European Space Policy Institute

RESPONSIVE SPACE FOR EUROPE

ELEMENTS FOR A ROADMAP FOR EUROPE BASED ON A COMPARATIVE ANALYSIS WITH THE U.S. OPERATIONAL RESPONSIVE SPACE CONCEPT

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Europe has adopted a broad understanding of the concept of security comprising: internal security threats such as terrorism and organised crime; environmental threats such as deforestation, climate change; natural disasters such as landslides, earth quakes and tsunamis; and external security threats including military aggression in the near abroad. Europe needs operational, responsive and flexible instruments with which to act. Given the broad range of potential threats Europe could face, it has to meet a broad range of user requirements for the prevention of and response to any of these threats.

Several EU research initiatives have looked into how space as an instrument can support security policy and missions both internally and externally: the EU's Framework Programme for Research and Technological Development (FP), the Security Panel of Experts (SPASEC) and its subsequent SPASEC-Report, the Group of Personalities (GoP) for Security Research, the European Security Research Advisory Board (ESRAB) and the European Security and Research Innovation Forum (ESRIF). They have given insights into existing capabilities and the improvements needed.

Additionally, several think tanks have looked into European approaches to security. These include the Belgian Royal Institute for International Relations initiative, which proposed a European security concept for the twenty-first century, and the EU Institute for Security Studies (EUISS) that put forward suggestions for Europe's ambitions for European defence in 2020. While not directly dealing with the use of space applications in the provision of security, these attempts have aimed to answer questions, which are also raised in the context of responsive space, such as the EU's relationship with NATO and the question of parliamentary oversight over the EU Common Security and Defence Policy.

In this setting, ESA is currently exploring new potential concepts in the realm of space and security consistent with its Convention, the European Space Policy (ESP), and the recent Resolutions adopted by the Space Council and by the ESA Council at Ministerial level. One of these is GIANUS (Global Integrated Architecture for iNovative Utilisation of space for Security), which aims at meeting user needs particularly with an eye to the increased dependence of the EU on space assets, the need for tools in the operational theatres and the increased opportunities arising from, in particular the FP 7 projects. GIANUS is currently designed to contain a responsive element.

Why does Europe need "Responsive Space"?

Considering the topics that are currently under discussion in the context of Europe and space policy, e.g. workshop and conference topics as well as study, article and presentation requests, the following recurring issues for Europe to solve can be identified:

- emerging new technology requirements;
- the need for operational capabilities, i.e. how to address the transition from demonstration to operation;
- the need to exploit synergies between military and civil applications;
- the need to involve users in the research and development process;
- issues related to data policy
    - standardisation and regulation, i.e. countering the EU's islands of data by establishing standardisation of data to improve data sharing,
    - protection of sensitive data while at the same time not hindering data sharing for, for example, emergency response, i.e. across borders and user communities;
- the need for a more integrated approach in terms of
    - integrating European and national assets, capabilities and services,
    - integrating SatCom, SatNav and EO, and

- o integrating space applications with other terrestrial applications.

Responsive Space (RS) is a concept that addresses all these issue-areas in a holistic manner (see Figure 1). Its main objective is to provide more flexible and more affordable space applications to users. RS could take up user requirements that are formulated and successfully demonstrated in FP projects and put them into practice. In this way it would address the transition from demonstration to operation and enhance user involvement in the research and development process. Given that user needs are diverse, RS draws upon an integrated approach and combines SatCom, SatNav and Earth Observation (EO) assets and applications as well as incorporating space applications into comprehensive concepts with terrestrial applications. Since RS relies on all existing assets, it will also need to establish a data policy thereby addressing the issue of standardisation and protection of sensitive data with an eye to increased data sharing, while at the same time trying not to pose trade barriers.

Responsive Space is neither a simple armament approach nor is it a futuristic technology-push model. It is a concept whose time for more detailed investigation has come and for which appropriate policy perspectives must be developed, now. Its benefits for European civilian and security related issue areas are abundant and should be given detailed and thorough consideration.

Conceptual Considerations for a European Approach

While the need for space responsiveness is unambiguously felt, as can be seen from demonstrations that are part of the FP projects, EU external relations missions such as EUFOR Chad and the current ATALANTA Navfor counter-piracy mission off the Somalian coast, "responsiveness" is still not a clearly defined and generally understood concept. "Responsiveness" can be understood as the ability to address needs in a timely manner. A system is commonly referred to as "responsive" if it can rapidly react to inputs

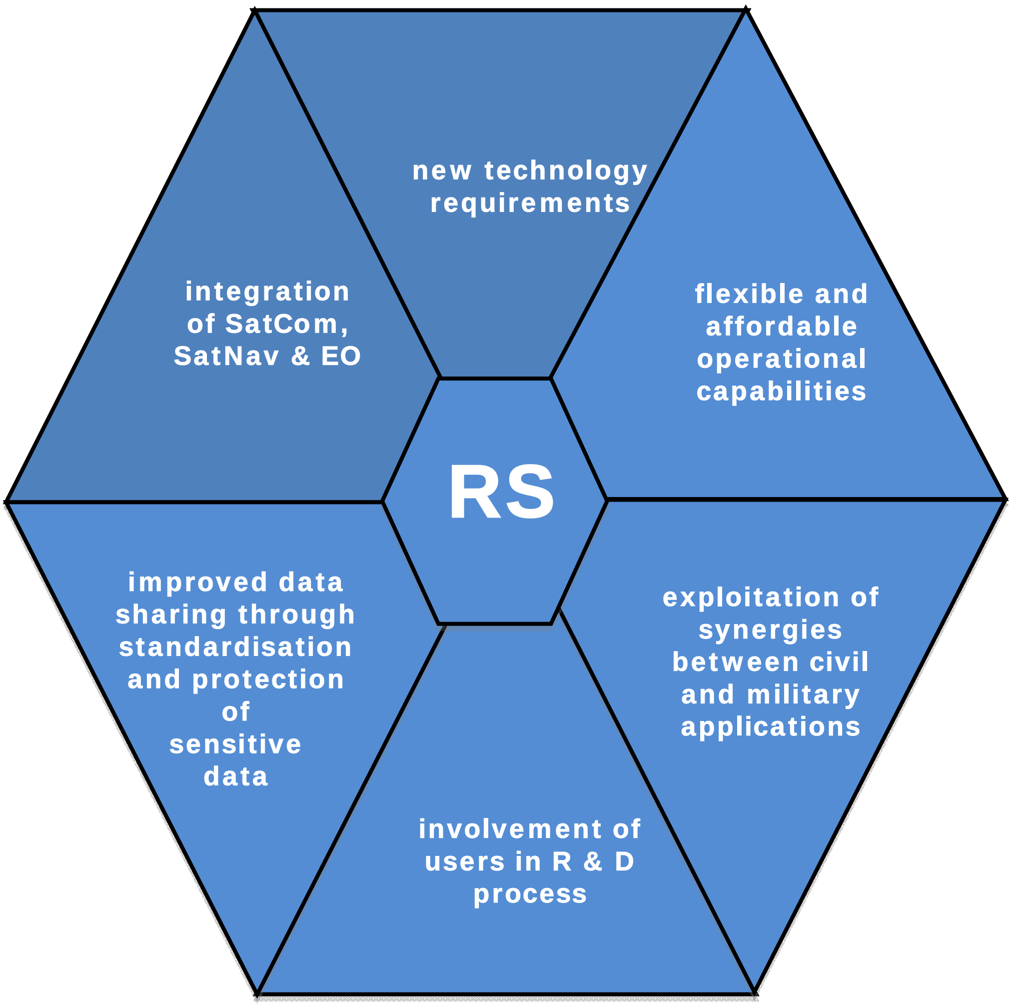

Figure 1: Responsive Space – A holistic approach to the issues currently at stake

or events or if it can efficiently cope with changes and uncertainty in its environment.

The main elements of "responsiveness" are: "flexibility (i.e. timely development and the ability to modernise), low costs and rapid launches. Hence, a thorough understanding of the schedule structure, i.e. the various activities within the space industry (e.g. design, production, reviews, integration, testing etc.) as well as the total-life-cycle cost (including acquisition, operation and maintenance costs) is required.

Another complementary way of analysing responsiveness is to see it from the perspectives of the different stakeholders: end-users, local customers and suppliers. Additionally, responsiveness depends on different levers: (1) design and architectural choices of a system, determined by the complexity of a system, the degree of use of identical units and repetitive tasks ("learning curve"), modularity, plug-and-play and standardisation of interfaces, (2) launch levers, i.e. launch vehicles and range and (3) soft levers of responsiveness, such as the selection process, design reviews and acquisition policies.

Show-Casing the U.S. Approach

In 2007, the U.S. Congress asked the Department of Defense (DoD) to formulate a plan to establish Operational Responsive Space (ORS) and authorised DoD to establish an ORS Office with a mission (1) to develop low-cost, rapid reaction payloads, buses, spacelift, and launch control capabilities, and (2) to coordinate and execute ORS efforts across the DoD. ORS in turn was defined as "[a]ssured space power focused on timely satisfaction of Joint Force Commanders' (JFC) needs".

The U.S. is currently the only space-faring nation that is developing an RS capability. The U.S. ORS concept originates from the military. When proposing a European approach to this matter, the U.S. experience served as a guiding theme, providing a case study on how responsive space can be developed. Given that the U.S. and Europe differ in terms of the objectives of their space policies, their threat perceptions and, consequently, their understanding of the concept of security, the U.S. ORS can only serve as an example and not as a "prototype" for Europe to simply take over.

Increasing reliance on space applications and emerging global challenges and threats have placed new demands on U.S. space capabilities, which were designed during the Cold War to counter Cold War security threats. Those threats have now changed. As an increasing number of nations have developed space programmes, the space environment is increasingly perceived as non-transparent and contested. Today, the JFC continues to be one of the main users of U.S. space capabilities. With the changed threat environment it is, however, facing new requirements. In contrast to the Cold War era, the military is no longer the sole and main user. Commercial satellites are increasingly providing vital space applications such as in the provision of security, emergency management and climate change. In the context of greater dependence on space applications, satellites are increasingly perceived as critical infrastructures, which are threatened by both intended and non-intended interference.

The main objectives of the U.S. ORS concept are to satisfy the needs of the JFC and to develop the enablers to allow for rapid development, deployment and operation of space assets to support JFC needs. The U.S. ORS follows a three-tiered strategy: (1) rapid exploitation of existing capabilities; (2) use of existing technologies and capabilities to replenish, augment and reconstitute; and (3) development of new technologies and capabilities to replenish, augment and reconstitute. DoD inaugurated the ORS Office in 2007, which has been tasked to coordinate the development of hardware as well as the development of the concept across the agencies involved.

Additionally, the U.S. follows several programmes for the development of responsive launch, e.g. Responsive Access, Small Cargo, Affordable Launch (RASCAL), Force Application and Launch from CONUS (FALCON), Evolved Expendable Launch Vehicle Programme (EELV), United Launch Initiative, and the Affordable Responsive Spacelift (ARES). Research has also investigated the choice of possible launch sites. The U.S. is also researching responsive payloads and buses as part of its TacSat Programme, an Airforce initiative that uses small spacecraft known as TacSats.

Elements for a Roadmap for Europe

The European Space Policy (ESP) is currently largely driven by civilian considerations but faces growing security-related demands. Given Europe's broad understanding of the concept of security, there is a need for instruments to support a wide variety of European security and safety missions (e.g. external security actions, border surveillance, maritime surveillance, anti-piracy, narco-trafficking, emergency response to natural disasters etc.). A European concept for RS would provide these instruments. Thus in contrast to the U.S. ORS, which deals solely with the military national security requirements, Europe's RS will need to develop a system to take both civil and military requirements into account.

The current degree of readiness of the European industry to become involved in RS is hard to assess. European industry has been involved in many demonstrations as part of the FP projects. Their feedback shows that they are ready to provide many of the requested technological requirements and are sometimes even far ahead of the outcomes of EU research projects. What has been lacking so far is the political will to encourage the industry to take the necessary future steps towards more integrated, flexible and affordable space applications for Europe. Specifically, it is the lack of political direction for European, rather than national, solutions. Quite often in the past, one nation (acting alone or together with several like-minded or interested other European States) took up a topic and put it on the agenda.

The institutional architecture supporting RS in Europe will need to look different than the one the U.S. has chosen. To empower one institutional actor to steer the RS seems to be necessary in order to ensure oversight and comprehensiveness, avoid duplication of efforts and guarantee that all stakeholders share the same understanding of RS. Currently, there does not seem to be an existing European institutional actor suited for this purpose. Hence, one element of a European RS could be to establish a dedicated institutional actor for this purpose. A EU Agency (which could be called "The STeering Agency for Responsive Space" - STARS) would be very suited to take up the task of steering and coordinating RS in Europe.

Based on the above-mentioned conceptual considerations and the U.S. ORS experience, elements of a roadmap for RS in Europe have been identified in this study. Basic problems that have to be tackled and answered before being able to formulate a European approach to RS are highlighted. More detailed elaboration on (1) institutional and architectural questions, (2) legal, organisational and managerial challenges, (3) time, (4) cost, (5) secure data policy and (6) the timeframe for the establishment of a European RS can be found in the related sections of this study.

1. The first step towards creating RS is to conduct a thorough assessment of current space assets both at European and national levels. This status report should enumerate existing capabilities and include a thorough gap analysis. The Joint Research Centre (JRC) has already conducted some first studies in the context of space applications for maritime security. It conducted benchmarking activities as part of the FP 5 DECLIMS project and, as part of the Commission's call for an integrated maritime policy, it evaluated existing maritime surveillance systems at national level and compiled a comprehensive report in a document entitled "Integrated Maritime Policy for the EU: Working Document III - On Maritime Surveillance Systems". A gap analysis should answer the following questions: Who are the users? What do they need? What do we have? In particular, how would Tactical Imagery Exploitation System (TIES), Multinational Space-based Imaging System (MUSIS), Galileo and Global Monitoring for Environment and Security (GMES) contribute to RS? What is missing? The gap analysis could draw on FP and national research. The resulting needs matrix should be subdivided into short-, mid- and longterm requirements in line with the three-tiered approach.

2. In addition to a status report on existing space capabilities, lessons learned and demonstration results of research and development projects at both European and national level should be taken as building blocks for Tier-2 and Tier-3 developments.

3. By compiling both of these, the stakeholders involved could be identified. From the very start, these should be included in the development process of a European Responsive Space as to agree on the definition for RS.

4. Once users have been identified, a requirements matrix should be

established. The matrix should be used to identify a way to feed-in the different user requirements for the RS architecture and development process.

5. Moreover, there is a need to develop the political will to use the capabilities that are available. Outreach activities showing users what is possible and presenting the case in all possible forums could help in fostering the necessary political will.

6. In the future, military requirements can be compiled by the European Defence Agency (EDA) and civilian ones by the European Commission (EC) supported by the Council.

7. Engagement and dialogue with users should be increased. The establishment of a user-exchange mechanism would be a step in this direction.

8. Access to systems in the event of a crisis is of utmost importance. In this context, ownership is crucial. However, guaranteeing that systems remain on the European side can also be achieved through the use of multinational missions or by signing treaties and agreements to cover these cases.

9. U.S. experience has shown that it is particularly important to establish an understanding of Responsive Space with all these stakeholders. In the U.S., the ORS Office is responsible for this. As ESA is a technology development agency and the European Commission is limited to engaging in space matters only upon Member States consent ("shared competence"), it seems difficult to entrustan existing actor with this task. Thus, the proposed agency would take this up.

10. Responsive Space is expected to create a whole new paradigm in the space field that, from a developer's perspective, requires specific technologies and new development and implementation approaches. As many new enabling technologies need to be investigated, a system for long-term R&D efforts to foresee future requirements needs to be found. Both academia and think tanks can be involved in this effort. Industry and satellite operators should also provide their input. RS will require adaptation of field operations, decision-making processes and of activation or allocation procedures. This would go hand-in-hand with adaptation of the industry value chain.

1. The Setting

1.1. The Overall Security Context for Europe

Europe has adopted a broad understanding of the concept of security, including internal security threats, such as terrorism and organised crime, environmental threats such as deforestation, climate change, natural disasters including landslides, earth quakes and tsunamis as well as external security threats including military aggression in the near abroad. Europe needs operational, responsive and flexible instruments to meet these threats. Given the broad range of potential threats Europe might face, it has to meet a broad range of user requirements for the prevention of and response to these potential threats. Prevention of and response operations are conducted by a variety of different emergency response forces as well as military and policy forces. All of these users have different needs and different working structures. The future European security architecture will therefore need integrated systems that are more flexible, robust and scalable compared to current systems, with an integrated space component as a key element.

1.2. Policy Approaches to European Security

In the EU context several recent steps, which act as policy drivers in the context of security related concerns and related requirements, can be identified. The European Security Strategy (ESS) of 2003 highlighted the range ofconstantly evolving threats Europe is facing and characterised them as divers, less visible and less predictable. Increasing research in both civil and military security as part of the EU's Framework Programme for Research and Technological Development (FP) as well as more specific attempts such as the Security Panel of Experts (SPASEC) and its subsequent SPASEC-Report, the Group of Personalities (GoP) for Security Research, the European Security Research Advisory Board (ESRAB) and the European Security and Research Innovation Forum (ESRIF), have investigated the question of how space as an instrument can be supportive in the provision of security.[1]

One of the results of this research has been a number of workshops and conferences on the topic of space and security. While these initially mainly discussed the use of space applications in the provision of external security, there is now increasing discussion on space as an instrument in the provision of internal security. One of the main conclusions of these conferences and workshops, such as the EDA-ESA-EC Workshop on "Space for Security and Defence" which took place on 16 September 2009 in Brussels, Belgium, was a call for sharing and pooling of resources of a civil and military nature. The main reason is that threats of a military and civilian nature are increasingly seen to form a continuum. In parallel to this, technology is perceived as inherently dual, and thus as an instrument to answer all of these.

Apart from these official EU initiatives, several think tanks have looked into European approaches to security. These include the Belgian Royal Institute for International Relations initiative, which proposed a European security concept for the twenty-first century, and the EU Institute for Security Studies (EUISS) that drew up a list of suggestions for Europe's ambitions for

[1] Council of the European Union. A Secure Europe in a Better World. European Security Strategy of 12 Dec. 2005. Brussels: European Union. <http://www.consilium.europa.eu/uedocs/cmsUpload/78367.pdf>. Group of Personalities in the field of Security Research. "Research for a Secure Europe: Report of the Group of Personalities in the field of Security Research." Luxembourg: Group of Personalities, 2004; [1] European Security Research and Innovation Forum (ESRIF) "European Security Research and Innovation in Support of European Security Policies. Intermediate Report." Luxembourg: Office for Official Publications of the European Communities, 2008. <http://www.esrif.eu/documents/intermediate_report.pdf>; European Security Research and Innovation Forum (ESRIF) "European Security Research and Innovation in Support of European Security Policies. Final Report." Luxembourg: Office for Official Publications of the European Communities, 2009. <http://ec.europa.eu/enterprise/newsroom/cf/newsbytheme.cfm?displayType=library&tpa_id=168&lang=en>. Panel of Experts on Space and Security. Report of Panel of Experts on Space and Security of Mar 2005. <http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=2408&userservice_id=1>.

European defence in 2020. While not directly dealing with the use of space applications in the provision of security, these attempts have aimed to answer questions, which are also raised in the context of responsive space, such as the EU's relationship with NATO and the question of parliamentary oversight over the EU Common Security and Defence Policy.

The Belgian Ministry for Foreign Affairs requested the Royal Institute for International Relations to draw up a general assessment of Europe's security and defence environment and to suggest a number of steps to further Europe's ambitions in these policy fields in 2002. An informal IRRI-KIIB working group was set up, comprising members from diplomatic, military, intelligence, academic and European circles in order to forge a European security concept.

With respect to Europe's security concept, the IRR-KIIB states that:

> [t]he first responsibility of any government is to protect its citizens from harm and to provide them with an environment that induces confidence in the future. Europe as an ever-closer Union shares this responsibility with its member states.[2]

In order to do so, the EU must have the necessary means and instruments. In this context, the European Union Institute for Security Studies (EUISS) has identified ten priorities for the next ten years,[3] which can be used as guiding themes and background information relating to the requirements and the changing context that calls for a European concept for responsive space. They are listed in the figure below.

[2] Coolsaet, Rik. "Presenting the 'European Security Concept for the 21st Century'." Presentation. Brussels, Belgium. 26 Nov 2003. 15 Dec 2009 <http://www.irri-kiib.be/speechnotes/02-03/Presentation%20 SecCon%20coolsaet.pdf> ; "A European Security Concept for the 21st Century." Egmont Paper. Brussels: Royal Institute for International Relations / Institut Royal des Relations Internationales / Koninklijk Instituut voor Internationale Betrekkingen (IRRI-KIIB), 2004. <http://www.egmontinstitute.be/paperegm/ep1.U560.pdf>.

[3] Vasconcelos, Álvaro de (Ed.). What ambitions for European defence in 2020? Paris: EU Institute for Security Studies, 2009. 153-63.

1. Crisis Management today – common defence beyond 2020

The EU should continue to do what it already does and should concentrate on doing it better: managing conflicts of a variety of types, in most cases internal wars in non-European States, as well as combating banditry, piracy, trans-national criminality including terrorism and cyber terrorism.

2. A human security doctrine may require the use of force

Respect for human rights and international justice at all levels of military operations is an essential component of their legitimacy and effectiveness. There is no contradiction between the notion of human security and undertaking the full range of military operations.

3. Civilian and military 'force-generation' goals must be met

National military and civilian commitments should be adequately publicised in order to increase transparency and an improved monitoring system of fixed benchmarks set in place to facilitate scrutiny. The EU is seeking to develop adequate capabilities to set up a number of civilian-military missions simultaneously, part of which will need a strong military component. The development of EU capabilities should build on 'Europeanising' existing national capabilities. A common budget should be established, to pay for the common structures and to finance a significant part of ESDP military missions. At-the-ready capabilities for civilian crisis management must be improved, with the goal to develop into an EU-crisis management package suited to different types and stages of civil and civilian military missions.

4. The case for a single European defence market and joint procurement

The success of the EU single market has yet to be extended to defence.

5. Prioritising the European military and civilian command

Need for a number of permanent structures: a formal Council of Defence Ministers, chaired by the EU 'Foreign Minister" etc.

6. Developing a European Perspective on the Role of NATO

The distinctive identities of NATO, a military alliance, and European defence, a security and crisis management component of the Union, should make the question of the role of each in international security quite easy. This should be the point of departure for the definition of an EU perspective on NATO.

7. Creating a European Parliamentary Council for Security and Defence

Democratic control of ESDP is becoming an issue, as European public opinion is demanding greater accountability and transparency with regard to the full spectrum of EU decisions. This requires the engagement of national parliaments and of the EP. More extensive parliamentary debates on ESDP will lead to increased public scrutiny and awareness of ESDP missions, thus enhancing their legitimacy, both at the European and national level.

8. Building an 'open' ESDP

There is no reason for the EU not to open ESDP to strategic partners and develop with them common training and interoperability necessary for the effectiveness of the missions.

9. Overcoming the political deficit: putting coherence first

A clear priority is to make the necessary reforms to ensure the coherence and the consistency of the EU's international action

10. Inclusiveness is a prerequisite for legitimacy

The ambition of the Union for 2020 should not be a European mini—defence project, spearheaded by the most militarily capable Member States but a powerful foreign, security and defence policy, able to pull together in a coherent and consistent way, the weight of all Member States and of all the EU institutions.

Figure 2: EUISS' Ten Priorities for the Next Ten Years

While none of these ten priorities explicitly mentions or refers to space applications, services or satellites, they give some insights into European values and perspectives in security policy. The EU ISS also aims to answer several questions, which are also raised in the context of responsive space, such as Priority 6 "developing a European perspective on the role of NATO" and Priority 7 "creating a European Parliamentary Council for Security and Defence". Priority 3 "civilian and military 'force-generation' goals must be met" emphasises the need for the EU to develop adequate capabilities for civilian and military missions simultaneously and calls upon the EU to rely on existing national assets. This is in line with the RS concept, as will be seen below.

The EU ISS is a Paris-based agency of the European Union whose objectives include: to find a common security culture for the EU, to help develop and project the CEDSP, and to enrich Europe's strategic debate. As a think tank, it researches security issues of relevance for the EU and provides a forum for debate. In its capacity as an EU agency, it offers analyses and forecasting to the Council of the European Union and to the High Representative for the Common Defence and Security Policy.[4] Thus, the above-mentioned priorities are of great importance to the EU and will most probably be considered very seriously by the Council. Any attempt to formulate a new approach to a security-related topic cannot overlook the EU ISS.

In this context, ESA is currently exploring new potential concepts in the realm of space and security consistent with its Convention, the European Space Policy[5] (ESP), and the recent Resolutions adopted by the Space Council and by the ESA Council at Ministerial level. One of these is GIANUS (Global Integrated Architecture for iNovative Utilisation of space for Security), which aims at answering user needs particularly with an eye to the increased dependence of the EU on space assets, the need for tools in the various theatres of operations and the increased opportunities arising from the FP 7, in particular. GIANUS also aims at responding to political declarations by the European Parliament's SEDE as well as by the EU Presidencies.[6] GIANUS is taking a holistic approach By including EO, Satellite Communications (SatCom), Satellite Navigation (SatNav) and launchers in one concept. GIANUS considers security in the widest sense of the term, thereby moving away from a strict differentiation between civil and military instruments for internal and external security. It is thus aimed at both military and civilian needs such as floods, tsunamis, counter-terrorism activities and anti-piracy.

This study represents a first step in defining a European approach to responsive space by conducting a preliminary investigation into existing concepts and indicating points of departure for Europe. While it can serve as a guiding document in the preparatory phase of GIANUS, it is an independent study as part of ESPI's Space and Security Programme. Thus, the main objective of this study is to provide an analysis of a European approach to responsive space.

1.3. Responsive Space as an Element of a European Security Strategy - An Assessment based on U.S. Experience

While the U.S. has already investigated the concept of responsive space (RS), or operational responsive space (ORS) as the U.S. concept is called, the question arises: How should and will Europe approach the matter? Given that the U.S. and Europe differ in terms of the objectives of their space policies, threat perceptions and consequently the understanding of the concept of security, the U.S. ORS can only serve as an example and not as a "prototype" for Europe to simply take over.

This study proposes that the understanding and concept of security form the basis for perceived threats, which are the motivations for and the basis of the objectives of RS. These objectives in turn provide the basis for the user requirements, which are the corner stone of a nation's approach to RS. The main question thus is "what type of security are we talking about?"

[4] The European Union Institute for Security Studies <http://www.iss.europa.eu/about-us>.

[5] Commission of the European Communities. Communication from the Commission to the Council and the European Parliament: European Space Policy. COM (2007)212 of 26 April 2007. Brussels: European Union. The document is also a document of the ESA Director General, Doc. ESA/C-M(2007)2.

[6] Duhamel, Erwin. "ESA and Security – An Evolving Commitment: GIANUS – Global Integrated Architecture for iNnovative Utilisation of space for Security." Presentation. EC-ESA-EDA Workshop on Space for Security and Defence. Brussels, Belgium. 16 Sept. 2009.

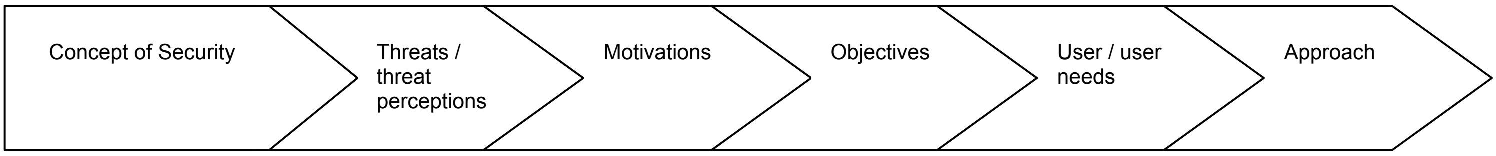

Figure 3: Approach of the Study towards a Roadmap for Europe

While most space policies are driven by security considerations, Europe's engagement in space was initially driven by civilian objectives. Thus, ESA is a civilian agency acting for "peaceful purposes". Its funding comes from civilian sources. U.S. funding sources are mainly militarian, with the DoD budget being larger than NASA's. The European Space Policy (ESP) follows primarily civilian objectives. Its strategic mission is based on the peaceful exploitation of Outer Space and seeks to meet Europe's security needs. The European Space Policy recognises duality and explores synergies in order to respond to increasing calls for coordination of civil and military means. A European RS will consider both civil and military requirements.[7] RS as a tool is not, per se, new to Europe: Europe has been a pioneer in the use of space tools for quick response to crisis since the establishment of the International Charter "Space and Major Disasters" by ESA and CNES in 2000.[8]

1.4. Why does Europe need "Responsive Space"?

Considering the topics that are currently under discussion in the context of Europe and space policy, such as workshop and conference topics as well as research, article and presentation requests, the following reoccurring issues for Europe to solve can be identified:

- emerging new technology requirements
- the need for operational capabilities, i.e. how to address the transition between demonstration and operation
- the need to exploit synergies between military and civil applications
- the need to involve users in the research and development process
- issues related to data policy
    - standardisation and regulation, i.e. countering the EU's islands of data and establishing standardisation of data to improve data sharing
    - protection of sensitive data while at the same time not hindering data sharing for, for example, emergency response, i.e. across borders and user communities
- the need for a more integrated approach, in terms of
    - integrating European and national assets, capabilities and services
    - integrating SatCom, SatNav and EO
    - integrating space applications with other terrestrial applications

Responsive Space is a concept. Its primary objective is to provide more flexible and more affordable space applications to users but it also unites all the issues listed above in a holistic manner. RS could take up the user requirements that were formulated and successfully demonstrated during the FP projects with the aim of putting them into practice. This way it would address the transition from demonstration to operation and enhance user involvement in the research and development process. Given that user needs are diverse, RS draws upon an integrated approach of SatCom, SatNav and EO as well as integrating space applications into comprehensive concepts including terrestrial applications. Since RS relies on all existing assets, it will need to establish a data policy as well, thereby addressing the issue of standardisation and protection of sensitive data with an eye to increased data sharing, while at the same time trying not to pose trade barriers.

Responsive Space is neither a simple armament approach nor is it a futuristic technology-push model. It is a concept whose time has come for investigation in more detail and for which the policy perspectives have to be developed now. Its benefits for European civilian and security related issue areas are abundant and should be considered thoroughly. Responsive Space can be understood as a non-material solution: it is about developing the political will to improve cooperation and sharing with the primary

[7] Duhamel, Erwin. op. cit.
[8] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. "A European Approach to Crisis Management by Responsive Space." Presentation. IAC, Daejon, South Korea. 2009.

objective of better using already existing space capabilities. If it proves to be impossible to better use existing capabilities, it will prove almost impossible to engage in cooperation for future projects. Interoperability, sharing, cooperation and integration are the building blocks of a responsive space. These elements prove the indispensability of a European, in contrast to a national, approach to this subject.

1.5. Goals and Approach of the Study

This study takes a first step in defining a European approach to responsive space by conducting a preliminary investigation into existing concepts and indicating points of departure for Europe. While it can serve as a guiding document in the preparatory phase of GIANUS, it is an independent study that is part of ESPI's Space and Security Programme. Thus, the main objective of this study is to propose a European approach to responsive space. "Responsiveness" is an emerging and enabling mission attribute responding to user needs including:

- timeliness/responsiveness/reactivity of space infrastructure
- affordability
- theatre-based operations doctrine
- the capability to reconstitute lost capabilities
- augmentation of existing capability in a short time
- filling of unanticipated gaps (through technology development).

In this context the goals of this study are to:

- provide an overview and detailed analysis of relevant existing responsive space models in the U.S. (section 3)
- assess the suitability of these existing responsive space concepts to meet potentially emerging European high-level needs (section 3 & 4)
- propose, on a preliminary basis, adapted perimeters and definitions for a European initiative to RS (section 4)
- identify underlying issues that need to be addressed by a European Responsive Space initiative (mainly section 4)

The study is divided into three sections. The first section covers the background. It identifies and characterises the general problem of current space assets, which led to the development of RS, and provides for the programmatic context in Europe. It also deals with some theoretical considerations related to RS. These will be taken as guiding assumptions to be tackled by issue areas in order to make space applications more responsive. The second section gives a detailed overview and analysis of the U.S. approach. It explains the U.S. ORS construct, its underlying motivations, outlines its objectives, highlights the obstacles and show-casts the institutional set-up. It also indicates potential areas for cooperation. The last section will use the previous theoretical and precedential analysis of the U.S. approach when highlighting the main issues to be tackled by Europe.

2. Background

2.1. The Underlying Problem

Space applications today depend on large and expensive satellites, which, for the most part, are designed for long life and high reliability and cannot be reconstituted quickly if compromised.[9] The life and reliability requirements are due in part to the high cost and limited availability of space launch.[10] In the context of increasing dependence on space assets for both military and civil applications, space applications are increasingly considered as critical infrastructures. Different threat scenarios thus lead to the need for careful consideration of rapid replacement possibilities, requiring both on-demand capabilities and rapid launches.

Current space systems require years to develop due to the complicated specialised design and manufacturing processes.[11] Space systems do not adapt well to change.[12]

> The high cost of launching space assets, and competition with the commercial launch market, require launch scheduling years in advance. Moreover, once it has been scheduled on a launch vehicle, it may take several months to checkout and integrate into the launch vehicle, and several additional months to become operational once it's in space. This existing capability is not operationally responsive.[13]

With customers' needs being dynamic, as they "emerge in time and evolve stochastically, prompted by unfolding environmental (political, economic, or technological) uncertainties and network externalities"[14], the resulting discrepancy between "the time associated with the emergence and change of customers' needs and the response time of the industry in delivering solutions to address these needs"[15] increasingly leads to the criticism of space assets as being too rigid and incapable of modernisation. Such needs can consist of completely new capabilities for different customers such as military or commercial users but can also translate to a modification or repositioning of an existing on-orbit asset. Typically, several years pass from the moment that a need is identified to the time when the asset becomes operational. Disadvantages resulting from these time delays range from the commercial competitive aspects, i.e. opportunity loss or failure to secure the first mover advantage, to the military context, i.e. loss of lives or failure to save lives. Other industry branches have faced similar problems in terms of the discrepancy between the rate of change of customers' needs and the ability of the industry to deliver timely solutions. These issues came to be known as the "just-in-time" concept. "Responsiveness" can be taken as the space industry's close analogy to the just-in-time concept in other industries.[16]

Apart from the delivery time problem, current space mission planning is also extremely costly. Thus, launching smaller spacecraft with less costly launch vehicles, reducing the cost of individual missions or other less costly alternatives are increasingly being considered. One side-effect in finding a

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9 Dal Bello, Richard. "OpEd: Putting the "Operational" in Operational Responsive Space." 10 Apr 2006. Space News. 28 Aug. 2009 <www.space.com/spacenews/archive06/DalBelloOpEd_041007.html.>.

10 Brown, Kendall K. "A Concept of Operations and Technology Implications for Operationally Responsive Space." 28 July 2004. Air & Space Power Journal. 20 Nov. 2009 <http://www.airpower.maxwell.af.mil/airchronicles/cc/brown2.html>.

11 Ibid.

12 Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/doggrell.html>.

13 Brown, Kendall K. op. cit.

14 Saleh, Joseph H. and Gregory F. Dubos. "Responsive Space: Concept Analysis and Theoretical Framework." Acta Astronautica 65 (2009): 376.

15 Ibid. 376-398.

16 Ibid. 377.

solution to the costliness of space missions will be the impact on the availability of space access to organisations and countries previously lacking adequate funding.[17]

2.2. Conceptual Considerations

While the need for space responsiveness is unambiguously felt, clear and agreed upon definitions of space responsiveness are lacking. In recent years the word "responsiveness" has become increasingly popular. In 2003 an annual Responsive Space Conference was established in the U.S. with the objective of bringing together various stakeholders in an effort to address problems associated with the lack of responsiveness in the space industry. Three years later, the conference chair, James Wertz, still had to acknowledge that, "there seemed to be more definitions of responsiveness than participants".[18] Similarly, the term has often been depicted as "fuzzy" with different meanings depending on the particular business section talked to, e.g. developer, operator, or customer of those systems.

As mentioned above, "responsiveness" can be understood as "the ability of an industry to address these needs in a timely way"[19]. A system in turn is commonly referred to as "responsive" if it can "rapidly react to stimulations and exogenous inputs or events" or if it is "in effect coping efficiently with changes and uncertainty in its environment". Based on the above analysis of the underlying problem, timely development, flexibility, (i.e. the ability to modernise), low costs and rapid launches can be identified as the main elements of today's understanding of "responsiveness".

2.2.1. Time

"Time" is one of the main elements of "responsiveness". The response-time of a system is defined as "the time elapsed between the onset of the input or stimulation and the time when the system's response gets "close enough to the steady-state level"[20]. Applied to space this means that the time dimension starts when the need for a new on-orbit capability is identified and formalised (i.e. when the request for proposal as a RFP is issued). In response to a request, the industry will undertake a series of events, design activities and reviews until the space asset is developed and ready to address the new identified need.

Hence, in order to improve responsiveness in the development of a new space asset or in modifying an on-orbit capability, there is a need to understand the various activities within the space industry (e.g. design, production, reviews, integration, testing, etc.) and how much time each activity contributes to the total time. This, however, requires a thorough understanding of the temporal breakdown of each activity including temporal overlaps enabling parallel tasking. It is important to acknowledge that these are not solely of a technical nature but can be legal, organisational or procedural activities. This is referred to as the "schedule structure" of a space programme. Understanding this schedule structure proves to be a pre-requisite for identifying bottlenecks and time inefficiencies.

Given that not all activities related to the schedule structure are technical in nature, it is important to identify legal, organisational and managerial aspects and related obstacles to responsiveness as well. This consideration already shows that satellite manufacturers are not the only players influencing the schedule structure. Government agencies (military and civilian), satellite operators, end-users, banks, investors, insurance companies and regulatory agencies all contribute and influence responsiveness in varying degrees. This value-chain is depicted in Figure 4[21]. The value chain for modified satellite applications will look differently and needs to be analysed separately depending on the modification. A modification in a satellite-based service, which would again be composed of a different value chain, can also be foreseen.

[17] Rao, Anil V., Arthur W. Scherich, Skylar Cox and Todd Mosher. "A Concept for Operationally Responsive Space Mission Planning Using Aeroassisted Orbital Transfer." AIAA-RS6-2008-1001. 6th Responsive Space Conference 2006.
[18] This section is largely based on the analysis in Saleh, Joseph H. and Gregory F. Dubos. op. cit. 377.
[19] Saleh, Joseph H. and Gregory F. Dubos. op. cit.
[20] This section is to a large degree based on Saleh, Joseph H. and Gregory F. Dubos. op. cit.
[21] Saleh, Joseph H. and Gregory F. Dubos. op. cit. 381

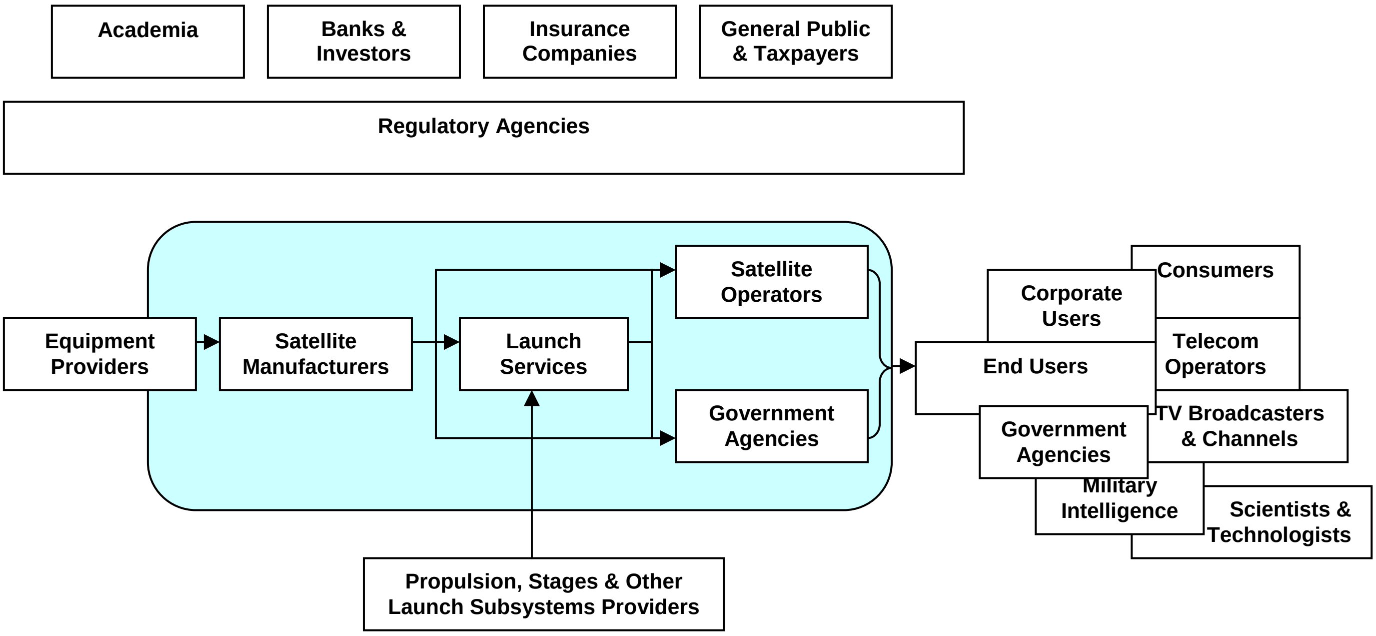

Figure 4: Stakeholders in the Space Industry Value-Chain of a New Satellite On-Orbit Capability

Summarising the above-mentioned considerations, it is critical that several points be identified and understood prior to defining an approach for responsive space. These are compiled in Figure 5. The answers to these questions might vary for different satellite applications such as Earth Observation, SatCom and SatNav. They will also be different for new on-orbit capabilities and modifying existing on-orbit capabilities.

Time-Related Considerations: Summary of Points for Departure

- What are all the activities (technical, legal, organisational or managerial in the space industry following the issuance of an RFP for a new or modified on-orbit capability?
- How much time does each activity contribute to the total time?
- How do all these activities contribute to the overall development and readiness of the system?
- What determines the duration of each activity?
- What is the degree of overlap between these activities?
- Where are the bottlenecks?
- What are the reasons for the bottlenecks and how can they be eliminated?
- Who are the main stakeholders in this schedule structure?
- To what extent does each stakeholder influence or hinder responsiveness?
- How can bottlenecks related to specific players be eliminated?

Figure 5: Time-Related Considerations: Summary of Points for Departure

2.2.2. Costs

Another way of considering responsiveness is from the costs perspective by conducting a cost analysis. This entails analysing the total-life-cycle costs (TCO), including acquisition cost, the costs to operate and maintain the specific system as well as other non-obvious and indirect costs incurred during the service life of the system.

There is a need to develop payloads that are both affordable and capable of performing their mission in only minutes after launch. As indicated earlier, the challenge is not only to make access rapid but also to make it affordable.[22] Research into micro-satellites

[22] Worden, Simon P. and Randall R. Correll. “Responsive Space and Strategic Information.” Defense Horizons 40 (2004): 1- 8.

(i.e. smaller satellites that can be built faster, are cheaper and can be launched together with other satellites) is a first step in this direction.

Cost-Related Considerations: Summary of Points for Departure
• What are the elements of the total-life-cycle cost (TCO)? • How much does each element contribute to the TCO? • What determines the cost of each element? • What problems raise costs and how can they be eliminated? • Who are the main stakeholders?

Figure 6: Cost-Related Considerations: Summary of Points for Departure

2.2.3. Levels of Responsiveness

Another complementary aspect of responsiveness is to look at it from the level of different stakeholders. One can identify three of these "levels of responsiveness". First, global industry-wide responsiveness looks at responsiveness from the end-user perspective. Such a perspective requires three different types of actions[23]:

- Eliminating bottlenecks in the value-chain and minimising waiting periods,
- Maximising overlap to the degree possible between different streams of activities with different suppliers
- Compressing the "response time" of each single supplier.

This level of responsiveness is the one mainly analysed in the above-mentioned section on time.

Secondly, responsiveness can be looked at from the perspective of the local customer in comparison to seeing it from the perspective of the end customer. This perspective can lead to the following actions:

- reducing or compressing delivery time for single action
- the responsiveness of each stakeholder is perceived from the perspective of its local customer.

Third, the responsiveness of a local customer is not only dependent upon and determined by the responsiveness of the suppliers but also by how well or efficiently the customer interacts and works with its suppliers. This is what is called interactive or inter-stakeholder responsiveness.

2.2.4. Levers of Responsiveness

The ground system, space vehicle, launch vehicle, and launch infrastructure all affect the responsiveness of space capabilities. Improving a launch vehicle's reaction time has little effect if the infrastructure and spacecraft have not similarly been improved. Responsiveness in general can also be improved by relying on terrestrial systems that can meet multiple space needs.[24]

Once the steps in the schedule architecture have been identified, specific "levers of

Levels of Responsive-ness	Identified Actions
Global industry-wide responsiveness: responsiveness taken from the end-users' perspectives	• Eliminating bottlenecks in the value-chain • Minimising waiting periods • Maximising overlap to the degree possible between different streams of activities at the level of different suppliers • Compressing the "response time" of each single supplier
Local stakeholder responsiveness: responsiveness as perceived by the local customer	• Reducing or compressing delivery time for single action • Responsiveness of each stakeholder perceived form the perspective of its local customer.
Inter-Stakeholder Perspective: responsiveness as being dependent on the interaction between customer and supplier	• Improving efficiency where necessary in the interaction of customer and supplier • Reducing the complexity of a system leading to involvement by fewer stakeholders' thus easing management tasks

Figure 7: Levels of Responsiveness Considering different Stakeholders' Perspectives

[23] This section is based on the account in Saleh, Joseph H. and Gregory F. Dubos. op. cit.

[24] Doggrell, Les. op. cit.

responsiveness" can be identified.[25] Since the schedule structure depends on the nature and characteristics under development, design choices and architecture can be identified as a lever of development. In this context, the complexity of the system under development proves to be a particularly dominant parameter in estimating the development schedule of an engineering product. Complexity, and consequently responsiveness, depends on:

- the total number of subsystems or components used in an engineering system, including identical ones,
- the number of different kinds of subsystems used,
- the number of interfaces and connections between these subsystems.

A decrease in system complexity reduces the number of subsystems and payload instruments to be developed, as well as their connections and interfaces and, in doing so, results in reduced complexity which in turn results in shorter design and development times for the different sections of a spacecraft. A decrease in system complexity also leads to a reduction inthe time needed to assemble and test. Additionally, reduced complexity will lead to less involvement of stakeholders and suppliers. With fewer suppliers and stakeholders to manage and take into account, interactive responsiveness can be improved. Another possibility is to reduce the time spent on system design and architecture by making use of repetitive tasks and production of multiple identical units whenever possible. This should result in time compression. The "plug-and-play" approach relying on modular design and standardisation of interfaces is another possibility to improve responsiveness in the design and architecture phase.

Another step to tackle in the schedule structure is the launch stage. It can be divided into launch vehicles and launch ranges, which together constitute the launch levers of responsiveness. Most of today's launch vehicles are built for a specific mission or spacecraft after a confirmed order with all financial guarantees for the vehicle being in place. This is what is referred to as Build-To-Order (BTO). Literature on responsive launch, however, advocates moving away from this "pull production system" to the Build-To-Inventory (BTI) or "push production system". In the BTI concept, products are manufactured not in response to a confirmed order but on the assumption that through "pushing" these products onto the market they will eventually be purchased. Apart from finding a responsive approach to launch vehicles it will be important to improve the existing launch ranges. Currently most ranges are government owned and function under certain restrictions that often result in delays in the order process.

Engineers and scientists will also have to explore how smaller payloads can be deployed rapidly to achieve useful effects, and how these can augment and reconstitute existing capabilities or enable new ones.[26] Currently, it is dependent upon a launch-on-schedule concept. In order for launches to be responsive, a launch on demand approach must be prepared.[27]

As indicated above, responsiveness not only depends on technical and operational characteristics but also on legal, organisational and managerial aspects, which are referred to as the "soft levers of responsiveness". The most prominent components of these are the selection process, design reviews and acquisition policies.

Turning to the first, the selection process is composed of the time from when the need is identified and formalised to the programme initiation. So far no research has been conducted to benchmark the selection process between competing proposals for on-orbit capabilities in a military acquisition context, in a government civilian context and in a commercial context. A reduction in the time of the selection process would constitute a major improvement in space responsiveness.

Multiple design reviews also add to the total amount of time spent in the development process. Given that they provide for progress visibility for all stakeholders, allow for the early identification of design errors and other problems, and allow for multi-disciplinary assessment of the level of quality and maturity of the project, they can well be said to be justified. While some research suggests that intense customer involvement in the development process can stretch the development schedule by over fifty percent, other sources indicate that a "handshake and trust" policy with suppliers is certainly practical. This however requires a delicate balance between trust between customers

[25] This concept has been introduced by Saleh, Joseph H. and Gregory F. Dubos. op. cit.

[26] Worden, Simon P. And Randall R. Correll. "Responsive Space and Strategic Information." Defense Horizons 40 (2004): 6.

[27] Doggrell, Les. op. cit.

and suppliers in the space industry, as well as trust between senior management and technical lead personnel.

Policies for the acquisition of space systems can also be an obstacle to responsiveness. Experience has shown that requirements for space systems are often not adequately defined at the start of the programme or that they change significantly after the programme has started, resulting in significant schedule delays. Conflicting demands for changing system requirements after a programme has started should be carefully balanced with the need for responsiveness. Furthermore, given the often large number of officials and organisations involved in requirement definitions and system acquisition, programme managers have to have the authority to make necessary trade-offs between requirements, changes in requirements / requirements growth and maintaining the programme on schedule and within budget. Thus effective programme management skills and team empowerment can also be taken to constitute a lever of responsiveness.

3. Show-Casing the U.S. Approach

The most well-known approach to Responsive Space is certainly the one currently under development by the U.S. Department of Defense (DoD).[28] In order for a European understanding and definition of Responsive Space to be agreed upon by the prospective stakeholders, an analysis of the U.S. approach to the problem is a useful starting point. Thus the goals of this section are to provide an overview and detailed analysis of the U.S. approach to RS as well as to assess the suitability of this existing responsive space concept for Europe.

3.1. Historical Development of the U.S. ORS

3.1.1. First Steps

The Rumsfeld Commission[29] in January 2001 identified problems in developing new space capabilities. One of the recommendations of the Commission was to establish a service like a Space Corps within the Department of Air Force.[30] A first step to streamlining space activities was conducted when the U.S. Strategic Command in Nebraska was established, placing all Air Force and National Reconnaissance Office space acquisition under a single office.[31]

DoD warned in 2001 about interference with satellites, when the former Secretary of Defense Donald Rumsfeld cautioned of a possible "space Pearl Harbour".[32] The motivations for ORS, i.e. to replace satellites which are considered as potentially vulnerable critical infrastructures, have existed for some years. Already under the Bush Administration in 2005 with the Space Transportation Policy Directive of 6 January 2005,[33] the motivations for ORS were identified by formulating a need to

> *demonstrate an initial capability for operationally responsive access to and use of space* - providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide *timely availability of tailored or new capabilities*—to support national security requirements. [emphasis added]

The Directive established 2010 as the date for demonstrating a responsive space capability. It gave the Secretary of Defense, in coordination with the Director of Central Intelligence, the task to

- develop the requirements and concept of operations for launch vehicles, infrastructure, and spacecraft to provide operationally responsive access to and use of space to support national security, including the ability to provide critical space capabilities in the event of a failure of launch or on-orbit capabilities; and
- identify the key modifications to space launch, spacecraft, or ground operations capabilities that will be required to implement an operationally responsive space launch capability.[34]

3.3.2. Recent Steps

In 2007 the U.S. Congress recognised the importance of ORS. Through the National Defense Authorisation Act (NDAA), Congress mandated DoD to formulate a plan to

[28] Other countries are developing elements of Responsive Space but have not developed a comprehensive approach such as the U.S. ORS. (see for example West, Jessica (Ed.). Space Security Index 2009. Waterloo: Project Ploughshares, 2009. <http://www.spacesecurity.org/SSI2009.pdf>. 19; 141.)

[29] Commission to Assess the United States National Security Space Management and Organization. Report of the Commission to Assess the United States National Security Space Management and Organization - Executive Summary. Pursuant to Public Law 106-65 of 11 Jan. 2001. Washington D.C. 20 Jan. 2010 <http://space.au.af.mil/space_commission/executive_summary.pdf>.

[30] Worden, Simon P. and Randall R. Correll. "Responsive Space and Strategic Information." Defense Horizons 40 (2004): 1- 8. 7.

[31] Ibid.

[32] Doggrell, Les. op. cit.

[33] U.S. Space Transportation Policy. National Security Presidential Directive of 6 Jan 2005. NSDP-40. 17 Dec. 2009 <http://www.fas.org/irp/offdocs/nspd/nspd-40.pdf>.

[34] Doggrell, Les. "The Reconstitution Imperative." 1 Dec. 2008. Air & Space Power Journal. 20 Nov. 2009 <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj08/win08/doggrell.html>.

establish ORS while at the same time authorising the DoD to establish an ORS Office reporting directly to the DoD Executive Agent for Space (EA for Space).

Specifically, Section 913 (c) of the so-called John Warner National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2007 required the Secretary of Defense to submit to the Congressional defense committees a report setting forth a plan, including eight required elements, for the acquisition by the Department of Defense (DoD) of capabilities for operationally responsive space to support military users and military operations.[35]

These eight elements were:

- An identification of the roles and missions of each military department, Defense Agency, and other component or element of the Department of Defense for the fulfillment of the mission of the Department with respect to operationally responsive space.
- An identification of the capabilities required by the Department to fulfill such mission during the period covered by the current future years defense program submitted to Congress pursuant to section 221 of title 10, United States Code, and an additional 10-year period.
- A description of the chain of command and reporting structure of the Operationally Responsive Space Program Office.
- A description of the classification of information required for the Operationally Responsive Space Program Office.
- A description of the acquisition policies and procedures applicable to the Operationally Responsive Space Program Office, including a description of any legislative or administrative action necessary to provide the Office additional acquisition authority to carry out its responsibilities.
- A schedule for the implementation of the plan and the establishment of the Operationally Responsive Space Program Office.
- The funding and personnel required to implement the plan over the course of the current future-years defense program.
- A description of any additional authorities and programmatic, organizational, or other changes necessary to ensure that the Operationally Responsive Space Program Office can successfully carry out its responsibilities.[36]

In response to Congress' initiative and based on the above mentioned eight elements, DoD started a community-wide effort to develop a plan for ORS which included defence, intelligence and civil agency participation but also "warfighters", operators, scientists, developers and acquirers. Given the current definition of ORS, a strong warfighter influence on the result can be identified. As a consequence, the DoD set forth a plan for the ORS office and the acquisition of the ORS capabilities,[37] which was presented to Congressional Defense Committees on 17 April 2007[38] and signed on 20 April 2007. It scopes ORS in a broader context characterising it as more than just rapid launch and small satellites and introduces the Tier approach. It further describes the ORS Office as more than just an acquisition programme office. Further details of this Plan will be given below in the outline of the ORS Office.

The initial ORS Concept of Operations (CONOPS) was approved by the Commander of the United States Strategic Command (CDRUSSTRATCOM) on 7 May 2007.[39] On 17 May 2007, the ORS office was established under the EA for Space with its Director reporting directly to the EA for Space. Col. Kevin McLaughlin was appointed as the first ORS Director on 20 May 2007. He was followed by Dr. Peter M. Wegner on 1 May 2008.[40] The ORS director is dual-hatted as ORS Director and as Space Development and Test Wing Commander (SDTW/CC). The initial ORS office was inaugurated on 21 May 2007 at Kirtland AFB, New Mexico.[41]

The utility of ORS in the context of space protection or the protection of critical infrastructures has recently been underlined again by President Obama, who said that "Operationally Responsive Space program, which uses smaller more nimble space assets to make US systems more robust and less vulnerable, is a way to invest in protecting America's space assets."[42]

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[35] Department of Defense. "Plan for Operationally Responsive Space. A Report to Congressional Defense Committees" 17 Apr. 2007. 20 Nov. 2009 <http://www.acq.osd.mil/nsso/ors/Plan%20for%20Operationally%20Responsive%20Space%20%20A%20Report%20to%20Congressional%20Defense%20Committees%20-%20April%2017%202007.pdf>.

[36] Congress of the United States of America. "John Warner National Defense Authorization Act for Fiscal Year 2007." 3 Jan. 2006. 20 Nov. 2009 <http://frwebgate.access.gpo.gov/cgibin/getdoc.cgi?dbname=109_cong_bills&docid=f:h5122enr.txt.pdf>.

[37] McLaughlin, Kevin. op. cit.

[38] Department of Defense. op. cit.

[39] McLaughlin, Kevin. op. cit.

[40] Wegner, Peter M. op. cit.

[41] McLaughlin, Kevin. op. cit.

[42] "2008 Year in Review & the Obama Administration." 26 Jan. 2009. ORS Newsletter Issue 6. 20 Nov. 2009

3.2. The Definition of the U.S. ORS

A first step was to establish a common definition and understanding of ORS, which initially meant different things to different people. Initial definitions ranged from a new business model to a low-coast launch vehicle, a programme to develop blimps and near space platforms, a small satellite programme, and global strike weapons to be part of an "unblinking eye offering persistent surveillance over the battle-space".[43] While the exact definition of ORS may remain in transition, its origins and intent are relatively straightforward: "ORS recognises that space systems and technologies are essential to the U.S. warfighter and primarily are responsible for conferring the "information dominance" on which the U.S. and allied troops currently rely" [emphasis added].[44]

When Congress in 2007 mandated DoD to formulate a plan to establish ORS and authorised it to establish an ORS Office, ORS was defined as "[a]ssured space power focused on timely satisfaction of Joint Force Commanders' (JFC) needs" [45]. In detail this means:

- "assured": "being sufficiently robust, timely, agile adaptive, and resilient to achieve desired outcomes, with a high degree of certainty"
- "space power": "the total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives"
- "focused": "a concentrated effort on a particular outcome"
- "timely satisfaction": "addressing needs & delivered within an operationally relevant timeframe".

"Joint Force Commanders Needs": "achieving desired effects through unified action".[46]

Specifically, ORS "will provide an affordable capability to promptly, accurately, and decisively position and operate national and military assets in and through space and near space."[47]. In order to do so new approaches to methods, development and acquisition are necessary to obtain ORS capabilities.

3.3. The Motivations Behind the U.S. ORS Concept

The ORS definition already gives some first insights into U.S. motivations behind the development of the ORS concept. Accordingly, the increasing reliance on space applications and emerging global challenges and threats place new demands on space capabilities.[48] U.S. space infrastructure was designed during the Cold War to counter the Soviet Union. Thus, given today's multi-polar world, today's JFC faces a very different security and threat environment. At the same time, during the Cold War, the U.S. and the Soviet Union had agreed not to attack each other's space assets, which provided for a certain degree of transparency given that both were the sole actors in space. Today, the space environment is increasingly perceived as a contested environment, with space applications being threatened by debris and the increasingly high number of actors in space, making space a crowded and competitive environment.

> At a time when over 60 nations are engaged in a space environment crowded with tens of thousands of man-made objects, a plan to augment and reconstitute critical space assets is vital to providing the warfighter with the national security space capabilities on which they rely.[49]

In today's world, having qualitatively high capabilities does not say much if these are not secured in a contested environment. China's Anti-Satellite Test (ASAT) of January 2007 further alarmed the U.S. (and global) space community into preparing to replace or reconstitute lost capability.[50] Thus, ORS was

<http://www.responsivespace.com/ors/reference/ORS%20Newsletter,%20Issue%206.2%5B1%5D.pdf>.

[43] Berube, Mark. "Operationally Responsive Space." Presentation of the National Security Space Office to the Commercial Space Transportation Advisory Committee. 11 Oct. 2007. Federal Aviation Administration 28 Aug. 2009 <http://www.faa.gov/about/office_org/headquarters_offices/ast/industry/advisory_committee/meeting_news/media/Berube.pdf>.

[44] Dal Bello, Richard. op. cit.

[45] Berube, Mark. op. cit.

[46] McLaughlin, Kevin. "Operationally Responsive Space Office." Presentation. 6 July 2007. 28 Aug. 2009 <http://www.responsivespace.com/ors/reference/McLaughlin.pdf>.

[47] Doggrell, Les. op. cit.

[48] McLaughlin, Kevin. op. cit.

[49] Aerospace Industries Association. "Robust Operationally Responsive Space: A Necessary Component of Affordable and Assured Space Power." AIA Position Paper. 28 Aug. 2008 <http://www.aia-aerospace.org/assets/wp_ors_paper_2009.pdf>.

[50] Doggrell, Les. "The Reconstitution Imperative." 1 Dec. 2008. Air & Space Power Journal. 20 Nov. 2009

also driven by the emerging perception that space applications constitute a critical infrastructure. In general, there was a growing realisation for a need for new capabilities with[51]

- increased flexibility and adaptability to respond to urgent needs
- the ability to rapidly infuse technological and operational innovationthe ability to rapidly augment or reconstitute space systems.

The U.S. ORS was further motivated by the fact that existing major military space development programmes were increasingly perceived as underperforming.[52] Also, budget pressures as well as technological advances in the military utility of small satellites called for a rethinking of the traditional space endeavour and thus contributed to the development of ORS.

3.4. The Objectives of the U.S. ORS Concept

> When it became obvious in September 1990, during the planning for Desert Storm, that existing satellite-communications capacity would not support the war effort, we made an urgent attempt to launch an additional Defense Satellite Communications System III spacecraft. That mission finally launched on 11 February 1992, missing the war by over a year. Luckily for the nation, we not only had access to a retired spacecraft but also were able to hire commercial communications capacity. The ability of the United States to support Iraqi Freedom with additional space capability has not significantly improved since Desert Storm.[53]

The above mentioned quote already indicates the main objectives of the U.S. ORS concept:

- to satisfy the needs of the JFC
- to develop the enablers to allow for rapid development, deployment and operation of space assets to support JFC needs.[54]

Specifically, this means fulfilling rapid, responsive, affordable, on-demand space support for military operations utilising both internal government and industry capabilities, to quickly reconstitute lost space capabilities and ultimately to enhance space survivability and deterrence.[55]

Further in line with these motivations, ORS provides means to

- reconstitute lost capabilities;
- augment/surge existing capabilities;
- fill unanticipated gaps in capabilities,
- exploit new technical/operational innovations;
- respond to unforeseen or episodic events;
- enhance survivability and deterrence.

Given that risk is usually the main issue in spacecraft development and launch, the U.S. ORS concept aims at taking a new approach to risk and mission assurance to ensure rapid deployment of “good enough” capabilities for the warfighter.[56]

The main difficulty in providing “timely” space capabilities is to anticipate requirements and capabilities for the next years, i.e. to foresee the future space environment. ORS is meant to be an intelligent approach to the future environment. While this future environment is still unknown, it is possible to already today identify some so-called chronic needs such as increased bandwidth as well as intelligence and remote sensing capabilities with higher resolutions that will persist in the future.

3.5. The U.S. ORS Programme in Detail

In accordance with the objective of making space assets affordable and to build a rapid reaction capability, the U.S. ORS Programme combines:

- quick identification and analysis of alternative solutions
- responsive spacecraft, payloads, space lift, ground systems, integration, command and control, and Tasking, Processing, Exploitation, and Dis-semination (TPED)[57].

<http://www.airpower.maxwell.af.mil/airchronicles/apj/apj08/win08/doggrell.html>.

51 McLaughlin, Kevin. op. cit.

52 Dal Bello, Richard. op. cit.

53 Doggrell, Les. op. cit.

54 Wegner, Peter M. “YIR: Operationally Responsive Space Office.“ Dec. 2008. SatMagazine.com. 28 Aug. 2009 <http://www.satmagazine.com/cgi-bin/display_article.cgi?number=735647891>.

55 Aerospace Industries Association. op. cit.

56 Wegner, Peter M. op. cit.

57 McLaughlin, Kevin. op. cit.

Thus, ORS is essentially aiming at two tasks:

- responding to joint force commander needs
- developing end-to-end enablers for small satellites to provide timely space solutions to joint force commanders

It thereby aims at contributing to traditional space force enhancement, space control and space support, reconstituting lost capabilities, augmenting/surging existing capabilities, exploiting new technical/operational innovations, and enhancing survivability and deterrence. ORS however does not aim to replace the existing approach of big multifunctional satellites but rather aims at exploring new approaches and architectures complementary to existing capabilities.[58]

In aiming at developing responsive platforms, payloads, busses with rapid development, deployment demonstration and transition to theatre,[59] it has adopted

> a multi-dimensional concept to implement ORS to improve the responsiveness of existing space capabilities (e.g., space segment, launch segment, ground segment) and to develop complementary, more affordable, small satellite/launch vehicle combinations and associated ground systems that can be deployed in operationally relevant timeframes,[60]

ORS thus aims at identifying the most likely emergent space needs, making plans and preparing to meet those needs, conducting operational experimentation and demonstrations, and preparing plans and procedures for operational deployment and / or employment. Thereby ORS is focused on the timely satisfaction of the urgent needs of the JFCs and other users and does not primarily deal with strategic or long-term needs.[61]

Thus the U.S. ORS concept encompasses payloads, launch vehicles and launch range as depicted in the figure below[62].

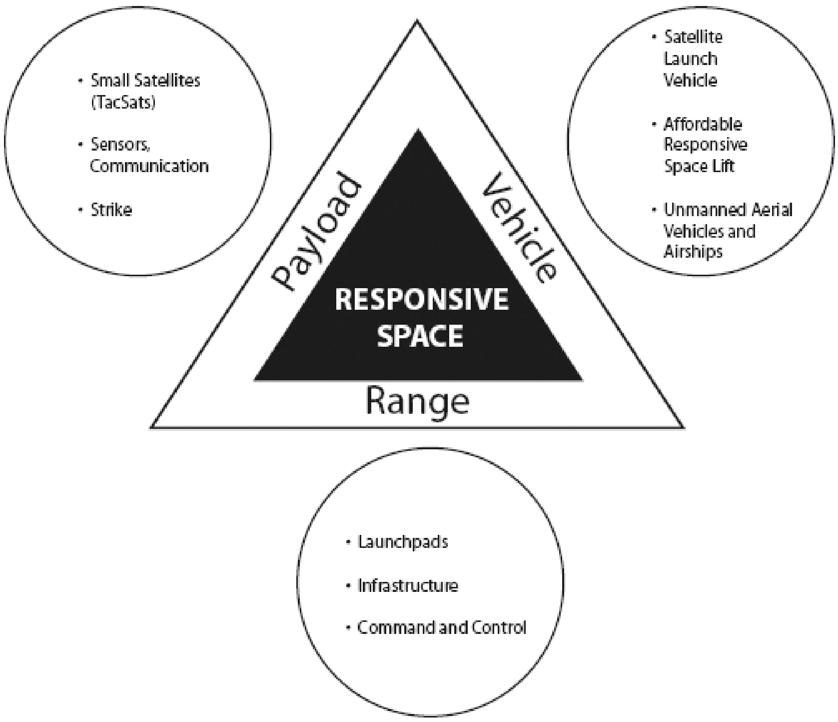


Figure 8: Responsiveness of space architecture: The ORS initiative divides improvements in responsiveness into categories that include the space vehicle, launch vehicle, and infrastructure. Improving each of these areas simultaneously presents a challenge

[58] Ibid.
[59] Ibid..

[60] Department of Defense. op. cit.
[61] Ibid. 3.
[62] Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/ airchronicles/apj/apj06/sum06/ doggrell.html>

In terms of augmenting and surging existing capabilities, responsiveness applies to actions such as reorienting or manoeuvring a spacecraft, modifying onboard software, or changing the pointing of the vehicle's antenna.[63] Beginning with the end user, the process of tasking, posting, processing, and using data must be timely, flexible, and tightly integrated with the war fighter's processing infrastructure and communications.

ORS will be fully integrated and interoperable with current and future architectures and will provide space services and benefits to war fighters and other users. ORS is a vision for transforming future space and near space operations, integration, and acquisition, at a lower cost. [64] It is not intended to replace or compete with the traditional model of exquisitely high performance systems.[65]

3.5.1. The Advantages

The U.S. ORS is said to have essentially three advantages:

1. assured space power to the warfighter
2. economic and industrial boost
3. exploitation of new technical and operational innovations.

The first advantage refers to the example of troops in isolated and hard to reach regions such as Afghanistan, which depend on space assets for life-saving intelligence, communications, and UAV support. In such a situation the ORS concept, provided it is adequately funded, could fulfil important response capabilities to unforeseen circumstances or unanticipated gaps in these space capabilities.[66]

Secondly, at a time of difficult and competing federal budgetary priorities, ORS seeks a low-cost approach to augment and surge existing space capabilities while at the same time trying to achieve an industrial boost for the space sector.

Third, ORS is developing and deploying new and innovative concepts for national security space systems such as "plug and play" technology and increased payload flexibility. These concepts reduce costs and increase responsiveness of critical national security space assets.[67]

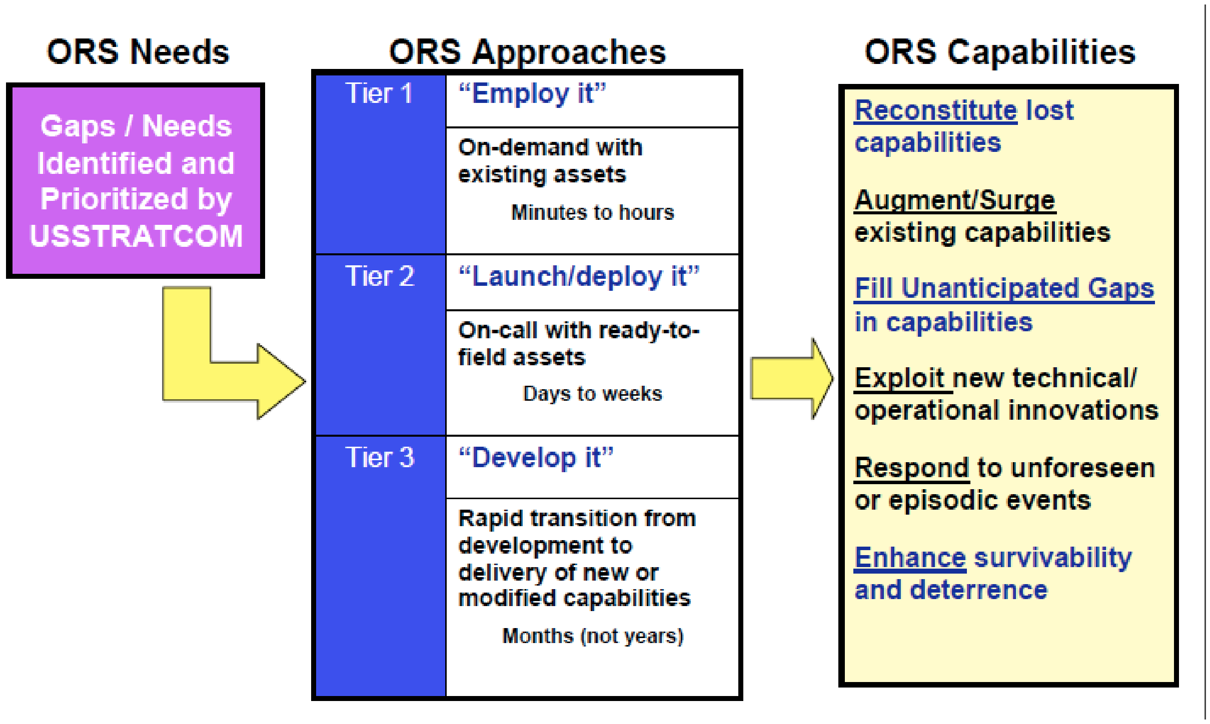


Figure 9: The Three Tiers

[63] Ibid.
[64] Footnote 3 in Doggrell, Les. op. cit.
[65] Wegner, Peter. "Operationally Responsive Space – Meeting the Joint Force Commanders' Needs." Presentation. Oct. 2008. <http://www.responsivespace.com/ors/reference/ORS%20Office%20Overview_PA_Cleared%20notes.pdf>.

[66] Aerospace Industries Association. op. cit.
[67] Ibid.

3.5.2. The Three Tiers

ORS offers a three-tiered strategy (cf. Figure 9[68]) outlined by the Department of Defense[69] that calls for

1. rapid exploitation of existing capabilities for urgently arising needs in minutes to hours;
2. use of existing technologies and capabilities to replenish, augment and reconstitute within days or weeks; and
3. development of new technologies and capabilities to replenish, augment and reconstitute within months and not years.

This capability is scheduled to be in place by 2015.

ORS aims at addressing issues in anywhere from minutes to hours to months.[70] In order to do so, it aims at bringing together operational, acquisition, industry partners, and science and technology communities to rapidly exploit emergent capabilities to fill operational gaps.[71] It also aims at actively engaging with all stakeholders in the space community (defence, civil, industry, academia) at the international level to define and promulgate spacecraft modular open standards.

3.5.3. Funding

The ORS programme is directly funded through the U.S. Department of Defense planning, programming, and budget cycle, with the funding being allocated to the ORS Office through the U.S. Air Force.[72]

3.5.4. The U.S. ORS Office

The ORS Office follows the mission to

- develop low-cost, rapid reaction payloads, buses, space lift, and launch control capabilities and
- coordinate and execute ORS efforts across the DoD.

The latter means that the ORS Office is not only tasked to coordinate the development of hardware but also to coordinate the development of the ORS concept across the various agencies involved.

The ORS office is led by the *ORS Office Director*, who is nominated and controls all resources in the ORS budget. The ORS core Office is composed of ten to twenty military and government civilian staff and is supported by up to forty research and development contractors. The ORS Office mainly liaises with key stakeholders in putting its emphasis on an effort to bringing the community together.[73] Direct oversight is provided by the DoD EA for Space and the CDRUSSTRATCOM. Continuity and depth of expertise is guaranteed through the assignment of a senior executive chief scientist/engineer, the *ORS Chief Scientist/ Engineer*. The ORS Office will distribute resources and authorities for a specific ORS project to existing organizations. Drawing upon existing capabilities the ORS office needs to reach out globally. Partnerships and collaboration are key to acquire, for example, Tier-1 capabilities. This organisational structure is depicted in Figure 10.[74]

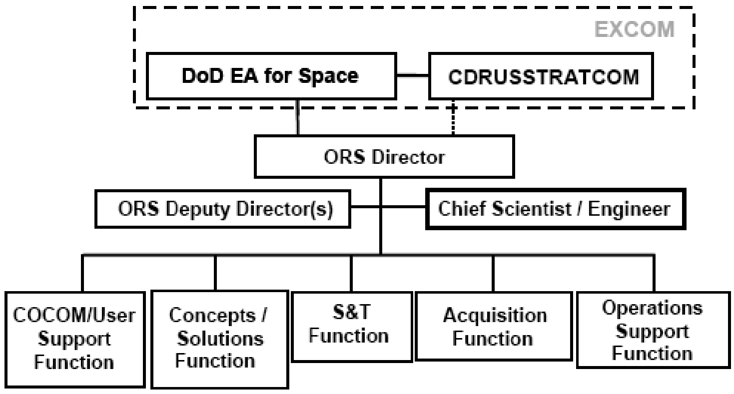


Figure 10: ORS Core Office[75]

Key Functions

According to the DoD Plan for the ORS Office, the ORS Office has essentially five key

[68] McLaughlin, Kevin. op. cit.
[69] Department of Defense. op. cit.
[70] Wegner, Peter. "Operationally Responsive Space – Meeting the Joint Force Commanders' Needs." Presentation. Oct. 2008. <http://www.responsivespace.com/ors/reference/ORS%20 Office%20Overview_PA_Cleared%20notes.pdf>.
[71] Ibid.
[72] Recently the Senate Armed Services Committee has recommended more than doubling the DoD's budget request for the ORS Office. It specifically proposed U.S. $ 115 million to start a prototyping programme for low-cost imaging satellites and an additional U.S $ 40 million to keep the office's first operational satellite on track. It also recommended adding U.S. $ 40 million to the service's, U.S. $ 31.9 million funding request for ORS-1, an intelligence, surveillance and reconnaissance satellite that is being developed to address a requirement from U.S. Central Command. (cf. Brinton, Turner. "Low-Cost Imaging Satellites Encouraged in Defense Bill." Space News 13 July 2009.).
[73] McLaughlin, Kevin. op. cit.
[74] A more detailed description of the organisational structure of the ORS Office can be found in: Congress: Department of Defense. op. cit. 5.
[75] Department of Defense. op. cit. 9.

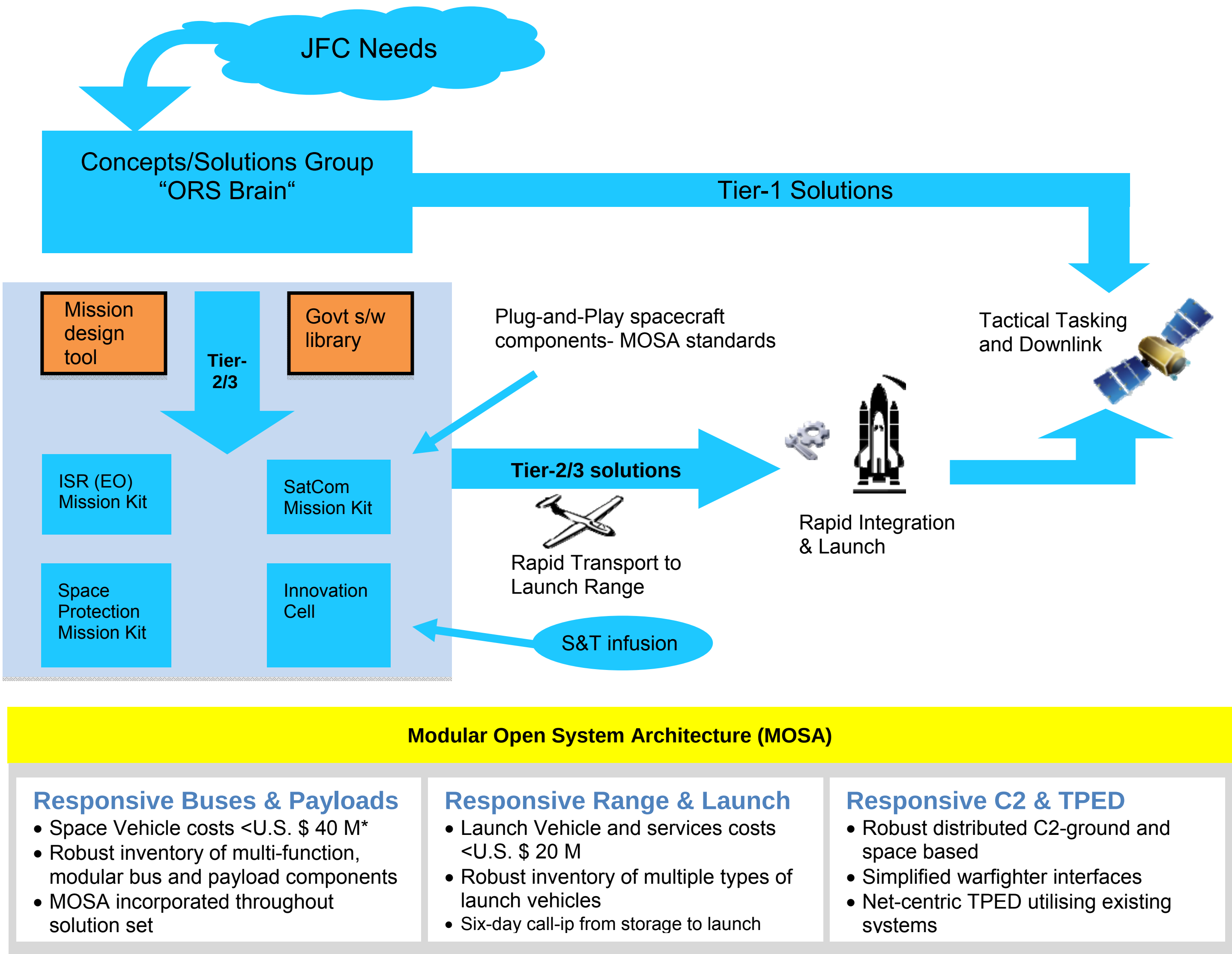
functions which are described in detail in the annex:

- Combatant Commander (COCOM)/User Support Function
- Concepts/Solutions Function
- Science & Technology (S&T) Function
- Acquisition Function
- Operations Support Function.[76]

Its foundational modus operandi is a "*Modular Open System Architecture*" (MOSA), which adapts "plug and play" concepts from the IT world to spacecraft, launch vehicles, and ground systems.[77] MOSA is an integrated business and technical strategy that:

- establishes an enabling environment conducive to open system implementation
- employs modular design tenets
- defines key interfaces where appropriate
- applies widely supported, consensus-based (i.e. open) standards that are published and maintained by a recognised industry standards organisation[78]

This working structure is depicted in the figure below. The upper section shows the MOSA concept and the procedure. Current achievements as well as targeted thresholds defined by Congress are shown below the yellow field.



* *targeted threshold defined by congress*

Figure 11: Modular Open System Architecture (MOSA) / The ORS 2015 Blueprint[79]

[76] The functions are in details described in the DoD Plan for ORS. Thus this section mainly relies on this document for outlining the different tasks of the ORS Office: Department of Defense. op. cit.

[77] "Space Power Lecture Covers Operationally Responsive Space." 28 July 2009. The Space Foundation. 25 Aug. 2009 <www.spacefoundation.org/news/story.php?id=793>.

[78] Skarupa, Valerie/Reese, Robert. "Operationally Responsive Space Office." Presentation. Responsive Space Roundtable. U.S. DoS, Washington D.C., U.S. 16 Nov. 2009.

[79] Ibid.

The MOSA shows the different modules of the ORS system architecture. Each of the modules is not supposed to be a fortress but resiliencies are supposed to be built in from the start when building up the architecture.

The ORS Office organisational structure mirrors the three tiers (see 3.4.2) of the Concept of Operations provided by U.S. Strategic Command and is composed of three divisions each dedicated to one pillar (see the Annex for details).

Immediate JFC needs are communicated to the ORS office. The latter does not necessarily own the required capabilities but needs to know on whom to draw upon (i.e. operators such as the Air Force, Army, Navy, commercial contractors or data services). This function of the ORS Office is often referred to as the "ORS brain". With Tier-1 capabilities being provided by the operators, the ORS office can focus on Tier-2 and Tier-3 enablers. This can be seen in Figure 12.

The ORS Requirements and Solutions Generation Process

The JFC or other users provide their needs to USSTRATCOM, which validates these needs. As part of the Requirements development phase, the Capability Review Team reviews these needs and converts them into a set of detailed requirements, which are then compiled into a Capabilities Requirements Document, which is reviewed by the user who submitted the need. These requirements are then reviewed by a team of joint and interagency community members – the Solutions Development Team - with an eye to developing potential solutions. Potential solutions are then reviewed by the Commander of U.S. Strategic Command and users get the opportunity to make an input. After being reviewed, solutions need to be approved by the Executive Agent for Space, which submits them to the ORS Office, which is responsible for the execution of the solutions. The user again provides input during the execution process. This process is depicted in Figure 13 below.

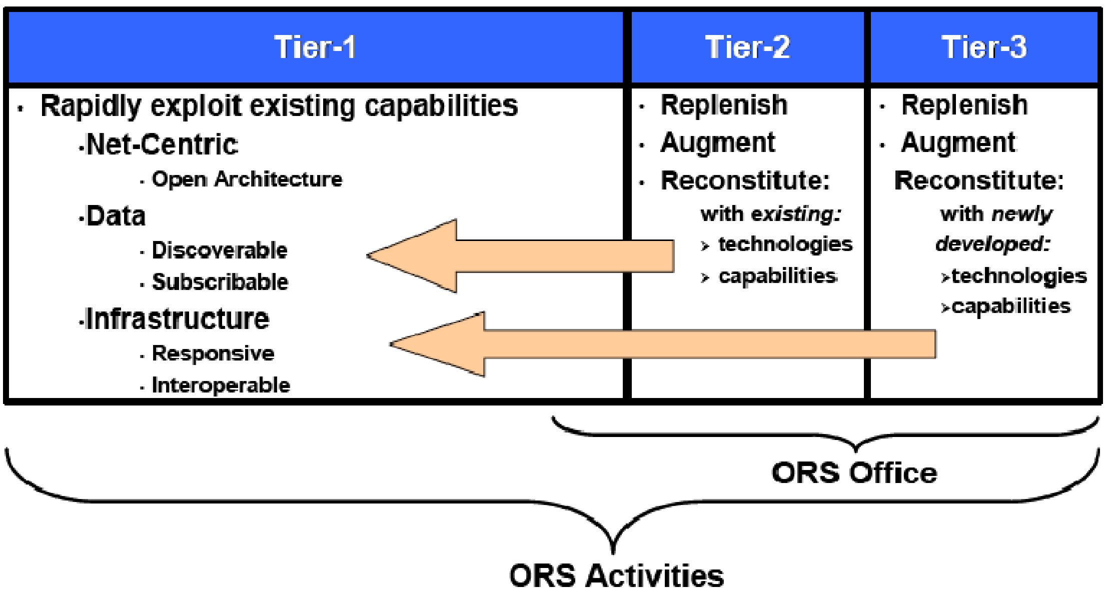


Figure 12: Tasks of the ORS Office and ORS activities[80]

[80] Department of Defense. op. cit. 4.

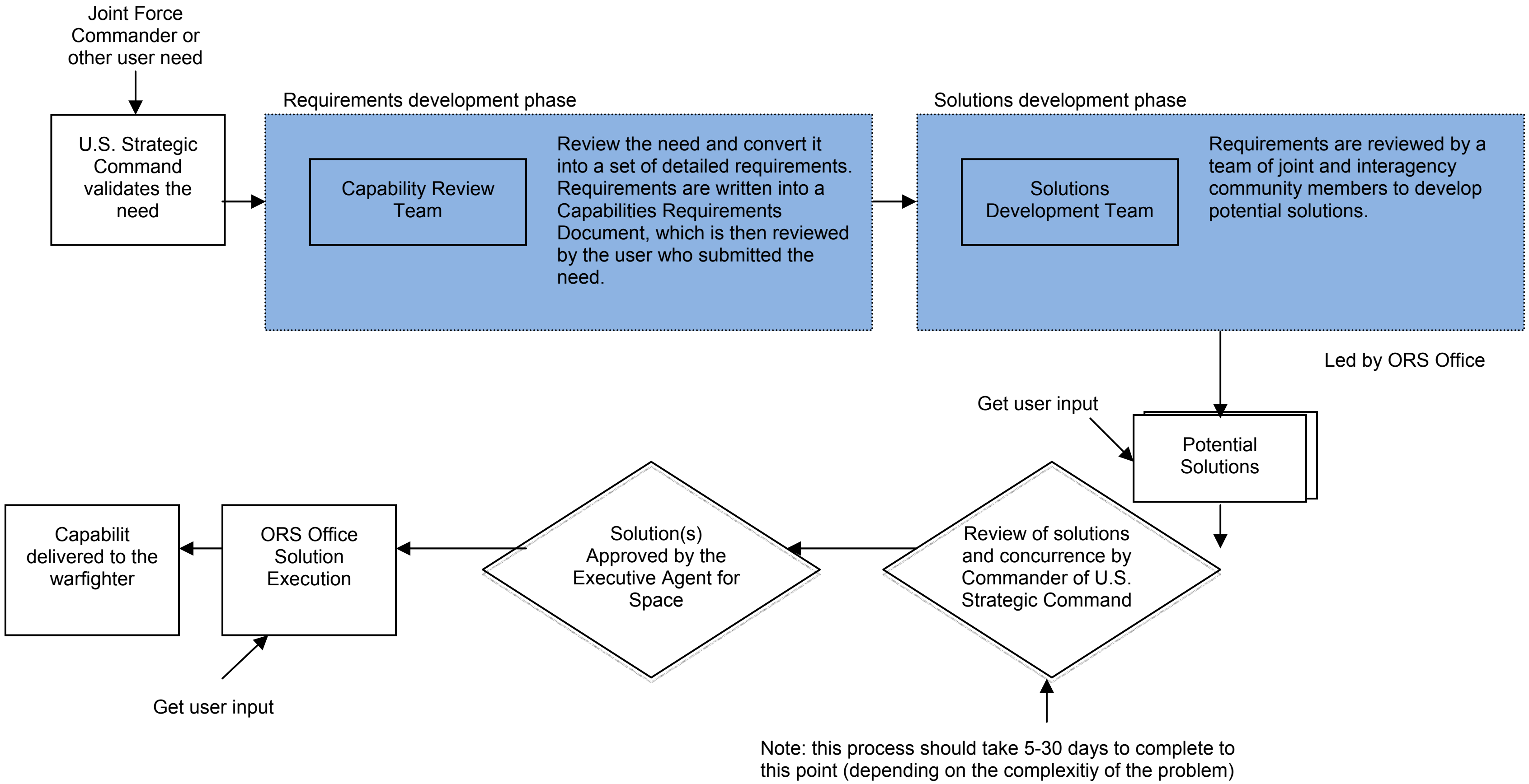


Figure 13: The ORS Requirements and Solutions Generation Process[81]

[81] United States Government Accountability Office. op. cit. 9.

Current Status: "Crawling"

According to the ORS' Implementation Plan, the "I-Plan", the ORS Office will accomplish its objectives in a "crawl, walk, and run" approach.[82] Currently, the concept is in the crawl phase meaning that the warfighter is becoming involved with the concept and the focus of ORS efforts is on demonstrating building blocks for later efforts, conducting experiments and determining what can be accomplished with current assets. All three elements of the above-illustrated MOSA have already been separately demonstrated this year. On 9 August, the Air Force Research Laboratory (AFRL) demonstrated the assembly of a plug-and-play spacecraft within four hours. On 1 September, a responsive aircraft transport was demonstrated. Before that on 2 August, the U.S. was able to demonstrate a six-day call-up to launch. Recently, on 8 December 2009, TacSat-3 was used to demonstrate Tier-1 capabilities, i.e. the modification of tasking and downlinks of an existing spacecraft. While all key processes have thus been demonstrated as being rapidly developed, an end-to-end demonstration is currently not yet possible. Such an end-to-end demonstration is foreseen to be finalised by 2015. Until then, evolving issues such as stockpiling of modules of a spacecraft and the costs involved in that will need to be resolved. The main analogy often referred to as an example of what ORS should aim for is the Reconnaissance Aircraft ("Reconwing") which can be modified within hours. The ORS Office has so far proposed concepts for three JFC needs that involve:

- commercially hosted payloads for UHF Satcom,
- utilisation of existing assets for SSA,
- rapid development of a new system for intelligence, surveillance and reconnaissance.[83]

In fiscal year 2008 further advancements were undertaken. A new rapid requirements process to validate and prepare solution in 30-60 days was adopted and a rapid (4 hr.) spacecraft assembly via plug-and-play using a modular open systems architecture in cooperation with the Air Force Research Laboratory was developed. The U.S. was able to integrate a trailblazer spacecraft in six-days onto a Falcon-3 rocket. The "warfighter" was able to rely on the Canadian RADARSAT-2 satellite, an international asset proving the usefulness of international cooperation in the context of responsive space. The ORS Office was able to demonstrate its first example of an end-to-end quick response through rapid acquisition for ORS-Sat-1 (contract in 17 days, and proposed launch of 24 months).[84]

The United States' Government Accountability Office described "walking" as the evolution of the ORS concept into a warfighter-driven concept with selected capabilities tied to gaps and integrated within the existing architecture."[85] According to the ORS Implementation Plan this phase will not begin until approximately 2010.

"Run" involves the ability to provide an end-to-end ORS structure, i.e. a full range of space effects delivered when and where needed. This is foreseen for 2015. The successful pre-2009 demonstrations of single elements of such an end-to-end demonstration can be said to have "propel[led] the ORS concept to somewhere between a walk and a run"[86].

3.5.5. The TacSat Programme

Apart from ORS, the U.S. is also looking into Responsive Payloads and Responsive Launch through various other programmes. While those mainly research efforts are not led by the ORS Office, they will eventually contribute to the development of the envisaged ORS capabilities.

One of the most prominent examples of a more holistic approach, contributing directly to ORS is the TacSat Programme. Spacecraft are notionally divided into two system segments: the payload and the non-payload support portions (known as the "bus"). The TacSat Programme is looking at both of these.[87] It derives its name from the use of small spacecrafts the TacSats, and came to be known as an Air Force initiative, exploring concepts for providing responsive

[82] United States Government Accountability Office." DoD Needs to Further Clarify Operationally Responsive Space Concept and Plan to Integrate and Support Future Satellites."GAO, 2008. 11.
[83] Wegner, Peter M. "YIR: Operationally Responsive Space Office." Dec. 2008. SatMagazine.com. 28 Aug. 2009 <http://www.satmagazine.com/cgi-bin/display_article.cgi?number=735647891>.
[84] Ibid.
[85] Ibid.
[86] Ibid.
[87] Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/doggrell.html>.

capabilities.[88] TacSat explores shorter acquisition cycles and on-orbit lifetimes so as to encourage faster technology refreshment in the space segment. Limiting the TacSat's scope allows DoD to trade off reliability and performance for speed, responsiveness, convenience, and customisation. DoD plans to test its utility level for the warfighter in theatre after launch.[89] TacSat-3 was recently launched on 19 May 2009 (for an overview of the existing TacSats cf. 5.5.).

TacSat as a programme existed prior to ORS. It has now been integrated into the general ORS concept and serves as a kind of "publicity campaign" for the ORS concept. As such, TacSats are also used for ORS demonstrations and most of their procurement is now conducted through the ORS Office.[90] TacSat combines existing military and commercial technologies such as imaging and communications with new commercial launch systems.[91]

TacSats are relatively inexpensive vehicles weighing less than 1.000 pounds that hold promise as a proving ground for new concepts that enhance the responsiveness and survivability of future systems. Such small spacecraft provide for the opportunity of designing distributed architectures featuring more spacecraft.[92] While providing more targets, each of them individually is a less critical target.[93]

Smaller spacecraft launched on short mission timelines will lead to an increased number of spacecraft and launch vehicles produced by the U.S. The small number of spacecraft and launch vehicles currently produced by the U.S. complicates the maintenance of an industrial base and increases the unit cost of each craft and vehicle. Costs could thus be reduced through exploitation of the economic concept of diminishing returns: With the costs for a launch pad or a vacuum test chamber remaining largely independent of the frequency of use leading to the expense of maintaining expertise becoming fixed when production rates stay low. Larger numbers of spacecraft and launch vehicles, even smaller ones, might result in economic production quantities and cost - reduction benefits, which in turn would allow exploration of new missions or new approaches to existing missions.[94]

Departing from typical spacecraft design, TacSat also explores alternative spacecraft bus design concepts. The "bus" is the platform that provides power, attitude, temperature control and other support to the satellite in space. The objective is to design a common modular, standard, or plug-and-play spacecraft bus, which could reduce the cost of the development and production schedule and in turn that of the fleet itself. Such a concept on the one hand allows for selection of the specific payload at the launch site. On the other, pre-integrated and tested spacecraft would accelerate and simplify necessary steps at the launch site.[95] Apart from the TacSat programme, the Air Force Research Laboratory is also demonstrating the capabilities of a plug-and-play architecture, accelerating satellite production through the use of standardised computer-like ports to connect standardised components.[96]

In addition to exploring alternative concepts for spacecraft it also researches into launch vehicles, range and operations.[97] Smaller launch vehicles - as already researched by the Air Force's and DARPA's Force Application Launch from the Continental United States programme - offer the prospect of reducing the time and cost of delivering small spacecraft to orbit.[98]

TacSat is directly supporting the ORS Office ORS-1 experiment. The Tier-1 Division (cf. 3.5.4. and 5.2.1.) of the ORS Office follows the TacSat end-to-end experiment and validates all architectures from request through delivery of products to expedite on-orbit check out and transition based on the ORS-1 experiment. ORS-1 is the ORS Office's first operational satellite. Initiated in 2009, ORS-1 uses an off-the-shelf TacSat-3 bus and a slightly modified U2 intelligence

[88] Doggrell, Les. op. cit.
[89] United States Government Accountability Office. op. cit. 4.
[90] West, Jessica (Ed.). op. cit. 111.
[91] Ibid. 139-40.
[92] Doggrell, Les. op. cit.
[93] For a similar analysis and recommendation to counter potential interferences with satellites refer to Remuss, Nina-Louisa. "The Need to Counter Space Terrorism – A European Perspective." ESPI Perspective 17. Vienna: European Space Policy Institute, 2009. <http://www.espi.or.at /images/stories/dokumente/Perspectives/espi%20perspectives%2017.pdf>.
[94] Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/doggrell.html>.
[95] Ibid.
[96] United States Government Accountability Office. "Space Acquisitions – DoD Is Making Progress to Rapidly Deliver Low cost Space Capabilities but Challenges Remain."GAO, 2008. 7.
[97] McLaughlin, Kevin. op. cit.
[98] Doggrell, Les. op. cit..

surveillance reconnaissance (ISR) payload.[99] The launch of ORS-1 is scheduled for December 2010. The idea of the ORS satellites programme is to develop modular open systems allowing for extremely compressed assembly, integration, test and launch of the asset.[100]

3.5.6. Stockpiling

The previous three sections have dealt with the stated ORS objective of providing greater capability in smaller, less expensive future projects and delivering these on shorter timelines. However, better, faster, and cheaper space systems have proven to be difficult. While a lot of research has already been conducted, the U.S. currently cannot produce small launch vehicles in less than 18 months with spacecraft-fabrication timelines being even longer, as was seen in the TacSat Programme. While attempts to reduce these timelines should be further pursued and not neglected, other military concepts have provided alternative ideas such as stockpiling to reconstitute lost spacecraft.[101]

Currently, military service research labs, such as AFRL and Naval Research Laboratory (NRL), are working on technologies to reduce the need to stockpile spacecraft, thereby still meeting a responsive timeline, with the objective of assembling a spacecraft within six days. This however requires either the government or a contractor to maintain an inventory of pre-engineered and pre-qualified components. Thus, costs for keeping an inventory and required personnel on standby to perform the assembly would still arise. Moreover, looking at other business areas such as computer production, it can be seen that the success of the rapid assembly and low-inventory business model, as illustrated by Dell computers, relies on high volume. A reconstitution system will thus require people to operate it and they will need to be trained and familiarised with the system. This involves costs for maintaining a full staff in "peace-time" and costs for demonstrations and training. Thus the question arises: would it be cheaper to assemble spacecraft at the launch site or to use a small-satellite inventory?. As an inventory providing a complete replacement of the on-orbit space capabilities is financially unrealistic, there is thus a need to perform an analysis determining the priority of missions and necessary system capabilities.[102]
Some literature[103] has already developed ORS operations complexes, which include storage facilities for stockpiling, in detail. The model of Kendall Brown includes storage facilities not only for fuel but also for payloads. According to his scheme, payloads are prepared and integrated with the vehicles and boosters in a "vehicle integration facility".[104]

Alternatively, one could stockpile spacecraft on orbit in advance. Such an on-orbit reserve could provide continuous capability. However, on-orbit stockpiles also provide new targets.[105] Additionally, considering the current lack of on orbit capabilities, there is first a need to get required capabilities on orbit before stockpiling can be thought of.

3.5.7. The International Dimension

The U.S. is currently undertaking the so-called "Space Posture Review" (SPR). While this SPR is not primarily driven by ORS, the question arises as to how ORS can play into the U.S. national space strategy. First, ORS contributes to the robustness, protection and resilience of space assets and makes them less fragile. Secondly, ORS contributes to a greater degree of cooperation.

The U.S. President, already in August 2006,[106] explicitly mentioned his objective to "encourage international collaborations with foreign nations to support national security." In this context ORS is a means to foster international collaboration and acts as a deterrent by affording the opportunity to participate in multi-national constellations. ORS can also serve as a tool of foreign diplomacy for military operations, humanitarian relief, economic growth and political strength.[107] ORS is aiming at drawing on its international partners. ORS aims at

[99] "Space Power Lecture Covers Operationally Responsive Space." op. cit.
[100] Skarupa, Valerie. Interview 17 Dec. 2009.
[101] Doggrell, Les. "The Reconstitution Imperative." 1 Dec. 2008. Air & Space Power Journal. 20 Nov. 2009 <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj08/win08/doggrell.html>.

[102] Ibid.
[103] See for example Brown, Kendall. op.cit.
[104] Brown's ORS Operations Complext: After the separation of the second stage vehicle, the booster vehicle lands on the runway and can be taken to the vehicle maintenance facility for maintenance or inspections. At the same time payloads are prepared and integrated with the second stage vehicles and taken to the vehicle integration facility for integration with the booster. The vehicle is then integrated horizontally and prepared for launch. It is then taken to the launch pad, rotated into the vertical launch configuration, and prepared for launch. Propellants arrive at the base via truck or rail for storage in tanks. Multiple launch pads provide the opportunity of several launches per day. (Ibid.)
[105] Ibid.
[106] cf. NSDO-49.
[107] Skarupa, Valerie/Reese, Robert. op. cit.

taking into account the partners' experience in small satellites, to learn from their different CONOPS and to take advantage of their existing technology. The U.S. side is interested to learn about corresponding activities on the European side and, in particular, in identifying European military or civil elements (e.g. commercial / EO satellites) that could potentially be integrated with the U.S. ORS architecture in order to increase its performance.

The ORS is currently working on a comprehensive ORS International Collaboration Strategy, which has not yet been approved by the U.S. government. It is currently envisaged to "help revitalise the U.S. Space industry and strengthen relations with allies by developing multinational initiatives delivering space capabilities."[108] Such an International Collaboration Strategy would have as its primary objective to "harness capabilities of unused and new space assets and participate in ORS constellations through international agreements". The current draft proposes to do so in four steps: First, the U.S. would develop a first satellite and coalition strategy on which basis an agreement for international participation would be established. Coalition partners would then procure or reproduce additional replica. Eventually all coalition partners would enter into data sharing and tasking agreements. As a result foreign collaboration for economic and scientific stimulus would be promoted and partners would receive the capability of a full constellation at the price of a single satellite.[109]

International collaboration is an ongoing effort as part of the U.S. ORS concept. The Secretary of the AF and OSD Space Policy has established an International Cooperation Assessment Team (ICAT) as a stepping-stone for future space collaboration. Additionally, the Globalise and Internationalise Standards Technology project has been established to overcome real and perceived barriers to international collaboration. It is suggested that ORS International Collaboration be established in at least three phases:

- standards development (as took place in the SSA context)
- research, development, test and evaluation
- acquisition.

[108] Ibid.
[109] Ibid.

3.5.8. Obstacles to ORS

The main obstacles to ORS, such as inadequate funding, inter-agency competition over resources and unwillingness to share data, arise from problems in changing the way people think about space systems. The industry still seems to be sceptical and perceives ORS as an Airforce programme that does not fulfil their objectives and thus the industry hesitates to become involved.

Some, however, perceive the current systems as high-value assets that must be protected. The United States Government Accountability Office (GAO) pointed to the need to communicate to stakeholders often and early and to clearly define specific objectives. It identified a disparity in stakeholder understanding of the ORS concept within the warfighter and national security space communities. Accordingly, this disparitiy exists because DoD has not clearly defined key elements of the ORS concept and has not effectively communicated the concept to key stakeholders right from the start. The GAO emphasised that without having a well-defined and commonly understood concept, DoD's ability to fully meet warfighter needs may be hampered. It advised DoD to establish an ongoing communications and outreach approach to communicate its definition and to foster understanding and acceptance of the ORS concept among stakeholders.[110] Such language issues should also be taken into account in the context of international collaboration. Thus the U.S. aims to establish a dialogue with industry partners in order to

- clarify the degree of support from the U.S. industrial base
- clarify the industries' requirements for a comprehensive ORS concept

The interagency approach is currently hampered by resource competition. It is important to do everything possible to remove any hint of service competition as this limits commitment.

Industry participation has to be fostered. The Aerospace Industry Association has thus called for ORS to rely on both internal government and industry capabilities in order to fulfil its objectives. Accordingly, there is a need to further pursue strategies to create an environment that enables industry

[110] United States Government Accountability Office. "DoD Needs to Further Clarify Operationally Responsive Space Concept and Plan to Integrate and Support Future Satellites."GAO, 2008. 4.

participation, helping to strengthen the U.S. space industrial base.[111]
With regard to data sharing, problems usually do not result from a lack of technology or limitations in technology but rather are a result of the limited commitment to sharing. ORS requires responsive thinking that is responsive in both policy and capabilities. The basis for this is trust.

3.5.9. Lessons Learned as a Blueprint for Europe

When showcasing and analysing the U.S. approach to responsive space, several distinct elements (motivations, objectives etc.), which serve as guiding themes for this section can be identified. The table below summarises the distinct elements of the U.S. approach. It also links the conceptual considerations as analysed in section 2 and discusses the U.S. approach to several of these levers of responsiveness. Having done so in a comprehensive manner, this approach also enables the identification of several basic questions that need to be clarified as a basis for Europe to adopt its own concept for responsive space.

The main lesson learned identified by the U.S. ORS Office is the difficulty in socialising new ways of doing business in the government. Much time and effort has to be dedicated to communicate the vision of ORS and the complementarity of ORS with the existing space architecture.[112] While there have also been many technical lessons learned, it can be generally concluded that many capabilities are technically already possible. There is a need to develop the political will to implement the technical capabilities. The analysis of the U.S. approach and, specifically, the analysis of the draft of the "ORS International Collaboration Strategy" has shown a strong component for international collaboration in RS. When it comes to developing new technical requirements, it does not make much sense to put money and time into R & D projects if similar efforts have already been conducted by the U.S. or another space-faring nation. Instead, States should share their lessons learned and work together on the development of new technological capabilities. In this context, other international partners should not be lost sight of. China, for example, is working to develop more capable microsatellites for military and other space missions as well as a classified "Shenlong air-launched booster" designed for drop from a Chinese H-6 badger bomber for smallsat launch operations."[113] Russia is also developing elements of responsive space systems particularly with the objective of rapidly rebuilding space systems after an attack and to reduce vulnerabilities in space.[114]

[111] Aerospace Industries Association. op. cit.
[112] Skarupa, Valerie, ORS Office. Personal Interview 17 Dec. 2009.
[113] West, Jessica (Ed.). Space Security Index 2009. Waterloo: Project Ploughshares, 2009. <http://www.spacesecurity.org/SSI2009.pdf>. 141.
[114] Ibid. 19.

The U.S. Approach to Responsive Space – Suitability and Questions for Europe

	Operational Responsive Space	Conclusions & Questions for Europe
Definition	"Assured space power focused on timely satisfaction of Joint Force Commanders' needs"	• U.S. poses emphasis on military needs, Europe's dual use characteristics of Space Policy as well as its engagement in civilian needs will not allow for a purely military focussed definition of RS: Thus there can either be two RS in Europe or one concept into which both civil and military requirements are fed • Since two RS in Europe would hinder the exploitation of synergies between defence and military capabilities and might result in duplication, Europe should consider an approach taking into account both civil and military requirements in one approach

Motivations	• the post-Cold War space environment has changed: U.S. space infrastructure was designed during the Cold War to counter the Soviet Union; in a new environment the needs and requirements for space systems have changed
	• space systems and technologies are essential to the U.S. warfighter and primarily are responsible for conferring the "information dominance" on which the U.S. and allied troops currently rely
	• growing realisation that there is a need for new capabilities
	    o Increased flexibility and adaptability to respond to urgent needs
	    o Ability to rapidly deploy technological and operational innovation
	    o Ability to rapidly augment or reconstitute space systems
	• non-traditional threats / space protection / robust space capabilities: space systems are increasingly seen as constituting critical infrastructures; ORS will introduce possibilities to replace or repair lost space applications in a fast manner
	• Improve current capabilities: perceived underperformance of nearly all major military space development programmes
	• budget pressures/new business model which is providing for faster/more cost effective solutions
	• technological advance in the military utility of small satellites
		similar motivations could be identified in Europe BUT: the ESP is currently following civil considerations as well
		• growing realisation that there is a need for new capabilities
		    o Increased flexibility and adaptability to respond to urgent needs
		    o Ability to rapidly deploytechnological and operational innovation
		    o Ability to rapidly augment or reconstitute space systems
		• need for improvement of current space systems
		• space systems are increasingly seen as constituting critical infrastructures
		• budget pressures
		• technological advancement in small satellite technology as a driving force

Objectives	• fulfilling rapid, responsive, affordable, on-demand space support for military operations utilising both internal government and industry capabilities • more flexible and responsive space strategies • to satisfy the needs of the JFC • counter space: capabilities to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while negating an adversary's ability to do the same • to quickly reconstitute lost space capabilities: ultimately to enhance space survivability and deterrence • space force enhancements: capabilities that contribute to maximising the effectiveness of military air, land, sea and space operations • space support: capabilities to provide critical launch and satellite control infrastructure, capabilities and technologies that enable the other mission areas to effectively perform their missions	*If responsiveness is based on threats = threat perception, then Europe has to adopt a different approach than the U.S. due to different threat perceptions* • fulfilling rapid, responsive, affordable, on-demand space support for military operations and civilian emergency management, i.e. the full spectrum of security threats, utilising both government and industry capabilities • more flexible space assets that can quickly adapt to new arising threats • to quickly reconstitute lost space capabilities: ultimately to enhance space survivability and deterrence • space force enhancements: capabilities that contribute to maximising the effectiveness of military air, land, sea and space operations • space support: capabilities to provide critical launch and satellite control infrastructure, capabilities and technologies that enable the other mission areas to effectively perform their missions
Institutional Set-Up	The ORS Office (1) develop low-cost, rapid reaction payloads, buses, spacelift, and launch control capabilities and (2) coordinate and execute ORS efforts across the DoD	*→What institutional structure can we foresee for Europe? Where would a European RS Office be located? How would it be structured? Which / Whose needs would it fulfil? In the U.S. it is the JFC / warfighter, but in Europe?*
Stakeholders involved	• aims at bringing together operational, acquisition, industry partners, and science and technology communities to rapidly exploit emergent capabilities to fill operational gaps. • aims at actively engaging with all stakeholders in the space community (defence, civil, industry, academia) at the international level to define and promulgate spacecraft modular open standards.	*Which players would be key players in Europe?* • apart from military needs, Europe's dual nature Space Policy will also fulfil the needs of civilian emergency management • Europe currently conducts Space Policy on both the national and European level; thus a setting for combining both in one concept has to be found
What steps are taken to make space applications more affordable?	• larger numbers of spacecraft and launch vehicles, even smaller ones, might result in economic production quantities and cost—reduction benefits, which in turn would allow exploration of new missions or new approaches to existing missions • TacSat is exploring designing a common modular, standard, or plug-and-play spacecraft bus, which could reduce the cost of the development and production schedule and in turn that of the fleet itself. • ARES concept relying on reusable boosters to improve cost-effectiveness	*Can Europe take advantage of technology development in the U.S. in, for example, plug-and-play, modularisation and standardisation?* *Can the results of the TacSat Programme contribute to a follow-up programme in Europe?*
Obstacles to ORS	• inadequate funding • rigid ways how people think about space	*→Are these the same in Europe?* *What obstacles to responsive space exist in Europe and how could they be countered?*

Figure 14: The U.S. Approach to Responsive Space – Suitability and Questions for Europe

Factors Influencing Responsiveness of a System		Identified Actions	The U.S. Approach	Questions for Europe?
1. Design Choices and Architecture of the System (Payloads, Buses)	**Complexity**	decrease a system's complexity, through • reduced numbers of subsystems and/or payload instruments • reduce the number of different kinds of subsystems • reduce the number of interfaces and connections between subsystems to the lowest level possible	n.a.	How to reduce the complexity of Europe's space systems?
	Learning Curve	make use of identical units and repetitive tasks in the development process	research into modularisation and standardisation	Can Europe take advantage of technology development in the U.S. in, for example, plug-and-play, modularisation and standardisation?
	Modularity, Plug-and-play and Standardisation of Interfaces	• elimination of certain tasks during the design and development of modules for subsequent systems: system development schedule is shortened and responsiveness is improved • the use of a given module design allows taking full advantage of the learning effects associated with the repetitive use of a module design	• aims at actively engaging with all stakeholders in the space community (defence, civil, industry, academia) at the international level to define and promulgate spacecraft modular open standards • Plug-and-play satellite payloads • Telescopes, communication packages, Mini-SAR[115] • RF ID, PAN/MSI/HIS backplane[116] • TacSat Programme: shorter acquisition cycles and on-orbit lifetimes to encourage faster technology refreshment in the space segment • TacSat also explores alternative spacecraft bus-design concepts. Its objective is to design a common modular, standard, or plug-and-play spacecraft bus, which could reduce the cost of the development and production schedule and in turn that of the fleet itself • The ORS Office Acquisition Function puts an emphasis on integration of off-the-shelf components whenever possible	• Who are all the stakeholders in Europe that need to be involved? • What programmes currently exist at both European and national level dealing with modularity, plug-and-play and standardisation of interfaces? • How can these be pooled?
2. Launch Levers	**Launch Vehicles**	move away from Build-To-Order to Build-To-Inventory concept for launch vehicles	• the U.S. ORS concepts aims at taking a new approach to risk and mission assurance to ensure rapid deployment of "good enough" capabilities for the warfighter. • On-demand launchers[117] • Flexible bus concepts using plug-and-play, standard interfaces and modularity[118]	Have similar attempts like the TacSat or ARES already been conducted in Europe?
	Launch Range	• improve existing launch range • identify restrictions for launch ranges • How can these be eliminated?	Study on launch in different weather conditions	How to improve the existing launch range for Europe?
3. Soft Levers of Space Responsiveness	**Selection Process**	• academia to conduct research to benchmark the selection process of competing proposal for on-orbit capabilities in a military acquisition context, in a government civilian context and in a commercial context • academia to provide thorough analysis of selection processes for different programmes and, within several agencies, the	example of capability selection process of TacSat 3 and 4: representatives from services and combatant commanders identified top 10 capability shortfalls using selection criteria such as need and urgency, joint value, user/ sponsor commitment. These were provided to representatives from the service labs and academia ↓ labs matched payload candidates	What is the average time for the selection process in Europe?

115 Wegner, Peter. "Operationally Responsive Space – Meeting the Joint Force Commanders' Needs." Presentation. Oct. 2008. <http://www.responsivespace.com/ors/reference/ORS%20Office%20Overview_PA_Cleared%20notes.pdf>.
116 Ibid.
117 Ibid.
118 Ibid.

		end-objective of such research would be to identify and share best practices that support responsiveness across the space industry • Analyse the structure and steps within the selection process • Identify bottlenecks and streamline the selection process	to the capability gaps and applied criteria such assuitability, feasibility and transferability ↓ the analysis was reviewed by a joint capability senior officer review panel ↓ labs assessed performance, cost and schedule for three payload candidates and evaluated which best met the TacSat's suitability, feasibility and transferability criteria ↓ a flag officer committee reviewed these evaluations and made the final payload selection ↓ the flag officer committee provided the final payload selection to the Under Secretary of the Air Force[119]	
	Design Reviews	trust can be identified as a prerequisite for fewer design reviews; more research is necessary to carefully explore trust as a lever of responsiveness	the U.S. ORS concepts aims at taking a new approach to risk and mission assurance to ensure rapid deployment of "good enough" capabilities for the warfighter.	In how far is trust a leaver of responsiveness? What factors influence the degree of trust?
	Acquisition Policies	• define system requirements as accurately as possible before the programme start • carefully balance conflicting urges of changing system requirements after a programme has started with the need for responsiveness • empower programme managers and give them the authority to make the necessary trade-offs between requirements, requirements growth, and maintaining the programme on schedule and within budget	Of its five key functions, the ORS Office also follows an acquisition function which essentially means: • to provide leadership • to integrate ORS acquisition efforts • to develop and delegate expedited acquisition authorities to executing organisations thereby employing a market-based approach • to utilise the broader space community and transfer its authorities to the executing organisations • to account for lifecycle sustainment of ORS capabilities • to accept increased risk tolerance for operational gain, using streamlined processes not waiting for hundred percent solutions • to put an emphasis on integration of off-the-shelf components whenever possible	• How is this conducted in Europe? • Who is involved in requirement definitions and system acquisitions? What are the obstacles? • How to combine civil and military requirements? • What institutional structured/group/team should be foreseen for this task? • Licensing in Europe is based on national space legislation; there is no European competence. How does a European RS have to consider this?

Figure15: Factors influencing the Responsiveness of a System, theoretically identified Actions, the Practical Approach of the U.S., Questions Arising for Europe

[119] United States Government Accountability Office. "DoD Needs a Departmentwide Strategy for Pursuing Low-Cost, Responsive Tactical Space Capabilities."GAO, 2006. 10.

4. What Approach to Responsive Space for Europe?

Based on the above analysis of relevant existing responsive space models in the U.S., this section aims to assess the suitability of the U.S. approach to meet European high-level needs and at the same time to preliminarily propose adapted perimeters and definitions for a European approach to RS. This section also aims to identify underlying issues needing to be addressed by a European Responsive Space initiative (civilian and defence sectors, at national and international / European level). It mainly identifies research questions, which can be seen as the basic problems that have to be tackled and answered before being able to formulate a European approach to RS.

Recalling the initially proposed approach laid out in the introductory chapter, this chapter will first identify the European definition of "security" and will describe the resulting perceived threats. It will then identify the main motivations driving towards developing responsive space in Europe and will put forward the main objectives of a European RS. Subsequently, more concrete questions related to the timeframe, the institutional architecture needed, legal, organisational and managerial challenges, technical challenges as well as data policy challenges will be depicted. A final section will revolve around the question of transatlantic and international cooperation.

4.1. The European Concept of Security

The development of an approach to responsive space will be based on the objective and motivations for the specific type of security that it is intended to achieve. While numerous countries' space policies are driven by security concerns it has taken Europe a long time to consider this impetus. Thus Europe's approach to space and its resulting space policy are fundamentally different from the U.S. in that space applications are not primarily perceived as being for military or defence purposes. Europe (as a whole) has been following almost exclusively civilian objectives for a long time. While the U.S. ORS concept comes from the defence community, Europe's will not be coming solely from the defence sector but also from the civilian / emergency management community thus meeting both external and internal security needs. Europe's Responsive Space will consider both civil and military requirements.[120]

The EU consists of twenty-seven nations. The only workable political direction for twenty-seven nations is to utilise a broad and generic security concept rather than a more classical military one. Thus, Europe's collective steps are based on a broad definition of security and the development of dual-use programmes and applications. Europe has moved away from the classical security

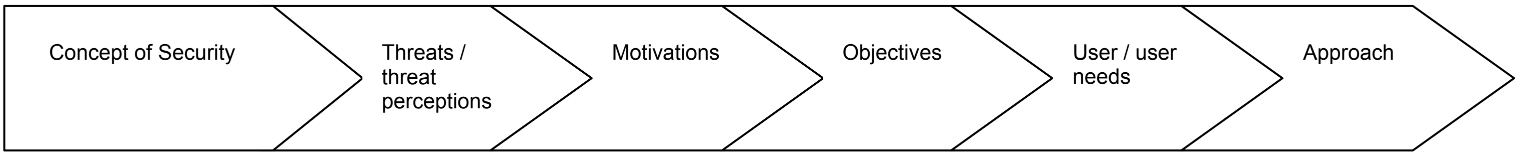


Figure 16: Approaching Responsive Space

[120] For an overview of Europe's security dimension refer to Peter, Nicolas. "European Space Activities in the Global Context – The Security Dimension." Yearbook on Space Policy 2007/2008. Eds. Kai-Uwe Schrogl, Charlotte Mathieu, and Nicolas Peter. Vienna: SpringerWienNewYork, 2008. 46-63.

perception that identified actor-focused threats to terroritory towards "functional security" in which the new threats are mainly structural threats that are not "actor/agency"-focused. Large-scale military aggression against territory has become unlikely, while new threats such as terrorism, illegal migration and organised crime have become the main sources of anxiety for both citizens and policy-makers.[121] Given the interconnectivity of European countries and the transnational character of the threats the world is currently facing, EU involvement is becoming inevitable. Europe will need to find a way to protect its civilian and dual-use space programme without relying heavily on military options that have never been attractive to its Member States and that have been deliberately precluded at the community level.[122]

4.2. Motivations for a European RS Concept

Apart from the changing security environment in the post Cold-War era, one can identify both political and technical driving forces that call for the development of a European approach to responsive space. The political context has already been laid out in chapter 1 (cf. 1.2), some samples from the field will further provide insights into the evolving needs, which point towards developing an approach to RS in Europe. They also provideexamples of the kind of needs and user requirements in Europe that RS will need to answer.

4.2.1. Space-Based Support for an EU Military Crisis Management Operation (EUFOR Chad / RCA)

Geographical considerations were a major determining factor in the kind of support that space applications could provide for the EU Military Crisis Management Operations "EUFOR Chad / RCA".. The mission was characterised primarily by the lack of supporting infrastructure in the host country and the particularly large area of operation. Additionally, there was only very limited time available for planning and set-up of the mission, with the mission starting three weeks after the official Council decision. Due to the great distances between the Operations Headquarters (OHQ) and field deployments, the mission totally depended on SatCom. However, the set-up of secure communications with high bandwidth proved to be timely and costly. Security could often not be guaranteed due to reliance on commercial satellites and the risk of interception by adversaries.[123]

Satellite Imagery was used for mapping in support of the mission. France contributed the SPOT-5 satellite pictures for geographic reference and enabled specific products such as traffic mapping, while the EUSC developed geospatial contingency support packages. In this imagery intelligence, the timeliness of service delivery is crucial as it might be the only possibility to validate information and situations provided by other sources. While the EUSC Imagery Analyst (IA) was able to deliver his analysis based on fast acquisition of Earth Observation data, the delivery often took days as no secure SatCom could be established.

4.2.2. Experiences from the RELEX Crisis Platform of the European Union Commission

The experiences of the RELEX Crisis Platform of the European Union Commission[124] can also give insights into how to approach responsive space and what elements or services a European approach to Responsive Space needs to cover. During and in the aftermath of a crisis, decision makers need satellite imagery in order to be able to assess the impact of the crisis. Impact assessment, however, can only be conducted if satellite imagery of the same spot but prior to the crisis is available. On the basis of this, change detection can be conducted and conclusions can be drawn on the impact of the crisis.[125]

Consequently, a geospatial data-base has to be established prior to the crisis. In order to do so, areas for regular monitoring by the EC's JRC have to be chosen. Such prioritised areas are usually areas where a crisis is

[121] Group of Personalities in the field of Security Research. "Research for a Secure Europe: Report of the Group of Personalities in the field of Security Research." Luxembourg: Group of Personalities, 2004. 9.
[122] Pasco, Xavier. op. cit. 12.

[123] Öller, Gustav. "European External Operations and Reliance on Space: A Case Study." Presentation. EC-ESA-EDA Workshop on Space for Security and Defence. Brussels, Belgium. 16 Sept. 2009.
[124] This case study is based on Cseko, Arpad. "EU Civilian Crisis Management: Today's Needs, Tomorrow's Challenges." Presentation. Presentation. EC-ESA-EDA Workshop on Space for Security and Defence. Brussels, Belgium. 16 Sept. 2009.
[125] Remuss, Nina-Louisa. "Space and Internal Security – Developing a Concept for Europe." ESPI Report 20. Vienna: European Space Policy Institute, 2009. <http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2020_final.pdf>. 15-28.

expected to happen. A timeframe for monitoring has to be assigned. Crisis-prone areas are monitored in shorter intervals than other areas. In order to prioritise areas to be monitored, early warning indicators such as intelligence are used.

Thus making satellite imagery acquisition and analyses more responsive is only one aspect. For accurate damage and impact assessment, regular monitoring and the establishment of a satellite imagery database in order to guarantee the continuous availability of satellite imagery is of equal necessity. It can be seen that responsive space does not consist solely of providing new hardware in space.

4.3. Objectives for a European RS Concept

Based on these case studies, the objectives of a European approach to Responsive Space become clear: It should introduce more robust and more affordable space applications, which would give the EU the tools to address security risks induced by climate change, humanitarian crises, natural and industrial disasters, terrorism, regional conflicts, organised crime and state failure.[126] Thus in contrast to the U.S. ORS that deals solely with the warfighters requirements, Europe's RS will need to develop a system to take into account both civil and military requirements. The table below summarises the European security concept and the main threats perceived in order to give insights into the motivations, objectives and requirements for a European RS.

[126] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. op. cit.

Concept of security	Threats/ threat perception	Motivations	Objectives	User/user needs
broad concept of "security" covering a wide range of actions ranging from disaster management and humanitarian assistance to peacekeeping operations, international treaties monitoring, border security, critical infrastructure protection and transport security	both civilian and military threats such as: floods, storms (land, coastal areas), tsunamis, earthquakes landslides, volcanic activity, drought, vegetation fires, accidents associated with transport, industrial activities, crisis anticipation, terrorism, external security threats, illegal border activities, threats related to maritime security, piracy, drug trafficking etc.	• the European Security Strategy (ESS) of 2003 highlighting the constantly evolving threats characterising them as diverse, less visible and less predictable. • increasing research in both civil and military security as part of the EU's Framework Programme for Research and Technological Development (FP) and more specific attempts like the Security Panel of Experts (SPASEC) and its subsequent SPASEC-Report, the Group of Personalities (GoP) for Security Research, the European Security Research Advisory Board (ESRAB) and the European Security and Research Innovation Forum (ESRIF) • security and space: increasing research into how to provide security through the use of space assets	• more robust space assets • more affordable space assets • space assets that answer both civil and military user needs in a comprehensive and integrated manner	• needs of the civil security community • needs of the military community

Figure 17: Summarising Table on the European Security Concept, Threat Perceptions, Motivations, Objectives and Requirements

4.4. Elements for a Roadmap for Europe

Based on the above-mentioned conceptual considerations and the U.S. ORS experience, elements of a roadmap for RS in Europe have been identified in this study. Basic problems that have to be tackled and answered before being able to formulate a European approach to RS are highlighted.

In the U.S., Congress had asked DoD to submit a report clarifying many elements for the establishment of ORS. [127] For Europe these translate to the following basic questions, which have been grouped into categories:

Governance, institutional and architectural questions:

- How should the institutional set-up look like in Europe?
- Who should coordinate /steer RS in Europe? Who should be responsible for it?
- What would be the chain of command and the reporting structure?
- What should acquisition policies and procedures look like?
- What would be the different roles and missions of existing space-related institutions?
- What would be the role of other institutional actors such as the ESDA/ assembly of the WEU?
- What would be the relationship with other security-related international organisations such as NATO and the OSCE?

Funding and Personnel:

- How should it be funded?
- What funding and personnel are required?

Data Policy:

- How should information requirements be classified? (e.g. data policies?)

Timeframe:

- What schedule should be adopted for the implementation of RS?

International Cooperation / the Transatlantic dimension:

- How to cooperate with the U.S. and other space-faring countries working towards developing responsive space (China etc.)?

The current degree of readiness of European industry to get involved in RS is hard to assess. European industry has been involved in many demonstrations as part of the FP projects. Their feedback shows that from a technological standpoint they are ready to provide many of the technological requirements as requested and are even sometimes far ahead of the outcomes of EU research projects. What has been lacking so far is the political will to encourage the industry to take the necessary future steps towards more integrated, flexible and affordable space applications for Europe.

1. The first step towards creating RS is to conduct a thorough assessment of current space assets both at the European and national levels. Such a status report should detail existing capabilities as well as provide for a thorough gap analysis. The Joint Research Centre has already conducted some first studies in the context of space applications for maritime security - as part of the FP 5 DECLIMS project it conducted benchmarking activities and as part of the Commission's call for an integrated maritime policy it evaluated the existing maritime surveillance systems at national level and compiled a comprehensive report in a document entitled "Integrated Maritime Policy for the EU: Working Document III - On Maritime Surveillance Systems". The status report should contain a gap analysis that essentially answers the following questions: Who are the users? What do users need? What do we have? In particular, how would TIES, MUSIS, Galileo and GMES contribute to RS? What is missing? The gap analysis could draw on FP and national research. The resulting needs matrix should be subdivided into short, mid and long-term requirements in line with the three-tiered approach.

   This would provide for comprehensive understanding of the available Tier-1 capabilities. In addition to existing hardware, i.e. satellites, an analysis of existing services should be conducted. These would also form part of the Tier-1 capabilities. Additionally, the gap analysis would provide first user requirements for both Tier-2 and Tier-3 of a European RS concept. The industry as well as

[127] Department of Defense. op. cit.

operators should also be involved in this analysis. This is in line with Priority 3 "civilian and military 'force-generation' goals must be met" of the EU ISS suggestions for European priorities for defence in 2020. The stated need for the EU to develop adequate capabilities for civilian and military missions simultaneously while relying on existing national assets fits perfectly with the RS concept. A status report and gap analysis will help to identify these existing national assets with an eye to increased sharing, and the three-tier approach will aim at answering arising user requirements of both a civil and a military nature. Increased sharing will, in the long run, reduce costs for space capabilities.

2. In addition to a status report of existing space capabilities, lessons learned and demonstration results of research and development projects at both European and national level should be taken as building blocks for Tier-2 and Tier-3 developments.

3. By compiling both of these, the stakeholders involved could be identified. These should be included in the development process of a European Responsive Space right from the start so as to agree on the definition of RS.

4. Once users have been identified, a requirements matrix should be established. This matrix is used to identify a way to feed the different user requirements into the RS architecture and development process.

5. Moreover, there is a need to develop the political will to use the capabilities that are available. Outreach activities showing users what is possible and presenting the case in all possible forums can help foster the necessary political will.

6. In the future, military requirements could be compiled by the European Defence Agency (EDA) and civilian ones by the European Commission (EC) supported by the Council. A similar division of labour has already been established for the formulation of user requirements for Space Situational Awareness (SSA).

7. Engagement and dialogue with users should be increased. The establishment of a user-exchange mechanism would be a step in this direction.[128] Europe also needs to conduct more outreach activities, broadening the existing user community. This would also increase support for space applications, which in turn might result in easier funding discussions.

8. Access to systems in the event of a crisis is of utmost importance. In this context ownership is crucial. However one can also guarantee that systems remain on the European side through using multinational missions or signing treaties and agreements covering these cases.

9. U.S. experience has shown that it is particularly important to establish an understanding of Responsive Space with all these stakeholders. In the U.S., this is done by the ORS Office. With ESA being a technology development agency and the European Commission being limited to engaging in space matters only upon Member States consent ("shared competence"), it seems difficult to embody an existing actor with this task. Thus, the proposed agency would take up this task. Achieving a common understanding and definition of RS Europe-wide should be a priority.

10. Responsive Space is expected to create a whole new paradigm in the space field, and it requires specific technologies and new development and implementation approaches from a developer's perspective. As many new enabling technologies need to be investigated, a system for long-term R&D efforts to foresee future requirements need to be found. Both academia and think tanks can be involved in this effort. Industry and satellite operators should provide their input too. RS will require an adaptation of operations in the field, the decision-making process and of activation or allocation procedures. This should go hand-in-hand with an adaptation of the industry value chain.

4.4.1. Institutional and Architectural Questions

Given that any European approach to RS will need to consider both civil and military user needs, an institutional architecture supporting European RS will have to look different to the one the U.S. has chosen.

[128] Matthieu,Charlotte."Space-based Services in Europe – Addressing the Transition between Demonstration and Operation." ESPI Report 17. Vienna: European Space Policy Institute, 2009. <http://www.espi.or.at/images/stories/dokumente/studies/espi%20report%2017_corr.pdf>. 6. ; Remuss, Nina-Louisa. op. cit. 9-10; 131-4.

Also, any European institutional structure needs to take into account both the EU and national levels and needs to foresee a role for current space-related institutions.

Looking at the example of the U.S., European institutions have to be assigned or founded to perform the following tasks:

Governance, coordination and conceptual tasks:

- setting the RS vision, defining the requirements and developing the enablers,
- steering and coordination of RS in Europe,
- integration of the user in the general RS process.

Technology-development related tasks:

- dealing with rapid acquisition, small launch capabilities, satellite C2 System developments and satellite operations,
- technology development in general,
- systems engineering, launch facilities and support,
- payload and bus development, contributing to the general technology development related to ORS,
- the integration of small satellites expertise as well as expertise in assembly, integration and test initiatives.

Commercial satellite operators should provide support services, deal with hardware and software, introduce new methods and contribute to technology development. RS should also draw on its international partners for their experience in small satellites and in the context of technology development.
To empower one institutional actor with the steering of the RS seems to be necessary in order to ensure oversight and comprehensiveness, avoid duplication of efforts and guarantee that all stakeholders share the same understanding of RS. Currently, in Europe there does not seem to be an existing institutional actor suited for this purpose. Hence, one element of a European RS could be to establish a dedicated institutional actor for this purpose. An EU Agency (it might be called STeering Agency for Responsive Space - STARS) would be very suited to take up the task of steering and coordinating RS in Europe.

Proposing the Founding of an EU dedicated RS Agency

In the past "a number of specialised and decentralised EU agencies have been established to support the EU Member States and their citizens."[129] Generally speaking, agencies are founded to "cope with new tasks of a legal, *technical and/or scientific nature*" [emphasis added]. "A Community agency is a body governed by European public law; it is distinct from the Community Institutions (Council, Parliament, Commission, etc.) and has its own legal personality. It is set up by an act of secondary legislation in order to accomplish a very specific technical, scientific or managerial task in the framework of the European Union's "first pillar"". With the pillar structures being dissolved, community agencies will continue to function as laid down in the regulation establishing them and the accompanying policy documents.

Agencies are to be established through a Regulation by the Council. The Lisbon Treaty establishes space as a "shared competence":

> In the areas of research, technological development and space, the Union shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs. [emphasis added][130]

However, the Union's competencies in space are limited by Member States consent. Thus, the most realistic way to establish an Agency for RS seems to be through the Space Council under the EU-ESA Framework Agreement. Alternatively, it could be established as part of the Union's security policy.

Organisational Structure

While all existing agencies are very different in terms of both size and purpose, they have a common basic structure and similar ways of operating. Thus, agencies function under the authority of an administrative / management board which lays down the general guidelines and adopts the work programmes of the particular agency, according to its basic mission, available resources and political priorities. This administrative / management board, or the Council of Ministers, nominates the executive director. The executive director

[129] "Agencies of the EU." EUROPA – Gateway to the European Union. 13 Dec. 2009 <http://europa.eu/agencies /index_en.htm>.
[130] Art.4 (3) TFEU

is responsible for all activities of the agency and the proper implementation of its work programmes. Agencies normally rely on one or more network(s) of partners located throughout the territory of the Union. Thus the proposed Agency for RS could rely on ESA and EUSC as partners.

Agencies also have certain common organisational characteristics: as was stated above, they all have an Administrative or Management Board, an Executive Director and one or more Technical or Scientific Committees.

The Administrative or Management Board's composition is laid down by the Regulation founding the agency and usually includes representatives from the Member States, one or several Commission representatives, and may include appointed members by the European Parliament. Non-member countries may also take part in certain cases but are not entitled to vote.

The Executive Director is the agency's legal representative. The Regulation founding the Agency sets out the distribution of powers between the Executive Director and the Administrative or Management Board. Further details are contained in the rules of procedure.
The Technical or Scientific Committee(s) are made up of experts specialising in the relevant field and assist the board and the executive director by drafting opinions. In the case of the proposed EU Agency steering RS, such a committee should be composed of experts from the Commission, ESA, EDA and EUSC, but might also, on a case by case basis for ad-hoc committees, include staff from specialised agencies (such as EMSA) depending on the requirements in question.

Most of the agencies are financed from a Community subsidy set aside for the purpose in the general budget of the European Union but may also be partially or entirely self-financed through contributions from their clients.[131]

The Proposed RS Agency Working Structure

Reconsidering the U.S. example of the three tiers and the resulting process from needs to approaches to capabilities, European requirements should be identified and prioritised by EDA and the EU Commission. EDA in consultation with the Member States shall be responsible for identifying and prioritising military requirements. This is in line with EDA's tasks as laid down in the Lisbon Treaty:

> The Agency in the field of defence capabilities development, research, acquisition and armaments (hereinafter referred to as 'the European Defence Agency') shall identify operational requirements, shall promote measures to satisfy those requirements, shall contribute to identifying and, where appropriate, implementing any measure needed to strengthen the industrial and technological base of the defence sector, shall participate in defining a European capabilities and armaments policy, and shall assist the Council in evaluating the improvement of military capabilities.[132]

Furthermore the Lisbon Treaty elaborates on Art. 42 para. 3 and says that EDA's tasks are to:

> (a) contribute to identifying the Member States' military capability objectives and evaluating observance of the capability commitments given by the Member States;
> (b) promote harmonisation of operational needs and adoption of effective, compatible procurement methods;
> (c) propose multilateral projects to fulfil the objectives in terms of military capabilities, ensure coordination of the programmes implemented by the Member States and management of specific cooperation programmes;
> (d) support defence technology research, and coordinate and plan joint research activities and the study of technical solutions meeting future operational needs;
> (e) contribute to identifying and, if necessary, implementing any useful measure for strengthening the industrial and technological base of the defence sector and for improving the effectiveness of military expenditure.[133]

Given that EDA is open "to all Member States wishing to be part of it"[134], in order for RS to be comprehensive, EDA should encourage

[131] This section is largely based on the explanatory notice referred to in "Agencies of the European Union – How do they function?" EUROPA – Gateway to the European Union. 13 Dec. 2009 <http://europa.eu/agencies/ community_agencies/function/index_en.htm>.

[132] Section 2 Provisions on the Common Security and Defence Policy, Art. 42(3). Consolidated Version of the TEU.<http://eur-lex.europa.eu/LexUriServ/ LexUriServ.do?uri=OJ:C:2008:115:0013:0045:EN:PDF>.
[133] Ibid. Art. 45
[134] Ibid.

Member States to participate. In this context EDA should closely review also the lessons learned from EU external relations military missions.

The EU Commission should identify and prioritise the civilian requirements thereby giving particular consideration to the results of the demonstrations of framework programmes. It will be necessary for the Commission to closely cooperate also with industry and satellite operators involved in the FP projects. The Lisbon Treaty further elaborates that "[t]he Agency shall carry out its tasks in liaison with the Commission where necessary."[135] In line with this, EDA and EC have to work closely together in this process as military and civilian requirements are increasingly coinciding and any competition or duplication should be avoided.

A Proposal for an RS Requirements and Solutions Generation Process in Europe

Users provide their needs to EDA or the EC, which validate these needs. According to the Lisbon Treaty, EDA can set up "[s]pecific groups (...) within the Agency bringing together Member States engaged in joint projects."[136] Thus, setting up a group on RS is in line with existing EU legislation and should thus not be too difficult to achieve.

Personnel of both EDA and EC should each form a Capability Review Team with the objective of reviewing these needs and converting them into a set of detailed requirements, which are then compiled into a Capabilities Requirements Document. The user who submitted the need reviews this document. The resulting requirements are then reviewed by a team from the Scientific or Technology Committee of the proposed Agency for RS. This Solutions Development Team aims at developing potential solutions. Potential solutions are then reviewed by the Council. Users have the opportunity to give some input to the final development. After being reviewed, solutions need to be approved by the Executive Agent of the proposed Agency for RS, which submits them to a newly founded RS Agency under the supervision of the Administrative or Management Board, which is responsible for the execution of the solutions. The user again provides input during the execution process. This process is depicted in the figure below.

[135] Ibid.
[136] Ibid. Art.45(2).

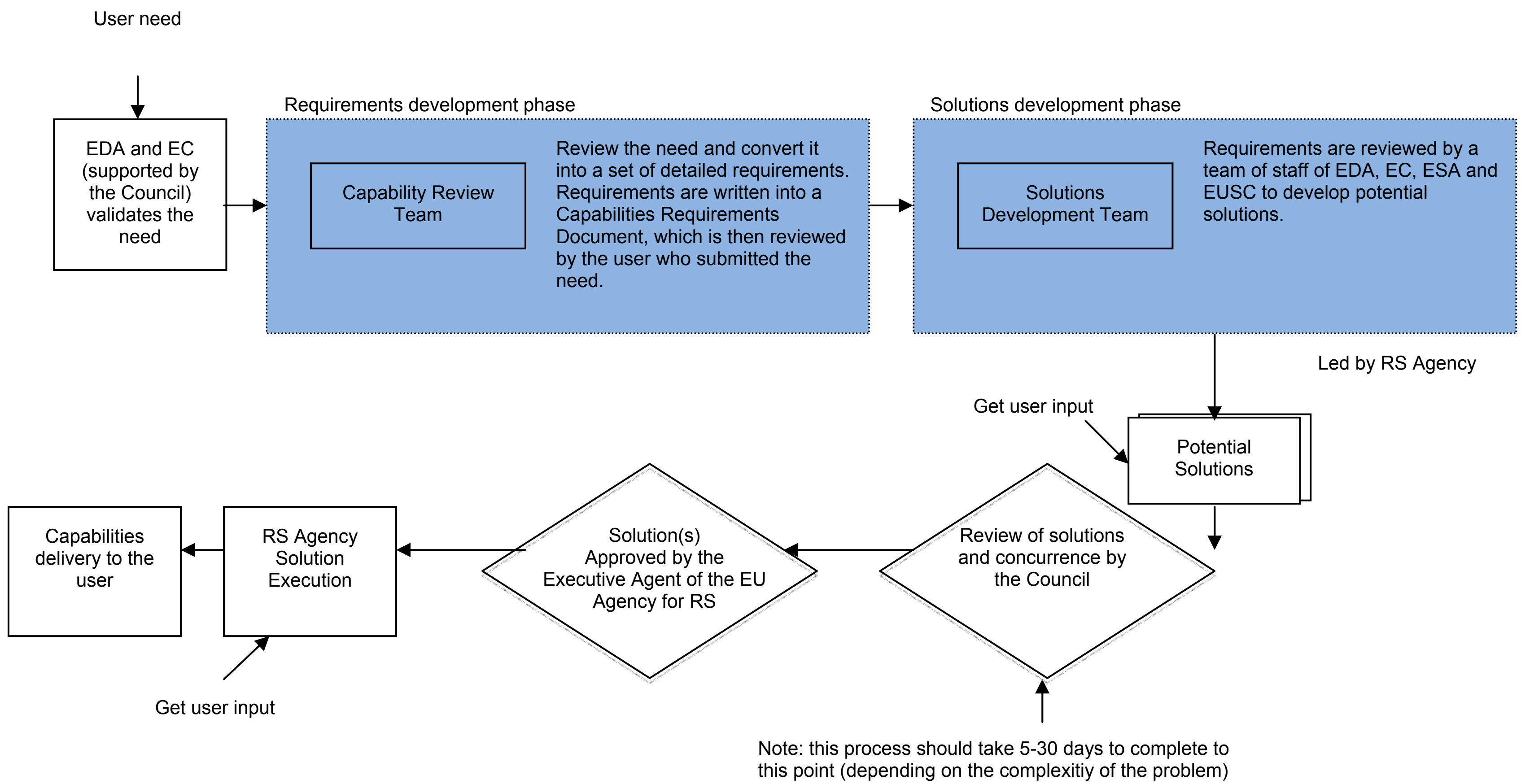


Figure 18: The Proposed European RS Requirements and Solutions Generation Process

The identified and prioritised needs shall then be submitted to a newly founded European RS Agency. This agency shall form part of the EU institutional architecture. The proposed RS structure is depicted in figure 19 below.

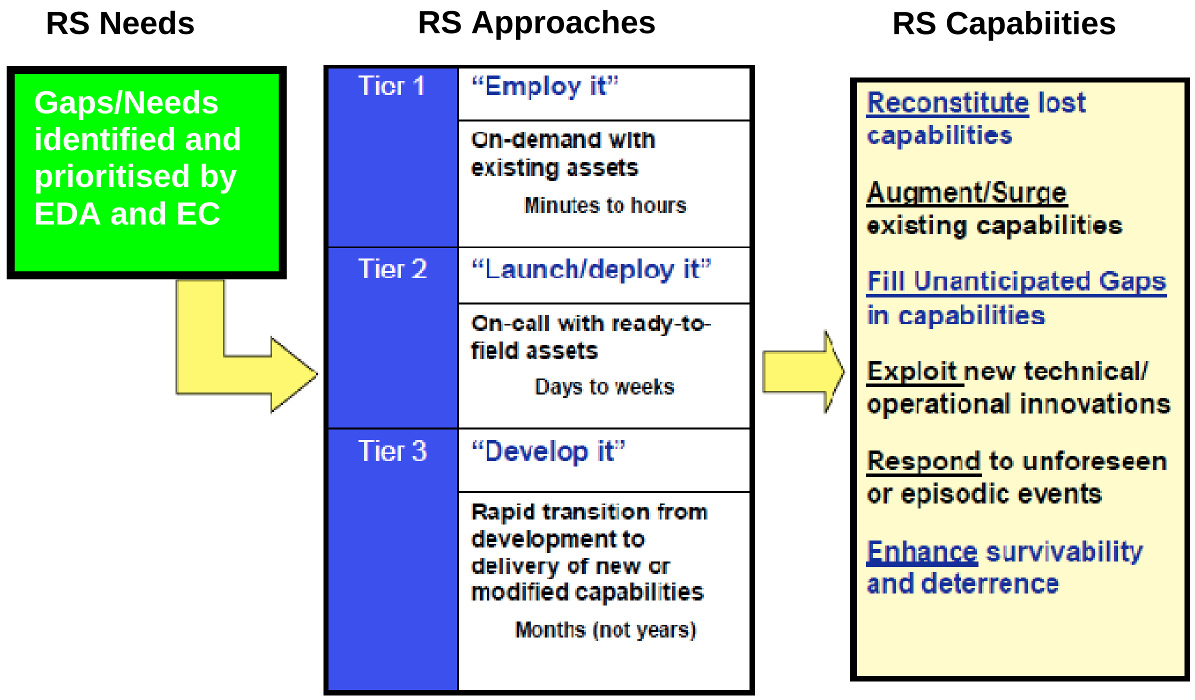


Figure 19: Proposed RS Working Structure[137]

Tier-1: On demand with existing assets

As was explained above, Tier-1 is about using existing infrastructure for delivery immediately or within a few days. In order to do so a detailed study on existing assets and their capabilities both at European and national level is required. Such a study should go beyond listing merely satellites and include existing services as well. It should also research what are the EO, SatCom and SatNav obstacles to responsiveness. GIANUS takes a first step in this direction as the initiative will build on what already exists or is under development at national and European level, in coordination with other relevant European organisations and Member States.

As has been shown in the above-elaborated case study, there is an urgent need for the establishment of an EO database. As a basis for this, pre-crisis data collection and regular monitoring of crisis-prone areas has to be conducted. It is important to build up reference geospatial databases for regions in crisis that, as pre-crisis data, will provide support for damage assessment. Without accurate datasets the damage assessment cannot be carried out efficiently or will take longer to provide.[138] Such an initiative can build on inter alia the JRC Global Crisis Atlas developed for DG RELEX, which collects datasets for "crisis countries".[139] However, countries or regions that are natural-disaster-prone, should be regularly monitored as well. Currently the main challenges are: How to prioritise?, Which regions to monitor?, Which early warning indicators to use? The required accuracy and length and frequency of monitoring periods and the coordination of this effort at EU level in order to optimise resources should be agreed upon.

Europe is also facing the need for independent access to very high resolution satellite imagery for data collection during a crisis situation. The two major Very High Resolution (VHR) satellite imagery providers, DigitalGlobe and Space Imaging, are based in the U.S. and have special commercial agreements with the U.S. and other governments and customers. Thus, their

[137] adapted from McLaughlin, Kevin. op. cit.

[138] This analysis is based on the case study presented above by Csekö, Árpád. EU Civilian Crisis Management: Today's Needs, Tomorrow's Challenges. Presentation. Workshop on Space for Security and Defence. 16 Sep 2009. Brussels, Belgium.
[139] Ibid.

requests take precedence. Furthermore, the U.S. DoD screens all image requests for sensitivity, possibly leading to cancellation or delays in requests. While it is impossible to purchase VHR (< 1m) imagery over certain areas, there may be temporary breaks in the service over other areas (such as Georgia and Lebanon recently). The only solution could be to establish independent European capabilities in the field of VHR satellite imaging. Rapid assessment of damages in twenty-four to forty-eight hours after the occurrence of a conflict or a natural disaster is of great importance, in order to acquire situation awareness and to plan international rescue and relief. Challenges in delivering these assessments rapidly persist due to commercial satellites' orbit limitations, access restrictions and weather conditions. The public as well as decision makers judge the usefulness of EO on the timely delivery time of these rapid assessment products.

Tier-2 and Tier-3

Tier-2 is about deploying new space-based infrastructure - without any major new developments (delivery in a few days to a few weeks). Tier-3 is about developing and deploying new space-based infrastructure (delivery in a few months to a year). Both will gain from a comprehensive study of existing assets, capabilities and services including a gap analysis.

There are many more stakeholders involved in the development process of a new satellite capability than just satellite manufacturers: government agencies (civil and military), satellite operators, end-users, banks and investors, insurance companies and regulatory agencies all participate in the space industry and influence it to varying degrees. Thus any study or plan to establish a European RS has to research the following questions:

- Who are the main stakeholders?
- What does the space industry value-chain look like?
- To what extent does the value-chain differ in the U.S. and Europe? What does this mean for the relative approaches to responsive space?
- What are the different tasks of the stakeholders?
- How much time is needed for each of these steps? How can this be improved?

4.4.2. Legal, Organisational and Managerial Challenges

Understanding space responsiveness requires identifying ways of improving it. Given that not all activities are technical in nature, efforts to improve space responsiveness should not only focus on the architecture and technical characteristics of the "artefacts created by the industry" but should also include the legal, organisational and managerial aspects of "doing business". Thus, any roadmap or plan pursuant to the objective of establishing a European RS should also aim to research the legal, organisational and managerial obstacles to responsiveness in Europe. One example of legal obstacles could be national legislation hindering the sharing of satellite imagery at a European level.

EO Data Sharing Legislation

As has been previously stated data sharing (especially EO satellite imagery) might be one of the obstacles to responsive space. Copyright laws and regulations regarding freedom of information play a role in the way EO data and information are distributed and used. They regulate important issues such as ownership, access and the rights attached to these assets. Differences in regulation among different States may affect cooperation within this field.[140] There are currently three different levels of guidelines for EO: (1) International Guidelines on Earth Observation, (2) EUMETSAT data policy and (3) EU data policy.[141]

At the international level, Resolution 41/65 entitled "Principles Relating to Remote Sensing of the Earth from Outer Space" of 1986 lays down the following:

> As soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms. The sensed State shall also have access to the available analysed information concerning the territory under the jurisdiction in the possession of any

[140] Doldirina, Catherine. "Are Intellectual Property Laws an Impediment to the Development of Collaborative Earth Observation Missions?" IAC-09.B1.1.7. Presentation. 60th International Astronautical Congress. Daejon, Korea. 12-16 Oct. 2009.

[141] This section is to a large degree based on the account in Dunk, Frans G. von der. "European Satellite Earth Observation: Law, Regulations, Policies, Projects, and Programmes." Creighton Law Review 42.3 (2009): 397-445.

> State participating in remote sensing activities on the same basis and terms, taking particularly into account the needs and interest of the developing countries.[142]

Additionally, the Charter on Space and Major Disasters of 1999 established an institutional structure for relevant space agencies and satellite operators thus hoping to ensure that data helpful in disaster mitigation and rehabilitation activities are expedited to the relevant disaster agencies as quickly, efficiently and inexpensively as possible.[143]

Resolution 40 of the World Meteorological Organisation (WMO) of 1995 laid down similar practices for the sharing of meteorological and related data and products. Similarly, EUMETSAT's data policy laid down that national meteorological services of Member States were to receive all Meteosat data for free for their official duty use.

Within the ESA, data policy (for example for ERS) reflects the spirit of Resolution 41/65: data policies were based on the idea that States should have free access to the data on an open and non-discriminatory basis. However, ESA's ownership and full title was used to restrict access to the data wherever and whenever free access to them was not deemed to be reasonable or desirable.

The European Union initially wanted to rely on EUMETSAT or ESA to establish a more comprehensive legal regime. However both institutions were too limited to do so. ESA for example could only implement relevant protection of EO data through individual contracts.

Thus the EU initiated the so-called "Gaudrat Study" in 1993, which researched the best way to establish any protection of remote sensing data under, for example, data bases. The subsequent Directive 96/9 EC[144], the "EU Database Directive", established a right of data base protection, (1) obliging EU Member States to include databases in their national intellectual property right regimes and (2) providing forextraction rights versus re-utilisation rights.

Different Standards and Quality of Satellite Data

Currently the EU has "islands of data" of different standards and quality. The current data situation in Europe often results in the absence of necessary information due to lack of coordination across borders and between levels of government, while a lack of common standards and their use results in incompatible information and information systems, fragmentation of information and redundancy. This situation is worsened by current data policy restrictions such as pricing, copyright, access rights and licensing policy.

With this in mind, in 2001 the European Commission launched an initiative to develop an Infrastructure for Spatial Information in Europe. The INSPIRE initiative aims mainly at developing a legal framework to underpin the creation of a European Spatial Data Infrastructure (ESDI) thereby starting from priorities in the environmental field. Spatial information refers to all geographic information integrated from a variety of disciplines for a number of uses, most notably uses relating to environmental protection and the formulation and implementation of EU policies in that area.[145][146] It should be noted that INSPIRE does not explicitly refer to space-borne data or satellitesas space-borne data and satellites are still considered to be of a special nature, lying outside of the scope of European Community law and relevant EU competences.

Already in 1999, the European Commission published a Green Paper on Public Sector Information in the Information Society. The Commission had been encouraged by inter alia EUROGI to set up a High-Level Working Group to prepare an Action Plan for a European Policy Framework on geographic information. This attempt might be useful in setting EO data and GI data in a wider information context.[147]

While the INSPIRE initiative, which is currently in its transposition phase, aims at solving the standardisation issues, other obstacles to satellite data exchange still persist. In this regard, architecture

142 United Nations General Assembly. Principles Relating to Remote Sensing of the Earth from Outer Space. GA Res. 41/65 of 3 Dec 1986. Principle XII. New York: United Nations.

143 Dunk, Frans G. von der. op. cit 419.

144 European Parliament and Council. Directive on the legal protection of databases. 96/9/EC of 11 March 1996. Brussels: European Union.

145 Doldirina, Christina. "INSPIRE: A Real Step Forward in Building an Interoperable and Unified Spatial Information Infrastructure for Europe?" ESPI Perspectives 20. Vienna. ESPI, 2009. <http://www.espi.or.at/images/stories/dokumente/Perspectives/espi%20perspectives%2020%20doldirina.pdf>.

146 Dunk, Frans G. von der. op. cit.

147 Harris, Ray. "New Technologies and Data Integration." Space Policy 16 (2000). 77-78.

constraints remain and, in particular, information exchange in risk management is not yet resolved.

Possible Resistance from Established Stakeholders

Furthermore, the development and implementation of responsive space requires a real paradigm shift from the traditional approach to space missions (i.e. long development, manufacturing and integration cycles and limited flexibility once launched and the associated services) to more responsive missions and services. This will require adaptation to change and therefore is likely to face resistance from established stakeholders who are focused ontraditional space missions and have large stakes in the status quo. New innovative solutions will require new investments. This is why it is of utmost importance to involve all stakeholders in the development process of RS right from the start. Industrial policy incentives such as contracted studies might be a way to facilitate this paradigm shift.[148]

4.4.3. Questions and Challenges of a Technical Nature

Europe should aim at adopting a comprehensive approach to RS, which ensures the complementarity of traditional ongoing activities and responsive space activities and missions.

One of the primary elements of RS will be to identify promising technologies and solutions. This will particularly mean investigation into technologies and concepts such as:

- learning curve effects
- reduced complexity
- highly reactive/reconfigurable constellations
- formation flights
- agility
- plug-and-play sensors/platform integration
- modularity
- interface standardisation
- rapid launch campaign concepts/ reactive launch
- reactive launch infrastructure
- mini/micro/nano standardised platforms
- the survivability of small satellites against potential threats.[149]

[148] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. op. cit.

[149] Ibid.; West, Jessica (Ed.). Space Security Index 2008. Waterloo: Project Ploughshares, 2008. <http://www.spacesecurity.org/SSI2008.pdf>. 21.

The proposed study on existing capabilities and services will provide a building block in this regard. It will provide a comprehensive status report of technology development. The information identified should be fed into a coordinated European effort bringing together agencies, industry, satellite operators and users.[150]

4.4.4. Questions and Challenges Related to Time

With respect to the development process of new space applications, the industry value chain needs to be further researched and analysed with a view to making it more responsive. The main questions for Europe to look into are:

- What is the full range of activities (technical, legal, organisational and managerial) in the space industry following the issuance of an RFP for a new or modified on-orbit capability?
- How much time does each activity contribute to the total time?
- How do all activities contribute to the overall development and readiness of the system?
- What determines the duration of each activity?
- What is the degree of overlap between these activities?
- Where are the bottlenecks?
- What are the reasons for the bottlenecks and how can they be eliminated?
- Who are the main stakeholders in this schedule structure?
- How far does each stakeholder influence or hinder responsiveness?
- How can bottlenecks related to specific players be eliminated?[151]

Having looked into these questions, the main actions for Europe to take in order to make the industry value chain more responsive are:

- eliminating bottlenecks in the value-chain
- minimising waiting periods
- maximising overlap to the degree possible between different streams of activities at different suppliers
- compressing the “response time” of each single supplier
- reducing or compressing delivery time for single action

[150] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. op. cit.

[151] Saleh, Joseph H. and Gregory F. Dubos. op. cit.

- improving the efficiency where necessary in the interaction between customer and supplier
- reducing the complexity of a system leads to the involvement of fewer stakeholders, thus easing management of them.

As has been previously indicated, the responsiveness of a system is dependant on the design choices and architecture of the system which in turn depends on: (1) its complexity, the steepness of the learning curve involved and the use of standardised interfaces; (2) the availability of launch vehicles and launch ranges; and (3) particular soft levers of responsiveness such as the selection process, design reviews and acquisition policies.

In order to improve overall responsiveness in Europe, each of these levers need to be looked at separately, the main obstacles need to be identified and strategies formulated on how to improve each of them. In this context further research into the following questions has to be conducted:

- What is the average time for the selection process in Europe? What is being done in the U.S. to reduce the time for the selection process? What is the structure and the various steps in the selection process? What are the bottlenecks and how can the whole process be streamlined in order to improve space responsiveness?

Recalling the theoretical assumptions, Europe has to conduct the following actions:

- decrease a system's complexity, through:
    - reduced numbers of subsystems and/or payload instruments,
    - reduced numbers of different kinds of subsystems,
    - reduced numbers of interfaces and connections between subsystems to the lowest level possible,
    - the use of identical units and repetitive tasks in the development process in order to make use of learning curve effects,
    - eliminating certain tasks during the design and development of modules for subsequent systems as this will shorten the system development schedule and improve responsiveness,
    - the use of given module design which enables taking full advantage of the learning effects associated with the repetitive use of a module design.
- improve launch responsiveness, through:
    - moving away from the Build-To-Order to the Build-To-Inventory concept for launch vehicles,
    - improving the existing launch range,
    - identifying restrictions on launch ranges,
    - researching how these restrictions can be eliminated.
- the selection process can be improved through:
    - academic research to benchmark the selection process of competing proposals for on-orbit capabilities in a military acquisition context, in a government civilian context and in a commercial context,
    - academic analysis of the selection processes for different programmes and within several agencies, in order to identify and share best practices that support responsiveness across the space industry,
    - analysis of the structure and steps within the selection process,
    - an identification of the bottlenecks and in turn streamlining of the selection process.
- Design Reviews can be made more responsive, through:
    - trust, which can be identified as a prerequisite for fewer design reviews; more research is necessary to carefully explore trust as a lever of responsiveness.
- Acquisition policies can be made more responsive, through:
    - Definition of system requirements as accurate as possible before the programme start
    - careful balancing of conflicting urges to change system requirements after a programme has started with the need for responsiveness
    - empowering programme managers and giving them the authority to make the necessary trade-offs between requirements, requirements growth, and maintaining the programme on schedule and within budget.

Also, Europe might want to look at how the U.S. is tackling these questions. It seems thatt the U.S. currently still needs to work on a greater involvement of the industry in the whole ORS effort. Additionally, U.S. and European industry value chains can differ in terms of obstacles to responsiveness. Thus researching the U.S. might not bring too many answers.

With responsiveness being not only about new space capabilities but also being about improving the responsiveness of existing on-orbit capabilities, the related modification process as well as the actors involved has to be identified. Similar questions to the ones above will then need to be answered.

4.4.5. Questions and Challenges Related to Costs

Responsive Space essentially follows two objectives: making space assets more reactive and flexible, and making them more affordable. Concerning the latter, Europe needs to explore the following questions:

- What are the elements of the total-life-cycle cost (TCO)?
- How much does each element contribute to the TCO?
- What determines the cost of each element?
- Where are the problems that raise costs and how can they be eliminated?

4.4.6. Questions and Challenges related to a Security Data Policy

The reuse of existing and available national assets in a European context requires the establishment of an appropriate security data policy.[152] Additionally, user requirements have to be protected as those might show vulnerabilities, which can be exploited by intruders. At present the Council is preparing a recommendation paper on data policy for GMES services that might provide for a precedent for RS. The question of data policy will be particularly complex given the system-of-system approach and the variety of user communities involved. As has been shown above, for some time already Europe has been trying to ease the sharing of data for satellite services while at the same time protecting them. RS can bring a new impetus to this debate. Potentially, one can draw on several international treaties such as: the Berne Convention on the Protection of Literary and Artistic Works of 1886; the World Intellectual Property Organisation Copyright Treaty of 1996 complementing the Berne Convention that specifically addresses issues coming about with the digitisation of works as well as with internet technologies; and the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement / World Trade Organisation Agreement[153], which regulates the use of intellectual property rights so as not to be a trade barrier.[154]

4.4.7. A Timeframe

As has been explained earlier, GIANUS foresees a responsive element. However, RS in Europe could also be developed as a separate programme. Responsive Space shouldbe developed in three phases: the preparatory phase, the technology readiness phase and the technology development phase.

Should RS in Europe be developed as part of GIANUS, the timeframe would look as follows: The preparatory phase (2009-2011) consists in the preparation of the GIANUS programme proposal to be submitted to the ESA Council at Ministerial level in 2011 in order to identify users requirements and the capability gaps. During the technology readiness phase (2011-2014), the required technology research will be executed. The development phase will run from 2014 onwards.

During the preparatory phase the so-called GIANUS User Representative Group (GURG) will collect user needs, conduct a gap analysis and define the architecture and services. It will be supported by the ESA's Concurrent Design Facility (CDF) as well as the industry. Only the second phase will deal with issues related to governance, data policy, architecture studies and building initial capacity based on existing assets. As part of the ESA initiative, technologies and solutions will be identified in the first, preparatory phase and, upon approval by ESA Member States, will be investigated during the second phase of technology development.

[152] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. op. cit.

[153] The full text of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement can be accessed here: <http://www.wto.org/english/tratop_e/trips_e/t_agm0_e.htm>.

[154] A detailed discussion and analysis of the related issues can be found in Aranzamendi-Sánchez, Matxalen. Report 23. Vienna: European Space Policy Institute, 2010. (forthcoming)

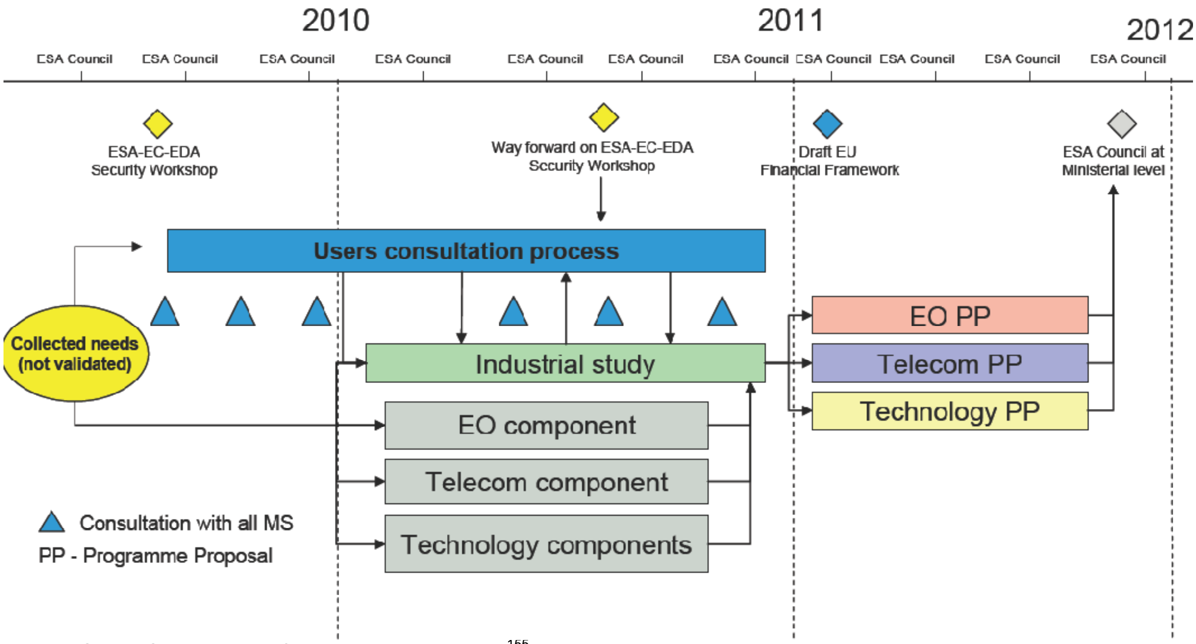


Figure 20: GIANUS' Roadmap of the Preparatory Phase[155]

4.4.8. The Transatlantic Dimension

Some literature[156] suggests distinguishing between short-term, mid-term and long-term responsiveness. The objectives of responsiveness seem to be based on perceived threats. Given that threat perception differs in the U.S. and Europe, the objectives of both Europe and the U.S. differ as well. These provide the basis for a European approach to responsive space. While Europe's objectives for Responsive Space have been previously discussed, the figure below will further differentiate these into short-, mid- and long-term and will present them in a comparative manner together with the U.S. objectives.

Considering short, mid and long-term threat perceptions of the U.S. and Europe in a comparative manner, both face the same threats and thus have the same objectives. Yet, a European RS (in contrast to the U.S. ORS) is evolving out of a broad security concept, highlighting civilian considerations (with the ESP being currently still predominantly driven by civilian considerations). With Europe's human security doctrine requiring that itundertakes the full range of military operations in the future (compare the EU ISS Priority 2), Europe as an actor will change in the future, meaning that the threats it will face might be the same ones the U.S. is facing already today. The RS that might be established now, should therefore not lag behind in the military capabilities dimension.

[155] Del Monte, Luca, Charlotte Mathieu and Erwin Duhamel. op. cit.
[156] Worden, Simon P. and Randall R. Correll. op. cit.

	The U.S.			Europe		
	Short-term responsiveness	**Mid-term responsiveness**	**Long-term responsiveness**	**Short-term responsiveness**	**Mid-term responsiveness**	**Long-term responsiveness**
Threats/ Motivations in short, mid and long-term	• To deter aggression, the U.S. must be able to respond to military movements in hours or days, instead of months, and to respond in a credible, non-nuclear manner • To deter or fight a war the U.S. needs the means to strike decisively and credibly in hours to days without forward bases	• negative world opinion being translated into enormous economic pressure • lack of access to vital utilities such as the internet or GPS could bring an economy to its knees in few weeks	• emergence of a nation or alliance hostile to U.S. national security interests • peer competition: an adversary with roughly comparable military power at least within its own region • the rise of virulent States armed with WMD and nuclear weapons • cyber threats • non-State actors taking advantage of the globally interlinked economy and society to attack the foundations of established polities • increased threats to space infrastructure and ground facilities	• To deter aggression, Europe must be able to respond to military movements in hours or days, instead of months, and to respond in a credible, non-nuclear manner • To deter or fight a war Europe needs the means to strike decisively and credibly in hours to days without forward bases • humanitarian crises, • natural disasters: floods, storms, tsunamis, earthquakes, landslides, volcanic activity, vegetation fires • industrial disasters • terrorism • regional conflicts • organised crime • State failure • Piracy	• negative world opinion being translated into enormous economic pressure • lack of access to vital utilities as internet or GPS could bring an economy to its knees in few weeks • climate change	• emergence of a nation or alliance hostile to Europe. national security interests • peer competition: an adversary with roughly comparable military power at least within its own region • the rise of virulent States armed with WMD and nuclear weapons • cyber threats • non-State actors taking advantage of the globally interlinked economy and society to attack the foundations of established polities • increased threats to space infrastructure and ground facilities

Objectives	• during a crisis: to greatly augment the ability to find, fix and track the forces of potential adversaries • a temporary capability based on reusable systems could be tailored for a particular crisis and region	• the ability to escalate in a rapid and measured way with space and information operations could be quite credible • escalation could start with mid-term denial of access to global utilities • even the threat of blocking access to global utilities could convince aggressors to step back from the brink during a crisis • this would require sortie access to space and cyberspace	• embark on a coherent cooperative programme to develop new global utilities, protect existing ones and make use of all such utilities to prevent the rise of the threats outlined above in order to eliminate the circumstances that enable individuals, groups, or nations to use violence to further their objectives • key feature: cooperative international arrangements →a go-it-alone policy encourages others to develop their own capabilities • protection of space as a critical infrastructure	• more robust space assets • more affordable space assets • space assets that answer both civil and military user needs in a comprehensive and integrated manner • during a crisis: to greatly augment the ability to find, fix and track the forces of potential adversaries • a temporary capability based on reusable systems could be tailored for a particular crisis and region	• the ability to escalate in a rapid and measured way with space and information operations could be quite credible • escalation could start with mid-term denial of access to global utilities • even the threat of blocking access to global utilities could convince aggressors to step back from the brink during a crisis • this would require sortie access to space and cyberspace	• embark on a coherent cooperative programme to develop new global utilities, protect existing ones and make use of all such utilities to prevent the rise of the threats outlined above in order to eliminate the circumstances that enable individuals, groups, or nations to use violence to further their objectives • key feature: cooperative international arrangements →a go-it-alone policy encourages others to develop their own capabilities • protection of space as a critical infrastructur

Figure 21: Short-, Mid- and Long-Term Threats and Resulting Objectives for U.S. ORS and European RS[157]

[157] The information on the U.S. contained in this figure is largely based on the related analysis in Worden, Simon P. and Randall R. Correll. op. cit.

That the U.S. and Europe each have different approaches to RS does not hinder them cooperating. Recalling the three-tier architecture (see figure below), there is much room for cooperation. Tier-1 is about rapid exploitation of existing capabilities. Cooperation between Europe and the U.S. could increase the range of existing capabilities. Other potential international partners should also be considered. Tier-3 is about developing new technologies. Both Tier-2 and Tier-3 require the capability for rapid launch. Thus, modular or standardisation of satellite designs and launchers in both Europe and the U.S. would allow for faster launches. Coordination in the technical development would allow both to gain. Additionally, each can learn from the experience of the other in the context of legal, organisational and managerial challenges. Workshops like the ones for cooperation in the context of SSA should be envisaged to agree right from the start on the most effective ways of cooperation.

could negotiate an agreement with the U.S. government to directly provide EU institutions (i.e. EC, EUSC) with VHR imagery in the event of emerging or major crises such as Georgia and Gaza. Such an agreement would notably reduce the usual delays incurred when procuring commercial data through the usual means employed by the EC and EUSC. The rapid assessment of damages in 24-48 hours after the occurrence of a conflict or a natural disaster is very important in order to acquire situation awareness and to plan international rescue and relief operations.[159]

4.5. Final Considerations

For the final considerations, we can again take the EU ISS's vision for a European security strategy as a guiding theme. In line with the EU ISS Priority 1 ("the EU should continue to do what it already does and should concentrate on doing it better"), RS should not be perceived as a push model but rather be understood as providing the tools for Europe to "do better" or at least to do it "appropriately".

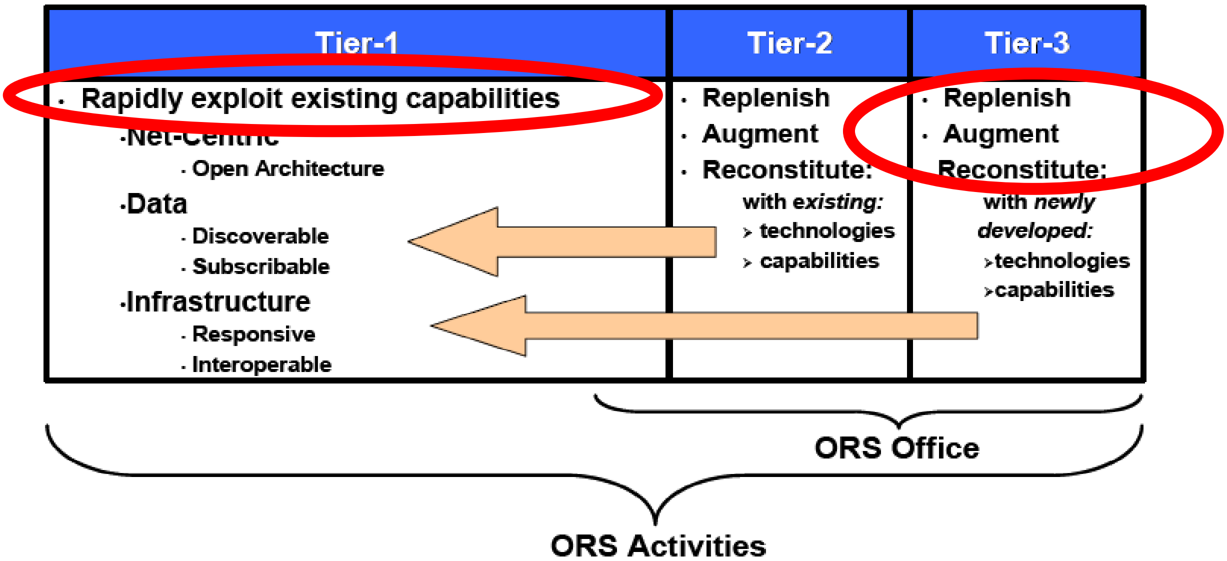


Figure 22: The Three Tier Architecture and its Room for Cooperation[158]

As has been indicated before, Europe is also facing the need for independent access to very high resolution satellite imagery for data collection during a crisis situation given that the two major Very High Resolution (VHR) satellite imagery providers, i.e. DigitalGlobe and Space Imaging, are based in the U.S. and have special commercial agreements with the U.S. and other governments and customers in which U.S. requests take precedence over European ones. Europe

The EU ISS further highlights (Priority 2) Europe's respect for human rights and the rule of law in the international system. Accordingly, Europe's human security doctrine may require undertaking the full range of military operations. RS would support both of these. On the one hand flexible, capable and affordable space capabilities will provide objective tools clarifying human rights and international justice issues, on the other hand, they will

[158] : Department of Defense. op. cit.

[159] Csekö, Árpád. op. cit.

prove to be irreplaceable supportive-instruments in any military operation.

The development of a European approach to RS will also require Europe to develop a perspective on the role of NATO (EU ISS Priority 6). The issue of the role of the EU and NATO and their division of labour is a reoccurring one in many different contexts, e.g. transatlantic relations, the fight against piracy etc. The main objective for Europe should be to avoid duplications and to find a solution in which both sides gain. NATO has not yet looked into RS. Nonetheless, Europe should aim at informing NATO about its attempts in the context of establishing a European approach to RS. This way it can be ensured that NATO, as a security stakeholder, is familiar with the European understanding of RS and NATO's concerns can be considered from the very beginning.

The introduction of a European approach to RS further leads to assessing the roles of other existing European bodies. The EU ISS called for the creation of a European Parliamentary Council for Security and Defence (Priority 7). Such a body already exists outside the EU institutional architecture: the European Security and Defence Assembly (ESDA) / Assembly of the Western European Union (WEU)[160]. ESDA has already debated space and security related topics. In the course of establishing a European approach to RS, a call for more parliamentary oversight might evolve. ESDA is well prepared to assist the European Parliament with its specialised expertise in security and defence related issues.

As can be seen, RS fits perfectly into various think tanks' initiatives. Consequently, RS should not be considered as an isolated concept but rather as part of a larger attempt to resolve many issues requiring a more integrated approach. Hence, while it is important to consider existing capabilities such as e.g. Galileo and GMES for RS, it is also important to consider RS in the context of the general policy of the EU with regard to e.g. data harmonisation, standardisation, and integration of European and national capabilities etc.

The recommendations above are to be understood as elements towards the development of a comprehensive approach for Europe to RS. The idea to conduct an assessment of existing European capabilities, the gap analysis as well as the proposed supportive institutional architecture, should thus be seen as elements of such an approach.

[160] Website of ESDA/Parliamentary Assembly of the WEU: <http://www.assembly-weu.org/>.

5 Annex

5.1. Five Key Functions of the ORS Office

5.1.1. Combattant Commander (COCOM) / User Support Function

This function will identify, advocate and plan for desired ORS capabilities. It will thereby support USSTRATCOM in collection, prioritisation and management of all users' ORS needs. It will also support National Security Strategy (NSS) organisations in conducting Tier-1 activities, in order to leverage current capabilities. This function forms an interface between the warfighter/user and the ORS service providers aiming at supporting augmentation/surge, reconstitution, and crisis response activities to match the user's priorities and timelines, across all three ORS tiers.

5.1.2. Concepts / Solutions Function

The Concepts/Solutions Function links ORS needs with S&T to develop the necessary capabilities to fill the operational needs and gaps. In details it

1. identifies and presents options for concepts/solutions and experimentation
2. conducts concepts development, solutions assessment, rapid evaluation of alternatives, experimentation and modelling and simulation (M&S) support
3. plans operational experimentation and Military Utility Analyses (MUAs)
4. develops budgetary recommendations for ORS solutions.

5.1.3. S&T Function

The S&T function plans and coordinates ORS S&T efforts, conducts operational experiments and expedites technology transition to ORS operational solutions.[161] This also involves developing, maintaining and executing an S&T roadmap and integrating ORS projects across the National Security Space S&T community. The S&T function focuses on affordable and innovative solutions. It also works closely with the Acquisition Function in transitioning and incorporating ORS technology in the development and acquisition of operational ORS systems.

5.1.4. Acquisition Function

The ORS Office's objectives are to optimise acquisition by streamlining development time and cost. The Acquisition Function is mainly about timely acquisition of ORS capabilities. In this context the Acquisition Function will provide leadership and integrate ORS acquisition efforts. It will develop and delegate expedited acquisition authorities to executing organisations thereby employing a market-based approach. It will utilise the broader space community and transfer its authorities to the executing organisations. It will account for lifecycle sustainment of ORS capabilities and accept an increased risk tolerance for operational gain. This will be done by using streamlined processing not waiting for hundred percent solutions putting an emphasis on integration of off-the-shelf components whenever possible.

Such a new acquisition system should have the following desired characteristics:

- timely — fast, agile, and flexible
- processes that are tailored and disciplined in execution
- networked, integrated, and comprehensive across the ORS community
- authority that is clear, delegated, and direct
- flexible and agile with resources responsive to the need
- funding/resource stability with a personnel and industrial base foundation

[161] McLaughlin, Kevin. op. cit.

- oversight that is appropriate and risk tolerant
- competitive with a market-based selection.

A first step to limit costs and improve responsiveness is to make sure Tier-1 options have been carefully investigated before considering Tier-2 and Tier-3 as alternative options. In order to guarantee this, the Acquisition Function will consult and collaborate with the IC and NSS organisations.

5.1.5. Operations Support Function

The Operations Support Function will coordinate operational experiment and military utility assessment, coordinate transition of ORS capabilities into operations by supporting USSTRATCOM and identify the services or agencies to conduct operations of ORS capabilities.

5.2. The ORS Office Organisational Structure

The ORS Office organisation is structured to mirror the three tiers (see 3.4.2) of the Concept of Operations provided by U.S. Strategic Command.

5.2.1. Tier-1 Division

The Tier-1 Employment division is tasked to develop a playbook in the form of a database or catalogue on existing space capabilities and to engage with Combatant Command (COCOM). This means that it

- conducts experimentation, demonstration, training, military utility assessment and transition (EDTMX) of space capabilities
- validates ORS architectures that support warfighter requirements
- conducts studies of COCOM ORS needs[162]
- facilitates international and commercial space integration.

It is thus also exercising on-orbit systems to prove the ORS architectures. Particularly, it follows the TacSat end-to-end experiment and validates all architectures from request through delivery of products to expedite on orbit check out and transition based on the ORS-1 experiment. ORS-1 uses an off-the-shelf TacSat3 bus and a slightly modified U2 intelligence surveillance reconnaissance (ISR) payload.[163] The detailed Tier-1 Employment Division's Strategy is depicted below.

5.2.2. Tier-2 Division

The Tier-2 Division is tasked to architect and demonstrate how to achieve a posture that includes on-call and ready-to-field assets. In practice that means that it is standing up the so-called Rapid Response Space Works (i.e. the Recon Wing for Space) through

- developing processes for rapid assembly of mission kits (modular bus and payloads)
- developing standards for modularity.

The Tier-2 Division also leads the efforts to build infrastructure ORS capabilities. Moreover, it conducts launch on schedule exercises.

5.2.3. Tier-3 Division

The Tier-3 Division is tasked to provide rapid transition from development to delivery of new or modified capabilities and exploit new technological operational innovations. It forms teams composed of experts on various subject matters and involves the users on the team. Thereby it is leveraging existing and emerging technology. It makes use of creative problem solving techniques and parallel thinking.

[162] Henderson, Tim. "ORS." ORS Briefing. Pentagon, USA. 23 Apr. 2009.
[163] "Space Power Lecture Covers Operationally Responsive Space." op. cit.

5.3. U.S. Programmes related to Responsive Payloads

Responsive Payloads are primarily categorised into three areas of satellite applications, namely SatCom, SatNav and EO. Responsive payload requirement changes and the continued increase in electronic capability and miniaturisation will reduce payload size, complexity, and cost. The ability to launch a satellite on demand allows for shorter life requirements. Satellite reliability can be ensured by using robust design practices.[164] Developing responsive payloads also includes making the assembly of the spacecraft faster. No concrete projects dealing solely with responsive payloads could be identified.

5.4. U.S. Programmes related to Responsive Launch

The USAF Space Command's Strategic Master Plan of 2006 noted that "[a]n operationally responsive space lift capability is critical to place timely missions on orbit assuring our access to space."[165] When considering responsive launch, the challenge is not only to make access more rapid but also more affordable. Particularly, the question arises as to how to place larger payloads into space cheaply and responsively.[166] Responsive systems must exploit existing military and commercial infrastructure in order to keep the effect of costs and logistics manageable. The U.S. has access to a highly responsive fleet of launch vehicles in the intercontinental ballistic missiles (ICBM) force.[167] Air Force Space Command (AFSPC), with support from AFRL and the Defense Advanced Research Projects Agency (DARPA), is currently conducting preliminary system-acquisition studies, technology development, and concept demonstrations to make responsive launch a reality.[168]

Prior to a formal decision to pursue a U.S. ORS programme a number of activities within the Air Force and the Department of Defense (DoD) have already made progress towards responsive launch and the development of Minotaur launch vehicles. Specifically, the Small Launch Vehicle subprogramme for a rocket capable of placing 100 to 1.000 kg into LEO on 24-hours notice for under U.S. $ 5 Million, which was ultimately linked to a long-term prompt global strike capability, made progress in this direction. Under this programme AirLaunch LLC was asked to develop the Quickreach air-launch rocket and SpaceX to develop the Falcon-1 to fulfil SLV requirements.[169] Before looking into FALCON, DARPA worked on the so-called "Responsive Access, Small Cargo, Affordable Launch" programme (RASCAL) to identify and develop low-cost, responsive launch concepts.

At the moment there are different responsive launch vehicles like the Minotaur family[170], RAPTOR, and Super Strypi[171]. Additionally there are several programmes looking into the development of launch vehicles.

5.4.1. Responsive Access, Small Cargo, Affordable Launch (RASCAL)

The *RASCAL programme* particularly focused on concepts for launching small vehicles from high-speed vehicles that could demonstrate ORS requirements. RASCAL was cancelled by DoD in February 2005 in favour of focussing on *FALCON*.

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[164] Brown, Kendall K. op. cit.
[165] West, Jessica (Ed.). Space Security Index 2009. Waterloo: Project Ploughshares, 2009. <http://www.spacesecurity.org /SSI2009.pdf>. 139-40.
[166] Worden, Simon P. and Randall R. Correll. op. cit.
[167] Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/doggrell.html>.
[168] Brown, Kendall K. op. cit.
[169] West, Jessica (Ed.). op. cit. 139-40.
[170] A detailed description can be found here: "Minotaur IV Users' Guide." Orbital Sciences Corporation, 2006. 15 Dec. 2009 <http://www.orbital.com/NewsInfo/Publications/Minotaur_IV_Guide.pdf>.
[171] "Introduction-- New Programs/Super Strypi." Presentation. NASA 9 Dec. 2009. <http://accesstospace.nasa.gov /ats3/accessmodes/new_programs/templates/introduction.asp?proxyid=guest&xsection=0&subxsection=15&subsubxsection=1&toolbox=6&boxvalue=introduction>.

5.4.2. Force Application and Launch from CONUS (FALCON)

DARPA expects to develop a vehicle that can send 100-1.000 kg to low-earth orbit within 24-hours for less than U.S. $ 5 million with an operational cost basis of twenty flights per year for ten years.[172] FALCON continues to investigate two distinctively different concepts: a conventional, multiple-stage, ground-launched rocket and a rocket deployed from the back of a C-17 cargo aircraft. FALCON also did a first step towards developing reusable boosters, as the expendable rocket developed under this programme could be used as such.[173] It is expected to flight test hypersonic technologies and be capable of launching small satellites such as TacSats.

5.4.3. Evolved Expendable Launch Vehicle (EELV) Programme

USAF started to work on the objective of reducing launch costs by at least 25 percent already in 1994 when starting to look into the U.S. $ 31.8 billion EELV programme. In this effort, USAF is partnering with industry to develop capabilities that could be used for both commercial and government purposes.

5.4.4. United Launch Initiative

Both Lockheed Martin and the Boeing Company are pursuing a Heavy Lift launch capability in a joint venture, the United Launch Alliance, which markets both the Delta-4 and the Atal-5 launch vehicles.[174]

5.4.5. Affordable Responsive Spacelift (ARES)

The Affordable Responsive Spacelift (ARES) programme[175] can be seen as the next step towards demonstrating the feasibility of an ORS system. The preliminary ORS Analysis of Alternatives (AoA) evaluated a wide range of launch vehicle architectures and determined that the system with the lowest life cycle cost was a partially reusable system - a reusable first-stage booster vehicle used in conjunction with expendable upper-stage vehicles.[176] ARES is such a hybrid configuration containing a reusable first stage with expendable upper stages. The reusable booster stage accelerates the expendable stages and payload to a separation point in near space. The separated expendable stages provide the remaining impulse to inject the payload into orbit. The reusable booster then returns to the launch base and can be prepared for the next launch. Several cost analyses by the government and industry have shown the advantage of fully reusable launch vehicles over expendable launch systems in terms of cost-effectiveness. For example Air Force Space Command has completed an analysis that indicates that reusable rocket technology can meet goals for a medium-size launch vehicle capable of placing more than 10.000 kg in orbit.[177] However such concepts require very high flight rates to offset development cost.[178]

5.4.6. The Choice of the Launch Site

Responsive Space launch however does not only depend on launch vehicles but also on the choice of the launch site. The site selection process must trade off a number of competing issues, including payload trajectories, operational security, public safety, environmental impact, and weather. ORS needs the capability to launch satellites into different orbits. Safety concerns limit the flight of launch vehicles over or near populated areas due to the risk to public safety in case of vehicle failures and the generated noise.[179] Weather has been a frequent cause of schedule delays for launches. An aerospace contractor studied potential basing locations for an Air Force Research Laboratory (AFRL) Space Operations Vehicle (SOV) concept, comparing the climatologic factors at different launch sites.[180]

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[172] United States Government Accountability Office. "DoD Needs a Departmentwide Strategy for Pursuing Low-Cost, Responsive Tactical Space Capabilities."GAO, 2006. 11.
[173] Brown, Kendall K. op. cit.
[174] West, Jessica (Ed.). op. cit. 141.
[175] ARES should not be confused with ARES-I and ARES-V launchers of the constellation programme.
[176] Brown, Kendall K. op. cit.
[177] Worden, Simon P. and Randall R. Correll. op. cit.
[178] Doggrell, Les. "Operationally Responsive Space – A Vision for the Future of Military Space." 1 June 2006. PIREP (Pilot Report). Air & Space Power Journal. 28 Aug. 2009 <www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/doggrell.html>.
[179] Brown, Kendall K. op. cit.
[180] Ibid.

5.4.7. Responsive Range

The U.S. currently draws on four different launch sites: Wallops flight facility, Kodiak Launch (KLC), featuring all indoor, all weather, processing and was designed specifically to provide optimal support for space launches to polar orbit, including circular and highly elliptical Molniya and Tundra orbits[181], Cape Carneveral also known as the Kennedy Space Center, Vandenberg AFB and Kwajalein.

5.4.8. Responsive Command and Control / Tasking, Planning, Exploitation and Dissemination Architectures

ORS also deals with Command and Control (C2) and Tasking, Planning, Exploitation, and Dissemination (TPED) architectures. In this context, novel concepts like the Multi-Mission Satellite Operation Center (MMSOC)[182], the Virtual Missions Operations Center (VMOC), Tactical Tasking, Planning, Exploitation and Dissemination (TPED) as well as Common Data Link Modular Interoperable Surface Terminal (CDL MIST) were introduced and integrated into the ORS concept.

5.5. Overview of the TacSat Programme

The TacSat programme is currently working on TacSat-3 and TacSat-4 based on the lessons learned from TacSat-2. TacSat-2 was launched in 2006 and relied heavily on inexpensive off-the-shelf components. TacSat-3 was developed in the most realistic setting possible. Its initial goals were costs of U.S. $ 50 million including launch and integration of the instruments in the spacecraft and testing. All of these steps were planned to be condensed to sixty days. A series of technical difficulties and supply-chain issues delayed the development of the satellite for more than a year and led to an increased final price of around U.S. $ 88 million.[183] TacSat-3's main instrument is the Advanced Responsive Tactically Effective Military Imaging Spectrometer (ARTEMIS). TacSat-3 was launched on 19 may 2009. TacSat-4 features several experimental telecommunications payloads was expected to launch in September 2009 was however postponed to August 2010 because of Minotaur-IV technical issues and changing DoD mission priorities.[184] An overview of the TacSat Programme is given in the table below.

[181] "Kordiak Launch Complex Overview – From the Last Frontier to the Final Frontier." Alaska Aerospace Corporation. 15 Dec. 2009 <http://www.akaerospace.com/klc_overview.html>.

[182] Walden, G.F., G. Warrender and F. Malzahn. "MMSOC GSA: Standards and Architecture Enabling Multi-Mission Interoperability. Presentation. <http://sunset.usc.edu/gsaw/gsaw2009/s2/walden.pdf>.

[183] Brinton, Turner. "Pentagon Readies Pioneering TacSat-3 for Launch." Space News 27 Apr. 2009: 12.

[184] Ibid.; "TacSat-4 spacecraft complete and awaiting launch." Science Blog. 15 Dec. 2009 <http://www.scienceblog.com/cms/tacsat-4-spacecraft-complete-and-awaiting-launch-27788.html>.

Satellite	TacSat 1	TacSat 2	TacSat 3	TacSat 4	TacSat 5
Payload	- radio frequency payload - ultra-high-frequency cross-platform link - low-resolution visible and infrared cameras - payload scheduling and data access via the Secret Internet Protocol Routing Network	- common data link x-band radio - tactical imaging and radio frequency - automated identification sensor - science payloads - payload scheduling and data access via the Secret Internet Protocol Routing Network	- hyperspectral imaging sensor for tactical targeting of camouflaged and hard-to-detect targets - secondary space communications payload for data exfiltration/infiltration to warfighter	- mobile data communication services - data relay from terrestrial sensors - friendly forces tracking - payload scheduling and data access via the Secret Internet Protocol Routing Network	- n.a.
Selection Process	Mission selected based on knowledge of specific combatant command's need	Mission selected based on existing Air Force Research Laboratory demonstration satellite	Mission selected through Air Force Space Command formalised process	Mission selected through Air Force Space Command formalised process	- n.a.
Developer / User	Office of Force Transformation/Naval Research Laboratory for U.S. Pacific Command	Air Force Research Laboratory for U.S. Strategic Command	Air Force Research Laboratory for U.S. Army Space and Missile Defense Command, U.S. Special Operations Command, and other combatant commands	Naval research Laboratory for U.S. Strategic Command	Army Space and Missile Defence Center, the Air Force Research Laboratory, Space and Missile Systems Center
Costs	U.S. $ 23 million + new sensors and new capabilities of U.S. $ 10.5 million The ORS Office, the Navy, the Cost Guards and the Department of Defense Research and Engineering are currently working to develop a cost sharing agreement	U.S. $ 39 million	U.S. $ 62.7 million [185]	n.a.	Costs still to be determined
Status	In progress: was developed in 2004 but has yet to be demonstrated due to problems with the development and testing of a low cost launch vehicle	Launched in December 2006 on a Minotaur I launch vehicle and participated in military exercises during the summer of 2007; demonstrations ended in December 2007	Successfully launched in May 2009	TacSat-4 features several experimental telecommunications payloads was expected to launch in September 2009 was however postponed to August 2010 because of Minotaur-IV technical issues and changing DoD mission priorities	In progress: launch date to be determined Payload experiments have not been finalised yet

Figure 23: Overview of TacSat Experiments[186]

In addition to the TacSat programme the U.S. army indicated the launch of an own constellation of eight small cubesats, which will provide the army with communications below brigade level in the parts of the world where the army does not posses SatComs.[187]

[185] This amount is based on a calculation of 2008. Final numbers seem to still be published.

[186] This figure is drawing on the following sources: United States Government Accountability Office. "DoD Needs a Departmentwide Strategy for Pursuing Low-Cost, Responsive Tactical Space Capabilities."GAO, 2006;. United States Government Accountability Office. "Space Acquisitions – DoD Is Making Progress to Rapidly Deliver Low cost Space Capabilities but Challenges Remain."GAO, 2008. 7.

[187] West, Jessica (Ed.). op. cit. 111.

List of Acronyms

A	
AF Space Command	Air Force Space Command
AFRL	Air Force Research Laboratory
AFSPC/SMC	Air Force Space Command/ Space and Missile Systems Center
AoA	Analysis of Alternatives
ARES	Affordable Space Lift
ARTEMIS	Advanced Responsive Tactically Effective Military Imaging Spectrometer
ASAT	Anti-Satellite Test
ASD(NII)	Assistant Secretary of Defense (Networks and Information Integration)
AT&L	Acquisition, Technology and Logistics
B	
BTI	Build-to-Inventory
BTO	Build-To-Order
C	
C2	Command and Control
CDF	Concurrent Design Facility
CDL MIST	Common Data Link Modular Interoperable Surface Terminal
CDRUSSTRATCOM	Commander of the United States Strategic Command
COCOM	Combatant Commander
CONOPS	Concept of Operations
D	
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director of Defense Research and Engineering
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
DNI	Director of National Intelligence
DoD	Department of Defense
E	
EA for Space	Executive Agent
EC	European Commission
EDA	European Defence Agency
EELV	Evolved Expendable Launch Vehicle
EMSA	European Maritime Safety Agency
EO	Earth Observation
ESA	European Space Agency
ESP	European Space Policy
ESRAB	European Security Research Advisory Board
ESRIF	European Security and Research Innovation Forum
ESS	European Security Strategy
EU	European Union
EU ISS	European Union Institute for Security Studies
EUSC	European Union Satellite Centre
F	
FALCON	Force Application and Launch from CONUS
FFRDC/SETA	Federally Funded Research and Development Center
FP	Framework Programme for Research and Technological Development
FY	Fiscal Year
G	
GAO	Government Accountability Office
GIANUS	Global Integrated Architecture for iNovativ Utilisation of space for Security
GMES	Global Monitoring for Environment and Security

GoP	Group of Personalities; here: Group of Personalities for Security Research
GURG	GIANUS User Representative Group
I	
IA	Imagery Analyst
ICAT	International Cooperation Assessment Team
ICBM	Intercontinental ballistic missile
IRRI-KIIB	Institute Royal des Relations Internationales/Koninglijk Instiuut voor Internationale Betrekkingen
ISR	Intelligence Surveillance Reconnaissance
J	
JAXA	Japanese Aerospace Exploration Agency
JFC	Joint Force Commander
JFCC Space	Joint Functional Component Command for Space
JRC	Joint Research Centre
M	
MMSOC	Multi-Mission Satellite Operation Center
MOSA	Modular Open System Architecture
MUSIS	Multinational Space-based Imaging System
N	
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorisation Act
NGA	National Geospatial-Intelligence Agency
NRO	National Reconnaissance Office
NSA	National Security Agency
O	
OHQ	Operations Head Quarter
ORS	Operational Responsive Space
ORS EXCOM	ORS Executive Committee
OSD	Office of the Secretary of Defense
R	
R&D	Research and Development
RASCAL	Responsive Access, Small Cargo, Affordable Launch
RS	Responsive Space
S	
S&T	Science and Technology
SAR	Synthetic Aperture Radar
SatCom	Satellite Communication
SatNav	Satellite Navigation
SDTW	Space Development and Test Wing
SDTW/CC	Space Development and Test Wind Commander
SEDE	Subcommittee on Security and Defence
SMDC	Space and Missile Defense Command
SPASEC	Security Panel of Experts
SSA	Space Situational Awareness
T	
TCO	Total-Life-cycle COst
TIES	Tactical Imagery Exploitation System
TPED	Tasking, Processing, Exploitation, and Dissemination
U	
UAV	Unmanned-Air-Vehicle
USD(I)	Under Secretary of Defence for Intelligence
USD(P)	Under Secretary of Defence for Policy
USECAF	Under Secretary of the Air Force

USSTRATCOM	U.S. Strategic Command

V

VHR	Very High Resolution
VMOC	Virtual Missions Operations Center

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ESPI Project Manager Nina-Louisa Remuß (right) with U.S. government representatives at the roundtable discussion organised at the U.S. State Department.

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Mission Statement of ESPI

The mission of the European Space Policy Institute (ESPI) is to provide decision-makers with an independent view and analysis on mid- to long-term issues relevant to the use of space.

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