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Space 2030
Tackling Society's Challenges
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ANNEX A

Case Studies on Selected Space-based Applications

Introduction

This annex provides an overview of the case studies conducted in the third phase of the project in order to explore – in close collaboration with members of the Project Steering Group – possible appropriate economic/business models for the successful development of specific space-based applications.

The purpose was not to identify actual business opportunities, but rather to reach a better understanding of the factors that are likely to play a critical role in the success of the applications under investigation and to map out areas in which government action may be required, so as to provide a more concrete basis for the policy-oriented reflection and the formulation of recommendations in the fourth and fifth phases of the project. Indeed the term "economic/business model" is used throughout to reflect the fact that in a number of cases the application under consideration will be carried out by the public sector to provide a public service rather than to exploit a market potential.

Five case studies were selected: telehealth via satellite, satellite entertainment, risk and disaster management, location-based road traffic management and space tourism. These case studies were chosen by the Steering Group and the OECD Project team because: *i)* they represent a useful cross-section of public-oriented applications with high social value, private-sector-driven applications with strong commercial dimensions, and applications offering a mixture of the two; *ii)* they take advantage of space technologies; and *iii)* they have a reasonably good probability of success in the longer run.

To facilitate comparability and readability, each of the five case studies is divided into five standard sections:

- An introduction gives the rationale used for selecting the application.

- A first section provides a brief description of the main actors and shows how they may interact with one another.
- A second section outlines the major factors that are critical for the success of the application.
- A third considers the economic/business models that can be used for the deployment of satellite-based solutions.
- A fourth explores the prospects for the respective economic/business models, taking into account the three scenarios developed in the second phase of the project and outlined in the Chapter 1 of this volume.
- A final section lists a number of references pertinent to the area concerned.

At the end of the annex, a concluding chapter identifies seven areas in which action is required to support the successful implementation of the economic/business models considered.

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1. Telehealth

Introduction

Health spending represents a large and growing share of GDP in most countries. OECD economies devoted on average almost 8.5% of their GDP to health expenditures in 2001, up from around 5.5% in 1970. Given the strong link between rising income levels and rising levels of resources devoted to health care, the upward trend is expected to continue in the coming years, albeit at a somewhat slower rate. There is concern in both OECD and non-OECD countries about the escalating cost of health services and about the limited access to health care experienced by many citizens in more remote regions. These problems are likely to be exacerbated in the coming decades as populations age, not only in OECD countries but also in some of the larger emerging economies.

Telemedicine and telehealth offer the prospect of helping to extend health-care coverage and to reduce health costs. By extending the reach of medical care to populations in remote areas, to disaster assistance teams, ships at sea, etc., they will help overcome geographical barriers to access. Telehealth can offer opportunities for satellite-based solutions in areas where satellites have a comparative advantage over terrestrial technologies. Public and private actors will have an important role to play in these developments.

Telehealth is generally defined as the use of information and communications technologies (ICTs) (including satellite communications) to support long-distance clinical health care, patient and professional health-related education, public health and health administration. It can help to alleviate the problems noted above by providing a broad range of services designed to improving the quality, geographical reach and timeliness of healthcare. Such services include:

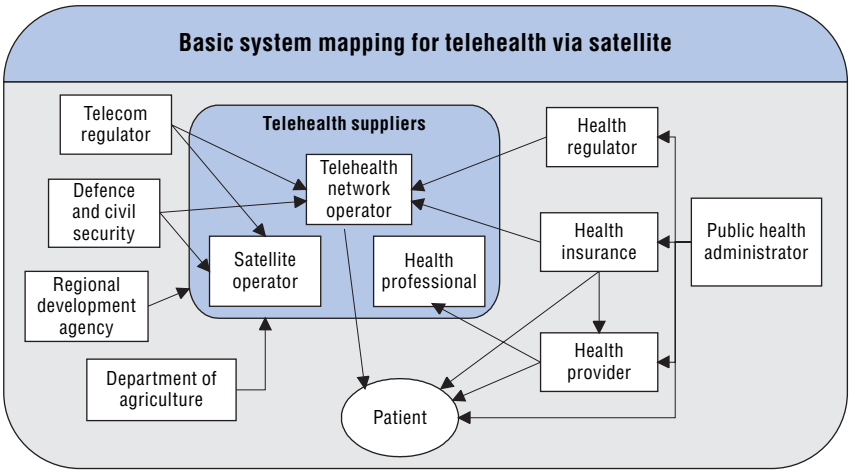
- ***Long-distance provision of health education and decision support material to professionals and patients.*** Health professionals can be kept informed in real time of the most up-to-date protocols and findings. Patients can receive timely information and recommendations made by health professionals.
- ***Long-distance administration of health services.*** The various health services using the network can be connected and integrated so as to offer a seamless continuum of care to patients.

- ***Long-distance diagnosis and treatment.*** Telehealth provides a tool for accomplishing several of the tasks involved in disease management. This includes the communication of physician guidelines to the patient, monitoring the health of the patient, patient education and behavioural modification interventions.

The main actors

The provision of telehealth services may involve different configurations of actors. Figure A.1 provides an illustration of what such configurations might look like. In the hypothetical example presented here, the provider of telehealth services is represented in the shaded square. It is assumed to be a joint venture between a satellite operator providing the communications link, affiliated health professionals offering the telehealth services and the telehealth network operator that uses the satellite communications link (and perhaps other ground-based communications links) to transmit telehealth data and that provides support for the operation of the telehealth equipment.

Figure A.1. **Main actors involved in the provision of telehealth services**



Source: Authors.

Outside the shaded square are represented some of the major actors that may influence the development and operation of the telehealth service. These include first, healthcare institutions which are potentially the main users and providers of telehealth services. Second, payers (public and private health insurance) play a key role since they determine whether telehealth services are reimbursed and how. Third, telecommunications and health regulators govern the day-to-day activities of the telehealth service provider.

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Finally, public health administrations may encourage the development of telehealth in order to facilitate access, reduce costs and improve the quality of health care, as well as to foster the dissemination of public health information. Politicians may also encourage the development of telehealth if they can be convinced that it may be able to address broad policy issues, such as inequalities in health care, and that it may reduce costs while delivering at least equivalent, if not better, standards of health care than more traditional alternatives. The funding of telehealth networks can be provided by national authorities, including national telecommunications agencies, regulatory bodies, health agencies and various other national ministries (*e.g.* Agriculture, Defence, Veteran Affairs), as well as regional authorities (*e.g.* states or provinces) and private foundations. In Europe, the funding can also be made through regional development programmes supported by structural funds and through Framework Programmes in the case of research projects.

Critical success factors

Telehealth service providers deal with many different actors and face many challenges. In this context, some factors (technical, economic, legal, regulatory, financial, among others) will be crucial to their success. These can be grouped under two main headings: *i*) the factors that relate to the business model to be used for the development of the application; and *ii*) the factors that shape the environment in which the application is implemented.

Critical success factors for the business model

To be successful, the telehealth application should be so designed as to fulfil the needs of health administrators, health professionals and patients in the most cost-effective manner. Moreover, sources of revenue should be clearly identified and all possible sources of funding should be tapped. More specifically, the application should:

- ***Fully meet the needs of health professionals.*** It should be user-friendly, save time for clinician professionals and offer diagnostic-quality images, diagnostic-quality sound and a true representation of paper-based information (lab reports, requisitions).
- ***Provide effective support at all telehealth sites.*** Such support is essential for building confidence in the telehealth network among health professionals and patients alike. This includes equipment, administrative and technical support, clinical support and clinical administrative support.
- ***Effectively address security and privacy requirements.*** This may require separate secure telecommunications links if encryption is not commercially available (*e.g.* for video telehealth services).

- ***Facilitate providers' acceptance.*** This may call for approaches to financing that reduce the risk borne by the user (*e.g.* leasing or outsourcing model).
- ***Clearly establish how revenues will be generated.*** Estimating revenues from a patchwork of public and private reimbursement policies is not easy for the telehealth provider and may require a specialised administrative capacity.
- ***Leveraging sources of funding.*** The success and sustainability of telehealth networks depend on their ability to leverage capital resources creatively (*e.g.* funds from public sources, private foundations and user fees).
- ***Provide for an efficient information flow.*** Recognising that poor information flows in health-care settings contribute to gross inefficiencies, inequities and quality variations, business models that focus on telehealth as an enabler of better, faster, cheaper information flows will present better cases for acceptability and profitability.

Critical success factors in the business environment

In addition to factors directly related to the design of the telehealth application discussed above, the telehealth entrepreneur must take into account critical factors in his/her business environment. This includes notably:

- ***Licensing.*** Because a telehealth network can extend over several jurisdictions, it is important to ensure that health professionals using the network are fully entitled to exercise their profession across all jurisdictions covered by the network or appropriate policies are put in place to meet licensing requirements.
- ***Standards.*** Lack of broadly accepted standards is a major obstacle to the development of a telehealth network. It restricts interoperability and prevents full exploitation of the capability of the technology.
- ***Communications.*** High communications cost is often cited as a major obstacle to the development of telehealth network, notably in rural and remote areas.
- ***Liability.*** Concern about liability suits may induce health professionals to shy away from procedures such as telehealth that are not considered "well established" in the profession. The definition of malpractice is based on the premise that the doctor did not follow widely accepted practices.
- ***Technology.*** Uncertainties regarding the future development of telehealth hinder private investment in the development of telehealth technologies. Moreover, technology transfer from the military has been slow.
- ***Provider acceptance.*** The adoption of telehealth is a challenge for health professionals: telehealth applications require technical knowledge and technical problem-solving skills. They also require a new workflow routine

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and organisational support. Moreover, if it is not accepted by all (*i.e.* health administrators, health professionals and patients), telehealth is unlikely to work effectively.

Economic/business models

Space-based telehealth services need to take advantage of space's particular strengths. This means that they should focus on three main areas of need: rural and remote populations; populations on the move; populations involved in a disaster.

Model 1: Providing telehealth services in rural and remote areas. The customers here are health professionals and patients. The network is run by an operator, which is set up by a consortium that may include satellite operators, health management organisations and research organisations. The network enables health professionals to provide remotely a number of health services, including health education, diagnosis, treatment and monitoring. The network should meet the critical success factors noted above. The consortium finances the construction and operation of the network. Such financing may involve both public and private funding. Typically, the key players will be the health service providers and the payer, who must accept to pay for telehealth services. Other major players are the public health authorities which have a mandate to promote equal access to health care and may be prepared to encourage financially the development of telemedicine in rural and remote areas.

Model 2: Serving the health needs of people on the move. Given that the clientele for this kind of service is affluent (*e.g.* tourists and executives of multinational enterprises) and emphasises quality of care and convenience, a private business model may be the most appropriate. The main actors might be an enterprising health service provider (*e.g.* a well-known hospital with a strong research and education capability) creating a joint venture with a satellite operator and a telehealth network specialist. The telehealth service would provide the link from the affiliated health service provider and the client, ensure installation and maintenance of the terminal equipment in the client site (*e.g.* cruise ship) and be responsible for training the client's health personnel in charge of using the terminal equipment.

Model 3: Serving the health needs of people in a crisis situation. In a crisis situation when ground facilities are destroyed, including terrestrial telecommunications links, satellite-based solutions may be the only ones able to function effectively. Moreover, satellites can be rapidly deployed over a crisis location. Hence, satellite-based telehealth networks are likely to be favoured by civil protection and national security authorities, at least as a backup to terrestrial ones. One might envisage, for instance, a satellite-based

telehealth network linking centres for disaster control to emergency response teams, disaster management assistance teams, and chemical, biological, radiological, nuclear or explosive teams. Such a network would essentially be public and is likely to involve space assets under military control.

Prospects for the future

The limited use of telehealth today is due to technical and institutional obstacles to its implementation, as well as insufficient empirical evidence regarding its cost effectiveness. However, there are reasons to believe that the situation will improve considerably in the coming years.

First, given the growing interest of health professionals, a stronger evidence base is likely to develop gradually, as well as better guidance for overcoming the obstacles to the successful implementation of telehealth systems.

Second, progress in a broad range of converging and complementary technologies should help to reduce significantly the cost of delivering telehealth services and to facilitate the development of a fully fledged telehealth network. This includes not only progress in telehealth technologies *per se*, but also progress in related disciplines, notably health informatics and e-health and more generally, progress in communications technologies (notably broadband).

At the same time as "technology push" may make telehealth increasingly feasible, changes on the demand side will "pull" its implementation. A growing number of individuals are likely to become more mobile, as incomes rise and transport becomes more efficient and there will therefore be a greater need to be able to provide health services wherever that population happens to be. Moreover, as the population in OECD countries ages, there will be an increasing demand for homecare, most of which might be accommodated via telehealth. In addition, growing concern about security will induce health authorities to develop emergency systems that can respond flexibly and effectively in times of crisis.

Fourth, greater concern about providing equal access to health care will drive the development of telehealth networks to serve the needs of individuals living in rural and remote areas or are unable to access health facilities easily. Finally, if the cost effectiveness of telehealth is confirmed convincingly by new empirical research, the greatest driver for telehealth may very well be governments seeking to cut healthcare costs.

On balance, the main conclusion is that there are indeed good reasons to believe that the pace of implementation of telehealth will accelerate in the coming years. Other things being equal, this should create, overall, a favourable environment for the satellite-based applications and the related

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business models outlined above. When considering the scenarios outlined in Chapter 1, it appears likely that the development of telehealth will be fastest under the Smooth Sailing scenario: the relatively open environment in this scenario is favourable to the implementation of space-based solutions and demand from people on the move is likely to be very high. Moreover, in this rather optimistic vision of the future, telehealth will be a powerful way to extend health care to the developing world and remote areas. In the Back to the Future scenario, the environment is less open and international co-operation is not as extensive, so that from this perspective the prospects for telehealth may not be as good. However, when both civil and military aspects of security are taken into account, greater security concerns may be an important driver for the further development of telehealth. In Stormy Weather, the prospects for telehealth appear to be less promising, notably satellite-based solutions. However, security concerns will remain a major positive driver. Cost considerations might also play a role, if telehealth truly contributes to cut health-care costs. Hence, on balance, the prospects for telehealth are good across all three scenarios, although they appear to be best under the first scenario.

2. Entertainment

Introduction

Satellite entertainment services represent a segment of the huge and dynamic media and entertainment sector. The services are provided by satellite direct-to-home (DTH) platforms and include: *i)* regular broadcasting services (which represent the bulk of such services today); *ii)* enhanced (including high-definition television – HDTV) and interactive services (such as interactive television – iTV); and *iii)* broadband entertainment services provided through broadband access (typically the Internet via satellite).

In recent years, satellite DTH platforms have grown rapidly, with close to 60 million subscribers as of January 2004. Rising subscriptions have been supported by the unchallenged diversity of content offered by satellite. DTH platforms currently broadcast more than 7 200 TV channels, and spend around USD 16 billion in programming a year.

The entertainment sector is currently in a state of flux, as disruptive new technologies, such as the digitalisation of content and the development of broadband access, offer new ways to produce and deliver content and call into question existing modes of operation. For DTH platforms, these developments offer new opportunities but also new challenges – not only to their ability to maintain their strong position in the broadcast distribution segment, but also to their capacity to penetrate other broadband entertainment markets and develop successful business models.

The main actors

The system mapping presented in Figure A.2 gives a general picture of how satellite broadcasting services are delivered and of the main actors involved. The key players are the satellite operators and the DTH platform operators which are either vertically integrated or linked through long-term lease contracts. In some cases, a DTH platform operator may lease an entire satellite for periods of up to 10 or 15 years. Other important actors are the content providers and content aggregators that provide the input to the system, while revenues come from advertising and subscriptions. The government plays a major role in determining the rules of the game, largely through the regulatory agencies.

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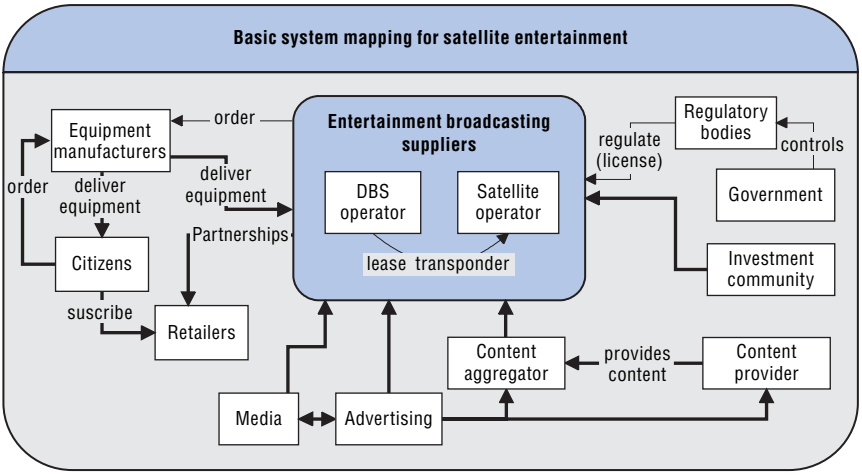
Figure A.2. **Main actors involved in the provision of satellite entertainment services**



Source: Authors.

In the case of broadband entertainment services (Figure A.3), the configuration of actors is somewhat different: a retailer uses the satellite capacity provided by the satellite operator to offer an end-to-end service to its customers, *i.e.* access services to Internet service providers (ISPs), telecommunications companies or large integrators, which in turn provide services under their brand names to their end users. This retailer may or may not be affiliated with the satellite operator.

Critical success factors

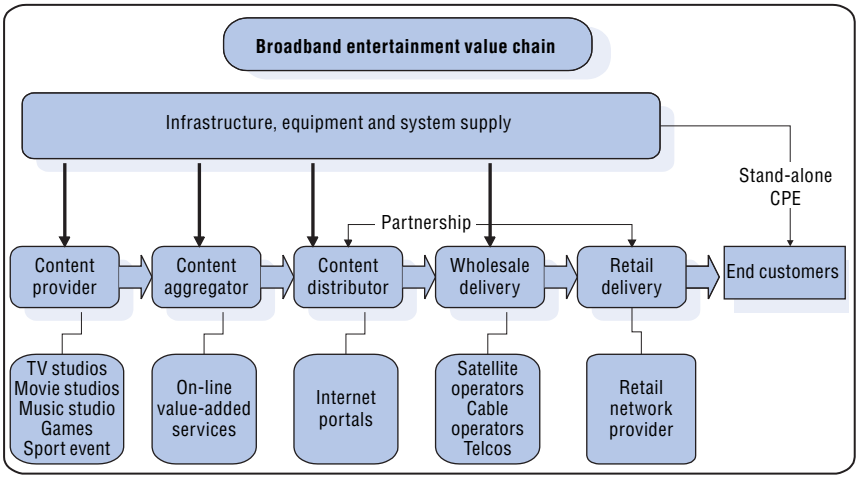
In the selection of applications and in the designing of the business model to be used for their development, entrepreneurs must take into account a number of factors that will be essential to their success.

Critical success factors for the business model

Take advantage of strength in broadcasting. When compared to terrestrial competitors, a major strength of satellites is in broadcasting, a form of transmission that is particularly well suited for the delivery of content directly to the home of consumers. Satellite actors should take advantage of this strength by concentrating on the provision of services that can rely on datacasting and require no, or only a limited amount of, interaction. In this way, they can take advantage of the large base of existing DTH subscribers.

Take advantage of capacity to tap underserved markets quickly. Another strength of satellites is their ability to provide service quickly in underserved

Figure A.3. **The broadband entertainment value chain**



Source: Authors.

markets where competing technologies are not yet present. This should be fully exploited, notably in emerging markets where satellite entertainment could make significant inroads (*e.g.* Central and Eastern Europe, Middle East, Latin America, Asia-Pacific).

Take advantage of complementary technology. DTH operators can "save on two-way communications" (where they are weak compared to terrestrial competitors) by "pushing" content directly into the home of consumers, taking advantage of the major progress achieved in storage capacity of personal video recorders (PVR). As most of the interaction takes place between the consumer and the set-top box/PVR, traffic on the return channel is significantly reduced.

Forge alliances with others. In the longer run, the ability to deliver compelling content to consumers at a reasonable price will be crucial to success in the market place. This means that DTH platform operators should pay particular attention to the forging of strong relationships with content producers and aggregators. Alliances with telecommunications companies may also be effective in markets where competing digital cable operators offer "triple play" (*i.e.* TV, telephony and Internet).

Success factors in the business environment

Availability of the Ka-band. While other bands are crowded, the Ka-band has remained largely open. It provides ample room for the development of new satellite-based services, notably broadband and HDTV services.

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Development of standards. The adoption of open standards has greatly enhanced the cost effectiveness of DTH services. It will be also a main factor for the success of satellite broadband. In particular, it can help to reduce significantly the cost of equipment by promoting interoperability and by facilitating the scalability of networks. Adoption of "plug and play" standards for the equipment installed in the home of the final consumer (customer premises equipment – CPE) should also greatly increase the attractiveness of such equipment, including PVRs.

Digital divide concerns. The desire of governments to reduce the digital divide between urban and rural areas induces policy makers to pay more attention to solutions – including satellite broadband – that can effectively deliver services in rural areas.

R&D in satellite broadband technology. Efforts under way should contribute to the introduction of new technologies that provide for more efficient use of spectrum and cut dramatically the cost of delivering satellite broadband.

Regulation. Regulation has traditionally tended to favour incumbents and existing services and to slow the introduction of innovative services. Changes in the regulatory regime (*e.g.* introduction of spectrum trading) may also be very disruptive to the business model of operators.

Competition from terrestrial technology. Progress in terrestrial wired and wireless technologies may gradually erode the satellite broadband niche market in rural and remote areas (*e.g.* ADSL, WIMAX). In the longer run, satellite entertainment as a whole may be vulnerable to the extension of fibre optic networks.

Market evolution. Two trends might adversely affect satellite entertainment: *i*) the trend towards "triple play": consumers may be tempted in future to prefer to deal with one supplier; and *ii*) changing consumption patterns, *i.e.* the growing demand for bandwidth and interactivity might put satellite at a disadvantage (the Korean model). The Korean experience is interesting because Korea is ahead of the rest of the world in terms of broadband access. More than half the population has had broadband access for more than three years. Particularly significant has been a 650% rise in online gaming from 1999 to 2001. As a result, the market share of online gaming has risen from 2% to 21% of the overall gaming market. If online gaming becomes as popular in other countries, as the penetration of broadband increases, the Korean experience could signal how consumer entertainment will change throughout the world. Gaming may presage changes in the value chain that will become common in other areas.

Economic/business models

Consideration of the critical factors outlined above suggests a strategy for the development of satellite entertainment. It involves the adoption of three business models:

Model 1: HDTV. By fully exploiting the current strength of satellites in the provision of broadcast services and the large existing subscriber base, this model involves the aggressive development of HDTV: it is almost non-existent in Europe today and emerging in the US market. HDTV offers higher-quality picture and sound than regular TV. Market studies have demonstrated that there is a significant pent-up demand for higher-quality images among consumers, notably for films and sporting events. It also involves the development of digital cinema: as content is increasingly produced in digital form, digital cinema represents a natural extension that satellites could fully exploit. The model would involve a partnership between satellite operators, HDTV distributors (to households as well as to digital cinemas), digital video broadcast content producers and manufacturers of high-definition equipment.

Model 2: ITV. This models develops iTV services, by taking advantage of the capability of the new PVRs: such devices offer increasing opportunities for providing quasi-interactive services via satellite, including video-on-demand, as their cost declines and as their capability and ease of use improve. For the DTH platform, the business strategy is first to expand the base of equipped subscribers by marketing aggressively services offering operator-sponsored PVRs, boosting in this way subscription revenues, as PVR clients generate more revenue than non-PVR clients. Once a critical base of customers is created, new possibilities for raising advertising revenues arise because the technology offers advertisers new opportunities to target their advertising messages more effectively.

Model 3: Satellite broadband. This model takes advantage of access policies to deploy broadband in rural and remote areas and introduce new technologies to cut costs. Satellite is the only technology able to fully bridge the digital divide. With public support, satellite broadband could be deployed in rural and remote areas where market demand is inherently weak. The use of the Ka band and new technologies (*e.g.* use of spot beams) that conform to newly established open standards (*e.g.* DVB-S2) could contribute to significant efficiency gains. A credible business model for satellite broadband entertainment needs to be based on competitive subscription rates, cheap terminals with very large storage capability and very sophisticated and easy to use electronic programme guides, WIFI connection for all the equipment installed in the home of the final consumer, and the provision of compelling entertainment content. This requires a strong partnership of several players in the value chain, including the manufacturer of equipment, the distributor of content and the operator of the broadband network.

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Prospects for the future

Model 1. Several factors will contribute to the rapid development of HDTV in the coming years, including the rapid decline in the cost of HDTV equipment and display as well as its attractiveness on the larger screens that will become the norm in future. DTH platforms are well-placed to take advantage of this development because of their strength in broadcasting and their large base of satisfied customers. On the negative side, limitations on the availability of frequencies might be a problem as HDTV uses twice as much spectrum than regular TV, even with progress in compression. The success of satellite HDTV is likely to be greater in a more open environment (the Smooth Sailing scenario) where the cost of equipment declines faster and where the cost of production of content can be spread over wider geographical regions than under more restrictive conditions (the Back to the Future and Stormy Weather scenarios).

Model 2. Like HDTV, iTV appears to have a bright future, not only because of progress in the technology (*e.g.* PVRs, electronic programming guides, or EPG) but also because of viewers' desire to have more control over their viewing experience and the desire of television announcers to target their commercials more effectively. DTH platforms should be able to capture a fair share of this new market because of their inherent strength in broadcasting and their large subscription base. Moreover, progress in satellite broadcasting technology (*e.g.* implementation of DVB-S2) should make the delivery of satellite iTV more cost-effective. However DTH operators will need to face growing competition from digital cable operators. As for HDTV, the development of satellite iTV is more promising under the more open environment of the Smooth Sailing scenario than under the other two.

Model 3. Broadband entertainment is likely to expand rapidly in the future as an increasing share of the world population has access to the broadband network. Given the inherent weakness of satellites for two-way communication, satellite broadband entertainment will largely be restricted to rural and remote areas. However, progress in satellite technology should contribute to bring costs down to more competitive levels. Moreover, strengths of satellites in broadcasting may continue to give it an edge over its rivals: entertainment is typically produced for large audiences rather than tailor-made for each individual, because of the large fixed cost in content production and the economies of scale in displaying content. Hence, datacasting is likely to remain the most efficient technique for bringing such content to users, including those on the move in an increasingly mobile society. Once again, the open environment of the Smooth Sailing scenario is more favourable to satellite broadband entertainment than the Back to the Future and Stormy Weather scenarios.

3. Location-based Service Applications: Road Traffic Management

Introduction

While road transport brings major benefits overall, it also imposes substantial costs on society at large. For instance, the economic costs of congestion and road accidents may amount to a staggering EUR 400 billion in Europe alone. Worldwide, road transport produces roughly 20% of carbon emissions and smaller shares of the other five greenhouse gases covered by the Kyoto Protocol (IEA, 2002). The situation may worsen in future. By 2030, the number of light vehicles and of kilometres travelled may more than double in the world (+137% for both), with an even larger increase for heavy vehicles (+190% vehicles and +192% kilometres travelled). By 2030, more than 1.5 billion light vehicles and 87 million heavy vehicles may be on the roads (OECD, 2001).

More effective traffic management should result in more efficient and safer use of transport infrastructure. This will translate into significant savings in terms of reduced costs of accidents (from a human as well as economic point of view) and of congestion, as well as a lesser need for the construction of new infrastructure.

Location-based services (LBS) can make a difference in this regard. Broadly speaking, they rely on the ability to locate an individual or an object (*e.g.* a car) in real time, using either satellite technology – notably global navigation satellite systems (GNSS) – or terrestrial technology or both. They have a broad range of applications, including transport telematics applications (*i.e.* the blending of computers and telecommunications, which combines wireless communication with location technologies such as GNSS to provide services to vehicles on the road) and the management of road traffic. Over the coming decades, such applications may help alleviate road traffic problems in terms of pollution, congestion and accidents.

The main actors

Several actors are involved in the provision of LBS. They include first of all customers, who may be public (*e.g.* road transport authorities that use LBS to monitor and control traffic) or private (*e.g.* road carriers that use LBS for fleet

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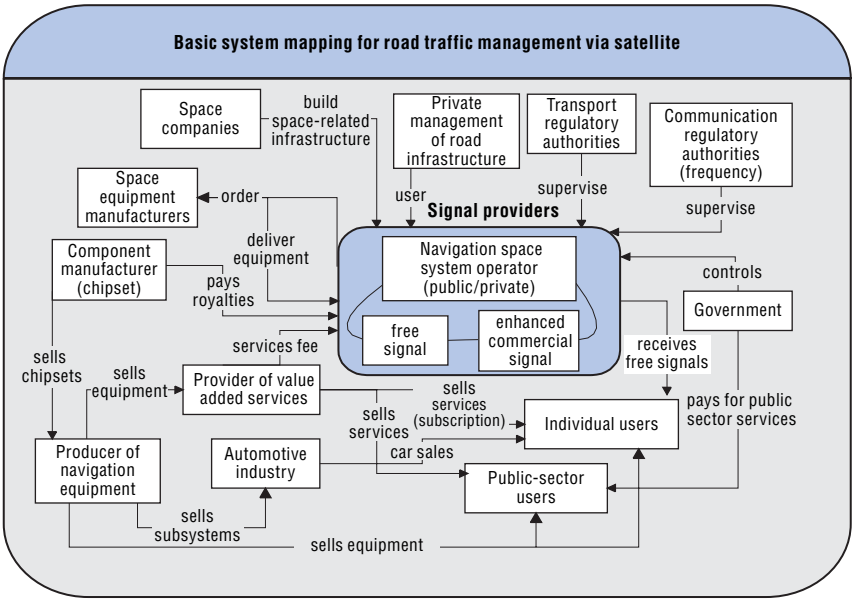
management, or individual users who acquire telematics equipment or subscribe to telematics services). They also include providers of navigation signals; providers of chipsets (*e.g.* GPS chips) and navigation equipment; the car industry (which integrates navigation equipment such as vehicle protection systems in new vehicles and other location-based telematics equipment); and the insurance industry (*e.g.* introduction of "pay-as-you-drive" insurance policies for which the premium is based on usage which can be monitored by location-based devices).

Figure A.4 illustrates a situation in which the signal provider consists of a system operator created in the context of a public-private partnership (PPP) that offers three signals: a free signal available to all, an enhanced public signal restricted to designated public users, and an enhanced commercial signal. The operator has three main sources of revenue: *i)* payment for the use of the enhanced public signal by the government, which can take the form of a fixed guaranteed level of revenue for such services; *ii)* royalty payments by the producers of the chipsets; and *iii)* service fees paid by providers of value-added services that use the commercial signal.[1] The car manufacturing industry appears in Figure A.4 not only as a customer of navigation equipment subsystems, but also as a provider of such systems when selling vehicles to the mass market. Moreover, car manufacturers may set up subsidiaries to offer telematics services to their clients.

Figure A.4. **General system mapping for LBS and road management**



Source: Authors.

Critical success factors

Technology. The signal provided must meet users' requirements in terms of accuracy, availability and integrity. This means that several signals may have to be on offer to meet these needs. The quality of the signal can also be enhanced by signal augmentation systems, either space-based (*e.g.* the European EGNOS) or ground-based. In future, interoperability between navigation systems (*e.g.* between GPS and Galileo) will enhance the quality of available signals.

Revenue streams. These need to be clearly established (public payments or royalties on chips or service fees) and sufficient to cover the large expenditure needed to acquire or upgrade the physical systems and the operating expenses, and provide an adequate return on investment.

Liability. The operators' risks should be clearly identified and the extent of their liability established, so that such risks can be insured.

Pricing. The critical success factor here is not to alienate the users with overpriced services. The GPS experience suggests that there is a rapidly growing demand for onboard navigation equipment based on the free GPS signal, where the GPS chip represents a very small cost item.[2] If a modest royalty was to be set on such chips (or the price of chips used by other navigation systems), the impact on the price of the equipment, hence on demand, should be very minor.[3] On the other hand, there is more uncertainty regarding the service fees providers of value-added services will be willing to pay for the use of the commercial signal, as this market remain largely undeveloped.

Business practices in the provision of the signal. Other things being equal, potential providers of value-added services are likely to give preference to signal offers that conform to standard business practices, including a long-term commitment by the service provider; a guarantee of service, including legal liability; ability to trace and audit past performance; transparency in terms of contract and operations; interoperability mechanisms with other systems; the possibility for integrated service provision ("one-stop shop"), especially for value adders that need signal specifications to create new products and services for road transport.

Standards/interoperability. All equipment needs to meet clearly established standards and be fully interoperable. Technology developers and operators tend to implement their own proprietary solutions. Open standards would help to stimulate the development of new equipment and new applications by fostering compatibility and interoperability in a multi-vendor environment.

Adequately addressing competing terrestrial technologies. Satellites give users of location signals global coverage (*i.e.* public road pricing systems developed over large areas, international road transport companies), although

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there may be an increasing merging of terrestrial communication technologies that compete directly with satellites. It is therefore important to ensure that space-based systems continue to complement usefully the large interconnected terrestrial-based communications networks to come.

Positive attitude of the auto and insurance industry. These are important stakeholders in the overall system as technology developers, customers of specific navigation products, and service providers to the mass market. Their influence needs to be taken into account for road transport applications to succeed.

Governments. The favourable political environment for improving road management should be reflected in decisive actions by governments, notably by departments of transport, to promote the development and implementation of road management systems. Road pricing should not only help to reduce pollution and congestion, it could also be a useful source of additional revenue for improving the transport infrastructure.

Economic/business models

Model 1: Car navigation. This model provides, for a fee, in-car telematics services that take advantage of the capacity to locate the vehicle in real time. Such services include roadside assistance, automatic notification of airbag deployment, tracking of a stolen vehicle, guidance for lost drivers, traffic information, dynamic re-routing and personalised services, including news, stock quotes, weather, messaging. The service may be offered by a subsidiary of the car manufacturer (*e.g.* OnStar, a subsidiary of GM). It could also result from a strategic alliance between two complementary players (*e.g.* the alliance between Ford and Vodaphone in Europe to offer telematics services involving a combination of GSM and GPS technologies).

Model 2: Road user charging. In such a model, a LBS device in the car provides information electronically to the road toll centre on distance travelled, route used and time of travel. Such information is then used to charge the user's account. The user is presented regularly with a bill, like any other utility bill, such as that for electricity or water.

Prospects for the future

Model 1: Car navigation. The "intelligent car" concept is gaining ground as advanced plug-in satellite navigation sensors are increasingly sold to original equipment manufacturers (OEM) that are developing applications for the automotive industry (Garmin, 2003), and partnerships between car manufacturers and communications operators are being set up to provide location services (*e.g.* Ford and Vodaphone).

This trend may accelerate in future owing to: *i)* the success of road assistance insurance schemes and the desire for increased safety; *ii)* the aspiration of users to reach their destination faster and more conveniently; *iii)* users' need to have access to a broad range of services when in their car; and *iv)* interest from insurance companies if such devices help to reduce claims.

Major catalysts could be the explosion of smart mobile devices (*e.g.* mobile phones equipped with GPS) and the development of satellite radio and broadband wireless as a way of downloading content to the vehicle's digital entertainment system.

The development of car navigation is likely to be faster in the open environment of the Smooth Sailing scenario than in the other two because it is in this scenario that mobility is likely to be the greatest, that the cost of equipment declines the most and that space-based solutions are the most effective, notably through the interoperability of GNSS. Prospects for car navigation services are still good under the Back to the Future scenario, although costs are likely to be higher, as economies of scale cannot be as fully exploited. In the Stormy Weather scenario, development takes place more slowly as populations are poorer and less mobile, costs remain high, while lack of interoperability and standardisation across countries limits the value of such systems for users.

Model 2: Road user charging. There are already several road charging demonstration and pilot projects using satellites under way worldwide, notably in Europe where there is great interest in the development of such systems. For instance, the European Commission proposed in July 2003 a new directive on road infrastructure charging which will, from 2008, allow for differentiating road tolls according to the type of vehicle and infrastructure, as well as the time, period, location and distance travelled, taking environmental and accident costs into account in the pricing. In future, such schemes are likely to be more widely implemented as technology improves and traffic congestion increases.

The impact of road charging could extend beyond car use and traffic flows. In particular, it could have far-reaching effects on the geographical distribution of activities (*i.e.* with road pricing, it might be cheaper to buy in the local store than in the distant shopping mall, thereby encouraging a renaissance of local trade).

The development of road user charging appears inevitable in all scenarios. Although the level of mobility is higher in the Smooth Sailing scenario than in the Back to the Future scenario, where it is still higher than in the Stormy Weather scenario, the level of public and private resources available for developing the road infrastructure varies as well and in the same direction. Hence, in all scenarios there will be growing pressures to curb traffic growth, and thus to apply road user charging schemes.

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Notes

1. For instance, in the business model developed by PWC for Galileo, it is estimated that the royalties on chipsets should represent the principal source of revenue in the early years of the system, while service revenues should develop over time as the market evolves (PWC, 2001).
2. The price of GPS chips is currently around USD 10 and is declining by 15% a year.
3. In the case of Galileo, PWC (2001) has estimated that the royalty on chipsets should not exceed EUR 0.50 per chipset. The study further notes that the proposed royalty level could be one of the criteria for bid evaluation in the final concession bid.

4. Risk and Disaster Management

Introduction

During the last decade, natural disasters affected more than a billion people and assets worth approximately USD 730 billion were destroyed, according to the *World Disaster Report* (International Federation of Red Cross and Red Crescent Societies, 2002). Moreover, the losses from such disasters are increasing, especially in less developed countries.

In an international context where development of effective risk and disaster management systems is becoming a major concern for governments (OECD, 2003a), there is growing interest in the capabilities Earth observation (EO) may offer for improving their effectiveness. Aside from weather satellites, which have proved their worth in the monitoring of dangerous weather conditions (WMO, 2004), attention is increasingly direct to the contribution that other EO satellites might make at different stages of the risk and disaster management (RDM) cycle.

RDM reflects the way society is organised to deal with hazards. In this context, a *hazard* is defined as a potential source of harm, *i.e.* a phenomenon that may cause disruption to humans and their infrastructure. It can be natural (*e.g.* fire caused by lightning) or man-made (*e.g.* accidental or voluntary fire). A *disaster* is an event that causes such disruption. The term *risk* refers here to the likelihood that a hazard will cause a disaster. Hence, risk and disaster management is a set of actions and processes designed to minimise the effects of a disaster (CEOS, 2003).

Several types of actions can be taken in RDM. These include, first, risk management measures, *i.e.* measures to reduce the risk of occurrence of the hazard in the first place (*e.g.* forbidding smoking in gas stations) and preventive measures to reduce the risk of extensive damage if the hazard occurs (*e.g.* use of fire-resistant material in fire-prone areas). Second, RDM involves disaster management measures, *i.e.* measures designed to ensure quick and effective response when the hazard occurs (*e.g.* having a fire extinguisher at hand and be trained to use it) as well as rapid and effective recovery after the disaster (*e.g.* having well-trained and well-equipped first responders arrive quickly to the site of the disaster and take care of victims effectively).

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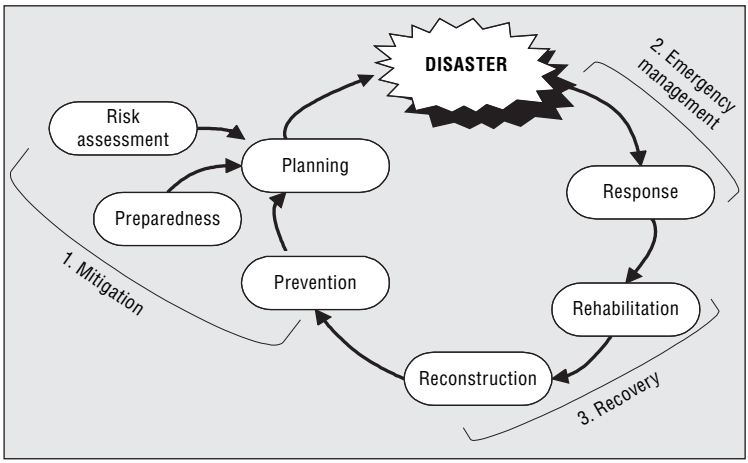
More generally, RDM involves three main phases (mitigation, emergency management, recovery), as illustrated in Figure A.5.

Figure A.5. **Risk and disaster management cycle**



Source: Adapted from World Health Organisation (2002), J. Adams and B. Wisner (eds.), *Environmental Health in Emergencies and Disasters: A Practical Guide*, World Health Organisation, Geneva.

An effective RDM system requires the timely input of actionable data and information in all three main phases of the management cycle. EO data may be one such input. The following is an exploration of how it could be applied to RDM in the case of two specific hazards (namely fire and flood). The examples serve to explore some of the key features of possible economic/business models that might be used for this purpose, identifying in the process the factors that are essential for their effective implementation.

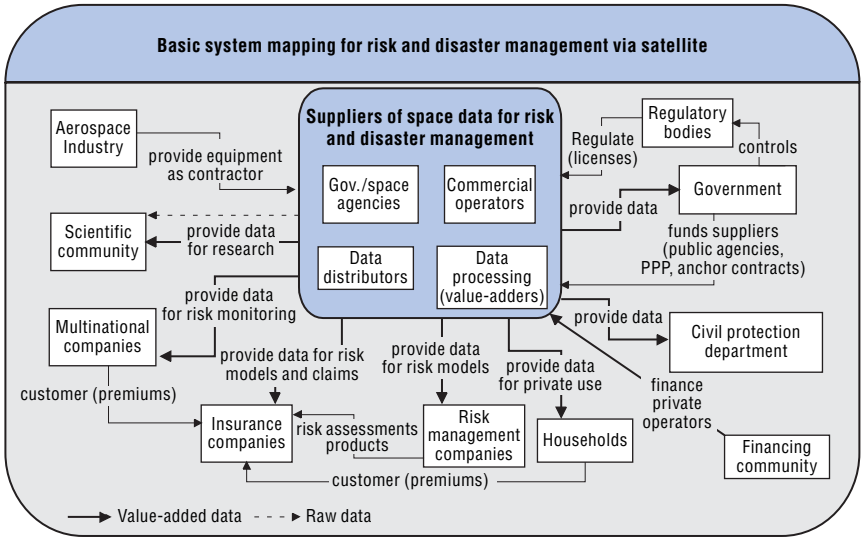
The main actors

The provision of space-based data for RDM may involve a large number of actors on both the supply and the demand side. Several configurations may be envisaged on the supply side:

- The provider may own and operate EO satellites dedicated or not to a particular type of hazard. The data can be directly provided to users or processed in house before delivery to RDM users.
- The provider may acquire the image from an EO satellite operator as well as other sources and process them for various RDM users.

Figure A.6 illustrates a situation in which the provider of EO data for RDM is a combination of public actors (*e.g.* space agencies, specialised application agencies) and private actors that operate EO systems for EO data acquisition,

Figure A.6. **The systemic view for risk and disaster management**



Source: Authors.

as well as essentially private actors that distribute and process data. Taken as a group, these actors provide both raw data and value-added data to public and private users.

Public users include civil protection departments as well as other government agencies that may need such data (*e.g.* environment agencies, departments of agriculture, commerce, tourism, transport). Private users may include insurance companies, multinational enterprises (MNEs), risk management companies, civil aviation, the media and even households (*e.g.* hazard maps when buying real estate). The scientific community is another important user of EO data for RDM and typically might use both raw data for some research applications as well as value-added data.

Other actors depicted in Figure A.6 include the regulatory bodies that issue licences to commercial operators and regulate their activities (*e.g.* in the United States, NOAA acts both as a EO data provider and as a regulator of private EO systems operators), the financial community, which may invest in private providers of EO data, and the aerospace industry, which provides the equipment necessary for the development of the EO systems.

Other actors might also be involved, such as suppliers of the hardware and software needed for data processing, data distribution and data archiving or the providers of broadband communication services used for distributing the value-added data to final users.

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Critical success factors

The nature of the service. The nature of the service provided very much depends on the use to be made of the data collected by the system. Typically, high revisit frequency, flexibility and speed in tasking, and high resolution will be required in the emergency phase of the RDM cycle. However, the requirements may be quite different in other phases. For instance, in the mitigation phase, the main need for EO data will be for the creation of hazard maps and inputs to predictive models. This will require high-resolution data but not high revisit frequency. During the rehabilitation phase, high-resolution data will also typically be needed for the planning and monitoring of the relief effort. The space system must also be suitable for the mission at hand. For instance, when heavy clouds or smoke covers the hazard scene, optical satellites will not be able to provide useful EO data, so that radar satellites would have to be used instead.

How the service is to be provided. On the production side, an important consideration is whether to adopt a multi-purpose or a dedicated approach. If conventional remote-sensing satellites are to be used, it is imperative for such spacecraft to fulfil as many requirements as possible so as to spread the fixed cost of the space asset over a maximum number of possible applications. Therefore, the mission specifications (particularly the spectral bands) should be chosen to provide good general-purpose imagery, suitable for a wide range of applications.

On the other hand, if micro-satellites can be considered, the economics of the system are significantly altered. Micro-satellites are sufficiently inexpensive to be affordable to individual government agencies or companies for their specific remote-sensing tasks. The spectral bands (or resolution, or orbit) of a dedicated imaging micro-satellite can be optimised for specialist requirements, which are not met effectively by general-purpose spacecraft. Another advantage of micro-satellites is that, because they can be deployed cheaply and quickly, they can be used to test new technologies within a short time frame. Constellations of micro-satellites also offer greater continuity of service than conventional satellites.

How will revenue be generated? Sufficient revenue to support the activity is obviously a major preoccupation of EO operators, whether public or private. The public model is viable only if the public financing is fully secure on an ongoing basis. This is not always the case however. For instance, space agencies that develop demonstration EO satellites are typically not in a position to continue to finance the system beyond the demonstration stage, so that it is important to create a sound alternative source of financing for such systems. A private operator needs to ensure that the revenues received from government contracts and commercial clients are sufficient to cover both

capital and operating expenses. So far, government contracts have represented the lion's share of revenues since the commercial market has not developed as originally hoped.

Open data standards. Open standards for the database that would integrate data from various sources would greatly facilitate the use and reduce the cost of using such data and provide as well opportunities for developing new hardware and software.

Level playing field. The development of the sector, notably the entry of private actors, would ideally require that all EO data providers be treated equally, so as to foster competition. However, this is not likely to occur in practice, given the importance of security considerations and the role played by public actors. Moreover, markets for EO data are so narrow that, in most cases (the United States is an exception), there may only be room for one firm in any given market. Even when the market is large enough to accommodate several players, firms may need a guaranteed revenue stream from the government (anchor tenancy contracts), as government is the main if not the only client for EO data.

Policies supporting the RDM process. Governments have a major responsibility to put in place policies that are supportive of RDM, such as policies that encourage municipalities to take stock of existing infrastructure, assess their vulnerability and develop contingency plans or civil security policies for strengthening their ability to anticipate disasters and respond effectively. Efforts to create RDM systems at international level are also important, notably for meeting the needs of less developed countries.

Involvement of users. Greater awareness of users and their implication in the definition of data requirements would give producers of EO data a firmer basis for making appropriate business decisions. The production and distribution of EO data must be fully integrated in the RDM cycle.

Economic/business models

For two important hazards (fire and flood), selected elements of the economic models for developing EO operational monitoring systems are discussed: the services that need to be provided, the main users to be served and the infrastructure needed to provide such services. None of the systems available today is fully operational.

Model 1: Fire management. An effective EO system needs to be capable of supporting effective disaster warning, response and recovery and of generating information products that enable planning and mitigation. This consists first in developing information on the nature and status of the biomass (volume and moisture), as well as EO data that can be used for

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assessing the possible impact of a fire (taking land-use patterns into account) and for taking preventive measures (*e.g.* clearing bush near built-up areas) and preparing emergency measures (*e.g.* access and escape routes).

The EO system should also provide data for fire detection (*i.e.* for detecting the position of the fire, its size and intensity, presence of fuel, and conditions) and monitoring (*i.e.* providing geo-reference images of the fire front with information on the surroundings). Finally, immediately after a fire, EO data should be made available for assessing the amount, degree and location of damage to structures and infrastructure and the condition of the soil and vegetation resources.

Main users. The main users of EO data for fire hazards are a very heterogeneous group with different requirements. They include RDM services on the ground (*e.g.* fire prevention personnel, emergency preparedness personnel, civil protection agencies, relief agencies), ministries with a mandate in this area (ranging from interior, agriculture and public works to national environment and public health agencies), international organisations (*e.g.* UN Environment Programme, International Panel on Climate Change, UN Food and Agriculture Organisation), the scientific community (including space agencies) as well as private-sector actors (*e.g.* land managers, news media, aviation communities, insurance companies, transport planners). Serving these diverse needs is a major challenge for the providers of EO data.

Infrastructure needs. Today, there is no operational system for monitoring fires. The various current fire monitoring activities are largely the domain of research. The MODIS (moderate resolution imaging spectroradiometer), a key instrument aboard NASA's Terra and Aqua satellites, and DLR's bi-spectral infrared detection (BIRD), the world's first dedicated small satellite for fire recognition, provide perhaps the most interesting prototypes of future operational fire monitoring systems.

To improve operational use of the available information, more attention needs to be given to data availability, product accuracy, data continuity, data access and how the data are being used to provide useful information. There is currently no standard *in situ* measurement and reporting system, and national reporting is extremely variable and wholly inadequate to provide a consistent regional or global assessment. It is also often hard to relate satellite and *in situ* data reporting. In the next few years it will be necessary to develop not only appropriate standard methods for fire monitoring but also the institutional infrastructures for operational global fire monitoring and reporting.

Model 2: Flood management. EO data can be used at all stages of the flood RDM cycle. First, they can be used as input to the mapping of geomorphic elements and land use, providing meteorological data for hydrological modelling and contributing to mapping historical events. Remote sensing may

also be used to map topography and define surface roughness and land cover as well as to update cartography for land use. Such data are used to develop the hydrological models that play a major role in assessing and forecasting flood risk. Model predictions of the potential extent of flooding can help emergency managers develop contingency plans well in advance of an event to help facilitate a more efficient and effective response.

During a crisis, remote sensing is the only cost-effective method of monitoring the spatial extent of flooding and is essential in areas that are not instrumentally monitored. EO data can also be used in this phase to make a first assessment of damage, including damage to buildings and infrastructure, and to evaluate secondary disasters, such as waste pollution.

During recovery, a more detailed assessment of the damage can be made, using both medium- and high-resolution remote-sensing images, together with an operational geographic information system (GIS). The medium-resolution data can establish the extent of the flood damage and can be used to establish new flood boundaries. They can also locate landslides and pollution due to discharge and sediments. High-resolution data is suitable for pinpointing the location and degree of damage. They can also be used as reference maps to rebuild bridges, washed-out roads, homes and facilities. Finally, they can be used by agencies to validate and refine the hydrological models that are used for flood prediction.

Main users. Users and customers of EO products vary over the RDM cycle. In terms of prevention, they include land planners (federal or national), hydro-meteorologists (including weather forecasters) and environmental and agricultural authorities. At the mitigation and prediction phase, the main users are emergency managers. In the preparedness warning phase (immediately before the flood), the users include civil protection specialists, hydro-meteorologists, local authorities, water management and the media. In the response phase (*i.e.* during the flood), users are essentially the same as in the preparedness category and also include insurance companies. In the recovery phase, the data are used mainly by land planners (federal or national), hydro-meteorologists (including weather forecasters), and environmental and agricultural authorities, and insurance companies

Infrastructure needs. Satellite data for flood management are provided by polar orbital Earth resource satellites and operational meteorological satellites. The former are of two types: *i)* optical sensors that cannot see through clouds and operate at low, medium and high resolution; and *ii)* microwave sensors that can see through clouds and include high-resolution active sensors such as synthetic aperture radar (SAR) and low resolution passive sensors (SSMI).

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Meteorological satellites are also of two types: geostationary and polar orbital. The geostationary satellite (GOES) is a powerful tool to observe the weather on a continuous basis. The orbit is at an altitude of 22 000 miles and picture frequency is normally on a half-hourly basis. Polar orbital satellites (POES) circle the earth twice a day at an altitude of approximately 850 km. Both of these satellites provide visible light and infra-red imagery and microwave data. With respect to precipitation estimates and moisture analysis, GOES offers higher resolution time and space scales, while POES microwave data are more physically related to precipitation and moisture processes.

Prospects for the future

The future of EO systems for RDM will very much depend on the ability of such systems to fully meet users' data needs in terms of accuracy, spatial and temporal resolution, timeliness and geographical coverage. Moreover, EO data require extensive integration in diverse data streams to be used for the generation and dissemination of the timely and accurate information needed by decision makers and the public. Such information includes, for instance, forecasts of the likely impact of the hazard event (*e.g.* flood) that is generated by predictive models that use EO data as one of their inputs. In the case of floods, EO provide data on the volume of rain expected to fall in a particular region, which can then be entered in a runoff model to assess its impact. The construction of the runoff model itself uses EO data (e.g. phase information obtained from SAR interferometry is used to derive digital elevation models, a major input to runoff models)

Although progress has been made in recent years in terms of data acquisition and predictive modelling, the requirements are not yet fully satisfied. Indeed, weather apart, few of the observational requirements related to major hazards are now available on a worldwide basis.

For instance, an important data gap is the lack of a suitable measure of soil moisture. Measuring soil moisture by satellite is still at the research state and may not be available on an acceptable operational basis for another ten years. This is very unfortunate, since soil moisture plays a key role for assessing the impact of a number of hazards, including fire and floods.

Moreover, some of the basic background information needed for generating meaningful hazard zoning maps, which are essential for planning and mitigation efforts, are inadequate to support disaster reduction strategies. Finally, co-ordination between observation organisations and research communities remains weak. EO information – whether from space, airborne or ground-based systems – is not used consistently in disaster management decision-making.

In future, some of these problems should gradually be addressed. First, new generations of satellites that take advantage of progress in satellite sensor technologies should contribute significantly to reducing existing technical gaps. In particular, progress in nanotechnologies and in optoelectronics and advances in onboard processing should greatly increase the capabilities and cost-effectiveness of space instruments (OECD, 2003b). For instance, very effective neuronal network processors show very good progress in machine intelligence and autonomy for aerospace systems. Such progress could be very valuable for disaster warning and hazard detection, which require quick classification and a short response time. Such tasks will require implementing a high-level data processing chain onboard the satellite.

Second, efforts under way to facilitate the distribution of EO data and their effective integration in GIS should encourage further use. Advances in software, data compression and archiving, coupled with the generalisation of broadband access, should offer opportunities for increasingly sophisticated user-friendly geospatial systems. Lower engineering costs are making direct broadcasting more easily achievable. This, in turn, enhances the opportunity for the development of real-time EO applications. The use of broadband Internet access is seen as an important factor in providing immediate services to private customers (*e.g.* urban planners, insurance companies).

As hardware and geospatial software become more affordable and more widely available, the prices of some standard products for disaster management should decline, especially with the development by the GIS industry of open standards.

Another strong driver that will foster the development of EO systems is the keen political interest in EO data in general, on sovereignty and military security grounds. There is also a strong interest in EO data in the scientific community. Hence, outside the military and scientific spheres, EO can be seen as a technology looking for applications beyond the well-established weather prediction. In this regard, the use of EO for RDM is attractive. It is a way to recognise the need to extend the concept of security more broadly to the civil sphere. Moreover, applying EO to RDM could be an effective way to project "soft power" at international level for two main reasons. First, RDM is an activity for which there is substantial scope for international co-operation. Second, EO may be viewed as an ideal tool for this purpose, given the ubiquity of space-based systems and given that, in many parts of the developing world, no effective alternative exist for generating the data necessary for RDM.

But meeting users' data needs is not enough. EO systems will only be used for RDM if the benefits are seen as substantial. However, such benefits are largely at the margin, since EO data represent a small input to the overall RDM process. In the case of fire, for instance, the most significant benefits are

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likely to be in terms of cost avoidance. This would be the case if EO data allow for the implementation of more effective fire-prevention measures as well as faster detection of fire and more rapid suppression. Benefits could arise also for more rapid recovery and avoidance of harmful secondary effects (*e.g.* faster and more precise identification of burnt areas makes possible faster and more effective implementation of measures designed to prevent landslides and to restore vegetation).

The same applies to flooding. Even if an ideal EO system were in place, the EO data produced would only be one of the inputs into the flood RDM process and could only improve flood management at the margin. In the short term, improvements would result largely from more effective preventive measures, and in the longer term, from changes in land use, limited soil sealing, reforestation, encouraging urbanisation in less risky areas, etc.

However, even a marginal improvement in the process could generate major economic and social benefits, given the high costs of flooding (for instance, the United States suffers an average of 225 casualties and more than USD 3.5 billion worth of property damage from flooding and heavy rainfalls every year). Hence, even if better use of EO data contributed to reduce damage by only 1%, this would represent for the United States alone a saving of the order of USD 35 million a year.

When considering the different visions of the future depicted in the scenarios developed in the second phase of the project, it is clear that the application of EO data to RDM is likely to be more extensive in the Smooth Sailing scenario. It offers the best prospects for international co-operation and the cost of the systems is likely to be lowest, with opportunities for the development of global dedicated systems using constellations of micro-satellites. Significant progress is still likely to be achieved in the Back to the Future scenario because security concerns are greater while the scope for effective international co-operation, although less than in Smooth Sailing, is still substantial. Prospects are less favourable in the Stormy Weather scenario, as international co-operation is severely curtailed, resulting in substantial duplication of effort across countries, and the cost of equipment remains high as markets remain fragmented.

5. Space Tourism

Introduction

In general terms, space tourism can be described as the business of taking ordinary healthy citizens who can afford it to space without special training. It may well eventually be a segment of the fast-growing tourism/adventure sector. Not only is there interest among the general public in such a venture, but progress in sub-orbital space travel may put a much more affordable way to reach the frontier of space within reach. Adventure tourism already accounts for a world market of around USD 50 billion a year, and space tourism has the potential to become one of the largest commercial space applications if a credible and affordable offer can be put together. Another reason for selecting this particular application is that space tourism may contribute, over time, to a reduction in the cost of access to space.

Space tourism operators might provide two different types of space travel: suborbital flights and orbital flights. In suborbital travel, customers are flown to space for a very short time on a parabolic trajectory culminating above a threshold altitude of 100 km, considered the edge of space (although not officially recognised as such by international space law). The entire suborbital experience only lasts a few minutes. It is estimated that from take-off to landing, flights may last about 15 minutes, including a few minutes of weightlessness. In orbital travel, customers are flown to space using an expendable or reusable launch vehicle able to reach orbital speed (about 8 km/s) and possibly to attach to an orbiting station like the International Space Station (ISS) with living quarters. The customers are then able to stay for a few days or weeks in the orbital facility.

The main actors

Many different actors have a role to play in the development of space tourism. They include space tourism companies and their shareholders (aerospace companies, travel and/or tourist companies, media companies, investment funds, banks, individual shareholders); potential customers (healthy citizens interested in travelling to space and able to fund their space venture directly or from collective support provided by sponsors, media [reality shows, games], lotteries, etc.); the aerospace industry which conducts the

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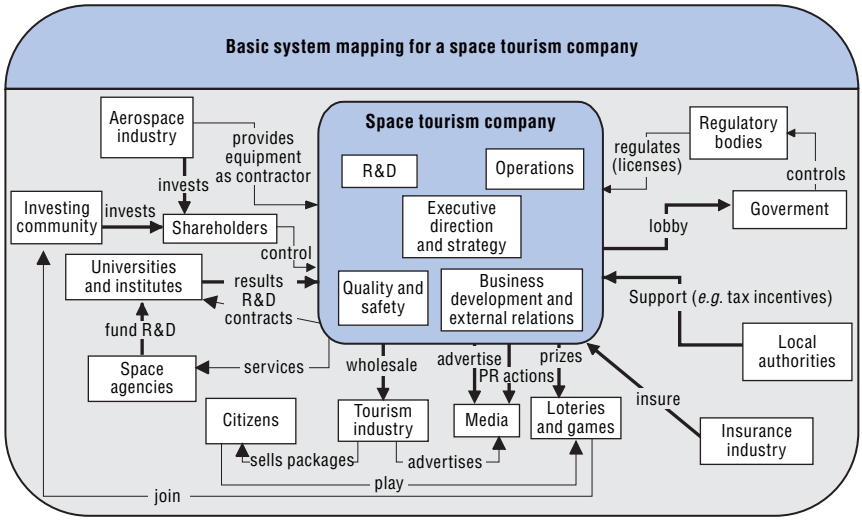
development and manufacturing of spaceships or space-planes and related ground equipment and facilities; the tourism industry which carries out the marketing and sales and provides additional services (lodging for customers and families, etc.); and space agencies, which can provide support for the development of space-planes suitable for space tourism and related research.[1]

Figure A.7 illustrates how the different actors are configured in the case of a private company, Space Tourism Co., which provides suborbital packages.

Figure A.7. **System mapping for space tourism**



Source: Authors.

Critical success factors

The development of space tourism will hinge on a number of factors that will play a critical role.

Overcoming the legal and regulatory hurdles. The full development of space tourism depends crucially on the resolution of a number of legal and regulatory issues related notably to whether space tourism should be regulated like the airline business and what the space tourism company's liability towards customers should be: Can customers be asked, after having had the risks clearly explained to them, to accept the risks without any recourse against the space tourism operators or other involved parties? Space tourism accidents may be much more visible than long-distance sailing or general aviation accidents and may negatively affect the business prospects of all space travel ventures. Liability issues also arise with respect to third parties: What level of third-party liability could private space tourism start-ups bear and would government act

to limit this liability? Finally, it still needs to be settled how spaceports should be regulated, particularly from the point of view of environmental acceptance.

Developing the right technological solutions. A sharp distinction needs to be made between suborbital and orbital flight. For suborbital flight, no major technological hurdle has to be overcome. Technologies and subsystems are available off the shelf and simply need to be integrated and tested as tourist transport systems. The main challenge will be operational rather than technical, *i.e.* to operate suborbital space-planes so that they fly often with little maintenance between flights, a challenge familiar to aviation but not to the space industry.

For orbital flights, the challenge will be to develop new orbital space transport systems that are much less expensive and probably reusable, at least in part. The development of reusable launch vehicle (RLV) technologies has been pursued for years by some space agencies with limited success as budgets have so far been quite limited (notably in Europe and Japan). Moreover, shifting priorities have resulted in the cancellation of some RLV projects (*e.g.* the DC-XA project) while other efforts have not proved as successful as expected (*e.g.* NASA's X33).

Reducing the costs of access to space. While suborbital space tourism could start without technical breakthroughs, further progress would clearly benefit from governmental R&D programmes and projects. Building on the success of a first generation of suborbital space-planes based on existing technologies, a second generation of commercial hypersonic tourism vehicles capable of crossing the frontier of space for longer periods of time and over longer distances could be developed by 2015-20. By 2025-30, a third generation capable of launching payloads in low Earth orbit (LEO) for only USD 100/kg might become viable. This would open a new era for space tourism, with orbital flights available for a few hundred thousands of dollars.

Establishing a customer base. The price tag for suborbital space tourism is very high (in theory, typically USD 100 000 in the early years) compared to other forms of adventure tourism. This means that very attractive packages need to be developed to justify the price. Potential customers are the wealthy (*e.g.* Internet millionaires or billionaires), the sponsors of lotteries, or individuals who want to use space flight as a way to promote their business activities.

Securing investment. Private funding is essential for suborbital space tourism and should preferably take the form of equity rather than debt. Public funding of basic R&D by space agencies could usefully complement it. Overall, the investment needed for a typical small space tourism firm could be of the order of USD 250 million. For orbital space tourism, the level of investment would be much higher, but it is impossible to estimate at this stage because of the many unknowns linked to the technical challenges that must be overcome.

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Economic/business models

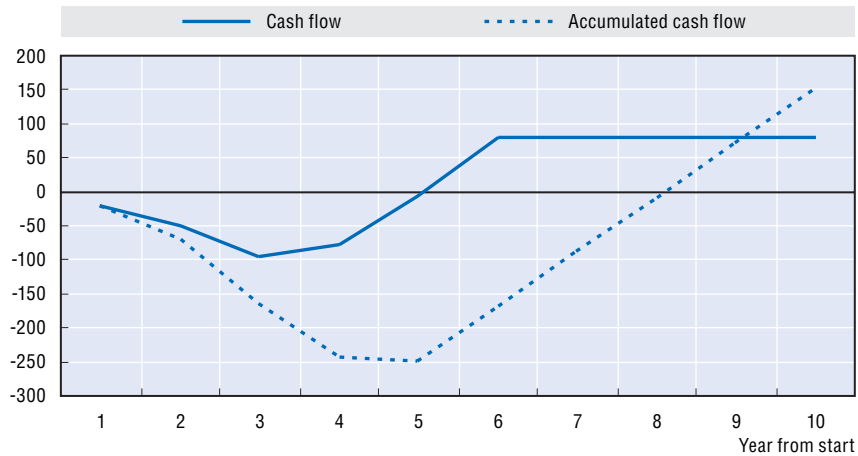
A market study conducted by Futron in 2003 suggests that by 2021 the suborbital tourism sector could be worth USD 800 million in revenue a year with 15 000 passengers in the US suborbital market alone.[2] For orbital tourism, only about 60 persons a year are thought to be able to afford the USD 5 million price tag expected by 2021, which would generating USD 300 million in revenue for space tourism entrepreneurs. This market study serves as the background for the study of two business models.

Model 1: Suborbital tourism. In this model, a private company provides suborbital travel to private customers. Cash flow estimates for the business model are made on the basis of assumptions regarding: development costs (USD 100 million); cost of vehicles (USD 30 million per space-plane); number of space-planes acquired (five); number of flights per vehicle per year (100); cost of ground infrastructure (USD 50 million); number of passengers per flight (two); fixed operational costs (USD 10 million), variable operational costs (USD 0.02 million per flight-vehicle); ticket price (USD 100 000).

Corresponding to traffic of 1 000 passengers a year when all five space-planes are in service, this business model is consistent with the Futron forecast for suborbital tourism. In this model, the company's operating income or EBIT (earnings before interest and taxes) becomes positive in year 5 and the cumulated cash flow becomes positive after year 8, as illustrated in Figure A.8. This is still quite long by current investment standards in high-technology sectors. Hence, suborbital tourism may not yet be economically viable. However, it may very well become so in the coming years, as costs come down.

Figure A.8. **Cash flow generated by the space tourism company**

Millions of EUR



Source: Authors.

Model 2: Orbital tourism. The development of orbital tourism will depend on whether sufficient progress is achieved in reducing the cost of access to space in the coming decades. As noted, such progress could be achieved in two phases following the development of suborbital tourism in the coming years:

- *From 2015-20:* Advanced suborbital tourism, using technologies developed by defence and civilian R&D organisations for hypersonic propulsion and trans-atmospheric flight.
- *From 2025-30:* Development of orbital tourism, taking advantage of advanced space transport systems (probably two-stage-to-orbit systems, with the first reusable stage derived from the hypersonic trans-atmospheric vehicles introduced in the preceding decade).

However, so many uncertainties surround these potential phases of development that it is impossible to propose any real assumptions for a business model. In fact, as suggested in the Futron study and others, orbital tourism may well continue to develop as a mere continuation of the trend initiated by Tito's flight, *i.e.* space tourists simply taking advantage of available seats on ferry vehicles (Soyuz at the beginning, replaced by an improved ferry vehicle around 2009) servicing the ISS until new technology come on stream in the late 2020s.

Prospects for the future

A number of favourable factors should contribute to the development of space tourism in the coming decades. First, there is no technological barrier to the development of suborbital tourism; this should allow the development of the initial phase of the activity in the coming years. Second, the great interest generated by the X-Prize and the historic flight of SpaceShipOne, which won the prize in October 2004, tends to confirm that there is in fact a potential market for space tourism/adventure.[3] Third, a number of wealthy entrepreneurs have demonstrated great willingness to pursue the development of the activity (*e.g.* Virgin's Richard Branson[4]). Finally, legislation passed in the United States in December 2004 should considerably reduce the regulatory uncertainties faced by space entrepreneurs and contribute to a more favourable business environment for space tourism in the coming years.[5] It is also giving space tourism greater credibility in the space community itself. In the longer run, space tourism will be able to take advantage of progress achieved in reducing the cost of access to space in other segments of the space sector.

Although the prospects for space tourism appear good overall, they are not equally good in all possible futures. For instance, they appear to be best in the Smooth Sailing scenario where the open environment for commercial space should be favourable to new space ventures, while the more competitive climate should put strong pressures on costs. Moreover, technology transfers

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from the military should be easier. On the other hand, less public money may be devoted by the military to the development of hypersonic planes. In the Back to the Future scenario, business conditions are somewhat less favourable but could be compensated in part by the greater emphasis on military R&D for reducing the cost of access to space. There might, however, be some reluctance to transfer this technology to the commercial sector, in the light of its dual use nature and the fear that it might fall into the "wrong hands". Prospects are least encouraging in the Stormy Weather scenario, in which money is scarce, security concerns are very high on the policy agenda and restrict technology transfers from the military to the commercial sector, and discretionary expenditures for leisure and tourism are drastically cut.

Notes

1. In the NASA/STA study (1998), it is recommended that NASA demonstrate technology that would increase safety, reliability and comfort, and decrease unit costs all by factors of ten; learn how to deal with high rocket launch noise, atmospheric pollution and debris collision concerns; learn how to provide low-cost human habitation facilities in orbit; and learn how to remedy passengers' discomfort and space sickness.
2. Many "market studies" on space tourism have been conducted in the past, but they were based on very sketchy and limited polls. Hence, their usually very optimistic conclusions cannot be taken as a serious indication of market size.The only useful information that can be extracted from these studies is a rough estimate of the price elasticity of the demand curve, when taking into account, on the one hand, the price paid for Soyuz orbital flights to the ISS, and on the other, the estimated market response to much cheaper offerings, based on hypothetical advanced low-cost space transport systems. The most recent market study was conducted by Futron and Zogby International (Futron, 2003). It is based on a survey of 450 "qualified" individuals (*i.e.* annual income of USD 250 000 or a net worth of USD 1 million) who were surveyed in January 2002.
3. The Ansari X-Prize, announced in the mid-1990s, offered USD 10 million to the first private team to develop a reusable spacecraft capable of carrying humans to suborbital space twice in two weeks. It was won in October 2004 by Burt Rutan's SpaceShipOne, financed by millionaire Paul Allen.
4. Branson, the Virgin Group's founder and chairman, announced in autumn 2004 that he was licensing the SpaceShipOne technology from Allen's Mojave Aerospace Ventures to launch Virgin Galactic Airlines in the next few years. Virgin Galactic would offer suborbital spaceflights to passengers willing to pay USD 200 000 for the experience.
5. The Commercial Space Launch Amendments Act of 2004 (H.R. 5382) underwent many revisions after first passing the House of Representatives in March by a vote of 402-1. It was not until December 2004 that the bill was finally sent to the White House for the US President's signature.

Areas for Action

Introduction

Although the applications reviewed here are diverse and take place in very different contexts, there is a high degree of communality from a policy perspective with regard to the issues that are critical for their successful development. To facilitate the presentation and put them in a public policy context, these issues are organised into seven policy clusters:

1. Creation and preservation of a stable and predictable environment for the applications.
2. Maintaining a level playing field.
3. Equitable access to services.
4. Support to the effective generation, distribution and use of information.
5. Support to the development of standards, compatibility and interoperability.
6. Development of physical and institutional infrastructure.
7. Support to basic R&D.

Each cluster represents what might be called a "generic" policy area which cuts across several of the applications explored in the preceding sections. Each is backed up by supporting examples taken from specific applications. The clusters reflect different types of actions that governments may take to foster economic and social development.

1. Creation and preservation of a stable and predictable environment for space applications

An important pre-condition for a thriving industry is a reasonably stable business environment at national and international levels and the confidence of market participants that an open multilateral system of trade and investment will be maintained and fostered. An unstable and unpredictable public policy environment increases the level of uncertainty for entrepreneurs, affects adversely their investment decisions and forces them to take a short-term approach to their business activities.

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The significance of this phenomenon is clearly evident in the case studies described in this study. For instance, the adverse impact of legal and regulatory uncertainties on business decisions was noted for satellite entertainment (*e.g.* uncertainties regarding the rules applying to spectrum allocation); Earth observation (*e.g.* uncertainties related to the application of "shutter control" regulations); location-based services (*e.g.* uncertainty regarding the legal consequences of a disruption of the signal both for the signal provider and the users of the signal); and space tourism (*e.g.* uncertainty regarding the legal regime applicable to space tourism planes).

Another important area concerns uncertainties relating to liability, notably for emerging applications. This applies to telehealth (*e.g.* liability attached to a tele-consultation); location-based services (liability linked to a failure of the navigation signal); and space tourism (liability of the space tourism entrepreneur *vis-à-vis* clients and third parties).

It is also clear that intellectual property issues are essential and cut across applications. Their importance is likely to increase as the private sector plays a growing role in the development of new space applications, in terms of both technical and financial contributions. Moreover, intellectual property protection is likely to be a key factor in the successful design and implementation of space business models involving public/private collaboration. Hence, an effective institutional and regulatory framework governing intellectual property will be needed to provide the kind of legal certainty on which space business can successfully thrive.

2. Maintaining a level playing field

The creation and maintenance of a level playing field is a major concern of economic policy in a market economy. If resources are to be used efficiently, all competitors should be on the same footing. Barriers to entry and exit should not be artificially raised. Notably, this means that existing rules should not give legacy actors an undue advantage and that regulations should be technology-neutral.

One lesson to emerge from the case studies is that creating and preserving a balanced competitive environment for space applications has three important (partly interrelated) dimensions: the degree to which the public sector is involved in investment in and operation of the application; the role of regulations that shape the economic environment; and the support provided by government to specific, sometimes competing, technologies.

The problem arises for instance regarding Earth observation (coexistence in the same market of public and private actors facing different sets of constraints); satellite entertainment (*e.g.* national ownership rules); and location-based services (*e.g.* competition between space-based and ground-based provision of navigation data).

3. Equitable access to services

"Equitable access" is a broad general policy principle in democratic societies. It is based on the premise that all citizens should be equal before the law and should have equal right of access to public services, as well as to private services that are deemed "essential", whenever it is economically feasible. This principle has been widely used, in the field of telecommunications for instance, to justify the cross-subsidy of rural subscribers by urban ones. In such cases, the application of the equitable principle involves a trade-off between equity and efficiency, and the extent to which lack of economic feasibility can be invoked in practice to justify exceptions to the application of this principle varies from country to country, depending on whether "individualistic" or "egalitarian" principles dominate.

For example, the issues surrounding equity of access to satellite-provided services extends beyond the "divide" between urban and remote areas to address questions of equal treatment of individuals and national entities. Indeed, the equitable access principle may also extend to access to knowledge and information derived from space activities in general. In view of Article I, paragraph 1 of the Outer Space Treaty, which stipulates that exploration and use of outer space "must be effected for the good and in the interest of all countries, regardless of their state of economic and scientific development, being the attribute of all mankind", it has been argued that the knowledge and information resulting from space activities should be available to all countries, and in particular to developing countries (Conseil Économique et Social, 2004).

4. Generation, distribution and use of information

Space-based services (*i.e.* space communications, Earth observation and location-based services) can be considered as information services. As such, they present characteristics that set them apart from other goods. Unlike standard economic goods, information can be exchanged and used many times; the consumption by one user does not diminish the amount available for other users. New information products can be easily created by forming different combinations of other information products, a process that is made easier by digitalisation.

These characteristics make the pricing of information particularly difficult or force producers of content to find ways other than direct pricing to finance production (*e.g.* advertising, product placement, sponsoring). It also justifies government intervention (*e.g.* public production or support to the production and distribution of certain forms of information which, although valuable for society as a whole, would not be produced and distributed otherwise), notably when the information has a strong social and cultural

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dimension. Government intervention is also justified to protect the privacy and confidentiality of personal information.

Regarding the pricing of data, issues arise for instance for EO data (public data are made available at no charge or at the marginal cost of reproduction, while private operators have to charge prices that cover their costs). Moreover, privacy and confidentiality issues affect the future of space applications such as telehealth (need for secure and confidential communications links); satellite entertainment (the greater scope for monitoring subscribers' viewing habits offered by new devices such as digital video recorders (DVRs) raises fear of misuse); location-based services (unsolicited wireless advertising could be an obstacle to their widespread adoption).

5. Standards, compatibility and interoperability

In most areas of economic activity, notably in high-technology sectors such as space, the development of open standards plays a major role in the market place by providing the basis for reaping economies of scale, for fostering the compatibility and interoperability of equipment, and for strengthening competition among equipment manufacturers.

Standards have a strong public good dimension. However, experience suggests that although governments should support their development, standards should not, as a general rule, be set by public fiat, and in particular governments should not try to use standards as a tool for protecting domestic industry (*e.g.* the setting of the colour TV standards). However, governments must ensure that the formulation of standards by particular groups of firms does not give them an undue advantage in the market place. Governments should therefore act both as coaches and as umpires to ensure that standards remain really open.

The case studies clearly demonstrate that greater compatibility between technological systems, standards, licensing practices and so on, are crucial to the future development of all the applications examined in this report. In the case of telehealth, for instance, licensing requirements are a major obstacle; in Earth observation, lack of data compatibility is a serious problem; in location-based services, global interoperability of services and applications is essential to the creation of seamless, wireless location bases services.

6. Development of physical and institutional infrastructure

Governments have the main responsibility for the development of infrastructure. However, they can often contract the development and operation of such infrastructure to the private sector. Moreover, the private sector may participate in the financing of infrastructure that can be used to

generate private revenues. In such cases, the public authority may either pay directly a share of the cost of the infrastructure or guarantee a revenue stream that is sufficient to induce the private partner to finance the infrastructure entirely on its own.

A recurring issue in the case studies is the important role of infrastructure and the extent to which public authorities should be involved in its provision and operation. For instance, government may encourage the extension of broadband services to rural and remote areas by private satellite operators, although this may violate the technology neutrality of public policy. Location-based services are provided by an infrastructure that has a strong public good characteristic (*e.g.* provision of safety and security) but can also be used for commercial purposes. EO data can be produced either by public agencies or by private firms.

7. Support of basic R&D

R&D activities are a major source of economic growth today and will become increasingly so as the technological sophistication of our economies increases. Governments have a key role to play in this regard, notably for ensuring that the level of funding and the allocation of funds to various areas of basic research are adequate and reflect public policy objectives. Governments also need to ensure that research results are fully exploited by the private sector.

In some application fields where the benefits are largely of a "public good" kind, there would seem to be a fairly clear-cut case to be made for encouraging government support of R&D. This applies for instance to telehealth, location-based services, Earth observation for disaster management and space tourism, as the R&D ties in with the broader public interest in reducing the cost of access to space.

Conclusion

The preceding consideration of case studies has been a useful exercise from a policy perspective. It makes it possible to set the many policy issues raised by the development of the space sector into a concrete context. It is clear from the above analysis that, although each space application is different, some common problems arise, many of which are obviously the responsibility of governments. Moreover, the case studies clearly demonstrate that many of the issues with an important bearing on space applications fall outside the field of space policy *per se* and need to be considered in a much broader public policy context.

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ANNEX B

The Space Project Steering Group

The Steering Group

At the beginning of the project entitled "The Commercialisation of Space and the Development of Space Infrastructure: The Role of Public and Private Actors" (the "Space Project"), a Steering Group was set up to provide overall advice to the OECD Project Team. It was composed of approximately 25 high-ranking experts and decision makers from public and private entities in the space and non-space sectors that contributed financially to the project. Throughout the duration of the project, there were four meetings of the Steering Group (April 2003, October 2003, May 2004 and December 2004).

Chairman

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Some members of the Steering Group were replaced during the two years of the Space Project and/or assisted by other experts from their organisations and/or third parties. The Steering Group members for Phases III, IV and V of the project were.

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ANNEX C

Experts Involved in the Project

Contributing experts

Throughout the project, several experts were called upon to draft papers on various topics. These reports provided a very valuable factual and conceptual basis for the work conducted by the project team.

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A large number of space and non-space professionals contributed their views, through meetings and via e-mail, in the course of the project. The OECD project team is particularly grateful for their input. The following is a non-exhaustive list of the external experts/professionals consulted.

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Acronyms

ACTS	Advanced Communications Technology Satellite
AGP	Agreement on Government Procurement
ASAT	Anti-satellite
ASI	Agenzia Spaziale Italiana
ATM	Air traffic management
ATV	Automated transfer vehicles
BBI	Broad-Band Interactive System
BIRD	Bi-spectral InfraRed Detection (DLR)
BNSC	British National Space Centre
CCSDS	Consultative Committee for Space Data Systems
CEOS	Committee on Earth Observation Satellites
CGMS	Co-ordination Group for Meteorological Satellites
CNES	Centre National d'Etudes Spatiales (France)
CNSA	China National Space Administration
CONAE	*Comisión Nacional de Actividades Espaciales*
COPUOS	Committee on the Peaceful Uses of Outer Space (UN)
COS	Commercial observation satellites
COSPAR	Committee on Space Research
CSA	Canadian Space Agency
CTBT	Comprehensive Nuclear Test Ban Treaty
CWAAS	Canadian Wide Area Augmentation System
DARPA	Defense Advanced Research Projects Agency (US)
DART	Demonstration for Autonomous Rendezvous Technology (US)
DBS	Direct broadcast satellites
DGA	*Délégation Générale pour l'Armement* (France)
DGPS	Differential GPS
DLR	German aerospace research centre (Deutsche Forschungsanstalt für Luft- und Raumfahrt)
DMSG	Disaster Management Support Group
DoC	Department of Commerce (US)
DoD	Department of Defense (US)
DTH	Direct-to-home
DTM	Digital terrain mapping

EBIT	Earnings before interest and taxes
ECSS	European Co-operation for Space Standardisation
EELV	Evolved Expendable Launch Vehicle
EGNOS	European Geostationary Navigation Overlay System
ELVs	Expendable launch vehicles
EO	Earth observation
EOS	Earth Observing System
ERS-1	European Remote Sensing Satellite
ESA	European Space Agency
ESF	European Science Foundation
ESTMP	European Space Technology Master Plan
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration (US)
FAO	Food and Agriculture Organization
FCC	Federal Communications Commission (US)
FDI	Foreign direct investment
FFG	Austrian Research Promotion Agency (*Österreichische Forschungsförderungsgesellschaft*)
FTTP	Fibre-to-the-premises
GAGAN	India's GPS and GEO Augmented Navigation programme
GAO	Government Accountability Office (US)
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GEO	Group on Earth Observations
GHG	Greenhouse gas
GIS	Geographic information systems
GMES	European Global Monitoring for Environment and Security
GNSS	Global navigation space system
GOES	Geostationary satellite
GPS	Global Positioning System
GSO	Geostationary satellite orbit
HCV	Hypersonic cruise vehicle
HDTV	High definition television
IADC	Inter-Agency Space Debris Co-ordination Committee
IAOPA	International Council of Aircraft Owner and Pilot Associations
ICAO	International Civil Aviation Organization
ICT	Information and communications technologies
IEA	International Energy Agency
IGA	Intergovernmental agreement
IGOS	Integrated Global Observing Strategy

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ILO	International Labour Organisation
IPO	Initial public stock offerings
ISA	International Space Agency
ISAS	Institute of Space and Aeronautical Science (Japan)
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation
ISS	International Space Station
ITAR	International Traffic in Arms Regulations (US)
ITS	Intelligent transport systems
ITU	International Telecommunications Union
JAXA	Japanese Aerospace Exploration Agency
JSF	Joint Strike fighter (US)
KARI	Korea Aerospace Research Institute
KSAT	Kongsberg Satellite Services
LAAS	Local Area Augmentation System (FAA US)
LBS	Location-based services
LEO	Low Earth orbit
LSA	Launch Services Alliance
MEXT	Ministry of Education, Culture, Sports, Science and Technology (Japan)
MODIS	Moderate Resolution Imaging Spectroradiometer
MSAS	Multifunctional Transport Satellite-based Augmentation System (Japan)
MSG	Meteosat Second Generation
MTCR	Missile Technology Control Regime
MTG	Meteosat Third Generation
NAFTA	North American Free Trade Agreement
NAL	National Aerospace Laboratory (Japan)
NASA	National Aeronautics and Space Administration (US)
NASDA	National Space Development Agency (Japan)
NGA	National Geospatial Intelligence Agency (US)
NIMA	National Imagery and Mapping Agency (US)
NIVR	Netherlands agency for aerospace programmes
NPOESS	National Polar-orbiting Operational Environment System
NPP	NPOESS Preparatory Project
NSAU	National Space Agency of Ukraine
OMB	Office of Management and Budget (US)
POES	Polar orbital satellites
PPP	Public-private partnership
PPS	Precise Positioning Service (GPS)
PRS	Public regulated service
PVR	Personal video recorders

RDM	Risk and disaster management
RLV	Reusable launch vehicles
ROSAVIAKOSMOS	Russian Aviation and Space Agency
SAI	Space Application Institute (Ispra, Italy)
SAR	Synthetic aperture radar
SBAS	Spaced-based augmentation systems
SIASGE	*Sistema Italo-Argentino de Satélites para la Gestión de Emergencias*
SLI	Space Launch Initiative
SPASEC	Panel of experts in the field of space and security (EU)
SPS	Standard Positioning Service (GPS)
TOMS	Total Ozone Mapping Spectrometer
TREES	Tropical Ecosystem Environment Observations by Satellites
TRIPS Agreement	Agreement on Trade Related Aspects of Intellectual Property Rights
TRMM	Tropical Rainfall Measuring Mission
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDROIT	International Institute for the Unification of Private Law
VoIP	Voice-over-Internet Protocol
VSAT	Very small aperture terminal satellite
WAAS	Wide Area Augmentation System (US)
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization
WINDS	Wideband Internetworking Engineering Test and Demonstration Satellite (Japan)
WIPO	World Intellectual Property Organisation
WME	Weapons of mass effects
WMO	World Meteorological Organization
WTO	World Trade Organisation
WTTC	World Travel and Tourism Council

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