoiding the costly relocation that also proved detrimental to their health.

20. Currently mobile telemedicine's most important applications had been in ambulances and on ships. Both of these applications could be used in time-critical situations. Equal speed of diagnosis was the primary reason to monitor the vital signs of patients and provide forewarning of treatment requirements to the hospital.

21. In a disaster scenario, terrestrial communications could be the first to suffer from the direct effects of earthquakes, fires or flooding. In such situations, satellites remained the only reliable means of direct liaison with the disaster area where

communication was critical for diagnosis, patient treatment and activity coordination. Also, satellite links could be installed in short periods of time.

A. Satellite technology

22. In the area of satellite technology, it was reported that the prospect of using satellite communications technologies and associated connectivity services in support of telemedicine was the reason why the ESA Telecommunications Department had been actively pursuing activities in that challenging domain since 1996. The integration of telemedicine into the working environment of health-care professionals could only be pursued though an intensive process of awareness-building among the user community and the stakeholders of the health-care system. The projects launched so far had provided a valuable contribution in that direction and had allowed the identification and exploration of new technical solutions and applications with clear potentials to become part of future telemedicine practices.

23. Since the mid-1990s, a number of activities had been initiated in Europe by national and international organizations aimed at demonstrating and promoting the use of satellite communications in the field of telemedicine. To a large extent, such pre-competitive activities had been set up by consortia composed of the telecommunication industry, health-care organizations and potential service providers, leading to a constellation of small and medium-sized exploratory projects. Through such projects it had been possible to demonstrate the technical feasibility of various satellite-based telemedicine systems and to raise awareness among potential users.

24. The use of satellite-based information communication technology for telemedicine was gradually moving from an exploratory phase towards a more stable and operational profile, in which integration into the existing health-care system and the rapid attainment of self-sustainability were essential preconditions for success.

25. AmerHis was an advanced communications system, based on the Alcatel 9343 digital video broadcasting (DVB) on-board processor, carried by Hispasat's Amazonas satellite. This processor had the capacity to provide the demodulation, decoding, switching, encoding and modulation for the four transponders on the Amazonas. Each Ku-band transponder covered one of the four areas served by the satellite, Brazil, Europe and North and South America.

26. Thanks to AmerHis, Hispasat was able to offer broadband interconnectivity to users anywhere in the four areas covered by Amazonas, with highly efficient usage of the space segment. It also allowed Hispasat to differentiate its portfolio of services from those of its competitors and to position itself as one of the most advanced satellite operators on either side of the Atlantic.

27. In addition to tele-health and tele-education, AmerHis could support a wide range of applications and tele-services such as distributed interactive television, video broadcasting on demand, radio/news broadcasting on demand, web browsing/news groups/e-mail, file transfer, videoconferencing/videophone/audio conferencing, teleshopping/telebanking, collaborative working, push applications,

Internet protocol multicast streaming, local area network (LAN) interconnection and virtual private networking (VPN).

28. ESA technical assets could be made available to projects that promoted the utilization of satellite communications. To be eligible, the proposed projects or initiatives should neither be commercially mature nor operational on a routine basis. Asset use was granted for a limited time span (linked to the pilot project lifetime). ESA resources were shared among a number of projects, which could have an impact on the schedule of activities.

B. Tele-health/telemedicine programmes and projects

29. Colombia was reportedly conducting studies related to users' concerns about the cost of services, regardless of the advantages or limitations of the satellite communication standards. Thus, what really counted for standards development was the associated terminal cost and consumed satellite capacity. In that sense, the main conclusion was that hybrid satellite/terrestrial designs were appealing, as they led to a significant reduction in equipment and total cost. Similarly, very small aperture terminal (VSAT) costs were less and less relevant. In that regard, DVB-return channel via satellite (RCS) showed the largest capacity of integration with terrestrial-based solutions. The other standards should overcome their terminals' limitations, which restricted the number of users per VSAT.

30. Overall, efforts to reduce service costs were conditioned by: (a) equipment specifications and network design aimed at increasing the number of users per VSAT; (b) development of techniques making it possible to reduce the required satellite bandwidth (which dealt with high-level modulations, robust to-satellite transponder non-linearities, adaptive coding and modulation (ACM) options and hub canceller techniques); and (c) bringing about cooperation between operators and manufacturers in order to achieve economies of scale that would in turn be reflected in lower service fees.

31. In its capacity as pro tempore secretariat of the Fourth Space Conference of the Americas, Colombia had been working on educational projects according to its plan of action. In particular, the Fourth Space Conference of the Americas was the focal point for the Cubesat programme in Colombia and other Latin American countries. That project allowed students to learn how to build satellites. The Cubesat was a pico-satellite with a mass of 1 kilogram, cubic shape and volume of 1,000 cubic centimetres. The Cubesat was being designed by students and professors at a university in Colombia and included all the steps to develop a satellite, including its launch.

32. The cost of the project was not more than $100,000. The advantages of the project were that students acquired the know-how of building satellites and the university established infrastructure for building satellites. Moreover, the university could develop space programmes for the project to be sustainable. Students could place simple payloads on Cubesats such as the global positioning system (GPS), telemetry, telecommand and so on. Two universities in Colombia were working on Cubesats. The mission for one of them was telemetry and for the other one was telemedicine for tele-consultations. The minimum success criteria were to exchange images and/or data.

33. In the medical field, a number of parameters, such as pressure, temperature, flow and acceleration, could be measured with micro-sensor systems. Having a monitoring system that sampled a number of parameters could increase the efficiency of diagnosis combined with patient comfort. By using complementary metal-oxide semiconductor (CMOS) technology, low power consumption could be achieved, making battery-operated systems feasible. The combination of monolithically integrated sensors and miniaturized transponder systems was suitable for medical applications. Beside miniaturization, the reduced power consumption of such devices made possible long-term operation. The concept of the systems must fit with the possibilities of implantation technologies, in combination with suitable biocompatible encapsulation materials.

34. When the decision was taken to become the first airline worldwide to implement high-speed Internet access on-board via satellite, the German airline Lufthansa already recognized opportunities for such an innovation that went far beyond that of a mere "communication feature". Consequently, telemedicine applications using Internet on-board had already been simultaneously tested during the first test flights.

35. At the end of the process, a piece of telemedical equipment would be made available, the use of which would be self-explanatory for crews and any medical practitioners who happened to be on board, making travel with Lufthansa even safer and more comfortable in a medical emergency or even as a service that could be booked in advance.

36. Tele-consultations implemented by the Centre national d'études spatiales (CNES) of France in French Guiana allowed access to a territory otherwise only accessible by water. That territory was populated by some 200,000 inhabitants, unequally distributed over an area the size of Portugal, with infrastructure and population concentrated in the coastal zone.

37. Using the Inmarsat satellite system, the network was established to provide for emergency communications with the isolated health centres on the borders of the Maroni river. A preliminary six-month assessment demonstrated good acceptance of the system by public health personnel working in local hospitals and the medical team in charge of the telemedicine project.

38. Clear interest from health professionals in using satellite-based applications in the fieldwork was confirmed. At present those applications were in the following phases: (a) tele-consultations were in many cases in an operational state; (b) tele-monitoring was in a validation phase; (c) tele-epidemiology was in use and progressing; (d) tele-education was in development; and (e) tele-robotics were in demonstration.

39. The portable telemedicine workstation (PTW) had been built with the following features: (a) use of commercially available medical instruments and devices, for which each country could find affordable suppliers; and (b) use of locally available communication channels. To date, the following satellite systems had been assessed: Inmarsat, Globalstar, Eutelsat and Thuraya. PTW was a versatile tool for telemedicine, using specific components depending on usage profile.

40. The Emercase network was a project to monitor Rift Valley fever in Senegal, supported by veterinary and medical networks. Local health staff collected data

using a personal digital assistant (PDA). Local sanitary services opened medical files using PTW for each suspicious case of disease. About 30 users shared medical information from the same server located in Dakar. E-mails on epidemiological and animal data were exchanged (up to 200 per month) and links between remote areas and Dakar were set up using satellites or fixed lines.

41. PTW worked as a component of a survey network for epidemics. By using it, professionals gained access to communications and positioning information. It could also be used to support mobile field teams connected to a server via satellites. For tele-consultation, examples in various countries demonstrated the capabilities of end users to work with PTW. Therefore, PTW tested in real conditions could become the backbone of telemedicine services.

42. In January 2000, the Government of Mexico proposed a national e-health and telemedicine programme consisting of three main components: tele-consultations, tele-education for medical professionals and electronic medical content (in particular in local languages). Based on those components, support for rural medical centres, reduction of barriers to access medical staff and services and creation of electronic medical content for the general public and medical staff was provided. The main technological issue was connectivity services throughout the country. To improve equal access, a network of 12 expert centres (national medical schools) and 10 general hospitals would be permanently interconnected to create a collaborative network. The network would allow for a transmission speed of up to 384 kilobits per second (Kbps) per site depending on the service requirements. At the same time, the network would include medical schools, other academic organizations as well as international institutions.

43. Countries with large territories like Mexico had isolated areas and rural monolingual communities. This resulted in problems in providing health services. The Institute for Security and Social Services for State Workers (ISSSTE) assisted the state workers, a total of 10 million people throughout the country. Since 1994, the cost of patient transfer had increased by 300 per cent in Mexico. Over the past 10 years, ISSSTE had provided 17,000 tele-consultations, 20,000 students had participated in tele-education training courses and 6,000 administrative sessions had been conducted. The network was equipped with VSAT stations delivering high-resolution videoconferencing and satellite-based Internet access. Seventy per cent of the time available to access a satellite transponder was devoted to tele-consultations and 20 per cent to tele-education on health-related issues.

44. Like most countries, Ecuador relied on health-care centres with differing levels of specialization. The telemedicine system developed for rural areas was built around the need for a customized electronic health record that could be shared both within a clinic and with other colleagues. Low-cost wireless networking (about $90 per computer) allowed any number of computers within a clinic to communicate internally.

45. A dial-up connection was adequate for many applications in telemedicine, especially the simple sharing of patient data—but also for image transfers and basic videoconferencing. The system in place in Ecuador made use of data transfer, image transfer and videoconferencing at speeds of only 22 Kbps.

46. Satellite communications had provided connectivity at times when a higher bandwidth was required or when regular communications had failed. Inmarsat

satellite phones were used for transmission of surgery video from remote sites and for real-time anaesthesia monitoring. The costs of satellite communications were higher than many smaller health systems could afford, $7.50 for 64 Kbps line, and such communications might also be restricted by the local government and telecommunication companies.

47. For a period of 11 years, the mobile surgery programme had used telemedicine when operating in the Ecuadorian Amazon jungle and the high slopes of the Andes and Pacific coastal plains. During that period, more than 5,000 operations had been carried out, with excellent results, high patient acceptance, no mortality and a very low complication rate. Over the last six years, telemedicine had also been used: (a) for pre-operative evaluation; (b) during operations for tele-mentoring and teaching; and (c) for post-operative follow-up and consultation of primary care family physicians.

48. Telemedicine was an excellent complement to mobile surgery. Pre-operative consultation saved precious time that could be spent in the operating room upon arrival at a remote place. Having an advanced knowledge of the types of surgery needed to be performed, an accurate appraisal of supplies and medicines needed to be taken could be made. The surgeon and anaesthesiologist felt much more comfortable if they knew patients and their problems in advance. More importantly, patients felt much better if they interacted with their doctors before an operation. Telemedicine permitted medical practitioners to maintain contact with patients until complete recovery, overcoming one of the main problems of intermittent mobile surgery.

49. Tele-mentoring in Ecuador was in its initial phase. The operating team being mentored had always had the ability to solve the problem by its own means. There had always been agreement with consultants about the identification of anatomical specifics and the surgical steps needed. Nevertheless, there were situations in Ecuador and in many other places in the world when a patient did not have access to an experienced surgeon and tele-consultation and tele-mentoring could resolve desperate situations and save lives.

C. Landscape epidemiology

50. It was reported that, despite the advances of modern medicine, diseases like malaria, dengue fever and even plague still afflicted millions of people each year, crippling some while proving fatal for others. Many such diseases were spread through infected, bloodsucking mosquitoes, which could cause widespread epidemics by feeding on people or animals then flying to another target. Malaria alone infected 350-500 million people each year, killing at least a million. Advances in satellite remote sensing, global positioning and geographical information systems (GIS), as well as in computer processing, now made it easier to integrate ecological, environmental and other data for the purpose of developing predictive models that could be used in disease surveillance and control activities. However, information about the capabilities of satellite-based remote sensing technology had not been fully disseminated to the health investigators and agencies that could be using them.

51. Landscape epidemiology was a relatively new interdisciplinary approach that involved the characterization of eco-geographical areas where diseases developed. It

could be understood as part of a second-generation application of remotely sensed data where the target could not be seen directly with satellite images. This was a holistic approach, which took into account the relationships and interactions between the different elements of ecosystems on the assumption that the biological dynamics of both host and vector population were driven by landscape elements such as temperature and vegetation.

52. Landscape epidemiology was based on the idea that knowledge of the environmental conditions necessary for maintenance of a pathogen in nature should allow one to identify spatial and temporal distribution of disease risk on the landscape. The geospatial technologies of remote sensing, GIS and GPS provided the tools to achieve the goals of landscape epidemiology. Remote sensing provided for direct measurement of the state of the environment and captured dynamic landscape processes. GIS provided an organizational and analytical framework, allowing a wide variety of environmental data to be pulled together for planning and analysis. GPS allowed work in the field to be easily and accurately related to existing data sources.

53. With the tools of geospatial technologies, one could attempt to delineate host or vector habitats, quantify factors of habitat quality that might influence population dynamics, identify varying degrees of isolation among sub-populations and estimate risks of host/vector species interaction with human activities.

54. Geospatial technologies provided a sophisticated mechanism for identifying the relationships of observed patterns and underlying processes. Such analyses might be exploratory, where observed patterns provided insights for formulation of hypotheses. Alternately, a deductive approach might test whether a process was reflected in the observed patterns. Either way, the examination of pattern and process in geospatial data must include a sophisticated consideration of the effects of measurement scale, as all measurements were affected by the scale of observation. In landscape epidemiology it was necessary to bridge an extremely wide range of scales, from a pathogen up to the landscape. This generally required a hierarchical approach.

55. Because of the challenges in using human case data, it was generally preferable in landscape epidemiology to directly measure the distribution and prevalence of pathogens in the host/vector species. Of course, that assumed that the general type of reservoir species was known. The distribution of human disease might be much more representative of a number of demographic characteristics, rather than having any bearing on landscape characteristics. For example, an area of very high risk might also have a low population density and hence few or no human cases. The complex travel patterns of humans raised questions regarding the actual location of exposure to the pathogen. Other complications, such as variable levels of susceptibility among subgroups, might confuse otherwise clear environmental relationships.

56. Two diseases carried by rodents were considered the major problems in public health in Argentina: Argentinian haemorrhagic fever and the hantavirus pulmonary syndrome. Different activities had been developed using information from remote sensing and GIS to predict the risk of these diseases. Studies had been conducted on the simplified hypothesis of the model of interactions among components of an ecosystem, where it was assumed that the risk of the disease in human beings was

directly related to the density of the population and that that density was influenced by the characteristics of biotic and environmental conditions that could be monitored using satellite-based remote sensing data.

57. Chagas disease, also called American trypanosomiasis, was an infection caused by the parasite *Trypanosoma cruzi*. The disease was transmitted by reduviid bugs, or kissing bugs, which lived in cracks and holes of substandard housing and were found primarily in South and Central America. The insects became infected after biting an animal or person who already had Chagas disease. Infection was spread to humans when an infected bug deposited faeces on a person's skin, usually while the person was asleep at night. The person often accidentally rubbed the faeces into the bite wound, an open cut, the eyes or mouth. Infected mothers could pass the infection to their babies during pregnancy, at delivery or while breastfeeding.

58. Chagas disease primarily affected low-income inhabitants of rural areas and many people caught the infection during childhood. The early stage of infection was usually not severe, but sometimes it could cause death, in particular in infants. However, in about one third of those infected, chronic symptoms developed after 10-20 years. For those who developed chronic symptoms, the average life expectancy decreased by an average of nine years.

59. Approximately 12 million people in Latin America were infected with Chagas disease. Eighty per cent of those cases were due to several species associated with housing. Those species were affected by and associated with environmental variables that could be studied using remote sensing data. Such a study in the region of the great Chaco forest of Argentina was in progress. The identification of areas where vectors were present, as well as differentiating areas with various potentials of re-infestation, was a starting point to building risk maps of re-infestation. That tool would help optimize the assignment of resources in the programmes to control the vectors of Chagas disease.

60. Spatial analysis tools had been applied to vector control of Chagas disease to describe spatio-temporal patterns of re-infestation and identify the epicentres of re-infestation by vectors after blanket residual insecticide spraying of rural communities in north-western Argentina using GIS, satellite images and spatial statistical tools. Understanding the spatio-temporal population dynamics of Chagas disease vectors in domestic and peridomestic habitats might help improve the effectiveness of control efforts. An effective control programme at the community level would be based on residual spraying with insecticides of the colonized site and all sites within a radius of 450 metres in order to prevent subsequent propagation after a community-wide residual spraying with insecticide. In order to reduce adult invasion from infested sites outside the community under surveillance, it was also necessary to cover a buffer zone up to 2,000 metres from the existing communities.

61. Chagas disease was reportedly a public health problem in Paraguay. It was estimated that 400,000 individuals, or 6 per cent of the total population, had been infected by insects mainly present in rural areas. Some 344,048 dwellings in 3,653 localities, distributed throughout 12 endemic departments, had been entomologically evaluated and sprayed in the last five years, and horizontal surveillance systems had been implemented with community participation to ensure the sustainability of vector control activities. Since 2003, GPS had been used by the

Paraguayan national control programme of Chagas disease and the historically recorded entomological database had been geo-referenced.

62. To date, geographical localization and spatial distribution of infested houses in areas under entomological surveillance were being used to visualize in maps the precise location of those houses, occurrence of re-infestation and the risk of infestation of neighbouring houses. Using GPS, the national programme evaluated areas previously sprayed in a retrospective analysis, by detecting spots with conglomerated houses considered to be newly infested dwellings. Those had been proved to be operational field failures that had occurred in the past during vector control activities. Another advantage observed with GPS technology was the possibility of designing operational strategies for vector control, calculating the number of personnel involved, the time required and the cost of transportation to hyper-endemic areas with a very low density of dwellings (60 per cent of Paraguayan territory had 28,500 houses spread over 246,925 square kilometres).

63. Among Latin American countries that carried out vector control activities in connection with Chagas disease, Chile was at an intermediate stage in the elimination of its vectors. The control activities since 1999 had resulted in a decrease in the vectoral transmission of the disease and domestic infection had stayed low. The use of GIS had allowed scientists to define risk areas, focus activities in geographical zones and thus handle individual data by house in the control zone of the Valparaíso region.

64. Dengue fever was caused by a virus transmitted by mosquitoes. It was a severe illness with a sudden onset that usually followed a benign course, with headache, fever, prostration, severe joint and muscle pain, swollen glands (lymphadenopathy) and a rash. The presence of the "dengue triad" of fever, rash and headache, as well as other pains, was particularly characteristic of the fever. It struck people with low levels of immunity. Dengue was now reaching the peak of a roughly five-year cycle. An attack of dengue produced immunity for a year or more, so once the outbreak ebbed, more people would be resistant to the viral disease and the cycle would begin again.

65. The space-time spread of the 2004 outbreak of dengue fever that occurred in the city of Tartagal, in north-western Argentina, was studied by integrating information of patients suspected of being infected with the fever. A total of 487 suspected dengue fever cases were recorded, with the location of their home and the date of onset of the symptoms. The spatio-temporal clustering of the cases was analysed using the Knox test concept. Maps of daily cases were generated for the 109-day outbreak, including 100 per cent of the reported cases. The age distribution of the reported dengue fever cases was different from the age distribution of the overall population in Tartagal, with 24 per cent of the dengue cases in young people under 15; 35 per cent in 15- to 29-year olds; 27 per cent in 30- to 44-year olds; and 14 per cent in those older than 45.

66. The results of the space-time localization of the cases showed some outbreak flash points and patterns of spread that could be explained by entomological and epidemiological factors, such as the mosquito survival, the extrinsic virus incubation and/or the effect of blocking insecticide techniques. A case map was drawn up based on the accumulative incidence of cases and an environmental risk prediction model was developed based on a synthetic multi-band image created

from the Land Remote Sensing Satellite (Landsat) 5 thematic mapper (TM). The final heterogeneity in the space-time distribution of the epidemic was estimated by using remote sensing tools.

67. Space technology was considered useful in evaluating the behaviour of human diseases in an integrated form. Using that approach, the risk of dengue fever was evaluated for two areas of Bolivia, Santa Cruz and Pando: four components were taken into consideration, anthropogenic pressure, climate change and variability, deforestation and ecosystem composition. Anthropogenic pressure was analysed by comparing the population from 1986 to 2000 in both areas. Climate change and variability were compared from 1960 to 1990 and actual climate from 1991 to 2004. Similarly, for both areas, deforestation, land use and land cover were compared using Landsat satellite images from the period 1986-2000. As far as composition of the ecosystem was concerned, previous studies carried out in those areas were used.

68. The results showed an increase of human presence, anthropogenic pressure, deforestation and warmer conditions for the period from January to May in both zones. This was correlated with outbreaks of dengue fever and changes in the vegetation and wild life of the ecosystem.

69. Dengue fever was registered in the Amazon basin of Peru in 1990. Since then, several epidemics of dengue 1, then dengue 2 and dengue 3 fever had occurred in recent years in many regions of the country. The Ministry of Health, through its institutions, had launched several prevention campaigns against the disease. Like many other capitals in Latin America, Lima received a permanent flow of immigrants coming from all over the country, including areas where dengue fever was endemic, namely the northern coast and the Amazon basin. Entomological information was collected and recorded in a GIS. An ad hoc study was conducted to relate the entomological findings of the prevention campaigns to the distribution of dengue fever cases during the outbreak. Similar studies were conducted in Costa Rica.

70. Infectious diseases currently represented an important threat to human health because of the emergence of new microbial species and strains. Changes in the immunological state of the population (people with a compromised immunity, aged people) and the pressures caused by increasing population and climatic changes were among the other reasons. As an example, a recent decrease in the microbiological quality of water and an increase in outbreaks of waterborne disease had been observed worldwide.

71. There was evidence that some environmental and climatic factors were involved in triggering outbreaks of infectious disease. For example, an increase in water temperature favoured multiplication of microbial agents; extremely high rainfall caused excessive run-off and washing of material of faecal origin into potable water; and extreme weather events could damage local sewage systems and cause contamination of water systems. On the basis of data on such factors, some infectious diseases were currently considered “climate-sensitive”, including airborne diseases such as meningitis and legionellosis, vector-borne diseases such as malaria and dengue fever and waterborne diseases such as cholera and salmonellosis.

72. The management of climate-sensitive infectious diseases, and more specifically waterborne diseases, required studies concerning microbial agents: it

became essential to study the ecology of pathogens in aquatic ecosystems, including their survival, transmission, reservoirs, host ranges and adaptative responses to environmental conditions. Moreover, the analysis of the state of health of the population, cultural aspects and feeding habitats could complete the needed information.

73. To predict and prevent outbreaks of waterborne disease, it could be very useful to rely on an early warning system revealing any alarming data or trend change in the climatic/environmental factors influencing the presence and persistence of waterborne pathogens. In general, early warning systems were based on telephonic and telematic communication networks and on epidemiological data allowing for: (a) rapid reporting of detected cases of communicable diseases; (b) isolation of infected people to avoid the spread of infection; and (c) preparations to respond to a possible epidemic. The permanent monitoring of the environmental factors by Earth observation and meteorological satellites would facilitate the construction of growing databases, which, when integrated with clinical and epidemiological data, could be useful in setting up more efficient early warning systems and in creating predictive models.

74. Data from environment monitoring satellites could also be integrated and archived to create models for communicable diseases that contained complete representations of the effects of climate on the population dynamics of pathogens and vectors.

75. Future climate scenarios in the Mediterranean anticipated global temperature increases and other changes that could further exacerbate existing problems over water scarcity and cause a decline in water quality and an increased intrusion of salt water into coastal aquifers. In order to analyse the impact that such changes could have on outbreaks of waterborne disease in the area, an international, multidisciplinary project was reportedly being initiated with the objective of establishing correlations between some environmental factors and the number and distribution of vibrios potentially pathogenic to humans. That relationship would be the basis for the establishment of a satellite-based early warning system capable of predicting and preventing outbreaks of vibrio-related disease in the area.

76. Ocean monitoring by means of satellite remote sensing began in the southern regions of Chile in 2002. Several applications of remotely sensed data from the ocean had been made in relation to public health and socio-economic factors associated with aquaculture and shellfish extraction activities. Scientific research and then a pre-operational project had focused on the use of satellite information to monitor environmental conditions of coastal waters and microscopic sea life and to detect possible deterioration of marine ecosystems.

77. Satellite products, derived primarily from the Medium Resolution Imaging Spectrometer (MERIS) and the Advanced Along Track Scanning Radiometer (AATSR) instruments aboard the ESA Envisat spacecraft, had been used extensively together with in-situ observations and sea-specific measurements. Data from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Terra and Aqua satellites of the National Aeronautics and Space Administration (NASA) of the United States had been also integrated. The advantages of using satellite data for early detection of ocean situations evolving towards marine environmental conditions that could endanger the health of sea and human lives had been widely

demonstrated. Thus satellite information was an important aid to decision-making for public and industry administrators; however, data integration and interpretation by skilled professionals were a fundamental prerequisite in view of the major impact that the final information might have in socio-economic and public health terms.

78. For Chile, as a commercial bridge between the countries of Asia and the Pacific and the Atlantic, it was extremely challenging to keep the country free from diseases such as dengue fever, yellow fever and malaria. Epidemiologists who must monitor those diseases urgently needed space technology-related tools to control their spread. A positive example was the recent control of dengue fever on Easter Island. GIS was becoming a more important instrument in handling re-emerging diseases such as tuberculosis.

79. The rapid growth of the human population, fast industrialization, unplanned housing build-up and forced displacement of population to areas with better socio-economic conditions resulted in perturbations in ecological systems. These factors contributed to the various spatial and temporal changes at different levels (global, regional and local). Such changes affected climate by altering its patterns, which in turn created climatic instability and subsequently altered ecological systems, a good example of which were metaxenic or vector-driven diseases such as dengue fever, encephalitis, malaria, leishmaniasis and Chagas disease. An analysis had been carried out to show how human activity and, in particular agricultural activity, in the State of Sucre of Venezuela (Bolivarian Republic of) were related to the resilience of malaria.

80. It was reported that, from 1930 to 1970, the Ministry of Health of Brazil had been developing programmes to combat malaria in the country, although in some places actions had not been successful. As a result of large-scale economic projects in the northern part of Brazil, new roads and railroads had been built to gain access to natural resources. Infrastructure development projects in Maraba County (State of Pará) had thus resulted in an increase in population in the northern areas and an increase in registered malaria cases. Two Landsat satellite images had been used to compare land use covering around 30 per cent of Maraba County's expansion areas. Processed images showed a reduction of 47.3 per cent of canopy and 51.8 per cent of medium-size vegetation and an increase in zones without vegetation. Those zones had been transformed into agriculture areas. The extraction of natural resources and expansion of agriculture activity in Maraba had exposed a large section of the population to malaria.

81. Malaria cases in Guatemala represented 45 per cent of the total malaria cases in the Mesoamerican region (a region extending south and east from central Mexico to include parts of Belize, Guatemala, Honduras and Nicaragua). Endemic areas in the country represented 74 per cent of the national territory. The population at risk was estimated at around 4 million people.

82. Low-resolution (1 km) SPOT and high-resolution Landsat images and GIS had also been used to analyse the correlation between climatic variability and the presence of yellow fever mosquitoes on the border between Argentina and Uruguay for the period 1998-2003.

83. The virus of St. Louis encephalitis (SLE) was widely distributed in the Americas from Canada down to Argentina. The virus had been isolated for the first

time from a patient during an outbreak of encephalitis in St. Louis, United States, in 1933. The severity of the disease provoked by the virus increased with the age of the patient. The distribution of SLE was wide in Argentina. In Córdoba, the prevalence of antibodies for SLE in human beings was 13.9 per cent. Between January and June 2005, an outbreak of SLE had been registered in the city of Córdoba. A joint effort had been initiated to identify the risk areas in the city by using satellite data and to build up more efficient control of the virus.

84. Tegumentary leishmaniasis was stated to be a re-emergent disease in Argentina. It was transmitted by the bite of infected female phlebotomine sand flies. In the first half of the twentieth century, an average of 40 cases per year had been reported in Argentina. Since 1985, several outbreaks had occurred, with up to 1,200 cases per year throughout the endemic epidemic area. With the objective of developing surveillance and control tools for tegumentary leishmaniasis in Argentina, an approach had therefore been developed combining three different time-space scales with the aid of satellite images: (a) regional 10-year periods; (b) epidemic-focused annual-biannual periods; and (c) vector population site weekly-annual periods. The three approaches, each with its own kind of information, were contributing to the development and validation of risk maps, forecasting models, early warning systems in health and response and surveillance strategies that could be applied in Argentina and adapted for use in other countries of the region.

III. Observations and recommendations

85. The Task Force on Health Using Space Technologies for Latin America and the Caribbean Region had been established. All the workshop participants had become members of the Task Force. Initially, the Task Force would address the following issues and themes: (a) establishment of a network forum aimed at information-sharing, reporting on the status of national projects, exchanging views, lobbying for governmental support in tele-health implementation and so on (completed in October 2005 and hosted by PAHO within its knowledge management framework); (b) identification of national and regional health-related projects; (c) addressing capacity-building in health services using satellite technologies as well as standardization (including common elements of satellite access protocol and interface requirements in the region), taking into account existing legislation of each country and tele-education for public health issues.

86. Participants agreed to implement a regional initiative based on the following components: (a) exploration of the possibility of training in landscape epidemiology to obtain formal academic certification; (b) development of a database for satellite imagery and cartography that could be used as a common baseline to be made available on the PAHO website; (c) development of risk maps and health early warning systems and responses for each disease (Chagas disease and water-, air-, soil-, mosquito-, rodent- and other biota-related diseases); (d) initiation of a chapter of a Latin American association of tele-epidemiology with its possible affiliation with the related worldwide associations; (e) creation of a database of institutions and individuals in the area, with a referential node in each country; and (f) initiation of a specific regional project in the near future.

Notes

[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1.

[2] *Official Records of the General Assembly, Fifty-ninth session, Supplement No. 20* and corrigenda (A/59/20 and Corr.1 and 2), para. 71.