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Enabling Europe's Key Foreign Policy Objectives via Space

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Table of Contents

Executive Summary

Background

The European Union (EU) foreign policy, embedded in the Common Foreign and Security Policy (CFSP) and anchored in international cooperation, seeks to advance key objectives in a number of categories including the six areas of sustainable development addressed in this study. As it is not a homogenous, single entity, the EU must strike a proper balance between the foreign policy and security interests of the individual MS and those of the EU. Given the accelerating pace of external impacts and influences on the EU MS resulting from the information revolution, the EU must become more institutionally agile and responsive to the often rapid decision-making requirements of the 21st century. Space represents a powerful enabler and "multiplier" to meet these evolving requirements with respect to increasingly "real time" responses to cascading events like that witnessed in Tunisia, Egypt, Iran, Libya, Yemen, Bahrain and elsewhere in the Middle East and North Africa.

For its part, sustainable development has been recognised as a key requirement for the proper functioning of Earth, the environment, resource management, and human well-being. In its Sustainable Development Strategy (SDS), the European Union (EU) established sustainable development as an overarching strategy for all EU policies and acknowledged it as a new dimension of economic and socio-political decision-making (including foreign policy) that is most effective when applied on global basis. Sustainable development is likewise a central element of the "Europe 2020" strategy designed to apply to five major areas over the next decade: employment, innovation, education, social inclusion, and climate/energy.[1]

Europe's space activities are coordinated among individual MS, ESA and the EU. It has been recognised in the May 2007 Resolution on European Space Policy (ESP) that space contributes to the CFSP and the EU's SDS, as well as Europe's standing as a major space-faring actor. The ESP emphasises the direct connection between the space capabilities and the EU's ability to exercise influence regionally and globally. It asserts that if the EU wants to be a leading global actor, it has to possess credible space assets, educate top-tier engineers and scientists, and invest in space research and development to build a knowledge society. Moreover, a credible ESP can also advance Europe's objectives in other areas of interest (e.g. the environment). Finally, space systems are a strategic asset for any nation, or group of nations, with global ambitions.[2] The 7th Space Council and subsequent Resolution entitled, "Global Challenges: Taking Full Benefit of European Space Systems", outlined the steps to be taken in order for Europe to continue to develop world-class space systems and derived applications.

As referenced above, this study focuses on six areas of sustainability where space can serve as an important "multiplier". These were originally identified in a publication by the European Space Policy Institute (ESPI), entitled "Threats, Risks and Sustainability: Answers by Space" and include: security, energy, environment, resources, knowledge and mobility.[3] The development of EGNOS (the European Geostationary Navigation Overlay Service) and Galileo (the planned European global navigation system) combined with the GPS, as well as the Global Monitoring for Environment and Security (GMES), will be able to advance a number of objectives delineated by the EU. In this connection, adequate security makes the peaceful use of space sustainable. Accordingly, space security provides a "blanket" under which many undertakings on Earth can be pursued more peacefully. It's fundamental to the sustainability equation in all of its various dimensions.

The study is presented in three main parts, the first of which provides an overview of the challenges and opportunities related to the EU's multi-faceted foreign policy. It also examines Europe as a space-faring entity with global ambitions. The second part delineates

[1] "Europe 2020". http://ec.europa.eu/europe2020/index_en.htm

[2] Logsdon, John. "The New European Space Policy as Seen from Across the Atlantic" in Schrogl, Kai-Uwe, at al. eds. Yearbook on Space Policy 2006/2007. Vienna: Springer WienNewYork (2008): 169.

[3] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009.

key foreign policy objectives in each of the six areas identified and how these areas can benefit from available space systems and derived applications and services. In the concluding section, the study analyses how cooperation in space can serve to advance Europe's political, economic and geostrategic aspirations and bolster the prospects for success in achieving these goals. Finally, recommendations focus on specific policy objectives in each of the six areas evaluated, as well as broader measures, to advance Europe's role as a visionary, leading steward of Earth and space.

Sustainability Areas

Security

Security-related governance in Europe consists of a combination of the priorities of individual Member States (MS) and the EU. Defence issues remain the domain of the MS. There is, as yet, no uniform definition of what the term security covers. Moreover, individual EU MS often see security challenges through a different lens. Consequently, many broad security policies are forged on an intergovernmental basis. With regard to security policy, a number of issues present themselves, among them: the ongoing financial crisis and severe budget constraints; the lack of a common assessment of military threats on the part of the MS; unpopular European involvement in Afghanistan; differing opinions about the Iraq war, and divergent views of a resurgent Russia. In short, while the EU's foreign policy looks outward, there is a great deal of intra-European work that must be done to reconcile differing national priorities and preferences.

From existing policy documents as well as actions taken by the EU, the following key EU objectives for security have been identified:

- Countering terrorism and penalising terrorist-sponsoring states
- Securing critical infrastructure
- Reducing cross-border crime and bolstering border security
- Fighting organised criminal activities
- Managing humanitarian and natural disasters
- Enhancing cyber security
- Diffusing maritime disputes and combating piracy
- Strengthening the strategic partnership with NATO
- Safeguarding international security
- Countering ballistic missile and WMD proliferation
- Combating illicit accumulation and trafficking of small arms and light weapons (SALW)
- Promoting anti-mine actions
- Preventing and/or managing regional conflicts and failed states

Space systems and applications constitute a critical element of the global information infrastructure. Space-based civil, commercial, and military systems help provide communication, environmental, observation, position, navigation, timing (PNT), and other important data and services to users. European space capabilities are often of a "dual-use" nature, with defence-related as well as civilian applications. Europe has been increasingly emphasising the use of space systems to enhance security. Security in this context covers not only the military uses of space, but space-based systems for environmental concerns, energy security, crisis management, peacekeeping, civil protection, and other areas. Europe's Earth observation initiative, the Global Monitoring for Environment and Security (GMES), for example, reflects such capabilities and its Emergency Response Service will provide improved disaster management support.

In recent years, the EU MS have been compelled to reach an EU-wide consensus on decisions related to foreign policy developments with security implications. Assured access to reliable information, including through space, advances the quality and timeliness of political decisions. Moreover, space and terrestrial security can also be reinforced by transparency and confidence-building measures (TCBM). In this connection, the EU is promoting behavioural norms in space through its draft Code of Conduct. It is an effort on the part of the EU to play a normative role in space security through the "principled" identity it seeks to achieve.[4]

Environment

The United Nations (UN) has traditionally been perceived as the leading entity for multilateral efforts on environmental issues. The most prominent role has been accorded to the UN Environment Programme (UNEP) that has organised global conferences on the environment and development. As early as 1972, the UN General Assembly called for a conference dedicated solely to the environment. Later, other UN efforts materialised in the Kyoto Protocol, a leading effort to reduce global emissions adopted in December 1997

[4] Robinson, Jana. "The Role of Transparency and Confidence-Building Measures in Advancing Space Security". European Space Policy Institute. Report 28 (September 2010).

under the auspices of the UN Framework Convention on Climate Change (UNFCCC). The agreement, which came into force in February 2005 and expires in 2012, set binding targets for 37 industrialised countries and the European Community for reducing greenhouse gas (GHG) emissions. It currently has 193 Parties, including the EU.[5]

The EU's environment policies have been structured around so-called Environmental Action Programmes (EAP). The latest of them, the 6th EAP, provides a framework for environmental policies in the period of 2002 – 2012. It also represents an environmental dimension of the EU's SDS and Europe 2020 strategy. There are four broad priorities delineated in the 6th EAP: climate change; nature and biodiversity; health and the quality of life; and natural resources and waste.[6] The 6th EAP introduced the concept of "Thematic Strategies" to be developed by the Commission. They include the following fields: air; waste prevention and recycling; marine environment; soil; pesticides; natural resources; and urban environment.[7] These strategies were designated to be the long-term objectives reflecting a truly global approach and were to create synergies among the various fields.

Environmental protection is also closely linked to the concept of sustainable energy, which seeks to balance environmental protection (including climate change), competitiveness and energy security.[8] This, in turn, is linked to sustainable management of natural resources. The integration of environmental policy into energy policy is summarised in the "2009 Climate and Energy Package".[9] In this connection, the EU is increasingly interested in assuming a greater role concerning Arctic-related issues. In December 2009, the EU Council adopted "Council Conclusions on Arctic issues" reiterating the need for a policy on Arctic issues, notably advancing EU's interests and responsibilities there.[10]

From the various policy documents described above, a number of key priorities for the EU can be extracted. They are:

- Scrutinising and managing climate change
- Conserving natural resources
- Protecting biodiversity and ecosystems
- Reducing various forms of pollution
- Improving urban environment quality
- Managing waste
- Integrating environmental concerns into EU's external relations
- Safeguarding the Arctic

Space-based assets have already proven indispensable in providing essential environment-related data for scientific research and political decision-making. Earth observation (EO) satellites play a special role as evidenced by the existence of EO-related organisations and initiatives such as: the Committee on Earth Observation Satellites (established in 1984); the first Earth Observation Summit (EOS) in July 2003 and subsequent establishment of the Group on Earth Observation (GEO); as well as a 10-year plan to create comprehensive cooperation in Earth observation through the Global Earth Observation System of Systems (GEOSS) endorsed at the third EOS. Europe's GMES constitutes Europe's contribution to the GEOSS Plan. The GMES Climate Service provides a framework for sustained space-based climate monitoring. The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) likewise plays an important role in climate monitoring. Other efforts include, for example, the European Space Agency's (ESA) Climate Change Initiative (CCI), which seeks to take advantage of data from ESA and MS EO space assets to analyse long-term global records of essential climate variables. Other environment-related initiatives, such as the REDD+ agreement, offer clear requirements and constitute a great potential for a beneficial use of space.[11]

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[5] Status of Ratification of Kyoto Protocol UNFCCC. <http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php>

[6] Commission of the European Communities. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions on the Mid-Term Review of the Sixth Community Environment Action Programme. COM(2007) 225 final of 30 Apr. 2007. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0225:FIN:EN:PDF>.

[7] <http://ec.europa.eu/environment/newprg/strategies_en.htm>.

[8] Commission of the European Communities. Green Paper – A Strategy for Sustainable, Competitive and Secure Energy. COM(2006) 105 final of 8 Mar. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0105:FIN:EN:PDF>.

[9] Commission Staff Working Document: 2009 Environmental Policy Review. SEC(2010) 975 final Part 1of 3 of 2 Aug. 2010. Brussels: European Union. <http://ec.europa.eu/environment/pdf/policy/EPR%202009_SEC_2010_0975_Part%201.pdf>.

[10] Council conclusions on Arctic issues. 2985th Foreign Affairs Council meeting, Brussels. 8 December 2009.

[11] REDD+ agreement, achieved at the United Nations Framework Convention on Climate Change 16th Conference of the Parties (UNFCCC COP16) in December 2010 in Cancun, Mexico, between Heads of the three UN agencies involved in the UN-REDD Programme (i.e. FAO, UNPP and UNEP), is an accord on Reducing Emissions from Deforestation and Forest Degradation and enhancing forest carbon stocks in developing countries.

Energy

Energy, and especially electricity, is essential for sustainable development. Most European countries are highly dependent on hydrocarbon sources of energy (i.e. oil and natural gas). Europe's energy imports rose some 56% over the past decade. Natural gas constitutes an estimated 24% of the primary energy mix of EU countries, with the exception of France. The current EU reliance on gas imports is some 57% and is estimated to increase to 84% by 2030[12]. The main alternatives to gas are coal and heavy oil, neither of which is viewed as environmentally friendly. Another alternative is nuclear energy. Looking ahead to 2035, nuclear power and other renewables will likely constitute up to 38% of the world's energy mix. In this scenario, the share occupied by nuclear energy would increase by some 50%.[13]

Concerning Europe's renewable energy, it derives from various sources, including: solar, large hydropower; onshore wind; biomass and first-generation biofuels. Wind power currently constitutes the highest share of new production capacity. Envisioned for the future are offshore wind, renewable electricity use in transport, and second-generation biofuels.[14] Moreover, CO2 capture and storage (CCS) constitutes an attractive climate change mitigation option, although currently is not economically viable.[15] Looking into the more distant future, research has also been conducted in space-related areas, such as space-based solar power, low-energy nuclear fusion, and microbial cells. The concept of the mining of resources on the Moon and other celestial bodies is a subject of more future-oriented debates.

In January 2007, the EC adopted a document, entitled "An Energy Policy for Europe", that essentially made energy relations a centrepiece "of all external EU relations".[16] Objectives concerning energy policy also include the so-called "20-20-20 strategy", that is shorthand for reducing greenhouse gas emissions by 20%, increasing the share of renewable energy resources by 20% and improving energy efficiency by 20%. Europe hopes to achieve these objectives by the year 2020.[17] In 2010, however, the EU missed its renewable energy target by as much as 75%.[18] Some view the focus on reducing emissions and improving energy efficiency in member states as merely a means of avoiding the much harder task of establishing a common energy posture.[19] Most experts believe that the undue dependency on energy imports cannot be significantly reduced for at least several years.[20] As a result, one of the most important elements of Europe's energy security will continue to be that of supply. In this connection, diversification of suppliers and transit routes remains the most important means of achieving security of supply.

In conclusion, Europe has a number of leading priorities concerning how to achieve "sustainable, secure and competitive" energy"[21]. They are summarised below:

- Diversification of energy sources and transport routes
- Developing greater energy efficiencies
- Creating a functional internal EU energy market
- Establishing trans-European energy infrastructure
- Securing internal EU energy supplies
- Assuring access to external supplies
- Increasing renewable energy availability
- Reducing greenhouse gas emissions
- Protecting critical energy infrastructure
- Developing nuclear energy on a safe and secure basis
- Managing nuclear waste
- Conducting cutting-edge research on nuclear energy

[12] EU dependency on oil imports is currently some 82% and is estimated increase to 93% by 2030 (Jacques Percebois, 2008).
[13] Nuclear to play prominent role in cutting CO2 emissions and securing energy supplies. http://www.foratom.org/e-bulletin-tout-1378/other-articles-tout-1385/775-nuclear-to-play-prominent-role-in-cutting-co2-emissions-and-securing-energy-supply-says-iea-study.html.
[14] State of Play in the EU energy policy. Accompanying document to the "Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy". COM(2010)639: 13-15.
[15] State of Play in the EU energy policy. Accompanying document to the "Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy". COM(2010)639: 16-17.
[16] "Communication From the Commission to the European Council and the European Parliament: An Energy Policy for Europe," Commission of the European Communities (SEC [2007]12, January 10, 2007), http://eur-lex.europa.eu/LexUriServ/site/en/com/2007/com2007_0001en01.pdf.
[17] "Will Ownership Unbundling Deliver?: Balancing European Energy Markets," *Ernst & Young* (2007) 14, http://www2.eycom.ch/publications/items/utilities/unbundling_thought_leadership/2007_ey_unbundling_thought_leadership.pdf
[18] Solar and Other Renewable Energy in North Africa Provides hope to the EU. Solarthermal Magazine. http://www.solarthermalmagazine.com/2010/07/07/solar-and-other-renewable-energy-in-north-africa-provides-hope-to-the-eu/.
[19] Francis David, "Europe Mixed on Russian Gas Reliance," *Christian Science Monitor*, Vol. 100, Issue 70 March 6, 2008).
[20] Umbach, Frank "Europe's Energy Dependence in Mid-Term Perspective," American Institute For Contemporary German Studies (2007) 3.
[21] Commission of the European Communities. Communication from the Commission to the European Council and the European Parliament – An Energy Policy for Europe. COM (2007) 1 final of 10 Jan. 2007. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0001:FIN:EN:PDF>.

- Establishing global leadership in smart and low carbon energy technologies
- Promoting sustainable use of energy worldwide
- Pursuing sustainable use of Arctic resources

Existing satellite systems for remote sensing, telecommunications, and positioning, navigation and timing (PNT) can all be put to use to contribute to a number of energy policy objectives. EO data provide valuable information on renewable energy sources. They can also support energy production and delivery, including pipeline and nuclear-facility monitoring. Telecommunications satellites facilitate wireless communication globally and can provide access to remote locations that are otherwise difficult to connect to power and information networks. Space-based services can also help monitor terrestrial energy grids and distribution networks. Navigation satellites can be used to monitor energy usage patterns in transportation systems and can help coordinate route planning to minimise wasted energy. Spin-off technologies and expertise can be transferred to other industries, including those that are energy-related. The space-related technologies referenced above, such as space-based solar power, microbial fuel cells or low-energy nuclear reactors have also been promoted as possible future energy sources.

Resources

The Oxford Dictionary describes natural resources as "materials or conditions occurring in nature and capable of economic exploitation".[22] As such, they include basic raw materials such as metals, minerals and fossil fuels, as well as biosphere and ecosystems that include renewable energy and life-supporting sources like water and food. Carefully planned utilisation of natural resources contributes to sustainable development. The growing scarcity of some natural resources, such as water and food, is closely connected to environmental concerns and impacts on a country's broader economy.

Although there are policies and initiatives already underway seeking to address the sustainable use of such resources, including those affecting climate change and biodiversity, the United Nations is now inclined to view resource management holistically to better understand the linkages among various resource issues. This approach is reflected in the work of the International Panel for Sustainable Resource Management (or Resource Panel), launched in November 2007, designed to bring scientific analysis of the environmental impact of resource use over the full cycle and propose methods of reducing negative effects, while identifying ways to decouple economic growth from environmental degradation.[23]

In Europe, the 6th Environment Action Plan (EAP) focuses, among other issues, on "better resource efficiency and improved resource and waste management to help bring about more sustainable patterns of production and consumption". The third of the seven EAP's Thematic Strategies deals with the "Sustainable Use of Natural Resources". It aims at making Europe one of the most resource-efficient economies globally.

Generating and preserving fresh water resources are among the key issues. The quality and quantity of water influences various areas of development, including food security, trade and transport, and health.[24] In addition to water, food security and safety are also the EU's priorities. In connection with the Millennium Development Goals and food security in developing counties, EU policy efforts are based on the following four pillars: increasing the availability of food; improving access to food; upgrading the nutritional content of food intake; and enhancing crisis prevention and management[25]. Protection of biodiversity constitutes another area of concern. Accordingly, the EU seeks to manage agriculture in such manner as to reduce significantly any harm to biodiversity.[26]

Access to minerals (i.e. non-energy raw materials) has recently become a global concern with China's embargo on rare-earth elements (RRE) to Japan, as well as a number of other countries, and subsequent market reactions.

[22] The Concise Oxford Dictionary: Ninth Edition. Oxford University Press (1995): 907.

[23] Resource Panel. United Nations Environment Programme, Division of Technology, Industry, and Economics. http://www.unep.fr/scp/rpanel/

[24] <http://europa.eu/legislation_summaries/development/sectoral_development_policies/r12514_en.htm>. Commission of the European Communities. Communication from the Commission to the Council and the European Parliament. Water Management in Developing Countries Policy and Priorities for EU Development Cooperation. COM(2002) 132 final of 12 Mar. 2002. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2002:0132:FIN:EN:PDF>.

[25] European Commission. Communication from the Commission to the Council and the European Parliament. An EU Policy Framework to assist developing countries in addressing food security challenges. COM(2010) 127 final of 31 Mar. 2010. Brussels: European Union. <http://ec.europa.eu/development/icenter/repository/COMM_PDF_COM_2010_0127_EN.PDF>.

[26] http://europa.eu/legislation_summaries/agriculture/environment/l28024_en.htm.

Access to raw materials has been on the EC's agenda for some time as the demand for metals grows continuously. The EU itself is dependent on the import of a variety of minerals, especially metal minerals, for many applications, including: building and construction; transport, electrical and electronic equipment; and jewelry. In this connection, recycling is now considered of critical importance for mitigating environmental impacts of mining metals.[27] The 2008 European Commission's Raw Materials Initiative stated that "securing reliable and undistorted access to raw materials is increasingly becoming an important factor in the EU's competitiveness and, hence, crucial to the success of the Lisbon Partnership for growth and jobs".[28]

From the above, the following EU objectives can be identified:

- Emphasising sustainable natural resource development
- Becoming more resource-efficient economies
- Reducing waste through recycling
- Enhancing European and global water security
- Implementing sustainable European food policies and monitoring global food security
- Maintaining access to strategic minerals

Space-based systems contribute to the more efficient use of natural resources. For example, EO is relevant for natural resource management. In this connection, the GMES Maritime and Land Services will be especially relevant. Satellite communications can also help bolster the efficient use of natural resources. They help gain real-time knowledge concerning resources (e.g. water), including resource monitoring, service breakdown alerts, and optimising of resource systems operation. With regard to navigation, GNSS applications, including those envisioned for Galileo, cover areas such as transport and communication, as well as land survey and other resource-relevant areas.[29]

Knowledge

Issues related to sustainability are often depicted in terms of their environmental, social/societal and economic impacts. Knowledge, which enables scientific and technological progress, can advance environmentally-friendly economic efficiencies. Knowledge and research are often part of the same equation. Research is an enabling tool for a number of EU policies and scientific and technical knowledge, which is continuously advanced by space, influences public policy decision-making. Since the 1990s, the terms "information society" and "knowledge society" have become considerably more prominent. Whereas an "information society" often refers to the concept of technological innovation, a "knowledge society" involves social, cultural, economic, political and institutional transformation. In this regard, education plays a key role in building knowledge societies.[30]

The EU considers education and training, as well as fostering employment, among its top priorities. Europe 2020 strategy includes among its drivers a "smart growth" concept that involves "developing an economy on knowledge and innovation".[31] It references the EU's goal of becoming the most dynamic and competitive knowledge-based economy in the world. This is to be achieved through a "knowledge triangle," integrating research, education and innovation. Accompanying these initiatives, the terms "i-conomy" and "i-society" are now being circulated. The "i-conomy" envisions effective partnerships among all relevant actors (i.e. states, universities, companies, civil society, etc.) to produce sound policies that will advance the agenda of Europe 2020. Innovation and knowledge are the engines that will create the "value-added" with global reach. Accordingly, the "i-conomy" is based on a concept of change which is promoted and reinforced by an "i-society" that is able to attract new investments, talents and ambitions.[32]

In conclusion, Europe has a number of leading priorities concerning how to achieve its goal of becoming the most competitive "knowledge society" globally. They are summarised below.

- Enabling wide access to Europe's education resources
- Increasing the efficiency of professional training and lifelong learning

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[27] Assessing Global Metal Flows: Metal Stocks in society and Recycling rates. UN Environment Program Flyer.
[28] Commission of the European Communities. Communication from the Commission to the European Parliament and the Council. The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe. COM(2008) 699 of Nov. 2008. Brussels: European Union. <http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=894&userservice_id=1>.
[29] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0769:REV1:EN:PDF
[30] Toward Knowledge Societies. An Interview with Abdul Waheed Khan. United Nations Educational, Scientific, and Cultural Organization (UNESCO) News (18 July 2003). http://portal.unesco.org/ci/en/ev.php-URL_ID=11958&URL_DO=DO_TOPIC&URL_SECTION=201.html
[31] "Europe 2020: A European Strategy for smart, sustainable and inclusive growth". COM(2010)2020: 3
[32] Giannopapa Christina. ESPI Report 24 (July 2010): 9. http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2024%20online_1.pdf.

- Modernising higher education
- Bolstering European cooperative arrangements and sharing best practices
- Promoting the advancement of scientific research, knowledge and innovation
- Maintaining leadership in basic research
- Developing transnational partnerships to proliferate knowledge
- Strengthening the link among education, business, research and innovation

As the space sector in Europe is, in large part, user-driven, space technology provides an impetus for economic growth and job creation.[33] The significant contribution that space science, technology, and derived applications and services can bring to policy-makers in Europe has already been recognised, including in an October 2010 European Commission Communication entitled "An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage".[34] In addition to space exploration and use and advancing the EU's strategic interests on the global scale, the Communication also cites the benefits to individual citizens, as well as economic competitiveness, where space is a "driver for innovation".[35] Space science produces asymmetrically large benefits for European society by driving research and development, education, public interest in science and technology, and innovative thinking. In short, space systems, and their derived applications and services, can advance a number of the key knowledge objectives.

Mobility

Due to the limitations imposed on the scope of this study, "mobility" refers solely to transport and related considerations. Specifically, it focuses on land, maritime, and air transportation, as well as virtual mobility, and the role that space systems play in advancing and upgrading these forms of mobility. Transport is a crucial element of the European economy as the transport industry constitutes approximately 7% of GDP and more than 5% of total EU employment. The transport sector is influenced and shaped by external factors (i.e. population, economic development, energy, technology development and social change) as well as internal factors, including infrastructure, vehicles and fuel development, and impact on the environment and society. Finally, policy decisions also guide the evolution of transport systems.[36]

Since road traffic is expected to remain the dominant passenger transport method for at least the next decade, new efficiencies, and technologies will be critical in reducing greenhouse gas (GHG) emissions in Europe, and particularly CO_2. For maritime transport, which accounts for some ninety percent of global trade, as well as for passenger air traffic, greater reliability and efficiency are likewise key aspirations, especially given oil price volatility.

Part of Europe 2020 strategy and the Common Transport Policy (CTP) is the concept of the Trans-European Transport Network (TEN-T). The overarching objective of the TEN-T is "a single, multimodal network covering both traditional ground-based structures and equipment (including intelligent transport systems) to enable safe and efficient traffic". The idea is to integrate land, sea and air transport infrastructure with a view to increasing the efficiency of traffic management through the employment of innovative systems, technical installations, information and telecommunications systems, as well as intelligent transport systems.[37]

Accordingly, Europe has a number of leading priorities concerning how to achieve its goal of advancing and modernising mobility. They include:

- Facilitating virtual mobility
- Strengthening transport safety and security
- Assuring environmentally sustainable transport
- Developing a Trans-European Transport Network (TEN-T)
- Increasing traffic management efficiency
- Ensuring long-term competitiveness of EU transport services and technologies

Satellite-based remote sensing, telecommunications, and positioning, navigation and timing (PNT) advance the transport modes referenced above (i.e. land, maritime, and air), increase traffic safety and security, as well as offer new applications for personal use. Sustainable mobility can contribute importantly to the EU SDS as it is closely linked to sustainable sources of energy and re-

[33] Giannopapa, Christina. Key Enabling Technologies and Open Innovation: New Impulse for the Space Sector. ESPI Report 24. http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2024%20online_1.pdf: 20.
[34] COM(2010)614.
[35] EC Communication COM(2010) 614: 24. http://ec.europa.eu/enterprise/policies/industrial-competitiveness/industrial-policy/files/communication_on_industrial_policy_en.pdf
[36] Report on Transport Scenarios with a 20 and 40 Year Horizon. European Commission DG TREN, TREN A2/78-2007 (24 March 2009): 11. http://ec.europa.eu/transport/strategies/studies/doc/future_of_transport/2009_02_transvisions_report.pdf
[37] The TEN-T Components. http://ec.europa.eu/transport/infrastructure/networks_eu/networks_eu_en.htm

sources, as well as the environment.[38] Earth observation data constitute a valuable information source for traffic management, especially in case of accidents and natural or man-induced disasters. Air and maritime traffic rely extensively on meteorological systems, including those that are space-based. In this connection, EUMETSAT provides important services for air and maritime traffic safety.

With regard to communications, beyond the most obvious virtual mobility application, namely TV through satellite broadcast, satellite communications offer a variety of other virtual mobility services (e.g. e-learning, e-shopping, etc.). They also enable traffic-related exchanges of information and tracking. Space-based PNT services, provided by the global navigation satellite systems (GNSS), are likewise important. The positioning of vehicles, goods, as well as their tracing and tracking, enables the development of applications that contribute to safer, cleaner and more efficient traffic. Moreover, space technology spin-offs can also improve transport technologies and services.

Conclusion and Final Recommendations

More than two decades after the release of the Brundtland Report, EU governments are still struggling to find a comprehensive approach to sustainable development. The EU's Strategy for Sustainable Development of 2001 and 2006, as well as the Europe 2020 strategy, all seek to address the economic, socio-political, and environmental challenges to EU's future growth and prosperity. Issues such as climate change and globalisation are on the agendas of nations worldwide and international partnerships are being forged to tackle them. As the EU configures itself to capitalise on its single legal identity, a more cohesive, integrated approach to pursuing bilateral relationships and participating in multilateral venues and international organisations is sought to meet challenges and find workable solutions. Security, environment, energy, resources, knowledge and mobility, as enablers of future prosperity, are properly a focus of attention in Brussels.

Space, as a strategic asset for any major nation in the 21st century, offers valuable services and applications for civilian, as well as military, users. Space policy and space-related cooperation are becoming an essential component of foreign policy planning and decision-making. The rationale for deeper and richer international cooperation in space is more compelling than ever, given the scale and long-term implementation periods of space programmes. As effective operations in space require cutting-edge technologies, large-scale funding, and multi-year support, enhanced cooperation among the European stakeholders (i.e. the EU MS, ESA and EU), as well as that of international partners, is increasingly essential. Such carefully-crafted cooperative efforts can also advance Europe's competitiveness in space and on Earth. Moreover, cooperation of this kind helps reaffirm the principle of the peaceful use of outer space, encourages transparency, and builds trust and confidence.

A cooperative approach to space also encourages responsible behavioural norms and a more uniform global space agenda that Europe is uniquely positioned to shape. This is, in large part, a leadership issue and one that Europe is preparing itself to meet. In short, an increasingly cooperative posture toward, and in, space would: accelerate the achievement of EU policy goals; multiply effectiveness in prosecuting these objectives; improve affordability via cost burden-sharing; offer a global agenda in several critical areas of sustainability; and educate governments and their respective publics.

The EU can use its prominent role within multilateral institutions to help design future cooperative work programmes which are consistent with the EU's agenda in each priority area of sustainability. This could also result in multilateral funding that augments and reinforces the EU's independent efforts today. Of course, such cooperation involves much more than the cost-sharing dimension. It could prove of great value to mankind, while strengthening Europe's space capabilities. To maximise the benefits and capabilities of space in addressing these six priority issue areas of Europe's foreign policy, the following individual sets of recommendations might be considered:

[38] Schrogl Kai-Uwe, Wolfgang Rathgeber, Blandina Baranes, and Christophe Venet (eds.). Yearbook On Space Policy: 2008/2009. Vienna: SpringerWienNewYork (2010): 12-13.

Sustainability Area	Recommendations
Security	With regard to security in Europe, there are a variety of different actors that interact with one another and possess different degrees of influence. Beyond intra-European influence, states outside Europe (e.g. China, Iran, Russia, etc.), as well as non-state actors, can profoundly affect Europe's security. Although the EU has introduced a "comprehensive" approach to security, as well as to its foreign policy, the reality is that the EU does not, as yet, possess full strategic independence. There exist two levels of dependency: external and internal. External factors include the international system (i.e. third countries, NATO, the UN etc.) and security-related developments, such as regional conflicts (e.g. the Middle East, the Balkans, the Korean Peninsula etc.). Internal dependence is illustrated by the European integration process itself. Although the Lisbon Treaty offers new possibilities, it depends on the MS to chart the path forward. It is a similar situation with respect to space security. To advance Europe's status as a major space power, the following recommendations are offered: • Develop a European space security strategy clearly identifying existing and emerging space-related challenges and threats for Europe. • Intensify the space security-related dialogue among the MS, European Council, European Commission, ESA, and other relevant entities (e.g. EDA, EUSC, etc.). • Identify the most prudent and cost-effective ways to address space security requirements, including a concentration on alternative funding. • Establish tools for better managing military space programmes (e.g. MUSIS), including avoiding the duplication of space assets. • Support development of Europe's capabilities for responsive space, such as envisioned by ESA's GIANUS concept of integrated space applications. • Develop the full potential of the EUSC, the European Centre for processing and analysing EO satellite data. • Assure availability of critical space technologies, launchers, satellite systems and know-how, via cooperative initiatives. • Enhance support for commercial space sector activities, particularly those that are "dual-use" in nature. • Clarify and reinforce space governance mechanisms and identify the operational requirements for the long-term utility of future European programmes, including Galileo and GMES. • Link space policies and capabilities to the management of the EU's internal and external security issues and explore new ways in which space can advance Europe's security requirements. • Employ the benefits of satellite use for civilian security needs, including for: managing heavy air traffic over Europe; maritime security; crisis management; and natural disaster prediction and management. • Improve protection of space assets and infrastructure (including through development of an advanced space situational awareness (SSA) capability). • Promote responsible behaviour in space, including via the EU's draft Code of Conduct for Outer Space Activities.
Environment	Satellites have been among the first technologies to reveal climate change issues. To ensure effective exploitation of existing satellite data and promote the development of advanced systems to manage the environment on a sustainable basis, the following recommendations are proposed: • Incorporate the monitoring of climate change variables from space in the implementation policies of the EU's Sustainable Development Strategy and Europe 2020 strategy. • Analyse near- and long-term priorities and opportunities of remote sensing for the environment to address effectively Europe's need for continuous environmental observations.

	• Continue to expand utilisation of space assets for environmental and climate change studies by exploiting fully the potential of existing space infrastructure. • Develop the GMES Space segment as it constitutes an inseparable part of the overall GMES system and represents an important contribution to environmental and climate change research. • Integrate space technologies into the evolving business model for a low-carbon economy. • Cooperate with science and environmental experts to utilise space systems along the lines of ESA's Living Planet Programme, which addresses the need to better understand the Earth system and its impact on human activity. • Emphasise the role of space assets to assist the newly established DG Climate Action and coordinate common use of space assets among the DG Climate Action, DG Environment (DG ENV) and the European Environment Agency (EEA).
Energy	Decision-makers in Europe have to weight carefully their investment strategies in a future energy mix to assure availability of energy supplies. There is already an emphasis on "green" energy, where a cost-effective solution is not viable in the near-term, but gains are expected in the long-term. Accordingly, together with securing imports of non-renewable resources, the right selection of renewable energy sources is of great importance. Space can advance both of the requirements referenced above, as well as contribute substantially to the effective use of the energy sources. Accordingly, the following recommendations are offered: • Integrate space in Europe's industrial policy. • Exploit new areas where space can advance both energy security and environmental protection (e.g. renewable sources of energy, satellite-based power grid control and monitoring systems, etc.). • Increase use of space systems for critical energy infrastructure protection (e.g. pipeline monitoring, cargo vessel monitoring, etc.) and effective exploitation of energy (e.g. use of weather satellite data to estimate potential of solar cell power plans and monitoring performance, etc.). • Work toward optimising maritime vessel utilisation via information and communications technologies. • Promote integration of maritime surveillance for transport security as outlined in a 2009 EC Communication entitled "Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain".[39] • Employ space assets for climate change research to understand better the direct (e.g. ocean storm patterns) and indirect (e.g. change of trade flows) threats to maritime transport, including ports.
Resources	A November 2010 report, entitled "Preparatory Study for the Review of the Thematic Strategy on the Sustainable Use of Natural Resources", conducted to support the review of the EU's Resource Strategy, pointed out the need to establish a strong knowledge base that would link environment and resource use to securing their sustainability.[40] Efficient use of natural resources, and especially water, energy and raw materials, constitutes a priority issue area for the EU. Accordingly, the following recommendations for space in resource management are offered: • Promote the use of existing space assets and related applications to help achieve the main objective of the EU's strategy on the sustainable use of natural resources and reduction of the negative environmental impacts caused by the use of these resources, while ensuring

[39] Towards the Integration of Maritime Surveillance: A Common Information Sharing Environment for the EU Maritime Domain. COM(2009) 538 final of 15 Oct. 2009. Brussels: European Union. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0538:FIN:EN:PDF>

[40] Preparatory Study for the Review of the Thematic Strategy on the Sustainable Use of Natural Resources. European Commission, DG Environment Report (November 2010): 5. <http://ec.europa.eu/environment/natres/pdf/BIO_TSR_FinalReport.pdf>

	economic growth. • Work towards assuring long-term availability and reliability of space-based information by integrating national and regional-level activities (e.g. supporting implementation of the GMES project, including its space segment). • Develop GMES services for extracting non-energy raw materials, including cooperation on three-dimensional (3D) geological models to advance Europe's scientific infrastructure. • Create a non-energy resource information database to map, evaluate, organise and structure the space-based data to be readily available to relevant EU bodies (e.g. via the Internet).
Knowledge	Space is a multiplier for scientific and technological (S&T) discovery. S&T is embedded in education, and promotes knowledge. Knowledge, in turn, is a key resource for innovation. Space-related research generates knowledge, including that related to advanced technology, and can serve as a driver for innovation and competitiveness. Accordingly, the following recommendations might be considered: • Continue to support space missions to advance scientific knowledge. • Organise space cooperative partnerships that create, and apply, scientific and technological knowledge in such a way as to advance environmental and economic objectives of sustainable development. • Identify where space knowledge can promote innovation, as well as enhance economic and socio-cultural assets. • Encourage and maintain active communication between policy-makers and the science and engineering communities. • Promote space science through cooperation with a view to producing a broader knowledge base which, in turn, generates professional development and European expertise. • Identify areas where space research and development can support EU policies and the Europe 2020 agenda and further the building of a knowledge society. • Take full advantage of the potential services offered by communications satellites to support Europe's Digital Agenda, the first of seven flagships under the Europe 2020 agenda.
Mobility	Efficient and effective transport contributes significantly to mobility, as well as other areas addressed in this study, including energy efficiency and environmental protection. To further the use of space for mobility, the following recommendations are offered: • Support space science that drives development of breakthrough technologies which can, in turn, advance future ways of mobility. • Include space systems in strategic decision-making on transport policy, including establishment of required infrastructure for integrating space-based services. • Incorporate EGNOS/Galileo services into decision-making on interlinking various modes of transport to establish an integrated transport system at the national and European levels (e.g. navigation systems for safer shipping etc.). • Encourage, and financially support, the development of satellite-based broadband services in low-density and difficult-to-access areas to advance virtual mobility.

1. Introduction

A sound foreign policy, based on the concept of sustainable development, can advance a number of key EU objectives. Sustainable development is increasingly proving key to the proper functioning, resource management, environment and inhabitants of our planet. The 1987 Brundtland Report of the UN World Commission on Environment and Development (WCED) entitled "Our Common Future" is widely viewed as an important milestone in describing the concept of sustainability based on a comprehensive socio-economic model. Its earlier iterations can be found, for example, in the ecological movement of the 1970s and World Conservation Strategy of 1980. During the decade of the 1970's, scientists and other experts probed the impact of technological development on the management of natural resources. An example is a publication, entitled "The Limits to Growth", prepared in 1972 by the Club of Rome, a small group of political leaders that was established in 1968.

The global environment was first debated on a multilateral basis during the 1972 United Nations Conference on the Human Environment held in Stockholm. As a consequence, the UN established the UN Environment Program and a number of governments set up environmental agencies. At that time, environmental sciences and related technology, as well as the ecology, became more visible and attention turned to global climate change. With the advent of the environmental movement, the concept of "sustainability" also began to be discussed for the first time.[41]

The World Conservation Strategy, referenced above, was published by then-International Union for Conservation of Nature and Natural Resources (currently called the World Conservation Union), the UN Environmental Programme (UNEP) and the World Wide Fund for Nature (WWF). It pointed out that humanity cannot survive without a steady effort to preserve nature and its natural resources. The objectives listed included: "maintaining essential ecological processes and life support systems; preserving genetic diversity; and ensuring the sustainable utilisation of species and ecosystems".[42] An updated version, entitled "Caring for the Earth: A Strategy for Sustainable Living", published in 1991, identifies sustainability as "improving the quality of human life while living within the carrying capacity of supporting ecosystems".[43]

The above mentioned Brundtland Report was a product of the so-called Brundtlandt Commission, established in 1983 by United Nations General Assembly Resolution (UNGA Res.) 38/161. The UN tasked the Commission to prepare a report on the environment and global issues out to the year 2000 and beyond, including proposed strategies for sustainable development.[44] It defines sustainability as: "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[45] Sustainable development is described as "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations".[46] The rather general nature of the Report emphasises the human dimension, notably the promise of a better life ahead via a deeper understanding of the ability of ecosystems to provide resources on a sustainable basis. A society must bear this responsibility for its members. Accordingly, its behaviour and actions are critical to accomplishing this goal. As the concept lays out the need for harmony among the natural, economic and social systems, these three should be carefully integrated in order to achieve economic sustainability, while assuring that social needs can be met over the long term.[47]

The European Union (EU) identified a number of areas of sustainability in its report, entitled "A Sustainable Europe for a Better World: A

[41] Young, Jennifer. „Education at the Commission on Sustainable Development: the Perception of the International Community". The Environmentalist, 20 (2000), 169.

[42] Extract from "Caring for the Earth". The World Conservation Union. http://www.ciesin.org/IC/iucn/CaringDS.html

[43] "Caring for the Earth. A Strategy for Sustainable Living." IUCN, UNEP, WWF (1991). Gland, Switzerland.

[44] UNGA Res. 38/161

[45] Brundtland Report, WCED 1987, p. 43

[46] Bruntland Report, WCED 1987, p.46.

[47] Lutteken Antonia and Konrad Hagedorn. "Concept and Issues of Sustainability in Countries in Transition – An Institutional Concept of Sustainability as a Basis for the Network." Humbolt University of Berlin. http://www.fao.org/regional/SEUR/ceesa/concept.htm

European Strategy for Sustainable Development," published in June 2001. This strategy was endorsed at a meeting of the European Council in Gothenburg in July 2001. The Council stated that sustainable development is a new dimension of economic and sociopolitical decision-making. It acknowledged that sustainable development is most effective when it is applied on global basis. Accordingly, the EU is seeking to promote sustainability in its bilateral cooperation efforts as well as within international organisations and other fora.[48] Areas of sustainability, embodied in the Gothenburg Strategy, were further elaborated on in the new EU Sustainable Development Strategy (SDS) of June 2006.[49] Sustainable development is likewise a central element of the "Europe 2020" strategy designed to accomplish, over the next decade, five ambitious goals that include employment, innovation, education, social inclusion, and climate and energy.[50]

The Consolidated Version of the Treaty on European Union (TEU) also refers to the term sustainability. The Preamble, for example, states that the countries are "determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development …". With regard to Europe itself, article 3.3. refers to "the sustainable development of Europe" in connection with the establishment of the Union's internal market. On a global basis, the EU pledges to contribute to "the sustainable development of the Earth" (TEU, art. 3.5.). The EU often refers to the UN Millennium Development Goals that also takes on this topic.[51] In September 2010, the Summit on the Millennium Development Goals, convened in New York, set out an agenda for the next five years, with eight goals that included ensuring environmental sustainability and developing a global partnership for development.[52]

It is now clearly evident from a large number of existing definitions of sustainable development that the concept of sustainability is evolving and has gained traction in many important international agreements and undertakings, particularly with respect to the environmental movement. There are a number of different criteria for identifying areas of sustainability. Space-based systems can advance a number of these. For example, images taken from outer space can provide valuable information concerning certain of these areas. They can also help mankind internalise the view that we are all on this small planet together and must exercise proper stewardship of nature and its resources if we are to sustain and grow our respective civilisations.

Accordingly, this study will focus on six areas of sustainability where space can serve as an important contributor. These were identified in a publication by the European Space Policy Institute (ESPI) entitled "Threats, Risks and Sustainability: Answers by Space" and include: security, energy, knowledge, environment, mobility, and resources.[53] In this connection, security makes the peaceful use of space sustainable. And space security provides a "blanket" under which all undertakings on Earth can be pursued more peacefully. It's fundamental to the sustainability equation in all of its dimensions.

This study is presented in three main parts, the first of which provides an overview of the challenges and opportunities related to the EU's multi-faceted foreign policy. It also examines Europe as a space-faring entity with global ambitions. The second part delineates key foreign policy objectives in each of the six areas identified and how these areas can benefit from available space systems and derived applications and services. In the concluding section, the study analyses how cooperation in space can serve to advance Europe's political, economic and geostrategic aspirations and bolstering the prospects for success in achieving these goals. In this connection, it discusses the potential for future partnering to achieve common interests. Finally, recommendations focus on specific policy objectives in each of the six areas evaluated as well as broader measures to advance Europe's role as a visionary, leading steward of the Earth.

[48] "Presidency Conclusions - Goteborg European Council." SN 200/1/01/REV1 15-16 June 2001. pp. 4-8.

[49] Council of the European Union. Note from the General Secretariat to the Delegations. Review of the EU Sustainable Development Strategy (EU SDS) – Renewed Strategy. 10917/06 of 26 June 2006. Brussels: European Union, http://register.consilium.europa.eu/pdf/en/06/st10/st10917.en06.pdf.

[50] "Europe 2020". http://ec.europa.eu/europe2020/index_en.htm

[51] http://www.un.org/millennium/declaration/ares552e.pdf. http://www.un.org/millenniumgoals/. http://unstats.un.org/unsd/mdg/Resources/Static/Products/Progress2006/MDGReport2006.pdf.

[52] The remaining six goals are: eradication of extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowerment of women; promoting global public health for all; reducing child mortality; improving maternal health; and combating HIV/AIDS, malaria and other diseases. http://www.un.org/en/mdg/summit2010/pdf/mdg%20outcome%20document.pdf

[53] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009.

2. Europe's Foreign Policy Opportunities and Challenges

The European Union (EU) is not a homogenous, single entity and must balance the foreign policy and security interests of the individual MS with those of the EU. It seeks to build its foreign policy on the social and political foundations of the EU itself. A dynamic exists between the internal functionality of EU's foreign policy apparatus and its strategy for execution which is based on consensus and external effectiveness. With regard to security policy, a number of challenges present themselves, among them: the ongoing financial crisis and severe budget constraints; the lack of a common assessment of military threats on the part of the MS, unpopular European involvement in Afghanistan, differing opinions about the Iraq war, and divergent views of a resurgent Russia. In short, while the EU's foreign policy looks outwards, there is a great deal of intra-European work that must be done to reconcile differing national priorities and preferences.

2.1 EU Foreign and Security Policy

The EU's foreign policy, anchored in international cooperation, is constantly seeking to advance key objectives, including in the areas of security, energy, environment, resources, knowledge and mobility. It is embedded in the Common Foreign and Security Policy (CFSP). The mandate for "external action" of the European Union (EU) is outlined in the Consolidated Version of the Treaty of European Union's (TEU) Title V under "General Provisions on the Union's External Action and Specific Provisions on the Common Foreign and Security Policy". Article 21 identifies "external action" as the "Union's action on the international scene". The CFSP is charged with effectively representing the EU's positions on various issues. The former pillar structure, where foreign policy belonged under the second pillar, has not entirely disappeared. Accordingly, the EU's external policy management remains under development.[54] EU Member States (MS) coordinate with the European Council to shape common positions and strategies on various international issues.

In this connection, the Lisbon Treaty created the positions of the President of the European Council and the High Representative for Foreign Affairs and Security Policy. The High Representative (HR) for Foreign Affairs and Security Policy, a merged position of the former HR for CFSP and the Vice-President of the Commission in charge of External Relations, also chairs the Foreign Affairs Council. This position is supported by the European External Action Service (EEAS), comprised of the European Council, European Commission and MS representatives, and seeks to establish Europe as a reliable, capable and predictable international partner.

The EU's external action service covers a broad range of foreign policy fields, including those addressed in this study.[55] The High Representative is tasked with ensuring consistency of EU external action, conducting the CFSP, and presenting the EU positions in the international organisations and international conferences. In addition to serving as the Head of the EEAS, the HR also presides over the Foreign Affairs Council (FAC).[56]

Under the Lisbon Treaty, the European Commission (EC), like the Presidency and the MS, also has responsibilities pertaining to the CFSP, through its "shared" right of initiative. Moreover, the EC supervises the management and implementation of the CFSP budget The Commission also oversees the coherence of all external activities as well as between external and "internal" EU action.[57] Accordingly, the EC has likewise developed external policies, including those related to representation in international organisations and dialogues with Third countries.

[54] German Ministry of Foreign Affairs. Europe – the European External Action Service. 20 Apr. 2010. 12 Oct. 2010.<http://www.auswaertiges-amt.de/diplo/en/Europa/Aussenpolitik/EAD.html>.

[55] European Union. External Action. Policies. 12 Oct. 2010. <http://www.eeas.europa.eu/policies/index_en.htm>.

[56] European Commission. External Relations. About us. <http://ec.europa.eu/dgs/external_relations/index_en.htm>.

[57] European Security and Defence 1999 – 2009. ESDP Newsletter (October 2009): 48-49. <http://www.iss.europa.eu/uploads/media/ESDP_Newsletter_10-year-special.pdf>.

Perhaps, the most effective way to illustrate the inner workings of, and challenges to, the CFSP and its associated EU entities is to cite specific cases that require action. It is also the case that what may appear to be intra-Europe problems can have profound implications for the EU's external policy portfolio. For example, the euro-zone crisis, which has matured over the past 12-18 months, has cast a shadow over perceived EU unity and its ability to meet the requirements of the fast-moving crises sweeping EU peripheral economies. The initially unexpected contagion effect (i.e. moving from one economy under attack by the bond market to another in a domino fashion) has been especially challenging for the European Central Bank (ECB) as well as forging a coordinated position among the MS that have quite different fiscal circumstances, debt to GDP ratios, budget deficits and overall stocks of debt.

At times, disagreements among the MS over how best to respond to this unprecedented crisis have proved costly and, with regard to Greece, may well have resulted in a "bailout" package that was several times larger than would have been required had EU had moved faster and with greater unity of purpose. World markets were scrutinising every action for signs that would bolster market confidence, hence the foreign policy implications. At this writing, there is some momentum behind making permanent a well-funded rescue mechanism (i.e. the European Financial Stability Facility-- EFSF), enhancing the EU's fiscal union and offering what is, in effect, a Euro-bond through the EFSF to replace or augment individual Member country bonds (with the full faith and credit of the EU backing them). It remains to be seen if international markets will be persuaded that these actions are sufficient to quell fears of default (or "restructuring") of certain MS debt burdens.[58]

This European-based financial crisis has resulted in rather dramatic austerity measures implemented by a number of the MS, notably Greece, Ireland, Portugal, and Spain. Even the EU has taken fairly radical deficit-reduction steps. It is also, as yet, unclear, how this wave of reduced budgets and overall indebtedness will impact on the six categories of sustainability addressed herein. It is probably inevitable, that some of the more ambitious undertakings in each of these areas may need to be trimmed in scope and implemented over a somewhat longer period of time than originally expected. The rise in oil prices to nearly $100/barrel (at this writing)[59] could represent another dampening effect on the visionary and ambitious plans associated with these six "sustainability" issue areas.

Similarly, it is also unclear how budgetary cut-backs will impact on MS space programmes, as well as the EU's growing involvement in space. Fortunately, there are a number of solid reasons as to why space budgets should be protected given the vital role of space systems and assets to MS' and Europe's key economic and security interests. That does not mean, however, that some officials charged with slashing budgets will not view space as a kind of luxury versus vital national and Europe-wide capabilities. Fortunately, Europe has demonstrated an enlightened view of how space can advance many EU foreign and security policy priorities and key initiatives.

2.2 Europe's Role as a Major Space-Faring Entity

Europe manages its space activities through coordination among individual MS, ESA and the EU. The first European Space Policy (ESP) was initially introduced in April 2007 as a joint Communication from the European Commission to the European Council and Parliament and as a proposal from the ESA Director General to the ESA Council. It was formalised on 22 May 2007 in a Resolution on the European Space Policy adopted at the EU-ESA Fourth Space Council. It is considered an important milestone for Europe as it includes, for the first time, the EU in space policy decision-making. An EC Staff Working paper entitled "Preliminary Elements for a European Space Programme", and prepared in cooperation with the High-Level Space Policy Group (HSPG)[60], accompanied the ESP and outlined the first strategic guidelines for Europe's future activities in space.[61]

The May 2007 Resolution on European Space Policy emphasised, among other items, the contribution of space to CFSP and the EU's

58 Interview with a representative of the RWR Advisory, a Washington DC-based consulting company (11 January 2011).

59 Dicolo, Jerry A. Crude Falls Amid Calls for OPEC to Boost Output. The Wall Street Journal (18 January 2011). <http://online.wsj.com/article/SB10001424052748703954004576089580867879972.html?KEYWORDS=oil+prices>

60 The High Level Space Policy Group (HLSPG) consists of representatives of the 29 ESA and/or EU member states, but not on the Ministerial level. It seeks to address issues concerning the practical implementation of the ESP and programme. The group also prepares the meetings of the Space Council. (The European Space Policy. Belgian High Representation for Space Policy. http://www.bhrs.be/eu_en.stm.)

61 Schrogl, Kai-Uwe, at al. eds. Yearbook on Space Policy 2006/2007. Vienna: Springer WienNewYork (2008): 23.

Sustainable Development Strategy, as well as Europe's standing as a major space-faring actor. Already in 2006, the Austrian and Finnish European Presidencies acknowledged the role space policy can play in advancing Europe's industrial and innovation policy. Also in 2006, the Austrian Presidency convened a conference that assessed the time frame, funding and governance of the Global Monitoring for Environment and Security (GMES), one of two EU flagship space programmes. Moreover, a decision was taken (under the Finnish Presidency) that a thematic area, "Space", is to be included in the EU's Seventh Framework Programme (FP7) for Research and Innovation for the period 2007 – 2013 with a budget of €1.43 billion over 7 years (out of some €50 billion for the entire FP7).[62] Roughly 85% of the budget was earmarked for GMES. The German Presidency followed up with another conference on GMES in 2007 to address the governance and operational funding issues. Besides the FP7, space activities were allocated a budget for Galileo, Europe's future global navigation satellite system (GNSS), through the Trans-European Network funds (€900 million over seven years for infrastructure development) and €70 million from the budget for "Competitiveness and Innovation.[63]

With regard to Europe's position as a space-faring power, the ESP emphasises the direct connection between the space capabilities and the EU's ability to exercise influence regionally and globally. It asserts that if the EU wants to be a leading global actor, it has to possess credible space assets, educate top-tier engineers and scientists, and invest in space research and development to build a knowledge society. Moreover, a credible ESP can also advance Europe's objectives in other areas of interest (e.g. environment). Finally, space systems are a strategic asset for any nation, or group of nations, with global ambitions and can contribute substantially to Europe's "autonomy" and "independence".[64]

The ESP under the Lisbon Treaty still awaits a more defined work programme. There exist many space projects, but a clear, integrated and coherent space policy is still in the process of being developed. To accelerate this process, Europe is seeking to generate the proper amount of political will, long-term commitments, and financial, technological and other resources to realise its vision for space. With a population of roughly 500 million, the EU is responsible for about 21% of the global economy and, as a trading block, accounts for some 20% of global imports and exports.[65] Given the right mix of the ingredients referenced above, Europe has the potential to shape and help define 21st century global space policy as a force for the benefit of all humanity, not just the interests of Europe and its MS.

In this connection, the 7th Space Council and subsequent Resolution entitled, "Global Challenges: Taking Full Benefit of European Space Systems", outlined the steps to be taken in order for Europe to continue to develop world-class space systems and derived applications. This document addressed: investments in scientific progress and promotion of innovation through a sound industrial policy for space; deployment of the EU's two flagship projects (i.e. Galileo and GMES); exploitation of space systems for climate change monitoring and security; space exploration; partnership with Africa to advance sustainable development; and governance of space activities in Europe.[66]

In summary, Europe is now positioned, through an improved mechanism to coordinate MS foreign policies via the Lisbon Treaty, to pursue a path that seeks to invigorate current space efforts for the benefit of its overall global standing. Space is an engine and a sound space policy, together and robust international cooperation, can realise the objectives associated with the six areas of sustainability outlined in this study.

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[62] In FP6 (2002-2006), space activities were included under the thematic area "Aeronautics and Space".

[63] Schrogl, Kai-Uwe, at al. eds. Yearbook on Space Policy 2006/2007. Vienna: Springer WienNewYork (2008): 26-28.

[64] Logsdon, John. "The New European Space Policy as Seen from Across the Atlantic" in Schrogl, Kai-Uwe, at al. eds. Yearbook on Space Policy 2006/2007. Vienna Springer WienNewYork (2008): 169.

[65] Report for Selected Country Groups and Subjects. International Monetary Fund, World Economic Outlook Database (April 2010). http://www.imf.org/external/pubs/ft/weo/2010/01/weodata/weo-rept.aspx?sy=2008&ey=2015&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=27&pr1.y=13&c=998&s=PPPGDP%2CPPPSH&grp=1&a=1.

[66] Global Challenges: Taking Full Benefit of European Space Systems. Brussels: 7th Space Council (25 November 2010). <http://download.esa.int/docs/7th_Space_Council_resolution.pdf>

3. Space as a "Multiplier" for Europe's Key Policy Priorities

Europe is cognizant of the fact that space systems are strategic assets and can contribute significantly to a number of key foreign policy priorities. Space policy, which is presently jointly configured by the EU member states (MS), ESA and the EU, is becoming an increasingly important item on the agendas of European policy decision-makers. There exist a number of policy areas that can benefit from space systems and applications. As effective operations in space require cutting-edge technologies and large-scale funding, the construction of such space-based systems needs multi-year support, cooperation among the European stakeholders, as well as that of international partners. Such carefully-crafted cooperation can also advance Europe's competitiveness in space and other areas globally. That said, it is apparent that the space-related challenges of the 21st century will require innovative and non-traditional approaches, including the know-how to sustain continuous development.

3.1 Security

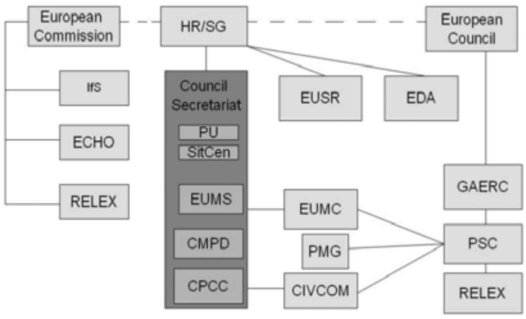
Security-related governance in Europe consists of a combination of the priorities of individual Member States (MS) and the EU. Defence issues remain the domain of the MS. There is, as yet, no uniform definition of what the term security covers. Moreover, individual EU Member States often see security challenges through a different lens. Consequently, many broad security policies are forged on an intergovernmental basis. The EU offers a definition of external and internal security and emphasises the connectivity between the two. Challenges such as fragile or failed states, terrorism, organised crime, the proliferation of weapons of mass destruction (WMD), and other issues of this kind are viewed as part of external security. Internal security pertains to broad domestic security concerns, such as protection of the critical infrastructure of key sectors (e.g. information and financial systems, energy and communication networks, transportation, etc.). Environmental impacts (e.g. climate change) that can negatively affect people's well-being are also considered to be within the internal security portfolio.

Europe likewise recognises the linkage between development and security. It emphasises that sustainable development cannot be achieved without a framework of peace and security. Indeed, absent sustainable development and poverty eradication this secure environment cannot be maintained. "The European Consensus" of December 2005, a joint tripartite declaration by the European Commission, Parliament, and the Council, laid out, for the first time, the "framework of common principles" for the EU and MS to take into account when implementing their development policies. The document acknowledges that "insecurity and violent conflict are amongst the biggest obstacles to achieving the Millennium Development Goals". It goes on to state that, "security and development are important and complementary aspects of EU relations with third countries".[67]

Accordingly, the EU is seeking to provide an overarching security framework through its Common Foreign and Security Policy (CFSP) and Common Security and Defence Policy (CSDP). By pursuing this goal, Europe hopes to improve continuously its standing as a major international actor in the area of conflict-prevention/resolution, crisis management, and peacekeeping. An important dimension of the EU's security-related decision-making is its partnership with the United Nations (UN) and NATO, both of which have a strong U.S. presence.

The Consolidated Version of the Treaty on European Union (TEU) tasks both the Council and the Commission to ensure consistency of the EU's external activities, including in the field of security, and mandates the European Council to identify the EU's strategic interests and related policy guidelines. The European Council basically seeks to assist and oversee cooperation among the MS to implement a variety of EU crisis management missions.

[67] European Parliament, Council of the European Union, Commission of the European Communities. Joint Statement by the Council and Representatives of the Governments of the Member States Meeting Within the Council, the European Parliament and the Commission on European Union Development Policy: 'The European Consensus'. 2006/ C 46/01 of 24 Feb. 2006. Brussels: European Union. 15 Dec. 2010. <http://ec.europa.eu/development/icenter/repository/european_consensus_2005_en.pdf>: 7.



ECHO = Directorate-General for Humanitarian Aid and Civil Protection
IfS= the Instrument for Stability
GAERC = the General Affairs and External Relations Council
PSC = the Political and Security Committee
EUMC = the European Union Military Committee
EUMS = the European Union Military Staff
CIVCOM = the Committee for Civilian Aspects of Crisis Management
SitCen = Situation Centre
CPCC = the Civilian Planning and Conducts Capability
PMG = Political Military Group
RELEX = the Foreign Relations Councellors
CMPD = Crisis Management and Planning Directorate
PU = the Policy Planning and Early Warning Unit, or Policy Unit
EDA = the European Defence Agency
EUSR = European Union Special Representative

Figure 1: CSDP Organisational Structure (Source: Swedish Defence Research Agency (FOI), Report FOI-R-3015-SE on Civil-Military Interaction in the European Union)

The Council is supported by the Political and Security Committee (PSC), the European Military Committee (EUMC), the European Union Military Staff (EUMS), and the Civilian Planning and Conduct Capability (CPCC), as well as the European Defence Agency (EDA).

As referenced above, the implementation of the CFSP is in the purview of the MS and the High Representative of the Union for Foreign Affairs and Security Policy. The High Representative is assisted by the European External Action Service (EEAS) and has an obligation to consult regularly with the European Parliament. The European Defence Agency (EDA) has been designated as the coordinating Agency for the development of MS defence capabilities as well as research, acquisition, and armaments. It is also in charge of defining the architecture of European capabilities and armaments and "assists the Council in evaluating the improvement of military capabilities" (see Figure 1). Specific duties under the framework of the CSDP are identified in Article 43(1) of the TEU: joint disarmament operations, humanitarian and rescue tasks, military advice and assistance tasks, conflict prevention and peacekeeping, the role of combat forces in crisis management, including peacemaking, post-conflict stabilisation and the fight against terrorism.[68]

All CSDP missions to date have been based on the Petersberg Tasks (i.e. humanitarian and rescue undertakings; peacekeeping operations; and combat missions, including crisis management and peacemaking). Europe also appreciates the necessity of increasingly focusing on global security challenges and their impact on its own security. Accordingly, the EU's CFSP and CSDP are expanding the number of global flash points covered.

3.1.1 Europe's Present Security Posture

The rather wide spectrum of issues that comprise the security field does not permit each to be treated in the limited scope of this study. Accordingly, this section focuses on two of the important elements of the European Security Strategy (ESS), namely internal and maritime security. There will also be attention paid to the EU-NATO partnership and external threats perceived by both entities. Europe's broader security objectives can be gleaned from a number of documents, including: "European Security Strategy: A Secure Europe in a Better World" (12 December 2003) ; "Report on the Implementation of the European Security Strategy: Providing Security in a Changing World" (11 December 2008); "Draft Internal Security Strategy for the European Union: Towards a European Security Model" (23 February 2010); "the EU Internal Security Strategy in Action: Five Steps Toward a More Secure Europe" (22 November 2010); "An Integrated Maritime Policy for the European Union" (so-called Blue Paper, 10 October 2007) and accompanying Action Plan; and the "Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation" (so-called NATO Strategic Concept, 19 November 2010).

A brief overview of the development of the post-Cold War security architecture and the increasing involvement of the EU in this arena will provide a background for the ob-

[68] Art. 42 Consolidated Version of the Treaty on European Union. Official Journal of the European Union. C 83 of 30 Mar. 2010.< http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:083:FULL:EN:PDF>

jectives later identified. The European Security Strategy (ESS), referenced above, was adopted in December 2003 by the European Council and laid the foundation for the EU's security priorities. It pointed out that individual European countries generally cannot tackle 21st century security challenges alone. The document also stated that "security is a precondition of development" since normal economic activities are generally encumbered or undermined during conflicts and heightened tensions.[69]

Key threats identified by the ESS included terrorism, proliferation of weapons of mass destruction, regional conflicts, failed states, and organised crime. To address these threats, three key strategic objectives for assuring the EU's security and values were put forth: reacting to the identified threats; building security in the EU's neighbourhood; and promoting international order based on effective multilateralism. These broad strategic objectives were to be pursued in a "more active, more coherent, and more capable" fashion, and "through work with partners".[70]

The 2008 "Report on the Implementation of the European Security Strategy: Providing Security in a Changing World", elaborating on the 2003 EES, pointed out that all global EU security-related work has been linked to UN objectives. This makes Europe well-positioned to be a leader of multilateral cooperation in this area. It likewise reaffirmed the validity of threats identified in the 2003 ESS and stated that the transatlantic relationship should remain the cornerstone of Europe's security-related cooperation. This document also called for strengthening the strategic partnership between the EU and NATO. [71]

The list of priority areas included: the proliferation of WMDs (with special attention to the Iranian and North Korean nuclear dramas); terrorism and organised crime; cyber security; energy security; climate change; piracy; proliferation of small arms and light weapons (SALW); and cluster munitions and landmines. The security risks associated with intensifying competition over natural resources such as oil, natural gas, water and raw materials was likewise referenced.[72] With respect to Europe's "near abroad", the stabilisation of the Balkan countries, Ukraine, conflicts on the eastern border, the Mediterranean and the Middle East were listed among the areas of concern.[73]

With regard to NATO-EU relations, pursuant to the Western European Union's (WEU) transfer to the EU in 1999, cooperation between the EU and NATO was formalised in 2001. It was further solidified by the NATO-EU Declaration on ESDP in December 2002 and the so-called "Berlin-Plus" arrangements in March 2003. The latter was an important milestone as it identified three areas in which the EU could directly benefit from NATO assets in a crisis management circumstance (even when NATO as a whole is not engaged).[74] Also in 2003, the NATO-EU Capability Group met for the first time to optimise the development of new military capabilities. Examples include the EU Battle Groups and the NATO Response Force. The European Defence Agency (EDA) was designated to assist the work of the Capability Group. Threats defined in NATO's new strategic concept overlap, to a large extent, with those identified by the EU (see figure 2 below).

As referenced earlier, two important dimensions of European security policy include internal and maritime security. With regard to the former, in early 2010, during the Spanish Presidency, an "Internal Security Strategy" (ISS) was approved. The strategy envisions a European security model based on the support of law enforcement, judicial cooperation, border management and civil protection, as well as shared European values.[75] The ISS was preceded by the so-called Stockholm Programme, the EU's programme for justice and home affairs for the period 2010-2014, and its associated Action Plan. The Stockholm Programme was a new work program, launched during the Swedish Presidency in the second half of 2009 to identify how EU countries can better cooperate in the areas of freedom, security and justice.

[69] European Council. A Secure Europe in a Better World – European Security Strategy. 12 Dec. 2003. Brussels. 15 Dec. 2010. <http://www.consilium.europa.eu/uedocs/cmsUpload/78367.pdf> : 2.
[70] Ibid.
[71] European Council. Report on the Implementation of the European Security Strategy – Providing Security in a Changing World. S407/08 of 11 Dec. 2008. Brussels. 15 Dec. 2010. <http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressdata/EN/reports/104630.pdf>: 2.
[72] European Council. Report on the Implementation of the European Security Strategy – Providing Security in a Changing World. S407/08 of 11 Dec. 2008. Brussels. 15 Dec. 2010. <http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressdata/EN/reports/104630.pdf>: 8.
[73] Ibid. <http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressdata/EN/reports/104630.pdf>.
[74] "NATO-EU: Strategic Partnership". http://www.nato.int/cps/en/natolive/topics_49217.htm (link was corrupted)
[75] Council of the European Union. EU Internal Security Strategy. 6870/10 (Presse44) of 25 February 2010. Brussels: European Union. 15 Dec. 2010. <http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/jha/113055.pdf>.

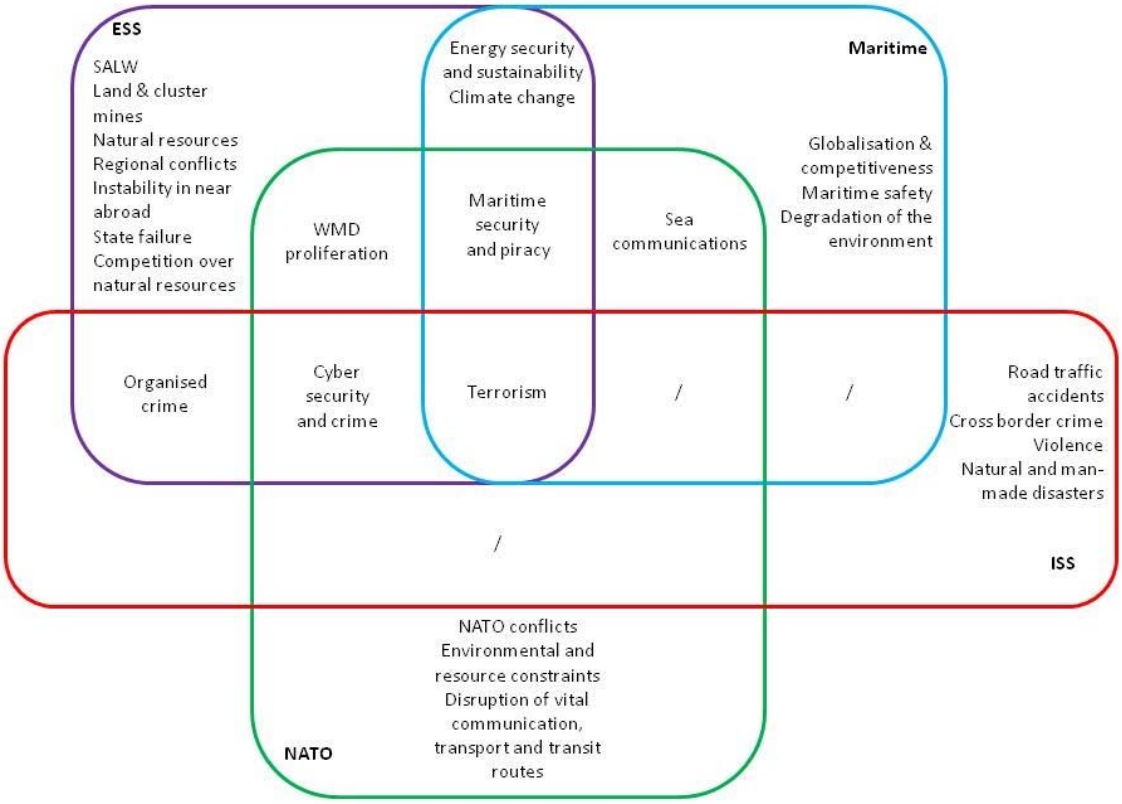


Figure 2: Threats identified by the EU (ESS, internal security and maritime policy) and NATO

The EC Communication of 22 November 2010, entitled "The EU Internal Security Strategy in Action: Five Steps Toward a More Secure Europe", outlined five strategic objectives and specific actions for 2011–2014. These objectives included: disruption of international crime networks; prevention of terrorism and addressing radicalisation and recruitment; raising levels of security for citizens and businesses in cyberspace; strengthening security through border management; and increasing Europe's resilience to crises and natural disasters. The proposed agenda also seeks to further improve coordination and cooperation among individual MS, the EU Parliament, the EC, the European Council and various agencies in order to strengthen Europe's overall security. The EC Communication also recognised that internal security cannot be achieved without taking into account global geopolitical developments. Therefore, the EU's internal security policy should be compatible with its external security priorities.

With regard to maritime security and safety, the EU places substantial emphasis on maritime-related threats. Among maritime security issues the EU includes terrorism, organised crime, and piracy. Additionally, maritime safety involves shipping, protection of maritime environment, cargo, navigation etc. In this connection, maritime surveillance is of high importance as it can provide continuous knowledge and awareness of maritime activities and contributes to informed and timely decision-making.[76] The EU seeks to put forth policies for improved maritime surveillance, coastal and port security, as well as better countering of illegal trade. In addition to the European Commission, the European Council and European Parliament, a number of other EU agencies are involved in efforts to implement these policies, often in cooperation with ESA.

EU Capabilities

The "Helsinki Headline Goal", introduced by the European Council in December 1999, delineated key objectives for Europe's military capabilities, including the decision to develop an autonomous defence capability by 2003. Specifically, this capability would consist of deploying up to 60,000 men within 60 days on missions of the duration of minimum one year, to be able to implement the Pe-

[76] Remuss, Nina-Louisa. Space Applications as a Supporting Tool for Countering Piracy – Outline for a European Approach. ESPI Report 29. Vienna: Springer. 2010: 21-22.

tersberg tasks (i.e. humanitarian and rescue tasks, peacekeeping tasks, and crisis management tasks of combat forces, including peacemaking.). Requirements for civilian crisis management were introduced in 2000 (at the Feira European Council in June). The Nice European Council of December 2000 defined the EU political and military bodies and structures (i.e. Political and Security Committee, Military Committee and Military Staff) and transferred the Western Union's (WEU) operational role to the EU.[77]

At the Capability Improvement Conference of November 2001, the MS agreed on a European Capability Action Plan (ECAP) to help achieve the Helsinki Headline Goal of December 1999. The ECAP outlined the capabilities required to meet EU goals. In 2004, the European Council endorsed "Headline Goal 2010". It also sought to fill existing gaps in crisis management operations. It emphasised interoperability, deployability and sustainability. These were to be achieved through more "flexible, mobile and interoperable" forces, better "use of available resources by pooling and sharing assets" and the "responsiveness of multinational forces". The establishment of the European Defence Agency (EDA) that same year was one of eight concrete milestones to be implemented in the period up to 2010.[78]

Strategic planning associated with the development of EU military capabilities, as called for in the "Headline Goal 2010", has been largely based on five hypothetical scenarios encompassing a number of military operations.[79] Three catalogues, namely the Requirements Catalogue, Force Catalogue, and Progress Catalogue, were configured to assess the capabilities available for different crisis scenarios. The Requirements Catalogue identified units, resources, and assets to manage the crises referenced above. The EU Force Catalogue described the military capabilities which the MS could make available to the EU. The Force Catalogue also served as a basis for identifying the EU's shortfalls and potential operational risks arising from them. The Progress Catalogue, approved in November 2007, set out recommendations to the MS on managing such shortfalls. The Headline Goal 2010 also referenced the work of the Space- Based Assets Project Group for its contribution to the development of the EU space policy.[80]

The Progress Catalogue 2007 made a comparative assessment of qualitative and quantitative military capability deficiencies based on the two other Catalogues referenced above. It concluded that the EU was ready to undertake a full spectrum of military ESDP missions, but with operational risks, especially where deficiencies remained "critical". These shortfalls included, the "capability to transport forces to the theatre, to deploy them in theatre, to protect them and to acquire information superiority". Based on this document as well as MS programmes, the Capability Development Plan (CDP) was introduced in July 2008.[81]

In 2007, the Civilian Headline Goal 2010 identified objectives for Europe's civilian capabilities for crisis management. This document elaborated on the previous "Civilian Headline Goal 2008" of December 2004. The objectives included: improving the quality of civilian EU crisis management; enhancing the availability of the MS to contribute to the ESDP missions; developing instruments to improve planning and conduct missions; and achieving synergies among "civilian and military ESDP", the European Community, third pillar actors (e.g. EUROPOL) as well as other countries and international organisations.[82]

In 2003, the first EU crisis management operations took place (i.e. EU Police Mission in Bosnia and Herzegovina, Concordia in Macedonia, and the Artemis mission in Congo) at the launch of the Iraq war. Due to deep internal divisions over the conflict in Iraq, the ESS outlined a common security concept at the end of 2003. For the first time, a common analysis of the threats and challenges for Europe's security were determined. Implementation of these policies was reviewed in 2008. When the Lisbon Treaty entered into force in December 2009, the ESDP became Common Security and Defence Policy (CSDP). As of beginning of 2010, over twenty mis-

[77] European Security and Defence 1999 – 2009. ESDP Newsletter (October 2009): 3-6. <http://www.iss.europa.eu/uploads/media/ESDP_Newsletter_10-year-special.pdf>.

[78] Council of the European Union. Headline Goal 2010. 17 May 2004. Brussels: European Union. 15 Dec. 2010. <http://www.consilium.europa.eu/uedocs/cmsUpload/2010%20Headline%20Goal.pdf>: 2-3.

[79] Five scenarios were as follows: separation of parties by force; stabilisation, reconstruction, and military advise to third countries; conflict prevention; evacuation operation; and assistance to humanitarian operations.

[80] Council of the European Union. Headline Goal 2010. 17 May 2004. Brussels: European Union. 15 Dec. 2010. <http://www.consilium.europa.eu/uedocs/cmsUpload/2010%20Headline%20Goal.pdf>: 7.

[81] Council of the European Union Secretariat. Press – Development of European Military Capabilities. July 2009. Brussels: European Union. 15 Dec. 2010. <http://www.europarl.europa.eu/meetdocs/2009_2014/documents/sede/dv/sede171109factsheemilcap_/sede171109factsheemilcap_en.pdf>.

[82] Council of the European Union. Headline Goal 2010. 17 May 2004. Brussels: European Union. 15 Dec. 2010. <http://www.consilium.europa.eu/uedocs/cmsUpload/Civilian_Headline_Goal_2010.pdf>: 3-5.

sions have been undertaken under the EU banner.[83]

As evidenced from the developments and related official documents described above, Europe has laid out ambitious objectives for its priority security issue areas. They are listed, together with NATO's priorities, in annex 2 and key objectives are summarised in table 1 below.

Key EU Objectives for Security
• Countering terrorism and penalising terrorist-sponsoring states • Securing critical infrastructure • Reducing cross-border crime and bolstering border security • Fighting organised criminal activities • Managing humanitarian and natural disasters • Enhancing cyber security • Diffusing maritime disputes and combating piracy • Strengthening the strategic partnership with NATO • Safeguarding international security • Countering ballistic missile and WMD proliferation • Combating illicit accumulation and trafficking of SALW • Promoting anti-mine actions • Preventing and/or managing regional conflicts and failed states

Table 1: EU's Key Objectives for Security

3.1.2 Space as a Means to Strengthen Security

Space systems and services constitute a critical element of the global information infrastructure. Space-based civil, commercial, and military systems help provide communication, environmental, image, position, location, timing, and other important data and services to users. European space capabilities are often of a "dual-use" nature, with defence-related as well as civilian applications. Europe has been increasingly emphasising the use of space systems to enhance security. Security in this context covers not only the military uses of space, but space-based systems for environmental, energy security, crisis management, peacekeeping, civil protection, and other areas.

European space activities are conducted at national, supranational, and multilateral levels and the MS are the dominant stakeholders in defence matters. The EU envisions moving toward more interoperable, coordinated space defence capabilities among the relevant entities as envisioned in the European Space Policy (ESP). The ESP, described in Chapter 2, recognises space as a strategic asset "contributing to the independence, security and prosperity of Europe and its role in the world".[84]

Earlier European Commission (EC) documents, including the 2003 "Green Paper" and "White Paper" on ESP, laid out the EU's ambitions in space. Currently, however, Europe's success in coordinating its security- and defence-related endeavours depends on the level of consensus among Europe's main space actors. Only when a clearly defined space policy has been formulated, will the EU be positioned to negotiate Europe-wide space security-related undertakings, including a structured EU-NATO partnership. In this connection, NATO will likewise need its own space policy.

The EC is the engine of civilian space security initiatives under EU leadership. In May 2004, the EC – ESA Framework Agreement formalised cooperation between these organisations and established a "Space Council" (recently extended until 2012) and a "High Level Space Policy Group". The EC likewise established a Space and Security Panel of Experts (SPASEC) that was convened in June 2004 and was followed by a SPASEC Report in March 2005. Also in 2005, the EC's jurisdiction over space policy was transferred from the Research Directorate to the Directorate General for Enterprise and Industry, including a unit dedicated to space matters. The EU thus demonstrated its intention to use space for broader purposes, not merely sponsoring space research.[85]

The funds allocated to the EC cannot be compared to the much larger expenditures on European space programmes by ESA. For example, in 2006 the EC's budget for space was approximately €189 million while ESA's was 2.9 billion.[86] At the same time, the EC is indispensable in generating the political will to strengthen and unify European space efforts. The 2008 ESP Progress Report stated:

[83] European Security and Defence 1999 – 2009. ESDP Newsletter (October 2009): 4-7. <http://www.iss.europa.eu/uploads/media/ESDP_Newsletter_10-year-special.pdf>.

[84] Council of the European Union. 4th Space Council Resolution on the European Space Policy. 22 May 2007. Brussels: European Union. 15 Dec. 2010. <http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/intm/94166.pdf>.

[85] Logsdon, John. "The New European Space Policy as Seen from Across the Atlantic". Yearbook on Space Policy 2006/2007: New Impetus for Europe. Eds. Kai-Uwe Schrogl, Charlotte Mathieu, and Nicolas Peter. Vienna: Springer. 2008: 172.

[86] European Space Agency Funding. Paris, 19 Oct 2007.

» European space capacities have become critical information tools in addressing a diversity of environmental, economic and security challenges of a global or regional scale. Autonomous access to information derived from space is thus a strategic EU asset. The EU will need to further strengthen its ability to respond to these challenges, including in the security and defence domains, both through improved coordination and through the development of indigenous capacities.[87]

Although Europe has made great strides in developing European space systems, there is hesitancy on the part of individual MS to pool, or share, their individual military space capabilities under the EU umbrella as the limitations of doing so are perceived to exceed the benefits. That said, a number of bilateral and multilateral cooperative arrangements have been forged among European countries. The conflicts in Bosnia, Kosovo, Afghanistan and Iraq contributed to altering Europe's approach to military space and greater efforts emerged to coordinate European military space assets, particularly satellite communications (SATCOM) and remote sensing.

Five MS constitute some 99% of military space expenditures. France is the most advanced in the development of military space systems.[88] It operates communications, earth observation and surveillance, and electronic intelligence (ELINT) and plans to launch an early warning system by 2020. Both Germany and Italy operate synthetic aperture radar (SAR) satellites and Germany also launched five medium-resolution, electro-optical satellites in 2008. France, the UK, Italy and Spain operate geosynchronous satellites for military communications.[89] The Athena-Fidus and SICRAL-2 satellites, for example, are a result of cooperation between the French and Italian governments and are slated to be launched in 2013 or early 2014 (SICRAL-1 was launched in 2001).

Concerning imaging capabilities, France took the lead in 2001, in cooperation with Germany, Italy, Spain, Belgium, and Greece, with a joint agreement on the Besoins Operationnels Communs (BOC, or common operational requirements). The purpose of BOC was to develop uniform requirements for a European global satellite observation system for security and defence purposes. The rationale was to expand already existing arrangements between France and Italy on Orfeo system, consisting of the Pleiades optical system and Italian Cosmo-SkyMed radar component.

In 2006, the six BOC signatory countries launched studies for a Multinational Space-Based Imaging System for Surveillance, Reconnaissance and Observation (MUSIS) with the goal of harmonising future optical and radar observation systems. It envisioned going beyond mere exchanges of military intelligence images and provide the users from the six countries with access to all space-based assets in a transparent and coherent manner. As EDA's Capability Development Plan (EDA) includes space-based imaging capability for CSDP missions, the EU also became involved in March 2009. EDA agreed to approve the MUSIS project, envisioned to be launched between 2015 - 2017.[90] In 2010, Poland and Sweden expressed interest in joining the EDA MUSIS programme.[91]

Another example of cooperative efforts is ESA's European Data Relay Satellite (EDRS) programme. Optical communication technologies can rapidly transmit a large amount of information to operation centres thousands of kilometres away and thus provide an important operational advantage. The 3-year (2004 - 2007) demonstration program, LOLA, was developed by EADS Astrium for the French Ministry of Defence. It investigated the feasibility of high data rate optical communications through the atmosphere. More than 50 successful communication sessions were accomplished over some 20 flights of an aircraft flying at 9,000 m with the Satellite Interlink Experiment (SILEX) terminal on the Artemis geostationary satellite. The European Space Agency is in the process of configuring the future EDRS to replace the Artemis GEO relay. The future system should offer high data rate optical links with demanding users like the GMES Sentinel LEO missions. In this connection, the German Space Agency is funding the Laser Communication Terminal (LCT) program currently tested on board the

[87] Commission of the European Communities. Commission Working Document – European Space Policy Progress Report. COM(2008)561 final of 11 Sep. 2008. Brussels: European Union. 15 Dec. 2010. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0561:FIN:en:PDF>: 6.

[88] Nardon, Laurence and Christophe Venet. The Evolving Architecture of Space and Security in Europe. IFRI. The Europe and Space Series 1.16 Nov. 2010. 15 Dec. 2010. <http://www.ifri.org/?page=contribution-detail&id=6313>.

[89] Single, Thomas (Lt Col). "New Horizons: Coalition Space Operations". Air and Power Journal. Summer 2010: 73.

[90] European Defence Agency. Press Release - "New EDA Project on Space-Based Earth Surveillance System". 5 Mar. 2009. Brussels: European Union. 15 Dec. 2010. <http://www.eda.europa.eu/newsitem.aspx?id=456>.

[91] Poland and Sweden to Join EDA Musis Programme. Army-technology.com (1 July 2010). <http://www.army-technology.com/news/news89337.html>.

TerraSAR satellite to demonstrate LEO-LEO optical communications.[92]

Other ESA projects vital to Europe's role as a global space power include the three-year Space Situational Awareness (SSA) Preparatory Programme launched in 2008 and the Global Integrated Architecture for Innovative Utilisation of Space for Security (GIANUS) initiative that is envisioned to provide the capabilities associated with the concept of responsive space.

European priority programmes, Galileo and GMES, are designed, among other tasks, to enhance the management of security-related challenges. Galileo, once operational, is envisioned to provide the armed forces of the MS, the EU Battlegroups and CSDP navigation capabilities. Although seen as an independent global navigation satellite system (GNSS) capability, Galileo will leverage the benefits of interoperability with the American Global Positioning System (GPS). The operational European Global Navigation Overlay System (EGNOSS), the predecessor of Galileo, is already deriving the advantages of cooperative arrangements.

One of the functions of the Global Monitoring for Environment and Security (GMES) programme, which will integrate Earth observation (EO) satellites and ground-based sensors, is to support the Petersberg Tasks. It will also be able to assist in the prevention of disasters such as flooding, forest fires and oil spills that all require timely and precise information. As such, GMES could prove a valuable asset to advance the CSDP mandate. Internationally, GMES should bolster Europe's global prestige as it is to become Europe's contribution to the global ten-year implementation plan for the Global Earth Observation System of Systems (GEOSS). It should also elevate Europe's participation in international efforts to assess climate change.

The next section examines how existing and planned space assets can significantly bolster key EU objectives in the areas of security identified in section 3.1.1.

Space Applications in Advancing Internal Security Strategy

A number of objectives identified in table 1 above fall into the category of the EU Internal Security Strategy (ISS) of February 2010. These include countering terrorism, securing critical infrastructure, reducing cross-border crime, illegal immigration and bolstering border security, fighting organised criminal activities, and managing humanitarian relief in case of natural disasters[93]. Current efforts to counterterrorism, for example, are impeded by a number of issues, including sovereignty over territory and airspace, and insufficient sharing of intelligence information. Although the SPASEC report already recognised space as an important element in the fight against terrorism, space applications have not, as yet, been a major contributor to resolving issues related to Europe's internal security.[94]

Space-based Earth observation (EO) enables unrestricted observation of areas difficult to access due to political or military factors and can provide evidence of illicit activities. Such images can be analysed by the European Union Satellite Centre (EUSC). EO can offer important intelligence for the European Maritime Safety Agency (EMSA), the European Agency for the Management of Operational Cooperation at the External Borders (FRONTEX), the European Defence Agency (EDA), and the Situation Centre (SitCen) of the Council Secretariat. This, in turn, translates into support for the EU's planning and decision-making. Besides the EU agencies, a number of EC Directorates (DGs) are engaged in matters related to internal security (e.g. DG for Justice, Freedom and Security, DG for Transport and Energy, DG for Enterprise and Industry, DG for Maritime Affairs and Fisheries, the Humanitarian Aid Office, the Joint Research Centre, the Civil Protection Unit of the DG Environment and the EC Maritime Affairs Task Force).

Earth observation satellites are required for today's management of natural and man-made disasters, including mitigation of their impact. Satellites are able to provide imagery of the disaster zones within 24 hours to advance damage assessment and manage relief efforts. In this regard, the International Charter on Space and Major Disasters, signed in 2000 by CNES, ESA and the Canadian space agency, is a fine example of cooperation in this area. As of 2010, ten organisations have joined the International Charter and have immediate access to critical data on disas-

[92] Vaillon, L., G. Planche, V. Chorvalli and L. Le Hors. Optical Communications Between an Aircraft and a GEO Relay Satellite : Design & Flight Results of the LOLA Demonstrator. 2008. 15 Dec. 2010. <http://www.icsoconference2008.com/cd/pdf/S13%20-%20Fiber-Free%20Space%20Optic%20-%20Vaillon.pdf>.

[93] EU Internal Security Strategy. Brussels: Council of the European Union (25 February 2010). http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/jha/113055.pdf

[94] Remuss, Nina Louisa. "Creating a European Internal Security Strategy Involving Space Applications". Space Policy 26.1 (2010): 11.

ters. Indeed, the Charter has been used more than 200 times since 2000.[95]

Concerning the EU and disaster management from space, the EU 7th Framework Programme (FP7) includes, for the first time, funds for security-related projects. For example, it supports the Services and Applications for Emergency Response (SAFER) project which provides rapid mapping of disaster-prone areas, as well as other tools, to help optimise disaster response.

Another example is the European Geostationary Navigation Overlay Service (EGNOS), the first European satellite navigation system, that has been offering its Open Service since October 2009. EGNOS improves the accuracy of position measurements of GPS to within three metres, informs users of the errors in the position measurement, and warns of disruption to a satellite signal within six seconds. Information about the accuracy of position measurements delivered by GPS is an important capability for many applications such as aviation, maritime, and land transport.[96] The EU Commission identified six priority domains of applications for EGNOS, and Galileo, the full global satellite navigation system under development in Europe. It includes the security-related area of "civil protection and surveillance.[97] With regard to fighting proliferation of small arms and light weapons (SALW), EGNOS and Galileo applications for road transport will contribute to road tracking and tracing of persons and goods, as well as the monitoring of dangerous goods.[98] Moreover, EGNOS and Galileo, combined with GPS, will be able to promote safer and more efficient navigation for: track control; ship-to-ship coordination; port approach and navigation; ship-to-shore coordination; shore-to-ship management; calamity avoidance, etc.[99]

GNSS offers an important tool to support emergency situations and Galileo is also envisioned to serve as an important element of civil protection in disaster situations. Position reporting is indispensable during emergency management operations, including involving the police, fire brigades, civil protection, etc. Galileo will, for example, be able to provide position information concerning the location of rescue teams and other crucial information for rescue and disaster management planning.

Moreover, EGNOS and Galileo will likewise contribute to prevention of certain disasters by the surveying and monitoring of various types of infrastructures such as dams and bridges. Galileo could be used, together with the future GMES service, to deliver complementary information concerning topography, hazard maps, etc.[100] The Mature Applications of Galileo for Emergency Scenarios (MAGES) project, for example, seeks to explore possible EGNOS and Galileo applications for emergency management.[101] The use of space for coping with disasters will be further elaborated on in section 3.3 of this report.

Galileo's Public Regulated Services (PRS), that will use encrypted and jamming-resistant signals, is designed for exclusive use by the MS, the EU Council, EU Commission, and possibly other authorised governmental bodies. Third countries and international organisations will also have select access to this system for a variety of security-related applications, including emergency situations, critical transportation and defence purposes.[102]

Diffusing maritime disputes and combating piracy

Space serves as an important element in advancing maritime security. For example, EUSC provided its services to support the EU ATALANTA NAVFOR mission. EUSC's Digital Geographic Information (DGI) products are able to identify pirates' operating bases and vessels. Naturally, to achieve a comprehensive maritime situational awareness, integrated access to data sources (e.g. on board automatic identification system (AIS), sat-AIS, on-board GPS, and EO ship detection) are required. The AIS is a new application that can locate ships of 300 tons and more provided the vessels are equipped with an AIS VHF transmitter.[103] Moreover, an integrated system of space and non-space services, such as in situ surveillance (using helicopters and aircraft), are indispensable in supporting counter piracy activities.

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[95] International Charter Space and Major Disasters: Charter Activations. http://www.disasterscharter.org/activations
[96] "How Does EGNOS Work?" European Space Agency. http://www.esa.int/esaNA/GGGQI950NDC_egnos_0.html
[97] Other five domains are: applications for individual handsets and mobile phones (LBS); road transport; aviation; maritime transport; and precision agriculture and environment protection.
[98] Satellite Navigation: Applications. European Commission, Enterprise and Industry. http://ec.europa.eu/enterprise/policies/satnav/galileo/applications/index_en.htm
[99] Ibid.

[100] Ibid.
[101] Mature applications of Galileo for emergency scenarios. European GNSS Agency. http://www.gsa.europa.eu/index.cfm?objectid=66043106-CE1A-6AEF-1F4C5A7A9A15D5AA
[102] Satellite Navigation: Applications. European Commission, Enterprise and Industry. http://ec.europa.eu/enterprise/policies/satnav/galileo/applications/index_en.htm
[103] European Space Directory 2010. Paris: ESD Partners (2010): 96.

That said, the surveillance of seas and waterways is a major contributor to anti-piracy efforts. Inmarsat, for example, operates Ships Security Alert System (SSAS), based on Long Range Identification and Tracking (LRIT), involving position reporting, a communications system and emergency calling.[104] The future GMES system also has the potential to help decision-makers address a number of key issue areas, including maritime security, the monitoring of coastal activities, marine resource management and ice survey and warning. The willingness to cooperate and properly integrate space-based technological capabilities, however, will be required to achieve the objectives set forth in the EU's maritime policy.

Enhancing cyber security

Critical infrastructure systems, including power grids and transportation systems, are run from a cyber platform. The potential economic, social and military effects of an attack would be significant, including the possible loss of life. Russia demonstrated offensive cyberspace capabilities in attacks against Estonia in 2007 and Georgia during the South Ossetia war in 2008. Space systems revolutionised the way information is transmitted and received, and play a critical role in the civilian, commercial and military spheres. As such, they are an attractive target for a cyber attack. The UK's recent National Security Strategy listed threats to cyber space among the top concerns of Britain.[105] Accordingly, the cyberspace domain presents governance challenges that require continued public-private sector cooperation and cyber security policy needs to cover protection of space systems.

Strengthening strategic partnership with NATO

The EU's ultimate configuration of its security architecture will shape the relationship with NATO going forward. It will also determine the effectiveness of the NATO-EU Capability Group. The ongoing operations in common theatres (i.e. Afghanistan, the Balkans and off the coast of East Africa), are testing Europe's political will to forge coherent military capabilities. Despite the fact that CSDP's mandate covers a broader range of issues than that of NATO, its aspirations require the availability of robust military capabilities. At the same time, NATO is more keenly aware of the future military requirements for civilian development, an area in which Europe excels.[106]

Safeguarding international security, including countering WMD Proliferation, combating illicit accumulation and trafficking of SALW, and promoting anti-mine actions

In recent years, the EU MS have been compelled to reach an EU-wide consensus on decisions related to foreign developments with security implications. Assured access to reliable information advances the quality and timeliness of political decisions. Europe seeks, for example to advance counter proliferation of WMD and ensure global verification of Treaties. Space and terrestrial security can also be reinforced by confidence-building measures (TCBMs). In this connection, the EU is promoting behavioural norms in space through its Draft Code of Conduct. It is an effort on the part of the EU to play a normative role in space security through the "principled" identity it seeks to achieve.[107] The EU Council Conclusions state that the Code of Conduct includes "transparency and confidence-building measures as a basis for consultations with key third countries" involved, or interested, in outer space activities.[108]

Remote sensing satellites constitute a key verification tool for Treaty monitoring and conflict prevention, including missile proliferation concerns. Civilian EO satellites in LEO (e.g. SPOT) and GEO (e.g. Meteosat) have the capability to monitor preparation for launches as well as the launches themselves. To detect a launch, higher temporal resolution is required (i.e. more frequent observation capability). Several satellites in LEO or a single satellite in GEO can satisfy this requirement.[109] Accordingly, as already demonstrated by the signing of the Anti-Ballistic Missile (ABM) in 1972, satellites offer the

[104] Remuss, Nina-Louisa. "Space and Maritime Security – Strategies for Countering the Pirates". Space Policy 26.2 (2010): 124-125.
[105] Gardham, Duncan and James Kirkup. "Terrorism and Cyber Attacks: the Risks that Britain Faces". The Telegraph. 18 Oct. 2010. 15 December 2010. <http://www.telegraph.co.uk/news/newstopics/politics/defence/8071963/Terrorism-and-cyber-attacks-the-risks-that-Britain-faces.html>.
[106] Sturm, Paul. NATO and the EU: Cooperation? ISIS Europe. European Security Review 48. Feb. 2010. 15 Dec. 2010. <http://www.isis-europe.org/pdf/2010_artrel_445_eu-nato-capabilities.pdf>.
[107] Ibid, 40.
[108] Council of the European Union. Cover Note from the General Secretariat to the Delegations – Council Conclusions and Draft Code of Conduct for Outer Space Activities.17175/08 of 17 Dec. 2008. Brussels: European Union.15 Dec. 2010. <http://register.consilium.europa.eu/pdf/en/08/st17/st17175.en08.pdf>: 2.
[109] Bhupendra, Jasani. "Improving Space Security by Monitoring Launches of Satellites and Missiles Using Some Space-Based Assets". Prospects for Transparency and Confidence-Building Measures in Space. Eds. Jana Robinson, Matthew Paul Schaeffer, Kai-Uwe Schrogl and Frans von der Dunk. ESPI Report 27. Vienna: ESPI. 2010: 14-20.

capability to verify some of the current arms control agreements and can strengthen TCBMs. The International Atomic Energy Agency (IAEA), as well as the EUSC, have already used satellite data for verification purposes.

Key EU Objectives for Security	Space as an Instrument
Advancing Internal Security	<u>Remote Sensing</u>: *Sample Applications:* • Unrestricted observation of areas difficult to access • Provide evidence of illicit activities • Border surveillance • Coastal surveillance • Vessel monitoring • Illegal logging detection • Illegal fishing or cropping • Prediction and management of natural and man-made disasters • Weather forecasting and now-casting • Provide complementary information concerning topography, hazard maps, etc. for disaster management • Monitor critical infrastructures (e.g. power stations, etc.) *Example:* • MERIS imagery (Envisat) of outbursts for disaster management (e.g. 2008 Chaiten volcano in Chili; 2007 Mount Gamkonora volcano in Indonesia, 2006 Etna volcano in Italy. • ASAR (Envisat) measures thermal-IR radiation to determine Earth's surface temperature. Satellite data can provide a fast and comprehensive overview of a crisis situation, assessing damage and risks. ATSR Data compilation is made public in the ATSR World Fire Atlas containing record of fires, times, dates and location of hot spots (e.g. 2009 California fires (ATSR + MERIS), 2008 Norway forest fires, 2007 Greek fires. <u>Telecommunications</u>: *Sample Applications:* • Commercial telecom services • Milsatcom applications • Access to information via the Internet • Enhancement security of important infrastructures • Deliver emergency information <u>Positioning, Navigation, and Timing (PNT):</u> *Sample Applications:* • Position and position reporting during emergency management operations, including the police, fire brigades, civil protection, etc. • Position data for aviation, maritime, and land transport • Monitor critical infrastructures (e.g. power stations, etc.) • Support cartography for emergency management • Tracking and tracing of goods • General transport safety enhancement • Search and rescue applications • Damage assessments *Example:* • The MAGES project, for example, seeks to explore possible EGNOS and Galileo applications for emergency management • EGNOS Safety of Life Services; future Galileo Search and Rescue Service. <u>Other Applications:</u> • Early warning • Electronic intelligence

Diffusing maritime disputes and combating piracy	Remote Sensing: *Sample Applications:* • Vessel monitoring systems • Identify pirates' operating bases and vessels • Monitor coastal activities *Example:* • Monitoring ships for increased maritime situational awareness Telecommunications Satellites: *Sample Applications:* • Security alert communications • Satellite Automatic Identification System (AIS) • Emergency communications *Example:* • Ships Security Alert System (SSAS) Positioning, Navigation and Timing (PNT): *Sample Applications:* • Vessel monitoring systems
Strengthening the strategic partnership with NATO	Remote Sensing: *Sample Applications:* • European contributions to NATO surveillance capabilities • Intelligence gathering • Support events in a theatre *Example:* • Use of SPOT-5 imagery on a strategic, tactical, and operational level Telecommunications: *Sample Applications:* • Milsatcom applications *Example:* • Syracuse, SICRAL and Skynet 5 provide NATO satellite communications capability for the SHF and UHF space segment from 2005 to 2019 (NATO's post-2000 SATCOM Program).
Safeguarding international security, including countering WMD Proliferation, combating illicit accumulation and trafficking of SALW, and promoting anti-mine actions	Remote Sensing: *Sample Applications:* • Vessel monitoring systems • Pollution detection (e.g. oil spills) • Counter-terrorism • Military surveillance • Verification of international treaties and agreements • Monitoring of missile launches *Example:* • Helios remote sensing military satellites proved valuable in military actions (e.g. in Kosovo, Lebanon, Afghanistan, Chad, and Darfur) Telecommunications: *Sample Applications:* • Commercial telecom services • Milsatcom applications Positioning, Navigation, Timing (PNT) *Sample Applications:* • Enabling driver tracking of hazardous goods, traffic information collection, etc.

Table 2: Space as an Instrument Enhancing Europe's Security Objectives

3.2 Environment

The United Nations (UN) has traditionally been perceived as the leading entity for multilateral efforts on environmental issues. The most prominent role has been accorded to the UN Environment Programme (UNEP) that has organised global conferences on the environment and development. It is therefore useful to review briefly the UNEP's initiatives to place current environment-related programmes, including those of the EU, into a global context.

The UN Environment Programme (UNEP) was established following UNGA Resolution 2997 (XXVII) of 15 December 1972. This resolution, together with the following associated documents, define the UNEP's mandate and objectives: Agenda 21 adopted at the UN Conference on Environment and Development (the so-called Earth Summit) in 1992; the Nairobi Declaration on the Role and Mandate of UNEP adopted by the UNEP Governing Council in 1997; the Malmö Ministerial Declaration and the UN Millennium Declaration, adopted in 2000; and recommendations related to international environmental governance approved by the 2002 World Summit on Sustainable Development and the 2005 World Summit. Currently, the UNEP defines five priority areas: environmental assessment and early warning; development of policy instruments; enhanced coordination with environmental conventions; technology transfer; and support to Africa.[110]

As early as 1972, the UN General Assembly called for a conference dedicated solely to the environment. It was convened in Sweden and produced the so-called "Stockholm Declaration" focusing on non-renewable and threatened resources. Later, other UN efforts materialised in the Kyoto Protocol, a leading effort to reduce global emissions. The Kyoto Protocol is a non-binding international agreement, adopted in December 1997 under the auspices of the UN Framework Convention on Climate Change (UNFCCC), which provides an overarching structure for intergovernmental efforts to deal with climate change. It currently has 193 Parties, including the EU.[111] The agreement, which came into force in February 2005, set binding targets for 37 industrialised countries and the European Community for reducing greenhouse gas (GHG) emissions.

Negotiations on a new agreement to follow the Kyoto Protocol, which will expire in 2012, were held in Copenhagen in 2009. The conference revealed the challenges of fulfilling ambitious climate change-related objectives. The proposed "Copenhagen Accord", agreed to by 114 Parties, commits countries to concrete and verifiable action to reduce GHG emissions. The areas covered included mitigation, adaptation, technology development and transfer, and financing. The last agenda item received special attention as developed countries committed $30 billion in so-called "fast-track funding" out to 2012 and to mobilise $100 billion annually by 2020. The aggregate and individual emission reduction targets for developed countries beyond 2012 and a suitable agreement on medium and long-term emissions remained elusive. As the EU was largely excluded from talks between the U.S. and the BASIC group (i.e. China, India, Brazil and South Africa), it saw the need to bolster its position as a key player in negotiations on climate change.[112]

The developed countries, including the EU and U.S., have argued that the Kyoto Protocol does not place enough responsibility on developing countries. They would like to see a more inclusive agreement similar to the Copenhagen Accord. Negotiations on such an agreement took place at the UN Cancún Climate Change conference on 29 November – 10 December 2010. The Cancún gathering garnered formal pledges to cut GHG emissions by 2020 in a UN document. It also achieved, for the first time, an agreement from the developing countries to look into ways to cut emissions, although without specific pledges or targets.[113]

The Cancún conference also agreed to establish a new global climate fund under the UNFCCC to help finance mitigation and adaptation to climate change. The Cancun Agreements of 11 December 2010 requested developed countries to provide the UNFCCC with details concerning their fast-start $30 billion contributions of the total $100 billion they pledged to deliver between 2010 and 2012. This was seen as a necessary step prior to forging an agreed long-term finance programme up to 2020. Previously, in 2008, the EU, the world's largest aid donor, provided $5.1 billion to developing countries for climate mitigation through its Official Devel-

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110 United Nations Environment Programme: Organization Profile.

111 Status of Ratification of Kyoto Protocol UNFCCC. <http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php>

112 The Copenhagen Accord: A Q&A With Our Policy Team. The Climate Group: 16 January 2010. http://www.theclimategroup.org/our-news/news/2010/1/16/copenhagen-accord-QA/

113 Adam Vaughan. Cancun Climate Change Agreements at Glance. 13 December 2010. http://www.guardian.co.uk/environment/2010/dec/13/cancun-climate-agreement

opment Assistance (ODA) programme which constituted 60% of global ODA for this purpose. In 2010, the EU committed €2.2 billion for the developing countries' climate change adaptation and mitigation efforts. This was part of the Copenhagen Accord commitment to deliver €7.2 billion in 2010-2012 for this purpose.[114]

With regard to the developing nations, the Cancún Agreements obliged them to report on their national emissions, as well as climate change actions and results of emission avoidance, every two years. Unlike the traditional UN-style negotiations among delegations, however, the Cancún Agreement was approved in a WTO-like process, where the Chairman of the meeting (i.e. Mexico), prepared the text and allowed for only a limited time for deliberations with no amendments accepted. This may prove a disadvantage for the post-Kyoto arrangement.[115]

3.2.1 Europe's Environmental Objectives

The EU's environment policies have been structured around so-called Environmental Action Programmes (EAP). The latest of them, the 6th EAP, provides a framework for environmental policies in the period of 2002 – 2012. The 6th EAP has been accompanied by the work of the Intergovernmental Panel on Climate Change (IPCC), the Millennium Ecosystem Assessment and the Stern Report on the Economics of Climate Change. The IPCC is a leading international scientific body assessing climate change that was established by the UNEP and the World Meteorological Organization (WMO) in 1988. The Millennium Ecosystem Assessment Synthesis Report published in 2005, a work by more than one thousand biological scientists on the state of the Earth's ecosystems, calculated the economic impact of the loss of eco-system services. Similarly, the Stern Report, a 700-page document by British economist published in October 2006, concluded that it is more costly to continue a business as usual approach than to invest in limiting global temperature rises.

The 6th EAP also represents an environmental dimension of the EU's Sustainable Development Strategy (SDS) and EU 2020 Strategy. The SDS for the EU, which was approved by the EU Council in June 2006, validated that "sustainable development" is the overarching EU objective governing all other EU's policies and activities. The EU 2020 Strategy, a successor to the Lisbon Strategy, identifies the following principles: smart growth, sustainable growth and inclusive growth. The first emphasises the development of an economy based on knowledge and innovation. The second is to promote a more resource efficient, greener and more competitive economy. The last is represented by a high-employment economy.[116] For example, the need to safeguard and improve the environment can lead to innovation which, in turn, advances competitiveness. Competitive businesses contribute to higher employment. The previous Lisbon Strategy, initiated in 2000, sought to address various globalisation-related challenges. At that time, the EU Council defined Europe's goal as becoming "the most dynamic and competitive knowledge-based economy in the world by 2010".[117]

There are four broad priorities delineated in the 6th EAP: climate change; nature and biodiversity; health and the quality of life; and natural resources and waste.[118] More specific objectives and recommended actions have been determined for each of these priority areas. The 6th EAP introduced the concept of

[114] Andrew Holland. Cancun Climate SummitTroubled By Copenhagen's Divisions. The International Institute for Strategic Studies. http://www.iiss.org/whats-new/iiss-voices/cancun-climate-summit-troubled-by-copenhagens-divisions/

[115] Strange Outcome of Cancun Conference. Third World Network. 13 December 2010. http://www.twnside.org.sg/title2/gtrends/gtrends324.htm

[116] European Commission. Communication from the Commission: Europe 2020 – A Strategy for Smart, Sustainable and Inclusive Growth. COM(2010) 2020 of 3 Mar. 2010. http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf.
Also: European Council. Cover Note from the General Secretariat to the Delegations: European Council 25-26 Mar. 2010 – Conclusions. EUCO 7/10 of 26 Mar. 2010. http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/113591.pdf.
European Council. Cover Note from the General Secretariat to the Delegations: European Council 17 June 2010 – Conclusions. EUCO 13/10. http://ec.europa.eu/eu2020/pdf/115346.pdf.
See also: European Commission. Commission Working Document: Consultation on the Future "EU 2020" Strategy. COM(2009) 647/3. http://ec.europa.eu/eu2020/pdf/eu2020.pdf.

[117] European Commission. Commission Staff Working Document. Lisbon Strategy Evaluation Document. SEC(2010) 114 final of 2 Feb. 2010. Brussels: European Union. <http://www.eref.eu/uploads/documents/Lisbon%20Strategy%20evaluation%20document.pdf>.
Original Lisbon Strategy Document:
European Council. Presidency Conclusions of the Lisbon European Council of 23 and 24 March 2000. <http://www.europarl.europa.eu/summits/lis1_en.htm>; <http://oesterreich.gv.at/DocView.axd?CobId=33361>.

[118] Commission of the European Communities. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions on the Mid-Term Review of the Sixth Community Environment Action Programme. COM(2007) 225 final of 30 Apr. 2007. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0225:FIN:EN:PDF>.

"Thematic Strategies" to be developed by the Commission. They include the following fields: air; waste prevention and recycling; marine environment; soil; pesticides; natural resources; and urban environment.[119] These strategies were designated to be the long-term objectives reflecting a truly global approach and were to create synergies among various strategies, including that of Lisbon.[120]

The ongoing debate on the 7th EAP indicates an even more ambitious approach to addressing environmental issues is in the works. For example, it envisions the establishment of a global framework for environmental policy. It also promotes connectivity among Europe's environment policy and other strategies, including Europe 2020 Strategy, the Sustainable Development Strategy and other policies (e.g. environment-health action plan). Moreover, it intends to endorse improved control, assessment and sanction mechanisms to achieve better governance. It will also likely recommend changes in methods of production, trade and consumption and promote ecological technologies, energy efficiency, and modified behavioural patterns.

A number of the general goals listed above are already reflected in present efforts underway. DG Environment, for example, lists among its objectives: contributing to curbing the level of pollution, supporting a "greener and more resource efficient economy"; promoting environmental protection at an international level; supporting the implementation of environmental legislation and protection requirements in coordination with other EU policies and activities, (i.e. the so-called "horizontal approach" to integration.) [121] This cross-cutting 'horizontal approach' was introduced by the Cardiff Process. The EU Council in Cardiff, under a British Presidency, in June 1998 laid a foundation for developing comprehensive strategies, later introduced in Gothenburg in June 2001. Under a Swedish Presidency, this gathering took the next steps in integrating the requirements of environmental protection and sustainable development into other policy areas.[122] The DG Environment identifies thirteen integration targets: agriculture; cohesion policy; development; economic recovery plan; employment; energy; enterprise; fisheries; internal market; research; trade and external relations; transport; and economic and financial affairs.[123]

The Lisbon Treaty also references the importance of environmental protection. Specifically, Article 3 of the TEU places improvement of the quality of the environment under general EU objectives. According to article 21.2(d, f) of the TEU, "fostering environmental development of developing countries" and "helping develop international measures to preserve and improve the quality of the environment and sustainable management natural resources", are regarded as an integral part of EU external policy. Article 4.2(e) of the TFEU designates the environment as a shared competence. Environmental protection is likewise addressed in the Article 11, which calls for requirements for environmental protection to be included in the definition and implementation of the EU's policies and activities.

Environmental protection is also closely linked to the concept of sustainable energy, which seeks to balance environmental protection (including climate change), competitiveness and energy security.[124] This, in turn, is linked to sustainable management of natural resources. An EC Communication from January 2006 entitled "External Action: Thematic programme for Environment and Sustainable Management of Natural Resources Including Energy", listed the following objectives: assistance to developing countries in reaching the Millennium Development Goals (MDG); promotion of environmental integration and sustainable management of natural resources, including energy; promotion of coherence in all EU policies that affect the global environment and security of supplies; promotion of international environmental governance; and support for sustainable energy options in partner countries and regions.[125]

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[119] http://ec.europa.eu/environment/newprg/strategies_en.htm.

[120] Sixth Environmental Action Programme. http://europa.eu/legislation_summaries/agriculture/environment/l28027_en.htm

[121] Op. Cit. European Commission. Management Plan 2010 – DG Environment. http://ec.europa.eu/dgs/environment/pdf/management_plan_2010.pdf.

[122] For the Cardiff Process, see: Commission of the European Communities. Communication from the Commission to the European Council: Partnership for Integration. A Strategy for Integrating Environment into EU Policies. Cardiff – June 1998. COM(1998) 333 final of 27 May 1998. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:1998:0333:FIN:EN:PDF>.

[123] http://ec.europa.eu/environment/integration/integration.htm. Links to the integration areas are available in this document.

[124] Commission of the European Communities. Green Paper – A Strategy for Sustainable, Competitive and Secure Energy. COM(2006) 105 final of 8 Mar. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0105:FIN:EN:PDF>.

[125] Commission of the European Communities. Communication from the Commission to the Council and European

The integration of environment policy into energy policy is summarised in the "2009 Climate and Energy Package".[126] The Package includes: a directive extending the EU Emissions Trading System (EU ETS) to cover some 45% of total EU greenhouse gas emissions; an "effort sharing" strategy for the period 2012-2020 for emissions from sectors not covered by the EU ETS; a directive setting binding national targets for increasing the share of renewable energy sources in the energy mix; and a directive creating a legal framework for the safe and environmentally-sound use of carbon capture and storage (CCS) technologies. In this connection, the EC will present in 2011 a proposal on the efficiency of resource use that will contain important socio-economic aspects for an environmental programme. The area of energy is addressed in greater detail in section 3.3.

In early 2007, the Intergovernmental Panel on Climate Change (IPCC) published its Fourth Assessment Report discussing current climate change science. The Panel's Summaries for Policymakers (SPM) of February, April and May 2007 indicated a substantial likelihood of climate being human-caused and described the negative effects of climate change, as well as a small number of those that could be beneficial. The SPM of May 2007 focused on the mitigation of climate change through reduction or elimination of GHG emissions. Also in 2007, the International Polar Year (IPY) was launched, a scientific programme for the period of March 2007 – 2009 that studied the Arctic and Antarctic regions.

In this connection, the EU is increasingly interested in assuming a greater role concerning Arctic-related issues. The March 2008 High Representative and European Commission Paper on Climate Change and International Security brought greater attention to the geopolitical dimension of the Arctic and was followed in November of that same year with an EC Communication entitled "The EU and the Arctic Region". As a first step, the Communication proposed a more structured and coordinated approach to Arctic issues. Later, in December 2009, the EU Council adopted "Council Conclusions on Arctic issues" reiterating the need for a policy on Arctic issues, notably advancing EU's interests and responsibilities there. The document pointed out three main objectives: preserving the Arctic in unison with its populations; promoting sustainable use of resources; and contributing to enhanced Arctic multilateral governance.[127]

Upon the initiation of the EC's DG Environment, a report compiled by four institutions, entitled "EU Arctic Footprint and Policy Assessment" was released in November 2010 to assess Arctic environmental impacts of current and future EU activities and examine the nine following issue areas: biodiversity; chemicals and transboundary pollution; climate change; energy; fisheries; forestry; tourism; transport; and Arctic indigenous and local livelihoods. As current EU environmental policies rarely mention the Arctic directly, the Report sought, through an analysis of these areas, to provide elements of an EU Arctic policy. The Report concluded, among other items, that climate change drives a number of the issue areas listed above. Accordingly, the EU has the potential to emerge as an international leader in motivating, and even compelling, important emission reductions.[128]

Climate change, an important dimension of the EU's sustainability effort, will also be the main criterion for its Arctic-related policy objectives. It was concluded in a 2010 update entitled "European Union and the Arctic: Main Developments July 2008 – July 2010" that Arctic-related activity has been most visible in the areas of environment and maritime affairs (and especially maritime transport). The report likewise concluded that the main actors on Arctic-related political issues are the Arctic states that all have national strategies with clearly defined views on the development of Arctic cooperation. They envision the Arctic Council to be the main forum for these types of exchanges, acknowledging that a number of its members are hesitant to open this forum to others, including the EU. Accordingly, the EU will have to demonstrate "value added" contributions to formulating internationally agreed solutions to Arctic-related challenges, including adaptation to climate change, air and maritime pollution, and safety of maritime transport. An EC progress report on Arctic policy scheduled to be released in 2011 should serve as a positive step in this direction.[129]

Parliament: External Action: Thematic Programme For Environment and Sustainable Management of Natural Resources Including Energy. COM(2006) 20 final of 25 Jan. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0020:FIN:EN:PDF>.

[126] Commission Staff Working Document: 2009 Environmental Policy Review. SEC(2010) 975 final Part 1of 3 of 2 Aug. 2010. Brussels: European Union. <http://ec.europa.eu/environment/pdf/policy/EPR%202009_SEC_2010_0975_Part%201.pdf>.

[127] Council conclusions on Arctic issues. 2985th Foreign Affairs Council meeting, Brussels. 8 December 2009.

[128] EU Arctic Footprint and Policy Assessment. Report summary. 8 November 2010: 18.

[129] European Union and the Arctic: Main Developments July 2008 – July 2010. Nordic Council of Ministers, Copenhagen 2010: 9-10.

From the various policy documents described above, a number of key priorities for the EU can be extracted. They are summarised in table 3 below.

Key EU Objectives for the Environment
• Scrutinising and managing climate change • Conserving natural resources • Protecting biodiversity and ecosystems • Safeguarding the Arctic • Reducing various forms of pollution • Improving urban environment quality • Managing waste • Integrating environmental concerns into EU's external relations

Table 3: Key EU Objectives for Environment

3.2.2 Space-Related Benefits

Space-based assets have already proven indispensable in providing essential environment-related data for scientific research and political decision-making. They can detect and monitor pollution from vegetation fires, forestry destruction, volcanic eruptions and ozone depletion. Earth observation (EO) satellites play a special role. For example, it has been documented that in situ measurements alone cannot monitor, characterise and predict changes in the Earth's system, and this can only be accomplished by the global coverage of EO satellites. The importance of remote sensing from space is also evident through the existence of EO-related organisations and initiatives, such as the Committee on Earth Observation Satellites (established in 1984); the first Earth Observation Summit (EOS) in July 2003 and subsequent establishment of the Group on Earth Observation (GEO), as well as a 10-year plan to create comprehensive cooperation in Earth observation through the Global Earth Observation System of Systems (GEOSS) endorsed at the third EOS.

The European Space Agency (ESA) has repeatedly demonstrated the usefulness of long-term satellite data for better understanding and managing climate change, including through its Climate Change Initiative (CCI). The CCI seeks to take advantage of data from ESA and MS EO space assets that go back three decades to analyse long-term global records of essential climate variables. These data, together with new missions, produce new information on GHG concentrations, sea-ice extent and thickness, sea-level rise, sea-surface temperature and salinity, etc.

Due to the complexity of the climate system, the only tools that provide quantitative estimates of future climate change are complex numerical models. Climate models or "general circulation models" (GCMs) are simplified, mathematical representations of the climate system. The ESA Sea Level CCI Project will advance the preciseness of climate models used for sea-level projections. Another project, ESA's Fire CCI, will seek to provide quality evaluations of burned areas globally to fine-tune climate-vegetation models for better assessment of global vegetation and atmospheric conditions related to fire. These examples show how ESA works to improve climate model predictions through satellite datasets.[130]

Europe's GMES, as contribution to the GEOSS Plan, will rely on five families of operational Sentinel observatories that will build upon the Envisat mission. The GMES programme has substantial potential to advance environment-related objectives. Advanced optical and radar sensors of the remote sensing satellites can establish an accurate analyses of Earth environment and human development. They can offer a permanent global view and update and upgrade continuously Geographic Information Systems (GIS). Accordingly, these capabilities, together with telecommunication and navigation systems, can advance a number of the EU's key political objectives. Some of the means in which the environment objectives can be enhanced through space are described and summarised in table 4 below.

Scrutinising and Managing Climate Change

Satellite systems offer unique capabilities for climate change research and management. They can provide sound data on the state of the environment. Earth observation and meteorological satellites have contributed significantly to scientific understanding of the environment. EO satellites can monitor global stratospheric ozone depletion, including at the Earth's poles, and detect tropospheric ozone (e.g. ERS 2, Envisat, etc.). They generate synoptic weather imagery and assimilate data for numerical weather prediction (e.g. MetOp weather satellite, etc.). They help discover the dynamics of ice sheet flows in Antarctica and Greenland (e.g. ERS-1, ERS-2, Envisat, etc.). They can also detect mesoscale variability of ocean surface topography and its importance in ocean mixing and observe the role of ocean in climate variabil-

[130] Climate Scientists Highlight ESA Climate Change Initiative. European Space Agency Website: 6 December 2010. http://www.esa.int/SPECIALS/Space_for_our_climate/SEMIOGOR9HG_0.html

ity (e.g. Topex/Poseidon, ERS-1, ERS-2, Envisat, etc.).[131]

ESA's Living Planet programme constitutes an important contribution to understanding and addressing global environmental challenges. Five of the missions are displayed in figure 3 below. Three of the missions have already been launched. The Gravity field and steady-state Ocean Circulation Explorer (GOCE), the first of a series of Earth Explorer satellites launched in March 2009, is designed to provide information on critical variables of the Earth system. Gravity and its variation in space are fundamental for every dynamic process on the Earth's surface and in its interior. Better understanding of how gravity affects the interaction between these processes can offer valuable knowledge.[132] ESA's Soil Moisture and Ocean Salinity (SMOS) mission, launched in October 2009, examines how climate change may be affecting evaporation patterns over land and sea. CryoSat-2, launched on 8 April 2010, measures the thickness of floating sea-ice in order to detect seasonal and multi-annual variations. It will likewise observe the surface of continental ice sheets for elevation change detection. For example, it will determine the contribution of the Antarctic and Greenland ice sheets to mean global sea level rise.[133]

Figure 3: Earth Explorers (Source: European Space Agency)

The monitoring of wind and other variables can serve as another example of the benefits of space-based assets. Wind is a global transportation system for heat, moisture and airborne particles. Since over 70% of the Earth is covered by water, the interaction between the ocean and atmosphere is a complex, but critical, part of our climate. Surface ocean circulation, coastal currents, waves and swell are primarily driven by the wind. Meanwhile, ocean circulation plays an important role in the distribution of heat and water vapour in the atmosphere. Monitoring the wind and other variables, such as air pressure, air temperature and water vapour, gives us valuable information about how the ocean and atmosphere interact to produce changes in our weather and climate.[134] ESA's Earth Explorer Atmospheric Dynamics Mission (ADM-Aeolus), to be launched in 2013, will seek to provide global observations of three-dimensional wind fields to improve atmospheric modelling and analysis techniques for operational weather forecasting and climate research.[135]

The GMES is designed to build upon existing scientific research based on EO from space and advance environmental research and climate change studies, including at an international level. As the thematic areas within so-called "GMES service components" include climate change information, besides coordinating the current efforts of individual actors, it will offer new capabilities. The GMES Space Segment will deliver land, sea and atmosphere data from space.[136]

Climate change and associated natural disaster management is an area which can benefit from telecommunication technologies. They can provide the necessary information concerning the context and assessment of the situation, as well as support an action plan for recovery. Information systems have the potential to collect real time environmental data to improve general public information on environmental risks and hazards. Specifically, satellite communications can collect, in real-time, data from sensors deployed over a wide area (e.g. regional, national, or continental), on board observation satellites or Unmanned Aerial Vehicles (UAV). They can likewise be used to relay the collected measurements to the relevant users for early disaster detection as well as to provide warning and guidance services for civil protection.[137]

[131] Space Technologies and Climate Change: Implications for Water Management, Marine Resources and Maritime Transport. Organisation for Economic Cooperation and Development. 2008: 73.

[132] Looking into the Forces that Shape Our Planet. European Space Agency Website. http://www.esa.int/SPECIALS/GOCE/SEM3Q2VHJCF_0.html

[133] Earth Explorers Overview. European Space Agency website. http://www.esa.int/esaEO/SEM9JP2VQUD_index_0_m.html

[134] http://seacoos.org/Data%20Access%20and%20Mapping/wind_product_desc/

[135] Aeolus: Wind Monitoring. Astrium-EADS website. http://www.astrium.eads.net/en/programme/aeolus.html

[136] GMES: Observing Our Planet for a Safer World. European Commission. http://ec.europa.eu/gmes/index_en.htm

[137] Chuberre Nicolas and Konstantinos Liolis. Contribution to Grand Societal Challenges. Integral SatCom Initiative

With regard to navigation, among Galileo services that are being examined are the tracking of pollutants and icebergs, mapping the oceans, and studying tides, currents and sea levels. They can be used to monitor the atmosphere, water vapour for weather forecasting and climate studies, and the ionosphere for radio communications, space science and earthquake prediction.[138]

Radio occultation (RO) monitoring provides a good example of the use of navigation systems for climate studies. The most significant source of energy for the climate system is radiation from the Sun. The Sun provides virtually all of its energy at wavelengths between 100 nm and 2 µm in the ultraviolet, visible, and near infrared region of the electromagnetic (EM) spectrum. For its part, the Earth (~ 255 K) emits most of its radiation between 4 µm and 60 µm in the infrared region. The global annual mean temperature near the Earth's surface is the result of a radiation equilibrium of incoming solar and outgoing terrestrial radiation. It is also influenced by the composition of the atmosphere as trace gases, aerosols, and clouds strongly interact with radiation. Climate variations may be caused by external radiation effects, including variations in solar radiation, aerosols from volcanic eruptions and internal interactions of components of the climate system (e.g. the El Niño-Southern Oscillation).

The RO technique is an active satellite-to-satellite limb sounding concept exploiting the global navigation satellite system (GNSS) signals. The phase and amplitude of the electromagnetic waves transmitted by GNSS satellites are observed by a high precision receiver onboard a satellite in low Earth orbit (LEO). Due to the measurement geometry, the GNSS-LEO link scans the Earth's ionosphere and neutral atmosphere near-vertically while, viewed from the LEO satellite, the transmitting GNSS satellite is setting or rising behind the Earth's limb (see figure x below). From the received signal's phase delay (relative to the vacuum phase) bending angles, the atmosphere's refractive index can be derived. In the next step, vertical profiles of basic atmospheric parameters like electron density, neutral density, pressure, temperature, geopotential height, and other additional background information can be derived. The application of the RO technique to the Earth's atmosphere became possible with the arrival of the U.S. Global Positioning System (GPS) in the early 1980's. Together with the European GALILEO and Russian GLONASS systems there is now a multitude of transmitter platforms available to be used for sounding Earth's atmosphere with high temporal and spatial resolution.[139]

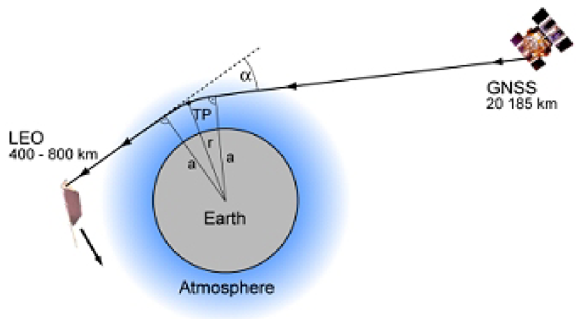

Figure 4: Geometry of a setting radio occultation event. TP: tangent point, a: impact parameter, r: tangent point distance from Earth's center, α: bending angle (Source: Scientific Report 5-2005 of the Wegener Center for Climate and Global Change at the University of Graz)

Conserving Natural Resources and Protecting Biodiversity and Ecosystems

Human development depends on natural resources for the supply of food, water and fuel. The conversion and fragmentation of natural habitats is one of the key causes of biodiversity loss. Careless land use, including deforestation, conversion of pasture into arable land, etc. negatively affect the ecosystem functions of habitat. Freshwater supply and its quality and quantity also impact biodiversity. Lost ecosystem services have to be substituted by technical applications. For example, water shortages require drinking water transportation, polluted water requires additional purification, etc.[140] A number of Earth observation missions referenced above contribute to better management of the Earth's natural resources, both biotic and abiotic, renewable and non-renewable. ESA's ERS-2, and Envisat satellites, as well as the Living Planet Programme missions help protect the environment, including its natural resources.

With regard to land, satellite sensors provide a concise overview of global surface land cover, as well as map the distribution of forests, deserts, water bodies and agricultural land. They can also precisely measure surface topography. Analysis of archived data can measure the rates of the deserts growth, forest clearings and coastline erosion. Space-based spectometers can map individual min-

(30 April 2010): 2-3. http://ec.europa.eu/invest-in-research/pdf/download_en/isi_contribution.pdf
[138] Galileo Applications. European GNSS Agency. http://www.gsa.europa.eu/go/home/galileo/applications/

[139] Gobiet, Andreas "Radio Occultation Data Analysis for Climate Change Monitoring and First Climatologies from CHAMP". Wegener Center for Climate and Global Change, Scientific Report No 6 (2005): 13 – 19. http://www.uni-graz.at/igam7www_wcv-scirep-no6-agobiet-dec2005.pdf
[140] Sustainable Development in the European Union. Eurostat: 151-153.

erals on the Earth's surface and assess the density, crop breed, water content and vegetation development stage.

Concerning water on land (i.e. rivers, lakes, snow and ice on mountains etc.), to monitor the water cycle that can cause droughts and subsequent severe weather, EO satellites are able to measure water vapour concentrations (e.g. ESA's EarthCARE missions). They can also estimate the thickness of snow and ice to determine downstream river volumes. Satellite-based interferometry can also map millimetre-scale land shifts above aquifers to deduce changes in groundwater levels. Moreover, ESA's GOCE mission will be able to identify subsurface aquifer locations worldwide. Earth observation also enables the analysis of changes between the distribution of wetlands (the most nutrient-rich and biologically active sites on Earth) and deserts which continuously grow. Finally, EO can monitor land use and negative impacts caused by, for example, over-cultivation and deforestation. Interferometry can also be used to observe the movements of volcanoes. During a volcanic eruption, optical and radar instruments can produce images of the lava flows, mud slides, ground fissures, and earthquakes.[141]

The oceans cover are home to many species, including phytoplankton, which is the base of the marine food chain, performs half of all photosynthesis, and absorbs a large amount of carbon dioxide. Space-based sensors, such as ESA's MERIS spectrometer on the Envisat satellite, can observe and monitor global phytoplankton distribution by detecting chlorophyll pigments in seawater. Satellites are also the only technology that can provide early wide-space warning of highly toxic algae blooms that endanger fish and poison large stretches of water.[142]

Satellite communication technology can help bolster the efficient use of natural resources. They offer the ability to receive information in near real-time without the costs associated with the physical presence of personnel. They can help gather and analyse relevant data for better management of critical natural resources. Satellite-based navigation services, such as those offered by EGNOS, have already become common in a number of areas, including agriculture, water resource management, and others. EGNOS offers precision farming applications, including livestock positioning and tracking, tractor guidance, crop yield optimisation and waste reduction. The use of communications and navigation systems for resource management is described in greater detail in section 3.4.

Safeguarding the Arctic

The cryosphere (i.e. sea, lake and river ice; snow cover; glaciers; ice caps and ice sheets; and frozen ground) is an important dimension of the global climate system as more than one-sixth of the world's population depends on snow and glaciers for their water supply. Changes in the cryosphere also impact global sea levels, regional water resources and terrestrial as well as aquatic ecosystems.[143] Space applications can help understand the complex nature of cryosphere-related processes.

Snow cover and sea/polar ice monitoring and forecasting are important capabilities for a number of applications, including in the areas of water management and the safety and efficiency of sea transportation and marine-related activities (e.g. offshore operations). Ice data are necessary for research on the Arctic. The European Polar View project, for example, using primarily Envisat and Radarsat data, works on the development and qualification of customised ice information services, including high resolution ice charts and ice forecasting information services.[144] TerraSAR-X and Envisat radar imagery can discover ice shelf destabilisation and the satellites' radar altimetry data employed for arctic sea ice thinning observations. ESA's CryoSat mission (CryoSat-2) will survey natural and human-induced changes to the Earth's cryosphere. The satellite is designed to provide precise data on polar ice sheets and sea-ice thickness. It will also contribute to providing information on the rates at which the ice cover is receding.

Reducing Various Forms of Pollution

Remote sensing satellites have been useful in detecting, monitoring and managing various forms of pollution, including soil degradation, water quality, greenhouse gases, oil spills, heavy metals and other. With regard to oil spills, it has been observed that most of the spills are away from costs and Earth observation monitoring is necessary to detect marine oil pollution. The Joint Research Centre (JRC) of the European Commission, for example,

[141] Space for our climate. European Space Agency website. http://www.esa.int/SPECIALS/Space_for_our_climate/SEMV9T2VQUD_2.html
[142] Space for our climate. European Space Agency website. http://www.esa.int/SPECIALS/Space_for_our_climate/SEMV9T2VQUD_0.html
[143] Space Technologies and Climate Change: Implications for Water Management, Marine Resources and Maritime Transport. Organisation for Economic Cooperation and Development. 2008: 82.
[144] Ibid, 82-83.

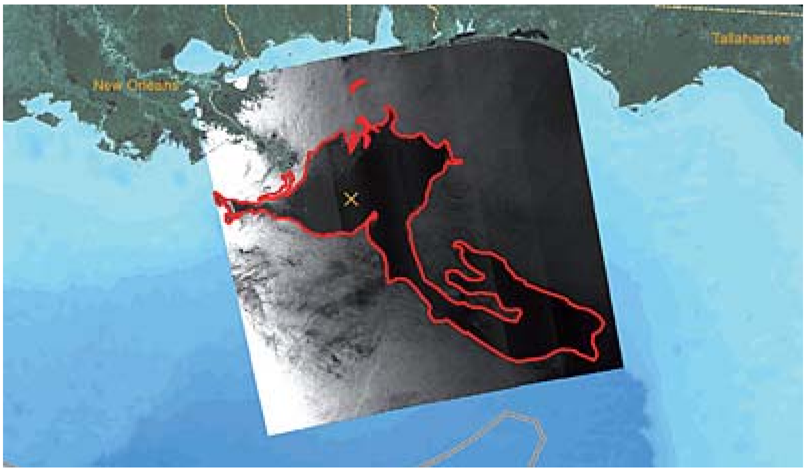

Figure 5: ESA's Envisat Advanced Synthetic Aperture Radar (ASAR) image of the extent of the oil spill in the Gulf of Mexico following the explosion of the Deepwater Horizon oil rig on 22 April 2010, acquired on 18 May 2010 (Source: European Space Agency).

based on the request of the Italian Ministry of Environment, studies examined oil pollution in the Mediterranean Sea over the period 1999–2004 near the Italian coasts. After analysing approximately 19,000 radar images from archives of Envisat, ERS-1 and ERS-2, over 9,000 possible oil spills were detected. It was concluded that most of the oil spills were away from the cost indicating possible deliberate intention to avoid possible legal actions in territorial waters.[145]

In 2006, an operational satellite-based oil slick detection service called CleanSeaNet was established for all European waters under the European Maritime Safety Agency (EMSA). It integrates SAR data from the European Envisat and the Canadian Radarsat satellites and provides notification of a pollution event within half an hour of the satellite overpass. This service, when combined with vessel information, helps identify potentially responsible vessels. There also exist other similar national and regional demonstration projects.[146]

Improving Urban Environment Quality

Urbanisation is accompanied by various issues including traffic congestion, noise, air pollution and others. Due to the complex, three-dimensional structure of the urban surface and variations in heat emission from objects, structures, vegetation, etc., a special capability is required to recognise different urban environments. Remote sensing satellites now offer very high resolution and, as a result, can offer a number of applications previously available only through airborne or on-site surveys. Specifically, they offer high geometrical and multispectral resolution; high radiometric sensitivity; revisit capabilities; wide area coverage in a single frame and accurate geometrical processing. Accordingly, remote sending data constitute a key source for a wide range of applications for urban areas. They also include satellite data for map generation and updating, road network mapping, three-dimensional city models for technical applications and tourism, analysis of vegetation areas, etc.[147]

Managing waste

Appropriate planning for waste management can reduce the prospect of environmental degradation. With regard to solid waste, landfills are the best practicable environmental option for certain types of waste. Earth observation can offer various waste management-related applications (e.g. Envisat, Proba, etc.). They include: waste production characterisation (land classification); landfill siting and monitoring; onsite waste management; monitoring changes and collecting site history for private concerns, including health; and illegal site detection.

Integrating environmental concerns into EU's external relations

Thanks to large amount of available environmental data generated on a daily basis by space-based and other sensors, international environmental conventions and similar gatherings can be supported by more informed decision-making. At the same time, due to the complex mechanisms driving global climate change, international cooperation on

[145] Space Technologies and Climate Change: Implications for Water Management, Marine Resources, and Maritime Transport. OECD Publications (2008): 145.
[146] Ibid. 145.

[147] Volpe Fabio, Use of QuickBird Satellite Data for Urban Environments. Paper from Urban Data Management Symposium 2004 in Chioggia, Italy.

making reliable predictions concerning the long-term consequences of climate change for human development is essential. Moreover, international conventions and other environmental-related agreements can be successful only when backed by solid verification of compliance.

In this connection, space-based systems are an invaluable source of information for better understanding and managing of our fragile Planet as well as for verification purposes. Satellites generate consistent measurements even in remote and uninhabited regions and complement in-situ and other measurements. There still exists a significant gap between having access to unique environmental data and understanding them. For example, GHG emissions, including carbon dioxide, still lack comprehensive monitoring and data collection. Space cooperation with other countries can advance Europe's role as an international leader in responding to climate change. Such cooperation already exists through the Committee on Earth Observing Satellites (CEOS) and other initiatives, including ESA's Climate Change Initiative (CCI) and ESA-EU joint „GMES Space Component" programme.

EU Key Objectives for the Environment	**Space-Related Benefits**
Scrutinising and managing climate change	<u>Remote Sensing:</u> *Sample Applications* • Monitoring global stratospheric depletion and detecting tropospheric ozone • Monitoring GHG emission • Generating synoptic weather imagery and assimilating data for numerical weather prediction • Helping determine the dynamics of continental ice sheet flows including in Antarctica and Greenland • Detecting mesoscale variability of ocean surface topography and its importance in ocean mixing • Observing the role of ocean in climate variability • Observing evaporation patterns over land and sea • Measuring soil moisture and sea/ocean salinity • Measuring the thickness of floating sea-ice to detect seasonal and multi-annual variations • Monitoring of wind and other variables such as air pressure and air temperature • Assessing water quality and the level of pollution • Providing information on gravity and its effect on Earth's processes • Mapping the oceans and studying tides, waves, currents and sea levels *Example*: • ESA's GOCE mission seeks to contribute to better understanding of the Earth's gravitational field and identify new possibilities for oceanography, geodesy and sea-level research <u>Telecommunications:</u> *Sample Applications* • Collecting real-time environmental data to improve information on environmental risks and hazards • Relaying collected data to the relevant users for early disaster detection and providing warning and guidance services <u>Navigation, Positioning, and Timing:</u> *Sample Applications* • Tracking pollutants and icebergs • Monitoring the atmosphere, water vapour for weather forecasting and climate studies • Monitoring ionosphere for radio communications, space science and earthquake prediction • Mapping the oceans and studying tides, waves, currents and sea levels (see the example below)

	Example • Radio occultation (RO) monitoring, i.e. active satellite-to-satellite limb sounding concept exploiting the GNSS signals.
Conserving natural resources	<u>Remote Sensing:</u> *Sample Applications* • Providing concise overview of global surface land cover • Mapping the distribution of forests, deserts, water bodies and agricultural land • Precise measuring of surface topography • Measuring the rates of the deserts growth, forest clearings and coastline erosion • Mapping individual minerals on the Earth's surface • Assessing the density, crop breed, water content and vegetation development stage • Measuring water vapour concentration to monitor the water cycle that can cause droughts and subsequent severe weather • Estimating the thickness of snow and ice on land to determine downstream river volumes • Mapping millimetre-scale land shifts above aquifers to deduce changes in groundwater levels • Identifying subsurface aquifer locations worldwide *Example* • Water: ESA's Soil Moisture and Ocean Salinity (SMOS) mission, launched in October 2009, examines how climate change may be affecting evaporation patterns over land and sea. <u>Telecommunications:</u> *Sample Applications* • Offering the ability to receive information in near real-time • Help gathering and analysing relevant data for better management of critical natural resources • Provide communication services for remote areas (resource excavation) • Providing communication services for on-board navigation applications *Example* • Security of transportation of natural resources by sea depend on communication services. <u>Navigation, Positioning and Timing:</u> *Sample Applications* • agricultural crop yielding, preventing over-fertilisation and soil degradation, sustainable agricultural development • Water resource management • Vessel monitoring systems *Example* • EGNOS allows for precision farming applications including livestock positioning and tracking, tractor guidance, crop yield optimisation and waste reduction • Most commercial ships transporting natural resources operate in ocean areas and need to carry adequate satellite-based equipment, including a GPS receiver.
Protecting biodiversity and ecosystems	<u>Remote Sensing:</u> *Sample Applications* • Monitoring biomass and biodiversity • Detecting biohazards • Advancing climate change studies • Monitoring land use and negative human-induced impacts (e.g. overcultivation, deforestation, etc.) • Detecting illegal activities (e.g. illegal logging) • Monitoring desertification and natural disasters • Analysing changes between the distribution of wetlands and deserts

	• Monitoring lava flows, mud slides, ground fissures and earthquakes during volcanic eruptions • Monitoring global phytoplankton distribution • Providing early wide-area warning of highly toxic algae blooms that endanger fish and poison large stretches of water • Monitoring water temperature and optimising fishery policy and management *Example* • Monitoring jellyfish proliferation in seas and oceans which has environmental and economic effects
Safeguarding the Arctic	<u>Remote Sensing:</u> *Sample Applications* • Help understanding the complex nature of cryosphere-related processes • Surveying natural and human-induced changes to the cryosphere • Providing ice information services (e.g. high-resolution ice charts, ice forecasting information services, etc.) • Detecting ice shelf destabilisation • Observing ice Arctic sea thinning • Detecting pollution (e.g. oil spills, chemicals, toxins, etc.) *Example* • ESA's CryoSat-2 mission (launched in April 2010) is designed to survey natural and human-induced changes to the Earth's cryosphere. The satellite will provide precise data on polar ice sheets and sea-ice thickness and information on the rates at which the ice cover is receding • European Polar View project <u>Telecommunications:</u> *Sample Application* • Communications services for the Arctic region *Example* • Satellite phones (e.g. the Canadian Polar Communication and Weather (PCW) system that will provide extended communication capacity over the Arctic)
Reducing various forms of pollution	<u>Remote Sensing:</u> *Sample Applications* • Detecting soil degradation and pollution • Monitoring water quality and pollution, including oceans and inland waterways and lakes • Monitoring atmospheric composition, greenhouse gases and air pollution • Detecting toxins and chemicals • Discovering and monitoring oil spills • Tracking illegal routes of ships and oil&gas vessels *Example* • After analysing approximately 19,000 Envisat, ERS-1, and ERS-2 archived radar images from the period between 1999 - 2004, the Joint Research Centre (JRC) of the European Commission detected over 9,000 possible oil spills in the Mediterranean Sea near the Italian coasts <u>Telecommunications:</u> *Sample application* • Mitigating and helping manage pollution events *Example* • 2010 Deepwater Horizon oil spill management • 2010 Hungaria Alumina sludge disaster management <u>Navigation, Positioning and Timing:</u>

	Sample Applications: • Contributing to more efficient transport and energy efficiency • Helping reduce CO2 emissions *Example* • Use of satellite navigation system to calculate optimal route for automobile, air and maritime transport
Improving urban environment quality	<u>Remote Sensing:</u> *Sample Applications* • Serving as a key source for a wide range of applications and urban areas-related decision making, including map generation and updating, road network mapping, three-dimensional city models for technical applications and tourism, analysis of vegetation areas, etc. • Observing urban region's transport and energy networks • Monitoring of air and water quality in urban areas, including the levels of CO2 • Urban heat wave forecasting *Example* • Envisat helps develop urban heat wave forecasting and appropriate alarm systems, and study spatial variability in urbanised areas in order to contribute to future urban planning and reduce detrimental effects of heat waves in cities <u>Telecommunications:</u> *Sample Applications* • Teleconferencing to decrease the need for urban transport • Cell phone navigation applications • Continue and near-real time communication for alarming citizens with breathing diseases (e.g. asthma) concerning density of GHG and CO2 emissions <u>Navigation, Positioning, Timing:</u> *Sample Applications* • Improving public transport capabilities in order to decrease need for individual transport vehicles • Improving urban planning • Increasing the sustainability of urban regions • Offering personal GPS services, cell phone applications
Managing waste	<u>Remote Sensing:</u> *Sample Applications* • Provide waste production characterisation • Monitoring and siting of landfills • Facilitating onsite waste management • Monitoring changes and collecting site history • Detecting illegal waste sites and criminal trades of toxic waste <u>Navigation, Positioning, Timing:</u> *Sample Application* • Navigation services for garbage truck fleets and urban operations of waste collections
Integrating environmental concerns into EU's external relations	<u>Remote Sensing:</u> *Sample Applications* • Supporting international environmental conventions and similar gatherings by more informed decision-making • Verifying compliance of international environmental-related agreements • Advancing Europe's role as an international leader through space cooperation *Example* • CO2 emission rates monitoring

Table 4: Space-related benefits for the environment.

3.3 Energy

The importance of the energy sector cannot be sufficiently underscored. Energy sector activities include: exploration, extraction, production, processing and transmission of fossil and nuclear fuels; electricity and fuel power generation and distribution; and the exploitation and harvesting of renewable energy resources (see figure 6 below).[148] Energy, and especially electricity, is essential for sustainable development. Most European countries are highly dependent on hydrocarbon sources of energy (i.e. oil and natural gas). Undue dependency on oil is a less urgent challenge as it is traded on the world markets and is often transported via tankers. Natural gas, on the other hand, is primarily transported through pipelines (i.e. fixed infrastructure). Accordingly, transit countries and routes become key factors in the reliability of supply. Gas can likewise be transmitted in liquefied form by tanker (LNG) – a rising trend - but some 80% of the world's commercial exchanges continue to be transmitted by pipelines. Data from 2006 indicates that Russia was the largest producer and exporter of natural gas and the second largest supplier of oil. Moreover, Russia has the world's largest natural gas reserves estimated to be some 1,680 trillion cubic feet (Tcf), almost double that of Iran which possesses the second largest reserves.[149]

Europe's energy imports rose some 56% over the past decade. Natural gas constitutes an estimated 24% of the primary energy mix of EU countries, with the exception of France. The current EU reliance on gas imports is some 57% and is estimated to increase to 84% by 2030[150]. Moreover, 60% of the gas bound for Europe crosses, at minimum, one border and several countries import 100% of their natural gas needs.[151] Pipelines transport some 90% of gas deliveries to the Continent with the remainder in liquefied form (LNG). European gas imports emanate from three primary sources, the largest of which is Russia at some 40 - 50%. All gas imports from Russia are delivered via pipelines.[152] According to the International Energy Agency (IEA), almost 50% of new electricity in Europe will be produced with natural gas by 2030.

The main alternatives to gas are coal and heavy oil, neither of which is viewed as environmentally friendly. Natural gas offers distinct advantages over other fossil fuels, including comparatively low greenhouse emissions, greater energy efficiency and ease of use.[153] Although gas transportation is more costly than that of oil, its reserve/production ratio is approximately 65 years as compared to 44 years for oil.[154] Another alternative is nuclear energy. Lithuania has the largest share of its dependency on electricity generated by nuclear energy (76.2% in 2009), followed by France (75.2%), Slovakia (53.5%), Belgium (51.7%), and Ukraine (48.6%). As of October 2010, there were 163 nuclear power plants in Europe (excluding Russia), with France having the largest share with 58. According to the latest International Energy Agency's World Energy Outlook of November 2010, nuclear power is expected to be among the significant low-carbon energy sources. Looking ahead to 2035, nuclear power and other renewables will likely constitute up to 38% of the energy mix. In this scenario, the share occupied by nuclear energy would increase by some 50%.[155] Naturally, the processing and storage of nuclear waste, the safety of operations, and preventing technology proliferation for WMD development all constitute major challenges for the industry.

Europe's renewable energy is currently supplied through the following technologies: large hydropower; onshore wind; biomass and first-generation biofuels. Wind power currently constitutes the highest share of new production capacity. Envisioned for the future are offshore wind, solar power, renewable electricity use in transport, biomass and second-generation biofuels.[156] Moreover, CO_2 capture and storage (CCS) constitutes a promising alternative and is an attractive climate change mitigation option. The EC established a CCS Project network to encour-

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[148] Sustainable Development Report. European Space Agency, April 2010: 18.

[149] 2007 World Proved Reserves, Energy Information Administration: Official Energy Statistics from the U.S. Government, http://tonto.eia.doe.gov/country/.

[150] EU dependency on oil imports is currently some 82% and is estimated increase to 93% by 2030 (Jacques Percebois, 2008).

[151] Percebois Jacques, *The Supply of Natural Gas in the European Union – Strategic Issues,* OPEC Energy Review, Oxford and Malden: Blackwell Publishing, March 2008, p. 34.

[152] Ibid. 47.

[153] Natural Gas, International Energy Agency, http://www.iea.org/Textbase/subjectqueries/keyresult.asp?KEYWORD_ID=4108

[154] Percebois Jacques, *The Supply of Natural Gas in the European Union – Strategic Issues,* OPEC Energy Review, Oxford and Malden: Blackwell Publishing, 2008, pp. 33-34.

[155] Nuclear to play prominent role in cutting CO2 emissions and securing energy supplies. http://www.foratom.org/e-bulletin-tout-1378/other-articles-tout-1385/775-nuclear-to-play-prominent-role-in-cutting-co2-emissions-and-securing-energy-supply-says-iea-study.html.

[156] State of Play in the EU energy policy. Accompanying document to the "Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy". COM(2010)639: 13-15.

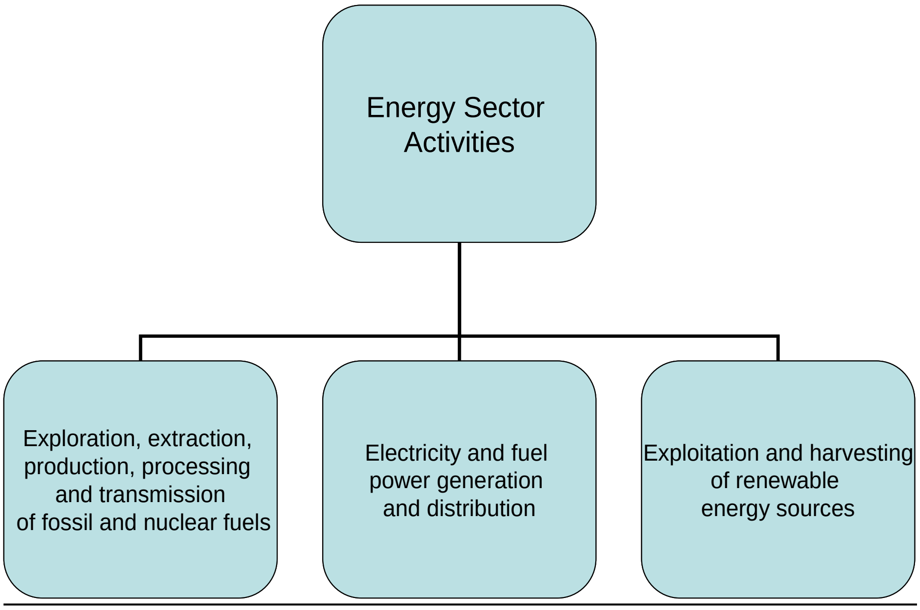

Figure 6: Energy sector activities

age international cooperation on this innovative technology that is, however, currently not economically viable and remains at a demonstration phase.[157]

With regard to solar power, the EU's € 400 billion DESERTEC project is designed to increase the percentage of renewable energy in Europe to 15% of the overall renewable energy mix by 2050. It envisions constructing solar panels in the Sahara. According to the research, the desert's solar panels can produce about 250 GWh of electricity per square metre, which is equivalent to about 1.5 million barrels of crude oil.[158] A space-based solution has also been considered. Solar radiation would be converted in space into electricity or laser beams. The energy produced would then be "beamed" to Earth where it would be converted back into electricity for onward transmission.

Among the benefits of this solution would be a continuous source of energy from the Sun. There currently exist, however, a number of technological, financial and legal hurdles to implementing this option. Looking into distant future, research has also been conducted in other space-related areas, such as low-energy nuclear fusion, and microbial cells. The concept of mining of resources on the Moon and other celestial bodies is a subject of more future-oriented debates.

The EU has also been increasingly alert to the Arctic region, including the question of whether Norwegian Arctic areas are emerging as a means for diversifying oil and gas deliveries to the EU. At this time, however, the EU is more focused on the broader goal of formulating an Arctic policy, stimulated by an EU Parliament resolution on Arctic governance in October 2008 (followed in November of that year by an EC communication entitled "the European Union and the Arctic Region").[159] The objectives set forth concentrated on general environmental concerns, including the sustainable use of the region's abundant resources. The Arctic region will also be discussed in greater detail in Chapter 3.2. on the environment.

3.3.1 Europe's Energy Objectives

For the most part, it is the individual EU member states that ultimately manage energy relations with outside suppliers. Bilateral approaches to securing energy supplies, have often proved insufficient. This was recognised more broadly during the 2006 Ukraine-Russia gas dispute which again showcased Europe's inordinate dependency on Russian gas supplies. The inability to respond in a coordinated manner, due to separate policies and interests, was interpreted by some in Moscow and elsewhere as weakness[160] As a reaction

[157] State of Play in the EU energy policy. Accompanying document to the "Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy". COM(2010)639: 16-17.
[158] Solar and Other Renewable Energy in North Africa Provides hope to the EU. Solarthermal Magazine. http://www.solarthermalmagazine.com/2010/07/07/solar-and-other-renewable-energy-in-north-africa-provides-hope-to-the-eu/.

[159] European Union and the Arctic: Main Developments July 2008 – July 2010. Nordic Council of Ministers, Copenhagen 2010: 19 – 24.
[160] "Gas Crisis Resolved But Lack of EU Energy Policy Remains Problem," *EurActiv.com* (January 4, 2006), http://www.euractiv.com/en/energy/gas-crisis-resolved-

to the 2006 incident, the European Commission (EC) published a "Green Paper" in March 2006 which stressed "sustainable, competitive and secure" energy supplies for Europe.[161]

Moreover, in January 2007, the EC adopted a document entitled "An Energy Policy for Europe", that essentially made energy relations a centrepiece "of all external EU relations".[162] In March of the same year, the European Council introduced a "2007 – 2009 Action Plan" that laid out concrete steps with regard to the EU's international energy relations.[163] This document emphasised: diversification of energy sources and transport routes; greater competence in responding to supply crises; a new cooperative relationship with Russia; improving relations with energy-rich countries in Central Asia; expanding the energy network connecting European countries; and improving the interoperability of the internal energy market.[164] The "EU Network of Energy Security Correspondence" was established in May 2007 to observe energy security concerns on the eastern borders of the EU.

The process of liberalisation of the EU gas and electricity markets has encountered obstacles and placed energy policy near the top of the EU's agenda. The EC has stressed that liberalisation of these markets increases the efficiency of the energy sector by generating enhanced competitiveness. The EU has adopted several proposals including so-called "unbundling". It establishes that energy transmission networks have to be managed independently with regard to producers and suppliers. Power and gas suppliers would compete in a free market setting. The gas sector today is largely controlled by a well-known list of major companies, including imports and domestic production.[165] As a result, the EU countries are still somewhat divided concerning the EC's efforts to achieve gas market liberalisation.

To help resolve some differing views among EU members, the Commission offered, in its September 2006 "Third Energy Package", two different options for separating gas and electricity production and supply. One option involved "ownership unbundling", whereby companies that control both energy generation and transmission would be obliged to divest part of their assets. The second option, "independent system operators" (ISO), was an alternative in which the companies involved in energy production and supply would be allowed to retain their network assets, but commercial and investment decisions would be managed by an independent ISO, an entity designated by national governments and approved by the EU Commission.[166] Some EU members like France, Germany, Austria, Cyprus, Greece, Bulgaria, Slovakia, Luxembourg and Latvia have certain reservations about the EU Commission's proposal to, in effect, break up energy companies. The UK, Sweden, Denmark, and the Netherlands, on the other hand, welcome such "ownership unbundling"[167].

Objectives concerning energy policy also include the so-called "20-20-20" strategy, that is shorthand for reducing greenhouse gas emissions by 20%, increasing the share of renewable energy resources by 20% and improving energy efficiency by 20%. Europe hopes to achieve these objectives by the year 2020.[168] In 2010, however, the EU missed its renewable energy target by as much as 75%.[169] Some view the focus on reducing emissions and improving energy efficiency in member states as merely a means of avoiding the much harder task of establishing a

lack-eu-energy-policy-remains-problem/article-151227 (accessed April 16, 2009).

[161] "Green Paper - A European Strategy for Sustainable, Competitive and Secure Energy," The European Commission (March 8, 2006), http://eurlex.europa.eu/smartapi/cgi/sga_doc?smartapi!celex-plus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2006&nu_doc=105.

[162] "Communication From the Commission to the European Council and the European Parliament: An Energy Policy for Europe," Commission of the European Communities (SEC [2007]12, January 10, 2007), http://eur-lex.europa.eu/LexUriServ/site/en/com/2007/com2007_0001en01.pdf.

[163] "Presidency Conclusions," The Council of the European Union (document 7224/1/2007, Brussels, March 8-9, 2007), http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf.

[164] "Q&A: EU Energy Plans," *BBC News* (March 9, 2007), http://news.bbc.co.uk/2/hi/europe/4783996.stm

[165] "Energy Ministers Agree to Disagree On Liberalization," *Renewable Energy Information* (February 29, 2008), http://renewenergy.wordpress.com/2008/02/29/energy-ministers-agree-to-disagree-on-liberalisation/

[166] "3rd Enegy Package:MEPs to Tacke "Unbundling," European Parliament (REF: 20080429STO27886, April 30, 2009).

[167] In contrast, Russia is pursuing a strategy of so-called "superbundling" by using its natural gas resources to gain a stake in the gas transit and supply systems in Europe (Global Utilities Center, 10).

[168] "Will Ownership Unbundling Deliver?: Balancing European Energy Markets," *Ernst & Young* (2007) 14, http://www2.eycom.ch/publications/items/utilities/unbundling_thought_leadership/2007_ey_unbundling_thought_leadership.pdf

[169] Solar and Other Renewable Energy in North Africa Provides hope to the EU. Solarthermal Magazine. http://www.solarthermalmagazine.com/2010/07/07/solar-and-other-renewable-energy-in-north-africa-provides-hope-to-the-eu/.

common energy posture.[170] Most experts believe that the undue dependency on energy imports cannot be significantly reduced for at least several years.[171] As a result, one of the most important elements of Europe's energy security will continue to be that of supply.

Not surprisingly, one of the EU's key energy relationships is with Russia. The stability of this relationship, however, is often contingent on the broader EU-Russia relationship and Moscow's ties to its near abroad (e.g. Ukraine). Bilateral dealings with Gazprom and the Kremlin on the part of individual member states also shape the nature and reliability of Russian supply. Moreover, each MS has a distinct energy mix and, therefore, do not necessarily place the same strategic emphasis on gas imports. Some European countries, including Slovakia, Latvia, and Lithuania are 100% dependent on Russian gas deliveries, while the Czech Republic and Hungary stand at 77% and 64%, respectively.

Other countries are considerably less reliant on Russian supplies, but politically support investments in joint infrastructure projects. Countries like Germany (with 39% dependency) and Italy (31% dependency) have chosen to move in the direction of ever-greater dependency on Russia, whereas Poland, the Czech Republic and Lithuania are actively seeking to reduce their undue dependency. Other former communist countries, like Hungary, are well-positioned to reduce its reliance on Russian gas, yet Budapest has been supporting Russia's South Stream project.[172] These examples of diverging interests and views have posed a significant challenge to achieving a comprehensive energy policy. As Daniel Yergin, Chairman of Cambridge Energy Research Associates (CERA), argued, energy security is inseparable from the broader relations among countries and their traditional ways of interacting.[173]

Despite former British Prime Minister Tony Blair's call for a common European energy policy in a speech to the European Parliament in October 2005, there has been an evident lack of progress since.[174] One of the primary reasons is that the security of supply for Europe has been primarily defined by long-term contracts with Russia, Norway, and Algeria.[175] The history of these long-term contracts goes back to the 1960's when the expensive transnational pipelines from the Soviet Union were initially constructed.[176] For such contracts sufficiently provide security of supply, bilateral relations need to be based on transparency and reliability. However, the EU's trust in its principal supplier, Russia, has been shaken several times since the early 1990's, with the last incident of disruption taking place in January 2009.

"Diversification" of suppliers and transit routes remains the most important means of achieving security of supply. It reduces the risk of supply reduction or disruption that can be catalysed by third party disputes or geopolitical events. For example, any changes in the political leadership of supplier or transit countries could pose a potential risk. As previously mentioned, the EU has been trying to establish a more flexible and agile environment and response network through a common energy market.[177]

The Consolidated Treaty on the European Union (TEU) designates "energy", together with "space" as "shared competence". With regard to energy policy, Art. 122 of the Treaty on the Functioning of the European Union (TFEU) delegates the EU Council to adopt appropriate economic policies in the event of energy supply shortfalls. Title 21 of the TFEU, dedicated to energy, describes the following general goals of the EU's energy policy: to ensure the functioning of the energy market and security of energy supply in the EU; to promote energy efficiency and saving and the development of new and renewable forms of energy; and to advance the interconnections of energy networks. In connection to the latter, the TFEU also indicates the role of the EU in the establishment and development of trans-European networks, including in the area of energy infrastructure.[178]

In conclusion, Europe has a number of leading priorities concerning how to achieve "sustainable, secure and competitive" energy"[179].

[170] Francis David, "Europe Mixed on Russian Gas Reliance," *Christian Science Monitor*, Vol. 100, Issue 70 March 6, 2008).
[171] Umbach Frank, "Europe's Energy Dependence in Mid-Term Perspective," American Institute For Contemporary German Studies (2007) 3.
[172] Gelb Bernard A., "Russian Natural Gas: Regional Dependence," CRS Report to the Congress (RS22562, January 5, 2007), http://www.usembassy.it/pdf/other/RS22562.pdf.
[173] Yergin Daniel, "Ensuring Energy Security," The Foreign Affairs (March/April 2006).
[174] "PM Says It Is Time To 'Get Europe Moving in the Right Direction'" The Official Site of the British Prime Minister's Office (October 26, 2005), http://www.number10.gov.uk/Page8374
[175] Percebois Jacques, The Supply of Natural Gas in the European Union – Strategic Issues, OPEC Energy Review, Oxford and Malden: Blackwell Publishing, 2008, p. 36.
[176] Ibid. 36.
[177] Ibid. 35.
[178] The other two areas are transport and telecommunications.
[179] Commission of the European Communities. Communication from the Commission to the European Council and the European Parliament – An Energy Policy for Europe. COM(2007) 1 final of 10 Jan. 2007. Brussels: European

They are summarised in table 5 below. The top priority remains security of supply. A key aspect of the security of supply is achieving diversification of energy sources, including renewable energy. Developing renewable energy also contributes to another priority that is finding its way to the upper echelons of the EU's agenda, mitigating the impacts of climate change.[180] This is to be achieved through "sustainable energy" (i.e. the right mix of environmental protection, competitiveness, and energy security.)[181] Renewable energy sources that have attracted the most attention are: wind energy, solar electricity, solar heating and cooling, geothermal energy, ocean energy, bio fuels and bio energy[182], and carbon capture and geological storage. Naturally, the viability of these sources and their market competitiveness will depend on access at reasonable prices[183]; a leadership role in energy innovation and technology (through a Strategic European Energy Technology Plan)[184]; and functioning internal market.[185]

Key EU Objectives for Energy
• Diversification of energy sources and transport routes
• Developing greater energy efficiencies
• Creating a functional internal EU energy market
• Establishing trans-European energy infrastructure
• Securing internal EU energy supplies
• Assuring access to external supplies
• Increasing renewable energy availability
• Reducing greenhouse gas emissions
• Protecting critical energy infrastructure
• Developing nuclear energy on a safe and secure basis
• Managing nuclear waste
• Conducting cutting-edge research on nuclear energy
• Establishing global leadership in smart and low carbon energy technologies
• Promoting sustainable use of energy worldwide
• Pursuing sustainable use of Arctic resources

Table 5: The EU's Key Objectives for Energy

3.3.2 Space as an Enabler

Three priorities identified by the International Energy Agency (IEA) in connection with energy activities included: energy security, economic development; and environmental protection. These are also reflected in the EU's energy policy based on security of supply, competitiveness and sustainability.[186] Naturally, space can, and already has, contributed to a number of energy policy objectives.

Satellite applications are currently the most technologically advanced areas where space can contribute to managing growing energy demand. Existing satellite systems for remote sensing, telecommunications, and navigation can all be put to use for this, and related, purposes. Remote sensing satellites gather Earth observation data that provide valuable information on renewable energy sources such as wind patterns or solar flux. They can likewise, for example, monitor waste energy. Telecommunication satellites facilitate wireless communication globally and can provide access to remote locations that are otherwise difficult to connect to power and information networks. Space-based services can also help monitor terrestrial energy grids and distribution networks. Navigation satellites can be used to monitor energy usage patterns in transportation systems and can help coordi-

Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0001:FIN:EN:PDF>.

[180] Commission of the European Communities. Communication from the Commission to the European Council and the European Parliament – An Energy Policy for Europe. COM(2007) 1 final of 10 Jan. 2007. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0001:FIN:EN:PDF>.

[181] Commission of the European Communities. Green Paper – A Strategy for Sustainable, Competitive and Secure Energy. COM(2006) 105 final of 8 Mar. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0105:FIN:EN:PDF>.

[182] European Parliament and Council of the European Union. Directive of the European Parliament and Council on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC. Directive No 2009/28/EC of 23 Apr. 2009. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF>.

[183] Commission of the European Communities. Green Paper – A Strategy for Sustainable, Competitive and Secure Energy. COM(2006) 105 final of 8 Mar. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0105:FIN:EN:PDF>.

[184] Commission of the European Communities. Green Paper – A Strategy for Sustainable, Competitive and Secure Energy. COM(2006) 105 final of 8 Mar. 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0105:FIN:EN:PDF>.

[185] http://europa.eu/legislation_summaries/energy/internal_energy_market/index_en.htm.

[186] Schrogl Kai-Uwe, Wolfgang Rathgeber, Blandina Baranes and Christophe Venet, eds. Yearbook on Space Policy 2008/2009: 8.

nate route planning to minimise wasted energy. Space systems can also support energy production and delivery, including pipeline and nuclear-facility monitoring. Spin-off technologies and expertise can be transferred to other industries, including those that are energy-related. The space-related technologies referenced in the previous section, such as space-based solar power (which envisions the beaming of solar power generated in space to the ground), microbial fuel cells or low energy nuclear reactors have also been promoted as possible future energy sources.

Some of the means in which the energy objectives identified in section 3.3.1. can be enhanced through space are described and summarised in table 6 below.

Exploration, Extraction Production, Processing and Transmission of Fossil and Nuclear Fuel

Remote sensing can significantly contribute to energy resource management. It can help assess, plan, and monitor exploration surveys (hydrocarbon and geophysical exploration). It can likewise serve as an exploration tool for mineral, petroleum and geothermal development, as well as environmental assessment. It provides a synoptic view of large areas in a small amount of time. Radar images can determine thermal characteristics of volcanoes, altered grounds, hot spring activities, determine rock types and locate geological fractures. Geothermal mapping is an important tool for geothermal exploration in assessing the most promising sites for more extensive exploration efforts.[187]

ESA, for example, partnered with MIR Teledetection of Canada to provide land use assessment and land use change detection and monitoring as well as high resolution topographic information in Nigeria, in a project entitled, "Polametric techniques for mining in tropical areas". Mining in such areas is expected to increase in the coming decades and only high-resolution radar capability can provide the required information on these locations due to persistent cloud cover. In this connection, TerraSAR-X, RADARSAT-2 and ENVISAT ASAR will be deployed. Satellite systems can advance eco-friendly development of areas selected for mining.[188]

Weather forecasting can help protect non-renewable energy infrastructures, including transportation of oil and gas through pipelines or via ships. Maritime traffic can likewise continuously monitored, as demonstrated in figure 7 below. ESA's Remote Sensing Satellites, ERS-1 and ERS-2, have collected a large amount of valuable data since their launch in 1991 and 1995, respectively. For nine months, the two spacecraft were linked in the first ever tandem mission and provided a unique window of opportunity to observe changes that occurred over a short time period. ERS-1 was de-orbited in 2000 and ERS-2 continues its operation. The ERS-2 Synthetic Aperture Radar (SAR) continuously monitors the Earth's surface in all weather conditions. It can track sea ice, oil slicks, and ships and thus increase maritime situational awareness. It has also been used for geological exploration of the type described above.

SAR interferometric measurements of topography can detect environmental risks such as earthquakes and land slides. The ERS-2 SAR Wave Mode images gather ocean wave information, including wave height, mean wavelength and propagation direction and gathered data can be used to forecast extreme waves. ERS-2 can now cover the North Atlantic and adjacent seas within 30 minutes and thus provide so-called weather "nowcasting". A special procedure has been developed to provide real-time ERS-2 scatterometer wind products. These data can be acquired even during heavy rain and can therefore help predict hurricanes, as well as provide useful data during extreme weather events, such as tornadoes.[189] The ERS-2 can operate simultaneously with another ESA satellite, Envisat. Envisat, launched in 2002, is the largest Earth Observation spacecraft ever built and carries both optical and radar instruments. Envisat's MERIS (Medium Resolution Imaging Spectrometer) instrument helped, for example, monitor the position of the ash cloud as well as the direction of the prevailing Atlantic winds during the recent Icelandic volcano eruption.

With regard to navigation, future services of Galileo are envisioned to offer navigation services for seismic acquisition vessels and seismic streamer arrays, as well as gun arrays, for marine seismic exploration in the oil and gas sector. Moreover, the safety of drilling activities can be significantly increased by high-resolution surveys of new sites and early identification of any geomorphologic or geophysical risks.[190]

[187] Pastor, Michael S. Application of Thermal Remote Sensing for Geothermal Mapping, Lake Naivasha, Kenya. Proceedings World Geothermal Congress 2010, Bali, Indonesia, 25-29 April 2010: 1.
[188] http://www.eomd.esa.int/contracts/contract336.asp
[189] http://earth.esa.int/ers/tenyears/sar_app.html
[190] Galileo Applications. European GNSS Agency. http://www.gsa.europa.eu/go/home/galileo/applications/

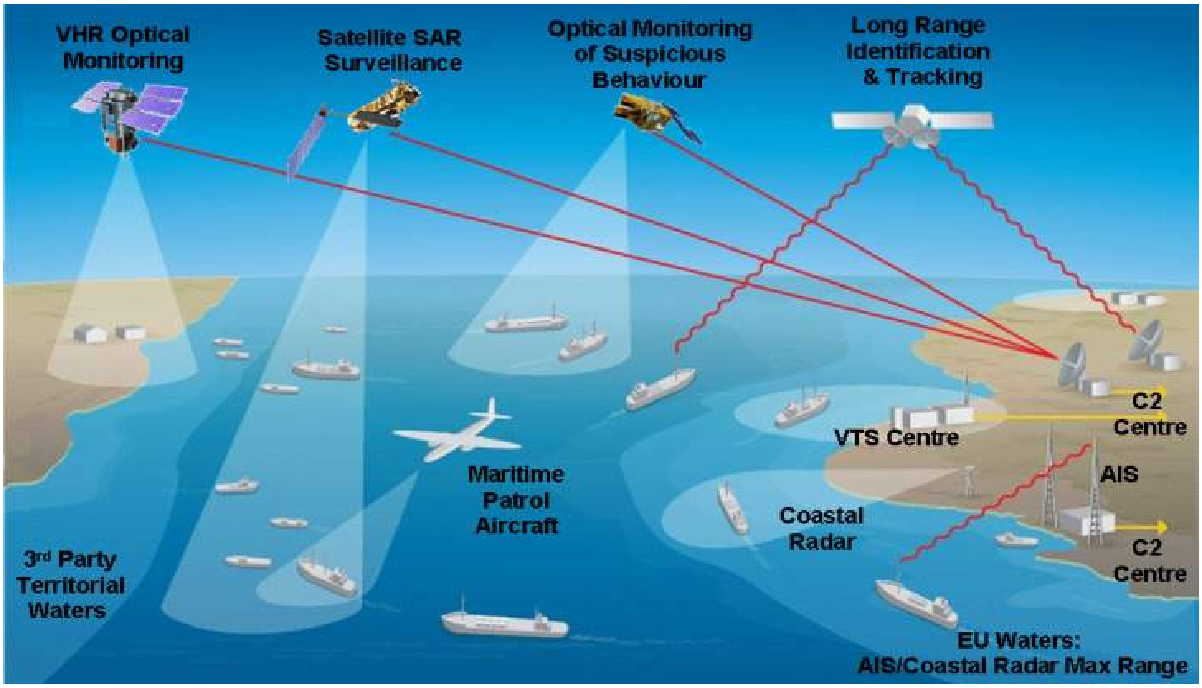

Figure 7: Integrated Ship Surveillance (Source: e-GEOS, 2009)

Electricity and Power Generation and Distribution

The design, construction, and operation of energy networks for electricity require accurate localisation systems. For example, power grids must be continuously monitored to ensure efficient operation. In case of a weakness or a power line break in the grid, synchronisation, with maximum accuracy, of monitoring instruments is crucial. In this regard, Galileo promises to offer improved navigation and time synchronisation services to advance energy transport and distribution.[191]

Telecommunication satellites can provide back-up communication links for a power plant in the event of an emergency or breakdown. Future application of satellite communications could promote real-time direct electricity/energy usage feedback via distributed electricity measurement from each household as well as between power providers and their household customers. This could help consumers conserve by making the association between their behaviour and their electricity/energy expenditures more apparent. Currently, consumer feedback occurs only once a month by means of an electricity bill, which is an indirect and reactive feedback mechanism.

Exploitation and Harvesting of Renewable Energy Resources

Remote sensing and meteorological data can help determine the variations of weather and climate conditions and thus help enhance the efficiency of energy production and distribution. Information from remote sensing satellites can likewise help determine the optimal location for power generation from renewable energy sources. Energy generation from certain renewable sources depends on climate, weather, and local topography. These dependencies are provided in table 7 below. Variations can directly affect the power generation and distribution and produce unpredictable fluctuations. The power capacity, density and variability of each renewable source differ with location and their proper mapping can advance decision-making on what constitutes an optimal energy mix regionally and even globally. For example, topographic surface maps can help determine suitable sites for wind farms. Synthetic aperture radars can provide wind vectors at the location of wind farms that help in integrating the wind generated energy into the larger energy grid.

[191] Galileo Applications. European GNSS Agency. http://www.gsa.europa.eu/go/home/galileo/applications/

Renewable Energy Source	Influence on Energy Production
Solar	Variation in solar irradiance Cloud cover Dust storms High winds
Hydropower	Land elevation/contours Speed/direction Flow through capacity
Wind	Land elevation/contours Temperature Pressure Land cover models
Biomass	Monitoring of agricultural sources (corn-derived ethanol)

Table 6: Dependencies for Renewable Energy Source (Space Aid for Energy Needs on earth, ISU SSP09)

Synthetic aperture radar (SAR)-equipped satellites can map wind speeds and investigate the effect of wind on downstream turbines. This capability is present in the ERS-2 SAR, ENVISAT ASAR satellites. Synthetic aperture radar (SAR) technology has been used for ocean wind mapping that provides the basis for detailed offshore wind farm wake studies and is highly useful for development of new wind retrieval algorithms from C-, L-, and X-band data. Satellite observations from SAR and scatterometer are used in offshore wind resource estimation. SAR has the advantage of covering the coastal zones where most offshore wind farms are located.[192]

Satellite imagery can also produce solar flux maps for photovoltaic and solar thermal generation, and observation of snow cover can estimate hydro-electric generation capacity. Meteorological satellites, for example, are able to provide solar radiation budget maps that could help in the site selection for optimal solar cell plants. Information from these satellites could also quantify the energy generation capacity.[193]

Telecommunication satellites can help balance energy supply and demand. It is likely that with the increasing number of renewable sources the power transmission mechanisms will be dispersed. For example, wind power is often distributed over large remote areas, even offshore, and requires reliable telecommunication and interconnections with the electrical grid to monitor and control wind-derived energy, as well as the condition of the infrastructure and early failure detection.

Navigation systems can provide evaluation of the site. They can, for example, provide initial evaluation of suitable solar flux for solar-concentrated thermal power sites. In the on-site detailed evaluation, handheld GPS can collect the position, height and elevation of obstacles for shading analysis. Accordingly, total access time to the sun, array position, and optimal orientation can be configured for achieving the best power output.[194]

Other Energy-Related Areas

Advanced remote sensing technology can provide useful information concerning energy consumption, for example, through night-time light and heat images of the Earth's surface. This data can serve as valuable information in an effort to reduce substantially energy waste. It can also help monitor greenhouse gas emission trends and increase awareness concerning the chronic level of energy waste.

Space systems also contribute to automobile and air traffic management and thus help reduce carbon emissions. With regard to navigation, the EU Commission identified road transport and aviation as two of six priority domains of applications for EGNOS and Galileo.[195] Intelligent road transport systems have been one of the most important GNSS consumer markets, with more than 60% annual growth over the past five years. Automobile transportation is largely dependent on oil consumption and carbon emissions are clearly aggravated by traffic congestion. EGNOS and Galileo will be able to reduce traffic and environmental effects by locating, in real time, trucks, buses, taxis, etc. to help optimise resources, fleet management and reduce travel time and fuel consumption. Traffic congestion can be remedied by pre-notifications concerning accidents and other causes of congestion, as well as by offering alternative routes. An advanced system that connects GNSS with local traffic control centres would significantly help improve this capability. Moreover, applications such as eCall programme could use GNSS positioning for in-vehicle emergency call systems. This would, in turn, assist the ability of emergency services to remotely locate vehicles after an accident.[196]

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[192] Hasager Charlotte Bay, et al. Remote Sensing Observation Used if Offshore Wind Energy. IEEE Journal of of Selected Topics in Applied Earth Observation and Remote Sensing. 1 (1), March 2008: 67.

[193] Space Aid for Energy Needs on Earth. International Space University Report, SSP09.

[194] Space Aid for Energy Needs on Earth. International Space University Report, SSP09.

[195] Other four domains are: applications for individual handsets and mobile phones (LBS); maritime transport; precision agriculture and environment protection; and civil protection and surveillance.

More efficient air traffic control systems enable shorter, faster and safer flights. The EU is in the process of implementing the Single European Sky ATM Research (SESAR) Programme for implementing a new Air Traffic Management (ATM) administrative, operational and technical concept. The European Space Agency's "Iris" programme, in coordination with the EC, EUROCONTROL, Air Navigation Service Procedures and the SESAR consortium, seeks to develop satellite communications for exchanges between aircraft and flight control centres, complementing existing and future systems in support of the growth of global air traffic operations. The Iris programme is part of the advanced "Research in Telecommunications Systems" (ARTES) programme, the backbone of telecommunication activities of ESA.[197]

Saving energy by reducing the need for travel has been increasingly facilitated by teleconferencing advances. Satellite applications enable people to gather information without the requirement of travel. Teleconferencing also enables other services such as virtual assistance to remote areas (e.g. remote surgery). It has not, however, been used on a large scale due to social norms and preferences.[198]

In short, there are a growing number of energy-related areas where space can serve as a powerful enabler in advancing many of the EU's energy-related foreign policy such as those identified above. The categories and space-relevant applications are summarised in table 7 below.

EU Key Objectives for Energy	Space As an Enabler
Developing Greater Energy Efficiencies	<u>Remote Sensing</u>: *Sample Applications* • Helping assess, plan and monitor exploration surveys (hydrocarbon and geophysical exploration) • Serving as an exploration tool for mineral, petroleum, and geothermal development and facilitating environmental assessment • Determining thermal characteristics of volcanoes, altered grounds, hot spring activities, rock types and locating geological fractures • Providing information on renewable sources (e.g. wind patterns, solar flux, etc.) • Determining optimal location for power generation from non-renewable energy sources • Advancing decision-making on optimal energy mix regionally, and even globally • Tracking the status of non-renewable resource extraction and distribution • Monitoring energy usage patterns in transportation systems to help coordinate route planning • Detecting night-time light and heat images of the Earth's surface to improve management of resources and prevent energy waste *Examples* • Land use assessment and land use change detection and monitoring and high resolution topographic information facilitated by SAR images, CosmoSkyMed, TerraSAR-X and RADARSAT-2, for mining in tropical areas • Oil spill detection by Radar Imageries to reduce ineffectual flow of oil <u>Telecommunications</u>: *Sample Applications* • Helping balance energy supply and demand • Providing reliable telecommunication and interconnections with

[196] GNSS is the best solution for traffic management initiatives. GSA website. http://www.egnos-portal.eu/index.cfm?objectid=0F1397FA-17C6-11DF-93B6005056861A4B
[197] Ricard Nathalie and Franco Ongaro. ESA's Iris Programme: Satellite Communications for Air Traffic Management. Journal Space Communications. 21 (3-4), August 2008.
[198] Space Aid for Energy Needs on Earth. International Space University Report, SSP09:

	electrical grids and controlling wind-derived energy • Providing real-time, direct electricity/energy usage feedback via distributed electricity measurement from each household, between power providers and their household customers • Providing access to remote locations • Facilitating wireless communication globally • Reducing the need to travel due to teleconferencing advances • Improving welfare of crew-members on oil and gas platforms in remote locations *Example* • Smart energy grids: satellite communications can contribute to implementing a global energy grid. Telecom satellites can easily back-up high availability links of the communication and control network in critical parts of the smart energy grids[199]. <u>Navigation, Positioning and Timing</u>: *Sample Applications* • Providing accurate localisation services for evaluating, designing, constructing and operation of energy networks for electricity, oil and gas • Monitoring power grids for efficient operation • Synchronising monitoring instruments for power grids in case of power line breaks or weakness occurrence • Navigation services to seismic acquisition vessels and seismic streamer and gun arrays for marine seismic exploration • Monitoring energy usage patterns in transportation systems and helping coordinate route planning to minimise wasted energy • Contributing to automobile and air traffic management • Precise timing services for switch-off & switch-on operations *Example* • Initial evaluation of suitable solar flux for solar-concentrated thermal power sites by GNSS systems • Handheld GPS can collect the position, height and elevation of obstacles for shading analysis for on-site detailed evaluation for the best power output
Securing internal EU energy supplies and assuring access to external supplies	<u>Remote Sensing</u>: *Sample Applications* • Helping assess, plan, and monitor exploration surveys • Monitoring sea ice, oil slicks, and ships and thus increase maritime situational awareness • Weather forecasting • Weather "nowcasting" *Example* • Pipeline remote sensing: Thanks to high-resolution remote sensing and image processing technology, spaceborne sensors can monitor natural gas pipelines, and replace vehicle and air patrols. The data can be acquired, for example, from Synthetic Aperture Radar (SAR) data of the ENVISAT, TerraSAR, and CosmoSkyMed satellites <u>Telecommunications</u>: *Sample Application* • Providing reliable telecommunications and interconnections with the electrical grid to monitor and control wind-derived energy, as well as the condition of the infrastructure and early failure detection *Example* • Smart energy grids: satellite communications can contribute to

[199] Chuberre Nicolas and Konstantinos Liolis. Contribution to Grand Societal Challenges. ISI (10 April 2010): 4.

	implementing a secure energy grid. Specifically, it has a potential to optimise efficiency of the global monitoring and black-out management and contributing to security of supply[200] <u>Navigation, Positioning and Timing</u>: *Sample Applications* • Contributing to maximising safety of transport by providing navigation signal to various forms of transportation, including maritime. *Example* • Possible applications for a European global navigation satellite system include: navigation; operations; traffic management; sea port operations; casualty analysis; offshore exploration and exploitation. EGNOS will complement the services already provided by marine radio beacons.
Increasing renewable energy availability	<u>Remote Sensing</u>: *Sample Applications* • Determining the optimal locations for power generation from renewable energy sources • Estimating offshore wind resource • Producing solar flux maps for photovoltaic and solar thermal generation • Observing snow cover to estimate hydro-electric generation capacity • Providing solar radiation budget maps that could help in site selection for optimal solar cell plants (meteorological satellites) *Example* • SAR-equipped satellites can map wind speeds and investigate the effect of wind on downstream turbines (e.g. ERS-2 SAR, ENVISAT ASAR).
Establishing global leadership in smart and low- carbon energy technologies	• Investigating future technologies such as space-based solar power, microbial fuel cells or low energy nuclear reactors • Transferring of spin-off technologies to other industries
Engaging in bilateral and multilateral exchanges on energy development in the Arctic	• Polar View remote sensing programme focused on both the Arctic and the Antarctic, supported by the European Space Agency (ESA) and the European Commission (EC) with participation from the Canadian Space Agency, is an excellent example of multilateral Arctic-related exchange. This programme, among other items, promotes utilisation of satellites in the area of sustainable economic development.
Protecting critical energy infrastructure	<u>Remote Sensing:</u> *Sample Applications* • Monitoring critical infrastructure, including pipelines and nuclear facilities • Protecting non-renewable energy infrastructure, including transportation of oil and gas, via weather forecasting • Increasing maritime situational awareness by tracking sea ice, oil slicks, and ships • Helping forecast hurricanes, tornadoes and extreme waves • Providing useful data during extreme weather events • Detecting environmental risks such as earthquakes and land slides *Example* • Envisat's MERIT instrument helped monitor the position of the ash cloud as well as the direction of the prevailing Atlantic winds during the volcanic eruption near Eyjafjallajoekull glacier in Iceland

[200] Chuberre Nicolas and Konstantinos Liolis. Contribution to Grand Societal Challenges. ISI (10 April 2010): 4.

	Telecommunications: • Providing back-up communication links for a power plant in case of emergency or breakdown
Reducing greenhouse gas emissions	Remote Sensing: *Sample application* • Monitoring of greenhouse gas emission trends and increase consumer awareness concerning the level of energy waste *Examples* • Continued and near-real time integrated system for alarming people concerning the density of greenhouse gases • Continued monitoring and assessment of greenhouse gases for implementation of mechanisms established by International Treaties on Climate Changes Telecommunications: *Sample Application* • Teleconferencing and other satellite applications as a way of reducing the need for travel Navigation, Positioning and Timing: *Sample Applications* • Facilitating more efficient automobile and air traffic control systems enabling shorter, faster and safer trips and flights • Pre-notifications concerning accidents and other causes of congestions and offering alternative routes

Table 6: Space as an Enabler for Advancing EU's Key Objectives for Energy

3.4 Resources

The Oxford Dictionary describes natural resources as "materials or conditions occurring in nature and capable of economic exploitation".[201] As such, they include basic raw materials such as metals, minerals and fossil fuels, as well as biosphere and ecosystems that include renewable energy and life-supporting sources like water and food. Carefully planned utilisation of natural resources contributes to sustainable development. The growing scarcity of some natural resources, such as water and food, is closely connected to environmental concerns and their impact on a country's broader economy. Global warming can, for example, threaten food and water sustainability or influence the use of renewable energy sources.[202]

Although there are policies and initiatives already underway seeking to address the sustainable use of such resources, including those affecting climate change and biodiversity, the United Nations is now inclined to view resource management holistically to better understand the linkages among various resource issues. This approach is reflected in the work of the International Panel for Sustainable Resource Management (or Resource Panel), launched in November 2007. The panel is designed to bring scientific analysis of the environmental impact of resource use over the full cycle and propose methods of reducing negative effects, as well as contribute to identifying ways to decouple economic growth from environmental degradation.[203]

In Europe, the 6th Environment Action Plan (EAP) focuses, among other issues, on "better resource efficiency and improved resource and waste management to help bring about more sustainable patterns of production and consumption". The goal is to achieve economic growth without causing environmental degradation. The third of the seven Thematic Strategies deals with the "Sustainable Use of Natural Resources". It aims at making Europe one of the most resource-efficient economies globally.

3.4.1 Europe's Resource Requirements

The EU has a number of policies that indirectly address resource management. They include environmental policy, a sustainable development strategy as well as energy, development, industrial and foreign policies,

[201] The Concise Oxford Dictionary: Ninth Edition. Oxford University Press (1995): 907.
[202] Schrogl Kai-Uwe, Wolfgang Rathgeber, Blandina Baranes, and Christophe Venet (eds.). Yearbook On Space Policy: 2008/2009. Vienna: SpringerWienNewYork (2010): 9.
[203] Resource Panel. United Nations Environment Programme, Division of Technology, Industry, and Economics. http://www.unep.fr/scp/rpanel/

etc. With regard to foreign policy, for example, Art. 21.2(f) of the TEU assigns the EU the task of developing "sustainable management of global natural resources in order to ensure sustainable development". The TFEU's Article 191.1. establishes "prudent and rational utilisation of natural resources". Accordingly, this section will seek to review the principal EU objectives concerning: water and food security; sustainable agriculture; fishing and forestry; access to crucial raw materials (as well as means to reduce Europe's dependency on them); and waste prevention, recycling and end-of-life disposal.

Europe 2020 Strategy promises to set three priorities and five "headline targets" through seven flagship initiatives. As referenced above, the three mutually reinforcing priorities of Europe 2020 are smart, sustainable, and inclusive growth. Sustainable growth is to be achieved via a more resource efficient, greener, and more competitive economy[204]. One of the seven flagship initiatives of the European Commission is termed "Resource Efficient Europe" which aims to delink economic growth from the use of resources. This is to be achieved through increased use of renewable energy sources, modernising transport sectors and promoting energy efficiency.[205]

Two of the key challenges, as identified by the EU Sustainable Development Strategy (EU SDS), are particularly relevant (i.e. sustainable consumption and production, and conservation and management of natural resources).[206] In this connection, in December 2005, the European Commission proposed a Strategy on the Sustainable Use of Natural Resources with the long-term (i.e. 25 years) objective of reducing the environmental impact associated with resource use in a growing economy.[207]

Generating and preserving fresh water resources are one of the issues. Globally, important concerns include transboundary water management, climate change and proper water handling (e.g. intensive agriculture, etc.).[208] The quality and quantity of water influences various areas of development, including food security, trade and transport, and health.[209] Accordingly, the EU, among its priorities, seeks to protect water resources and fresh and salt water ecosystems, (including via pollution prevention).[210] In addition to water, food security and safety are also among EU's priorities. In connection with the Millennium Development Goals and food security in developing counties, EU policy efforts are based on the following four pillars: increasing the availability of food; improving access to food; upgrading the nutritional content of food intake; and enhancing crisis prevention and management[211].

As mentioned in the section on the environment, protection of biodiversity constitutes another area of concern. Accordingly, the EU seeks to manage agriculture in such manner as to reduce significantly the impact on biodiversity.[212] With regard to forest resources, the EU directs its attention to combating deforestation, fighting against illegal logging, and other objectives defined in the EU forestry strategy and action plan. These cover the improved use of forest products and services; protection of the environment, including biodiversity; carbon sequestration; the integrity, health and resilience of forest ecosystems at multiple geographical scales; im-

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204 European Commission. Communication from the Commission. Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth. COM(2010) 2020 of 3 Mar. 2010. Brussels: European Union. <http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf>.

205 European Commission. Communication from the Commission. Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth. COM(2010) 2020 of 3 Mar. 2010. Brussels: European Union. <http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf>.

206 Council of the European Union. Note from the General Secretariat to the Delegations. Review of the EU Sustainable Development Strategy (EU SDS) – Renewed Strategy. 10917/06 of 26 June 2006. Brussels: European Union, http://register.consilium.europa.eu/pdf/en/06/st10/st10917.en06.pdf.

207 Thematic Strategy on the Sustainable use of Natural resources. Communication COM 670 (2005)

208 Op. cit. http://europa.eu/legislation_summaries/development/sectoral_development_policies/r12514_en.htm.

209 http://europa.eu/legislation_summaries/development/sectoral_development_policies/r12514_en.htm. Commission of the European Communities. Communication from the Commission to the Council and the European Parliament. Water Management in Developing Countries Policy and Priorities for EU Development Cooperation. COM(2002) 132 final of 12 Mar. 2002. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2002:0132:FIN:EN:PDF>.

210 Water. European Commission: Environment. http://ec.europa.eu/environment/water/index_en.htm

211 European Commission. Communication from the Commission to the Council and the European Parliament. An EU Policy Framework to assist developing countries in addressing food security challenges. COM(2010) 127 final of 31 Mar. 2010. Brussels: European Union. <http://ec.europa.eu/development/icenter/repository/COM_PDF_COM_2010_0127_EN.PDF>.

212 http://europa.eu/legislation_summaries/agriculture/environment/l28024_en.htm.

proved coordination and communication with other sectors; and the preservation and improvement of the social and cultural dimensions of forests.[213]

Marine ecosystems protection involves, for example, management of fishery resources and marine environment.[214] To preserve these resources, the EU seeks to, for example, reduce unwanted by-catches and eliminate discards; manage deep-sea fish stocks; protect sharks; conserve fisheries resources in the Mediterranean;[215] protect vulnerable marine ecosystems from bottom fishing and destructive fishing practices[216]; and integrate environmental requirements into the Common Foreign Policy[217].

Access to minerals (i.e. non-energy raw materials) has recently become a global concern with China's embargo on rare-earth elements (RRE) to Japan and a number of other countries and subsequent market reactions. For example, prices of cerium for certain applications have increased more than 1,000 percent in the past year (cerium is used in semiconductor manufacturing).[218] Access to raw materials has been on the EC's agenda for some time as the demand for metals grows continuously. The EU itself is dependent on the import of a variety of minerals, and especially metal minerals, for many applications, including: building and construction; transport, electrical and electronic equipment; and jewelry. In this connection, recycling is now considered of critical importance for mitigating environmental impacts of mining metals.[219]

Other raw material-related challenges are embodied in the increasing demand and uneven supply, high dependency of green technologies on RRE, and resource scarcity as a result of intra- and inter-state conflicts. The 2008 European Commission's Raw Materials Initiative stated that "securing reliable and undistorted access to raw materials is increasingly becoming an important factor in the EU's competitiveness and, hence, crucial to the success of the Lisbon Partnership for growth and jobs".[220] Policy actions in this area are based on three principles: accessing minerals by international markets on an unfettered basis; fostering the sustainable supply of European sources (e.g. geological surveys; promoting research innovation, etc.); and reducing EU consumption of raw materials through, for example, efficiency and recycling (so/called 'metal-lean' strategy).[221] The strategy includes decreasing the continent's dependency on metal imports.

To help cope with these issues at a global level, a project called POLINARES was launched in January 2010 under the 7th Framework Programme. This two-year project specifically examines competition for access to oil, gas and mineral resources and will propose collaborative solutions for policy actors, including the EU.[222]

From the above, the following objectives can be identified:

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[213] Commission of the European Communities.. COM(2006) 302 final of 15 June 2006. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0302:FIN:EN:PDF>.
[214]http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/index_en.htm.
European Commission. Commission Staff Working Document: Synthesis of the Consultation on the Reform of the Common Fisheries Policy. SEC(2010) 428 final of 16 Apr. 2010. Brussels: European Union. <http://ec.europa.eu/fisheries/reform/sec%282010%290428_en.pdf>.
[215] "Eight objectives for the Community fisheries policy in the Mediterranean.Op. Cit. <http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/l66012_en.htm>.
Commission of the European Communities. COM(2002) 535 final of 9 Oct. 2002. Brussels: European Union. <http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/l66012_en.htm>.
[216]Council of the European Union. Council Regulation on the Protection of Vulnerable Marine Ecosystems in the High Seas from the Adverse Impacts of Bottom Fishing Gears. Regulation (EC) No 734/2008 of 15 July 2008. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:201:0008:0013:EN:PDF>.
Commission of the European Communities. COM(2007) 604 final of 17 Oct. 2007. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0604:FIN:EN:PDF>.
[217] Commission of the European. COM(2002) 186 final of 28 May 2002. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2002:0186:FIN:EN:PDF>.
[218] China's Rare Earh Embargo Triggers Price Hikes. CNET News (8 November 2010). http://news.cnet.com/8301-13924_3-20022161-64.html
[219] Assessing Global Metal Flows: Metal Stocks in society and Recycling rates. UN Environment Program Flyer.
[220] Commission of the European Communities. Communication from the Commission to the European Parliament and the Council. The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe. COM(2008) 699 of Nov. 2008. Brussels: European Union. <http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=894&userservice_id=1>.
[221] Non-energy raw materials. EC Enterprise and Industry. http://ec.europa.eu/enterprise/policies/raw-materials/index_en.htm
[222] Project statement on: http://www.polinares.eu/project.html.

Key EU Objectives for Resource Management
• Emphasising sustainable natural resource development • Becoming more resource-efficient economy • Reducing waste through recycling • Enhancing European and global water security • Implementing sustainable European food policies and monitoring global food security • Maintaining access to strategic minerals

Table 8: EU's Key Objectives for Resource Management

3.4.2 Identifying and Developing Resources via Space

It has been determined that space-based systems collect data on thirty-four so-called essential climate variables (ECV) from the atmosphere, oceans, and land. These variables are used by various bodies (e.g. UNFCCC, etc.) to research and monitor climate change.[223] They are summarised in table 9 below. A number of these capabilities also contribute to resource-related objectives, including those identified in section 3.4.1.

For example, ESA's Envisat satellite, the largest Earth observation satellite ever built, carries 10 sophisticated optical and radar instruments that provide continuous observation and measurement of oceans, land, ice caps, and atmosphere that contribute to understanding the effects of natural phenomena and man-made activities on climate change, as well as the weather information necessary for the management of natural resources.[224]

Other contributions of satellites in identifying, developing, and managing natural resources and the advancement of some key EU foreign policy objectives are described and summarised in table 10 below.

Emphasising Sustainable Natural Resource Development

The more efficient use of natural resources is one of the EU's environmental priorities. The first two of five main service categories that are being developed under the GMES programme (i.e. marine services; land monitoring services; atmosphere services; emergency response services; and security services) are particularly relevant for natural resource management. Specifically, the marine services will provide applications improving the safety and efficiency of maritime transport. Accordingly, they will advance decision-making on the exploitation and sustainable management of ocean resources (e.g. offshore oil reserves, fisheries etc.). MyOcean Project, which represents the implementation of the GMES Marine Core Ser-

Domain	Essential Climate Variables (ECV)
Atmospheric (over land, sea and ice)	*Surface:* Air temperature, precipitation, air pressure, surface radiation budget, wind speed and direction, water vapour *Upper-air:* Earth radiation budget (including solar irradiance), upper-air temperature (including Microwave Sounding Unit (MSU) radiances), wind speed and direction (especially over the oceans), water vapour, cloud properties *Composition:* Carbon dioxide, methane, ozone, other lasting greenhouse gases, aerosol properties
Oceanic	*Surface:* Sea surface temperature, sea surface salinity, sea level, sea state, sea ice, current, ocean colour (for biological activity), carbon dioxide partial pressure *Sub-surface:* Temperature, salinity, current, nutrients, carbon, ocean tracers, phytoplankton
Terrestrial	River discharge, water use, ground water, lake levels, snow cover, glaciers and ice caps, permafrost and seasonally frozen ground, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation (FAPAR), leaf area index (LAI), biomass, fire disturbance, soil moisture

Table 9: Thirty-four essential climate variables (ECV) and their dependence on satellite observations (Source: CEOS, 2010).

[223] Space Technologies and Climate Change: Implications for Water Management, Marine Reources, and Maritime Transport. OECD (2008): 74.

[224] Ibid: 81

vice, includes applications such as marine resource management, water quality and pollution, and seasonal forecasting.[225]

GMES' land monitoring services will support various global change and sustainable development policies (e.g. the UNFCCC, EU Council Regulations on Food Aid Policy, etc.). They produce basic geo-information on land cover and use as well as annual and seasonal changes. Moreover, biophysical parameters describing the continental vegetation state, the radiation budget at the surface, and the water cycle will contribute to specific resource-related policies. These services are being configured under the GeoLand project.[226]

Becoming a More Resource-Efficient Economy

Satellite communication technologies can also help bolster the efficient use of natural resources. Communication water management systems represent a good illustration of the multiple benefits facilitated by these systems. Communication systems help gain real-time knowledge concerning water quantity and quality, reduce costs and improve public safety. Satellite-based communication terminals can monitor water flow data from devices like stream gages and agricultural water meters and be collected in a central location in near-real time. They can also notify responsible agencies of water events and monitor equipment breakdowns. Flow forecasts are used for optimising water resource systems operation, including reservoir operation, shipping commerce on rivers, industrial water supply, etc. Flow monitoring can likewise help protect habitats.

Concerning the water consumption involved in thermoelectric-power generation, for example, communication satellites can monitor and control flow rate to ensure the correct amount of water is entering the plant. Reservoir or tank levels can also be monitored to ensure water availability for the electricity generation process. In farming, satellite communications help avoid water waste and can transfer information on weather and soil moisture to improve irrigation systems. These can also be controlled remotely and satisfy different soil requirements. In short, the yield of crops can be optimised and water usage and cost can be minimised.

Finally, satellite-based monitoring systems can reliably transmit data on weather events such as floods, overloading of sewer systems, and other events that can influence water quality and quantity. These data can be, in turn, fed to irrigation and other water management systems.[227] As in other areas, communication systems offer the ability to receive information in near real-time without the costs associated with the physical presence of personnel. They can help gather and analyse relevant data for better management of critical natural resources.

With regard to navigation, GNSS applications, including those envisioned for Galileo, cover areas such as transport and communication, as well as land survey and other resource-relevant areas.[228]

Enhancing European and Global Water Security

Several space-borne sensors can contribute to existing knowledge about the global water cycle by studying the atmosphere. They can monitor clouds, water vapours, precipitation and winds and thus complement the ground systems (e.g. ground-based radars). Concerning cloud monitoring, satellites equipped with the Advanced Very High Resolution Radiometer (AVHRR), the Moderate Resolution Imaging Spectrometer (MODIS), and Medium Resolution Imaging Spectrometer (MERIS) can provide data on the interactions of clouds, pollution and rainfall. For example, data from five satellites (i.e. NASA's Aqua, Aura, CloudSat, CALIPSO and CNES' PARASON), combined with other data revealed that South American clouds infused with high levels of carbon monoxide (produced by power plants or agricultural fires) tended to produce less rain than their clean counterparts during the region's dry season.[229]

Soil moisture and salinity are important variables for efficient water management practices. Soil moisture content affects the process of water entry from surface sources (e.g. rainfall, irrigation, etc.), runoff, and the water available for use by vegetation. Soil moisture measurements, usually required to depths of 1 to 2 metres (so-called "root zone"), contribute significantly to temperature and precipitation forecasts. Satellites can estimate water content in the upper 5-10 cm of soil.[230] For example, the Soil Moisture and Ocean Salinity (SMOS) mission (the second Earth Explorer mission) observes soil moisture over

[225] Schrogl Kai-Uwe, Wolfgang Rathgeber, Blandina Baranes, and Christophe Venet (eds.). Yearbook On Space Policy: 2008/2009. Vienna: SpringerWienNewYork (2010): 191-192.
[226] Ibid: 193.
[227] Water Management with Satellite Technology. White Paper. SkyWave Mobile Communications (2010).
[228] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0769:REV1:EN:PDF
[229] Space Technologies and Climate Change: Implications for Water Management, Marine Reources, and Maritime Transport. OECD (2008): 77.
[230] Ibid: 79.

the Earth's landmasses and salinity over the ocean.

In connection with water quality, new methods of extracting various in-water and bio-optical properties from remote sensing data are being developed. For example, satellites can advance the method of "streamgaging" or physically measuring the channel geometry and velocity of the water on a periodic basis. In-situ measurements are difficult (even dangerous), expensive, and difficult to conduct frequently as the data is needed over the entire range of river flow situations. Radar satellites can contribute to the two essential pieces of information required for this measurement: water velocity and channel cross-sectional area (depth and width).[231]

Topographic and geomorphologic data from satellite sensors can improve water movements (surface and ground water) detection and water storage (surface waters, aquifers). Information can be obtained from optical and synthetic aperture radar (SAR) instruments with stereo image capabilities (e.g. Envisat, SPOT). Digital elevation models (e.g. digital elevation maps), can provide an accurate description of terrain. These data can be then used for various applications including, hydrology, agriculture, forestry, land cover classification, and cartography.[232]

Height measurement, referred to as geopotential height, is used in meteorology and climate studies. It is the height of a pressure surface above mean sea level. Radiosondes have been used since the 1940s to measure pressure, temperature and humidity profiles, variables used to calculate geopotential height. Radiosondes equipped with GPS signals have brought greatly improved accuracy and standardisation of measures. For example, all GPS height measurements at Mauritius corresponded within ±20 metres from the surface to a 34-kilometre altitude when in the mid-1980s the differences were in the order of 500 metres to a 30-kilometre altitude.[233]

Implementing Sustainable European Food Policy and Monitoring Global Food Security

Surveillance and monitoring of maritime activities, such as fishing, are part of the effort to protect the environment and encourage the responsible use of marine natural resources. EU efforts have focused on: the establishment of an EU control system to ensure compliance with the Rules of the Common Fisheries Policy[234]; combating illegal, unreported and unregulated fishing[235]; establishing an EU framework for the collection, management and use of data in the fisheries sector[236]; and work toward an integrated maritime surveillance system. The GMES Space Segment will provide information services that will advance a number of maritime surveillance objectives. For example, advanced systems for the monitoring of vessels (see table 6 in the Energy section) will be able to help counter illegal fishing as well as control marine resource preservation.

Similarly, GMES-based Earth observation will help optimise land use for agriculture and, together with EGNOS/Galileo, will advance precision farming. Earth observation already helps monitor crops. The European EGNOS system has been implemented in the precision agriculture sector. It is estimated that by 2020, 90% of tractors will be equipped with GNSS. The system allows automatic steering guidance and reduces overlaps, including in bad weather conditions. When complemented by satellite imagery, EGNOS optimises the benefits of fertilisers and herbicides to protect

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[231] Ibid: 85.

[232] Space Technologies and Climate Change: Implications for Water Management, Marine Reources, and Maritime Transport. OECD (2008): 90.

[233] Space Technologies and Climate Change: Implications for Water Management, Marine Reources, and Maritime Transport. OECD (2008): 89.

[234] Extension of VMS. <http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/pe0012_en.htm>.
Council of the European Union. Council Regulation Establishing a Community Control System for Ensuring Compliance with the Rules of the Common Fisheries Policy, Amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and Repealing Regulations (EEC) No 2847/93, (EC) 1627/94 and (EC) 1966/2006. Regulation (EC) No 1224/2009 of 20 Nov. 2009. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:343:0001:0050:EN:PDF>.

[235] http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/pe0005_en.htm.
Council of the European Union. Council Regulation Establishing a Community System to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing, Amending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and Repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999. Regulation (EC) No 1005/2008 of 29 Sep. 2008. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:286:0001:0032:EN:PDF>.

[236] Council of the European Union. Council Regulation Concerning the Establishment of a Community Framework for the Collection, Management and Use of Data in the Fisheries Sector and Support for Scientific Advice Regarding the Common Fisheries Policy. Regulation (EC) No 199/2009 of 25 Feb. 2008. Brussels: European Union. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:060:0001:0012:EN:PDF>.

the environment against the excessive use of chemicals. Other interesting applications include: tracking individual livestock and confining them to a limited area; tracing food enhancement by adding timing and location of the harvest; and the management and control of the Common Agriculture Policy (CAP).[237]

Telecommunications, together with navigation, will contribute to transportation safety, including that of food and livestock. GNSS units in trucks carrying livestock will prevent sanitary fraud, ensure food safety, and the welfare of live animals. In agriculture, GNSS can provide the location and size of parcels to verify commercial exchange information or the requests for government subsidies. In sum, GNSS can help optimise crops, reduce nutrients and pesticides, and ensure optimal use of soil and water.[238]

Maintaining Access to Strategic Minerals

The efficient use of space-based information, including that provided by GMES, can improve the EU's knowledge concerning mineral deposits. In June 2010, an ad hoc Working Group on Exchanging Best Practice on Land Use Planning, Permitting and Geological Knowledge (a sub-group of the Raw Materials Supply Group), chaired by the European Commission, produced a report entitled "Critical Raw Materials for the EU"[239] (part of which was an abridged version of "Improving Framework Conditions for Extracting Minerals for the EU".)[240] A portion of the report focused on how GMES can contribute to the Raw Material Initiative (RMI), specifically, to acquiring terrestrial sub-surface information. It was pointed out that only multi-method Earth observation, involving satellites, airborne and in-situ data acquisition can provide a complex Earth system picture from 0 – 4000 metres for discovering deep-seated resources.

While in-situ observations for RMI are considered the most important, as they assess possible future subsurface penetration from tens to thousands of metres (through ground-based geophysical survey tools and geological and geochemical sampling), airborne and space-borne geophysical surveys are also indispensable. They use radiometrics, gravity, magnetics and electro-magnetics and airborne measurements. Some of the sensing methods can be both air- and space-based and each offers its own advantages. While aircraft measurements provide better resolution and penetration, satellites offer a unique synoptic view. Satellite data are provided by national space agencies, ESA, as well as commercial businesses.

The GMES Space Component will provide continuous radar capacity with Sentinel-1 that will have the capability to monitor gradual ground movements to: detect centimetre-level deformations; generate elevation models; and contribute to three-dimensional geological models (together with digital surface geology and borehole data). Other services envisioned for GMES include operational land-use services, measuring surface topography and changes to it, geology, soils, chemistry, mineral and physical properties of sub-surface zones in three-dimensional structures (e.g. ground stability monitoring).[241]

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237 Satellite Navigation: Applications. EC Enterprise and Industry. http://ec.europa.eu/enterprise/policies/satnav/galileo/applications/index_en.htm

238 Green Paper on Satellite Navigation Applications. COM (2006) 769 final/2: 8. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0769:REV1:EN:PDF

239 Critical Raw Materials for the EU. EC Enterprise and Industry Report. http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf

240 Improving Framework Conditions for Extracting Minerals for the EU <http://ec.europa.eu/enterprise/policies/raw-materials/sustainable-supply/index_en.htm>.

241 Improving Framework Conditions for Extracting Minerals for the EU. Abridged Report of the Ad-Hoc Working Group on Exchanging Best Practice on Land Use Planning, Permitting and Geological Knowledge Sharing. 1 July 2010. Brussels: European Union. <http://ec.europa.eu/enterprise/policies/raw-materials/files/best-practices/sust-abridged-report_en.pdf>.

Key EU Objectives for Resources	Identifying and Developing Resources via Space
Emphasising sustainable natural resource development	<u>Remote Sensing</u>: *Sample Applications* • Facilitate decision-making on exploitation and sustainable management of ocean resources (e.g. offshore oil reserves and fisheries) • Advance marine resource management • Provide information on water quality and pollution • Contribute to seasonal forecasting • Produce basic geo-information on land cover and use and seasonal and annual changes • Provide information on the continental vegetation state, the radiation budget at the surface, water cycle, and other land-related biophysical parameters *Examples* • SPOT-4/5 illegal crops detection; observation of ecosystems endangered by mining activities • MyOcean Project <u>Navigation</u>: *Sample applications:* • Agricultural applications: variable ploughing, seeding and spraying; tractor guidance; livestock positioning and tracking; virtual fencing; land parcel identification and geo-traceability; post-harvest pick-up; field measuring; field boundary mapping and updating; precision farming; reducing waste and over-fertilisation, crop yield optimisation; optimisation of agricultural equipment life-time. • Fisheries: vessel monitoring systems *Example:* • Monitoring of fishing boats with EGNOS applications for fish stock management
Becoming a more resource-efficient economy	<u>Remote Sensing</u>: *Sample applications* • Geology applications for minerals excavation (exploration and exploitation) • Forestry • Agricultural development • Land use • Provide information concerning abuse of resources (e.g. unauthorised building constructions that damage the occupants of the land *Example* • Increasing the productivity of farmland by applications derived from remote sensing data, including crop status development, yielding, harvesting, fertilisation and spraying cycles • Project MISTRALS by Campania Regio and CIRA in Italy assessing unauthorised building constrictions over 551 Municipalities every 6 months <u>Telecommunications</u>: *Sample Applications* • Helping bolster the efficient use of natural resources • Achieve greater effectiveness of water management (via real-time knowledge of water quantity and quality; monitoring water flow data; notifying responsible agencies of water events; monitoring equipment breakdowns) • Provide flow forecasts (for water resource systems operation; shipping commerce on rivers; industrial water supple, protecting habitat, etc.)

	• Monitor and control flow rates to optimise consumption (e.g. for thermoelectric power generation, etc.) • Monitor weather and soil moisture for agriculture (to improve irrigation system) • Transmit data on weather events (e.g. floods, overloading of sewer systems, etc.) • Improving coordination measures during post-disaster management *Example* • Reducing the needs for in-situ presence of workers in remote mining exploitation sites. <u>Navigation</u>: *Sample Applications* • Fisheries: vessel monitoring systems • Agricultural applications • Transport applications *Example* • Use of EGNOS for optimising fuel consumption of fishing boat fleets or tractors
Enhancing European and global water security	<u>Remote Sensing</u>: *Sample Applications* • Contributing to existing knowledge about the global water cycle (through studying the atmosphere: i.e. monitoring clouds, water vapour precipitation and winds) • Contribute to soil moisture and salinity measurements • Extract various in-water and bio-optical properties to help monitor water quality • Improve water movement detection (surface and ground water) and water storage (surface waters, aquifers) *Example* • GRACE data was used in a Dutch-Chinese project to address water shortages and desertification in Northern China, and assess current and future water resource management scenarios (2007-2008). <u>Navigation</u>: *Sample Applications* • Remote asset tracking and monitoring • Water resource management applications • Advance geopotential height measurements used in meteorology and climate change *Example:* • Radiosondes (used in meteorology and climate studies) equipped with GPS signals improved accuracy and standardisation of measures
Implementing sustainable European food policy and monitoring global food security	<u>Remote Sensing</u>: *Sample Applications* • Acquire precipitation data for agricultural purposes • Provide surveillance and monitoring of maritime vessels and activities, including fishing, to help protect responsible exploitation of marine resources • Facilitate optimised land use for agriculture (e.g. advancing precision farming) • Monitor crops • Help manage humanitarian programmes *Example* • MERIS (Envisat) imagery used to create maps of existing water resources, suitable dam locations, and help solve water

	shortage issues (e.g. for agriculture) in Zambia in 2007. Telecommunication and Navigation: *Sample applications* • Track individual livestock and confining them to a limited area • Manage and control the Common Agriculture Policy (CAP) • Complement vessel monitoring systems (e.g. for fisheries) • Facilitate food transport safety *Example:* • EGNOS applications to track live stock transport in order to enhance food security and to guarantee quality of transported food
Maintaining access to strategic minerals	Remote Sensing: *Sample Applications* • Improve knowledge about mineral deposits • Contribute to geophysical surveys • Enable 3D geological models • Provide unique synoptic view of Earth • Enable continuous observation capacity (including in bad weather conditions) for monitoring gradual ground movements to detect centimetre-level deformations • Measure surface topography and its changes • Contribute to measuring of geology, soils, chemistry, mineral and physical properties of subsurface zones *Examples* • Satellite missions such as GOCE and GRACE have enabled the study of geoid signals (i.e. geopotential surface that would coincide with the mean ocean surface of the Earth, if the oceans were in equilibrium, at rest, and extended through the continents). • SPOT-4/5: Geologic and structural terrain information for resource exploration applications minimising risks, time, and costs Telecommunications: *Sample applications* • Facilitate mineral excavation in remote regions, deep mining or in deep waters (remote asset tracking and monitoring) • Optimise industrial activities (*e.g.* drilling phase requires large amount of effort and resources)

Table 10: Identifying and Developing Resources via Space

3.5 Knowledge

Issues related to sustainability are often depicted in terms of their environmental, social/societal and economic impacts (see figure 8 below). Accordingly, sustainable development is the ability to progress via environmentally-friendly economic efficiencies. Such efficiencies can be, in turn, achieved through scientific and technological progress. Although environmental issues have an increasing effect on people's lives, there are many times contesting views concerning the reality and degree of such effects. Sound policies based on scientific research findings, however, can inform and enrich the debate and produce positive engagement by the public.

Since the 1990s, the terms "information society" and "knowledge society" have become considerably more prominent. Whereas an "information society" often refers to the concept of technological innovation, a "knowledge society" involves social, cultural, economic, political and institutional transformation. In this regard, education plays a key role in building knowledge societies and knowledge is essential to achieving sustainable development, including poverty reduction, protection of the environment, consolidation of democracy, disease prevention, income generation and other issues.[242]

Knowledge and research are often part of the same equation. Research is an enabling tool for a number of EU policies and the fragmentation of research can reduce effectiveness and competitiveness. Scientific and technical knowledge, which is continuously advanced by space, influences not only science and technology policy, but many other public policies as decision-makers seek knowledge to enhance quality of their decisions. Science and technology policy seek the optimal means of enhancing Europe's education in these fields (e.g. engineering, mathematics, etc.) and responding to societal challenges. At the same time, science, engineering, and innovation are entwined with societal and

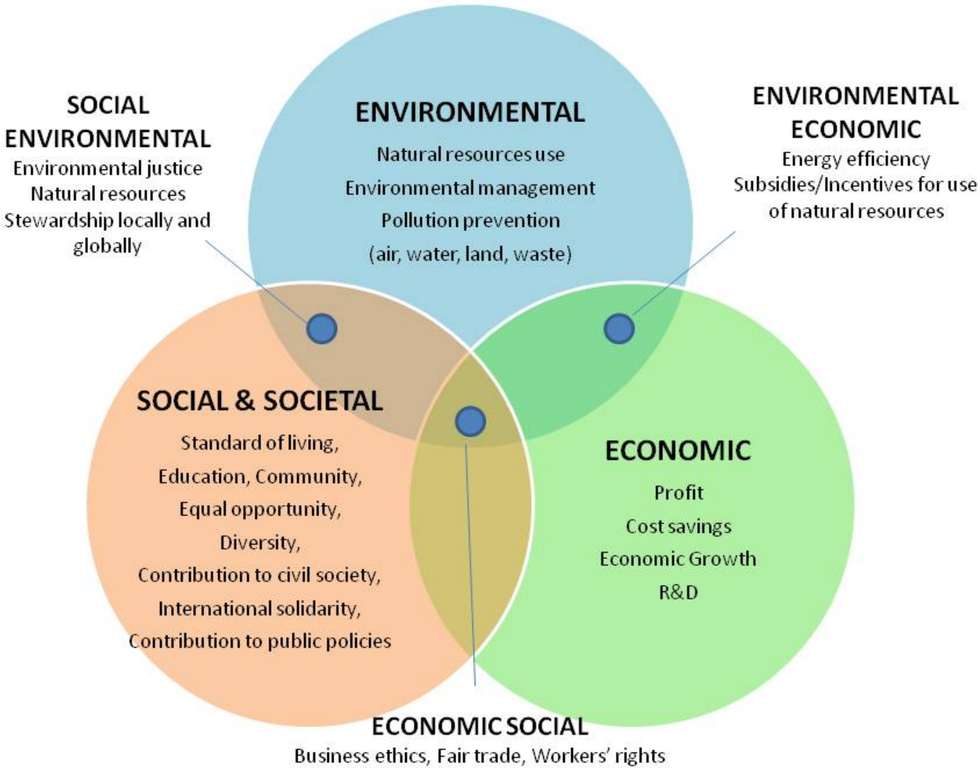

Figure 8: The three spheres of sustainability (Source: University of Michigan 2002 Sustainability Assessment)

[242] Toward Knowledge Societies. An Interview with Abdul Waheed Khan. United Nations Educational, Scientific, and Cultural Organization (UNESCO) News (18 July 2003). http://portal.unesco.org/ci/en/ev.php-URL_ID=11958&URL_DO=DO_TOPIC&URL_SECTION=201.html

economic development in areas such as transportation, communication, agriculture, education, environment, health, security, and jobs.[243]

On matters of scientific and technical knowledge, an opinion emerges when various groups of scientists and engineers achieve a broad consensus on the evidence and implications of their findings. Policy-makers then have to decide, based on this consensus as well as their own knowledge, what actions, if any, are appropriate. In short, scientific and technical knowledge can provide policymakers with the tools to make their decisions based on the best information available, together with other factors they might take into account, such as cultural and other values, so that the societal and economic benefits are strengthened and losses are mitigated.[244]

3.5.1 Europe's Knowledge Objectives

The European Union considers education and training, as well as fostering employment, among its top priorities. In July 1997, the European Commission (EC) released a Communication entitled "Agenda 2000: For a Stronger and Wider Union" in an effort to address how to best develop the EU and its policy positions, including its financial framework. Agenda 2000 emphasised the need to "put knowledge at the forefront" to respond to globalisation and the information and communication technologies that have become fundamental to the global economy and the cause of peace. The document points out that the level of global competitiveness is largely determined by the degree of a "knowledge society". The rationale behind promoting so-called "knowledge-based policies" as one of the four fundamental pillars of the EU's internal policies in Agenda 2000, was that economic and technological advancement can be significantly elevated through knowledge. The Communication observed that real wealth is no longer generated by merely the production of physical goods, but production and dissemination of knowledge gained through research, education, training and innovation.[245]

In March 2010, the European Commission (EC) launched the so-called "Europe 2020 Strategy" to overcome the present economic/financial crisis. It is described in an EC Communication entitled "Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth". As described in the previous sections, the three drivers, or objectives, are smart, sustainable and inclusive growth to be implemented through national policies. These objectives will be measured against five headline EU targets.[246] "Smart growth" involves "developing an economy on knowledge and innovation".[247] It references the EU's goal of becoming the most dynamic and competitive knowledge-based economies in the world. This is to be achieved through a "knowledge triangle," integrating research, education and innovation. The document also identified seven flagship initiatives to support the three overarching priorities. A number of these are closely connected with knowledge-building, including "Innovation Union", "Youth on the Move" and "An Agenda for New Skills and Jobs". The first is to improve the financial and other conditions needed to support innovative ideas with respect to concrete products and services. The second is an effort to improve educational systems and the transition from schools to the labour market. The last aims at lifelong development of workers' skills to allow for job mobility.[248]

Accompanying these initiatives, the terms "i-conomy" and "i-society" are now being circulated. The "i-conomy" envisions effective partnerships among all relevant actors (i.e. states, universities, companies, civil society, etc.) to produce sound policies that will advance the EU's Agenda 2020. Innovation and knowledge are the engines that will create the "value-added" with global reach. Accordingly, the "i-conomy" is based on a concept of change which is promoted and reinforced by an "i-society" that is able to attract new investments, talents and ambitions.[249]

To realise Europe's 2020 agenda, a number of new initiatives have been launched, for example, in the area of international cooperation in science and technology. A number of

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[243] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 30.

[244] Dtine Deborah D. „Science and Technology Policymaking: A Primer".http://www.fas.org/sgp/crs/misc/RL34454.pdf

[245] Towards a Europe Of Knowledge. EC Communication COM(97) 563 final (12 November 1997).

[246] The Headline Targets are: "75 % of the population aged 20-64 should be employed; 3% of the EU's GDP should be invested in R&D; The "20/20/20" climate/energy targets should be met; The share of early school leavers should be under 10% and at least 40% of the younger generation should have a degree or diploma; and 20 million less people should be at risk of poverty".

[247] "Europe 2020: A European Strategy for smart, sustainable and inclusive growth". COM(2010)2020: 3

[248] European Commission. Communication from the Commission. Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth. COM(2010) 2020 of 3 Mar. 2010. Brussels: European Union. <http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf: 3-4.

[249] Giannopapa Christina. ESPI Report 24 (July 2010): 9. http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2024%20online_1.pdf.

European institutions and programmes also help advance this agenda, among them the European Research Council (ERC), the European Institute of Innovation and Technology (EIT), the Joint Research Centre (JRC), and the European Technology Platforms (ETP). The ERC, officially launched in February 2007, was created to bridge the gap between national funding bodies for fundamental research and promoting this Europe-wide agenda. The EIT, which launched its activities in 2008, was established by the EC to bring together top-tier expertise to produce technological solutions to environmental problems. It seeks to combine the "knowledge triangle" and transition research and development to the markets. The ETPs aim at developing coordinated scientific research agendas of the key stakeholders.[250]

The JRC organises its work around five policy themes, one of which is under the heading "Prosperity in a knowledge-intensive society". It is grounded in an increased investment in research, a central priority for the EU in promoting growth and jobs. Five agendas advance this policy theme: competitiveness and innovation; the European Research Area (ERA); energy and transport; information society; and life sciences and biotechnology.[251] An Information Society, for example, is supported by Information Society Technology policies that seek to analyse trends up to 15 years forward and produce longer-term strategies related to building a knowledge society.[252]

In conclusion, Europe has a number of leading priorities concerning how to achieve its goal of becoming the most competitive "knowledge society" globally. They are summarised in table 11 below.

Key EU Objectives for Knowledge
• Enabling wide access to Europe's education resources • Increasing the efficiency of professional training and lifelong learning • Modernising higher education • Bolstering European cooperative arrangements and sharing best practices • Promoting the advancement of scientific research, knowledge and innovation • Maintaining leadership in basic research • Developing transnational partnerships to proliferate knowledge • Strengthening the link among education, business, research and innovation

Table11: EU's Key Objectives for Knowledge

3.5.2 Space as a Stimulant

The significant contribution that space science, technology, and derived applications and services can bring to policy-makers in Europe has already been recognised, including in an October 2010 European Commission Communication entitled "An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage" (COM(2010)614). In addition to space exploration and use, and advancing the EU's strategic interests on the global scale, the Communication also cites the benefits to individual citizens, as well as economic competitiveness, where space is a "driver for innovation".[253]

As the space sector in Europe is, in large part, user-driven, space technology provides an impetus for economic growth and job creation.[254] Although the use of space systems for science constitutes a much smaller percentage than use of space for operational purposes (e.g. Earth observation, telecommunications, and navigation, positioning and timing), it produces asymmetrically large benefits for European society by driving research and development, education, public interest in science and technology, and innovative thinking. In short, space systems, and their derived applications and services, can advance a number of the key EU objectives identified in section 3.5.1. They are described and summarised in table 12 below.

[250] Giannopapa Christina. ESPI Report 24 (July 2010): 41-49. http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2024%20online_1.pdf: 6.
[251] "Research Areas". http://ec.europa.eu/dgs/jrc/index.cfm?id=1590
[252] "Information Society". http://ec.europa.eu/dgs/jrc/index.cfm?id=1630&lang=en

[253] EC Communication COM(2010) 614 : 24. http://ec.europa.eu/enterprise/policies/industrial-competitiveness/industrial-policy/files/communication_on_industrial_policy_en.pdf
[254] http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2024%20online_1.pdf: 20.

Enabling Wide Access to Europe's Educational Resources

Space stimulates intellectual curiosity, including among young children. It likewise develops knowledge as it touches various disciplines such as science, technology, philosophy, etc. It inspires young people to become astronauts, scientists, engineers and to seek new and exciting discoveries. In Europe, the European Space Agency (ESA), national space agencies, non-governmental organisations, research centres, and universities all help drive the interest in space and space-related disciplines, including at the secondary school level. ESA's Eduspace programme, for example, provides internet-based resources to secondary schools, including images and satellite data. This programme stimulates interest in the environment, natural resources as well as specific areas such as Volcanology, space science, etc.[255]

At the same time, space technologies facilitate access to information for the general public. The above-mentioned EC Communication of October 2010 on Europe's industrial policy (COM(2010)614), endorsed by the EU Council the following month, stated that "satellite communications is a key space sector from both an economic and technology standpoint" and "contributes to the Digital Agenda for Europe, and notably to closing the broadband gap". Accordingly, satellite communication services not only improve the quality of life and upgrade individual capabilities, but also provide access to information and educational resources.

The Digital Agenda and the Broadband initiatives, under EC auspices, are closely related to providing educational resources. The Digital Agenda is a strategy to achieve a thriving digital economy by 2020 (i.e. a digital economy is based on electronic goods and services produced by an electronic business and traded through electronic commerce). Telecommunication systems can likewise contribute to the Digital Agenda. Specifically, they can help overcome the Digital/Speed divide when targeting universal broadband coverage objectives with internet speeds increasing up to 30 Mbps. Powerful multi-beam satellite networks can secure broadband access in low-populated areas.[256]

[255] Sustainable Development Report. European Space Agency (April 2010): 25.

[256] Fargnoli Maurizio. A New Vision of Space. Telespazio PPT Presentation at the Workshop organized by the European Space Policy Institute (ESPI) on SatCom. Vienna (15 December 2010). http://www.espi.or.at/images/stories/dokumente/conference2010/Fargnoli.pdf

Increasing the Efficiency of Professional Training and Lifelong Learning

As space activities are, by their nature, a cooperative endeavour and involve people from different disciplines, cultures, and countries, they can serve as a model for structuring interdisciplinary and continuous educational exchanges. Space facilitates exchanges among different professions (e.g. business and management, law, policy, physical and life sciences, and engineering), and advances professional training. Concerning the environment, for example, space contributes to the study of natural processes that enable the functioning of Earth's ecosystems. Understanding these processes provides a basis for advancing society and helps answer questions connected with long-term sustainability. Space systems deliver comprehensive images of the Earth and advance various broad disciplines including climate and environmental research, meteorology, oceanography, and others.[257] Accordingly, this knowledge can help structure the direction of professional training of environmental-related government agencies, organisations, and companies.

Telecommunications technologies also help catalyse social progress. Satellites facilitate affordable communications to a majority of European citizens. They also connect those that live in less developed areas without terrestrial cable or wireless links that provide internet access. Satellite broadband with user terminals adjusted to their needs and conditions create training and educational opportunities without the need for travel. Applications such as e-learning (i.e. training provided using the Internet) provide access to information and contacts that enhance other more traditional methods.[258]

Bolstering European Cooperative Arrangements and Sharing Best Practices

Cooperation among various European entities is often key to sustainable social and economic development, including in the area of research. Research underpins credible knowledge, professional skills, and competitive advantage. It is also the linchpin of new scientific and technological breakthroughs. In the last decade, cooperative "clusters" of small/medium size enterprises working together with larger firms, research institutes and universities in technology-related industries, have become more prominent. They interact under the model called "open innova-

[257] Op. Cit. Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 25-29.

[258] Sustainable Development Report. European Space Agency (April 2010): 21-22.

tion"[259] and frequently establish science parks and centres as well as strengthen links between different regions.[260] In this connection, the European Space Agency (ESA) has proposed a number of initiatives to help stimulate the growth of Small and Medium-sized Enterprises (SME). By allowing the SMEs to participate on ESA's programmes, ESA encourages innovation and supports the emergence of internationally-competitive SMEs through the development of more sophisticated technologies and products.[261]

In 2002, four partners involving ESA, the European Business and Innovation Centre Network (EBN), the WSL, and D'Appolonia established an experimental platform for sharing knowledge and technologies called the European Space Incubators Network (ESINET). It has become a leading network of incubators focused mainly on space-related technologies. Since 2009, the ESINET has been managed by the EBN, which is considered to be the foundation of Innovative Entrepreneurship and Incubation in Europe.[262]

Promoting the Advancement of Scientific Research, Knowledge and Innovation

As mentioned above, research stimulates scientific knowledge and innovation. Innovation, in particular, has received high-level of attention. For these purposes, innovation can be defined as "the use of new, or existing, ideas, discoveries and inventions from other sectors in the space sector (i.e. spin-in), and vice versa, to create economic and social benefits".[263] The traditional linear model of innovation, involving the flow from science to technology and from business to markets, has been replaced by innovation concept as a self-propelling, complex system where everything is interconnected, and space is involved in all crucial determinants in the innovative (see figure 9 below). Accordingly, European science policy benefits greatly from space-related research.

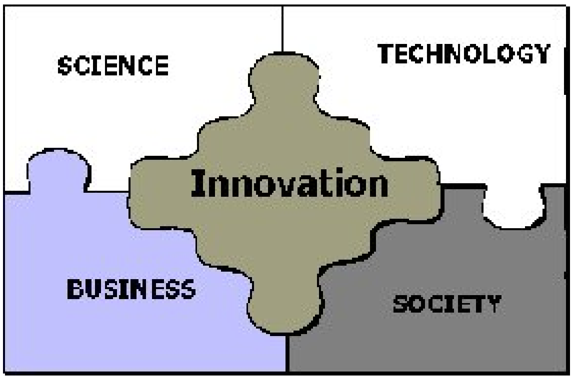

Figure 9: Crucial players in the innovation (Source: Economics Web Institute[264])

For example, space exploration can advance research concerning the origin of universe and our life on Earth.[265] Solar and space weather research helps us understand solar-terrestrial relations and their impact on technological systems as well as on the human condition.[266] As space systems require demanding engineering solutions, they also catalyse technological innovation. The European Space Agency (ESA) is at the forefront of science and technology research and development. ESA also has a distinguished history of building partnerships with different institutions and organisations, as well as governments. Accordingly, it provides valuable expertise in identifying important technologies and selecting cooperation partners to achieve cutting-edge innovation.[267]

Space-based remote sensing provides a unique view of the entire Earth, enables observation of large-scale phenomena with a high level of accuracy and monitors gradual environmental changes. Accordingly, it contributes to understanding about various interactions of the ecosystems. It improves environmental knowledge by providing information on ocean levels, ocean salinity, polar ice sheet thickness, oil spills, soil humidity, vegetation cover, crop types and evolution, land cover classification, habitat, etc.

Moreover, space-based sensors can conduct various measurements, including measuring the topography, or calculating earthquake-

[259] "Open innovation" paradigm is based on an idea that firms, in their effort to advance their technology, can, and should, use both extarnal and internal ideas and paths to market.
[260] Giannopapa Christina. Key Enabling Technologies and Open Innovation. ESPI Report 24 (July 2010): 13.
[261] Sustainable Development Report. European Space Agency (April 2010): 23.
[262] About ESINET. ESINET Website. http://www.esinet.eu/DisplayPage.aspx
[263] Giannopapa Christina. Key Enabling Technologies and Open Innovation. ESPI Report 24 (July 2010): 12.

[264] Piana Valentino. Innovation. Economics Web Institute. http://economicswebinstitute.org/glossary/innovate.htm
[265] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 47-59.
[266] Rodgers David J.. Benefits of a European Space Weather Programme. Defence Evaluation and Research Agency UK for ESA. ESWPS-DER-TN-0001 (21 July 2000). http://www.esa-space-weather.net/spweather/esa_initiatives/spweatherstudies/RAL/TR110v2_1.pdf-a.pdf
[267] Sustainable Development Report. European Space Agency (April 2010): 20.

induced land movements at the centimetre scale.[268] Remote sensing advances other areas of science as well, including physical geography, geology, geophysics, meteorology, oceanography, climatology, global environmental changes, biochemical cycles, natural resources, fundamental physics, material sciences, biotechnology and others.[269] In this regard, ESA's Earth Explorers in orbit (i.e. GOCE, SMOS, and CryoSat-2) demonstrate Europe's strong capability in Earth observation for the study of the environment, including climate change.[270]

Observations of space phenomena advance domains such as astronomy, astrophysics, the observation of exoplanets, cosmology and fundamental physics, solar and heliospheric physics and the exploration of the solar system.[271] To illustrate this point, astronomy drives, for example, the development of extremely sophisticated ground-based telescopes. Four telescope units built in Atacama Desert in Chile (the Paranal Observatory) by the European Southern Observatory (ESO), constitute the Very Large Telescope (VLT). The VLT is the world's most capable astronomical infrastructure and can offer high-resolution observation of very distant objects in the universe and facilitate the conduct of multi-wavelength analyses of electromagnetic radiation emitted by various objects in space (e.g. planets, galaxies, etc.).[272] The Committee on Space Research (COSPAR), an international organisation promoting scientific research in space, emphasises information exchanges of opinions and results that is open to scientists globally.[273]

Human space flight and exploration have significantly contributed to expanding human knowledge about the universe and have driven innovation. The International Space Station (ISS), the only international orbiting facility and laboratory, has been used to conduct research, scientific experiments, as well as stimulate debate on the future approach to human space flight and exploration where innovative solutions will be critical for success.[274]

Telecommunications systems advance knowledge and promote innovation simply by facilitating the exchange of information among scientists, as well as the general public. They make possible radio, television and telephone communications. Scientific domains such as information technologies and optronics enable technological development in other fields, including telemedicine/telesurgery, health alert systems, etc.[275] Distribution of scientific information also enhances knowledge. In this connection, the EC and ESA launched a project called GENESI-DR (Ground European Network for Earth Science Interoperations-Digital Repositories) that seeks to provide an integrated platform. Such a platform will allow scientists to access, combine, and integrate historical and present Earth-related data from space, airborne and in situ sensors from various digital repositories in Europe via the Internet.[276]

Maintaining Leadership in Basic Research and Developing Partnerships to Proliferate Knowledge

Traditionally, "basic" research has focused on answering fundamental questions raised by various sciences. "Applied" research involves the use of acquired knowledge to, for example, spur technology development. As the distinction between the two are sometimes less relevant in today's scientific community, the term "frontier" research might better be used.[277] Information and data are required to advance knowledge and satellites offer various forms of information and data to fuel research. For example, as remote sensing satellites are able to take global snapshots and repeat the process at regular intervals, they can build a database of global change. The datasets include, for example, global temperature and radiation balance, ice-cover monitoring, the melting of the polar caps, etc.[278] Science satellites provide images and other data on space objects and physical processes in outer space.

An excellent example of how space contributes to expanding our knowledge base

[268] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 36.
[269] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 27-29.
[270] Dordain Jean-Jacques. Forward. European Space Directory 2010: 4.
[271] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 33.
[272] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 27-29.
[273] Committee on Space Research (COSPAR) website. http://cosparhq.cnes.fr/About/about.htm
[274] Space for Innovation in Sustainable Development Report. European Space Agency (April, 2010): 20.
[275] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 40.
[276] GENESI-DR in depth. http://www.genesi-dr.eu/index.php?menu=infos&type=background
[277] Giannopapa Christina. Key Enabling Technologies and Open Innovation. ESPI Report 24 (July 2010): 12.
[278] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork (2009): 50-52.

through international cooperation is the Hubble Space Telescope, one of the most significant scientific projects to date. The basic mission of this NASA telescope is astronomy and enables far-sighted scientific advances that will enhance human understanding of our place in the universe. For over 20 years (the Hubble Telescope was launched in April 1990), the Hubble has allowed observation of the universe and has made a number of fundamental discoveries in astronomy and physics.

Europe has been involved in the mission through ESA, which has a 15% stake and provided, for example, the Faint Object camera and the first two sets of solar panels that powered the spacecraft until 2002. ESA's contribution entitles European astronomers up to 25% of the telescope's observing time and European scientists can exchange views at the Space Telescope European Coordinating Facility (ST-ECF). The Hubble Telescope mission also demonstrates successful cooperation among scientists. Two main centres for Hubble science employ dedicated groups of full-time astronomers at the Space Telescope European Coordinating Facility near Munich and the Space Telescope Science Institute (STScl) in Baltimore, and many other astronomers in Europe can take advantage of the Hubble.[279]

Strengthening the Links among Education, Business, Research and Innovation

The EU has been focusing considerable energy on how to promote partnerships that can form a so-called "knowledge triangle" of education, innovation and research. It has involved the creation of a European Research Area. The Seventh Framework Programme (FP7) is comprised of concrete projects to advance this effort which basically entails all research-related EU initiatives under a joint umbrella. Space-related projects, which have their own research budget for the first time in FP7, will contribute to promoting scientific progress and excellence, as well as to the development of a comprehensive European Space Policy. Space-based science and research activities, including those covered under the FP7, will likewise drive new technological developments.

Space-related research activities under the FP7 include: space-based applications for European society (i.e. satellite observation systems, including GMES services); exploration of space (including support for collaborative initiatives between ESA and national space agencies and efforts to develop space-borne telescopes); and research and technological development for strengthening space foundations (to address long term needs such as space transportation, bio-medicine, life and physical sciences in space).[280] Galileo and GMES, the two EU flagship programmes, demonstrate Europe's resolve to undergird space-related projects that can offer a broad range of applications.

Key EU Objectives for Knowledge	**Space as a Stimulant**
Enabling wide access to Europe's education resources	<u>General Contribution</u>: *Sample Applications:* • Stimulating curiosity • Inspiring young people to undertake new discoveries about the universe • Developing knowledge through scientific and technological challenges *Example* • ESA's Eduspace programme that provides space-related resources via the Internet <u>Telecommunications</u>: *Sample Applications:* • Facilitating access to information for the general public • Improving the quality of life and meeting individuals' needs • Providing access to educational resources • Contributing to the Digital Agenda for Europe (e.g. help overcom-

[279] Note Antonella, Mark McCaughrean, Bob Fosbury, Colleen Sharkey, and Carl Walker. Seeing With Hubble-Vision. ESA Bulletin No.142 (May 2010): 3-11.
[280] FP7: Tomorrow's Answers Start Today. European Commission, FP7 Factsheet. http://ec.europa.eu/research/fp7/pdf/fp7-factsheets_en.pdf

	• ing the Digital/Speed divide band securing broadband access to low-populated areas) • Offering an e-education (e.g. e-library, e-learning, e-forum for debates, etc.) *Example:* • There exist a number of online intra-European, as well as Europe-Latin American and African countries Master Programmes
Increasing efficiency of professional training and lifelong learning	<u>General Contribution</u>: *Sample Applications* • Viewing space activities as a cooperative endeavour that can serve as a model for structuring interdisciplinary educational and professional training exchanges • Facilitating exchanges among different professions (e.g. law, business/management, engineering, etc.) <u>Remote Sensing:</u> • Remote sensing images and other products can advance other disciplines (e.g. study of the Earth's ecosystems) and contribute to the structuring of professional training in different fields by government agencies, non-governmental organisations and universities <u>Telecommunications</u>: *Sample applications:* • Contributing to social progress • Facilitating affordable communications to a majority of European citizens • Connecting those that live in less-developed areas without terrestrial cable or wireless links that provide internet access • Training and educational opportunities without the need for travel *Example* • E-learning • Internet services
Bolstering European cooperative arrangements and sharing best practices	<u>General Contribution:</u> *Sample Applications* • Cooperating at the frontier of scientific and technological breakthroughs • Creating cooperative "clusters" of small/medium size enterprises together with large companies, research institutes and universities in technology-related industries (based on "open innovation" models) *Examples* • ESA presented initiatives to help the growth of SMEs by their participation in ESA's programmes • European Space Incubators Network (ESINET)
Promoting the advancement of scientific research, knowledge and innovation	<u>General Contribution:</u> *Sample Applications* • Employing existing or new ideas, discoveries and inventions originated in the space sector for other sectors (spin-offs) to generate economic and social benefits • Supporting European science policy through space-related research • Advancing technological innovation *Example* • ESA's building of partnerships with different institutions, organisations and governments to provide valuable expertise in identifying important technologies and selecting cooperation partners • EC-ESA joint project GENESI-DR (Ground European Network for Science Interoperations-Digital Repositories) distributing scientific

	information <u>Remote Sensing</u>: *Sample Applications:* • Providing unique view of the entire Earth • Enabling observation of large-scale phenomena with a high level of accuracy • Monitoring gradual environmental changes • Improving understanding of various interactions of the Earth's system • Providing information on ocean levels, ocean salinity, polar ice sheet thickness, oil spills, soil humidity, vegetation cover, crop types and evolution, land cover classification, habitat, etc. • Conducting various measurements, including of the topography, or calculating earthquake-induced land movements at the centimetre scale. • Advancing other areas of science, including physical geography, geology, geophysics, meteorology, oceanography, climatology, global environmental changes, biochemical cycles, natural resources, fundamental physics, material sciences, biotechnology, etc • Remote sensing activities to study deep space to provide new knowledge about the Universe *Example* • ESA's Earth Explorers in orbit (i.e. GOCE, SMOS, and CryoSat-2) • SIRAL (CryoSat-2) is a new generation altimetry system derived from the Poseidon ocean altimeter on Jason and combines three measurement modes to determine: the topography of land and sea ice masses; low resolution for conventional altimetry; Synthetic Aperture Radar (SAR) for high resolution imagery of floating ice; and interferometric radar mode for the study of very active areas. SILAR is the result of 20 years of altimetry systems development <u>Science and Exploration</u>: *Sample Applications* • Advancing research concerning the origin of the universe and life on Earth • Helping understand solar-terrestrial relations and their impact on technological systems and human lives • Advancing: astronomy; astrophysics; the observation of exoplanets; cosmology and fundamental physics; solar and heliospheric physics and the exploration of the solar system. *Examples:* • Very Large Telescope (consisting of four telescope units built in Atacama Desert in Chile), operated by the European Southern Observatory (ESO), integrated with the interferometer infrastructure (VLTI), is the most sophisticated astronomical infrastructure on Earth. It can produce high-resolution of distant objects in the universe, and can conduct multi-wavelength observations of electromagnetic radiation emitted by various objects in space (e.g. planets, galaxies, etc.). • SOHO is a cooperative solar exploration mission including NASA, ESA, and ESA Member States. • ISS, the international orbiting facility and laboratory, has been used to conduct research, scientific experiments, as well as stimulated debates on the future approach to human space flight and exploration. <u>Telecommunications:</u> *Sample Applications* • Facilitating exchanges among scientists as well as general public • Enabling technological developments in other fields through, for

	example, information technologies and optronics (e.g. telemedicine/telesurgery, health alert systems, etc.) • Testing operations for advanced telecommunication through deep space (e.g. Ka-band in atmosphere-free environment) • Data Relay Satellite to guarantee continued and real-time communication involving humans in outer space
Maintaining leadership in basic research and Developing partnerships to proliferate knowledge	(Note: See also the previous section of this table) <u>General Contribution</u>: *Sample Application:* • Providing information and data advancing basic research knowledge (e.g. remote sensing and science satellites) *Example:* • The Hubble Space Telescope enables cutting-edge scientific advances and demonstrates successful cooperation among scientists • The ISS is the pinnacle of international cooperation in space activities for the proliferation of scientific and technologic knowledge <u>Science and Exploration</u>: *Sample Applications:* • Astronomy • Life sciences • Gravity research • Micrgravity research • Solar exploration • Exploration of the Solar System • Space system technology *Example:* • The Integral mission, a gamma ray astronomy mission, is performing basic research for better understanding of extreme celestial bodies such as black holes and supernovas.
Strengthening the links among education, business, research and innovation	<u>General Contribution:</u> *Sample Applications* • Space-related projects contribute to promoting scientific progress and excellence as well as the development of a European Space Policy • Space-based science and research drives new technological developments, advanced knowledge and innovation

Table 12: Space as a Stimulant for Knowledge

3.6 Mobility

The term mobility covers a wide range of fields, including sociology, engineering, science, and others. Due to the limitations imposed on the scope of this study, "mobility" in this section will refer solely to transport and related considerations. Specifically, it will focus on land, maritime, and air transportation, as well as virtual mobility, and the role that space systems play in advancing and upgrading these forms of transportation. Antonio Tajani, Vice-President of the EU Commission and Commissioner for Transport, observed in his Foreword to an EC Communication of June 2009, that "transport is the backbone of the European economy".[281] The transport sector is influenced and shaped by external factors (i.e. population, economic development, energy, technology development and social change) as well as internal factors, including infrastructure, vehicles and fuel development, and impact on the environment and society. Finally, policy decisions also guide the evolution of transport systems.[282]

[281] A Sustainable Future for Transport: Towards an Integrated, Technology-led and User-Friendly System. European Communities (2009): 3. http://ec.europa.eu/transport/publications/doc/2009_future_of_transport_en.pdf

[282] Report on Transport Scenarios with a 20 and 40 Year Horizon. European Commission DG TREN, TREN A2/78-2007 (24 March 2009): 11. http://ec.europa.eu/transport/strategies/studies/doc/future_of_transport/2009_02_transvisions_report.pdf

Since road traffic is expected to remain the dominant passenger transport method for at least the next decade, new efficiencies, and technologies will be critical in reducing greenhouse gas (GHG) emissions in Europe, and particularly CO_2. For maritime transport, which accounts for some ninety percent of global trade, as well as for passenger air traffic, greater reliability and efficiency are likewise key aspirations, especially given oil price volatility. Satellite-based remote sensing, telecommunications, and navigation and positioning advance the transport modes referenced (i.e. land, maritime, and air), increase traffic safety and security, as well as offer new applications for personal use. Sustainable mobility would contribute importantly to the EU's Sustainable Development Strategy (EU SDS) as it is closely linked to sustainable sources of energy and resources, as well as environment.[283]

3.6.1 Europe's Mobility Objectives

The EU's next "Transport White Paper" will build on a 2001 White Paper that established an agenda for the European transport policy (ETP) until 2010.[284] The 2001 White Paper was later updated in 2006[285] and defined a strategy and action plan for transport policy over the next decade in order to contribute to the EU's 2020 Strategy's flagship initiatives of "Innovation Union" and "Resource-efficient Europe". The 2010 White Paper will likewise outline new concepts and modalities to reduce emissions in the course of the next four decades (up to 2050). The "roadmap" for the 2010 White Paper cited the following challenges: reducing transport-related pollution and GHG emissions; creating a complete internal transport market (e.g. in the maritime sector); reducing safety and security threats (e.g. road accidents); and forging a common EU position for presentations and negotiations in international organisations (e.g. lack of EU membership in specialised international organisations).[286]

With regard to the first item, road transport had the highest growth rate of GHG emissions from all sectors compared to 1990 levels.[287] In 2004, for example, 19% of GHG emissions originated from transport sector. The transport sector was also the only one that reported higher emissions (+26%) from 1990 to 2004 and road transport was responsible for more than 90% of these emissions.[288] Moreover, transport still depends up to 97% on fossil fuels, impacting negatively on the security of energy supplies. To address this problem, the 2009 Climate and Energy Package established a binding target of a 10% share of renewable sources in transport by 2020.[289] This effort to reduce transport-related pollution and GHG emissions is aimed at contributing to the goals of the EU Sustainable Development Strategy (EU SDS), an area where the ETP is still lagging behind.[290]

As mentioned in the introductory section, transport is a crucial element of the European economy as the transport industry constitutes approximately 7% of GDP and more than 5% of total EU employment. Besides the challenges referenced above, other mobility-relevant issues need to be taken into account. Among them are: ageing (by 2060, the number of people over 75 is expected to represent 30% of the population as opposed to today's 17%); migration and internal mobility (over the next five decade, 56 million people are expected to migrate to the EU); urbanisation (84% of Europe's population is expected to live in the cities by 2050 and urban transport already constitutes 40% of CO_2 emissions and 70% of road transport-related pollution); and globalisation (the increase in the world population to over 9 billion by 2050 and resulting increased demand on global resources).[291]

Given the complexities associated with establishing a sustainable and efficient transport system and improving mobility, a draft White Paper on Transport entitled "A Single Transport Area: Smart Mobility for People and Business", identified a number of objectives in accordance with the three overarching goals of the Agenda 2020. Concerning "smart growth", the objectives include: implementing the concept of a Single Transport Area; modern infrastructures for greener transport; low-carbon technologies; and secure funding.

283 Schrogl Kai-Uwe, Wolfgang Rathgeber, Blandina Baranes, and Christophe Venet (eds.). Yearbook On Space Policy: 2008/2009. Vienna: SpringerWienNewYork (2010): 12-13.
284 COM(2001) 370.
285 COM(2006) 314.
286 Roadmap – 2010 Transport White Paper. Brussels: European Union. <http://ec.europa.eu/governance/impact/planned_ia/docs/18_move_white_paper_future_transport_en.pdf>.
287 DG TREN (2009), EU energy and transport in figures. Statistical pocketbook 2009.

288 Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 208.
289 OJ L 140, 5.6.2009, p. 16-62, Directive 2009/28/EC.
290 Progress Report on the Sustainable Development Strategy 2007. Brussels: EC Communication (COM(2007) 642 final) 22 October 2007. < http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0642:FIN:EN:PDF>
291 White Paper on Transport. Part 1: Challenges. Draft 06/08/2010. http://www.euractiv.com/sites/all/euractiv/files/transport_whitepaper_part%20I-1.doc

Objectives for transport in the area of "inclusive growth" involve quality services and jobs and territorial cohesion. Territorial cohesion is defined as encouraging balanced territorial development and access to all territories notwithstanding their remoteness and density of population through transportation infrastructure. The principal "sustainable growth" transport objective continues to be constraining GHG emissions.[292]

A Single Transport Area will seek to eliminate existing barriers among different national systems and modes as well as increase transport efficiency. In this connection, application of traffic management systems to alleviate congestion is envisioned through so-called Intelligent Transport Systems (ITS). The ITS use information and communications technologies for transport, including computers, electronics, satellites, and sensors (e.g. future Galileo system).[293] To advance the EU 2020 Strategy's flagship initiative, "Resource efficient Europe", smooth cross-border connections and transportation platforms for cities, ports and logistics are to be developed that are environmentally friendly and safe. Technological development is to drive the development of low-carbon technologies. Accordingly, the EU will seek to identify the most promising transport-relevant technologies and encourage cooperation among relevant actors in the transport systems.

Part of Europe's 2020 Strategy and the Common Transport Policy (CTP) is the concept of the Trans-European Transport Network (TEN-T). The overarching objective of the TEN-T is "a single, multimodal network covering both traditional ground-based structures and equipment (including intelligent transport systems) to enable safe and efficient traffic". The idea is to integrate land, sea and air transport infrastructure with a view to increasing efficiency of traffic management through the employment of innovative systems, technical installation, information and telecommunications systems, as well as intelligent transport systems.[294]

In conclusion, Europe has a number of leading priorities concerning how to achieve its goal of advancing and modernising mobility in accordance with its Agenda 2020 and EU SDS objectives. They are summarised in table 13 below.

Key EU Objectives for Mobility
• Facilitating virtual mobility • Strengthening transport safety and security • Assuring environmentally sustainable transport • Developing a Trans-European Transport Network (TEN-T) • Increasing traffic management efficiency • Ensuring long-term competitiveness of EU transport services and technologies

Table 13: EU's Key Objectives for Mobility

3.6.2 Space as a Means to Promote Mobility

In the area of mobility, space-based positioning, navigation and timing (PNT) services provided by the global navigation satellite systems (GNSS) are especially useful. The positioning of vehicles, goods, and their tracing and tracking enables the development of applications that contribute to safer, cleaner and more efficient traffic. Europe's Geostationary Navigation Overlay Service (EGNOS) is Europe's satellite-based augmentation system (SBAS) which upgrades the Global Positioning System's (GPS) open public service.

EGNOS constitutes three geostationary satellites over Europe and a network of ground stations and is the precursor to the EU's Galileo, a GNSS system. It improves the accuracy of GPS to within a three-metre range. It also verifies the GPS system's integrity, that is the correctness of the location information and warnings about when GPS data should not be used to safety-critical applications (e.g. for aviation and maritime). Three services offered by EGNOS are: Open Service (operational since October 2009); Safety-of-life Service that will provide integrity message warnings of GPS malfunctioning within six seconds; and a Commercial Service, a terrestrial commercial data service. EGNOS can provide a valuable contribution to aviation, road transport, agriculture, various applications using Location-Based Services (LBS), and maritime transport.[295]

Facilitating Virtual Mobility

Computers and communications systems form computer networks which represent critical information infrastructure.[296] Virtual

[292] Draft White Paper on Transport. Part II: Goals and Vision. http://www.euractiv.com/sites/all/euractiv/files/transport_whitepaper_part%20II.doc

[293] Intelligent Transport Systems. European Commision, Mobility & Transport. http://ec.europa.eu/transport/its/index_en.htm

[294] The TEN-T Components. http://ec.europa.eu/transport/infrastructure/networks_eu/networks_eu_en.htm

[295] About EGNOS. GSA Website. <http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos>.

[296] Dertouzos, Michael (1998). What will be: how the new world of information will change our lives. Harper, New York (1998).

mobility is a set of information and communications technology (ICT)-supported activities that offer access to courses and study schemes and facilitate communication exchanges among teachers, fellow students, etc. Although student mobility encourages internationalisation, it is often not realistic to arrange physical exchanges for the majority of students. Accordingly, virtual mobility is now perceived as a necessary addition to traditional education. It can also enhance international work placement by preparing students for the fast-changing, knowledge-based economy. The EU-VIP (Enterprise-University Virtual Placements) project, for example, examines ways in which virtual mobility can enhance international work placement.[297] Other projects include the Hamlet project which provides full integration of different media's didactic-pedagogical possibilities to create a flexible learning environment through satellite communications and terrestrial-based Internet; and CROCUS (Cross-Cultural Satellite services for immigrant communities in Europe) project which disseminates multimedia and interactive didactic units for first and second language learning and intercultural education via satellite, and a number of other capabilities.[298]

Beyond the most obvious virtual mobility application, namely TV through satellite broadcast, other applications of satellite communications for virtual mobility include: online shopping (e.g. Advanced Broadcast Architecture for Retail Internet Services that allows multicasting of music products from World Wide Web); providing broadband internet connection to rural areas without ADSL access (e.g. the Distributed Satellite Broadband – DSB project); and others.[299]

Virtual mobility can also help advance other fields such as medical services at distance (i.e. telemedicine/medical e-training). As referenced above, satellite communications have the ability to distribute educational content over vast geographical areas and bring broadband connectivity to even remote locales. ESA has initiated a number of telemedicine-related projects. They include: the mobile telemedicine demonstrator DELTASS; the European Medical Network (EMN) that created a distance-learning service for medical professions in Europe; Euromednet that coordinates telemedicine services through the Tele-medicine Operational Centre (TOC); Health Information Services, a television- and IP-based information platform addressing patients in waiting rooms and doctors in surgeries; MIST (Marine Interactive Satellite Technologies) project providing teleconsulting for isolated and mobile sites like ambulances and ferries; and a number of others.[300]

Strengthening Transport Safety and Security

Increasing demand for mobility also stimulates increased demand for information and the need to address safety and security issues. Navigation systems can provide information and related services concerning the users' mobility and geographic position (so-called LSB, Location-Based Services). The GPS in cars represents the most obvious case of space positioning and location services.[301] As described in the introduction, Europe operates the European Geostationary Navigation Overlay System (EGNOS), which augments the American GPS and provides improved service for European users. In the future, a GPS-equivalent, Galileo, is envisioned for full-scale NPT services.

A number of satellite-based services improve air traffic safety. Satellite navigation offers continuous services and is already used for en route navigation. Communications systems (i.e. Satellite Data Link System - SDLS) have the ability to broadcast quality-of-service data to aircrafts. Monitoring of the flight plan and route according to the Flight Management System (FMS), as well as notification of the aircraft crew and, in some cases, the air traffic organisations or relevant institutions, is carried out by a system consisting of three segments, including satellite navigation. The System includes: a mobile segment (comprising the Aeronautical Earth Station, the GNSS receiver, the FMS, and the on-board computer); a space segment (GPS, SDLS, EGNOS/Galileo); and a ground segment, mainly involving the Ground Earth Station (an SDSL component), the Wide Area Network (WAN), and the server.[302]

Due to safety issues, the GPS does not fulfil the safety system requirements whereby pilots need to be informed in seconds about system performance degradation for applications such as airplane landing. The EGNOS

[297] EU-VIP Project Website. http://www.euvip.eu/index.html
[298] Ten Years of ESA Telecommunications Applications. The European Space Agency (2 December 2008) 23-24. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=29067
[299] Ten Years of ESA Telecommunications Applications. The European Space Agency (2 December 2008) 11-22. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=29067
[300] Ten Years of ESA Telecommunications Applications. The European Space Agency (2 December 2008) 5-10. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=29067
[301] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 222.
[302] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 224.

ground infrastructure constantly monitors GPS performance and provides error corrections. Accordingly, it increases the navigation accuracy of the signal and is also able to detect GPS satellite faults and transmit timely warnings. The U.S. uses a similar augmentation system (the US WAAS) for the North American region. After acquiring certification by civil authorities, EGNOS will be available for civil aviation landing.[303] Similarly, to improve road safety, EGNOS can offer a number of useful applications. They include: driving assistance; emergency call; anti-theft systems; speed enforcement; tracking hazardous goods; traffic information collection, and others.[304]

Personal navigation services are also based on GNSS technologies and assist rescue missions, such as those involving leisure yachts.[305] They also provide personal safety services to individuals, including those with impairments or disabilities. A satellite navigation console, for example, offers an audio feed describing the route to people with visual impairments.[306] Other technologies include adapted applications for smart phones. A project under the GALILEO FP7 R&D programme called INCLUSION, for example, aims at helping alleviate the difficulties associated with personal mobility for disabled people. This programme is developing a set of applications, including the development of a location-based service (LBS) for motor-impaired people. It should contribute to the adoption of GNSS systems and ground-based systems for LBS applications for disabled people.[307]

Space telecommunications enable the continuous exchange of information and tracking control, including for deep-sea navigation. The Automatic Identification System (AIS) is supported by navigation and telecommunications systems (the AIS is described in the "*Increasing Traffic Management Efficiency*" subsection below). Remote sensing satellites increase safety and security of navigation by providing high-resolution mapping on land, ocean-related information for maritime traffic, and weather information. Accordingly, the combination of all space-based services enhances safety in the increasingly heavy maritime, land, and air traffic. To conclude, new technologies such as satellite navigation, broadband telecommunications, and geographic information system (GIS) can support transport management, including for the transportation of dangerous goods.

Assuring Environmentally Sustainable Transport

To reduce, or even prevent, heavy traffic congestions and reduce energy waste and harmful emissions, an inter-modal system (i.e. a system that matches all possible modes of transport) has been introduced. It involves the movement of passengers or freight from one mode of transport to another, usually occurring at a terminal specifically designed for such a purpose.[308] Intermodality improves economic performance and facilitates movement. It can also provide a service with "one ticket" for passengers or "one bill of lading" for freight.[309] Maritime transport, for example, which constitutes part of the inter-modal system, can be supported by guided navigation to manage harbour-related services and improve seaport systems by advancing the accuracy, safety, and speed of entering and mooring.[310]

For road traffic, one of the means to measure traffic status is to use data from vehicles that send their satellite-based positions (so-called Floating Car Data-FCD). This enables estimation of actual travel time and potential traffic jams and can calculate precise and fast route guidance. The FLEET project (Fleet Logistics Service Enhancement with Egnos & Galileo Satellite Technology) used vehicles as test beds to determine traffic status and provide traffic information without depending on traditional roadside equipment (e.g. induction loops). The acquired data are then transformed into valuable traffic information for travellers.[311]

[303] Aviation Case Study: Landing With Satellite Navigation. The GSA Website. http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos/case-studies/aviation-case-study-landing-with-satellite-navigation
[304] Road Transport Case Study: Road Pricing and Pay-Per-Use Insurance. The GSA website. http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos/case-studies/road-transport-case-study-road-pricing-and-pay-per-use-insurance
[305] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 227-228.
[306] Modern Pilgrims Boost Satellite Navigation For All. The GSA Website. http://egnos-portal.gsa.europa.eu/news/modern-pilgrims-boost-satellite-navigation-for-all
[307] INCLUSION Project. Project Background. http://inclusion-fp7.org/
[308] Rodrigue Jean Paul, Brian Slack, and Claude Comtois. Intermodal Transportation. The Geography of Transport Systems. Hofstra University. http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/ch3c6en.html
[309] Ibid.
[310] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 227-228.
[311] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 235-240.

Developing a Trans-European Transport Network (TEN-T)

The European initiative, EUPOS (European Position Determination System), aims at establishing a uniform Differential Global Navigation Satellite System (DGNSS) infrastructure in Central and East European Countries (in 15participating states).[312] It is a good example of efforts to improve traffic flow and optimise transport modes. By the implementation of transport management systems based on EUPOS, traffic can be made significantly more efficient. The DGNSS correction data for real-time positioning and navigation, and DGNSS observation data for post processing positioning, will fulfil accuracy requirements of geodesy and navigation. It will also guarantee availability and quality of service. Europe's future Galileo will become the main GNSS standard for EUPOS.[313]

Increasing Traffic Management Efficiency

Each transportation mode is connected to traffic management. Traffic management centres often serve only one mode of transport. In the case of ground-based public means of transport, integrated traffic management pre-plans data to optimise performance and ensure safety of the traffic (i.e. railways, trams, buses and metros). With regard to road transport, traffic management is based on statistical data such as traffic density, average speed, etc. In the case of maritime, air and rail transport, individual vehicles serve as the basis for traffic management. Under normal circumstances all the information that is fed into the traffic management systems are available in advance. In the event of a disaster or major accident, the detection, identification, and measurements of the strength and direction of traffic flows are extremely important. Remote sensing can provide this valuable information. Consequently, the communication networks step in and distribute the information to qualified receivers. Finally, navigation, positioning and timing systems are able to locate and navigate emergency and/or rescue operations (i.e. crew, emergency cars, etc).[314]

In addition to aiding navigation, EGNOS can also serve as a positioning information system. The Automatic Identification System (AIS) uses VHF communications for the distribution of maritime-vessel identification, position, course, speed and other navigation information. It can likewise provide differential corrections. EGNOS offers position accuracy and integrity data for the AIS applications (e.g. port manoeuvres). For example, the AIS VHF communication channel can be used to report an EGNOS-based computed position on the ship. ESA's MARLET Project (the Maritime LOPOS EGNOS Test Bed), has demonstrated the high reliability of EGNOS positioning even under adverse conditions.[315]

In this connection, the marine Vessel Traffic System (VTS) constitutes an improved radar harbour surveillance sensor, computer and display system that monitors marine harbour traffic and provides advisories to vessels. The VTS operators receive early warning on traffic conflicts in the harbour waterways through multiple collection sites around the harbour and integrates, records, and merges the data on a single operator display.[316]

Ensuring Long-Term Competitiveness of the EU Transport Services and Technologies

Space technology serves as a driver for innovation for the non-space industry. Space technology spin-offs can also improve transport technologies and services. In the motor industry for example, the sensor technology called "Kinaeasthic Textiles", developed by the Canadian Space Agency for the robotic arm on the International Space Station (ISS), was transferred for Earth applications, including the automotive and aeronautical industries (e.g. touchpads, bed sensors, etc.). In the automotive industry, for example, the technology can be used to advance passenger security measures (e.g. occupant sensing for airbag mechanisms, crash sensing for pedestrian safety, etc.). In the aeronautics field, the sensors are used in projects for improving crash safety for helicopter crews, safety skin for robots to allow humans and robots to work together, or for concepts such as Ambient Assisted Living that aim at enhancing the quality of life for older people.[317]

Satellite vibration-damping technology, such as the France's SPADD (Smart Passive Damping Device), increase the natural damping of a structure by installing a lightweight, energy-dissipating device while preserving the structure's static behaviour. This technology is considered to be a technological breakthrough in vibro-acoustics and has been em-

[312] European Position Determination System (EUPOS). EUPOS Webiste. < http://www.eupos.org/>.
[313] EUPOS: Project Objectives. EUPOS Website. http://eupos.vgtu.lt/index.php?pg_name=general-information
[314] Schrogl, K.-U., C. Mathieu and A. Lukaszczyk, eds. Threats, Risk and Sustainability – Answers by Space. Vienna:SpringerWienNewYork, 2009: 217-218.

[315] EGNOS: The European Geostationary Navigation Overlay System, a Cornerstone of Galileo. The European Space Agency, Noordwijk (2006): 330 – 332.
[316] Jordan Robert J., Douglas C. Herndon; Joseph A. McMorrow; John E. Harrington; Harold E. Constantine. Marine Vessel Traffic System. Naval Air Warfare Center (19 June 2001).

ployed on the Ariane-5 launcher and a number of satellites (e-g- Metop). This technology also has the potential to be used, for example in the high-end car market.[318]

Space technology-derived sensing innovation that synchronises manipulators of individual parts with vehicle assembly lines serves as another illustration. Manipulators (i.e. large, manually-controlled robotic parts handlers) are used to fit large space modules into vehicles. The "MDUSpace", a Dutch-based high-tech spin-off company enhances the precision and quality of the assembly process and reduces considerably the costs for synchronisation.[319] The MDUSpace automation system employs a live camera feed and software for object recognition (derived from spacecraft docking mechanisms) to synchronise the manipulators with the vehicles on the assembly line in an easier and less costly manner.[320]

Other examples include: innovative technology derived from ESA space radar providing high-resolution radar imaging for small Unmanned Aerial Vehicles (UAV); location-based services utilising satellite navigation data applications for personal use (via mobile telephone); and satellite-based, on demand public bus services.[321] The last application mentioned also demonstrates how space technologies can advance the EU's goal of "accessing all territories notwithstanding their remoteness and density of population".

Key EU Objectives for Mobility	Space as a Means to Promote Mobility
Facilitating virtual mobility	<u>Telecommunications:</u> *Sample Applications* • Facilitate communication exchanges (e.g. among teachers, fellow students) • Offering TV through satellite broadcast • Facilitating online shopping • Providing broadband internet connection to rural areas • Offering educational content (e.g. study schemes, interactive didactic programmes, telemedicine-related services, etc.) over the Internet • Enhancing international work placement • Providing integration of different media's didactic-pedagogical possibilities to create flexible learning environment *Examples* • The EU-VIP project examines ways in which virtual mobility enhances international work placement • CROCUS project disseminates multimedia and interactive didactic units for first and second language learning and intercultural education via satellite • the European Medical Network (EMN) created a distance-learning service for the medical professionals in Europe • DELTASS, a mobile telemedicine demonstrator • Euromednet that coordinates telemedicine services through the Tele-medicine Operational Centre (TOC) • Health Information Services is a television- and IP-based information platform addressing patients in waiting rooms and doctors in surgeries • MIST (Marine Interactive Satellite Technologies) project provides teleconsulting for isolated and mobile sites like ambulances and ferries
Strengthening transport safety and security	<u>Remote Sensing</u>: *Sample Applications :* • Vessel tracking • High resolution mapping on land, ocean-related informa-

317 Down to Earth: How Space Technology Improves Our Lives. The European Space Agency (September 2009): 8-9.
318 Ibid: 10-11.
319 About Us. MDUSpace website. <http://www.mduspace.com/MDU-Company.html>.
320 Ibid: 12-13.
321 Down to Earth: How Space Technology Improves Our Lives. The European Space Agency (September 2009): 22-75.

	tion for maritime traffic • Disaster monitoring, (e.g. ash cloud propagation) • Sea ice monitoring • Urban transport planning and evaluation • Accurate and timely weather forecasting • Improving safety of transport of dangerous goods • Road usage monitoring <u>Telecommunications</u>: *Sample Applications* • Broadcasting interference data to aircrafts (Satellite Data Link System - SDLS) • Continuous exchange of information and tracking control, including for deep sea navigation <u>Positioning, Navigation, Timing</u>: *Sample Applications* • Generally improving traffic safety for all modes of transport • Providing information and related services concerning the users' mobility and geographic position (so-called LSB, Location-Based Services) • navigation in cars • Enabling driver assistance, emergency calls, anti-theft systems, speed enforcement, tracking hazardous goods, traffic information collection, etc. • Improving air traffic safety (e.g. en route navigation) • Monitoring of flight plans and routes according to the Flight Management System (FMS), as well as notification of the aircraft crew and, in some cases, the air traffic organisations or relevant institutions • Assisting rescue missions (e.g. those involving leisure yachts) • Providing personal safety, including to those with impairments or disabilities and workers exposed to a high rise environments (e.g. toxic gases, anaerobic rooms, high level of noise, etc.) *Example:* • For civilian landing, EGNOS ground infrastructure constantly monitors GPS performance and provides error corrections. It is also able to detect GPS satellite faults and transmit timely warnings. • GALILEO FP7 R&D programme called INCLUSION, is developing a set of applications, including the development of a location-based service (LBS) for motor-impaired people.
Assuring environmentally sustainable transport	<u>Remote Sensing</u>: *Sample Applications* • Urban transport planning and evaluation • Land use and transport network planning • Road usage monitoring • Monitoring atmospheric composition, including CO_2 <u>Telecommunications</u>: *Sample Application* • Making transport more environmentally sustainable by satellite communication applications • Intelligent transport <u>Positioning, Navigation, Timing:</u> *Sample Applications:* • Help develop inter-modal transport system by guided

	navigation • Optimising transport routes for fuel economy • Comparing ecological footprint of different transport solutions • Optimising fuel consumption of individual transport vehicles • Reducing noise pollution by more precise, shorter approaches in air transport • Fleet management (road, rail, air, and sea) *Example* • The FLEET project (Fleet Logistics Service Enhancement with Egnos & Galileo Satellite Technology) used vehicles as a test bed to determine traffic status and provide traffic information without depending on the traditional roadside equipment (i.e. induction loops). The acquired data are transformed into valuable traffic information for travellers
Developing a Trans-European transport network (TEN-T)	<u>Telecommunications</u>: *Sample Applications:* • Enhancing European transport network by improving communication network • Air traffic control • Maritime traffic control • Railway traffic control • Fleet management (road, rail, air, and sea) <u>Positioning, Navigation, Timing</u>: *Sample Applications* • Optimisation transport networks • Unification transport networks • Interoperability among various transport networks for higher guarantee and quality of services (e,g. transport of goods) • Detecting criminal actions (e.g. robberies, theft, drug trafficking, etc.) *Example:* • The European initiative, EUPOS (European Position Determination System), aims at establishing a uniform Differential Global Navigation Satellite System (DGNSS) infrastructure in Central and East European Countries
Increasing Traffic Management Efficiency	<u>Remote Sensing:</u> *Sample Applications:* • Vessel monitoring systems • Remote sensing applications to meet coast guard objectives • Weather forecasting <u>Telecommunications</u>: *Sample Applications* • Optimising transport networks • Improving integrated traffic management centres operations • Telecommunications for maritime applications (e.g. VSAT) • Satellite Automatic Identification System (AIS) <u>Positioning, Navigation, Timing</u>: *Sample Applications* • Optimising transport routes for fuel economy and time saving • Increasing seaport operations safety

	• Fleet management • Providing position accuracy and integrity data for the AIS applications (e.g. port manoeuvres). • Sea border protection and management applications (including vessel monitoring systems) *Example* • The AIS VHF communication channel can be used to report EGNOS-based computed position on the ship. ESA's MARLET Project (the Maritime LOPOS EGNOS Test Bed) demonstrated the high reliability of EGNOS positioning even under adverse conditions
Ensuring Long-Term Competitiveness of the EU Transport Services and Technologies	General Contribution: *Sample Application* • Space technology spin-offs • Transfer of knowledge Examples • "Kinaesthic Textiles" developed by the Canadian Space Agency for the robotic arm on the International Space Station (ISS), was transferred for Earth applications, including the automotive and aeronautical industries (e.g. touchpads, bed sensors, etc.) • Satellite vibration-damping technology, such as the France's SPADD (Smart Passive Damping Device), increase the natural damping of a structure by installing a lightweight, energy-dissipating device, while preserving the structure's static behaviour. This technology is considered to be a technological breakthrough in vibro-acoustics and has the potential to be used, for example in the high-end car market • Manipulators (I.e. large, manually-controlled robotic parts handlers) are used to fit large space modules into vehicles. The "MDUSpace" enhances the precision and quality of the assembly process and reduces considerably the costs of synchronisation. The MDUSpace automation system employs a live camera feed and software for object recognition (derived from spacecraft docking mechanisms) to synchronise the manipulators with the vehicles on the assembly line in an easier and less costly manner. • high-resolution radar imaging for small Unmanned Aerial Vehicles (UAV) • location-based service utilising satellite navigation data applications for personal use (via mobile telephone) • satellite-based, on demand bus services Positioning, Navigation, Timing: *Sample Applications* • Optimisation of transport routes for enhancing competitiveness • Fleet management

Table 14: Space as a Means to Promote EU Objectives for Mobility

4. Conclusion and Final Recommendations

This section identifies areas where a shared concentration of space capabilities, together with common interests, can advance the EU's key foreign policy objectives, particularly in the six areas of sustainability referenced. It will also seek to demonstrate the benefits of European cooperation with other space-faring governments, international organisations and multilateral fora, among them the ability to multiply the positive results and cost-effectiveness of these worthy EU endeavours.

More than two decades after the release of the Brundtland Report, EU governments are still struggling to find a comprehensive approach to sustainable development. The EU's Strategy for Sustainable Development of 2001 and 2006, as well as the Europe 2020 strategy all address the economic, socio-political, and environmental challenges to EU's future growth and prosperity. Issues such as climate change and globalisation are on the agendas of nations worldwide and international partnerships are being forged to tackle them. As the EU configures itself to capitalise on its single legal identity, a more cohesive, integrated approach to pursuing bilateral relationships and participating in multilateral venues and international organisations is underway to meet challenges and find workable solutions. Security, environment, energy, resources, knowledge and mobility, as enablers of future prosperity, are properly a focus of attention in Brussels.

Space, as a strategic asset for any major nation in the 21st century, offers valuable services and applications for civilian, as well as military, users. Space policy and space-related cooperation are becoming an essential component of foreign policy planning and decision-making. The rationale for deeper and richer international cooperation in space is more compelling than ever given the scale and long-term implementation periods of space programmes. As effective operations in space require cutting-edge technologies, large-scale funding, and multi-year support, enhanced cooperation among the European stakeholders (i.e. the EU, ESA and MS), as well as that of international partners, is increasingly essential. Such carefully-crafted cooperative efforts can also advance Europe's competitiveness in space and on Earth. Moreover, cooperation of this kind helps reaffirm the principle of the peaceful use of outer space, encourages transparency, and builds trust and confidence.

The European Space Policy (ESP) of 2007 recognised the connectivity between space capabilities and the EU's exercise of influence regionally and globally. Moreover, these capabilities advance Europe's objectives in the key categories examined in this study. With regard to the security, space facilitates the implementation of the EU's security framework under the CSDP, improves Europe's standing as a major international actor in the areas of conflict-prevention, crisis management, and peacekeeping, as well as advances security-minded cooperation with other nations. Research, scientific knowledge and technological innovation in the information age are the foundation of space activities that enable operations in space, understanding of space phenomena and the observation and monitoring of Earth. The latter activity offers, through a large variety of applications, an opportunity to advance, on an accelerated basis, Europe's abiding commitments to manage climate change and resource development.

A cooperative approach to space also encourages responsible behavioural norms and a more uniform global space agenda that Europe is uniquely positioned to shape. This is, in large part, a leadership issue and one that Europe is preparing itself to meet. It has already travelled a good distance down this road and is realising specific terrestrial goals in areas of sustainable development that other space-faring nations can rally around. In short, an increasingly cooperative posture toward, and in, space would:

- Accelerate achievement of EU policy goals
- Multiply effectiveness in prosecuting these objectives
- Improve affordability via cost burden-sharing
- Offer a global agenda in several critical areas of sustainability
- Educate governments and their respective publics

The EU can use its prominent role within multilateral institutions to help design future cooperative work programmes which are consistent with the EU's agenda in each priority area of sustainability. This could also result in multilateral funding that augments and reinforces the EU's is independent efforts today. Of course, such cooperation involves much more than the cost-sharing dimension. It could prove of great value to mankind, while strengthening Europe's space capabilities.

To maximise the benefits and capabilities of space in addressing these six priority issue areas of Europe's foreign policy, the following individual sets of recommendations might be considered:

Sustainability Area	**Recommendations**
Security	With regard to security in Europe, there are a variety of different actors that interact with one another and possess different degrees of influence. Beyond intra-European influence, states outside Europe (e.g. China, Iran, Russia, etc.), as well as non-state actors, can profoundly affect Europe's security. Although the EU has introduced a "comprehensive" approach to security, as well as to its foreign policy, the reality is that the EU does not, as yet, possess full strategic independence. There exist two levels of dependency: external and internal. External factors include the international system (i.e. third countries, NATO, the UN etc.) and security-related developments, such as regional conflicts (e.g. the Middle East, the Balkans, the Korean Peninsula etc.). Internal dependence is illustrated by the European integration process itself. Although the Lisbon Treaty offers new possibilities, it depends on the MS to chart the path forward. It is a similar situation with respect to space security. To advance Europe's status as a major space power, the following recommendations are offered: • Develop a European space security strategy clearly identifying existing and emerging space-related challenges and threats for Europe. • Intensify the space security-related dialogue among the MS, European Council, European Commission, ESA, and other relevant entities (e.g. EDA, EUSC, etc.). • Identify the most prudent and cost-effective ways to address space security requirements, including a concentration on alternative funding. • Establish tools for better managing military space programmes (e.g. MUSIS), including avoiding the duplication of space assets. • Support development of Europe's capabilities for responsive space, such as envisioned by ESA's GIANUS concept of integrated space applications. • Develop the full potential of the EUSC, the European Centre for processing and analysing EO satellite data. • Assure availability of critical space technologies, launchers, satellite systems and know-how, via cooperative initiatives. • Enhance support for commercial space sector activities, particularly those that are "dual-use" in nature. • Clarify and reinforce space governance mechanisms and identify the operational requirements for the long-term utility of future European programmes, including Galileo and GMES. • Link space policies and capabilities to the management of the EU's internal and external security issues and explore new ways in which space can advance Europe's security requirements. • Employ the benefits of satellite use for civilian security needs, including for: managing heavy air traffic over Europe; maritime security; crisis management; and natural disaster prediction and management. • Improve protection of space assets and infrastructure (including through development of an advanced space situational awareness (SSA) capability). • Promote responsible behaviour in space, including via the EU's draft Code of Conduct for Outer Space Activities.
Environment	Satellites have been among the first technologies to reveal climate change issues. To ensure effective exploitation of existing satellite data and promote

	the development of advanced systems to manage the environment on a sustainable basis, the following recommendations are proposed: • Incorporate the monitoring of climate change variables from space in the implementation policies of the EU's Sustainable Development Strategy and Europe 2020 strategy. • Analyse near- and long-term priorities and opportunities of remote sensing for the environment to address effectively Europe's need for continuous environmental observations. • Continue to expand utilisation of space assets for environmental and climate change studies by exploiting fully the potential of existing space infrastructure. • Develop the GMES Space segment as it constitutes an inseparable part of the overall GMES system and represents an important contribution to environmental and climate change research. • Integrate space technologies into the evolving business model for a low-carbon economy. • Cooperate with science and environmental experts to utilise space systems along the lines of ESA's Living Planet Programme, which addresses the need to better understand the Earth system and its impact on human activity. • Emphasise the role of space assets to assist the newly established DG Climate Action and coordinate common use of space assets among the DG Climate Action, DG Environment (DG ENV) and the European Environment Agency (EEA).
Energy	Decision-makers in Europe have to weight carefully their investment strategies in a future energy mix to assure availability of energy supplies. There is already an emphasis on "green" energy, where a cost-effective solution is not viable in the near-term, but gains are expected in the long-term. Accordingly, together with securing imports of non-renewable resources, the right selection of renewable energy sources is of great importance. Space can advance both of the requirements referenced above, as well as contribute substantially to the effective use of the energy sources. Accordingly, the following recommendations are offered: • Integrate space in Europe's industrial policy. • Exploit new areas where space can advance both energy security and environmental protection (e.g. renewable sources of energy, satellite-based power grid control and monitoring systems, etc.). • Increase use of space systems for critical energy infrastructure protection (e.g. pipeline monitoring, cargo vessel monitoring, etc.) and effective exploitation of energy (e.g. use of weather satellite data to estimate potential of solar cell power plans and monitoring performance, etc.). • Work toward optimising maritime vessel utilisation via information and communications technologies. • Promote integration of maritime surveillance for transport security as outlined in a 2009 EC Communication entitled "Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain".[322] • Employ space assets for climate change research to understand better the direct (e.g. ocean storm patterns) and indirect (e.g. change of trade flows) threats to maritime transport, including ports.
Resources	A November 2010 report, entitled "Preparatory Study for the Review of the Thematic Strategy on the Sustainable Use of Natural Resources", conducted to support the review of the EU's Resource Strategy, pointed out the need to establish a strong knowledge base that would link environment and resource use to securing their sustainability.[323] Efficient use of natural resources, and

[322] Towards the Integration of Maritime Surveillance: A Common Information Sharing Environment for the EU Maritime Domain. COM(2009) 538 final of 15 Oct. 2009. Brussels: European Union. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0538:FIN:EN:PDF>

[323] Preparatory Study for the Review of the Thematic Strategy on the Sustainable Use of Natural Resources. European Commission, DG Environment Report (November 2010): 5. <http://ec.europa.eu/environment/natres/pdf/BIO_TSR_FinalReport.pdf>

	especially water, energy and raw materials, constitutes a priority issue area for the EU. Accordingly, the following recommendations for space in resource management are offered: • Promote the use of existing space assets and related applications to help achieve the main objective of the EU's strategy on the sustainable use of natural resources and reduction of the negative environmental impacts caused by the use of these resources, while ensuring economic growth. • Work towards assuring long-term availability and reliability of space-based information by integrating national and regional-level activities (e.g. supporting implementation of the GMES project, including its space segment). • Develop GMES services for extracting non-energy raw materials, including cooperation on three-dimensional (3D) geological models to advance Europe's scientific infrastructure. • Create a non-energy resource information database to map, evaluate, organise and structure the space-based data to be readily available to relevant EU bodies (e.g. via the Internet).
Knowledge	Space is a multiplier for scientific and technological (S&T) discovery. S&T is embedded in education, and promotes knowledge. Knowledge, in turn, is a key resource for innovation. Space-related research generates knowledge, including that related to advanced technology, and can serve as a driver for innovation and competitiveness. Accordingly, the following recommendations might be considered: • Continue to support space missions to advance scientific knowledge. • Organise space cooperative partnerships that create, and apply, scientific and technological knowledge in such a way as to advance environmental and economic objectives of sustainable development. • Identify where space knowledge can promote innovation, as well as enhance economic and socio-cultural assets. • Encourage and maintain active communication between policy-makers and the science and engineering communities. • Promote space science through cooperation with a view to producing a broader knowledge base which, in turn, generates professional development and European expertise. • Identify areas where space research and development can support EU policies and the Europe 2020 agenda and further the building of a knowledge society. • Take full advantage of the potential services offered by communications satellites to support Europe's Digital Agenda, the first of seven flagships under the Europe 2020 agenda.
Mobility	Efficient and effective transport contributes significantly to mobility, as well as other areas addressed in this study, including energy efficiency and environmental protection. To further the use of space for mobility, the following recommendations are offered: • Support space science that drives development of breakthrough technologies which can, in turn, advance future ways of mobility. • Include space systems in strategic decision-making on transport policy, including establishment of required infrastructure for integrating space-based services. • Incorporate EGNOS/Galileo services into decision-making on inter-linking various modes of transport to establish an integrated transport system at the national and European levels (e.g. navigation systems for safer shipping etc.). • Encourage, and financially support, the development of satellite-based broadband services in low-density and difficult-to-access areas to advance virtual mobility.

Table 15: Recommendations for areas of sustainability addressed in this study.

Annex: European Space Contributions to Six Sustainability Areas

ASSET and TECHNICAL INFORMATION	MISSION OBJECTIVES + CONTRIBUTION to the SIX AREAS of SUSTAINABILITY: APPLICATIONS and EXAMPLES
REMOTE SENSING	
Name: **ADM-Aeolus** (Atmospheric Dynamics Mission) *Owner*: European Space Agency (ESA) *Mission lifetime*: 28 Feb. 2012 – 28 May 2015 *Instruments:* Atmospheric Laser Doppler Instrument (ALADIN) *Orbital parameters:* Type: sun-synchronous Altitude: 405 km Period: 92.5 mins Inclination: 97.01 deg Repeat Cycle: 7 days Local Solar Time – Time of satellite equator overpass (LST): 18.00 Ascending	*Mission Objectives*: Demonstration of the space borne Doppler wind lidar for the creation of wind profiles (up to altitude of 30 km); wind measurements on a global scale for global 3D wind field products used for studying atmospheric dynamics (including global transport of energy, water, aerosols, and chemicals). *Security*: More accurate extreme weather events predictions and early warning. *Environment*: Improvement of weather forecasting accuracy and better understanding of tropical and climate variability processes.
Name: **AISSat-1** (Automatic Identification System Satellite-1) *Owner*: Norwegian Space Centre (NSC) *Mission lifetime*: 12 July 2010 – 1 Aug. 2013 *Instruments*: Software Defined Radio (SDR) *Orbital parameters*: Type: sun-synchronous Altitude: 643 km Period: 97.3 mins Inclination: 98.1 deg	*Mission Objectives*: Demonstrator to investigate the feasibility and performance of a space-based Automated Identification System (AIS) in LEO to complement the existing land-based AIS currently operated by the Norwegian Coastal Service; observation of ship traffic. *Security*: Enhancing safety of marine activities; border security purposes and law enforcement. *Mobility*: Sea transport efficiency improvements.
Name: **Aura** (formerly EOS Chemistry) *Owner*: National Aeronautics and Space Administration (NASA) / Netherlands Space Office (NSO) / Finnish Meteorological Institute (FMI) / British National Space Centre (BNSC) *Mission lifetime*: 15 July 2004 – 30 Sep. 2011 *Instruments*: Earth Observation System – Microwave Limb Sounder (EOS-MLS) Tropospheric Emission Spectrometer (TES) High Resolution Dynamics Limb Sounder (HiRDLS) Ozone Monitoring Instrument (OMI) *Orbital* parameters: Type: sun-synchronous Altitude: 705 km Period: 98.8 mins Inclination: 98.2 deg	*Mission Objectives*: To study the chemical composition and dynamics of the Earth's atmosphere (status of the stratospheric ozone layer; evolution of the chemistry of the troposphere; and the role of upper tropospheric aerosols, water vapour and ozone in climate change) *Security*: Data for determination of risks of ash clouds to aviation. *Environment*: Study of atmospheric composition, including air quality; OMI near-real time volcanic SO2 and ash imagery (e.g. Kasatochi volcano on the Aleutian Islands in Aug. 2008; Piton de la Fournaise volcano on Réunion Island – in Mar. 2007, and Grímsvötn volcano on Iceland in Nov. 2004); TES spectrometer provides daily surveys and profile measurements of O3, CO, CH4, NO2, nitric acid, and water vapour. *Mobility*: OMI near-real time volcanic SO2 and ash imagery used for air traffic control (e.g. Eyjafjalljokull volcano on

Repeat Cycle: 16 days LST: 13.30 Ascending	Iceland in Apr. 2010) *Note*: Aura is part of the A-Train space observatory constellation. A-Train consists of five satellites (Aqua, AURA, Glory, Cloudsat, an CALIPSO) obtaining near-simultaneous collocated data on atmospheric phenomena.
Name: **CALIPSO** (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) *Owner*: NASA / Centre National d'Etudes Spatiales (CNES) *Mission lifetime*: 28 Apr. 2006 – 30 Sep. 2011 *Instruments*: Wide Field Camera (WFC) Imaging Infrared Imager (IIR) Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) *Orbital parameters*: Type: sun-synchronous Altitude: 705 km Period: 98.8 mins Inclination: 98.2 deg LST: 13.30 Ascending	*Mission Objectives*: Study aerosol and cloud properties for climate predictions; determination of cloud altitude, aerosol layers and their overlap. *Environment*: Urban heat wave forecasting and appropriate alarm systems; study of spatial variability in urbanised areas in order to contribute to future urban planning and reduce detrimental effects of heat waves in cities; data on the interactions of clouds, rainfall and pollution; better understanding of climate dynamics. *Note*: CALIPSO is part of the A-Train space observatory constellation. A-Train consists of five satellites (Aqua, AURA, Glory, Cloudsat, and CALIPSO) obtaining near-simultaneous collocated data on atmospheric phenomena.
Name: **CHAMP** (Challenging Mini-Satellite Payload for Geophysical Research and Application) *Owner*: Deutsches Zentrum für Luft- und Raumfahrt (DLR) / CNES / Jet Propulsion Laboratory (JPL) *Mission lifetime*: 15 July 2000 – 20 Sep. 2010 (re-entry) *Instruments*: CHAMP Gravity Package CHAMP Magnetometry Package CHAMP GPS Sounder *Orbital parameters*: Type: inclined, non-sunsynchronous Inclination: 87 deg	*Mission Objectives*: geophysical research; study of the Earth's gravity field, precise geoid, magnetic field, atmospheric physics; accurate data provision that can improve remote sensing applications and cartography.
Name: **COSMO-Skymed** (Constellation of small Satellites for Mediterranean basin Observation) *Owner*: Italian Space Agency (ASI) / Italian Ministry of Defence (MoD) *Mission lifetime*: COSMO-Skymed-1: 8 June 2007 – 8 June 2014 COSMO-Skymed-2: 9 Dec. 2007 – 9 Dec. 2014 COSMO-Skymed-3: 27 Oct. 2008 – 27 Oct. 2015 COSMO-Skymed-4: 3 Nov. 2010 – 15 Oct. 2017 *Instruments*: SAR2000 (X-Band) (Synthetic Aperture Radar) *Orbital parameters*: Type: sun-synchronous Altitude: 620 km Period: 97.1 mins Inclination: 97.8 deg Repeat Cycle: 16 days LST: 6.00 Ascending	*Mission Objectives*: Civil and defence objectives: monitoring for environmental objectives, surveillance and risk management, resource management, maritime security and management, Earth topographic mapping, border security and law enforcement, and scientific applications. *Security*: Military reconnaissance purposes: surveillance and intelligence, damage and vulnerability assessments; risk management for natural disasters: floods, fires, droughts, earthquakes, landslides, and volcanoes; marine security objectives: small vessel and oil spill detection; border protection applications. *Environment*: Sea oil spill detection (e.g. Deepwater Horizon in Gulf of Mexico in 2010); environmental protection applications, monitoring of urban sprawl; coastal surveillance (erosion); sea and river pollution detection; ocean and ice monitoring applications; technical cartography and urban planning applications; hydrology. *Knowledge*: Contribution to Europe's base in SAR radar remote sensing; observations for archaeological purposes. *Resources*: Natural resources management in agriculture (harvest monitoring and treatment cycles) and forestry; geology applications for mineral resources exploration and exploitation.

Name: **CSG** (COSMO-Skymed Second Generation) *Owner*: ASI / Italian MoD *Mission lifetime*: CSG-1: 30 Apr. 2014 – 30 Oct. 2021 CSG-2: 30 Apr. 2015 – 30 Oct. 2022 *Instruments*: SAR2000 Second generation (S.G.) *Orbital parameters*: Type: sun-synchronous Altitude: 620 km Period: 97.1 mins Inclination: 97.8 deg Repeat Cycle: 16 days LST: 6.00 Ascending	*Mission Objectives*: Civil and defence objectives: Monitoring for environmental objectives, surveillance and risk management, resource management, maritime security and management, Earth topographic mapping, border security and law enforcement, and scientific applications.
Name: **CryoSat-2** *Owner*: ESA *Mission lifetime*: 8 Apr. 2010 – 8 July 2013 *Instruments*: Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS-NG) SAR Interferometric Radar Altimeter (SIRAL) Laser Reflectors *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 717 km Period: 100 mins Inclination: 92 deg Repeat Cycle: 369 days	*Mission Objectives*: To determine fluctuations in the mass of the Earth's major land and marine ice fields; floating sea ice thickness measuring. *Environment*: Data of unprecedented accuracy concerning the ice sheets in Antarctica and Greenland leading to better understanding of the effect of climate change on the polar ice. *Knowledge*: SIRAL is new generation altimetry system derived from the Poseidon ocean altimeter on Jason and combines three measurements modes to determine the topography of land and sea ice masses: low resolution for conventional altimetry, Synthetic Aperture Radar (SAR) for high resolution imagery of floating ice, and interferometric radar mode for the study of very active areas. SILAR is the result of 20 years of altimetry systems development. *Note*: First Cryosat mission lost due to launch anomaly on 8 Oct. 2005.
Name: **CSO-MUSIS** (Composante Spatiale Optique of MUSIS(Multinational Space Based Imaging System for Surveillance, Reconnaissance and Observation)) *Owner*: DGA *Mission lifetime*: Constellation of 2 satellites (launch in 2016 and 2017) to be complemented by a third one on the long term. Instruments: Very high resolution optical instrument	*Mission Objectives:* Next generation optical observation capabilities of European armed forces. *Security:* Remote sensing for military applications; crisis management. *Note:* CSO is the optical component of MUSIS provided by France (successor of Helios), whereas Germany and Italy supply the radar component for MUSIS.
Name: **DEMETER** (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) *Owner*: CNES *Mission lifetime*: 29 June 2004 – 9 Dec. 2010 *Instruments*: Instrument Champ Electrique (ICE) Instrument Magnetometer Search-Coil (IMSC) Instrument Analyseur Plasma (IAP) Instrument Sonde de Langmuir (ISL) Plasma Detection Instrument (IDP) *Orbital parameters*: Type: sun-synchronous Altitude: 710 km (lowered to 660 km in 2005) Inclination: 98.23 deg	*Mission Objectives*: To measure all geophysical parameters of the upper atmosphere that can be affected by telluric or volcanic activity on Earth; seismology and volcanology: better understanding of the Earth's electromagnetic environment in order to be able to forecast earthquakes. *Security*: Earthquake forecasting and rapid alerting. *Environment*: Volcanic activity monitoring. *Knowledge*: Better understanding of the pre-seismic signals observable in the upper atmosphere (e.g. data gathering on the connection between earthquakes and atmospheric disturbance in Haiti in Jan. 2010).
Name: **Diadème 1 & 2**	*Mission Objectives*: Geodetic measuring using satellite

Owner: CNES *Mission lifetime*: 8 & 15 Feb. 1967 – 31 Dec. 2050 *Instruments*: Retrereflector Array (RRA) *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 1200 km Period: 101 mins Inclination: 98.7 deg LST: 20.29 Ascending	laser ranging.
Name: **EarthCARE** (Earth Clouds, Aerosols and Radiation Explorer) *Owner*: ESA/JAXA *Mission lifetime*: 25 Oct. 2013 – 25 Oct. 2016 *Instruments*: Cloud Profiling Radar (CPR) Atmospheric Lidar (ATLID) Broadband Radiometer (BBR) Multi-Spectral Imager (MSI) *Orbital parameters:* Type: sun-synchronous Altitude: 450 km	*Mission Objectives*: Study of atmospheric cloud-aerosol interactions and of the Earth's radiative balance in order to enhance weather prediction and climate evolution models. *Security*: Improvement to weather predictions allowing better extreme weather preventive warnings. *Environment*: Numerical weather and climate forecasting models; better understanding of climate change.
Name: **EnMAP** (Environmental Mapping & Analysis Program) *Owner*: DLR *Mission lifetime*: 9 May 2014 – 9 May 2019 *Instruments*: Hyperspectral Instrument (HSI) *Orbital parameters*: Type: sun-synchronous Altitude: 653 km Period: 97.5 mins Inclination: 97.96 deg Repeat Cycle: 21 days LST: 11.00 Decending	*Mission Objectives*: Hyperspectral imaging, land surface, geological and environmental investigation. *Security:* Crisis information: land and sea pollution detection; risk assessments for natural disasters; lava flow prediction in case of volcano eruptions; vulnerability assessments; development disaster mapping algorithms; critical infrastructure monitoring; following evolutions of natural phenomena. *Environment:* Detailed land use and land cover data including vegetation, surface rocks and waterways (information about the mineralogical composition of rocks, the damage to plants caused by pollution and the degree of soil pollution); protection of coastal zones: improved chlorophyll quantification, the differentiation between ecological important phytoplankton groups and dissolved organic compounds; the identification of different fractions of suspended mineral and organic particles; lake ecology; algal bloom monitoring; distribution of sediments in tidal flats and their phytobenthos, wetlands, mangrove forests and submerse and emerse macrophytes distribution; shallow water habitat mapping (submerged macrophytes, seagrass, corals) and bathymetry; changes in coastal morphology and monitoring coastal erosion. Land degradation: monitoring of degradation processes due to $CaCO_3$, iron content, organic content, salinity, infiltration rate, or physical crusting; soil condition determination; detection and identification of pollutants; erosion mapping; vegetation estimates and land cover assessments and evolutions in vulnerable ecosystems. Forest Protection: forest species distribution mapping; development of canopy reflections models for forest risk assessments; development of optical indices that will serve as bio-indicators of forest condition; canopy changes monitoring. Agricultural sustainability purposes. *Resources*: Geology: mineralogical mapping including waste deposits; study of internal and external parameters in spectral signature of rock and soil; development of geospatial tools and integration techniques for sustainable mine site management purposes. Agriculture: improving

	accuracy of crop parameter retrieval methodologies with HSI data (crop type, LAI, APAR, chlorophyll content, PRI, plant water content, canopy geometrical structure); enhancing crop production modelling; determining crop condition variability; Improved discrimination of crop stress caused by nitrogen deficiency, crop disease, insect infestation, water stress, and chlorosis; crop yielding and forecasting.
Name: **Envisat** (Environmental Satellite) *Owner*: ESA *Mission lifetime*: 1 Mar. 2002 – 31 Dec. 2013 *Instruments*: Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS-NG) Microwave Radiometer (MWR) Advanced synthetic Aperture Radar (ASAR) (image mode (C-Band) and wave mode) ENVISAT Comms Medium Resolution Imaging spectrometer (MERIS) Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) Global Ozone Monitoring by Occultation of Stars (GOMOS) Scanning Imaging Absorption Spectrometer for Atmospheric cartography (SCIAMACHY) Radio Altimeter (RA-2) Advanced Along-Tracker Scanning Radiometer (AATSR) Laser Retro-Reflector (LRR) *Orbital parameters*: Type: sun-synchronous Altitude: 782 km Period: 10.5 mins Inclination: 98.52 deg Repeat Cycle: 35 days LST: 10.30 Descending	*Mission Objectives*: ESA remote sensing mission including instruments for physical oceanography, monitoring of the land surface, ice and snow, atmospheric chemistry, atmospheric dynamics/water and energy cycles. *Security:* Early warning, crisis management and post-crisis relief applications: Volcanoes: MERIS imagery of outbursts for disaster management (e.g. 2008 Chaiten volcano in Chili; 2007 Mount Gamkonora volcano in Indonesia, 2006 Etna volcano in Italy); earthquakes (e.g. ASAR planning of the earthquake and tsunami in Indonesia in Oct. 2010, 2009 earthquake in Italy, and the 2008 China Earthquake); Interferometry activities: Satellite data can be used to detect small changes that can foretell an earthquake, thus providing the possibility of early warning (SAR interferometry was used for the Jan. 2010 eruption of Mount Nyamulagira in Congo). This also provides new insights into tectonic motion and improves the ability for impact assessments in the event of earthquakes (e.g. Dec. 2003 earthquake in Bam, Iran: Envisat pre-earthquake imagery was compared to post-earthquake image leading to better scientific understanding of geological processes in this region and allowing for better hazard assessment in the case of future earthquakes); Fire detection: ASAR measures thermal-IR radiation to determine Earth's surface temperature. Satellite data can provide fast and comprehensive overview of the crisis situation assessing damage and risks. ATSR Data compilation is made public in the ATSR World Fire Atlas containing record of fires, times, dates and location of hot spots (e.g. 2009 California fires (ATSR + MERIS), 2008 Norway forest fires, 2007 Greek fires); Hurricane monitoring: MERIS optical imaging shows the swirling cloud-tops; ASAR imagery cuts through the clouds and monitors how the wind fields shape the sea surface in order to estimate the destructive power of the extreme weather events. RA-2 uses radar pulses to measure sea surface heights. The near-real time radar data provided by Envisat allows constant monitoring of the hurricane's progress and predictions of its potential impact. The AATSR acquires sea temperature readings and return atmospheric data. MERIS imaging and AATSR data are combined to predict the hurricane's precipitation potential (e.g. Typhoon Megi in Oct. 2010, Hurricane Earl in Sep. 2010, Typhoon Mindulle in Aug. 2010, Hurricane Jimena in Aug. 2010, and Hurricane Morakot in Aug. 2009, and Hurricane Dean in 2007); Floods and droughts: SAR data can be used to determine soil moisture (soil moisture maps allow better flooding or drought forecasting and predictions); Sea ice monitoring to enhance efficiency and safety of sea transportation, off-shore operations, fisheries or other marine activities. The European Polar View Project provides high resolution imagery (from Envisat and Radarsat) of sea ice in the Svalbard region, including ice forecasting information services. *Environment:* Oil spill monitoring (e.g. ASAR and MERIS imagery of the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, and

	the oil spill coming from the tanker Prestige, 100 km off the Spanish Coast in Nov. 2002). Volcano outbursts: atmospheric sensors can be used for identification and intensity of the gases and aerosols from the eruption for environmental impact assessments (e.g. MERIS imagery of SO2 and ash plume for 2010 eruption of Eyjafjallajoekull volcano in Iceland). Atmospheric composition monitoring: SCIAMACHY near-real time O3 field measurements and CO, CH4, NO2, CH2O forecasting, providing of UV-index and UV-dose data, SO2 images, BrO observations, cloud fractions and cloud pressure data. Biodiversity and biohazard monitoring, e.g. 2003 MERIS imagery of the Southern Ocean off the coast of Chili combined with AATSR sea surface temperature data for the identification and monitoring of hazardous algae blooms (fish farms are particularly vulnerable to algae because the fish cannot flee affected areas); AATSR data for Coral Reef monitoring (use of Earth observation data to map the most vulnerable locations likely to experience coral bleaching); ASAR data for providing better boreal forest biomass maps (these maps are also useful for effective forest fire monitoring). Urbanisation challenges: Envisat helps developing urban heat wave forecasting and appropriate alarm systems, an adds to the study of spatial variability in urbanised areas in order to contribute to future urban planning and reduce detrimental effects of heat waves in cities. The acquired dataset comes from various satellites, including ERS-2, Landsat-5, Terra, Aqua, MSG, the NOAA constellation, CALIPSO, and Envisat. Ice shelf destabilisation: increased understanding by combining the observations of the high resolution TerraSAR-X and more frequently obtained Envisat radar data; radar altimetry data for monitoring Arctic sea ice thinning. River monitoring: RA-2 data for monitoring river heights, assessing the impact of climate change, and water resource management. Inland water bodies are often regions of maximum biodiversity and can indicate regional climate change. Envisat provides SAR data on sea surface roughness, wind velocities, tidal movements, and sea surface objects (likes ships and flotsam), altimeter data on sea ice, and MERIS data on bio-optical properties of oceanic waters., and optical data on surface currents, fronts and circulation. MERIS imagery of snow: monitoring of glacier snowmelt runoff provides crucial info used for water and other resources management, flood predictions and hydropower operations. MERIS imagery for water quality measurements (water colour indicates the presence and/or concentration of specific minerals or substances, e.g. chlorophyll and gelbstoff concentration in surface layers) Ozone layer monitoring: GOMOS measures ozone and GHG in the UV-spectrum; SCIAMACHY, and MIPAS. *Energy:* Applications for oil field exploitation (e.g. MERIS imagery of the entire northern oil sand region in Northeast Alberta (Canada) allow to monitor vegetation, track land use changes, and provide baseline environmental information before developing new areas). *Knowledge*: Contribution to Europe's technology base and scientific knowledge. Use of advanced radar technology of ERS-2 and Envisat on UAVs for high-resolution deformation monitoring at lower costs and 2D and 3D map creation. *Mobility:* Sea ice monitoring to enhance sea transportation efficiency. Resources: MERIS imagery for the creation of land cover

	map (land cover data is indispensible for sustainable resource management, food security, humanitarian programmes and environmental protection). Water resource management: RA-2 river heights monitoring for water resource management: inland water bodies are indispensible for water and food for the people living around them; MERIS imagery was used to create maps of existing water resources, suitable dam locations, and help solve water shortage issues in Zambia in 2007, use of optical and SAR data for the management of natural resources and forestry.
Name: **ERS-2** (European Remote Sensing satellite – 2) *Owner*: ESA *Mission lifetime*: 21 Apr. 1995 – 30 June 2011 *Instruments*: Mircrowave Radiometer (MWR) ERS Comms Global Ozone Monitoring Experiment (GOME) Radar Altimeter (RA) Along Track Scanning Radiometer (ATSR/M & ATSR-2) Synthetic Aperture Radar (SAR) (image mode (C-Band) and wave mode) Wind Scatterometer (WS) Precise Range and Range-Rate Equipment (PRARE) *Orbital parameters*: Type: sun-synchronous Altitude: 782 km Period: 100.5 mins Inclination: 98.52 deg Repeat Cycle: 35 days LST: 10.30 Descending	*Mission Objectives*: ESA remote sensing mission for purposes concerning Earth resources and physical oceanography, ice and snow, land surface, meteorology, geodesy/gravity, environmental monitoring, and atmospheric chemistry. *Security:* Fire detection: SAR (combined with Envisat ASAR) measures thermal-IR radiation to determine Earth's surface temperature. Satellite data can provide fast and comprehensive overview of the crisis situation assessing damage and risks. ATSR Data compilation is made public in the ATSR World Fire Atlas containing record of fires, times, dates and location of hot spots (e.g. 2009 California fires (ATSR + MERIS), 2008 Norway forest fires, 2007 Greek fires, and 2007 Canary Island fires). Interferometry activities: satellite data can be used to detect small changes that can foretell an earthquake, thus providing the possibility of early warning (SAR interferometry was used for the Jan. 2010 eruption of Mount Nyamulagira in Congo). This also provides new insights into tectonic motion and improves the ability for impact assessments in the event of earthquakes (e.g. Dec. 2003 earthquake in Bam, Iran: Envisat pre-earthquake imagery was compared to post-earthquake image leading to better scientific understanding of geological processes in this region and allowing for better hazard assessment in the case of future earthquakes). Hurricane monitoring: ERS-2 uses its radar scatterometer for the observation of the hurricane's underlying wind field allowing the determination of wind speed and direction across the water (e.g. Hurricane Dean in 2007). *Environment:* Urban Challenges: ERS-2 helps developing urban heat wave forecasting and appropriate alarm systems, an adds to the study of spatial variability in urbanised areas in order to contribute to future urban planning and reduce detrimental effects of heat waves in cities. Atmopsheric composition monitoring: GOME Tropospheric O3, NO2, CH2O, aerosol optical depth and BrO data measurements. Ozone layer monitoring: GOME is a spectrometer measuring solar radiation reflected towards space by the surface of Earth and by atmospheric constituents, and direct measuring of the solar spectrum. Altimeter and SAR data on sea surface roughness, wind velocities, tidal movements, and sea ice; use data for provision of sea level anomalies information. *Knowledge:* Contribution to Europe's technology base; use of advanced radar technology of ERS-2 and Envisat on UAVs for high-resolution deformation monitoring at lower costs and 2D and 3D map creation. *Resources:* RA river heights monitoring for water resource management: inland water bodies are indispensible for water and food for the people living around them.

Name: **GMES** (Global Monitoring for Environment and Security) *Owner*: EC/ESA GMES is a system of systems of Earth monitoring data collected from satellites, air borne, water borne and land based data gathering systems. GMES dedicated space component is coming operational from 2012 onwards: See infra. Current satellite assets contributing to GMES: SAR missions: ERS-2, Envisat, COSMO-Skymed, RADARSAT-2, TerraSAR-X and TanDEM-X. Optical missions: Envisat, DMC, EnMAP (2012), Eros-A/-B, Pleiades, Rapideye, SEOSAT-INGENIO (2012), SPOT, TopSat. Altimetry missions: ERS-2, Envisat, Cryosat-2, Jason 1 & 2, and Altika (on SARAL satellite).	*Mission Objectives*: Independent European surveillance and monitoring capability at local, regional and global scales for environmental and security purposes, in support of European policies and EU international commitments. *Security:* Crisis management including all natural and man-made disasters; humanitarian aid; international agreement verification. *Environment:* Ocean and ice monitoring including protection of the Arctic environment; soil and water quality; forest protection; urban environment; international agreement verification; vegetation cover; atmospheric observations; and coastal zones protection. *Energy:* Energy network observing including pipeline monitoring; energy exploration and exploitation applications. *Knowledge:* Understanding Earth dynamics, environment and climate evolution; enhancing Europe's technology base. *Mobility:* Urban transport planning, monitoring and assessing. *Resources:* Agricultural observations; forestry; food and water resource management; resource exploration and exploitation applications; land use and cover.
Name: **GMES Space Component Sentinel 1** *Owner*: EC/ESA *Mission lifetime*: Sentinel-1A: 15 Dec. 2012 – 15 Mar. 2020 Sentinal-1B: 15 Dec. 2014 – 15 Mar. 2022 Sentinel-1C: 31 Mar. 2019 – 30 June 2026 (considered) *Instruments*: C-Band Synthetic aperture radar (SAR) *Orbital parameters*: Type: Sun-synchronous Altitude: 693 km Period : 98.74 mins Inclination : 98.19 deg Repeat cycle : 12 days LST: 18.00	*Mission Objectives*: SAR imaging for land and ocean services. *Security*: Surveillance of marine environment; mapping for humanitarian aid and civil crisis mitigation and damage assessments; land surface motion risk monitoring; ship detection for maritime security. *Environment*: Monitoring sea ice zones and the arctic environment; surveillance of marine environment; monitoring of land surface motion risks; forest monitoring; water and soil monitoring; oil spill monitoring. *Energy*: Interferometry applications for the oil and gas industry including efficient exploration and exploitation, sustainable development and environmental performance reporting. *Knowledge*: Contribution to Europe's technology base. *Mobility*: Vessel monitoring applications for optimising marine transport and safety. *Resources*: Land mapping for agricultural purposes; forest monitoring; high resolution soil moisture maps and accurate biomass data.
Name: **GMES Space Component Sentinel 2** *Owner*: EC/ESA Sentinel-2A: 1 May 2013 – 1 Aug. 2020 Sentinel-2B: 31 Dec. 2014 – 31 Mar. 2022 Sentinel-2C: 1 Jan. 2020 – 1 Apr. 2027 (considered) *Instruments*: Multi-Spectral Imager (MSI) *Orbital Parameters*: Type: Sun-synchronous Altitude: 786 km Period: 100.7 mins Inclination: 98.62 deg Repeat cycle: 10 days LST: 10.30	*Mission Objectives*: High resolution optical imaging for land services. *Security*: Risk mapping and disaster relief; emergency services; extreme weather event forecasting and monitoring. *Environment*: Data on vegetation, soil and water for land, inland waterways and coastal regions; geophysical variables mapping, e.g. leaf are index, leaf chlorophyll content, and leaf water content. *Knowledge*: Contribution to Europe's technology base. *Resources*: Land cover and land use mapping; detection of changes in land use.

Name: **GMES Space Component Sentinel 3** *Owner*: EC/ESA Sentinel-3A: 15 Apr. 2013 15 Aug. 2020 Sentinel-3B: 31 Dec. 2014 – 30 Apr. 2022 Sentinel-3C: 1 Jan. 2020 – 1 May 2027 (considered) *Instruments*: Ocean and Land Colour Instrument (OLCI) Sea and Land Surface Temperature Radiometer (SLSTR) SAR Radar Altimeter (SRAL) Laser Retroreflector (LRR) Microwave Radiometer (MWR) *Orbital Parameters*: Type: Sun-synchronous Altitude: 814 km Period: 100 mins Inclination: 98.65 deg Repeat cycle: 27 days LST: 10.00	*Mission Objectives*: Supporting global land and ocean monitoring service, including an altimetry instrument package. *Environment*: Sea and land colour data and surface temperature; sea surface and land ice topography, coastal zones, inland waters and sea ice topography; vegetation product data; surface elevation data for oceans, ice regions and inland waterways surface measuring. *Knowledge*: Contribution to Europe's technology base.
Name: **GMES Space Component Sentinel 4** *Owner*: EC/ESA Sentinel-4A (on MTG-S1): 15 Dec. 2018 – 15 June 2027. Sentinel-4B (on MTG-S2): 15 Dec. 2026 – 15 June 2035 *Instruments*: Infra-Red sounder (IRS) Ultraviolet/Visible/Near-Infrared Imaging spectrometer (UVN) *Orbital Parameters*: Type: GEO	*Mission Objectives*: Supporting European Atmospheric composition and air quality monitoring services. *Environment*: Atmospheric composition monitoring; air quality; monitoring climate change; stratospheric ozone and solar radiation observations. *Knowledge*: Contribution to Europe's technology base.
Name: **GMES Space Component Sentinel 5** *Owner*: EC/ESA Sentinel-5 Precursor: 1 Oct. 2014 – 1 Jan. 2020 Sentinel-5 (on Post-EPS Meteorological Operational Polar Satellite): 1 Dec. 2019 – 1 Dec. 2024 *Instruments*: Sentinel-5 Precursor: Ultraviolet/Visible/Near-Infrared Imaging spectrometer (UVNS) Sentinel-5: Infra-Red Sounder (IRS) Multispectral Imager (METimage) Ultraviolet/Visible/Near-Infrared Imaging spectrometer (UVNS) *Orbital Parameters*: Sentinel-5 Precursor: Type: Sun-synchronous Altitude: 824 km Inclination: 98.742 deg Repeat cycle: LST: 13.30 Ascending Sentinel-5: Type: sun-synchronous	*Mission Objectives*: Sentinel-5 Precursor will support global atmospheric composition and air quality monitoring services. It will bridge the gap between Envisat and Sentinel-5. Sentinel-5 will support European Atmospheric composition and air quality monitoring services. *Environment*: Atmospheric composition monitoring; air quality; monitoring climate change; stratospheric ozone and solar radiation observations. *Knowledge*: Contribution to Europe's technology base.
Name: **GOCE** (Gravity Field and Steady-State Ocean Circulation Explorer) *Owner*: ESA *Mission lifetime*: 17 Mar. 2009 – 17 Apr. 2011	*Mission Objectives*: Research in steady-state ocean circulation, physics of the Earth's interior and levelling systems (based on GPS) data provision on the Earth's gravity field and geoid modelling for advancing ocean circulation

Instruments: Electrostatic Gravity Gradiometer (EGG) Lagrange GPS Receiver Satellite to Satellite Tracking Instrument (SSTI) Laser Retroreflector (LRR) *Orbital parameters:* Type: sun-synchronous Altitude: 270 km Period: 90 mins Inclination: 96.7 deg Repeat Cycle: 61 days	knowledge, and geodesy surveying. *Environment*: Accurate geoid data are crucial for measuring of ocean circulation, mean ocean level data and sea-level change, ice dynamics, and climate change in general. *Energy*: Gravity measurement technology is being used to help oil and gas companies find optimal drilling locations for their wells / detection of mineral resources. *Resources*: Use of geoid data for mineral resources detection.
Name: **GPM-Br** (Global Precipitation Measurement Satellite - Brazil) Owner: National Institute for Space Research in Brazil (INPE)/CNES Mission lifetime: 1 Dec. 2016 – 1 Dec. 2020 *Instruments*: Scanning Radiometer (RADIOMETRO) Lightning Imaging sensor (LIS) Data Collecting System (DCS) *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 600 km Inclination: 30 deg Descending	*Mission Objectives*: Global precipitation measurements. *Security*: Better forecasting; natural disaster monitoring. *Environment*: Understanding climate change; hydrology. Resources: Precipitation forecasting and predictions for agricultural applications.
Name: **GRACE** (Gravity Recovery And Climate Experiment) (2 satellites GRACE-A and GRACE-B) *Owner*: NASA/DLR *Mission lifetime*: 17 Mar. 2002 – 30 Sep. 2011 *Instruments*: GRACE instrument *Orbital parameters:* Type: inclined, non-sunsychronous Altitude: 400 km Period: 94 mins Inclination: 89 deg	*Mission Objectives*: High precision gravitation measurements for gravity field models. *Environment*: Understanding of global ocean circulation including monitoring of changes in deep ocean currents and sea level changes, changes in the mass distribution of polar ice hydrological applications: monitoring of water storage changes and ocean mass variability; thermal expansion of warming water and salinity changes; detection of changes in continental hydrology. *Resources*: Ground water measurements: high-precision satellite-to-satellite tracking to measure changes in water mass distributions, e.g. Dutch-Chinese project to address water shortages and desertification in Northern China, and assess current and future water resource management scenarios (2007-2008).
Name: **Helios** *Owner*: DGA/CNES (contributions of Spain, Belgium, Greece and Italy in Helios II) *Mission lifetime*: Helios IA: 7 July 1995 – 2011 Helios IB: 3 Dec. 1999 – Oct. 2004 Helios IIA: 18 Dec. 2004 – Helios IIB: 18 Dec. 2009 – *Instruments*: Very High Resolution and Infra-red Optical Instrument *Orbital parameters*: Type: quasi polar, sun-synchronous Altitude: 700 km	*Mission Objectives*: Military surveillance; intelligence and operations. *Security*: Military remote sensing applications (support targeting, guidance, mission planning and battle damage assessment); treaty compliance verification purposes; crisis management applications. *Note*: France and Germany share Helios II and SAR-Lupe data. Belgium and Spain can access Helios II under shared cost agreement.
Name: **Ingenio** (SEOSAT – Spanish Earth Observation Satellite) Owner: Centre for the Development of Industrial Technology in Spain (CDTI)/ESA	*Mission Objectives*: Spanish flagship mission for Space Strategic Plan 2007-2011: cartography, land use, urban management, water management, environmental monitoring, risk management and security purposes.

Mission lifetime: Jan. 2014 – Jan. 2021 *Instruments*: Optical Panchromatic and Multispectral Imaging Detector (PAN+MS: 4 bands in red, green, and blue and near infra-red (RGB+NIR)) Ultra Violet and near infra-red Atmospheric Sounder (UVAS) *Orbital parameters*: Type: sun-synchronous Altitude: 668 km Period: 98 mins Inclination: 98 deg Repeat Cycle: 43 days LST: 10.30 Descending	*Security*: Crisis management; military intelligence applications. *Environment*: Environmental monitoring purposes; urban challenges and land use observations. *Resources*: Agricultural and water resources applications.
Name: **JASON OSTM** (Ocean Surface Topography Mission) *Owner*: National Oceanic and Atmospheric Administration (NOAA)/ European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)/CNES *Mission lifetime*: JASON-1: 7 Dec. 2001 – 30 Sep. 2011 JASON-2: 20 June 2008 – 31 Dec. 2013 JASON-3: 30 June 2013 – 31 Dec. 2018 *Instruments*: JASON-1: Laser Reflector Array (LRA) Jason-1 Microwave Radiometer (JMR) Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS-NG) POSEIDON-2 Altimeter (SSALT-2) Turbo Rogue Space Receiver (TRSR) JASON-2: POSEIDON-3 Altimeter Advanced Microwave Radiometer (AMR) Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS-NG) Laser Reflector Array (LRA) Carmen 2 LPT T2L2 JASON-3 : POSEIDON class Altimeter Microwave Radiometer *Orbital parameters*: JASON-1: Type: inclined, non-sunsynchronous Altitude: 1336 km Period: 112.4 mins Inclination: 66 deg Repeat Cycle: 10 days JASON-2: Type: inclined, non-synchronous Altitude: 1336 km Period: 112.4 mins Inclination: 66 deg Repeat Cycle: 10 days JASON-3: Altitude: 1336 km Inclination: 66 deg Repeat Cycle: 10 days	*Mission Objectives*: Ocean observatory: model and predict the changes in oceans and their interactions with the climate. *Security:* Mitigation of flooding risks by monitoring of short- and medium-term effects of ocean currents and tides in coastal regions, serving as a valuable decision-support tool for policymakers. *Environment:* Oceanography: global ocean circulation; mapping of major marine currents; monitoring ocean changes, tides and various climate events; estimate the typology of the ocean floor; and providing accurate and continuous measurements of mean sea level. Accurate climate change predictions, monitoring of specific events like el nino and la nina, and ocean eddies. *Energy:* Providing date for off-shore oil exploration and production applications. *Mobility:* Use of oceanographic data for optimising maritime navigation (data made available by Météo France).
Name: **JPSS** (Joint Polar Satellite System) Owner: NOAA/EUMETSAT/NASA	*Mission Objectives*: Meteorology; climatology; terrestrial and oceanographic applications; solar geophysical applica-

Mission lifetime: JPSS-1: 1 Jan. 2015 – 1 June 2023 JPSS-2: 1 Jan. 2018 – 1 Oct. 2026 *Instruments*: Cross-Track Infra-red Sounder (CrIS) Cloud and Earth's Radiant Energy system (CERES) Visible Infrared Imager Radiometer Suite (VIIRS) Advanced Technology Microware Sounder (ATMS) Ozone Mapping and Profiler Suite (OMPS) Advanced Data Collection System 4 (A-DCS4) Search and Rescue Satellite Aided tracking (SARSAT) Space Environment Monitor – NPOESS (SEM-N) *Orbital parameters:* JPSS-1: Type: sun-synchronous Altitude: 824 km Period: 101 mins Inclination: 98.75 deg Repeat Cycle: LST: 13.30 Ascending JPSS-2: Type: sun-synchronous Altitude: 833 km Period: 101 mins Inclination: 98.75 deg Repeat Cycle: LST: 13.30 Ascending	tions. *Security*: Accurate weather forecasting; search and rescue capabilities; improving the accurateness and cost-effectiveness of public warning services; search and rescue applications. *Environment*: Providing global environmental data used in numerical weather prediction models for forecasts; long term use of collected data to understand climate change and determine possibilities for climate change mitigation and adaptation.
Name: **LAGEOS** (Laser Geodynamics Satellite) *Owner*: NASA/ASI *Mission lifetime*: LAGEOS-1: 4 May 1976 – 4 May 2016 (NASA) LAGEOS-2: 22 Oct. 1992 – 22 Oct. 2032 (NASA and ASI) *Instruments*: Laser Retroreflector Array (LRA) *Orbital parameters*: LAGEOS-1: Type: inclined, non-sunsynchronous Altitude: 5858 x 5958 km Period: 226 mins Inclination: 109.8 deg LAGEOS-2: Type: inclined, non-sunsynchronous Altitude: 5616 x 5950 km Period: 223 mins Inclination: 52.6 deg	*Mission Objectives*: Geodesy; crustal motion and gravity field measurements. *Security*: Use of LAGEOS gravity measurements for reference point determination in precision Earth dynamic measurements needed in earthquake hazard assessments. *Environment*: Long term monitoring of temporal variations in the Earth's gravity field allow for climate change monitoring purposes (including a reference system for post-glacial rebound, sea level and ice volume evolutions, determination of distribution of solid Earth, oceans and atmosphere, and solar heating variations monitoring).
Name: **LARES** (Laser Relativity Satellite) Owner: ASI *Mission lifetime*: 31 Mar. 2011 – 1 Jan. 2050 *Instruments*: Laser Corner Cube Reflector Assembly (LCCRA) *Orbital parameters*: Type: inclined, non-sunsychronous Altitude: 1450 km Period: 99.1 mins Inclination: 71 deg	*Mission Objectives*: Geodynamics; measuring crustal motion and gravity field; measurement of 'frame-dragging' due to the Earth's angular momentum.
Name: **MEGHA-TROPIQUES** (Meteorological LEO Observations in the Intertropical Zone)	*Mission Objectives*: Study of the inter-tropical zone and its water and energy cycles; data on the contribution of the

Owner: CNES/Indian Space Research Organisation (ISRO) *Mission lifetime*: 1 Jan. 2011 – 1 Apr. 2015 *Instruments*: Scanner for Radiation Budget (Scarab) Sondeur Atmosphérique du Profil d'Humidité Intertropicale par Radiométrie (SAPHIR) Microwave Analysis and Detection of Rain and Atmosphere systems (MADRAS) Radio Occultation Sounder for Atmosphere (ROSA) Orbital parameters: Type: inclined, non-sunsynchronous Altitude: 867 km Period: 102.16 mins Inclination: 20 deg Repeat Cycle: 7 days Ascending	water cycle to the tropical atmosphere, with information on condensed water in clouds, water vapour in the atmosphere, precipitation, and evaporation. Radiation budget measurements in the top of the atmosphere. *Environment*: Atmosphere, precipitation, and evaporation data for environmental purposes. *Knowledge*: Improving our knowledge regarding the water cycle in the intertropical region, and evaluation of the consequences of the energy budget.
Name: **MFG** (Meteosat first generation) Owner: EUMETSAT/ESA Mission lifetime: Meteosat-1: 23 Nov. 1977 – 1984 Meteosat-2: 10 June 1981 – Dec. 1991 Metoesat-3: 15 June 1988 – 1995 Meteosat-4: 19 Apr. 1989 – Nov. 1996 Meteosat-5: 2 Mar. 1991 – Feb. 2007 Meteosat-6: 20 Nov. 1993 – 31 Dec. 2013 Meteosat-7: 3 Sep. 1997 – 31 Dec. 2013 *Instruments*: Meteosat Visible and Infra-Red Imager (MVIRI) *Orbital parameters*: Type: GEO	*Mission Objectives*: Meteorology; climatology; atmospheric dynamics and water cycles. *Security*: Extreme weather event forecasting, e.g. prediction of evolution of drought or desertification on the African continent; observation of dormant volcanoes behaviour. Anticipating epidemics propagation (relation between climatic conditions and epidemics onset); hurricane monitoring, e.g. forecasting of Hurricane Andrew in 1992 allowed air traffic to be re-routed accordingly and risk mitigation purposes to be taken on the ground. *Environment*: Data for study of climate dynamics and change. *Mobility*: Use of weather forecasting data in air and sea traffic management. *Resources*: Use of MFG data for precipitation monitoring for agriculture (e.g. determining optimal sowing periods in the African Sahel and diagnosing of risk periods for crops and monitoring of surface temperature variations in the region).
Name: **MSG** (Meteosat Second Generation) *Owner*: EUMETSAT/ESA *Mission lifetime*: Meteosat-8 (MSG-1): 13 Aug. 2002 – 30 June 2011 Meteosat-9 (MSG-2): 21 Dec. 2005 – 30 June 2014 Meteosat-10 (MSG-3): 31 Jan. 2012 – 31 Jan. 2019 Meteosat-11 (MSG-4): 31 Jan. 2014 – 31 Jan. 2021 *Instruments*: Spining Enhanced visible and Infra-Red Imager (SEVIRI) Geostationary Earth Radiation budget (GERB) Geostationary Search & Rescue (GEOS&R) *Orbital parameters*: Type: GEO	*Mission Objectives*: Meteorology; climatology; atmospheric dynamics and water cycles. *Security*: Natural hazards forecasting and monitoring, including natural and man-made disasters (pre-crisis, crisis, and post-crisis management); extreme weather event forecasting (e.g. prediction of evolution of drought or desertification on the African continent); observation of dormant volcanoes behaviour. Anticipating epidemics propagation (relation between climatic conditions and epidemics onset); hurricane monitoring; monitoring of African vegetation fires; search and rescue applications. *Environment*: Urbanisation challenges (MSG helps developing urban heat wave forecasting and appropriate alarm systems, an adds to the study of spatial variability in urbanised areas in order to contribute to future urban planning and reduce detrimental effects of heat waves in cities); weather (numerical weather prediction) and climate modelling; ecosystem observations (e.g. taxonomic data, biomass data, tree density, carbon budget assessment) research; hydrology: study of the water cycle (soil moisture data, temporal land surface temperature variations, and surface anisotropy observations; study of global climate variables including the global carbon cycle. *Mobility*: Specialised forecasts for marine and aviation transport.

	Resources: Specialised forecasting for agricultural purposes; food security and sustainability by monitoring of vegetation productivity of crops, pastures or forests; water resource management purposes including estimations of water needs and irrigation planning; huge potential of SEVIRI data for resource management in Africa (agriculture, food security, soil moisture, ecosystem data, environmental protection, and forest resource assessments).
Name: **MTG-S** (Meteosat Third Generation (sounding satellite)) *Owner*: EUMETSAT/EC/ESA *Mission lifetime*: MTG-S1: 15 Dec. 2018 – 15 June 2027 MTG-S2: 15 Dec. 2026 – 15 June 2035 *Instruments*: Infra-Red Sounder (IRS) Ultraviolet-Visible Near infra-red (UVN) Spectrometer *Orbital parameters*: Type: GEO	*Mission Objectives*: Supporting atmospheric and air quality monitoring services. *Note*: MTG S1 carries the Sentinel-4A Mission; MTG S2 carries the Sentinel-4B Mission.
Name: **MERLIN** (Methane Remote Sensing LIDAR Mission) *Owner*: DLR/CNES *Mission lifetime*: 1 Jan. 2014 – 1 Jan. 2017 *Instruments*: Light Detection and Ranging (LIDAR) *Orbital parameters*: Type: sun-synchronous Altitude: 650 km	*Mission Objectives*: Study of the global atmospheric methane concentration. *Environment*: Greenhouse gas monitoring; better understanding the effects of greenhouse gasses emission on the climate; potential uses for climate convention compliance monitoring. *Knowledge*: Conclusions on the sources of methane gas; understanding climate change.
Name: **Metop** (Meteorological Operational Polar Satellite) *Owner*: EUMETSAT/ESA *Mission lifetime*: Metop-A: 19 Oct. 2006 – 30 Apr. 2012 Metop-B: 2 Apr. 2012 – 1 May 2017 Metop-C: 2 Apr. 2016 – 1 Dec. 2021 *Instruments*: Metop-A: Space Environment Monitor-2 (SEM-2) Remote Data Collection System (ARGOS) Search & Rescue Satelltie aided Tracking system (S&RSAT) (NOAA) Microwave Humidity sounder (MHS) Improved Atmospeheric Sounder Interferometer (IASI) GNSS Receiver for Atmospheric Sounding (GRAS) Global Ozone Monitoring Experiment – 2 (GOME-2) Advanced Wind Scatterometer (ASCAT) Advanced Microwave Sounding Unit-A (AMSU-A) Advanced Very High Resolution Radiometer-3 (AVHRR/3) High Resolution Infra-Red Sounder-4 (HIRS/4) *Orbital parameters*: Metop-A: Type: sun-synchronous Altitude: 840 km Period: 107.1 mins Inclination: 98.8 deg Repeat Cycle: 29 days LST: 9.30	*Mission Objectives*: Polar meteorology and climatology. *Security*: Accurate weather forecasting and extreme weather predictions; search and rescue applications. *Environment*: Atmospheric composition monitoring: GOME-2 Tropospheric NO2, CH20, measurements and cloud fraction and cloud pressure data; near-real time volcanic SO2 and ash images. ARGOS 3rd generation instrument: protecting the environment by the study of the oceans and the atmosphere, monitoring water resources, preserving wildlife, managing and protecting marine ecosystems, ensuring maritime security, and humanitarian applications. Hydrology: water cycle, continental snow and mountain glaciers, land cover, soil moisture, vegetation. Oceanography: general ocean circulation and fluxes of heat, momentum and gases. Pollution control, natural disasters, renewable resources. Sea and continental ice monitoring. *Mobility*: Applications for offshore activities, ship routing, fishing, sea ice routing; volcanic ash cloud advisory centres use remote sensing date on ash plumes for air traffic purposes. *Resources*: AVHRR data provides continuous information on snow cover during daytime in cloud-free areas: monitoring of glacier snowmelt runoff provides crucial info used for water and other resources management, flood predictions and hydropower operations.

Metop-B: Type: sun-synchronous Altitude: 840 km Period: 101.7 mins Inclination: 98.8 deg Repeat Cycle: 29 days LST: 9.30 Metop-C: Type: sun-synchronous Altitude: 840 km Period: 101.7 mins Inclination: 98.8 deg Repeat Cycle: 29 days LST: 9.30	
Name: **MTG-I** (Meteosat Third Generation Imaging satellite) *Owner*: EUMETSAT/ESA *Mission lifetime*: MTG-I1: 15 Dec. 2016 - 15 June 2025 MTG-I2: 15 June 2021 – 15 Dec. 2029 MTG-I3: 15 Jan. 2025 – 15 July 2033 MTG-I4: 15 June 2029 – 15 Dec. 2037 *Instruments*: Flexible Combined Imager (FCI) Lightning Imager (LI) *Orbital parameters*: Type: GEO	*Mission Objectives*: Meteorology; climatology, atmospheric dynamics and water cycles.
Name: **MIOSAT** (Missione Ottica su microsatellite) *Owner*: ASI *Mission lifetime*: 1 Jan. 2013 – 1 Jan. 2016 *Instruments*: Pan Camera Aerospace Leap-frog Imaging Stationary Interferometer for Earth Observation (ALISEO) Mach Zehnder Interferometer (MZI) *Orbital parameters*: Type: sun-synchronous Attitude: 523 km Inclination : 97.4 deg Repeat Cycle : 8 days Descending	*Mission Objectives*: Land surface; agriculture and forestry applications. Regional geology, land use studies, water resource management, vegetation studies, coastal zone and soil protection; atmospheric composition; low cost technology demonstrator mission.
Name: **Odin** *Owner*: Swedish National Space Board (SNSB)/ National Technology agency of Finland (TEKES)/CNES/Canadian Space Agency (CSA)/ Natural Sciences and Engineering Research Council (Canada) (NSERC) *Mission lifetime*: 20 Feb. 2001 – 31 Dec. 2012 *Instruments*: Optical Spectrograph and Infrared Imaging System (OSIRIS) Submillimeterwave Radiometer (SMR) *Orbital parameters*: Type: sun-synchronous Altitude: 590 km Period: 97.6 mins Inclination: 97.8 deg Repeat Cycle: LST: 18.00	*Mission Objectives*: Atmospheric Research, stratospheric ozone chemistry, mesospheric ozone science, summer mesospheric science. *Environment*: Atmospheric composition monitoring (water, CO and ozone distributions) *Knowledge*: Astronomy (interstellar H20 and O2 observations) and aeronomy applications.

Name: **Oersted** (Geomagnetic Mission) Owner: Danish Space Research Institute (DSRI)/CNES Mission lifetime: 23 Feb. 1999 – 31 Dec. 2010 *Instruments*: Overhauser (OVH) scalar magnetometer Compact Speherical Coil Fluxgate Vector Magnetometer (CSC FVM) Star Imager (SI) Compass GPS Radio Occultation System (GPSRO) *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 655 x 857 km Inclination: 96.48deg Period: 100 mins Ascending	*Mission Objectives*: Earth magnetic field mapping. *Environment*: Climate change: combining the data from ice cores drilled in the Arctic with geodetic modelling based on measurements from Oersted; measuring ocean currents. *Knowledge*: Better understanding of the properties of the Van Allen Radiation Belts by high-energy particles detection; information on the electrical properties of the mineral mass in the Earth's mantle.
Name: **PARASOL** (Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a LIDAR) *Owner*: CNES *Mission lifetime*: 1 Dec. 2004 – 30 June 2011 *Instruments*: Polarization and Directionality of the Earth's Reflectances (POLDER) *Orbital parameters*: Type: sun-synchronous Altitude: 705 km Period: 98.8 mins Inclination: 98.21 deg	*Mission Objectives*: Micro-satellite with the aim of characterisation of the clouds and aerosols microphysical and radiative properties, needed to understand and model the radiative impact of clouds and aerosols on climate mechanisms. *Environment*: Data on the interactions of clouds, rainfall and pollution; quantity and size distribution of aerosols over ocean regions, and turbidity index over land surfaces. *Note*: PARASOL was part of the A-Train space observatory constellation. A-Train consisted of six satellites (Aqua, AURA, Glory, Cloudsat, CALIPSO, and PARASOL) obtaining near-simultaneous collocated data on atmospheric phenomena. PARASOL is since Dec. 2009 no longer part of the A-train constellation due to fuel shortage and orbit has been lowered to a slightly lower orbit (to limit collision risk) and continues to gather Earth observation data.
Name: **PAZ** (SEOSAR – Spanish Earth Observation SAR) *Owner*: CDTI *Mission lifetime*: 31 Dec. 2011 – 31 Dec. 2016 *Instruments*: PAZ SAR-X *Orbital parameters*: Type: sun-synchronous Altitude: 510 km Period: 90 mins Inclination: 98 deg Ascending	*Mission Objectives*: Various Earth observation purposes. *Security*: Crisis management purposes; risk and damage assessing. *Environment*: Environmental monitoring purposes; urban development. *Resources*: Land use monitoring.
Name: **PICARD** Owner: CNES/ Centre National de la Recherche Scientifique (France) (CNRS) /Swiss Space Office/Belgian Federal Space Policy Office (BELSPO) *Mission lifetime*: 15 June 2010 – 1 Dec. 2011 *Instruments*: Solar Diameter Imager and Surface Mapper (SODISM) Solar Constant Variability Picard (SOVAP) Precision Monitoring of Solar Variability (PREMOS) *Orbital parameters*: Type: sun-synchronous Altitude: 725 km	*Mission Objectives*: Study of the influence of the Sun on the Earth's climate (effects of solar variability and its possible effects on the Earth's climate including the relationship between UV radiation and stratospheric ozone and the link between solar cycles and temperature on Earth); simultaneous measurements of solar diameter, differential rotation, solar constant, and variability. *Environment*: Better understanding of the dynamics of climate change. *Knowledge*: Effects sun on Earth's environment and climate; helioseismology.

Inclination: 98 deg	
Name: **Pleiades** *Owner*: CNES/Austrian space agency/Belgian Federal Space Policy Office/Spanish space agency/SNSB/DGA/Spanish and Italian defence agencies *Mission lifetime*: Pleiades-1: 31 Mar. 2011 – 31 Mar. 2016 Pleiades-2: 31 Mar. 2012 – 31 Mar. 2017 *Instruments*: High Resolution Imager (HiRI) *Orbital parameters*: Type: sun-synchronous Altitude: 694 km Inclination: 98.2 deg Repeat Cycle: 26 days LST: 10.15 Descending	*Mission Objectives*: Objective is to cover all European metric-resolution requirements for civil and security purposes. *Security*: Crisis management, risk and damage assessments, defence applications. *Environment*: Environmental monitoring applications. *Resources*: Land use digital terrain modelling; agriculture and forestry objectives; cartography.
Name: **Post-EPS** (Meteorological Operational Polar Satellite) *Owner*: EUMETSAT/EC/ESA *Mission lifetime*: 1 Dec. 2019 – 1 Dec. 2024 *Instruments*: *Orbital parameters*:	*Mission Objectives*: Early mission definition, carries sentinel 5-mission.
Name: **Prisma** (Hyperspectral precursor of the application mission) *Owner*: ASI *Mission lifetime*: 1 Jan. 2012 – 1 Jan. 2017 *Instruments*: Pan Camera *Orbital parameters*: Type: sun-synchronous Altitude: 650 km Period: 99 mins Inclination: 97.8 deg Repeat Cycle: 25 days LST: 10.30 Descending	*Mission Objectives*: Demonstrator mission for Earth observation and testing of the hyperspectral payload. *Security*: Environmental risk management. *Environment*: Monitoring of atmospheric characteristics; inland water quality, coastal zones, soil moisture and carbon cycle monitoring. *Resources*: Natural resource monitoring applications; land cover and agricultural monitoring (crop status).
Name: **Proba-1** (Project for On-Board Autonomy-1) Owner: ESA/collaborative countries *Mission lifetime*: 22 Oct. 2001 – 31 Dec. 2012 *Instruments*: Compact High Resolution Imaging Spectrometer (CHRIS) High Resolution Camera (HRC) Wide Angle Camera (WAC) Space Radiation Environment Monitor (SREM) Debris In-orbit Evaluator (DEBIE) Smart Instrument Points (SIPs) Miniaturised Radiation Monitor (MRM) Payload Autonomous Star Sensor (PASS) *Orbital parameters*: Type: sun-synchronous Altitude: 615 km Period: 96.97 mins Inclination: 97.9 deg	*Mission Objectives*: Technology experiment to demonstrate the on-board autonomy of a generic platform suitable for small scientific or application missions; Earth observation purposes. *Security*: Natural catastrophes damage assessments (e.g. HRC imagery of April 2010 volcanic eruption of Iceland's Eyjafjallajökull); use of CHRIS data in support of the International Charter for Space and Major Disasters and individual search and rescue teams responding to natural disasters. *Environment*: Environmental impact assessments (e.g. 2003 CHRIS Image of China's Three Gorges Dam); CHRIS imagery for aerosol retrieval evaluation in Hong Kong; snow cover data of the Swiss National Park; Assessing the role of woodland as sinks and source of CO. *Knowledge*: Testing of new technologies including new lithium ion battery, autonomous navigation system, and the performance of attitude control systems; CHRIS imagery for identification of ancient Roman buildings for

Repeat Cycle: 7 days LST: 10.30	archaeological projects. *Resources*: Use of CHRIS imagery for assessments of different land use strategies in the Savannahs of Central Namibia; monitoring of landfill operations.
Name: **PROBA-V** (Project for On-Board Autonomy-Vegetation) *Owner*: ESA *Mission Lifetime*: 2012 – Instruments: Vegetation Instrument Proba (VGT-P) Spectrometer Orbital Parameters: Type: sun-synchronous, polar Altitude: 820 km LST: 10.30 Descending	*Mission objectives:* Vegetation monitoring, filling the gap between SPOT-4 and 5, and the GMES Sentinel-3 satellites. Security: Fire detection and early warning; severe droughts predictions by monitoring of vegetation behaviour. Environment: Monitoring biophysical parameters for ecosystem vulnerability purposes; land use and land cover mapping; Resources: Use of data on biophysical parameters for water resource management and agricultural applications.
Name: **RapidEye** (5 satellites constellation) Owner: RapidEye/DLR *Mission lifetime*: 29 Aug. 2008 – 30 Aug. 2015 *Instruments*: Multispectral Imager (MSI) *Orbital parameters*: Type: sun-synchronous Altitude: 622 km Inclination: 98.7 deg Repeat Cycle: 1 days LST: 11.00 Descending	*Mission Objectives*: Remote sensing for cartography, land usage, digital terrain modelling, disaster and environmental monitoring. *Security*: Disaster management purposes. *Environment*: Forest monitoring for environmental protection including tree species and bio diversity, infestation detection, and stem volume estimations; environmental protection purposes by chlorophyll content monitoring, following vegetation health, and measurements of nitrogen and protein content in biomass; detection of desertification and illegal logging; invasive species monitoring. *Energy*: Pipeline monitoring purposes. *Mobility*: Updating transport network databases. *Resources*: Agricultural objectives (precision farming services) including crop identification and typing, yield forecasting, harvest mapping, crop damage assessments and risk management; land cover and land use applications; forest monitoring.
Name: **SARAL** (Satellite with Argos and ALtiKa) *Owner*: CNES/ISRO *Mission lifetime*: 1 Oct. 2011 – 1 Oct. 2013 *Instruments*: ARGOS-3 instrument Altimeter Ka-Band Instrument (ALtiKa) Laser Retroreflector Array (LRA) Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS) *Orbital parameters*: Type: sun-synchronous Altitude: 799 km Period: 100.59 mins Inclination: 98.55 deg Repeat Cycle: 35 days Descending	*Mission Objectives*: Precision, repetitive global measurements of sea surface height, significant wave heights and wind speed. *Environment*: Continuous observation for the objectives of characterisation of the mesoscale ocean and coastal areas, seasonal forecasting, and climate studies; operational meteorology; protection of marine ecosystems.
Name: **SAR-Lupe** Owner: German Ministry of Defence (Bundesministerium der Verteidigung) (BMVg) *Mission lifetime*: 10 years SAR-Lupe 1: 19 Dec. 2006 - SAR-Lupe 2: 2 July 2007 - SAR-Lupe 3:1 Nov. 2007 -	*Mission Objectives*: Satellite-based reconnaissance purposes: crisis management and early warning services; avoiding unilateral dependencies in reconnaissance data. *Security*: Marine security objectives: small vessel and oil spill detection potential of the advanced radar systems on SAR-Lupe and COSMO-Skymed constellation (can improve

SAR-Lupe 4 : 27 Mar. 2008 - SAR-Lupe 5 : 22 July 2008 - *Instruments*: Synthetic Aperture Radar (SAR) (S-Band inter-satellite transmitter and X-Band transmitter) *Orbital parameters*: 3 orbital planes Altitude: app. 500 km Inclination: near-polar orbits	the radar based marine observation); disaster management; defensive applications in planning and execution of operations/support of armed forces with continuous intelligence. *Environment*: Environmental protection purposes; *Resources*: Exploration of natural resources applications. *Note*: France and Germany share Helios II and SAR-Lupe data.
Name: **SMOS** (Soil Moisture and Ocean Salinity) Owner: ESA/CDTI/CNES/National Institute for Aerospace Technology in Spain (INTA) Mission lifetime: 2 Nov. 2009 – 2 Nov. 2012 *Instruments*: Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) *Orbital parameters*: Type: sun-synchronous Altitude: 758 km Period: 100.075 mins Inclination: 98.44 deg Repeat Cycle: 23 days LST: 6.00 Ascending	*Mission Objectives*: monitoring of soil moisture and ocean salinity data, vegetation water content, snow cover and ice structure. *Environment*: Soil moisture and salinity data are used to advance understanding of and support applications for climatologic, meteorological, hydrologic and oceanographic purposes. *Knowledge*: Soil moisture technology is being applied for uses in monitoring of dams and dikes by Airborne Passive Microwave Radiometry (APMR). *Resources*: Soils moisture is relevant indicator for agriculture.
Name: **SPOT** (Satellite pour l'Observation de la Terre) *Owner*: CNES *Mission lifetime*: SPOT-1: 22 Feb. 1986 – 28 Nov. 2003 SPOT-2: 22 Jan. 1990 – July 2009 SPOT-3: 26 Sep. 1993 – 14 Nov. 1996 SPOT-4: 24 Mar. 1998 – 1 June 2013 SPOT-5: 4 May 2002 – 1 June 2014 SPOT-6: 2013 – SPOT-7: 2014 – *Instruments*: SPOT-4: High Resolution Visible and Infra-red Sensor (HRVIR) Vegetation Monitoring Instrument (VEGETATION 1) Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Semiconductor Intersatellite Link Experiment (SILEX) POAM-III (Polar Ozone and Aerosol Measurement) SPOT-5: High Resolution Geometric (HRG) Vegetation Monitoring Instrument (VEGETATION 2) High Resolution Stereoscopic (HRS) Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS-NG) *Orbital parameters*: SPOT-4/5: Type: sun-synchronous Altitude: 832 km Period: 101.4 mins Inclination: 98.7 deg Repeat Cycle: 26 days LST: 10.30 Descending SPOT-6/7: Type: Sun-synchronous	*Mission Objectives*: Observing the Earth's resources, detect and forecast phenomena involving climatology and oceanography, monitoring of human activities and natural phenomena. *Security*: Monitoring and decision-support tool for crisis mitigation and management. Crisis prevention, assessments, monitoring and relief applications (e.g. Tsunami in 2004 in Asia and 2006 floods in Asia); emergency management and relief teams; military intelligence: data used at three levels: strategic, tactical, and operational. SPOT-5 simultaneous stereopair acquisition is of particular importance (SPOT complements Helios satellites' data). *Environment*: Oceanography: DORIS system is used in "ocean or ice fields altimetry missions, studies of the shape and movements of Earth, as well as many location services". VEGETATION studies changes in crop yields and forests, providing insight in the interaction between the biosphere and climate. Land use: SPOT can provide an inventory of land use, (e.g. monitor the growth of the 50 biggest cities in China, and the implementation of Manila's development plan in the Philippines). Wetland monitoring in Queensland (Australia): identification of beach protection of vulnerable bio environments (e.g. scrub areas in the Queensland coastal area to determine areas for priority environmental action in order to protect these regions from (further) deterioration). Monitoring of urban development: data for urban dynamic assessment, classification of urban areas, urban environmental databases. Forest monitoring: evaluating storm damage. *Energy*: Stereoscopic images are a key asset for oil and mineral exploration to achieve a synoptic view of a site and its geographic features; energy infrastructure planning. *Knowledge*: Creation of dedicated geographic databases

Altitude: 800 km Repeat Cycle: 26 days	for telecommunication purposes; VEGETATION and ATSR-2 data are combined to create a monthly leaf are index (carbon assimilation modelling); civil engineering applications. *Resources*: Infrastructure planning; utility corridor mapping. Agricultural applications: VEGETATION crop yielding data (inventories of crop acreage, forecast crop yields, manage farming practices and monitor agricultural aid measures); illegal crops detection, which are often planted in remote regions; identifying, mapping and monitoring of pastures; precise crop identification (e.g. used in the checking of agricultural subsidy claims). Geology: Geologic and structural terrain information for resource exploration applications minimising risks, time, and costs. Water resource management: observations of interaction of water and land surfaces. Applications range from managing disasters such as flooding to harnessing this natural resource for irrigation, recreation and other human development projects. Forestry: State forest monitoring and evaluating; identification of suitable land to offset loss of endangered ecosystems through mining; biodiversity protection in mining areas.
Name: **STARLETTE** (Satellite de Taille Adaptée avec Réflecteurs Laser pour les Etudes de Terre) *Owner*: CNES *Mission lifetime*: 6 Feb. 1975 – 31 Dec. 2050 *Instruments*: Laser reflectors *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 812 km Period: 104 mins Inclination: 49.83 deg	*Mission Objectives*: Study of the Earth's gravitational field and its temporal variations (geodesy). *Note*: STARLETTE is almost identical satellite to STELLA; STELLA provides coverage of polar regions not observed by STARLETTE.
Name: **STELLA** *Owner*: CNES *Mission lifetime*: 26 Sep. 1993 – 31 Dec. 2050 *Instruments*: Laser reflectors *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 800km Period: 101 mins Inclination: 98.6 deg	*Mission Objectives*: Study of the Earth's gravitational field and its temporal variations (geodesy). *Note*: STELLA is almost identical satellite to STARLETTE; STELLA provides coverage of polar regions not observed by STARLETTE.
Name: **Swarm** (Earth Magnetic Field and Environment Explorers) (3 satellites constellation) *Owner*: ESA/CNES/CSA/Danish Technical University Space (DTU Space) *Mission lifetime*: 2012 – *Instruments*: Vector Field Magnetometer (VFM) Absolute Scalar Magnetometer (ASM) Electrical Field Instrument (EFI) Accelerometer (ACC) Laser Retroreflector (LRR) *Orbital parameters*: Type: polar Altitude: 2 satellites at 450 km, 1 at 530 km Inclination: 2 satellites at 87.4 deg, 1 at 88 deg	*Mission Objectives*: Objective is to provide the most accurate survey ever of the Earth's geomagnetic field. *Environment*: Data on ocean currents; use of geomagnetic field data for insights of atmospheric processes related to weather and climate. *Knowledge*: Improving our understanding of the Earth's interior and climate; enhancing our knowledge on space weather including solar wind analysis; strength of the Earth's gravitational field.

Name: **SWOT** (Surface Water Ocean Topography) *Owner*: NASA/CNES *Mission lifetime*: 1 Jan. 2020 – 1 Jan. 2023 *Instruments*: CO Sensor (ASCENDS) Kaband Rader INterferometer (KaRIN) *Orbital parameters*: Type: inclined, non-sunsynchronous Altitude: 970 km Inclination: 78 deg Repeat Cycle: 22 days	*Mission Objectives*: Earth observations objectives concerning the oceans, lakes, and river water levels.
Name: **TanDEM-X** (TerraSAR-X Add-on for Digital Elevation Measurements) *Owner*: DLR/Astrium GmbH *Mission lifetime*: 21 June 2010 – 31 Dec. 2015 *Instruments*: Synthetic aperture Radar (SAR) (X-band) *Orbital parameters*: Type: sun-synchronous Altitude: 514.8 km Period: 94.85 mins Inclination: 97.44 deg Repeat Cycle: 11 days LST: 18.00 Ascending	*Mission Objectives*: remote sensing for cartography, land surface, civil planning and mapping, digital terrain models, environmental monitoring. *Security*: Fire protection services; flood and/or Earthquake crisis management and geological data gathering (across-track synthetic aperture radar interferometry); Tsunami predictions; volcanology and eruption crisis management: (e.g. 3D imagery of Eyjafjallajökull volcano from TanDEM-X and TerraSAR-X). *Environment*: Topographical mapping applications; land use and vegetation monitoring (across-track synthetic aperture radar interferometry); glaciology: understanding the effects of climate change (along-track and across-track synthetic aperture radar interferometry); oceanography (along-track synthetic aperture radar interferometry). *Knowledge:* Enhancing Europe's technology base in SAR remote sensing. *Mobility*: Traffic monitoring (along-track synthetic aperture radar interferometry). *Resources*: Water resource management, drainage channels monitoring; soil moisture, hydrological and topographical characteristics of areas, and transnational modelling of watershed yields. *Note*: TanDEM-X and TerraSAR-X (flying in formation) are in the process of preparing a three year mission (starting Jan. 2011) to map the entire Earth's land mass in stereo (3D elevation model of Earth).
Name: **TerraSAR-X** Owner: DLR/BMBF/Astrium GmbH Mission lifetime: 15 June 2007 – 31 Dec. 2012 *Instruments*: Synthetic Aperture Radar (SAR) (X-band) GPSRO (Terra-SAR) Laser Communication Terminal (LCT) Tracking, Occultation and Ranging Experiment (TOR) *Orbital parameters*: Type: sun-synchronous Altitude: 514.8 km Period: 94.85 mins Inclination: 97.44 deg Repeat Cycle: 11 days LST: 18.00 Ascending	*Mission Objectives*: remote sensing cartography, land surface, civil planning and mapping, digital terrain models, environmental monitoring. *Security*: Crisis prevention, assessments, monitoring and relief applications; volcanology and eruption crisis management, e.g. 3D imagery of Eyjafjallajökull volcano from TanDEM-X and TerraSAR-X; earthquake crisis mitigation, e.g. radar imagery of Earth crust movement in Haïti in Jan. 2010 by comparison between data from before and after the earthquake. *Environment*: Land use and regional / urban planning applications (track record in forest monitoring (e.g. Mato Grosso in Brazil in 2007 for data on rainforest logging), global carbon cycle studies and compliance verification of international agreement obligations). Snow and ice coverage monitoring for understanding of the effects of climate change (e.g. radar imagery of the Patagonia Upsala Glacier (Argentina) in 2008), agricultural purposes (e.g. Nördlinger Ries Flat (Swabian Jura) in 2007), flood predictions and flood crisis management (e.g. in England 2007 or Mexico in 2007) and hydroelectric

	power generation. X-band is particularly suited for sea ice monitoring. TerraSAR-X measurements of wind fields and strengths. Sea monitoring and oil spill detection (e.g. Aug. 2010 radar imagery of Deepwater horizon oil spill in Gulf of Mexico (used for oil drift predictions)). Imagery of the Sidney Botany Bay area for coastal zone protection and shipping objectives in 2007. Glaciology: tracking changes of ice dynamics (e.g. Drygalski glacier in Antarctica). Oceanography: under water topography by monitoring how swells (formation of long-wavelength surface waves) break on underwater walls by studying diffraction patterns. Forest mapping services. *Knowledge*: Enhancing Europe's technology base in SAR remote sensing; radar imagery of the Pyramids of Giza in Egypt (2007) for archaeological purposes. *Mobility*: Monitoring of marine traffic, e.g. imagery of the Strait of Gibraltar (2007); highway imagery for traffic management purposes and congestion prevention/reduction (e.g. Autostrade del Sole in Italy); traffic monitoring by tracking and measurements of moving objects and determination of velocity (e.g. monitoring of highway A4 near Dresden in 2009). *Resources*: Land use determination purposes: identification of areas best suitable for tourism and/or agriculture (e.g. Imagery of National Park on Mount Egmont in New Zealand in 2007); land use and vegetation cover monitoring; agricultural mapping services through multitemporal and multipolarisation observations and facilities large area assessments. *Note*: TanDEM-X and TerraSAR-X (flying in formation) are in the process of preparing a three year mission (starting Jan. 2011) to map the entire Earth's land mass in stereo (3D elevation model of Earth).
Name: **Topsat** (Tactical Optical Imaging Satellite) *Owner*: British National Space Centre (BNSC)/ British Ministry of Defence (MoD) *Mission lifetime*: 27 Oct. 2005 – 31 Dec. 2010 *Instruments*: TOPSAT Telescope *Orbital parameters*: Type: sun-synchronous Altitude: 685km Period: 98.5 mins Inclination: 98 deg Repeat Cycle: LST: 10.30 Ascending	*Mission Objectives*: Prototype low-cost high-resolution imager that provides data for civilian and military uses. *Security*: Support for disaster relief operations.
Name: **UK-DMC-1G** (UK Disaster Monitoring Constellation First Generation) Owner: BNSC *Mission lifetime*: 27 Sep. 2003 – 31 Dec. 2010 *Instruments*: SLIM-6 *Orbital parameters*: Type: sun-synchronous Altitude: 686 km Period: 98.4 mins Inclination: 98.2 deg Repeat Cycle: 5 days LST: 9.00	*Mission Objectives*: Wide area, medium resolution optical imaging for mapping, crop monitoring, environmental resource and disaster management. *Security*: Monitoring of natural and man-made disasters including fire and burn scar mapping; coastal protection, flood monitoring and hydrology objectives. *Note*: DMC-1G is an international cooperation project. Other satellites from DMC-1G are i.a. AISAT-1, NigeriaSat-1, BILSAT, and Beijing-1.

Ascending	
Name: **UK-DMC-2G** (UK Disaster Monitoring Constellation Second Generation) Owner: BNSC/Surrey Satellite Technology Limited (SSTL) *Mission lifetime*: 29 July 2009 – 29 July 2014 *Instruments*: SLIM-6-22 *Orbital parameters* : Type: sun-synchronous Altitude: 670 km Period: 98.5 mins Inclination: 98.14 deg Repeat Cycle: 5 days LST: 10.45 Ascending	*Mission Objectives*: Wide area, medium resolution optical imaging for mapping, crop monitoring, environmental resource and disaster management. *Security*: Monitoring of natural and man-made disasters including fire and burn scar mapping; coastal protection, flood monitoring and hydrology objectives. *Note*: DMC-2G is an international cooperation project. Other satellites from DMC-2G are i.a. Deimos-1 and NigeriaSat-2.
Name: **VENUS** (Vegetation and Environment monitoring on a New Microsatellite) Owner: CNES/ Israeli Space Agency (ISA) *Mission lifetime*: 31 Jan. 2013 – 31 Jan. 2016 *Instruments*: Venus Super Spectral Camera (VSSC) *Orbital parameters*: Type: sun-synchronous Altitude: 720 km Inclination: 98.27 deg Repeat Cycle: 2 days Descending	*Mission Objectives*: Earth observation environmental and resource management related objectives and Electric propulsion technology demonstrator mission. *Environment*: Observation of high-altitude layer of sulphur dioxide in Nov. 2010. *Resources*: Vegetation and agriculture monitoring, water management; Crop yielding and carbon fluxes assessments.
SATELLITE NAVIGATION	
Name: **EGNOS** (European Geostationary Navigation Overlay System) *Owner*: ESA/EC/Eurocontrol *Mission:* GEO satellites currently providing the EGNOS signal (Inmarsat 3F2, Inmarsat 4F2, ESA Artemis, and SES ASTRA Sirius 5) *Orbital parameters*: Type: GEO	*Mission Objectives*: EGNOS is a satellite-based augmentation system (SBAS) for the current GPS and GLONASS constellations; multipurpose applications in maritime, aeronautical, land based and timing activities; EGNOS provides three basic services: Open Service, EGNOS Data Access Service (EDAS), and Safety of Life Service. *Security*: Safer hazardous waste transport; traffic accident mitigation; remote asset tracking; general transport safety enhancement; search and rescue applications; general emergency management (disaster mitigation and damage assessments); law enforcement purposes; post-disaster relief organisation; humanitarian aid applications. *Environment*: Inland water level measurements; improving our efforts in mitigating climate change by making transport more efficient and more environment-friendly. *Energy*: Monitoring critical energy infrastructures including power plants, power line infrastructures, oil and gas pipe lines; applications for energy transport and distribution; seismic exploration applications; precision positioning applications for energy exploitation and supply. *Knowledge*: Enhancing Europe's technology base in satellite navigation; technology and facilities development; improving our time standards, better mapping and enhanced geographic information; use of GNSS to create near-real time measurements of water levels for better flood prediction technology; use of satellite navigation technology for maintenance and inspection purposes for buildings, bridges, industrial plants; tourist information on cell phone applications; calculations of the transport car-

	bon footprint of individuals; smart drive techniques that help reduce car fuel consumption. *Mobility*: Applications for improving road, rail, maritime and air traffic; assistance for blind pedestrians; improving general aviation efficiency and safety; enhancing air traffic control including landing and en-route navigation; personal mobility enhancement by providing navigation applications on personal receivers; autonomous transport on-board positioning systems; optimisation of various mobility solutions including passenger and freight transport; improving urban mobility / public transport planning, monitoring, optimising and evaluations. Resources: Agricultural applications, e.g. variable ploughing, seeding and spraying; tractor guidance; livestock positioning and tracking; virtual fencing; land parcel identification and geo-traceability; post-harvest pick-up; field measuring; field boundary mapping and updating; precision farming; reducing waste and over-fertilisation, crop yield optimisation; optimisation agricultural equipment lifetime. Remote asset tracking; mining applications; water resource management.
Name: **Galileo** *Owner*: EC/ESA *Mission lifetime*: 30 satellites constellation Designated lifetime per satellite is 10 years Experimental satellites GIOVE-A (28 Dec. 2005 -) and GIOVE-B (27 Apr. 2008 -) (in orbit-validation of Galileo system) *Instruments*: L-band antenna Search and Rescue antenna C-band antenna S-band antennas IR Earth sensors Sun sensor Laser Retro-reflectors *Orbital parameters*: Type: near-circular MEO Altitude: 23222 km Inclination: 56° 27/3/1 constellation	*Mission Objectives*: Satellite navigation constellation. Galileo will provide 5 main levels of service: Open Service: free access for anyone with a Galileo receiver for positioning, navigation and timing data compatible with GPS and GLONASS; Commercial Service: Various added-value services with the possibility to transmit complementary data; Safety of Life Service for safety applications in as air, sea and land transport; Public Regulated Service (public security services); Search and Rescue Service. Three initial services (Initial Open Service, Initial Public Regulated Service, and Initial Search and Rescue Service) are to be provided by early 2014. *Security*: Increasing transport safety; civil protection and crisis management; humanitarian aid purposes; increasing safety of transport of dangerous goods; search and rescue services; maintenance of public order; immigration and border control (e.g. fighting illegal migration); *Environment*: Making traffic less polluting by increasing transport efficiency; environmental applications including pollutant tracking, ice berg studies, atmospheric observations, and weather forecasting for understanding climate change. *Energy*: Use of satellite navigation systems for energy exploration and exploitation; enhancing safety and security of oil and gas transport; synchronising European electricity distribution networks. *Knowledge*: Enhancing Europe's science and technology base; public works and civil engineering applications; better time referencing. *Mobility*: Making transport more efficient; Improving personal mobility (location based services); automatic toll systems; transport insurance applications (e.g. pay-per-use); enhancing train operating systems; optimisation of marine transportation and vessel monitoring system (VMS) applications; optimisation of air traffic control; public transport optimisation, planning and evaluation. *Resources*: Food safety purposes (e.g. requirements for food transport, livestock transport standards, and verification / monitoring); agricultural applications (e.g. CAP payments monitoring, reducing fertiliser need, optimising crop yielding, making land and water use more efficient),

	parcel measuring; land cover and usage; waste disposal purposes; water resource management applications; better fish stock management; *Note*: Objective of interoperability of EGNOS with GPS and GLONASS constellations.
TELECOMMUNICATIONS	
Name: **ALPHASAT** Owner: ESA/Inmarsat (Alphabus is Joint Venture Thales Alenia Space/EADS Astrium/CNES/ESA) Mission lifetime: early 2012 *Orbital parameters:* Type: GEO	*Mission Objectives*: Telecommunications provision for Europe, parts of Africa and the Middle East (In framework of Inmarsat's Broadband Global Area Network); 4 technological demonstration missions; in-orbit validation of Alphabus platform. XL-Band applications. *Knowledge*: Enhancing European technology base; first use of the Alphabus platform for GEO satellites (ideal bus for communication satellites; TV broadcasting, internet, mobile telephony and broadband services); exploring the use of Q-Band and V-Band and XL-Band. *Mobility*: Use of XL-Band for data and video transfer for railway applications.
Name: **ARTEMIS** (Advanced Relay and Technology Mission Satellite) *Owner*: ESA *Mission lifetime*: 12 July 2001 - near end of life *Instruments*: Semiconductor Intersatellite Link Experiment (SILEX) Passager Spot de Télecommunications Laser (PASTEL) Optical Payload for Intersatellite Link Experiment (OPALE) EGNOS Navigation payload *Orbital parameters*: Type: GEO	*Mission Objectives*: GEO data relay for other satellites in orbit and the ISS, laser transmission experiments, transponder for the support of EGNOS. *Knowledge*: Use of telecommunication applications in terrestrial technology to improve public transport coverage in rural areas (requests for public transport (bus on demand) are processed within minutes and bus routes adapted); satellite mobile communications provision; *Mobility*: Navigation services for EGNOS.
Name: **Athena-Fidus** (Access on Theatres for European Allied Forces Nations – French Italian Dual Use Satellite) Owner: CNES/ASI/ MoD of France, Belgium and Italy, and French and Italian civil protection agencies. *Mission lifetime:* to be launched in 2013, + 15 years End of life (EOL) *Orbital parameters:* Type: GEO	*Mission Objectives*: Military telecom objectives; to provide broadband satellite telecommunications services to the French, Belgian and Italian armed forces and to the French and Italian civil protection services. *Security*: military operations and applications; civil crisis management purposes. *Note*: Completes the Syracuse system and SICRAL 1 & 2 system.
Name: **EDRS** (European Data Relay System) *Owner*: ESA/private partners *Mission Lifetime*: 2012 - *Orbital Parameters:* Type: GEO	*Mission Objectives:* European independent system for reducing time delays in relay of large data quantities by enabling LEO satellites to relay data continuously by GEO satellites via laser and Ka-Band radio links. The EDRS space component consists of two payloads in GEO: EDRS-A and EDRS-C. EDRS-A will be a piggyback on a GEO satellite. EDRS-C will be implemented on a shared small GEO platform. *Security*: EDRS supports the functionality of time-critical services provided by other space assets in crisis monitoring; support for search and rescue teams; support for military data transmission; telecommunication services in cut-off areas. *Environment*: Enhancing data rely for GMES data.

	Energy: Telecommunication services for oil and gas exploration and exploitation. *Knowledge:* Enhancing European knowledge base; contribution to knowledge based information society. *Mobility:* Telecommunication services for cut-off areas. *Resources:* Telecom services for remote mineral exploration and exploitation. *Note:* EDRS is a Public-Private Partnership (PPP) and is being developed under ARTES 7 (element 7 of ESA's Advanced Research in Telecommunication Systems).
Name: **EURASIAT-1 (TURKSAT2A)** *Owner*: EURASIASAT (subsidiary Turksat A.S.) *Mission Lifetime*: 10 Jan. 2001 – 15 years EOL *Orbital Parameters:* Type: GEO	*Mission Objectives:* Satellite communications services. *Knowledge:* Contribution to making Europe an information based knowledge society.
Name: **EUTELSAT Fleet** *Owner*: EUTELSAT S.A. *Current Fleet:* HOT BIRD Constellation (HOT BIRD 6, 8, and 9)) EUROBIRD Constellation (EUROBIRD 1, 2, 3, 4A, 9A, and 16) W SERIES Satellites Constellation (W 2A, 2M, 3A, 4, 5, 6, 7, 48, 75) SESAT Constellation (SESAT 1 and 2) ATLANTIC BIRD Constellation (ATLANTIC BIRD 1, 2, 3, and 4A) *Planned Launches:* KA-SAT W3C ATLANTIC BIRD 7 W6A W5A EUROBIRD 2A *Orbital Parameters:* Type: GEO	*Mission Objectives:* Commercial satellite based services: broadcast services, broadband services, telecommunication and data services, mobile and maritime communications. HOT BIRD: TV broadcasting, radio stations and multimedia services in EMEA. EUROBIRD: broadcasting and telecommunication in Western and Central European region. W SERIES: Telecom, TV and multimedia services in Europe, Asia and Africa. SESAT: Telecom services in Europe and the Asian territories of Russia. ATLANTIC BIRD: Trans-Atlantic video, IP, and data applications. *Knowledge:* Enhancing and maintaining European's technology base; contribution to making Europe an information based knowledge society.
Name: **Heinrich Hertz** *Owner*: DLR/ German Federal Ministry of Economics and Technology (BMWi) *Mission Lifetime*: 2014/2015 – *Orbital Parameters:* Type: GEO	*Mission Objectives:* Verification of satellite communications technology; qualification of innovative telecommunications-research instruments; demonstration of Ka-Band communication systems; preparation of pre-operational German satellites communications services. *Knowledge:* Enhancing Europe's technology base. *Note:* Heinrich Hertz will use the SMALL GEO SAT Platform.
Name: **HELLAS SAT 2** *Owner*: HELLAS SAT *Mission Lifetime*: 13 May 2003 – 15 years EOL *Orbital Parameters:* Type: GEO	*Mission Objectives:* Satellite communications services. *Knowledge:* Enhancing European knowledge based and contribution to the knowledge-based society.
Name: **HISPASAT** *Owner*: *Current Fleet*: Hispasat 1C: 3 Feb. 2000 – EOL 15 years Hispasat 1D: 18 Sep. 2002 – EOL 15 years Amazonas 1: 4 Aug. 2004 – 2014 Amazonas 2: 1 Oct. 2009 – EOL 15 years Xtar-Eur: 12 Feb. 2005 –	*Mission Objectives:* Satellite communication services. *Security:* Xtar-Eur and Spainsat provide communications services for the Spanish Ministry of Defence and other government institutions; applications in civil crisis management, humanitarian operations and development aid, and natural crisis mitigation; disaster recovery. *Energy:* Applications for oil and gas industry by providing

Spainsat: 11 Mar. 2006 – *Future Fleet:* HISPASAT 1E: 21 Dec. 2010 – Amazonas 3: 30 Dec. 2012 – HISPASAT AG-1: 30 Dec. 2012 – *Orbital Parameters:* Type: GEO	communication services in remote areas; remote control of electricity substation control systems *Knowledge:* Enhance in Europe's technology and contribution to knowledge based information society; tele-medicine and tele-education applications. *Mobility:* Fleet management applications. *Resources:* Applications for mineral excavation industries by providing communication services in remote areas; remote control of water resource infrastructure; *Note:* Xtar-Eur and Spainsat were launched in 2005 and 2006 by HISDESAT, a company partially owned by HISPASAT. The two satellites offer efficient solutions for security and defence applications.
Name: **HYLAS** (Highly Adaptable Satellite) *Owner*: Avanti Communications PLC/BNSC *Mission Lifetime*: Hylas 1: 26 Nov. 2010 – Hylas 2: 6 June 2012 – *Instruments:* Hylas 1: 2 Ku-Band Transponders 6 Ka-band Transponders *Orbital Parameters:* Type: GEO	*Mission Objectives:* High Definition TV and broadband services provision; High-speed broadband services to remote rural areas in Europe. *Knowledge:* Contribution to European technology base and information society.
Name: **INMARSAT Fleet** *Owner*: INMARSAT *Current Fleet:* Inmarsat-2 F1 Inmarsat-2 F2 Inmarsat-2 F4 Inmarsat-3 F1 Inmarsat-3 F2 Inmarsat-3 F3 Inmarsat-3 F4 Inmarsat-3 F5 Inmarsat-4 F1 Inmarsat-4 F2 Inmarsat-4 F3 *Future Fleet:* ALPHASAT will supplement Inmarsat-4 by providing L-Band coverage for EMEA Inmarsat-5 (Ka-Band) are planned for launch in 2013-2014 *Orbital Parameters:* Type: GEO	*Mission Objectives:* Providing mobile satellite services. *Security:* Maritime safety applications; aviation safety communications. *Environment:* Fuel and time saving by re-routing planes due to changing winds. *Energy:* Services for remote site high-speed data connectivity contribute to optimising oil and gas exploration and exploitation activities. *Knowledge:* Contribution to Europe's knowledge based and information based knowledge society. *Mobility:* Cost-effective maritime and aviation communication applications, including telephony, internet and e-mail, weather predictions, vessel tracking services, faxing, and texting. *Resources:* Services for remote site high-speed data connectivity contribute to optimising mineral exploration and excavation activities.
Name: **IRIS** *Owner*: ESA Pre-operational service capability by 2015; fully operational status by 2020	*Mission Objectives:* Air-Ground communications system for air traffic management. It is the satellite based solution for the Single European Sky Air Traffic Management (ATM) Research Programme (SESAR). *Knowledge:* Enhancing European technology base and contribution to the knowledge based information society. *Mobility:* Modernisation of air traffic control; making air travel in Europe safer, more efficient, cost-effective and environmentally friendly. *Note:* IRIS is being developed under ARTES 10 (element 10 of ESA's Advanced Research in Telecommunication Systems.

Name: **SatcomBw** (Satellite Communciations of Bundeswehr) *Owner*: BMVg (IT-AmtBw) *Mission Lifetime:* COMSATBw-1: 1 Oct. 2009 – 15 years EOL COMSATBw-2: 21 May 2010 – 15 years EOL *Orbital parameters*: Type: GEO	*Mission Objectives*: Worldwide satellite-based communication system for German armed forces (dedicated military communications satellites). *Security*: Secured military communications (flexible and independent, reliable and secure, expandable and mobile); telecommunications purposes in military and civil crisis management; voice, fax, advanced data, video and multimedia applications. *Note*: MilSat Services GmbH is prime contractor for the SATCOMBw operations and performance of the command and control segment. MilSat Services will also provide the German armed forces with access to transmission capacity of Intelsat satellites. COMSATBw-1 was launched together with HISPASAT's Amazonas 2.
Name: **SES ASTRA Fleet** *Owner*: SES ASTRA *Current fleet:* 19.2° East: ASTRA 1H, ASTRA 1KR, ASTRA 1L, ASTRA 1M 28.2° East: ASTRA 2A, ASTRA 2B, ASTRA 2D 23.5° East: ASTRA 3A, ASTRA 3B 5° East: ASTRA 4A, ASTRA 1E 31.5° East: ASTRA 1G, ASTRA 2C *Future fleet:* ASTRA 1N (2011 –) ASTRA 4B (2011 –) ASTRA 2F (2012 –) ASTRA 2E (2013 –) ASTRA 5B (2013 –) ASTRA 2G (2014 –) *Orbital Parameters:* Type: GEO	*Mission Objectives:* Broadcasting services; broadband access and network solutions. *Security:* Military communications, rapid emergency response applications; critical data back-up systems. *Environment*: Efficient data dissemination for Earth observation applications and weather forecasting. *Knowledge:* Enhancing Europe's technology base and contribution to the knowledge based information society; services for telemedicine, e-learning, and development programmes. Mobility: Voice and data networks for air traffic control.
Name: **SICRAL** (Sistema Italiano per Comunicazione Riservate et Allarmi (Italian System for Secure Communications and Alerts)) *Owner:* Italian MoD (SICRAL 2 is joint Italian-French mission (DGA)) *Mission lifetime:* SICRAL 1: 7 Feb. 2001 – 2009 SICRAL 1B: 20 Apr. 2009 – 13 years EOL SICRAL 2/Syracuse 3C: 2013 – 15 years EOL *Instruments:* Communications system in UHF, SHF (X-Band), and EHF *Orbital parameters:* Type: GEO	*Mission Objectives:* Italian military satellite communication constellation until 2025. *Security:* Military communication objectives; NATO satellite communication needs; law enforcement; management of critical infrastructures. *Note*: SICRAL 2/Syracuse 3C is Italian-French cooperative mission. Syracuse, SICRAL and Skynet provide the NATO satellite communications capability for the SHF and UHF space segment from 2005 to 2019 (NATO's post-2000 SATCOM Program).
Name: **Skynet 5** *Owner:* British MoD *Mission lifetime:* Skynet 5A: 11 Mar. 2007 – 15 years EOL Skynet 5B: 14 Nov. 2007 – 15 years EOL Skynet 5C: 12 June 2008 – 15 years EOL Skynet 5D: 2013 – 15 years EOL *Orbital parameters:* Type: GEO	*Mission Objectives:* UK military telecom satellite constellation. *Security:* Defensive communications applications and crisis management purposes. *Note*: SICRAL 2/Syracuse 3C is Italian-French cooperative mission. Syracuse, SICRAL and Skynet provide the NATO satellite communications capability for the SHF and UHF space segment from 2005 to 2019 (NATO's post-2000 SATCOM Program).
Name: **SMALL GEO SAT** *Owner*: ESA/DLR/Hispasat/OHB *Mission Lifetime*: development and implementation	*Mission Objectives:* Development of a general multipurpose platform for a small GEO satellite (payload up to 300 kg and power of 3 kW)

of the SMALL GEO SAT platform on Hispasat AG-1, to be launched on 30 Dec. 2012 - *Orbital Parameters:* Type: GEO	*Knowledge:* enhancing Europe's knowledge base and contribution to the knowledge based information society. *Note:* SMALL GEO SAT is being developed under ARTES 11 (element 11 of ESA's Advanced Research in Telecommunication Systems).
Name: **SOLARIS** *Owner*: Solaris Mobile (Joint Venture of EUTELSAT and SES ASTRA) *Mission Lifetime*: EUTELSAT W2A (with Solaris S-Band payload): 4 Mar. 2009 – EOL 15 years *Orbital Parameters:* Type: GEO	*Mission Objectives:* Mobile satellite services provider; exploring the possibilities for use of S-Band. *Knowledge:* Contribution to Europe's technology base in telecommunication services and use of S-Band. Note: Satellite malfunctioning is preventing full S-Band service provision.
Name: **Syracuse 3** (System for Radio Communication Using a SatellitE) *Owner*: DGA/CNES/ Italian MoD (SICRAL 2) Mission lifetime: Syracuse 3A: 14 Oct. 2005 – 15 years EOL Syracuse 3B: 11 Aug. 2006 – 15 years EOL Syracuse 3C/ SICRAL 2: 2013 – 15 years EOL *Orbital parameters*: Type: GEO	*Mission Objectives*: French armed forces satellite based telecommunications system; telecom objectives in strictly defence related framework; secure and jamming resistant and robustness against EMP Security: Military communications applications. *Note*: SICRAL 2/Syracuse 3C is Italian-French cooperative mission. Syracuse, SICRAL and Skynet provide the NATO satellite communications capability for the SHF and UHF space segment from 2005 to 2019 (NATO's post-2000 SATCOM Program).
Name: **TELENOR fleet** *Owner*: TELENOR *Mission Lifetime*: THOR III: 9 June 1998 – June 2010 IS 10-02 (THOR 4) (Intelsat partially owned by Telenor): 16 June 2004 – EOL 13 years THOR 5: 11 Feb. 2008 – EOL 15 years THOR 6: 29 Oct. 2009 – EOL 15 years *Orbital Parameters:* Type: GEO	*Mission Objectives:* Providing telecommunications services including mobile services, TV broadcasting, and broadband. *Knowledge:* Contributing to Europe's technology and knowledge based information society.
ELECTRONIC INTELLIGENCE / EARLY WARNING	
Name: **CERES** (Capacité de Renseignement Electromagnétique Spatial) Owner: DGA/Sweden/Greece Mission lifetime: 2015 – *Orbital parameters*: Type: GEO	*Mission Objectives*: Detection and interception of space based radar or telecommunication signals (ELINT – Electronic Intelligence). Security: Electronic intelligence gathering.
Name: **ELISA** *Owner*: CNES/DGA *Mission lifetime*: 4 satellite to be launched in Apr. 2011	*Mission Objectives*: To update databases for the use of electronic warfare and detection and monitoring of operational activities. *Security:* Military intelligence applications.
Name: **Essaim** *Owner*: DGA *Mission lifetime*: Constellation of 4 Myriade micro-satellites: 2004 – In extended mission lifetime, to be deorbited	*Mission Objectives*: Demonstrator project to explore new concept for information-gathering, outside visible and IR range. *Security:* Military intelligence applications.
Name: **Spirale** (Système Preparatoire Infrarouge	*Mission Objectives*: Assessment of the feasibility of a reli-

pour L'ALErte) *Owner*: DGA *Mission lifetime*: two Spirale IR early-warning demonstrators have been launched on 12 Feb. 2009. Launch of the first satellite of the complete early-warning system is planned for 2019. *Orbital parameters:* Type: GTO	able operational system for ballistic missile launch detection and acquiring IR signatures in different contexts; preparations for the future complete early warning system. *Security:* Early warning applications.

SCIENCE & EXPLORATION

Name: **BEPICOLOMBO** Owner: ESA/JAXA *Mission lifetime*: 2014 – *Instruments*: Mercury Planetary Orbiter (**MPO**) payload: BepiColombo Laser Altimeter (BELA) Italian Spring Accelerator (ISA) Mercury Magnetometer (MERMAG-MAG) Mercury Thermal Infrared Spectrometer (MERTIS) Mercury Gamma-ray and Neutron Spectrometer (MGNS) Mercury Imaging X-ray Spectrometer (MIXS) Mercury Orbiter Radio Science Experiment (MORE) Probing of Hermean Exosphere by Ultraviolet Spectroscopy (PHEBUS) Search for Exosphere Refilling and Emitted Neutral Abundances (SERENA) Spectrometers and Imagers for MPO BepiColombo Integrated Observatory System (SYMBIO-SYS) Solar Intensity X-Ray Spectrometer (SIXS) Mercury Magnetospheric Orbiter (**MMO**) payload: Mercury Magnetometer (MERMAG-MGF) Mercury Plasma Particle Experiment (MPPE) Mercury Plasma Wave Instrument (PWI) Mercury Sodium Atmospheric Spectral Imager (MSASI) Mercury Dust Monitor (MDM) *Orbital parameters*: Type: elliptical Mercury orbits	*Mission Objectives*: Exploration of Mercury: MPO focuses on the global characterisation of the planet itself, whereas MMO studies the environment around Mercury, including exosphere and magnetosphere. *Knowledge*: Enhancing our knowledge on planet Mercury, and the formation and characterisation of our Solar System and its planets.
Name: **CASSINI-HUYGENS** *Owner*: NASA/ESA *Mission lifetime*: 15 Oct. 1997, arrival around Saturn on 1 July 2004, Huygens' decent through Saturn atmosphere on 14 Jan. 2005 – Extended until mid-2017 under the name Cassini Solstice Mission; ESA contribution at least until end 2014. *Instruments*: **Huygens** payload: Huygnes Atmospheric Structure Instrument (HASI) Gas Chromatograph Mass Spectrometer (GCMS) Aerosol Collector and Pyrolyser (ACP) Descent Imager / Spectral Radiometer (DISR) Doppler Wind Experiment (DWE) Surface Science Package (SSP) **Cassini** Saturn Orbiter Payload: Composite Infrared Spectrometer (CIRS) Imaging Science Subsystem (ISS) Ultraviolet Imaging Spectrometer (UVIS) Visible and Infrared Mapper Spectrometer (VIMS) Cassine Radar (RADAR)	*Mission Objectives*: Saturn and Titan exploration mission with probe and orbiter. *Knowledge*: Scientific highlights: information on Saturn's origin, interior, atmosphere, magnetosphere and rings; information on Icy satellites; origin, evolution, surface and interior of Titan; Titan's volatiles and atmosphere (including the abundance of methane gas), and the interaction of Titan with the magnetosphere of Saturn. *Notes*: Launch on 15 Oct. 1997 Venus swinbgy on 26 Apr. 1998 Deep space manoeuvre on 3 Dec. 1998 Venus swingby on 24 June 1999 Earth swingby on 18 Aug. 1999 Jupiter swingby 30 Dec. 2000 Saturn arrival on 1 July 2004

Radio Science Instrument (RSS) Magnetospheric Imaging Instrument (MIMI) Cassini Plasma Spectrometer (CAPS) Cosmic Dust Analyser (CDA) Dual Technique Magnetometer (MAG) Ion and Neutral Mass Spectrometer (INMS) Radio and Plasma Wave Science (RPWS) *Orbital parameters*: Type: Saturn orbit	
Name: **CLUSTER (II)** Owner: ESA Mission lifetime: 4 satellites launched in pairs on 16 July and 19 Aug. 2000 – 31 Dec. 2014 *Instruments*: Fluxgate Magnetometer (FGM) Electron Drift Instrument (EDI) Spatio-Temporal Analysis of Field Fluctuation experiment (STAFF) Electric Field and Wave experiment (EFW) Digital Wave Processing experiment (DWP) Waves of High Frequency & Sounder for Probing of Electron Density by Relaxation experiment (WHISPER) Wide Band Data instrument (WBD) Plasma Electron And Current Experiment (PEACE) Cluster Ion Spectrometry experiment (CIS) Research with Adaptive Particle Imaging Detectors (RAPID) Wave Experiment Consortium (WEC) Active Spacecraft Potential Control experiment (ASPOC) *Orbital parameters:* Type: elliptical Altitude: 19.000 km – 119.000 km	*Mission Objectives*: Study of the interactions between solar winds and the magnetosphere by four satellites in a tetrahedral formation. *Knowledge*: Detailed study of the interactions between the solar wind and the Earth's atmosphere enables scientists to build 3D models of the magnetosphere and leads to improved understanding of the dynamics and processes inside the magnetosphere; understanding of how turbulence develops in space; observations of the plasmasphere; upper atmospheric physics; quantification of atmosphere hydrogen leaking; investigation of the multiscale development of Kelvin-Helmholtz waves at Earth's magnetopause; dynamics of the Earth's magnetotail. *Note*: Cluster I was lost during launch in June 1996.
Name: **COROT** (Convection Rotation and Planetary Transits) Owner: ESA/CNES/Austria/Belgium/Brazil/ Germany and Spain Mission lifetime: 27 Dec. 2006 – 31 Mar. 2013 *Instruments*: Telescope 2 Wide Field Camera (WFC) *Orbital parameters*: Type: circular orbit Altitude: 896 km Inclination: 90 deg	*Mission Objectives*: Study of the vibratory performance of stars in order to determine the internal structure, age and composition of stars; to study stellar interiors through the detection of acoustical p-modes and activity; search for planets outside our Solar System (exoplanets). *Knowledge*: Improving our understanding of the dynamics of stars and their interiors (astroseismology); detection and analysis of exoplanets.
Name: **ExoMars** Owner: ESA/NASA Mission lifetime: Orbiter and EDL demonstrator to be launched in 2016 Rover and sample-catching rover to be launched in 2018 *Instruments*: ESA ExoMars rover: Panoramic Camera (PanCam) System Shallow ground-penetrating radar (WISDOM) Borehole infrared spectrometer (MA_MISS) Infra-red imaging spectrometer (MicrOmega IR) Raman Laser Spectrometer	*Mission Objectives*: 2016 ExoMars will include a Mars orbiter and an entry, decent and landing (EDL) demonstrator. The 2018 mission includes two rovers; Investigate if life existed on Mars and technology demonstration; Study of atmospheric trace gasses; sample collection and analysis; Mars sample return. *Knowledge*: Understanding of geochemical conditions on Mars; study Martian atmospheric trace gasses and their sources; Mars soil sample collection and analysis; exobiology and geochemistry research; study of Mars environment for feasibility of human Mars exploration missions; return of Mars sample. *Resources*: Use of ESA's Ground penetrating radar technology (GINGER) has found applications in the mining

X-ray diffractometer for mineral analysis (Mars-XRD) Mars Organic Molecule Analyser (MOMA) Close-Up Imager (CLUPI) Life Marker Chip (LMC) *Orbital parameters*: Type: Mars orbit	industry to reduce safety risks: Crack Identification System (CRIS) for hard rock mines and the Potash Roof Inspection System (PRIS) for potash mines.
Name: **GAIA** Owner: ESA Mission lifetime: 2012 – 5 year EOL *Instruments*: Two 1.45m x 0.5m SiC telescopes *Orbital parameters*: Type: Lagrange L2 orbit	*Mission Objectives*: Galaxy mapping mission (precise 3D map of the entire galaxy). *Knowledge*: Providing detailed physical properties of each observed star, including data on luminosity, temperature, gravity and composition; understanding of the origin and evolution of the universe.
Name: **HERSCHEL** Owner: ESA Mission lifetime: 14 May 2009 – 31 Dec. 2012 *Instruments*: 3.5m diameter SiC telescope Photodetector Array Camera and Spectrometer (PACS) Spectral and Photometric Imaging Receiver (SPIRE) Heterodyne Instrument for the Far Infra-red (HIFI) *Orbital parameters*: Type: Lagrange point L2 orbit	*Mission Objectives*: Far-infrared and sub-millimetre astronomy for understanding of star and galaxy formation and evolution, and origin of the universe. *Knowledge*: Study of the molecular content of the interstellar clouds, the formation and evolution of stars and galaxies, and the study of the atmosphere and satellites of giant planets, as well as comets; deep extragalactic broadband photometric surveys; study of Kuiper Belt Objects; Herschel data has led to the discovery that UV starlight is the key ingredient for water creation in space.
Name: **Hinode (Solar-B)** (Sunrise) Owner: JAXA/NASA/ESA/NSC/UK Mission lifetime: 23 Sep. 2006 – 2014 (ESA contribution) *Instruments*: Solar Optical Telescope (SOT) X-Ray Telescope (XRT) Extreme UV Imaging Spectrometer (EIS) *Orbital parameters*: Type: polar sun-synchronous Altitude: 600 km Period: 96 mins	*Mission Objectives*: Solar physics mission. *Knowledge*: Understanding the dynamics of the Sun's magnetic field, study of the Sun-Earth environment; study of solar flares and coronal mass ejections.
Name: **HST** (Hubble Space Telescope) *Owner*: NASA/ESA *Mission lifetime*: 24 Apr. 1990 – ESA contribution at least until end 2014 *Instruments*: 2.4 meter primary mirror Wide Field Camera 3 (WFC3) Cosmic Origin Spectrograph (COS) Space Telescope Imaging Spectrograph (STIS) Advanced Camera for Surveys (ACS) *Orbital parameters*: Type: circular inclined Altitude: 575 km Inclination: 28.5 deg Period: 96-97 mins	*Mission Objectives*: UV/optical/near-IR astronomy. *Knowledge*: Enhancing our knowledge of the universe (e.g. Hubble has taken the first visible-light image of a planet circling another star (Fomalhaut b); characterisation of exoplanet atmospheres and has found traces of sodium, carbon and oxygen; Hubble maps of Pluto show surface changes; evidence pointing towards the existence of dark energy). *Note*: Last repairs to Hubble were in conducted during Servicing Mission 4 in May 2010 (Shuttle Atlantis).
Name: **INTEGRAL** (INTErnational Gamma-Ray Astrophysics Laboratory) *Owner*: ESA	*Mission Objectives*: Gamma ray astronomy mission; better understanding of the characteristics of extreme celestial bodies such as supernovas and black holes.

Mission lifetime: 17 Oct. 2002 – 31 Dec. 2014 *Instruments*: IBIS Imaging System (IBIS) SPI Spectrometer (SPI) X-Ray Monitor (JEM-X) Optical Monitoring Camera (OMC) *Orbital parameters*: Type: elliptical Earth orbit Altitude: 9.000 – 153.000 km Inclination: 52 deg	*Knowledge*: Scientific highlights: mapping the galactic plane in gamma-rays and Integral source catalogue; study of slow rotating neutron stars (soft gamma-ray repeaters and anomalous X-ray pulsars); study of supernova remnants (crab pulsars and nebulae); observing high-mass X-ray binaries; tracing massive stars; extragalactic point sources; gamma-ray bursts. Gamma-ray detection technology is used for radioactive material detection and identification on 'dirty' bombs.
Name: **ISS** (International Space Station) *Owner*: US, Russia, Canada, Japan, and Europe with 11 ESA MS (Germany, Belgium, Denmark, Spain, France, Italy, Norway, the Netherlands, Sweden, and Switzerland) *Mission lifetime*: 1998 – To be determined *Orbital parameters*: Altitude: 335 – 460 km Inclination: 51.6 deg	*Mission Objectives*: International cooperation in space; life science experimenting, physical science, human space flight, space exploration objectives, testing platform for new technologies, space tourism. *Environment:* Earth observation applications including plasma and ionosphere studies. *Knowledge*: Enhancing Europe's technology base and contribution to the information based knowledge society; astronomy and astrophysics, biology, exobiology, and biotechnology; human physiology, Earth sciences; fundamental physics; material sciences; fluid physics and combustion research; solar system research and planter science; space engineering and technology; space radiation research. ISS plasma-based bio-operation technology is finding applications to help protect hospitals, food products, aircraft passengers and pharmaceuticals against infections and contaminations risks.
Name: **JWST** (James Webb Space Telescope) *Owner*: ESA/NASA *Mission lifetime*: 2014 – nominal EOL 5 years, extendable to 10 years. *Instruments*: Passively cooled 6.55m telescope for performance in near-IR, but with extension to visible and mid-IR regions Near-Infrared Camera (NIRCam) Near-Infrared spectrograph (NIRSpec) Mid-infrared Instrument (MIRI) Tunable Filter Imager (TFI) *Orbital parameters*: Type: Lagrange Point L2orbit	*Mission Objectives*: Next-generation space telescope (general purpose observatory); scientific goals: first light after Big Bang; assembly of galaxies; birth of stars and proto-planetary systems; planetary systems and the birth of life. *Knowledge*: Enhancing technology base; expanding knowledge of astronomy and the universe.
Name: **LISA PATHFINDER** (Laser Interferometer Space Antenna Pathfinder) (a.k.a. SMART-2 (Small Missions for Advanced Research in Technology-2)) Owner: ESA/NASA Mission lifetime: June 2011 – 1 year EOL *Instruments*: ESA Lisa Technology Package (LTP) NASA Disturbance Reduction System (DRS) *Orbital parameters*: Type: Lagrange point L1 orbit	*Mission Objectives*: Preparation mission for future LISA mission (Laser Interferometer Space Antenna); testing gravitational wave detection. *Knowledge:* Enhancing technology base and scientific knowledge.
Name: **MARS EXPRESS** (orbiter and lander) *Owner*: ESA *Mission lifetime*: 2 June 2003 – 31 Dec. 2014 *Instruments*: Mars Express Orbiter:	*Mission Objectives*: Creating a mineralogical map of the Martian surface and conduct an in-depth study of its atmosphere; looking for life and water on Mars. *Knowledge*: Enhancing technology base and scientific knowledge; scientific highlights: discovery of phyllosili-

Sub-surface Sounding Radar Altimeter (MARSIS) Ultraviolet and Infrared Atmospheric Spectrometer (SPICAM) Visible and Infrared Mineralogical Mapping spectrometer (OMEGA) Energetic Neutral Atoms Analyser (ASPERA) Planetary Fourier Spectrometer (PFS) Mars Radio Science Experiment (MaRS) High Resolution Stereo Camera (HRSC) Mars Beagle 2 Lander *Orbital parameters*: Type: near-polar and highly elliptical Mars orbit Altitude: 250 – 11.583 km Period: 6 hours 43 min Inclination: 86.3 deg	cates; PFS detected CH4; HRSC identified tropical and equatorial glacial landforms; MARSIS and OMEGA produced maps of H20 and CO2 ice in the polar regions; ASPERA provided data on the penetration of the solar wind in to the atmosphere of Mars; SPICAM detected auroras; Mars mass estimations, CO2 clouds detection; the discovery that dust content controls the density of the upper atmosphere.
Name: **MICROSCOPE** (Micro-Satellite à traînée Compensée pour l'Observation du Principe d'Equivalence) (Microsatellite with Drag Control for the Observation of the Equivalence Principle) Owner: CNES/Office National des Etudes et Recherches Aérospatiales) (French Aerospace Research Center) ONERA/ESA Mission lifetime: 2014 – 1 year EOL *Instruments*: 2 Space Accelerometer for Gravity Experiment (SAGE) *Orbital parameters*: Altitude: 730 km Inclination: 98.2 deg	*Mission Objectives*: Science mission to test the validity of the equivalence principle with very high accuracy. *Knowledge*: Contributing to scientific knowledge and technology base.
Name: **MSL** (Mars Science Laboratory) Owner: US, Russia, Germany, France, Spain Mission lifetime: 25 Nov. 2011 – *Instruments*: Mars Hand-Lens Imager (Mahli) Mast Camera (MastCam) Mars Descent Imager (Mardi) Alpha-Particle-X-Ray-Spectrometer (APXS) Chemistry Camera (ChemCam) Chemistry and Mineralogy (CheMin) Sample Analysis at Mars (SAM) Radiation Assessment Detector (RAD) Dynamic of Albedo Neutrons (DAN) Rover Environmental Monitoring Station (REMS)	*Mission Objectives*: Mars robotic exploration mission: looking for life and water by analysis of the evolution of soil and surface of Mars; additional use of data for assessment of the capacity of the Mars surface for potential heavy infrastructures used in human exploration. *Knowledge*: Enhancing technology base and scientific knowledge. *Note*: Landing on Mars of Mars Science Laboratory Rover in 2012.
Name: **PLANCK** Owner: ESA/France/Italy/Canada/Spain/US/UK/ Germany/The Netherlands/Switzerland/Sweden/ Ireland/ Denmark Mission lifetime: 14 May 2009 – 31 Dec. 2014 *Instruments*: 1.5m diameter offset Telescope(CFRP and Al) High Frequency Instrument (HFI) Low Frequency Instrument (LFI) *Orbital parameters*: Type: Lagrange point L2 orbit	*Mission Objectives*: Study of the origins of the Universe by observing Cosmic Microwave Background (CMB). *Knowledge*: Contribution to technology base and scientific knowledge of the universe and its origin.
Name: **Prisma** Owner: SNSB/ Swedish Space Corporation (SSC)/CNES/DLR/Denmark Technical University (DTU) Mission lifetime: 15 June 2010 – 10 months EOL	*Mission Objectives*: Testing of formation flying and rendezvousing by two satellites; testing of autonomous control in formation flying and in rendezvous manoeuvres, validating navigation, guidance and control algorithms, and testing the cold-gas micro-thrusters system.

Instruments: Vision Based Sensor (VBS) Formation Flying Radio frequency Package (FFRF) Spaceborne Autonomous Formation Flying Experiment (SAFE) *Orbital parameters:* Type: sun-synchronous Altitude: 700 km	*Knowledge*: Contribution to technology base.
Name: **Proba-2** (Project for On-Board Autonomy 2) *Owner*: ESA/collaborative countries *Mission lifetime*: 2 Nov. 2009 – Dec. 2014 *Instruments*: Sun Watcher using APS and image processing (SWAP) Large Yield Radiometer (LYRA) Dual Segmented Langmuir Probe (DSLP) TMPU (Thermal Plasma Measurement Unit for Microsatellites (TMPU) *Orbital parameters*: Type: sun-synchronous Altitude: 757 km Inclination : 98 deg LST : 6.00 Ascending	*Mission Objectives*: Demonstration microsatellite of high-performance and volatile systems on a small spacecraft; scientific objectives from 4 instruments on board (solar monitoring) *Knowledge*: Technology demonstration of new lithium ion-battery, advanced power management system, digital sun sensor, upgraded telecommand systems, testing of star tracker to be used on BepiColombo, xenon gas propulsion system; solar observation experiments by LYRA and SWAP instruments; space weather experiments by DSLP and CZ instruments. *Note*: Proba-2 was launched as co-passenger of ESA's second Earth Explorer Satellite (SMOS).
Name: **Proba-3** (Project for On-board Autonomy 3) *Owner*: ESA/Belgium/Sweden/UK/Spain/Portugal/Canada/Switzerland/Norway/Luxembourg/Denmark/Italy *Mission Lifetime*: 2015/2016 – 2 years EOL *Instruments*: Coronal Imager *Orbital Parameters*: Type: high elliptical Earth orbit Altitude: 800-60524 km Period: 19.7 hours	*Mission objectives:* Formation flying demonstration mission by two small satellites; study of the inner solar corona (coronagraph observation). *Knowledge:* Contribution to Europe's technology base and scientific knowledge of the Sun.
Name: **ROSETTA** *Owner*: ESA *Mission lifetime*: 2 Mar. 2004 – Dec. 2015 *Instruments*: Rosetta orbiter: Optical, Spectroscopic, and Infrared Remote Imaging System (OSIRIS) Ultraviolet Imaging spectrometer (ALICE) Visible and Infrared Mapping Spectrometer (VIRTIS) Microwave Instrument for the Rosetta Orbiter (MIRO) Rosetta Orbiter spectrometer for Ion and Neutral Analysis (ROSINA) Cometary secondary Ion Mass Analyser (COSIMA) Micro-Imaging Dust Analysis System (MIDAS) Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT) Grain Impact Analyser and Dust Accumulator (GIADA) Rosetta Plasma Consortium (RPC) Radio Science Investigation (RSI) Philae Lander: Alpha Proton X-Ray Spectrometer (APXS) Sample and Distribution Device (SD2) Cometary Sampling and Composition Experiment	*Mission Objectives*: Comet rendezvous and asteroid exploration mission including an orbiter with eleven experiments and a lander. *Knowledge*: Contribution to technology base and spin-off technology (e.g. Piezoelectric transducer technology from ROSETTA is used in wristwatch insulin pump); Increasing scientific knowledge of asteroid: characteristics of asteroids; study of the origin of comets, relation between cometary and interstellar materials, and the implications with regard to the origin of the Solar System; global characterisation of the nuclei of comets; determination of composition of volatiles and refractories in nuclei; physical properties of refractories and volatiles in nuclei; study of the development of cometary activity; global characterisation of asteroids, including determination of dynamic properties, surface morphology and composition. *Note*: Mission milestones: Launch on 2 Mar. 2004 Earth gravity assist 1 on 4 Mar. 2005 Mars gravity assist on 25 Feb. 2007 Earth gravity assist on 13 Nov. 2007 Asteroid Steins flyby 5 Sep. 2008 Earth gravity assist 3 on 13 Nov. 2009 Asteroid Lutetia flyby on 10 July 2010 Hibernation period between July 2011 and Jan. 2014

(COSAC) Evolved Gas Analyser (Modulus Ptolemy Instrument) Comet Nucleus Infrared and Visible Analyser (CIVA) Rosetta Lander Imaging System (ROLIS) Surface, Electrical, Seismic and Acoustic Monitoring Experiment (SESAME) Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT) Multi-Purpose Sensor for surface and Subsurface Science (MUPUS) Rosetta Lander Magnetometer and Plasma Monitor (ROMAP) *Orbital parameters*: Type: interplanetary orbit	Rendezvous manoeuvre in May 2014 Start global mapping phase in Aug. 2014 Lander delivery in Nov. 2014 Perihelion passage in Aug. 2015
Name: **SOHO** Owner: ESA/NASA/collaborating countries Mission lifetime: 2 Dec. 1995 – ESA contribution at least until end 2014. *Instruments*: Global Oscillations at Low Frequencies (GOLF) Variability of solar IRadiance and Gravity Oscillations (VIRGO) Michelson Doppler Imager (MDI) Solar UV Measurements of Emitted Radiation (SUMER) Coronal Diagnostic Spectrometer (CDS) Extreme-ultraviolet Imaging Telescope (EIT) Ultraviolet Coronagraph Spectrometer (UVCS) Large Angle and Spectrometric Coronagraph (LASCO) Solar Wind Anisotropies (SWAN) Charge, Element and Isotope Analysis System (CELIAS) Comprehensive SupraThermal Energetic Particle Analyser (COSTEP) Energetic and Relativistic Nuclei and Electron Experiment (ERNE) *Orbital parameters*: Type: Lagrange Point L1 orbit	*Mission Objectives*: Study of the solar atmosphere, helioseismology, and solar wind study. *Knowledge*: Contribution of scientific knowledge including: evidence of long-term trend in total solar irradiance; extreme Ultraviolet irradiance variations and thermospheric density models; solar flares drive global Sun oscillations; sound speed variations at the solar tacholine; solar EUV/UV irradiance predictions; variations of the solar internal rotation rate; cycle changes of the Sun's zonal flow pattern; observation of solar emission in the lyman-ɑ line; measurements of ion temperatures in coronal holes; analysis of oxygen ion velocity distributions in the extended solar corona; automated CME catalogue; solar storm forecasting; measurements of the absolute abundance of P, Al, K and Na in the slow solar wind speed ranges.
Name: **TARANIS** (Tool for the Analysis of Radiations from Lightnings and Spirits) Owner: CNES Mission lifetime: 2013 – 2 years EOL *Instruments*: Micro Camera and Photometer experiment (MCP) X-ray, Gamma-ray and Relativistic Electron Experiment (XGRE) Instrument Détecteurs d'Electrons Energétiques (IDEE) (Energetic Electron Instrument) Instrument de Mesure de champ Electrique-Basse Fréquence (IME-BF) (Low Frequency Electric Field Instrument) Instrument de Mesure de champ Electrique-Haute Fréquence (IME-HF) (High Frequency Electric Field Instrument) Instrument de Mesure du champ Magnétique (IMM) (Magnetic Field Measurement) Multi Experiment Interface Controller equipment (MEXIC) *Orbital parameters*: Type: sun-synchronous Altitude: 700 km	*Mission Objectives*: Study of phenomena associated with atmospheric storms including detection and characterisation of transient luminous events, terrestrial gamma ray flashes, runaway electrons, and the effects of transient luminous events and precipitated electrons in the coupling between atmosphere and magnetosphere. *Knowledge*: Enhancing the scientific knowledge of atmospheric phenomena.

Name: **VENUS EXPRESS** Owner: ESA Mission lifetime: 9 Nov. 2005 – 31 Dec. 2014 *Instruments*: Venus Monitoring Camera (VMC) Analyser of Space Plasma and Energetic Atoms (ASPERA) Planetary Fourier Spectrometer (PFS) Visible and Infra-Red Thermal Imaging Spectrometer (VIRTIS) Magnetometer (MAG) Venus Radio Science Experiment (VeRa) Spectroscopy for Investigation of characteristics of the Atmosphere of Venus / Solar Occultation at Infrared (SPICAV/SOIR) *Orbital parameters*: Type: elliptical Venus orbit Altitude : 250-66000 km Inclination: 90 deg Period : 24 hours	*Mission Objectives*: Venus exploration mission to study the complex dynamics and chemistry, and interactions between the atmosphere and the surface of the planet, interactions between the atmosphere and the solar wind. *Knowledge*: Contribution to scientific knowledge of including the understanding of Venus atmospheric dynamics: identification of 3 different dynamical regimes; studies of the polar vortex region; atmospheric thermal structure; Venus surface temperature observations; and data on the magnetosphere.
Name: **XMM-Newton** (X-ray Multi Mirror Observatory) Owner: ESA Mission lifetime: 10 Dec. 1999 – 31 Dec. 2014 *Instruments*: European Photon Imaging Cameras (EPICs) (3 x-ray cameras), Reflection Grating Spectrometer (RGS) (2 network spectrometers) 1 optical monitor (OM) 1 external radiation monitor *Orbital parameters*: Type: eccentric Earth orbit Altitude: 7000 to 114000 km Period: 48 hours	*Mission Objectives*: X-ray astronomy. *Knowledge*: Contribution to astronomy including knowledge on young stellar objects, detection of supernova remnants and neutron stars, observations of black holes and active galactic nuclei, information on the properties of exploding stars, and distant galaxy cluster detection.

List of Acronyms

Acronym	Explanation
3D	Three-dimensional
ABM	Anti-Ballistic Missile
ADM-Aeolus	Atmospheric Dynamics Mission
AIS	Automatic Identification System
ARTES	Advanced "Research in Telecommunications Systems
ATM	Air Traffic Management
ASAR	Advanced Synthetic Aperture Radar
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BASIC (group)	China, India, Brazil and South Africa
BOC	Besoins Operationnels Communs
CAP	Common Agriculture Policy
CCI	Climate Change Initiative
CCS	Carbon Capture and Storage
CDP	Capability Development Plan
CEOS	Committee on Earth Observing Satellites
CERA	Cambridge Energy Research Associates
CFSP	Common Foreign and Security Policy
CIVCOM	Committee for Civilian Aspects of Crisis Management
CMPD	Crisis Management and Planning Directorate
CNES	Centre National d'Études Spatiales
CPCC	Civilian Planning and Conduct Capability
CROCUS	Cross-Cultural Satellite services for immigrant communities in Europe
CSDP	Common Security and Defence Policy
CTP	Common Transport Policy
DG ENV	DG Environment
DGI	Digital Geographic Information
DGNSS	Differential Global Navigation Satellite System
DSB	Distributed Satellite Broadband
EADS	European Aeronautic Defence and Space Company
EAP	Environmental Action Programmes
EBN	European Business and Innovation Centre Network
EC	European Commission
ECAP	European Capability Action Plan

Acronym	Explanation
ECB	European Central Bank
ECHO	European Commission Directorate-General for Humanitarian Aid and Civil Protection
ECV	Essential Climate Variables
EDA	European Defence Agency
EDRS	European Data Relay Satellite
EEA	European Environment Agency
EEAS	European External Action Service
EFSF	European Financial Stability Facility
EGNOS	European Geostationary Navigation Overlay Service
EIT	European Institute of Innovation and Technology
ELINT	Electronic Intelligence
EM	Electro-Magnetic
EMN	European Medical Network
EMSA	European Maritime Safety Agency
EnviSat	Environmental Satellite
EO	Earth Observation
EOS	Earth Observation Summit
ERA	European Research Area
ERS	European Remote-Sensing Satellite
ESA	European Space Agency
ESINET	European Space Incubators Network
ESS	European Security Strategy
ETP	European Technology Platforms
ETP	European Transport Policy
EU	European Union
NAVFOR	Naval Force
EU ETS	EU Emissions Trading System
EUMC	European Union Military Committee
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUMS	European Union Military Staff
EUPOS	European Position Determination System
EUROPOL	Enterprise-University Virtual Placements
EUSC	European Union Satellite Centre
EUSR	European Union Special Representative
EU-VIP	Enterprise-University Virtual Placements
FAC	Foreign Affairs Council
FAPAR	Photosynthetically Active Radiation
FLEET	Fleet Logistics Service Enhancement with Egnos & Galileo Satellite Technology
FMS	Flight Management System

Acronym	Explanation
FP7	Seventh Framework Programme
FRONTEX	European Agency for the Management of Operational Cooperation at the External Borders
GAERC	General Affairs and External Relations Council
GCMs	General Circulation Models
GENESI-DR	Ground European Network for Science Interoperations-Digital Repositories
GEOSS	Global Earth Observation System of Systems
GIANUS	Global Integrated Architecture for Innovative Utilisation of Space for Security
GIS	Geographic Information Systems
GHG	Greenhouse Gas
GOCE	Gravity field and steady-state Ocean Circulation Explorer
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HR	High Representative
HSPG	High-Level Space Policy Group
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IfS	Instrument for Stability
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
ISS	Internal Security Strategy
ISS	International Space Station
ITS	Information Technology Services
JRC	Joint Research Centre
LBS	Location-Based Services
LCT	Laser Communication Terminal
LNG	Liquefied Natural Gas
LOLA	Liaison Optique Laser Aéroportée
LOPOS	Local Oxidation of Polycrystalline Silicon
LRIT	Long Range Identification and Tracking
LSB	Location-Based Services
MAGES	Mature Applications of Galileo for Emergency Scenarios
MARLET	Maritime LOPOS EGNOS Test Bed
MDG	Millennium Development Goals
MERIS	Medium Resolution Imaging Spectrometer
MIR	Mineral Potential Assessment
MIST	Marine Interactive Satellite Technologies
MODIS	Moderate Resolution Imaging Spectrometer
MUSIS	Multinational Space-based Imaging System for Surveillance, Reconnaissance and Observation

Acronym	Explanation
MS	Member States
MSU	Microwave Sounding Unit
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NPT	Navigation, Positioning and Timing
ODA	Official Development Assistance
PCW	Polar Communication and Weather
PMG	Political Military Group
POLINARES	EU Policy on Natural Resources
PRS	Public Regulated Services
PSC	Political and Security Committee
PNT	Position, Navigation, Timing
PSC	Political and Security Committee
PU	Policy Planning and Early Warning Unit, or Policy Unit
RO	Radio Occultation
RMI	Raw Material Initiative
RRE	Rare-Earth Elements
SATCOM	Satellite Communications
SALW	Small Arms and Light Weapons
SBAS	Satellite-Based Augmentation System
SESAR	Single European Sky ATM Research
SDLS	Satellite Data Link System
SDS	Sustainable Development Strategy
SHF	Super High Frequency
SICRAL	Sistema Italiano per Comunicazioni Riservate ed Allarme
SitCen	Situation Centre
SILEX	Satellite Interlink Experiment
SME	Small and Medium-sized Enterprises
SMOS	Soil Moisture and Ocean Salinity
SPADD	Smart Passive Damping Device
SPASEC	Space and Security Panel of Experts
SPM	Summaries for Policymakers
SPOT	Satellite Pour l'Observation de la Terre
SSA	Space Situational Awareness
SSAS	Ships Security Alert System
ST-ECF	Space Telescope European Coordinating Facility
STScl	Space Telescope Science Institute
S&T	Scientific and Technological
TCBMs	Transparency and Confidence-Building Measures
TFEU	Treaty on the Functioning of the European Union

Acronym	Explanation
TEN-T	Trans-European Transport Network
TEU	Treaty on European Union
TOC	Tele-medicine Operational Centre
UAV	Unmanned Aerial Vehicles
UHF	Ultra High Frequency
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UNEP	UN Environmental Programme
UNFCCC	UN Framework Convention on Climate Change
UNGA Res.	United Nations General Assembly Resolution
US	Unites States of America
VHF	Very high frequency
VTS	Vessel Traffic System
WAAS	Wide Area Augmentation System
WAN	Wide Area Network
WCED	UN World Commission on Environment and Development
WMO	World Meteorological Organization
WSL	World Satellite Limited
WTO	World Trade Organization
WWF	World Wide Fund for Nature

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