Space Applications for International Development

Executive Summary

Space-related activities generate $257 billion each year and are often thought of as the domain of wealthy and technologically advanced nations. This perspective is misleading, however, as science and technology increasingly help address many of the challenges faced by developing countries. Space systems, particularly communications satellites and remote sensing satellites, have the potential to play a large role in these efforts.

Communications Satellites and Applications

Communications satellites play an important role in increasing the information and communication technology infrastructure of developing nations. A high percentage of the population in many developing nations is located in remote, rural areas that are least likely to have access to terrestrial communication infrastructure. Satellites can provide voice and data broadband service, and the market for satellite communications is high due to the lack of traditional alternatives in rural areas. Communication technology can be used to provide farmers with information that aids productivity. It can enable telemedicine or tele-education in remote areas. After a disaster has occurred, satellite communication may provide the only reliable communication method during the response and rebuilding efforts. The following recommendations would enable the realization of these benefits in a more efficient and effective way:

1. Commercial satellite companies operating in developing nations should work closely with experts in international development and with local government and/or nongovernmental organizations (NGOs) to ensure that space solutions are culturally appropriate. This will allow solutions to be more readily adapted and accepted by these communities.

2. Studies should be initiated to continue to define the market for communications satellite services in developing nations. This will provide an understanding of the complexities and differences in various areas and suggest the best ways to proceed in introducing new technology. This may be done by governments interested in understanding the most efficient method for investing in communications infrastructure, or by companies interested in identifying potential new markets.

3. Governments in developing nations and commercial communications satellite operators should work together to develop a logical regulatory scheme in developing nations. In addition, clear guidance should be provided by governments on how to work within existing regulations.

4. Governments in developing nations should consider investing in affordable ground technology to provide satellite communication access in rural areas, particularly for clinics, schools, and other community centers. The technology would be used to directly address the U.N. Millennium Development Goals as well as national goals in health, education, and other areas.

Remote Sensing Satellites and Applications

Remote sensing satellites are well-suited to addressing some of the challenges faced in developing nations. These satellites provide the ability to observe large areas without the need for data collection on the ground. This may be the only cost-effective way to collect data about large, sparsely populated areas. Satellite remote sensing data can be used to create models that predict outbreaks of many diseases, including malaria, cholera, dengue fever, and others. It can be used to identify conditions conducive to disasters, such as wild fires or famines. This advanced warning allows nations to target relief efforts and provide aid more efficiently, thus reducing costs while saving more lives. Governments can use satellite imagery to make coherent land use policies and support sustainable development and use of natural resources. Remote sensing from space immediately following a disaster can allow a rapid assessment of areas most affected, and aid can then be targeted to these areas. The United Nations High Commission on Refugees (UNHCR) has found that imagery from space can be essential for locating displaced populations and coordinating the provision of aid. Satellite imagery can also be used to identify locations with adequate resources to support refugee populations and act as the basis of U.N.-supported refugee camps. The following recommendations are intended to make these opportunities more widely available:

1. Remote sensing providers, developed nations that own remote sensing satellites, and developing nations should work together to define the means by which reliable and useful remote sensing data can be provided to developing nations, particularly for disease and disaster prevention. This would allow developing nations to begin making use of this data immediately for these essential efforts.

2. Further research should be done to assist developing countries in employing space products to create useful operational models for disease and disaster prevention.

3. Governments in developing nations should support efforts to integrate remote sensing data with other data sources through funding and policy initiatives. Governments should also seek to work with satellite operators in data integration efforts. Systems with integrated data will provide more robust outcomes and reduce uncertainty, which help target action where it is needed.

Capacity Building and Space Applications

The ability of a nation to drive innovation and economic progress depends on its science and technology capacity. According to a report by the RAND Corporation, this includes "the infrastructure, investment, institutional and regulatory framework, and personnel available to conduct scientific research and technological development." Investing in the space sector is a productive method for nations to begin growing their capacity and addressing these issues. At a minimum, nations may cultivate space experts to help understand how space assets can be applied to national priorities. This knowledge would allow the country to have a voice in international efforts related to space and to take full advantage of international space application programs that already exist. A space program can be one part of the science and technology infrastructure of a nation, but its development should be coordinated with the development of supporting institutions, whether public or private. By starting a space program,

developing nations can grow and maintain a technologically advanced workforce. They can also encourage increased study of science and technology, including space science and engineering, in schools and universities. Initially, engaging in space activities may be challenging for developing nations, and these recommendations offer methods to help facilitate their entry into this field:

1. Space programs in developing nations should begin by focusing on programs with a direct benefit to society. They should keep costs as low as possible and ensure that the benefits are clearly communicated to the public. It is advisable for governments to track the return on their investment so the public understands that the funds are being used wisely.

2. Developing nations should consider international collaboration as a method for incremental development of a space program. Working with developed nations, already experienced in creating space technology, can help to reduce risk and reduce costs.

3. When creating their own national policies, developing nations should take note of other nations' existing national legislation on space activities. This effort should be coordinated with the United Nations' efforts to identify common principles, norms, and procedures among nations with existing space legislation.

Efforts must be undertaken to increase awareness of the benefits of space assets to developing nations and the specific challenges that they face. This will lead to the development of space technologies tailored to the needs of these nations. Research should be done to develop applications for small scale entrepreneurial and agricultural uses. Research should address simpler, more automated applications for tele-education, telemedicine, and telebusiness. The developed world should provide support in building indigenous science and technology capacity in developing nations through increased cooperation in the space sector. By taking steps such as these, the benefit of space applications can be realized by developing nations.

Background

The World Bank classifies 144 nations, more than two thirds of the world's total, as middle or low income – often referred to as developing nations.[1] These nations are located throughout the world but are concentrated in Africa, Latin America, and Southeast Asia. Developing nations are often home to low-density populations in rural areas, with little transportation or communication infrastructure connecting these regions. They frequently struggle to meet the basic needs of their citizens. Food is often scarce and malnutrition is common. Millions of people die each year of preventable diseases, many of them young children. Housing is often inadequate and does not provide protection against natural disasters. In response to this situation, the United States and other developed nations spend billions of dollars each year on aid for developing nations.[2] These programs provide food, clothing, medicine, and other essentials. Yet, despite these efforts, the problems of developing nations continue to grow.

Space-related activities generate $257 billion each year and are often thought of as the domain of wealthy and technologically advanced nations.[3] This perspective is misleading, however, as science and technology increasingly help address many of the challenges faced by developing countries. Space systems, particularly communications satellites and remote sensing satellites, have the potential to play a large role in these efforts. Communications satellites can connect remote areas, allowing the spread of information, whether for medical purposes, education, or disaster relief. Remote sensing satellites allow rapid collection of data about large areas of land – information that is essential to creating models for predicting and preventing famine or disease. Remote sensing can also be used to monitor conflicts or natural disasters and help identify where aid is needed most. Developed nations should work with developing nations to create these capabilities.

International Activity

There has already been a noticeable trend of growth in the number of developing nations beginning or expanding their space activities, including India, Brazil, Nigeria, and many others. Developed nations are also recognizing the value of applying space applications to the needs of developing nations. NASA provides satellite data and expertise to the Famine Early Warning System (FEWS) for developing nations.[4] Africa and the European Union have developed a partnership with the African Union for "Science, Information Society and Space."[5] The United Nations Program on Space Applications carries out projects to promote the practical uses of space technology in sustainable development, particularly in developing countries.[6] These efforts indicate that governments and international organizations are beginning to recognize the potential for space assets to be used to help address the challenges faced by developing nations.

Commercial Involvement

Commercial companies are involved as well. Intelsat, the world's largest satellite communications company, has supported projects using satellite-based models for improving education and health in Africa.[7] A number of satellite communications companies, such as SES World Skies, offer communication services in developing areas. These activities are having an impact, and their specific application and future development are important for all nations and their leaders to understand and support.

In addition to the practical solutions communication and remote sensing satellites can provide for addressing national challenges, indigenous space activities have the potential to enable wide-reaching economic growth, allowing countries to break the cycle of poverty and international aid. These space programs may consist of trained professionals and facilities capable of analyzing data collected by the satellites of other nations, rather than indigenously developed satellites, rockets, or other hardware. Indigenous space programs enable developing nations to focus the use of space assets on objectives that are critical for survival and growth. By investing in space capabilities, developing nations spur progress in science and technology in the broader sense. Building the

human and technical infrastructure for space activities helps develop educated citizens and technology-smart government. It also encourages high-tech industry to grow. Investing in space activities can play a part in allowing developing nations to take control of their futures.

Space infrastructure and assets certainly cannot solve all of the problems these nations face, but they can provide a valuable means to help them improve physical conditions for their people and economies and reduce their reliance on foreign aid. These practical uses make space an important, if not essential, investment for sustainable development in Third World countries.

Investment in Space Activities

It is important to understand that significant investment is not necessary in order for developing nations to reap the benefits of space technologies. Applications of space assets – such as famine or disease prediction maps – may be created by countries with well developed space programs, or by international groups like the United Nations, and provided to developing nations for little or no cost. However, a developing nation may gain additional benefit by creating its own space program. At a minimum, a space program may simply include a group of space experts, enabling the country's leadership to understand how space assets can be used to address its national goals. This understanding can guide future national space policy and can be expressed in global forums, giving the nation a voice in international efforts. It can also provide the country a starting point for identifying and cultivating strategic partnerships with nations that already have advanced space technology. With more investment in cultivating trained experts as well as some investment in research and analysis facilities, developing countries can carry out their own analysis on remote sensing data provided by developed nations or international organizations at a low cost or even for free. This level of investment and capability would allow many, if not all, of the benefits discussed in this paper to be realized. Nations interested in further investment in space may choose to develop their own hardware, such as communications or remote sensing satellites. This can be done with limited funds by including training programs as part of a satellite-building contract. This was the approach Nigeria took in its partnerships with Surrey Satellite Technology, Ltd. (SSTL) in the United Kingdom.

FIGURE 1

Communications Satellites and Applications

Information and communication technology (ICT) has been recognized as a key enabler of development. This technology provides remote locations with a link to information and to the rest of the world. Only 9.7 percent of the population in developing nations has access to Internet services; this is one sixth as many as in developed countries. Internet access in developing nations is also unevenly distributed. According to United Nations Conference on Trade and Development, four out of 54 countries in Africa (Nigeria, Morocco, Egypt, and South Africa) account for almost 60 percent of Internet users in the region. The number of users is considerably lower for broadband Internet connections, which enable applications such as the high quality video needed for telemedicine. No country in Africa has more than 2 percent broadband penetration.[8] With

such a small portion of the population having access to information and the ability to communicate, technological progress and development are difficult.

Communications satellites play an important role in increasing the ICT infrastructure of developing nations. A high percentage of the population in many developing nations is located in remote, rural areas that are least likely to have access to terrestrial communication infrastructure. This is often due to the cost or difficulty of installing fiber cables or cell phone towers in remote areas with rough terrain. However, satellite backbones for rural connectivity provide an alternative. Satellites can provide voice and data broadband service, and the market for satellite communications is high due to the lack of traditional alternatives in rural areas. A number of satellite operators, such as SES World Skies, Eutelsat, Intelsat, Hispasat, Thuraya, and others already offer services in developing areas. Indonesia, a lower middle-income nation made up of more than 6,000 inhabited islands, developed a communications satellite constellation in the 1970s. Since then, this constellation has provided regional communications for the country as well as coverage in the Philippines, Malaysia, and Singapore.[9]

The United Nations Millennium Development Goals highlight some of the challenges faced by developing nations, including poverty and hunger, a lack of access to education, and health issues. Space systems that supply Internet and voice connectivity can help developing nations and provide numerous opportunities for addressing these issues and improving the situation of rural populations.

Agriculture and Business

The availability of information in remote areas provides previously isolated people with an opportunity to increase the security and productivity of their business or possibly expand their trade to new markets. Agriculture is the primary industry in many rural areas, and communications connectivity allows farmers to receive critical weather forecasts, market price information, and expert advice on how to increase productivity for existing crops or grow additional crops. A program in South Africa in which farmers received text messages regarding correct irrigation timing was estimated to have saved these farmers approximately $300 per hectare (2.47 acres).[10] This money could then be reinvested in other farm improvements. The Indian Space Research Organisation (ISRO) has already begun a program to provide satellite communication services to 600,000 villages throughout India. These Village Resource Centres (VRCs) would provide access to a variety of space-based services and deliverables, including information on natural resources and interactive advisories on agriculture, fisheries, and resource management for both land and water.[11]

Medicine

Providing adequate medical care in remote areas poses a number of difficulties. Rural clinics are often not well staffed and lack professionals trained in specialty fields. Telemedicine has the capability to provide assistance and expertise to personnel working in remote areas. This technology has been used in the United States for more than 40 years, providing improved access to rural communities at lower costs.[12] The International Institution for Communication and Development (IICD) recently conducted a project focused on teleradiology in Mali. There are approximately a dozen radiologists in the country, all located in the city of Bamako, Mali's capital. IICD set up the necessary technology infrastructure, such as scanners, software, and Internet connections, and provided training to allow rural clinics to send x-rays to a central hospital in Bamako. The radiologists in Bamako were then able to provide diagnoses to the patients at the rural clinics. In one case, an initial diagnosis in a rural clinic of bone cancer was revealed by radiologists at the central hospital to be an error in the radio film, saving the patient from an unnecessary amputation.[13] In another example, Intelsat partnered with the Digital Solidarity Fund, an organization whose goal

is to reduce the digital divide, to set up broadband satellite infrastructure in medical clinics in remote areas of the west African country of Burkina Faso. This enabled doctors at these clinics to communicate with other health professionals and receive ongoing training.[14] Well-connected medical clinics in developing nations could contribute to many lives being saved.

Education

Education and the opportunities it provides are key to eliminating poverty. Schools in remote areas can benefit greatly from access to ICT. Distance learning courses allow teachers to continue their education and access curricula updates while students obtain information and educational materials that would not otherwise be available. Online education programs are also of great benefit for adult education and job training. Access to the Internet is essential for post-secondary students in developing nations because it is often the only method for viewing academic journal articles. Without this type of connectivity, it is almost impossible for students in developing countries to participate in and contribute to globally relevant research. One of the leaders in this field has been the Indian government, which recognized the potential of space technology for improving education. In 2004, ISRO launched EDUSAT, a communications satellite dedicated to educational uses. Within its first four years of operation, ISRO used the EDUSAT to provide connectivity to more than 30,000 classrooms. EDUSAT's broadcasts and interactive networks cover 20 states within India. In 2008, ISRO worked with the prestigious Indian Institute of Technology (IIT) in Bombay to provide satellite-based tele-education facilities to students and teachers at engineering colleges across the country.[15]

Disaster Relief

Reliable access to communication technology is essential before and after natural disasters. Without this, it is almost impossible to provide adequate advanced warning to populations in remote areas. Advanced warning systems may rely on satellites for sending real-time alerts, particularly to boats and airplanes. Tsunami early warning systems rely on ocean-based sensors that send warnings to alert centers via communications satellites.[16] After a disaster has occurred, satellite communication may provide the only reliable communication method. After Hurricane Katrina hit the United States, usage of satellite communications was estimated to be 30 times higher than normal. Within a week of the disaster, more than 10,000 satellite phones had been shipped to the region, with most being used by emergency-response agencies.[17] Following a flood in Zambia in April 2008, the International Telecommunications Union (ITU) Framework for Cooperation in Emergencies provided 25 satellite terminals to aid in coordination of humanitarian aid efforts. As part of the effort, Thuraya satellite phones were used for voice communications and GPS locating, and Inmarsat terminals were used for voice and high speed data. These assets were critical for effective response.[18] Satellite communication can also be essential for longer-term rebuilding. Construction workers in remote areas of Afghanistan have used satellite technology to communicate and send updated photographs and engineering plans to main offices. Previously, this communication would only have been possible through frequent trips into cities, greatly slowing their progress.[19]

Recommendations

Social Considerations

Bringing Information and Communication Technologies (ICT) to developing nations is not an automatic solution for every situation. There are scores of examples of projects that have failed due to inadequate understanding of social issues and local conditions. Equity of access and the effect on local culture must both be considered.[20] This may include relatively

straightforward issues such as the ability of a non-English speaking community to make use of the Internet or Western keyboards. It could also include considerations of the effect of greater access to Western culture on remote societies.[21]

ICT must be need-driven rather than technology-driven, and the full lifecycle of a project should be considered. Adequate training must be provided when infrastructure is installed, and issues and costs associated with maintainability must be addressed.

Recommendation:

Commercial satellite companies operating in developing nations should work closely with experts in international development and with local government or nongovernmental organizations (NGOs) to ensure that space solutions are culturally appropriate. This will allow solutions to be more readily adapted and accepted by these communities.

Regulatory Reform

For satellite communication technology to become a real solution in developing countries, it is important that governments in developing nations reform existing regulatory schemes or make efforts to improve public understanding of current regulations.[22]

For instance, the regulatory framework for telecommunications varies among the 54 nations in Africa. Even within countries, existing regulations may be confusing. This makes coordination among nations difficult and provides challenges for international organizations, which must go through a wide variety of licensing procedures to operate in multiple countries.[23] Commercial companies and international organizations can help to provide guidance. Existing activities in this area, such as the coordination of regulatory workshops by the Global VSAT Forum, should be encouraged.[24]

Recommendation:

Governments in developing nations and commercial communications satellite operators should work together to develop a logical regulatory scheme in developing nations. In addition, clear guidance should be provided by governments on how to work within existing regulations.

Identifying Specific Market Opportunities

According to *The Space Report 2009*, industry analysts agree that satellite transfer or "backhaul" of cellular communications, among other satellite services, will be key to the growth of the communications satellite industry. [25] The relevance of satellite-based information and communication technology among other options, such as cell phone or fiber-based ICTs, will vary by location. It is likely that in cities and other highly populated areas, cell phone towers and fiber optic cables will provide most connectivity. However, this is usually not the case in more remote areas. In these regions, the cost per user of installing cell phone towers or cables may be prohibitive, while small satellite terminals are viable. However, these terminals still require a relatively large investment, and participation of national governments in promoting and distributing this technology is likely necessary. In addition to physical differences among regions, there will be differences in culture, economic well-being, and daily activities. Companies should take into account these differences, and tailor cost, business models and product designs to specific regions.[26]

Communications satellite operators have recognized that developing nations provide a large potential market in need of connectivity. Some companies are already working to take advantage of this growing market. The O3B Networks, a small start-up company, aims to provide broadband connectivity for the "other 3 billion" people in the world who do not have Internet access. To do this, O3B plans to put five satellites into low Earth orbit by late 2010, with additional satellites at a later date. The mission is to lower costs and increase availability, particularly in developing nations in Africa, the Middle East, Asia, and Latin America. In addition, the International Telecommunication Union (ITU) "Connect the World" program aims to mobilize resources of companies, governments, and other organizations to provide connectivity to the places in the world where it is not yet available.[27] Additional projects that focus on the needs of this population are likely to grow. Better understanding of these needs may best be accomplished by partnering with local development organizations or local user communities.

Recommendation:

Studies should be initiated to continue to define the market for communications satellite services in developing nations. This will provide an understanding of the complexities and differences in various areas and suggest the best ways to proceed in introducing new technology. This may be done by governments interested in understanding the most efficient method for investing in communications infrastructure, or by companies interested in identifying potential new markets.

Cost-Effective Ground Infrastructure

The operation of communications satellites that provide service in developing nations must be complemented with cost-effective ground infrastructure to enable use of these services. Technology has advanced at an impressive rate, and there are a number of promising options to fill this need, including Very Small Aperture Terminals (VSATs) as well as mobile satellite services (MSS).

Approximately 2.5 meters (8.2 feet) in diameter, VSATs are about 1/10th the price of older, larger satellite terminals.[28] Compared to fiber and towers, VSATs require less significant infrastructure investments. Remote terminals can be installed relatively quickly and easily by field technicians in all kinds of terrain. VSATs are designed for low power use, and can be run using built-in or attached solar panels if electricity is not available. [29] National governments should consider the integration of VSAT technology as a method of providing communications access in rural areas.

MSS technology can provide voice and data connectivity via handheld satellite phones. Certain models of handheld devices can be battery-operated and solar-charged. These small systems eliminate the need for complicated or costly installation efforts. In the United States, mobile chips are already being developed that integrate satellite and cellular communication technology, to allow mass market access to satellite connectivity.[30]

Recommendation:

Governments in developing nations should consider investing in affordable ground technology to provide satellite communication access in rural areas, particularly for clinics, schools, and other community centers. The technology would be used to directly address the U.N. Millennium Development Goals as well as national goals in health, education, and other areas.

Remote Sensing Satellites and Applications

Remote sensing satellites are well-suited to addressing some of the challenges faced in developing nations. These satellites provide the ability to observe large areas, without the need for scientists or data collection on the ground. This may be the only cost-effective way to collect data about large, sparsely populated areas in developing nations. For example, in Egypt, where 96 percent of the nation consists of desert, remote sensing offered one of the few methods for studying the vast desert.[31] In fact, the Egyptian Space Research Center was originally operated as a part of the Desert Environment Research Institute within Minufiya University.[32] Remote sensing satellites vary in their capabilities and can gather imagery and data at more wavelengths than the human eye can perceive unaided. This technology has allowed a wide array of applications to be developed to address many of the needs of developing nations.

Medicine

Although malaria has been eradicated in the United States and other developed nations, it is still a serious concern in developing countries. According to the U.S. Centers for Disease Control and Prevention, malaria, which is spread through mosquito bites, kills more than one million people each year, most of them young children in sub-Saharan Africa. Remote sensing satellites can identify meteorological conditions and geographical areas where mosquitoes are most likely to thrive. This data can be analyzed and combined with other information to generate risk maps. Officials are then able to target distribution of resources, such as mosquito nets for sleeping quarters, to prevent outbreaks in the regions most likely to be affected.[33] Similar processes can be used to predict and avoid outbreaks of many other diseases, including cholera, dengue fever, and dysentery.[34] Using these methods to target relief efforts can help developed nations provide aid more efficiently, thus reducing costs while saving more lives, and can help developing nations identify and try to provide long-term solutions in problem areas.

Land Use Planning

Remote sensing satellites often take multiple images of the same areas over an extended period of time. Analyzing changes in these images can provide insight into changes in land use and population. It is possible to see where land is being cultivated, where groundwater is available, and where deforestation is prevalent.[35] Governments can use this information to make coherent land use policies and support sustainable development and use of natural resources.[36] The Brazilian National Institute for Space Research operates a deforestation monitoring and warning system in the Amazon region.[37] Remote sensing data can also play a role in urban planning by allowing governments to monitor urban expansion over time.[38] This type of information will allow governments to make informed decisions about how to direct development, supporting growth in areas with drinkable groundwater and arable land. A more organized development of urban areas could significantly improve the quality of life for people in these areas.

Disaster Prediction

A United Nations report in 1998 on the use of Space for Disaster Prediction, Warning, and Mitigation estimated that in 1992 the world economy lost more money (US $62 billion) from natural disasters in the less developed countries than it spent on development aid (US $60 billion).[39] Just as remote sensing data can be used to identify environmental conditions likely to lead to

disease outbreaks, it can be used to identify conditions conducive to disasters, such as wild fires or famines. The Famine Early Warning System (FEWS), funded by the United States Agency for International Development (USAID), integrates remote sensing information with other data, such as market prices for food, to provide predictions of areas at risk of famine.[40] Fire prediction using remote sensing data has already been implemented in the United States and could be extended for use in developing nations.[41] Research has also been carried out on earthquake prediction from space.[42] Being able to accurately predict areas at risk of natural disasters allows nations to address these issues in advance, saving many lives, and conserving or redirecting funds that would otherwise have been spent on expensive relief efforts.

Satellite image of a large dust storm off the coast of North Africa.

Picture courtesy of GeoEye Satellite Image

Disaster Relief

A natural disaster, such as an earthquake or tsunami, can have devastating effects on a developing nation. Remote sensing from space immediately following a disaster can allow a rapid assessment of areas most affected. Aid can then be targeted to these areas. Since there is often little communication or transportation infrastructure in developing nations, this information may be impossible to collect in any other way. The International Charter on Space and Major Disasters was developed by the European and French Space Agencies in 2000. Signatories to this charter commit space resources to support the provisions of the Charter and thus help to mitigate the effects of disasters on human life and property.[43] China, which is a member, activated the charter in response to the 2008 earthquake in Sichuan, giving response teams access to 18 satellites run by other charter members. Satellite imagery was used to assess damage and more efficiently distribute resources.[44] The United Nations Office for Outer Space Affairs partnered with the United Nations Development Program on a project called "Space-based Information for Disaster Management and Emergency Response" (UN-SPIDER). The mission of UN-SPIDER is to ensure that all countries have access to and develop the capacity to use space-based information to support disaster management.[45] However, this program is in its early stages, and further innovations in the use of remote sensing technology for disaster relief are essential to providing a more rapid response.

Efficient Aid Distribution

In conflict situations, it is common for large groups of people to flee their homes, resulting in internally displaced people and refugees. In these cases, the international community would like to provide aid as quickly and efficiently as possible, but locating such groups can be a challenge. The United Nations High Commission on Refugees (UNHCR) has found that imagery from space can be essential for locating displaced populations and coordinating the provision of aid. Satellite imagery can also be used to identify locations with adequate resources to support refugee populations and act as the basis of U.N.-supported refugee camps. For example, satellite images and geospatial information were used by the UNHCR to identify surface and ground water resources to assist Sudanese refugees in Chad.[46] Applying satellite technology in situations such as this can save time, money, and lives. It is important that developed country governments and international aid organizations continue to develop satellite applications that allow for more targeted and efficient aid distribution.

Lower Cost and Improved Data Quality

Although remote sensing has the potential to be very useful, access can be limited by cost and availability of data. If developing nations do not own or do not have assured access to a satellite, it may be difficult to ensure that they will be able to obtain the appropriate data. Depending on the data quality and the level of correlation of the data with observed effects, uncertainty and error in prediction still pose a challenge.

The image resolution of remote sensing satellites continues to improve. This can include spatial resolution, which affects the level of detail that can be seen in a given area, as well as other types of resolution, such as radiometric, which allows scientists to distinguish more precisely between different types of materials detected. Increased precision in imaging will lead to more targeted and reliable prediction models, and a greater reliance on remote sensing in the future.

Recommendation:

- Remote sensing providers, developed nations that own remote sensing satellites, and developing nations should work together to define the means by which reliable and useful remote sensing data can be provided to developing nations, particularly for disease and disaster prevention. This would allow developing nations to begin making use of this data immediately for these essential efforts.
- Further research should be done to assist developing countries in employing space products to create useful operational models for disease and disaster prevention.

Increased Integration (Geospatial Information Systems)

Remote sensing is a very useful technology and its utility can be greatly enhanced by integrating or fusing remote sensing data with other location-specific data. This data, which includes geographic positioning information, is often referred to as geospatial data. Comparing satellite imagery with historical information or ground-collected geospatial data can improve interpretive and predictive capabilities. Adding relevant parameters to models, such as economic or social conditions, will improve image-only predictions. This trend is already being seen in many academic studies and in programs such as FEWS. Adding supporting data to remote sensing models, or incorporating remote sensing data into existing models will provide more robust results. As integration with other data leads to more reliable observations and predictions, these models are likely to become further integrated into decision making processes, improving their effectiveness for informing policy and action. The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) is actively promoting the use of space-derived geospatial data for sustainable development. Multiple delegations to the committee noted that it is "of paramount importance for developing countries to develop their own national infrastructure for space-derived geospatial data."[47]

Recommendation:

Governments in developing nations should support efforts to integrate remote sensing data with other data sources through funding and policy initiatives. Governments should also seek to work with satellite operators in data integration efforts. Systems with integrated data will provide more robust outcomes and reduce uncertainty, helping to target action where it is needed.

Figure 2: Developing Countries with a Space Program

Country	Income Group*
Algeria	Lower Middle
Argentina	Upper Middle
Bangladesh	Low
Brazil	Upper Middle
Bulgaria	Upper Middle
Chile	Upper Middle
China	Lower Middle
Colombia	Lower Middle
Egypt, Arab Rep.	Lower Middle
India	Lower Middle
Indonesia	Lower Middle
Iran, Islamic Rep.	Lower Middle
Kazakhstan	Upper Middle
Korea, Dem Rep.	Low
Malaysia	Upper Middle
Mexico	Upper Middle
Nigeria	Low
Pakistan	Low
Peru	Lower Middle
Philippines	Lower Middle
Poland	Upper Middle
Romania	Upper Middle
Russian Federation	Upper Middle
South Africa	Upper Middle
Thailand	Lower Middle
Turkey	Upper Middle
Ukraine	Lower Middle

*World Bank income groups as of 2008. According to the World Bank, "Low-income and middle-income economies are sometimes referred to as developing economies. The use of the term is convenient; it is not intended to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development. Classification by income does not necessarily reflect development status."[50]

Capacity Building and Space Applications

Science and technology drive innovation, and their importance to economic growth is recognized throughout the world. The ability of a nation to drive innovation and economic progress depends on its science and technology capacity. This includes "the infrastructure, investment, institutional and regulatory framework, and personnel available to conduct scientific research and technological development."[48] Much work has already been done to increase the science and technology capacity in developing nations.

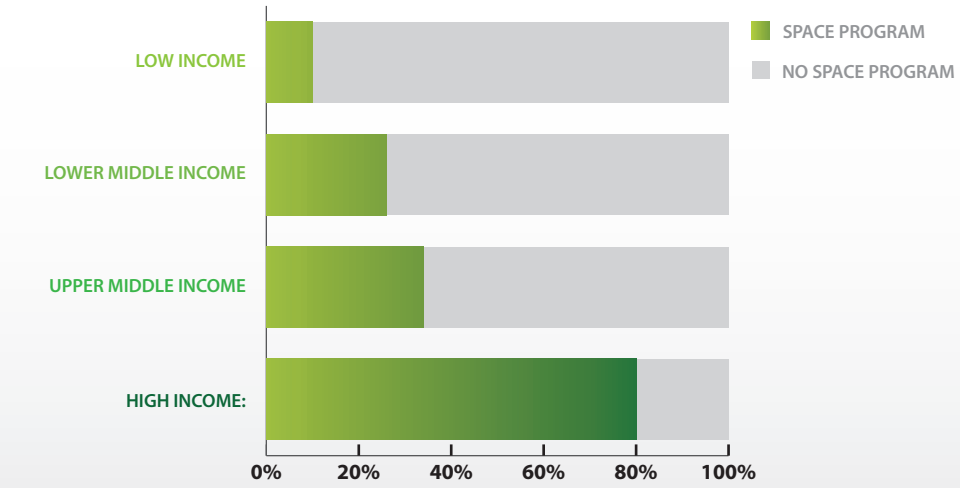
If developing nations are able to foster their own science and technology sector, they can reduce reliance on other nations. They can create human capital and address the specific needs of their nation. Increased science and technology capacity would allow developing nations to accelerate development. Well-trained scientists and engineers can increase communication and collaboration with other nations and improve international relations. Investing in the space sector is a productive method for nations to begin growing their capacity and addressing these issues.

There are already a number of developing nations that have space capabilities. Figure 2 shows a list of developing nations that have space programs or capabilities, along with their income level as defined by the World Bank in 2008.[49]

Investment and Infrastructure

There are many ways that a nation can create science and technology capacity, and supporting space activities should not be the only method undertaken. However, space programs are attractive because they can be developed incrementally. At a minimum, nations may cultivate space experts to help understand how space assets can be applied to national priorities. This knowledge would allow the country to have a voice in international efforts related to space and to take full advantage of international space application programs that already exist. A nation may chose to train professionals and develop facilities to apply data gathered by other nations' space assets to address its own priorities, without investing in its own hardware. Egypt followed this path when it opened a Remote Sensing Center in 1971, nearly three decades before launching its own remote sensing satellite in 1997.[51] If a country does decide to develop hardware, this can be done through strategic partnerships to avoid the costs of developing the capability from scratch. Nigeria began by contracting China to build and launch its satellites, while also training Nigerian engineers in the process. The Nigerian government intends to gradually develop indigenous

design, manufacturing, testing and integration capabilities. These practices allow nations to gain technological expertise while minimizing initial capital costs.



Low and Middle Income groups are drawn from World Bank data for 2008. The High Income group consists of member states of the Organization for Economic Cooperation and Development (OECD).

FIGURE 3

A space program can be one part of the science and technology infrastructure of a nation, but its development should be coordinated with the development of supporting institutions, whether public or private. The creation of a space program will necessitate the creation of other science and technology infrastructure in the nation. It will promote public investment in science and technology, and require prioritization of issues, policy making, and regulation. If a nation runs a domestic space program, it is able to focus research to address its own needs. All of these developments add to the science and technology capacity of a nation.

Technologically Advanced Workforce

By starting a space program, developing nations can grow and maintain a technologically advanced workforce. The space sector is recognized worldwide as an indicator of science and technology ability. A successful space program can help attract and maintain native talent. This is seen in India, as the successful launch of their lunar probe, Chandrayaan-1, has caused many highly trained Indian citizens living abroad to become interested in returning.[52] In addition to scientists and engineers, a space program facilitates the growth and learning of technologically-savvy policy makers, which can be important to innovation policy and future growth. Nigeria has made developing a pool of Nigerian satellite engineers a cornerstone of its space program. Already, Nigeria has more than 100 spacecraft engineers who have the capacity to design, assemble, integrate and test a satellite with available facilities. Nigerians have developed competency in spacecraft station-keeping as well as telemetry software engineering. These capabilities are now being channeled in applied research to address national needs and challenges.[53]

NX and NigeriaSat-2, the latest spacecraft manufactured for the National Space Research & Development Agency, under environmental testing at Rutherford Appleton Laboratory, Didcot UK. Both satellites were manufactured at SSTL Guildford.

Picture courtesy of SSTL

Education

Not only does the development of a space program result in the training and growth of the workforce in the program, it also leads to increased study of these topics in schools and universities. Knowing that there are opportunities for employment encourages students to study science and technology. India has established a space university at Thiruvananthapuram where

students train in space technology and applications specifically to support the personnel needs of its space program. Similar institutions have been founded in Nigeria. The United Nations has supported these efforts by creating five Regional Centres for Space Science and Technology Education, located in Mexico, Brazil, Morocco, Nigeria, and India. The principal goal of each centre is "the development of the skills and knowledge of university educators and research and applications scientists."[54] In addition to supporting advanced education by creating a need for scientists and engineers, space programs can provide the data needed to support advanced graduate research. For example, government-owned satellite imagery can be provided to universities for free, allowing graduate students, including those in non-technical fields, to work with relevant data.

Recommendations

Focus on Economic Benefit

Because space programs have traditionally been the province of large, developed nations, the cost of entry to this industry has typically been viewed as prohibitive to developing nations. Space activities are sometimes mistakenly considered to be purely a matter of prestige, without offering a direct benefit to society. In developing countries, which face high rates of poverty, famine, and disease, the logic of investing in space activities may be not be obvious immediately. This could lead to a lack of public support for space activities, causing a nation to choose not to invest in this area.

Space agencies in developing nations should begin by focusing on addressing national priorities. The research and activities in these space agencies should be based on direct benefit to society rather than pure science or exploration. Space assets may include communication and remote sensing satellites, with less emphasis on astronomy research satellites or human space flight programs. This allows nations to make clear the benefits of a space agency and helps defend against arguments that space assets are not an efficient use of public funds. This is already seen in the large-scale efforts focused on these topics in places such as India, Brazil, and Nigeria.

Recommendation:

Space programs in developing nations should begin by focusing on programs with a direct benefit to society. They should keep costs as low as possible and ensure that the benefits are clearly communicated to the public. It is advisable for governments to track the return on their investment so the public understands that the funds are being used wisely.

National Legislation

As developing nations make the decision to begin space activities, it is necessary to create the policy framework to support these programs. Often national legislation is necessary in order to coordinate national space activities, regulate private sector involvement, or fulfill treaty obligations; however, regulation of governmental and non-governmental space activities is a complicated legal issue. To create legislation, it would be beneficial for developing countries to make use of existing space-related legislation. The United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) has recognized this need and created a working group on "National Legislation Relevant to the Peaceful Exploration and Use of Outer Space." One of the aims of this group is to develop a paper providing an overview of existing national regulatory frameworks based on information received from Member States. It has recognized that this would contribute to "capacity-building in space law" and would be particularly valuable to developing countries.[55]

Recommendation:

When creating their own national policies, developing nations should take note of other nations' existing national legislation on space activities. This effort should be coordinated with the United Nations' efforts to identify common principles, norms, and procedures among nations with existing space legislation.

International Collaboration

Numerous international cooperative efforts are currently underway. These include regional space alliances, such as the proposed African Association of Remote Sensing or the Asia Pacific Satellite Communications Council. There are also partnerships between developing and developed nations. The United States, Europe, Russia, and others have collaborated with developing nations to support space technology development. China has worked with both Nigeria and Venezuela to develop satellites and train space professionals.[56]

In addition to official government-to-government interaction, there are events such as the Global Space Development Summit, organized by the Center for Strategic and International Studies in partnership with the Space Foundation, the American Institute of Aeronautics and Astronautics, and the Chinese Society for Astronautics. This event is intended to bring together individuals from around the world from governments, nonprofit organizations, industry, and academia to focus on the future of international coordination and governance structures for space development. Another event, the International Astronautical Conference, held by the International Astronautical Federation, the International Academy of Astronautics, and the International Institute of Space Law attracts an average of 1,500 participants a year and has been held in a wide variety of locations, including India and Brazil.

There are some developing nations, such as Kenya, Bolivia, and Nicaragua that do not have national space programs but are a part of UN COPUOS, which provides them a voice in the international space community. Collaboration can, and should, take place on multiple levels, including with universities, commercial companies, NGOs, national governments, and international organizations. Because nations may have difficulty developing space capabilities independently, there is likely to be an increase in international collaboration – both among developing countries and between developing and developed nations.

Recommendation:

Developing nations should consider international collaboration as a method for incremental development of a space program. Working with developed nations, already experienced in creating space technology, can help to reduce risk and reduce costs.

Conclusion

Developing nations face a number of serious social and economic challenges. Developed nations provide aid, but often it is not distributed efficiently and does not help to build developing nations' capacity to address the root causes of these issues. Science and technology, and particularly space technology, can contribute to addressing these issues.

Communications satellites can be used to connect people in remote areas. They provide medical expertise to areas where specialized personnel are not available. Communications satellites can help students and teachers to access improved educational content. They promote business and growth. Remote sensing satellites improve health and safety by providing information that leads to disease avoidance and food security. Remote sensing can help sustainable development by informing policy-makers about changes in land use. It can be essential to providing timely aid in the event of a natural disaster. If developing nations choose to invest in space technology and develop their own space programs, they can enhance their science and technology capacity and experience increased economic growth.

Efforts must begin to increase awareness of the benefits of space assets to developing nations and the specific challenges that they face. This will lead to the development of space technologies tailored to the needs of these nations. Research should be done to develop applications for small scale entrepreneurial and agricultural uses. Research should address simpler, more automated applications for tele-education, telemedicine, and telebusiness. The developed world should provide support in building indigenous science and technology capacity in developing nations through increased cooperation in the space sector. By taking steps such as these, the benefit of space applications can be realized by developing nations.

If you have questions about this paper, please contact research@spacefoundation.org or call 202.463.6122.

Marty Hauser
VP, Washington Operations, Research and Analysis

Mariel John
Research Analyst

To learn more about the Space Foundation, visit www.SpaceFoundation.org
Space Foundation research products can be found at www.SpaceFoundation.org/research

End Notes

1. "Country Classification." *Data & Statistics*. The World Bank. Web. 21 Aug. 2009. <http://go.worldbank.org/K2CKM78CC0>.
2. Shah, Anup. "US and Foreign Aid Assistance." Global Issues. 13 Apr. 2009. 30 June 2009 <http://www.globalissues.org/article/35/us-and-foreign-aid-assistance>.
3. The Space Report 2009. Publication. Colorado Springs: Space Foundation, 2009. 26 August 2009 <http://www.thespacereport.org/>.
4. "Famine Early Warning Systems Network." FEWSNET Home Page. United States Agency for International Development. 30 June 2009 <http://www.fews.net>.
5. "The EU-Africa Strategic Partnership." Europa - The European Union On-Line. 30 Sept. 2008. 30 June 2009 <http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/601&format=HTML&aged=0&language=EN&guiLanguage=en>.
6. United Nations. United Nations Program on Space Applications. Brochure. Austria: 2006. Jan. 2006. United Nations Program on Outer Space Affairs. 30 June 2009 <http://www.cig.ensmp.fr/~iahs/links-NR/psa-brochure.pdf>.
7. "Intelsat and Mindset Network join forces to deliver education to Africa." Global VSAT Forum. 30 June 2009 <http://www.gvf.org/members_directory/documents/5376-CaseStudy-Mindset.pdf>.
   "Intelsat and the Global Digital Solidarity Fund (DSF) join forces to fight Aids in Burundi and Burkina Faso." Global VSAT Forum. 30 June 2009 <http://www.gvf.org/members_directory/documents/5313-CaseStudy-DSF-BCom-aids.pdf>.
8. Information Economy Report. Rep. 2007. United Nations Conference on Trade and Development. 30 June 2009 <http://www.unctad.org/en/docs/sdteecb20071ch1_en.pdf>.
9. "Palapa Program." Mission and Spacecraft Library. NASA Jet Propulsion Laboratory. 30 June 2009 <http://msl.jpl.nasa.gov/Programs/palapa.html>.
10. Zvomuya, Fidelis. "SA: Cellphone helps reduce irrigation costs." Africa News 10 Jan. 2008. 30 June 2009 <http://www.africanews.com/site/list_messages/14531>.
11. "Current Projects." *National Natural Resource Managment Program*. Government of India and Indian Space Research Organisation, 21 Feb. 2009. Web. 21 Aug. 2009. <http://www.nnrms.gov.in/nnrms/vrcclick.html>.
12. American Telemedicine Association. What Is Telemedicine & Telehealth? American Telemedicine Association. 30 June 2009 <http://www.americantelemed.org/files/public/abouttelemedicine/What_Is_Telemedicine.pdf>.
13. "Teleradiology in Mali." International Institute for Communication and Development (IICD). 30 June 2009 <http://www.iicd.org/projects/articles/mali-teleradiology>.
14. "Intelsat and the Global Digital Solidarity Fund (DSF) join forces to fight Aids in Burundi and Burkina Faso." Global VSAT Forum. 30 June 2009 <http://www.gvf.org/members_directory/documents/5313-CaseStudy-DSF-BCom-aids.pdf>.
15. "Inauguration of ISRO-IIT, Bombay EDUSAT Network." 1 Jan. 2008. Indian Space Research Organisation. 30 June 2009 <http://www.isro.org/pressrelease/Jan01_2008.htm>.
16. "Indian Ocean tsunami warning system." BBC News 23 Dec. 2005. 30 June 2009 <http://news.bbc.co.uk/2/hi/science/nature/4524642.stm>.
17. Glasner, Joanna. "Sat Phones Surge After Katrina." Wired 7 Sept. 2005. 30 June 2009 <http://www.wired.com/gadgets/miscellaneous/news/2005/09/68768>.
    Mohammed, Arshad, and Yuki Noguchi. "Crisis Communications Network Criticized." Washington Post 23 Sept. 2005. 30 June 2009

<http://www.washingtonpost.com/wp-dyn/content/article/2005/09/22/AR2005092202160.html>.

18. Schwartz, Michael. "Zambia flood victims enjoy reconstruction via ITU satellites." Developing Telecoms 1 Apr. 2008. 30 June 2009 <http://www.developingtelecoms.com/content/view/1192/100/>.
19. "Remote, but in control." CHF International 2005. 30 June 2009 <http://www.chfinternational.org/node/20681>.
20. Morales-Gómez, Daniel, and Martha Melesse. "Utilizing Information and Communication Technologies for Development: The Social Dimensions." Journal of Information Technology for Development 8 (1998): 3-13. Social Development and Policy Group Ltd. 30 June 2009 <http://www.sdpgroup.com/docs/ICTs.pdf>.
21. Morales-Gómez, Daniel, and Martha Melesse. "Utilizing Information and Communication Technologies for Development: The Social Dimensions." Journal of Information Technology for Development 8 (1998): 3-13. Social Development and Policy Group Ltd. 30 June 2009 <http://www.sdpgroup.com/docs/ICTs.pdf>.
22. Johnson, Engr N. Regulating Satellite Communications and Associated Technologies in Nigeria: Imperatives for the Year 2000-2001. 30 June 2009 <http://www.ncc.gov.ng/Events%20Archives/NationalTelecomsPolicyWorkshop/REGULATING%20SATELLITE%20COMMUNICATIONS%20AND%20ASSOCIATED%20-%20Asinogu.pdf>.
23. "Cape Town to Cairo: Connecting Africa." The International Development Research Center. 30 June 2009 <http://www.idrc.ca/en/ev-113485-201-1-DO_TOPIC.html>.
24. Rose, Jeremy L. "Satellite Access in Africa." AfriNet 2005. Nigeria, Abuja. 22 Feb. 2005. 4th Africa Internet Summit and Exhibition. 22 Feb. 2005. Nigerian Communications Commission. 30 June 2009 <http://www.ncc.gov.ng/AFRINET/Afrinet2005/afrinet2k5main.htm>.
25. The Space Report 2009. Publication. Colorado Springs: Space Foundation, 2009. 26 August 2009 <http://www.thespacereport.org/>.
26. Weiss, Gebhard. "The Global Perspective of the Digital Divide -Satellite Services in Asia and Africa." Digital Divide and Satellite: Chances, Difficulties and Actions. Germany, Bonn. 11 Feb. 2004. DLR: German Space Agency. 30 June 2009 <http://www.dlr.de/rd/Portaldata/28/Resources/dokumente/kommunikation/weiss.pdf>.
27. "Connect The World." International Telecommunication Union. 30 June 2009 <http://www.itu.int/ITU-D/connect/index.html>.
28. "Cape Town to Cairo: Connecting Africa." The International Development Research Center. 30 June 2009 <http://www.idrc.ca/en/ev-113485-201-1-DO_TOPIC.html>.
29. "Why VSAT?" Alldean Satellite Networks. 30 June 2009 <http://www.alldean.com/why_vsat/economy.html>.
30. Verlini, Giovanni. "New Era Dawns for Mobile Satellite Services." Satellite Today 1 May 2009. 30 June 2009 <http://www.satellitetoday.com/broadband/applications/40/New-Era-Dawns-for-Mobile-Satellite-Services_30661.html>.
31. Shaltout, Mosalam. The Way Forward in Capacity Building in Developing Countries: Space Research Center at Minoufiyia University, Egypt, as Case Study. Issue brief. 30 June 2009 <http://www.cosis.net/abstracts/COSPAR04/00486/COSPAR04-A-00486.pdf>.
32. Shaltout, Mosalam. "Space science education for postgraduate students in Minoufiyia University, Egypt." 35th COSPAR Scientific Assembly. France, Paris. 18 July 2004. SAO/NASA Astrophysics Data System. 30 June 2009 <http://adsabs.harvard.edu/abs/2004cosp.meet..491M>.
33. Thompson, Madeleine. "Predicting Malaria Infection in Gambian Children from Satellite Data and Bed Net Use Surveys: The Importance of Spatial Correlation in the Interpretation of Results." The American Journal of Tropical Medicine and Hygiene 61 (1999): 2-8. 30 June 2009 <http://www.ajtmh.org/cgi/reprint/61/1/2.pdf>.
34. Kalluri S, Gilruth P, Rogers D, Szczur M (2007) Surveillance of Arthropod Vector-Borne Infectious Diseases Using Remote Sensing Techniques: A Review. PLoS Pathog 3(10): e116.

Colwell, Rita, and Anwar Huq. Remote Sensing of Cholera Outbreaks. Rep. Aug. 2000. University of Maryland Biotechnology Institute. 30 June 2009 <http://geo.arc.nasa.gov/sge/health/projects/cholera/cholera.html>.

Hay, Simon I., David J. Rogers, and Robert W. Snow. "Predicting malaria seasons in Kenya using multitemporal meteorological satellite sensor data." The Royal Society of Tropical Medicine and Hygiene 92 (1998): 12-20. 30 June 2009 <http://users.ox.ac.uk/~hay/007.pdf>.

Thompson, Madeleine. "Predicting Malaria Infection in Gambian Children from Satellite Data and Bed Net Use Surveys: The Importance of Spatial Correlation in the Interpretation of Results." The American Journal of Tropical Medicine and Hygiene 61 (1999): 2-8. 30 June 2009 <http://www.ajtmh.org/cgi/reprint/61/1/2.pdf>.

35. Goyal, Rohit, and A. N. Arora. Use of Remote Sensing in Ground Water Modeling. Rep. GIS Development. 30 June 2009 <http://www.gisdevelopment.net/application/nrm/water/ground/mi03022.htm>.
36. Pfaff, Alexander S. What Drives Deforestation in the Brazilian Amazon? Rep. no. 16. Dec. 1996. MIT Global Change Science Policy. 30 June 2009 <http://dspace.mit.edu/bitstream/handle/1721.1/3633/MITJPSPGC_Rpt16.pdf;jsessionid=130D967E0D687BA579BF2C0005654A4D?sequence=1>.
37. Brazil National Institute for Space Research. "In three-month intervals of clouds coverage, DETER confirms 197km2 of deforestation in the Amazon state." Press release. 2 June 2009. <http://www.inpe.br/ingles/news/news_dest65.php>.
38. Gar-on Yeh, Anthony, and Xia La. "An integrated remote sensing and GIS approach in the monitoring and evaluation of rapid urban growth for sustainable development in the Pearl River Delta, China." International Planning Studies 2 (1997): 193-210. 30 June 2009 <http://www.informaworld.com/smpp/content~content=a777428511~db=all>.
39. Disaster Prediction, Warning, and Mitigation. 25 May 1998. United Nations Conference on the Exploration and Peaceful Uses of Outer Space. 30 June 2009 <http://web.rosa.ro/Common/Documents/UNBP/bp2_disasters.pdf>.
40. "Famine Early Warning Systems Network." FEWSNET Home Page. United States Agency for International Development. 30 June 2009 <http://www.fews.net>.
41. Burgan, R. E., R. W. Klaver, and J. N. Klaver. "Fuel Models and Fire Potential From Satellite and Surface Observations." International Journal of Wildland Fire 8 (1998): 159-70. 30 June 2009 <http://www.publish.csiro.au/nid/114/paper/WF9980159.htm>.
42. Eves, Stuart. "Earthquake Prediction From Space." UK Space Conference. Mar. 2008. 30 June 2009 <http://www.slideshare.net/Stellvia/uk-space-conference-earthquake-prediction-from-space-stuart-eves>.
43. "Home Page." International Charter Space and Major Disasters. 30 June 2009 <http://www.disasterscharter.org/index_e.html>.
44. "Remote Sensors Speed China Earthquake Rescue." Asian Surveying and Mapping 16 May 2008. 30 June 2009 <http://www.asmmag.com/news/remote-sensors-speed-china-earthquake-rescue>.
45. "About UN-SPIDER." United Nations Office for Outer Space Affairs. 30 June 2009 <http://www.unoosa.org/oosa/en/unspider/about_us.html>.
46. Bouchardy, Jean-Yves. Radar Images and Geographic Information Helping Identify Water Resources During Humanitarian Crisis: The Case of the Chad/Sudan (Darfur) Emergency. 30 June 2009 <http://www.isprs.org/publications/related/ISRSE/html/papers/911.pdf>.
47. "International Cooperation in Promoting the Use of Space-Derived Geospatial Data for Sustainable Development." Committee on the Peaceful Uses of Outer Space Fifty-second Session. 28 May 2009.
48. Wagner, Caroline S., Irene Brahmakulam, Brian Jackson, Anny Wong, and Tatsuro Yoda. Science and Technology Collaboration: Building Capacity in Developing Countries? Rep. Mar. 2001. Rand Science and Technology. 30 June 2009

<http://wwwcgi.rand.org/pubs/monograph_reports/2005/MR1357.0.pdf>.

49. "Country Classification." *Data & Statistics.* The World Bank. Web. 21 Aug. 2009. <http://go.worldbank.org/K2CKM78CC0>.
50. "Country Classification." *Data & Statistics.* The World Bank. Web. 21 Aug. 2009. <http://go.worldbank.org/K2CKM78CC0>.
    Arab Republic of Egypt Ministry of State for Scientific Research. National Authority for Remote Sensing And Space Sciences. "Egypt launched its first scientific satellite." Press release. 16 May 2007. 30 June 2009 <http://www.narss.sci.eg/NewsDetails.aspx?NewsID=31>.
51. "Chandrayaan sends Indian space scientists rushing back home." Sify News 28 Oct. 2008. 30 June 2009 <http://sify.com/news/fullstory.php?id=14785162>.
52. "Nigerian satellite fails in space." BBC News 13 Nov. 2008. 30 June 2009 <http://news.bbc.co.uk/2/hi/africa/7726951.stm>.
53. "Regional Centres for Space Science and Technology Education." United Nations Office for Outer Space Affairs. 30 June 2009 <http://www.oosa.unvienna.org/oosa/en/SAP/centres/index.html>.
54. Report of the Legal Subcommittee on its forty-eighth session, held in Vienna from 23 March to 3 April 2009. Proc. of Committee on the Peaceful Uses of Outer Space Fifty-second Session, Austria, Vienna. 20 Apr. 2009. United Nations. 30 June 2009 <http://www.unoosa.org/pdf/reports/ac105/AC105_935E.pdf>.
55. The Space Report 2009. Publication. Colorado Springs: Space Foundation, 2009. 26 August 2009 <http://www.thespacereport.org/>.