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THIRD UNITED NATIONS CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE

COMMERCIAL ASPECTS OF SPACE EXPLORATION, INCLUDING SPIN-OFF BENEFITS

Background paper 7

The full list of the background papers:

1. The Earth and its environment in space
2. Disaster prediction, warning and mitigation
3. Management of Earth resources
4. Satellite navigation and location systems
5. Space communications and applications
6. Basic space science and microgravity research and their benefits
7. Commercial aspects of space exploration, including spin-off benefits
8. Information systems for research and applications
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PREFACE

The General Assembly, in its resolution 52/56, agreed that the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) should be convened at the United Nations Office at Vienna from 19 to 30 July 1999 as a special session of the Committee on the Peaceful Uses of Outer Space, open to all Member States of the United Nations.

The primary objectives of UNISPACE III will be:

(a) To promote effective means of using space technology to assist in the solution of problems of regional or global significance;

(b) To strengthen the capabilities of Member States, in particular developing countries, to use the applications of space research for economic and cultural development.

Other objectives of UNISPACE III will be as follows:

(a) To provide developing countries with opportunities to define their needs for space applications for development purposes;

(b) To consider ways of expediting the use of space applications by Member States to promote sustainable development;

(c) To address the various issues related to education, training and technical assistance in space science and technology;

(d) To provide a valuable forum for a critical evaluation of space activities and to increase awareness among the general public regarding the benefits of space technology;

(e) To strengthen international cooperation in the development and use of space technology and applications.

As one of the preparatory activities for UNISPACE III, the United Nations Office for Outer Space Affairs of the Secretariat has prepared a number of background papers to provide Member States participating in the Conference, as well as in the regional preparatory meetings, with information on the latest status and trends in the use of space-related technologies. The papers have been prepared on the basis of input provided by international organizations, space agencies and experts from all over the world. A set of 12 complementary background papers have been published and should be read collectively.

Member States, international organizations and space industries planning to attend UNISPACE III should consider the contents of the present paper, particularly in deciding on the composition of their delegation and in formulating contributions to the work of the conference.

Sources and information provided by the World Meteorological Organization (WMO), the European Space Agency (ESA), the Centre national d'études spatiales (CNES) of France, the National Aeronautics and Space Administration (NASA) of the United States of America, the International Space University (ISU), France, and the President of the International Society for Photogrammetry and Remote Sensing (ISPRS) and review of the paper by experts from ESA, CNES, the Canadian Space Agency (CSA), the Indian Space Research Organization (ISRO), the Department of Space of the Government of India, the National Institute of Aeronautics and Space (LAPAN) of Indonesia, ISU, University College London and Novespace, France, are gratefully acknowledged. The following publications have also been used in the preparation of this paper: (a) "State of the space industry—1997 outlook", developed by SpaceVest (KPMG Peat Marwick, Space Publications, Center for Wireless Telecommunications); (b) the series of "Spin-off" publications produced by NASA; and (c) the European Community's working paper entitled "The European Union and space: fostering applications, markets and industrial competitiveness".

The assistance of M. J. Rycroft (ISU and Cambridge University, United Kingdom of Great Britain and Northern Ireland) as technical editor of background papers 1 to 10 (A/CONF.184/BP/1-10) is also gratefully acknowledged.

SUMMARY

Space activities incorporate some of the most important areas of high technology: computer software and hardware development, sophisticated electronics, telecommunications, satellite manufacturing, life sciences, advanced materials and launch technology. Space activities also involve some of the most significant issues of international trade and policy: global markets, gaining access to remote areas, government-subsidized competition and international standardization and regulation.

With an estimated US$ 77 billion in revenues and more than 800,000 people employed worldwide in 1996, the global space industry is one of the important economic engines of the world. The space industry also represents an immensely valuable bank of know-how that is used by thousands of companies worldwide to bring new products, processes and services to the world market at more competitive prices. Such indirect effects of space technology applications, which in the past were considered by-products of research and development, are increasingly looked upon as primary effects and a meaningful element of an industrial policy. Non-space industrial sectors are more demanding of new technology, new processes and new materials in order to remain competitive in their fields. The origin of much of the new spin-off technology can be found in space industry.

The present paper reviews the status of the space industry, the main segments of the commercial space market, market trends and statistics. Special emphasis is placed on issues associated with space technology transfer and spin-offs.

I. OVERVIEW

1. For more than 40 years, space has proved to be of crucial strategic, political, socio-economic and scientific importance. Both the major economic Powers and the developing nations have established and implemented

programmes to enable all the parties involved, essentially the public authorities, industry and academic institutions, to demonstrate and exploit the potential of space technologies. The creation of international space organizations, national space agencies or authorities and research and applications institutions has stimulated the development of technological capabilities and industrial infrastructures, along with growing user/consumer markets all over the world.

2. As a result of that effort, the global space industry has become one of the largest industries in the world, with an estimated US$ 77 billion in revenues and more than 800,000 people employed worldwide in 1996 (this includes infrastructure, telecommunications, applications and support services). To appreciate the economic importance of the industry fully, it must be seen as a key element in a larger value-added chain. Usually, the bulk of that chain is made up of services, which together with the ground and user segments may represent more than 10 times the value of the spacecraft and launchers. Therefore, the narrow view of the space industry as limited to the space segment manufacturers should be avoided.

3. In addition to economic interests, practically every country could have strategic interests in the development of or access to space applications. These have an impact on such important components of policy as the environment, agriculture, sustainable development, communications networks, natural disaster prediction, education and health care, to name but a few. In that context, when space technology is placed in the proper political framework, it may play a key role in policy- and decision-making processes at the national, regional and international levels.

4. The geographical distribution of space activities and, consequently, of space-related industrial and research potential has an uneven character, with a higher concentration in the major economic Powers, followed by a number of developing countries. The same may be true for the benefits derived from space technology applications. However, as space systems are neutral from a geographical point of view, they could favour relatively more the less advanced countries and regions and thus have a higher impact on the political, economic and social processes in such areas.

5. Since the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) held at Vienna from 9 to 21 August 1982, the space industry, including the ground segment and related services, has had to cope with a number of global political, economic and technological changes that have had a strong impact on the industry's operating environment. Those changes include but are not limited to the following:

(a) The end of the era of geo-political antagonism, which had fuelled the growth of the space industry for decades;

(b) The economic slowdown experienced by many countries and, as a result, tied budgetary policies directly affecting space research and development programmes;

(c) Increased globalization and the opening of the international marketplace, as well as the emergence of new competitors;

(d) The global trend towards the liberalization and deregulation of telecommunications services and privatization of many traditional government space activities;

(e) Recent technological developments and the convergence of telecommunications and information technologies;

(f) The acceptance of space commercialization by the capital markets.

6. Some of the above factors may be of a temporary nature, whereas others will require permanent changes in the way the industry operates and in the role of Governments in the field. Industry is conscious of the fact that its present structure will have to be adapted in response to those changes, but, in many cases, still lacks a clear indication from the appropriate government authorities as to what the new environment will be.

7. Though the development of the space industry worldwide still depends to a large extent on government funding for research and development and procurement of both civilian and military systems, the above-mentioned transformations are changing that situation. It is therefore quite likely that, over the next five years, the commercial market may overtake Governments as the largest customer of the space industry.

8. The most striking departure from past practices is the totally private financing of radically new telecommunications systems, such as mobile systems based on low- and middle-Earth orbit (LEO and MEO) satellite constellations for a cost of US$ 2.5 billion to US$ 5 billion over three to five years. In 1996 alone, almost US$ 3 billion was raised on financial markets for the financing of space projects. The demand for satellite services has, in turn, driven the launch service market.

9. Fuelled by current and planned commercial applications, many with growth rates greater than 20 per cent annually, total industry revenues are expected to surpass US$ 100 billion before the year 2000, with continued growth projected through the early years of the next century.

II. SPACE MARKET SEGMENTS

A. Satellite manufacturing

10. Spawned by continued government procurements coupled with the tremendous demand for commercial telecommunications, remote-sensing and mobile LEO systems, space manufacturing has experienced unprecedented development in recent years. Historically, growth projections for the manufacture of commercial satellites and launch vehicles have been revised upward on an annual basis as demand has exceeded expectations. That trend is expected to continue as several mobile communications systems and new multimedia services begin operations over the next few years. A certain downturn is forecast in the number of satellites ordered in the period 2001-2005, relating to the time between the period when the satellites currently on order are placed into orbit and when their replacements need to be built and launched (see table 1).

Table 1. Satellite manufacturing activity
(Millions of United States dollars)

	1995	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	2000[a]
Commercial	2 739	2 989	3 884	5 044	6 552	8 510
Government	5 883	5 959	5 946	6 100	6 093	6 079

Source: *State of the Space Industry: 1997 Outlook* .
[a]Forecast.

11. The strong and continuous demand for new satellite manufacturing is stimulated by a number of market trends. These may be summarized as follows:

(a) *Demand for greater telecommunications capacity*. More bandwidth is required to satisfy the steadily growing demand for the transfer of data, voice and images. Expansion of the overall capacity will take place through the deployment of new infrastructure, as well as development of new technologies for signal compression. Until new compression techniques are proven and tested, the capacity will expand predominantly through increases in satellite infrastructure, as it provides a quick and relatively inexpensive means of expansion.

(b) *LEO/MEO market*. Numerous planned mobile satellite services based on LEO and MEO satellite constellations require hundreds, if not thousands, of satellites to be manufactured, not to mention spares. As the demand for mobile satellite services is rising, this will keep the space industry with a steady backlog of orders for such satellites;

(c) *Reduced manufacturing cost.* The development of satellite constellations, as well as the need for more geostationary satellites, is expanding technology and providing manufacturers with an opportunity to improve efficiency. As the cost of manufacturing and launching satellites decreases, users of the next generation of satellites will create a number of new applications made possible by lower costs;

(d) *Small satellite market*. Manufacturing activity for small satellites is expected to more than triple by the year 2002, with scientific missions, the qualifying and testing of new hardware in space and emerging applications driving that expansion. Previously limited only to scientific missions, new technologies are beginning to allow the use of such satellites for commercial applications, including telecommunications and Earth observations. A number of small and medium-sized manufacturers worldwide are promoting the use of small satellites for various niche markets. Several universities in different countries, including developing ones, have been designing and manufacturing small satellites both as a teaching tool for students and platforms from which to operate small scientific experiments;

(e) *Future applications*. New applications of space technologies and services are currently being developed. Services such as remote monitoring of the status of oil pipelines, automated data collection and satellite-routed access to the Internet, to name but a few, will further the need for additional satellites to be manufactured and deployed.

B. Launching services

12. Between 1987 and 1996 the commercial market amounted to 36 satellites launched on average each year. With a projected 1,697 satellites to be launched during the period 1998-2007, the commercial launch-vehicle industry is forecast to expand at more than 10 per cent annually. The nature of the demand is also changing. Geostationary orbit (GEO) satellites are growing in mass, the time between their purchase and launch is being reduced greatly and the launch of constellations has become a thriving commercial trend.

13. The total market value for launching services over the decade 1997-2006 is estimated at US$ 33.4 billion, of which US$ 21 billion will be used for launching GEO satellites (based on the conservative estimate of 262 GEO satellites given in section D below). Of the US$ 21 billion for GEO, 55 per cent are already covered by firm contracts signed by October 1996 and another 6 per cent are considered “captive”, leaving 39 per cent of the market still open for international competition. About two thirds of the total market value will be generated by commercial operators, the remainder coming from government agencies (see table 2).

Table 2. Launch-vehicle revenues
(Millions of United States dollars)

Expendable launch vehicle	*1995*	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	*2000*[a]

Commercial	1 325	1 811	2 214	2 400	2 594	2 700
Government	3 101	3 143	3 134	3 220	3 215	3 205
Total	4 426	4 954	5 348	5 620	5 809	5 905

Source: *State of the Space Industry: 1997 Outlook.*
[a]Forecast.

14. Current launch manifests for commercial payloads are booked through 1999, with a record number of flights scheduled in order to meet demand. In addition to placing payloads in geostationary orbit, several of the proposed LEO ventures began launch campaigns in 1997.

15. Expendable launch vehicles (ELVs) currently make up the greatest part of the commercial market for placing payloads into orbit. Based on proven technology, current ELVs have historically achieved a better than 80 per cent success rate for placing payloads into orbit, at a cost of between US$ 16,000 and US$ 20,000 per kilogram. New ELVs or upgrades with potentially scalable lifting capabilities are currently under development a number of countries.

16. A number of small launchers (such as Cosmos, Pegasus, Taurus and polar satellite launch vehicles (PSVLs) are being used for placing small satellites into orbit by various countries. With small spacecraft costing substantially less than larger ones, the market for placing such payloads into orbit is expected to grow dramatically. Led by a market fuelled by the “space-faring” nations, researchers and companies with limited budgets, over 10 different vehicles are under development, including offerings from Brazil, India and Israel.

17. Reusable launch vehicles (RLVs), that is, vehicles that can leave the Earth’s surface, place a payload in orbit, return to Earth and be refuelled for another launch, are seen by industry as a way to reduce the cost to orbit by a factor of up to a 100. The Space Shuttle represents the only operational RLV to date, but its use for placing commercial payloads into orbit is precluded by United States government policy. Several new RLV projects under development (such as Eclipse, K1, Hope X and X-33) are planned for commercial use. The development of those projects still faces many technical challenges, such as keeping the weight of the vehicle down and the need for new materials, structures and control systems. Once operational, however, those RLVs would initiate a rapid expansion of the space industry, enabling new applications as a result of the substantial reduction in launch costs.

18. Another important component of launching services is launch facilities or spaceports. Though a relatively modest growth in revenue is expected within the sector, its activity is at a historical high. Several new facilities are scheduled to begin operations in the next few years, while additional resources are being channelled to modify existing spaceports in order to handle multiple types of launch vehicles. They are expected to reduce the time to launch and support requirements and to save millions of dollars in annual operational costs. An ocean-based launch platform, commercially developed with the participation of companies from a number of countries, is expected to begin operation in 1999.

19. The international marketplace for launch services is expected to be highly competitive over the next few years owing to the international marketing of several launch vehicles with overlapping payload weight capabilities. While the Delta, Atlas and Ariane vehicles have in the past launched most of the commercial payloads, launchers from the Russian Federation, Ukraine and China take a relatively small share of the overall market, owing to agreements signed with the United States of America limiting the number of commercial launches those countries are permitted to conduct (see table 3).

Table 3. 1992-1997 market share based on number of commercial payloads
(Percentage)

United States of America	33.0
Arianespace	48.5
Commonwealth of Independent States/China	18.5

Source: United States Department of Transportation.

20. With current demand outstripping supply, an oversupply of launch vehicles is forecast by some industry analysts when some other countries with launching capabilities enter the international marketplace of launch services and when the number of projected payloads levels out between 2002 and 2006. However, estimates of the number of payloads to be placed into orbit have routinely been underestimated and new emerging applications may spur on the further demand for launch services.

C. Ground segment (ground station design, manufacturing and operation)

21. The ground segment for supporting space systems and services is one of the largest markets within the space industry. Demand for ground facilities, mobile receivers, handsets, very small aperture terminals (VSAT) and direct broadcast receivers has been growing substantially over the past few years, with higher growth forecast for the near future (see table 4). In addition to hardware that receives data broadcast or distributed via satellites, the ground segment of the space industry also includes other activities and services, such as the operation and monitoring of satellites and testing facilities. Predominantly, the largest source of revenue within the sector is from the operation and manufacture of receivers and transmitters, including hub stations, VSAT terminals, direct-to-home (DTH) dishes and mobile handsets.

Table 4. Ground segment revenues
(Millions of United States dollars)

	1995	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	2000[a]
Ground equipment	10 740	11 330	12 830	14 450	15 670	17 240
Space Shuttle operations	3 176	3 144	3 151	2 998	3 019	2 979
Other operations	7 208	7 275	7 218	7 448	7 401	7 380

Source: State of the Space Industry: 1997 outlook .
[a]Forecast.

22. For the past few years, the two products driving this segment have been VSAT terminals and direct broadcast antennas. VSAT networks link factories with main offices, retail stores with central purchasing offices and remote consumer service equipment with central processing facilities, and are increasingly used by financial institutions to link remote branches with central computers. Primary usage has been by large corporations for voice, data and video communications, but small companies and consumers are now joining the purchasers of small Earth stations. More sophisticated satellites, less expensive ground equipment and better software have led to VSAT transmission services becoming competitive with the services provided by dial-up lines. VSAT sales worldwide are expected to increase by 62 per cent between 1995 and 2001. In Asia and the Pacific, the growth is expected nearly to triple. North

America, with an estimated US$ 88 million in sales, is expected to grow slightly less than 40 per cent. The European market is expected to double and Latin American demand to increase nearly two and half times over the six-year period. Such growth may be accelerated by the planned introduction of interactive, two-way mesh VSAT networks.

23. Satellite antennas that receive digital direct broadcast signals have become the fastest-growing consumer electronic products, with most of that growth occurring in the United States and Europe. Worldwide, a dramatic increase in manufacturing and sales of such equipment is expected to take place between 1997 and 2000, as direct broadcast satellites are due to be placed in orbit over the markets of Latin America, Asia and the Pacific and the Middle East. In the four years from 1997 to 2000 sales are expected to quadruple.

24. Beginning in 1998, the sale of mobile terminals and handsets for transmitting and receiving signals from LEO satellite constellations is expected to generate significant new revenues. Personal communications system handsets and mobile terminals relying on various LEO/MEO satellite systems are expected to generate sales of hundreds of millions of dollars over a five-year period.

25. Supporting ground stations, which control the satellites and the flow of data from them, constitute one of the most important segments of the space industry. Although the number of satellites and ground stations is increasing, growth in the ground operations market is flat because of better computer hardware and commercial off-the-shelf software allowing satellite operations to be handled in-house and in a more efficient way.

D. Telecommunications*

26. The telecommunications satellite market is certainly the most mature space market. According to some studies, the world market for commercial geostationary communications satellites between 1996 and 2006 is estimated at some 262 to 313 satellites, with a total value of between US$ 23.8 billion and US$ 28.7 billion. To this should be added the LEO and MEO constellations for mobile telephony and multimedia applications. Combined with the deregulation of the world's telecommunications, the existing and planned satellite systems create an unprecedented potential for the satellite telecommunications services market, with substantial room for growth (see table 5).

27. Given its inherent cost and capability advantages for supporting many global and mobile services, satellite telecommunications have evolved into a core part of the US$ 550 billion global telecommunications marketplace. The transmission of international telephony services, interconnection with national telephone networks and distribution of video signals for cable and television programmers have provided a core base of revenue for the sector. The worldwide growth of those activities, combined with new services requiring expanded bandwidths and the capability to operate in nearly every country almost immediately, will quickly lead to a tripling of direct satellite revenues for those services to an estimated US$ 29 billion by the year 2000.

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*A detailed description of satellite telecommunications services and applications is given in background paper 5, "Space communications and applications" (A/CONF.184/BP/5).

Table 5. Revenues in some sectors of the telecommunications market
(Millions of United States dollars)

	1995	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	*2000*[a]
Fixed satellite services—transponder leasing	4 300	5 000	5 775	6 584	7 505	9 000
Mobile satellite services	780	850	1 450	2 400	4 500	8 000
Direct-to-home services	1 800	2 856	4 600	6 800	9 400	12 000

Source: *State of the Space Industry: 1997 Outlook* .
[a]Forecast.

28. Another service driving the telecommunications market is direct broadcast satellites. Worldwide, DTH satellite television services are expected to meet the needs of more than 800 million television households and more than 2 billion people now without access to television.

29. With rising worldwide demand for mobile satellite services, especially in developing countries, which often lack an adequate terrestrial telephone line infrastructure, planned LEO and MEO systems will supplement GEO satellite communications services. The development and commercial operation of mobile satellite services is expected to reshape the market dramatically by lowering access costs and expanding overall capacity.

30. Mobile satellite service systems will offer the following three types of services: (a) worldwide personal communications services to users via single- or dual-mode cellular/satellite phones; (b) mobile data terminals used to transmit "store-and-forward" messages; and (c) fixed applications in the developing countries and emerging markets such as "village phones". Those services would also provide numerous opportunities for commercial applications such as fleet and cargo tracking and monitoring, low-cost messaging to rescue workers, transmitting data from remotely monitored automated devices (unattended pipeline control stations, automated platforms for collecting environmental and weather data in rural areas and so on) and stolen property recovery.

31. With an unserved telecommunications market estimated at 5 billion people, the satellite telecommunications market has substantial room for growth. The deployment of new GEO and constellations of LEO satellite systems will enable low-cost telephony access to even the most remote areas of the world. Such access will spur numerous commercial services in areas such as telephony, high-speed data transfer, connection to the Internet, tele-medicine, tele-education, tele-banking, emergency communications, distribution of video signals for cable and television programmers and other multimedia applications, thus making the global information highway a reality.

32. The use of satellite communications for sustainable development, training and mass education purposes is a socially important component of the telecommunications sector. Extensive experience gained by several developing countries, including Brazil, China and India, through experiments in the area has demonstrated the potential of satellite communications systems for developing countries in this respect.

E. Remote sensing and geographic information systems*

33. Next to the telecommunications market, remote sensing and geographic information systems (GIS) may be among the most significant commercial applications in the space industry (see table 6). Remote-sensing data are widely used in agriculture, civil planning, environmental management, forestry, natural resource management and many other applications. With the launch of 20 new remote-sensing satellites expected by the year 2002, the capacity for data collection will increase dramatically. The new systems will include sensor technology that will provide users with the option of spatial resolutions down to one metre. This will be combined with other factors driving the industry, including the increase in cost-effective computing power and data-compression capability, as well as the related increase in sophistication of applications adapted to specific user needs and more user-friendly software.

Table 6. Remote-sensing and geographic information systems revenues
(Millions of United States dollars)

	1995	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	*2000*[a]
Remote sensing	535	611	698	838	1 048	1 234
Geographic information systems	1 200	1 428	1 699	2 022	2 406	2 864

Source: *State of the Space Industry: 1997 Outlook* .
[a]Forecast.

34. The impact of remote-sensing activities on various segments of the global space market may be estimated as follows:

(a) From US$ 580 million to US$ 620 million a year for satellite manufacturing, including both meteorological and remote-sensing spacecraft and payloads;

(b) From US$ 230 million to US$ 250 million a year for satellite launches, funded by the space agencies;

(c) US$ 60 million a year for sales of raw data used mostly for commercial purposes and priced in a number of ways, ranging from the marginal cost of reproduction to a price reflecting a steady transfer of the operating cost to users and, in the longer term, the cost of satellite system renewal;

(d) From US$ 280 million to US$ 300 million a year for manufacturing ground equipment for receiving, storing and processing satellite data;

(e) From US$ 830 million to US$ 850 million a year for remote-sensing data distribution, processing and interpretation services and the sale of value-added products and services, essentially by private companies, primarily to public, semi-public and cooperative organizations concerned with pollution control, agriculture, utility infrastructure, urban planning, zoning and water management.

35. Within the next 10 years this market is expected to grow by a factor of three to five, depending on the development of some promising market segments (such as real estate, utilities, legal services, insurance, precision

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*A detailed description of remote sensing and geographic information systems applications is given in background paper 3, “Management of Earth resources” (A/CONF.184/BP/3).

farming and telecommunications, which should be conceived increasingly as market niches for specialized value-added product/service suppliers. The expansion of the market will also depend on the restructuring of the present data/product distribution system to one of solution-oriented systems that can serve a larger number of public and private enterprises dealing with real estate development, disaster-related losses, crop insurance, small projects, environmental assessment, wasteland reclamation, infrastructure and utilities that can afford to pay much higher fees for the value-added services.

36. GIS are a tool for assessing, integrating and distributing large spatially referenced sets of data. With their capability of combining data derived from multiple sources—satellite imagery, digitized maps, census bureau data, soil composition, vegetation, types of water supply and so on—in order to present an overall picture of the situation in a given area, GIS have become extremely valuable in numerous applications, ranging from business and market analyses to disaster management planning, and from environmental monitoring to urban development.

37. Originally, the use of GIS was limited to Governments, universities and large companies that could afford the infrastructure, which included expensive and sophisticated software and hardware, and to researchers and trained technicians. As the technology has advanced, off-the-shelf software for personal computers has opened up access to the GIS market to a variety of new users, mostly small and medium-sized companies all over the world. Fuelled by the growing demand for GIS services and software, this market could reach a level of US$ 5 billion in sales by the year 2000.

F. Navigation services*

38. Since 1993, when the global positioning system (GPS) was declared operational, the market for GPS equipment alone has increased from about US$ 0.5 billion to US$ 2 billion in 1996, and is expected to reach US$ 6 billion to US$ 8 billion in 2000. The most performance- and integrity-demanding applications (military, aviation and marine) correspond to the smallest market shares (2-5 per cent of the total market each), while the market share of civil ground applications, which already constitutes almost 90 per cent of the total market, will keep growing. The wide range of new commercial applications and services includes automotive navigation systems, emergency assistance, geodesy, GIS and precision engineering, among others. This market development has become possible as a result of the dramatic increase in GPS performance through the use of local or regional systems transmitting corrections and the steep drop in price of GPS equipment. GPS is thus becoming an enabling technology, fuelling the market by offering accurate, real-time positioning data to be integrated with other types of information.

39. The future use of GPS relies more and more on the consumer market. In fact, GPS services are expected to complete the transition from a stand-alone device to a standard feature integrated into a variety of multi-function products, such as wireless personal communications devices, leading to the development of true mass consumer markets, with the average selling price per unit being about US$ 100.

G. Space manufacturing and processing

40. Space manufacturing is the use of the near-zero gravity and vacuum environment of space for the production, processing and manufacture of materials for commercial purposes. This is a very broad definition, which includes industrial and research activities such as the zero-gravity production of metal alloys, plastics or glasses, the processing and analysis of organic matter and the study of the physiology and behaviour of humans, animals, and plants in the unique environment of space. While space provides a whole new realm of opportunity and a vast potential market for industry and business, it is still perceived by many as a final frontier rather than an economic

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*A detailed description of satellite navigation services and applications is given in background paper 4, "Satellite navigation and location systems" (A/CONF.184/BP/4).

market ripe for expansion. This is reinforced by the tremendous costs of today's space infrastructure, elements such as cost per kilogram launched, the cost of electricity generated in space, launch expenses and safety requirements.

41. The unique conditions of near-zero gravity in an orbiting satellite or spacecraft would allow industries to manufacture new materials simply because the absence of gravity allows for the creation of perfectly even and consistent mixtures of materials with vastly different mass and densities. These alloys would have physical properties that nobody on Earth could duplicate and could lead to the production of much faster computers, smaller and much more powerful batteries that could power future electric cars and many other new products. In order to facilitate the commercialization of the tremendous potential market of space, the cost of the basic space infrastructure must be reduced dramatically.

42. The international space station, with operations beginning early in the next century, will expand the segment's capabilities to perform both automated and manually operated experiments. However, with limited space and manpower and a backlog of scientific experiments, the station is expected to have less of an effect on commercial activities than unmanned reusable vehicles that can also serve as experiment carriers.

43. Governments should do more to promote, attract and aid the presence of private sector in space.

H. Other and future market segments

44. Many ideas and strategies have been proposed and in some cases implemented with a view to taking advantage of the bountiful prospects of the space market. These include space advertising and space burial services that are already commercially operational. Tourism in space may also prove to be a viable market for new space industries. If the costs of the space infrastructure are drastically reduced and safety levels increased, tourism in space could be a tremendous market.

45. Another potentially profitable space activity is the disposal of nuclear waste and other hazardous materials. The disposal of hazardous waste material has long been a problem for Governments and industries and continues to be so today. With the development of new technology and reduced costs, the ability to transport hazardous materials from remote locations on Earth into space and the propulsion of that material into far-out orbit could become a realistic and desirable option. Space can also provide an optimum location for orbiting platforms that can be used to transmit electrical energy to Earth and microwave energy transmission technology. This would be a new and environmentally safe method of generation and transmission of electrical power.

46. However, a fundamental aspect of all such innovative plans is the reduction—and minimization—of costs, thus making efficiency, economy and cost-efficiency primary concerns.

III. INDIRECT MARKETS

A. Support services

47. The support services segment is composed of a variety of space market services, such as engineering, technical support, business consulting, financial and legal services, space insurance and publishing (see table 7).

Table 7. Support service revenue
(Millions of United States dollars)

	1995	*1996*	*1997*[a]	*1998*[a]	*1999*[a]	*2000*[a]
Professional services[b]	1 321	1 227	1 228	1 188	1 152	1 115
Financial services	–	1 250	750	1 100	950	875
Space insurance	849	796	1 030	950	1 075	1 150
Publishing	12	13	14	14	15	16

Source: *State of the Space Industry: 1997 Outlook* .

[a]Forecast.

[b]The decline is due for the most part to those professional services which relate to overhead/general management support to Governments.

1. Professional services

48. The sophistication and complexity of new products and services offered by the space industry have led to a demand for specialized engineering and technical services that provide integrated system solutions and the incorporation of diverse technologies. New companies are entering various market niches of the space industry to meet the demand for experienced professional consulting and business service providers. In addition, a number of companies specialize in providing support to government agencies in a variety of capacities.

49. Fees associated with contract preparation, business activities and regulatory licensing of satellites and launch vehicles are expected to increase in proportion to the number of new commercial ventures. The growth of those services is forecast at about 10 per cent per year.

2. Space insurance

50. The space insurance market, with underwriting organizations in different countries, provides coverage for the loss of vehicles and payloads, damage to launch facilities and third-party liability. Vehicle and payload insurance covers the value of the launch vehicle and spacecraft from launch through initial operations and may also include coverage beyond that for commercial operations in orbit.

51. During 1996, insurance rates for space launches ranged from 15 to 18 per cent of the insured value. Gross premium revenues rose in 1996 to almost US$ 800 million. Payments for failures in 1996 totalled US$ 508 million, leading to the segment having a gross profit of US$ 288 million for the year. With an increased rate of launching expected for 1997-2000, insurance premiums are anticipated to reach over US$ 1 billion per year.

3. Financial services

52. The space industry is becoming an increasingly important sector of the financial service industry. Mergers, acquisitions and the raising of capital for new ventures are feeding the number of deals within the industry. According to market analysts, revenues jumped dramatically during 1996 as the number of initial public offerings, dealings with national regulatory bodies and the volume of mergers increased. Those revenues are expected to fluctuate from year to year, but remain at a level much higher than at the beginning of the 1990s.

4. Publishing

53. Business development activities depend on information. A large number of publications focusing on news, opportunities, legal and regulatory developments and technology transfer within the space industry exist to meet this need. In addition, specialized newsletters are published to inform the industry and market about technical and market niches.

B. Space technology transfer and spin-offs

54. The global political, economic and technological changes referred to in the introduction to the present paper have altered the space industry's operating environment. In that context, space technology is no longer a means to achieve political supremacy, but rather an economic asset and an immensely valuable source of know-how, which is used, through an extensive transfer process, by thousands of companies worldwide to bring new products, processes and services to the world market at more competitive prices.

55. The indirect effects of space technology applications, which were in the past considered by-products of research and development, are increasingly being looked upon as primary effects that can constitute a meaningful element of an industrial policy, with a strong impact on new market developments, economic growth and job creation or saving. Industrial sectors, which used to be almost independent as regards technology development, are more and more demanding in terms of new technologies, new processes and new materials, the origin of which can be found in the space industry. Further, the manpower devoted to "high-tech" developments in a company is a valuable asset, benefiting not only space activities. Accordingly, such indirect effects can also be considered primary objectives of an industrial corporate strategy.

56. Programmes of technology transfer and spin-off (i.e. products and processes that have emerged as secondary applications of space technology) developed by national and international space agencies now demonstrate a market-oriented approach, based on demand and clearly identified market segments. Thus, space technology no longer appears to be a luxury product and process, but more a reservoir of potential solutions for industry. Of course, that process requires a high level of interaction between the developer and the recipient of the technology, as well as a well-defined government policy and established organizational infrastructures.

57. Thousands of spin-off products have resulted from the application of space-derived technology in such fields as human resource development, environmental monitoring, natural resource management, public health, medicine and public safety, telecommunications, computers and information technology, industrial productivity and manufacturing technology and transportation (see table 8). Technology transfer and spin-off products and processes collectively make an enormous contribution to national economies, to the creation of new jobs and to industrial productivity. They also represent a substantial dividend on national investments in aerospace research.

58. The vast range of industries and products derived from spin-offs makes it impossible to calculate exact figures relating to their economic impact. The relatively long time to complete a technology transfer, which typically ranges from two to seven years, also raises difficulties in determining the overall annual revenue effect of spin-off technologies. In that respect, the development of a systematic quantitative and qualitative approach that measures the effectiveness of a spin-off programme in terms of both results and efficiency is extremely important in facilitating the process of transfer. Such measurements or metrics can then be used to improve the mechanisms and objectives of the programme. Current budgetary reductions experienced by many countries have become an additional reason for applying metrics that can be used to justify and promote both space research and development programmes and technology transfer programmes.

Table 8. Some examples of space technology spin-offs

Environment	***Health care***	***Industrial productivity***
Hazardous gas detectors	Patient-monitoring systems	Cable testers
Pollution-control devices	Portable X-ray equipment	Laser technologies
Wind generators	Physical therapy equipment	Wood-bond testing
Sewage-treatment systems	Invisible dental braces	Inspection tools
Image-processing software	New pharmaceuticals	Industrial robotics
Oil spill clean-up	Scratch-resistant lenses	Industrial control systems
Public safety	***Transportation***	***Computer technology***
Fire-fighting systems	Aircraft de-icing systems	Expert system software
Cathode-ray tube filter lenses	Car airbags	Software management systems
Radiation blocking	Car anti-lock braking systems	Data-acquisition systems
Noise-reduction technology	Electromagnetic compatibility test facilities	Error-free software
Traffic-monitoring systems		Image-compression devices
Advanced materials	***Construction***	***Consumer and home products***
Composite materials	Energy-efficient coatings	Redundancy flashlight systems
Dry lubricants	Accurate surveying	Art preservation
Teflon and non-stick coatings	Computer-aided design/manufacturing enhancements	Velcro fasteners
High-temperature coatings	Lightweight structures	Cordless tools
Metal coatings	Analysis software	Tang orange drink
Plasma-heating devices	Piping connectors	Water filters

1. Technology transfer strategies

59. The approaches used in technology transfer programmes by government agencies and industrial sectors across the world can be divided into three broad categories: technology-push, market-pull and interactive strategies. These are identified as the main strategies of innovation by which spin-offs occur.

(a) Technology-push strategy

60. This strategy was introduced in the 1960s and 1970s, when the priority had been given to the space industry to identify the know-how, expertise and products that could be used as transferable assets for non-space applications. In other words, the innovation process was “pushed” to the market by research and development in the belief that increased economic development could be achieved by increased funding for science only. That strategy, in which a given product or technology had to search for a particular application, often led to difficulties. In some cases, the product did not correspond to a market need, while in other cases, it corresponded to a real need, but the adaptation of the space technology became too costly. The level of risk inherent in many of the space technologies often discouraged the potential recipient company from investing in the adaptation.

(b) Market-pull strategy

61. Consequently, the space industry has developed a “market-pull” strategy, which starts from the potential customer’s demand and systematically researches the market needs. Then the objective is to find the adequate technology, or set of technologies, that could offer a solution to the industrial, economic, societal or other problems. Such a market-oriented approach has the advantage of being based on demand and on clearly identified market segments. Of course, the process requires a higher level of interaction between the developer and the recipient of the technology. This approach corresponds to a “market-meet” strategy, in which the space companies acquire an in-depth understanding of the market needs and problems through face-to-face interaction with experts from both sides.

(c) Interactive strategy

62. The interactive strategy, also called the “chain-link” model of innovation, stresses the importance of the links between science, technology and the marketplace. The interactive strategy constitutes a linking of science and the market with a number of feedback loops. This approach attempts to satisfy the needs of technology transfer by approaching the problem from both ends, that is, by promoting both “push” and “pull”. A distinguishing characteristic of the strategy is that at each step there is access and interaction with the knowledge base, as well as a greater responsibility of all parties for their part of the project, combined with greater communication between all those concerned.

2. Technology transfer mechanisms

63. The successful transfer of technology and spin-offs require appropriate methods and an infrastructure in place, as well as clearly defined government policy on the matter and support from it. Major mechanisms used for technology transfer and spin-offs are summarized below. It should be noted that not one but a number of mechanisms should be activated in order to establish an efficient technology transfer infrastructure.

(a) Organizational structure

64. Organizational structures in agencies and industry can either promote or discourage technology transfer. An example of a successful organizational mechanism in place to aid technology transfer and spin-offs in the space sector is the technology transfer and/or commercialization office established within a government space agency. Agencies that have a dedicated structure in place can demonstrate visible success in conducting and successfully completing technology transfer. Umbrella organizations devoted to promoting technology transfer between sectors can also be created. The role of the transfer offices, umbrella organizations and the technology brokers involved can be an extremely complex one, depending on the structure of the organization, its role and its constraints.

(b) Contractual mechanisms

65. Contractual mechanisms to aid technology transfer are a relatively recent development in the space sector and are based on an appropriate government or international space policy. Such mechanisms encourage private companies to enter into cooperative agreements with space agencies in order to develop commercially technologies already developed by agencies or to work with agencies’ scientists to produce new technologies or products and to use the agencies’ research facilities. Contractual mechanisms can promote cost-sharing, cross-fertilize ideas and reduce the duplication of effort. In a joint work programme, the parallel development of a technology can also lead to joint ownership and to shared profits. Such an approach is also very beneficial for small and medium-sized companies lacking their own research and development facilities or personnel.

(c) Marketing and market research

66. Marketing is an integral part of the commercial use of space technologies and is essential to technology transfer. The market demand for technology has led to the establishment of numerous technology brokerage companies. Brokers act as go-betweens in a transfer of technology, essentially matching donor to receiver and aiding both parties where possible. The establishment of spin-off companies as a result of technology transfer is very often a direct outcome of activities carried out by such brokerage companies.

67. Other marketing mechanisms focus on a widespread promotion of technology. These include such events as technology transfer exhibitions or fairs, awareness campaigns and conferences organized by space agencies, their umbrella organizations or brokerage companies. Also in this category are more passive mechanisms, such as technology catalogues and databases of marketable technologies, as well as various magazines and newsletters focusing on technology transfer and spin-off benefits. The latter, however, rely on donors and receivers having an active interest and motivation in finding technological partners.

(d) Education and training

68. One of the most essential elements of technology transfer is education. Training courses are being implemented in the major space agencies to make employees more aware of the process of technology innovation and technology transfer. Education is equally important in industry, public research institutes and the general public. While those professionally involved in technology development at the various stages require knowledge of how to initiate a transfer (e.g. acquisition or promotion), those not part of that process need to be educated on the benefits of technology transfer. The most important group to be educated is that of decision makers and policy makers. For all groups, education and training are the means to bring about transfer of technology and related spin-offs.

(e) Financial mechanisms

69. The most obvious financial mechanism is funding in various forms. Direct government funding of fundamental research is an integral part of the "technology-push" approach to innovation. Various financial incentives can be used for innovators in the form of royalties, encouraging them to publicize and to market their technologies. Other financial mechanisms may include tax incentives for entrepreneurs and innovators, subsidies and financing on a liberal and competitive basis.

3. Legal issues associated with transfer of technology and spin-offs

70. The most important question related to technology transfer is the issue of intellectual property rights, as no efficient transfer can take place without a reasonable level of legal protection. It is pointless to transfer or license a technology to a recipient if competitors may copy the technology and begin marketing it before the recipient can. Before a technology is transferred, therefore, it must be protected. It may be protected in two ways, by patent or by trade secret. The reasons for choosing the trade secret approach are twofold: firstly, not all technologies can be patented and, secondly, for a technology with a short lifetime, it might be cheaper to keep the invention secret. However, the patent is the most common form of protecting a technology.

71. Three conditions generally have to be met in order to obtain a patent: the invention must be new, useful and not obvious. Although conditions are very similar worldwide, two administrative systems coexist for the granting of the patent: the "first-to-file" principle, common in most industrialized countries, and the "first-to-invent" principle used in the United States of America. The patent grants monopoly rights for the exploitation of an invention within a certain time limit. On the other hand, the disadvantage of the patent is that it is expensive to obtain and to maintain, which are inherent obstacles to successful legal protection and thus to technology transfers. However, the trend set by the Agreement on Trade-Related Intellectual Property Rights, Including Trade in Counterfeit Goods of the General Agreement on Tariffs and Trade, which established a provisionary patent application system, raises certain expectations in that respect.

72. Once the invention has been patented and the candidate transferee has been found, the appropriate form of licensing agreement must be chosen. Depending on the market situation and the business goals of the parties involved in the transaction, there are a wide range of licensing provisions (exclusive or non-exclusive licence, territorial, time or field-of-use restrictions, etc.) that will influence the relationships between the licensor and the licensee.

73. Another controversial issue affecting the international cooperation in transfer of technology and spin-offs is the practice of using bilateral or multilateral agreements instead of appropriate international treaties, while such agreements do not always match the related treaties. Some countries, including developing ones, believe that such an approach would make the international transfer process faster and more flexible.

IV. APPRAISAL

74. Since UNISPACE 82, the commercialization of space activities has become an irreversible and expanding process. The new political and economic environment has resulted in shifting the space industry's resources towards commercial opportunities. The industry is continuing its evolution from a government-driven, project-defined industry to one in which Governments play a lesser role and market forces predominantly dictate growth.

75. This process allows both industrialized and developing countries to benefit from such opportunities through strengthening economies, new market developments, job creation, educational opportunities and a higher standard of living. For developing countries, the commercial use of space technologies may also provide new opportunities for catching up with the industrialized countries. To maintain that momentum, it is extremely important that a collaborative environment is established and encouraged between government and industry, between science and the marketplace and between the industrialized and the developing countries.

76. When considering the numerous beneficial applications of technologies derived from space that can address the global needs expressed by society (environmental concerns, monitoring of mega-cities, increasing needs of security, etc.), it may be observed that space has a great potential to offer, in association with other sectors, to contribute to global solutions.