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Commerce in Space

Infrastructures, Technologies, and Applications

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Commerce in Space:
Infrastructures, Technologies, and Applications

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Detailed Table of Contents

This chapter summarizes the collective work of a team of students who participated in the 2004 International Space University Summer Session Program in Adelaide, Australia. The project is called STREAM, which stands for Space Technologies for the Research of Effective wAter Management. The work represented in this chapter was accomplished as part of the intensive space studies curriculum offered during the summer session. The team project focused on the importance of fresh water resource management and its impact on the surrounding communities. The team explored various space technologies and their current and future potential to enhance water resource management. A real world case study of Australia's Murray-Darling Basin (MDB) was performed to provide the central focus of the project. Based on the results of the case study, the team then extrapolated their results to other regions of the globe that are experiencing challenges to their fresh water supply. A significant space technology recommendation developed by the STREAM project team was to improve the soil moisture measurement capabilities in the MDB. The primary goal of the STREAM project team is that the recommendations outlined in the extensive final report (STREAM Team, 2004) will receive full attention from policy makers concerned with the water issues surrounding the MDB.

Deliberate exploitation of natural resources and excessive use of environmentally abhorrent materials have resulted in environmental disruptions threatening the life support systems. Human centric approach of development has already damaged nature to a large extent. This has attracted the attention of environmental specialists and policy makers. It has also led to discussions at various national and international conventions. The objective of protecting natural resources cannot be achieved without the involvement of professionals from multidisciplinary areas. This chapter recommends a model for the creation of knowledge based system for natural resources management. Further it describes making use of unique capabilities of remote sensing satellites for conserving natural resources and managing natural disasters. It is exclusively for the people who are not familiar with the technology and who are given the task of framing policies.

The theme of this chapter is how space technologies and satellite applications can mitigate the impact of natural and man-made disasters. The objective is to provide the reader with an overview of the most important space technologies for both monitoring and telecommunications and to shown the main issues in managing a disaster response. The chapter is divided into three parts. Firstly, the potential of remote sensing satellites related to natural disasters is described. Then, in the second part of the chapter, the strength and the weakness of space-based telecommunication architectures for the emergency and recovery phase are outlined. Finally, international policies currently applied for emergency management and disaster recovery will be described trying to individuate the needs for an optimal provision of information and accessibility of space related services and coordination of existing in-orbit assets in case of disaster.

This chapter outlines the development and evolution of the Cospas-Sarsat system, describes the principle of operation, presents the current status and looks at the future of the system. Cospas-Sarsat, an international satellite system for search and rescue, started operating in 1982 and has been credited with saving many thousands of lives since then. More than a million aviators, mariners and land users worldwide are equipped with Cospas-Sarsat distress beacons that could help save their lives in emergency situations anywhere in the world. A constellation of satellites is circling the globe monitoring for distress signals, while tracking stations on six continents receive the satellite signals, compute the location of the emergency and quickly forward the distress alert information to the appropriate rescue authorities. This is a big improvement over the pre-satellite era, when distress signals from remote regions or far out at sea might not have been heard for many days or even weeks.

Section II
Satellite Internet and Navigational Technologies

This chapter introduces the concept of Satellite Navigation in the context of space infrastructures and technologies that can contribute for improvement of life on Earth. It includes a review of the motivations for developing a satellite navigation system, and the applications and services these systems have in daily life. Furthermore, currently existing Global Navigation Satellite Systems (GPS and GLONASS) and other GNSS systems under development (GALILEO) are described from different perspectives: from the technical and architectural aspects to the ways chosen to finance their development and operations. To round up this chapter, an analysis of the expected trends in GNSS systems is presented and potential scenarios for future evolution of global satellite navigation are discussed.

The aim of this chapter is to show the satellite Internet as a new quality, which was created thanks to the convergence of satellite communication and data networks. The chapter describes the development of satellite communication and satellite data networks, presents methods of Internet access via satellite and discuss the opportunities and challenges of building effective commercial services based on satellite Internet. The main advantages of the satellite Internet are high bandwidth, very good availability (in practice: anywhere in the world), and natural IP multicasting. Although getting broadband Internet access by satellite is considered very expensive, independence from the local infrastructure results in the satellite Internet being a good solution for both business communications (a corporate network or its fragments) and remote area communications (rural communications and services to isolated communities).

Nowadays it is possible to achieve low cost and short production times space missions using satellites with a mass below 10 kg. These small satellites are described as nanosatellites.
Current microelectronic technology makes it possible to develop nanosatellites for scientific experiments and relatively complex measurements (as well as for other applications) making it easy for universities and small research groups to have access to space science exploration and to exploit the new economic possibilities that emerge. This chapter, describes an experiment developed in Argentina at the Universidad Nacional del Comahue to design and construct a nanosatellite called Pehuensat-1.

characteristics of EO and discusses the unique advantages of EO in collecting the environmental information which is a key for effective implementation of MEAs. It also studies the challenges and future steps for application of EO into MEAs process. Emerging trends and recent initiatives are introduced for reader's future consideration. By showing the issues surrounding such an application, author hopes to contribute to the further promotion of EO application to the effective implementation of MEAs.

This chapter examines macro-projects to be deployed in outer space. A feasibility study is used to analyze the deployment of such projects in extraterrestrial realms. Moreover, the author argues that these projects will have substantial socio-economic and political impacts on the international community of nations. Deploying permanent human facilities in space, mining planetary surfaces, asteroids, and a host of other activities will require the use of macro-projects. These macro-projects will be complex by nature. They will require the use of human and technical networks for their completion. All that can be done. It can be accomplished by using the skills and talents of people coming from a variety of ethnic, racial, and cultural backgrounds.

This chapter presents an initial identification of direct and indirect benefits for space agencies and space and non-space companies from new markets development, creation of new collaborations and an analysis of the costs and financing of future human interplanetary exploration. Commercialization of space technology is the process by which private companies commercially exploit space technology, without being its owners. Commercialization of space technology for future interplanetary missions is considered as a primary focus and principle benefit in this vision. Before private companies invest in commercial projects for interplanetary missions they will have to perform cost benefit analysis for their commercial projects for future interplanetary missions.

One of the key problems faced by organizations is that of managing knowledge: how does an organization improve and maintain performance by generating, maintaining, and sharing knowledge? High tech organizations are much more dependent on knowledge as a commodity than those in the manufacturing sector. NASA certainly is the epitome of a high tech organization. It faces complex and deep challenges —not the least of which is how to address the loss of knowledge as the workforce ages and retires. In addition, NASA faces the consequences of a program that, in the face of programmatic constraints, subsumes the process of generating knowledge to the demands of maintaining commitments. Those commitments may not provide the optimal path for generating knowledge relevant to the future success of the organization. For a space-faring organization, mission cadence is one of the key determinants of cost and risk. Mission cadence is also important as it determines the number of people in the organization with direct and relevant experience with space missions. Under a constrained budget, mission cadence can be increased by reducing the size and scope of the missions. Small spacecraft missions can afford to be innovative and thus create a culture in which new ideas are welcomed and/or sought. These smaller missions can preserve and generate knowledge by training the next generation of scientists, engineers and program managers.

Section IV
Space and Society

Chapter XIV

This chapter introduces the ethical questioning in the field of space activities, especially space commerce. If the 1967 Outer Space Treaty defines space as the "property of all" and its exploration as the "province of all mankind", the future utilization of near-Earth (and tomorrow Greater Earth) space needs probably a new ethics (if ethics means not only legal applications but also and for example the application of the "rule of three Ps": protection, promotion and preparation). Orbital debris mitigation, the International Charter on Space and Major Disasters or, in the future, the safety of private astronauts crews offer lessons in realism and sources of prospective reflections. Space ethics is still in its infancy.

Chapter XV

Space tourism is the term broadly applied to the concept of paying customers traveling beyond Earth's atmosphere. Operating reusable launch vehicles might be a first step to realize mass space tourism. Thus, the aim of this chapter is to investigate the potential hurdles along with other important aspects of space tourism flights utilizing reusable launch vehicles. The primary elements are social issues, e.g. "Is space tourism acceptable concerning ethical aspects?", institutional issues, e.g. "Is environmental pollution caused by space tourism harmful compared to other emission sources?" and financial issues, e.g. "Are there any potential investors interested in space tourism?".

Chapter XVI

The first part of this paper describes how the Space Elevator is expected to work, and the advantage of access to space via the SE versus using primarily rockets. A compendium of information from a variety of sources is included in order to explain how the Space Elevator would be designed, constructed, and how it could solve the problems of transporting cargo into Space easily, cheaply, and frequently. The Space Elevator is a relatively new topic in the area of realistic science concepts and was merely science fiction not too long ago. The Space Elevator ("SE") concept has only been in the spotlight in the last five years due to the work of Dr. Bradley Edwards of Carbon Designs Inc. Acceptance of the SE will be a

Foreword

There is no longer any doubt that the peaceful uses of space infrastructure provides a prevailing tool for expanding the well-being of humanity and the Earth's environment. Space architecture and applications are fundamental for providing important services to people on earth. Some of these services are intertwined into our daily lives such as the use weather forecasts, satellite TV and radio. More recently, we are seeing more innovative personal communications devices with integrated GPS technology. Space technology is currently being incorporated into Health care, learning, transport systems, disaster relief, and search-and-rescue operations.

Using space infrastructures provide opportunities in a wide range of public missions in a cost-effective way. In particular, space infrastructure can generate solutions for long-term societal needs such as climate monitoring, resource management, disaster relief, and digital inclusion. Unfortunately, these opportunities are not being exploited for a variety of reasons, which range include lack of information, technical problems, and the existence of bureaucratic rules that prevent the effective use of the infrastructures.

To realize the full potential of space infrastructure, there are some critical issues that need to be addressed: space infrastructure must be continuously improved and upgraded; there must be increased efforts to integrate space applications with terrestrial systems, ensuring infrastructure sustainability, address the digital divide, and mandating ethical use of space resources. In order to achieve these critical issues, governments and decision makers will need to consider the challenges from a technological, legal, economic, and regulatory dimension.

This book provides an insight into work that is being done around the globe to address these critical issues. It also provide, in only one document, a comprehensive review of how space technology can influence the future of people on earth across multiple domains such as health, education, disaster management, and communication. The book describes real world problems using case studies and opens at the same time a perspective towards the future by discussing the utilization of space technology at global, national and regional levels for resolving specific problems.

Preface

THE UNTOLD IMPACT OF SPACE TECHNOLOGY ON SOCIETY

Satellites and space technology play important roles relaying information to terrestrial systems for knowledge generation and decision-making. They are becoming more prominent in the data transfer, communication, navigation, and environmental observation markets. In developed nations, the use of space technology is deeply entrenched in modern applications (Cohendet, 2004). The areas that rely heavily on space infrastructures include meteorology, mobile communication systems, television broadcasting, natural resource management, navigation, health, environmental management, and disaster management, which consequently influence virtually every facet of human endeavor. It is therefore no surprise that this industry is anticipated to be a significant growth industry in the 21st century, leading to technological developments in several fields ranging from telecommunications, tele-health, tele-education, multimedia, opto-electronics, robotics, life sciences, energy, and nanotechnology (Hukill, Ono, & Vallath, 2000).

When discussing the advancement of space science and space technology most people instinctively think about deep space flights, lunar stations, and thrilling outer space adventures. The fact is that the majority of the human technology in space, which comprises of satellites, point toward Earth and most of the technology in space is used to provide services and fulfill the goals for people on planet Earth. The growing role of space technology is so profound it has almost become ubiquitous and prevalent in society.

In today's global society, it appears that economic prosperity is the most important human goal; however, the foremost goal of the human race should be to sustain a livable biosphere. The objective must be to improve the environment at least gradually over the next few centuries, a task "easier said than done." This is not something that can be done quickly. The planet is facing some fundamental challenges, which are expected to become much worse over the next couple of decades (Pelton, 2000). The problems that must be addressed extend over a spectrum of environmental, technological, and humanitarian domains. Currently, one of the most topical issues is the dilemma of global warming, which comprises of problems such as the carbon dioxide and methane build up and the disappearing ice caps.

The next set of challenges stems from global pollution and includes issues such as destruction of the rain forests, desertification, reduction of arable land, and the over reliance on dwindling petrochemical energy sources. Another series of problems relates to humanitarian issues that are compounded by the spiraling growth of the human population. There are inappropriate distributions of natural and agricultural resources to manage the growing population. About 1 billion people—one fifth of the world's population—live on less than $1 a day (World-Bank, 2006). Unfortunately, this is also reflected in the lack of universal access to information technology, global education, and health care, called the digital divide. Over the last decade, we have also increased the level of hatred between nations and races, fueled primarily by religious ideology rather than political allegiances, which has led to an increase in terrorism. Other random problems that we must overcome in order to survive the next century are new biological virus mutations such as bird flu and HIV AIDS, techno-terrorism, nuclear proliferation, and abuses from technologies such as bio-engineering and cloning.

Humans are not the only inhabitants on Earth who have ever faced environmental dilemmas. One could hypothesize the giant dinosaurs which once ruled the Earth would have been more fortunate if our sophisticated space technology was available. As Sir Arthur Clarke pointed out, “The dinosaurs failed to survive due to the lack of a space program.” The most important message from this saying is not necessarily the creation of an International Space Program, but the ability to have the foresight to predict the future and plan accordingly.

The idea of using data and technologies from space infrastructure is not entirely new; however, the rate at which data is being integrated into terrestrial systems is experiencing colossal growth and acceptance, creating a phenomenon this book describes as space business (s-business). S-business relates to any venture performed by a group of diverse actors leading to the provision of goods or services involving financial, commercial, or humanitarian activity that is facilitated by the use of a space technological infrastructure in the Earth’s orbit. The commercialization of space is creating opportunities for new types of information systems (IS) and information technology (IT) architectures.

Although the space technological infrastructure is primarily composed of the satellites in orbit, the supporting infrastructure is a collection of interconnected technological systems, social processes, and organizational elements that enable space data to be collected, processed, stored, and broadcast to devices or base stations on Earth. Once this data is received on Earth, it can be translated into meaningful information, leading to knowledge which can be used to aid the planning process and decision making. There are five established discernible space infrastructures: telecommunication, positioning and navigation, broadcasting, Earth observation, and micro gravity research (MGR) and tourism. Each space infrastructure has a specialized function; however, there is an increasing theme of convergence between these infrastructures, as can be seen from the descriptions as follows.

Telecommunications

It is currently the most important and the most dynamic market for space applications. It includes voice, data, Internet, and multimedia mobile services. Communication satellites are used to transmit voice and data services anywhere in the world. The main advantage over terrestrial communication systems is that satellites do not have to be connected to a ground network. Communication satellites have ubiquitous access and can reach people in remote villages, crews in the middle of the ocean, or explorers at the top of a mountain. They are ideal for situations in which the ground infrastructure is not available or has been temporarily damaged by natural disasters. In combination with ground-based networks, satellites can provide access to the World Wide Web. Satellite telecommunications have the potential to deliver information to rural and remote areas, and may also help countries kick start their economical development. Information and services delivered via satellites to technology deprived regions can also contribute to a nations sustainable development program, providing access to information and helping members of the public participate in decision-making, or more generally by improving education and health services and promoting favourable conditions for environmental protection.

The satellite telecommunications sector has faced some difficulties in recent years. Some of these difficulties are as follows:

- Reduction in demand for wireless satellite constellation development
- The proliferation of new actors in the field
- Larger commercial communication satellites lasting longer on their on-orbit stay times

There are numerous applications, such as domestic/international trunking, in-flight Internet service, broadband Internet, Internet backbone, roaming, wireless networks (VSAT), messaging, and asset management that make this multibillion dollar industry the most profitable space sector. The growth of the Internet, along with interactive multimedia applications, is causing an overload on terrestrial networks run by the telecommunications operators, creating an increase in the adoption of satellite communication.

Broadcasting

Organizations in the satellite broadcasting sector provide services such as digital TV, digital radio, multimedia, Internet content, and educational content. Satellite television and radio provide entertainment delivered by satellites as opposed to conventional terrestrial technologies. Satellite television has been around since the 1960s. This infrastructure was originally conceived with limited coverage and to serve a limited number of professional users. Satellite broadcasting has evolved to provide global coverage to a wide array of users.

The first satellite television signal was relayed from Europe to the Telstar satellite over North America in 1962, and the world's first commercial communication satellite, called Early Bird, was launched into synchronous orbit on April 6, 1965. In many areas of the world, satellite television services supplement older terrestrial signals, providing a wider range of channels and services, including subscription-only services. The recent additions to this technology include cutting-edge innovation, such as high definition, interactive programming features, mix channels, and pay-per-view.

Satellite radio is a digital radio that receives signals broadcast by communications satellite, which covers a much wider geographical range than terrestrial radio signals.

Satellite radio services are all commercial business entities. Accessing packages of channels requires a subscription to a commercial satellite for signal propagation. Currently, the main satellite radio providers are WorldSpace, XM, and Sirius. WorldSpace covers Europe, Asia and Africa, while XM Radio and Sirius both cover North America.

Earth Observation

Earth observation is vital for measuring and monitoring the world's climate and atmosphere, and for recording and mapping our valuable resources. Earth observation is a continuation of meteorology that is extending new domains, including agriculture, resource management, exploration, mapping and planning, hazard monitoring, and disaster assessment (landslides, earthquakes, volcanic eruptions, floods, and droughts) as well as security, defense, and the enforcement of international agreements (OECD, 2006).

Currently, there are millions of space-based sensors collecting data around the world by various countries and organizations providing the foundation for sound decision-making. Unfortunately, they operate independently with little integration. The concept of an integrated Earth information system requires an interdisciplinary focus, utilizing a wide array of technological sensors. There are sound social, economic, and scientific drivers that are dictating the need for building an integrated Earth information and data management system. Images retrieved from Earth observation satellites incorporated into geographic information systems (GIS) offer a wealth of vital information to policy makers, scientists, and the general public about the planet's variable environment. Satellite images provide information about:

- Land cover and land use
- Remote and difficult-to-access areas like dense forests, glaciated areas, deserts and, swamps
- Areas undergoing rapid environmental change, including loss or fragmentation of ecosystems and related

loss of biodiversity
- Effects of natural disasters such as floods, droughts, forest fires, and volcanic eruptions
- Wide-ranging impacts of pollution, from depletion of the ozone layer to tracing oil spills and photochemical smog
- War-torn regions and the environmental impacts of armed conflicts

Positioning and Navigation

The uses of satellites for localization and navigation activities are rapidly expanding. The implementation of satellite positioning constellations have created a growing number of applications such as air transport, maritime transport, land transport, and localization of isolated individuals, and provides a universal referential time and location standard for a number of systems. Satellite navigation is achieved by using a global network of satellites that transmit radio signals from approximately 11,000 miles in high Earth orbit.

The technology is accurate enough to pinpoint locations anywhere in the world, 24 hours a day, and can operate in any weather. These constellations of satellites are referred to as global navigation satellite systems (GNSSs). There are currently two GNSS systems in operation, the navigation satellite timing and ranging system (NAVSTAR), commonly referred to as the global positioning system (GPS) owned by the United States of America, and GLONASS (Global´naya Navigatsivannaya Sputnikovaya Sistema) of the Russian Federation. A third system called GALILEO is under development by the European Community (EC) countries, which will be interoperable with the existing systems. The United States and Russia have offered the international communities free use of their respective systems.

The business model for GALILEO will be similar to GPS for basic users; however, not all applications will be free, as some applications that require a high quality of service will incur a charge. GNSS is revolutionizing and revitalizing a variety of application markets such as aviation, maritime, land transportation, mapping and surveying, precision agriculture, power and telecommunications, urban gaming, and disaster monitoring.

Micro Gravity Research and Space Tourism

The initial stage of micro gravity activities is currently under way at the International Space Station (ISS). If the costs of space flights fall significantly below $1 million per passenger, a growing number of companies will find it profitable to finance commercial activities in space (Collins, 1990). Initially, these will potentially include high-technology activities such as microgravity research, advanced materials development, bio-technology, and solid-state physics research. Some researchers believe that the demand for launches could exceed 100 passengers per day from the Pacific Rim alone within 20 years (Yamanaka & Nagatomo, 1986).

Involvement to date by these companies in the space industry has been restricted to the use of telecommunications satellites for transmission and broadcasting of programming material, including concerts, sports events, films, and television programmers[6]. When the launch of personnel into orbit is relatively low-cost, safe, and routine, it is likely they will make extensive use of the unique possibilities of zero gravity to record programming material in orbit. As the cost of a flight to orbit falls below $100,000 per passenger, the demand from individuals for recreational space travel is expected to grow rapidly. Several unique attractions (Collins, 1990) of a short orbital visit include: observation of the Earth, astronomical observation, zero gravity phenomena, zero gravity flying, and zero gravity water sports.

Synopsis of Chapters

This book contains work from scientists, educators, lawyers, and policy analysts from 12 countries. The book is divided into three sections, each containing between three and four chapters. The sections reflect the current trends that are emerging from the space arena.

- Section I: Space Technology for Managing Resources
- Section II: Satellite Internet and Navigational Technologies.
- Section III: Space Policy and Economics
- Section IV: Space and Society

The first section, "Space Technology for Managing Resources" contains four chapters.
The first chapter in this section is titled "Space Technologies for Research of Effective Water Management: A Case Study," written by Angie Bukley and Dr. Olga Zhdanovich. This chapter summarizes findings from a project called *STREAM*, which stands for Space Technologies for the Research of Effective wAter Management. The team project focused on the importance of fresh water resource management and its impact on the surrounding communities. A real world case study of Australia's Murray-Darling Basin (MDB) was performed. Based on the results of the case study, the team then extrapolated their results to other regions of the globe that are experiencing challenges to their fresh water supply.

The second chapter in this section is titled "Using Space Technology for Natural Resource Management," by N. Raghavendra Rao. This chapter recommends a model for the creation of knowledge-based systems for natural resources management. It also describes techniques for utilizing unique capabilities of remote sensing satellites for conserving natural resources and managing natural disasters. This chapter was written exclusively for the people who are not familiar with the technology and who are given the task of framing policies.

The third chapter in this section is titled "Using Space Technology for Disaster Monitoring, Mitigation, and Damage Assessment," by Pasquale Pace, Gianluca Aloi, and Luigi Boccia, from Italy. This chapter presents information on how space technologies and satellite applications can mitigate the impact of natural and man-made disasters. The objective is to provide the reader with an overview of the most important space technologies for both monitoring and telecommunications, and to highlight the main issues in managing a disaster response.

The final chapter in this section is titled "Cospas-Sarsat Satellite System for Search and Rescue," by James V. King. This chapter outlines the development and evolution of the Cospas-Sarsat system, describes the principle of operation, presents the current status, and looks at the future of the system. Cospas-Sarsat, an international satellite system for search and rescue, started operating in 1982 and has been credited with saving many thousands of lives since then. More than a million aviators, mariners, and land users worldwide are equipped with Cospas-Sarsat distress beacons that could help save their lives in emergency situations anywhere in the world.

The second section of this book contains a combination of social and technical chapters that investigate using next generation satellite more effectively to deliver Internet and location services. This section is called "Satellite Internet and Navigational Technologies." The first chapter in this section is titled "Global Navigation Satellite Systems and Services," by Justo Alcázar Díaz and Tirso Velasco. This chapter provides a detailed analysis of global navigation satellite systems (GNSS), which refers collectively to the worldwide positioning, navigation, and timing (PNT) determination capabilities available from satellite constellations. This chapter provide a summary of the future and existing systems along with the business models, limitations, and capabilities.

The second chapter in this section is titled "The Satellite Internet: The Convergence of Communication and Data Networks," written by Agnieszka Chodorek and Robert R. Chodorek. This chapter investigates the development of satellite communication and satellite data networks. A brief overview of the Internet technology, along with a convergence of the Internet and space technologies, is presented. This chapter discusses the importance of broadband Internet, which is available anywhere—in almost all locations on the Earth—and for millions people.

The third chapter in this section is titled "The Era of Nanosatellites: Pehuensat Development Status," authored by Juan Jorge Quiroga, Roberto Fernández, and Jorge Lassig. This chapter describes the technical elements of the development of a nanosatelite by an educational institution in Argentina.

The final chapter in this section is titled "Digital Bridges: Extending ICT to Rural Communities Using Space Technologies," by Phillip Olla. This chapter describes how a satellite technology can be used to bridge the digital divide. This chapter proposes a two-phased approach. The first phase involves the definition and implementation of the satellite global infrastructure to provide connectivity to underserved regions. The second phase introduces the concept of a coalition of space Internet providers (COSIP) model. The aim of this model is to encourage the diffusion of space technology infrastructure at the grassroots level.

The first chapter in the "Space Policy and Economics" section was written by Lesley Jane Smith and Kay-Uwe Hörl. The chapter is titled "Constructing the European Space Policy: Past, Present, and Future." This chapter assesses today's European space landscape, with a focused view on the evolution of the European Space Policy as well as on the ongoing and projected space applications. This chapter also sheds some light on the historical parameters that framed Europe's first steps into the space arena, and examines the current European motivations to implement policy and develop space programs in a particular way.

The next chapter in this section is titled "Application of Satellite Earth Observation for Improving the Implementation of Multilateral Environmental Agreements," written by Ikuko Kuriyama from Japan's Aerospace Exploration Agency (JAXA). This chapter provides a broad overview of the issues related to the application of EO for effective implementation of multilateral environmental agreements (MEA). The chapter reviews the characteristics of EO technology, and examines its potential to support effective implementation of and compliance with MEAs. The chapter proposes possible solutions and future steps to facilitate actual application of EO in the MEA process, and provides an insight on this issue for readers in the IT community.

The third chapter in this section is titled "Extraterrestrial Space Regimes and Macroprojects: A Review of Socioeconomic and Political Issues," by Dimitris J. Kraniou. The author examines macroprojects to be deployed in outer space. A feasibility study is being used to analyze the deployment of such projects in extraterrestrial realms.

The fourth chapter in this section is titled "Commercialisation of Space Technology for Tomorrow's Space Missions," by Stella Tkatchova and Michel van Pelt. The chapter discusses the direct and indirect benefits for the different stakeholders from commercialization of space technologies for future moon and Mars missions. These include NASA's Moon and Mars vision and the ESA Aurora program.

The final chapter in this section, by Larry J. Paxton, is titled "Challenges in Knowledge Management: Maintaining Capabilities Through Innovative Space Missions." This chapter discusses how organizations improve and maintain performance by generating, maintaining, and sharing knowledge. This chapter uses NASA as an example. High tech organizations are much more dependent on knowledge as a commodity than those in the manufacturing sector. NASA certainly is the epitome of a high tech organization. It faces complex and deep challenges, not the least of which is how to address the loss of knowledge as the workforce ages and retires.

The first contribution in the "Space and Society" section is by Jacques Arnould, from the French Space Agency (CNES). This chapter asks some critical questions of the space industry, which must be addressed at some point in the future. These critical questions include who will dispose of satellites at the end of their life? What resources should governments be prepared to commit to tracking such debris, for the benefit of commercial business? What is the use of satellite-based observation, communication, and positioning systems? How will the safety of private crews be guaranteed? If they are no longer "envoys of humanity" in the accepted modern legal sense, what duties will governments have toward them on Earth and in space?