



European Space Policy Institute

A large, light grey circular graphic with a splatter or ink-blot effect around its perimeter. It is centered on the page and serves as a background for the main title.

STIMULATING AND SUSTAINING TECHNOLOGY INNOVATION IN THE SPACE SECTOR

Report 9, December 2007
Rolf Skaar, ESPI



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Foreword

The main purpose of this report is to investigate what policy and which actions will best stimulate technology innovation and create a competitive space industry at European level.

The report is a result of desk top studies, and in particular the result of an ESPI workshop with representatives from space industry, space agencies, academia and institutions responsible for technology innovation funding. Preceding this workshop and as a follow-up several in-depth interviews were held in order to get the view of many individuals and their organizations reflected in this report.

The study is also expected to provide useful insight and information for policy and decision-makers at Government's level and Space Agencies in Europe.

The author wishes to thank all the participants at the ESPI workshop 19th October for their contribution to this study, both during the workshop with the brainstorming and discussion and with their input to this final text. The Author also thanks the staff from ESA, CNES and Eurospace who significantly provided useful ideas both to the workshop and to this report. Also a special thanks to his colleagues and the staff of ESPI for their valuable input with a special thanks to Ms Charlotte Mathieu and Mr Nicolas Peter for their support in preparing and organizing the ESPI workshop, and for all their valuable comments to the final text. In particular, I am grateful to the Director of ESPI, Prof. Dr. Kai-Uwe Schrogl, for his guidance and support to the final report. Also special thanks to Ségolène van den Steen and to Michel Jakob for their input and for making the final layout and preparing for production of the final report.

Vienna December 14th 2007.

Rolf Skaar,
Study Leader



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Attachments

- 1 List of participants at ESPI workshop and contributors to this report
2. Programme of the ESPI workshop on Innovation
3. Presentation on Prizes
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5. Summary of ESA funding with strong Research and Technology part

Executive Summary

This executive summary will follow the same headlines as outlined in The Statement of Work with these 3 subtitles:

- **Identifying the main factors that can stimulate innovation**

In this study we use the OECD definition of innovation¹, this implies much more than technology or disruptive innovations.

We start by looking at innovation from a supply/demand type perspective and looking at which stimuli creates a demand for innovation and then what stimuli is needed for innovation to take place.

The author strongly believes that the most important driving force for stimulating innovation in space is demanding missions requiring innovation. Such missions obviously include the advanced science and exploration missions, both robotic and manned. The demanding missions for Earth observation including weather forecasting and climate change monitoring, and the missions producing services, like satellite communications and navigation, are also creating a major demand for innovation. In the 50-year history of space activities, it is the demand for innovation that has really brought innovation and technological progress in the field.

Another very important driver for innovation is competitiveness. In the commercial space sector (which is the largest civilian space activity), innovation both in technology and in processes is a must to stay competitive. Even with

conservative customers like satellite communications service provider companies, without innovative suppliers their business would stagnate.

The efforts to make space more affordable by using smaller satellites, as well as their use of more advanced components is another driver for innovation. These smaller satellites are becoming more and more capable.

Finally, both entrepreneurial companies and students, with typically modest funds, will not only depend on innovative ideas but also foster them with their smart use of available technologies to reach their ambitions in space.

For innovation to take place, the education system, including universities, should be able to educate and prepare candidates, including scientists and engineers, who are capable of generating new ideas and implementing them.

Most European countries have, as part of their policies, programmes to support innovation and research. Such policies are a major contributor to innovation stimulation, and if well implemented, will result in several benefits including a more competitive industry and more cost effective products and services coming. Also the cross fertilisation between space and non-space is beneficial to both sectors.

- **Reviewing the current situation in Europe and pointing out strengths and weaknesses within industry and institutions**

The most striking feature of Europe's situation in space is that, despite that the United States' government invests six times more than Europe. European companies are doing extraordinarily well in commercial activities, i.e. the satellite communications industry with its geostationary satellites, the launchers, and the services produced by these space systems. European companies

¹ OECD Definition: Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.



have more than 50% of the global market for launchers, more than 50% of the order book for new communication satellites and hold the #2 (SES Global, Luxembourg) and #3 (Eutelsat, France) rank in the global satellite communication service providers. Europe has until now been winning such competition because, firstly industry reaped the benefits of past investments which resulted in good performance in-orbit and many new orders. Then it put a lot of efforts to increase cost competitiveness, and lately industry were forced to sell with reduced margins in order to remain in the market. Now, European industry faces multiple threats, the most advanced communications satellites are only available from U.S. companies, and India and China are entering the market with lower cost satellites with performance deemed acceptable for some customers.

Another observation is that for advanced robotic science missions, Europe seems to be approaching the same level as the United States in its ability to perform complex missions. The United States has vastly more experience than Europe in planetary missions including landings, however the basic ESA science programme is ranked to be about equal with the equivalent NASA science programme. However, this position depends on the use of some key components only available from U.S. manufacturers and subject to U.S. restrictions on their export (International Traffic in Arms Regulations (ITAR)-regulated). This creates a risk for Europe in its ability to make its own decisions and setting its own priorities in space matters.

Europe currently lacks the capability of independent manned missions to space; only Russia, the United States and recently China have demonstrated this manned spaceflight capability using national means. Europe also lacks capabilities in the area of security and space situational awareness (SSA).

Broadly speaking, Europe has the available technology and expertise (although some critical components are

only available from U.S. manufacturers) to perform both advanced robotic science and exploration missions, and to put an infrastructure in space to provide cost-effective services for weather forecasting, Earth observation, navigation, positioning and timing, and satellite communications.

There is a real risk that Europe might lose its currently #3 position in overall space capabilities (after the United States and Russia) and being overtaken, first by China, and maybe later by India.

If Galileo is further delayed, it may be put in operation after the new U.S. GPS III, the revived and fully implemented Russian GLONASS, and even after the planned Chinese Compass/Beidou.

In the United States, Russia, China and India, decisions related to Space are made at the highest political level, and Space is used strategically and as a foreign policy tool. It is a fact that in Europe Space decisions are *de facto* made nationally (even for ESA and European Union decisions on space matters) and the European will to use space as part of a European overall Common Foreign and Security Policy (CFSP) and European Security and Defence Policy (ESDP) is currently not there. This is limiting the funding of Europe's ambitions in space, both as regards space science and exploration missions and space infrastructure to provide services.

This issue with decision-making in Europe is also reflected in the funding of technology innovation. Such funding is fragmented, not sufficient to create non-dependence and with major risk of not funding elements critical for the competitiveness of the European industry and for the ability to achieve future complex missions.

The funding of ESA missions is totally dependent upon ESA industrial policy with its fair geographic contribution rule. This has both strengths and weaknesses as regards technology innovation. The Member States willingness to fund optional ESA missions depends in a

significant way on what these Member States can derive from those missions, in particular industrial activities. This may result in several Member States making certain demands for roles which they give priority to because of their national interests. Sometimes this leads to threats to decrease their participation if they do not get their priority part. Such pressure may lead to both delays and a final solution which is far from optimal.

The larger the project, the larger this issue becomes. In recent times many of Galileo delays, cost overruns and now risk of not being implemented, have been caused by Member States putting their national interests above the European interests.

The structure of the European space industry is a reflection of the ESA fair geographic contribution industrial policy. The two large space companies in Europe; Thales Alenia Space and EADS Astrium (i.e. The "Primes") have most of their industrial activities in France, Germany, UK, Italy and Spain, then in addition at a smaller level Belgium and Netherlands. This opens up for the next level of major subcontractors and again their sub suppliers to have better geographical return potential if they are located outside these five large countries. This industrial structure has both strengths and weaknesses; it gives the two Primes a very competitive market for their first and second tier sub supplies, with the possibility to get some Member States to support their local space companies such that these companies are offering the lowest possible prices to the Primes.

This structure also prevents too much vertical integration by the Primes; in most other industries it has been observed that too much vertical integration leads to less innovation. It can therefore be argued that this wide geographic distribution of space companies actually will stimulate innovation, not at least because of the intense competition in the lower tier companies. The author feels it is worth mentioning, that also in the United States, starting with the Apollo

programme, there is a geographical distribution of space activities among the various U.S. States in order to secure the necessary votes in the U.S. Congress.

There is one innovation stimuli missing on the European side compared to the United States. In the United States the very demanding requirements for the advanced satellites for the military and for homeland security, has been probably the most important driver for technological innovation for space, and due to its large funding these systems has given the U.S. companies a definite advantage.

Venture Capital in Europe is much less specialized in early stage financing than in the United States and also Business Angels are less frequent in Europe to stimulate innovative entrepreneurial space companies. A likely reason for this is that from a business point of view, investing in space is risky, has a high barrier to entry, and with often a long wait for the financial returns.

- **Proposing actions to be taken in order to ensure that indeed the European industry will keep, if not augment, its competitive edge**

The most efficient stimuli for technology innovation are demand-related. Only by having advanced missions requiring innovation can Europe be assured of continuing to make progress. By far, most of the investments in technology innovation are coming from the missions, whether it is for launchers, for science and exploration, or for the service-oriented missions.

To make future missions affordable and avoid delays it is important to plan well in advance the research and development needed to develop the new necessary technologies. It requires both planning and coordination and appropriate funding. It is strongly recommended to strengthen the space technology policy, coordinated by ESA, with improved planning and decision-



making for such development to take place. Hopefully, the larger ESA Member States will see the benefits for them and their industries of a better coordination of the total technology development. Such coordination must also have as one of its goals to increase Europe's non-dependence for critical components needed for its space missions. The major tool for funding innovation at ESA is its TRP (Basic Technology Research Programme) and it is recommended to substantially increase this mandatory program being a part of ESA General Budget.

It is recommended to continue the use of spin-ins of commercial off-the-shelf (COTS) components in order to both achieve non-dependence and to reduce the time gap between space and the non-space world in their use of state-of-the-art components. Such efforts will increase the competitiveness for Europe's space industry, and it will lower the cost of future missions.

It is further recommended that ESA is given an increased mandate to enforce a more standardized architecture for spacecrafts and satellites with standard interfaces between the various units. This will allow for more identical units to be procured, resulting in the typical very high non-recurring development cost to be shared among a higher number of units manufactured. Such more standardized architecture needs to be developed in close coordination with space industry, in particular with the main space companies, however with a final say to ESA. Such standardization should include innovative concepts and a willingness to try new ideas coming from outside of ESA.

It is recommended to strengthen technology innovation funding and we support the planning of the ESA NewPro to be decided by the ESA Ministerial Council in November 2008. A close involvement of the space industry in NewPro planning through their common

organization, Eurospace is recommended. An important part of NewPro is to provide opportunities for more in-orbit demonstrations in order to test and space qualify new technologies. This study proposes that an agreement is negotiated with Arianespace, as part of EGAS (European Guaranteed Access to Space), for the provision of regular piggy-back launch opportunities for such in-orbit-demonstrations.

It is recommended to limit duplication and re-enforce harmonisation process in ESA members states in order to avoid waste of funding and concentrate efforts on key identified technologies and products.

We recommend continuing to stimulate innovation by engaging young students in student satellites, both the low cost nano-satellites and the more collaborate efforts like the YES2 project (Young Engineers Satellite 2). The best way to recruit the best and brightest engineers and scientists for space is to engage them early with hands-on experience during their studies.

To further encourage such activity, and to stimulate innovative entrepreneurship, we recommend the use of Prize awards (like the ones put forward by the X-Prize Foundation in the United States). A concrete proposal for a Prize and its associated challenge is described in 3.2 (page 18).

Furthermore to engage more of academia (Universities and research institutes) we encourage in particular ESA and national Space Agencies to broaden their contact with a broader field of basic Science. It is a general feeling that today the contact with academia institutions in space matters is limited, and mainly to those who established a space network long ago. Widening this network is believed important to reach new scientists with new ideas and also relevant for space.

1. Why the space sector needs technology innovation

Although the United States put humans on the Moon and returned them safely using 1960's technology and remembering that the most powerful rocket ever made, the Saturn V, also is 1960's technology, few would argue against that continued innovation is a must for the space sector. Without innovation, space would lose its attractiveness, lose its best people, and with reduced ability to recruit the best and brightest young engineers and scientists, the space sector would decline in a downward spiral.

In this respect innovation is more than technological break-through inventions, using the OECD definition for innovation is also relevant for the space sector²:

Space can be divided into two main markets:

Commercial Satellite communication is the largest non military market. It is global and very competitive and also provides for the largest launcher business and has resulted in a global space services business of providing TV-distribution, internet, broadband and telephony to any spot on Earth, fixed or mobile. Total annual sales are around 3 billions U.S. dollars for satellite systems and 2 billions U.S. dollars for launch services. The commercial satellite sector generates revenues in services equal to 8 billions U.S. dollars at satellite operations level and around 50 billions U.S. dollars for multimedia services revenues offered through the satellites.

² Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.

The other main market is the government or institutional market comprising military and security, science and exploration and providing important services to its citizens in weather forecasting, navigation positioning and timing, and Earth observation including climate change. The institutional market represents worldwide between 80% and 90% of the total business of the space manufacturing industry, and supports most technology development and innovation, with the main technological developments (in volume) funded by the United States through Department of Defense (DoD) and NASA programmes.

For both of these sectors, innovation is a key to a viable space industry and to affordable services and to the ability to explore new frontiers and do breathtaking science. Innovation is needed not only in technologies (whether continuous improvement or disruptive break-through), but also in processes including management and in the way science and basic research are done. Some of the current missions in advanced planning phase are so demanding that they can only be accomplished by major new technological developments.

1.1. Importance of spin-ins

In the United States, the Apollo programme consumed up to 7% per year of the U.S. Federal Budget. In technology development the space sector was highly visible and enormously attractive for young engineers and scientists. Today the space sector is still visible, in particular human space flight; however in innovation and technology



terms it is no longer the driving force. If we look at a state-of-the-art mobile phone, a laptop computer, a camera, or even an automobile, it is rather obvious that space can benefit from spin-ins from the commercial non-space world.

However, commercial technologies can not simply be used as they are in the space environment. They need to be space qualified which means that they have to be put on a proper technology readiness level (TRL) to be used in any important space project. There will always be a time-gap between what is available in the commercial world, and what is ready for space. It is important to reduce this time-gap. Some smaller and also the entrepreneurial space companies, have as their business model to reduce this time-gap by using as new as possible, electronic components and sensors, such that their satellites becomes smaller, however still fairly capable.

The technology base, in particular for submicron electronics, is changing and this put even higher priority on spin-ins. A previous NASA Administrator, Dan Goldin, with a background from private industry, became frustrated over the high cost and long development time for the large NASA missions, and he therefore introduced the slogan "Faster, Better, Cheaper". Experience, however showed that this was not so easy with several mission failures resulting from not enough testing.

It must also be mentioned that some critical technologies like propulsion are space specific and innovation for these technologies can not be achieved by spin-ins.

1.2 Some comments on spin-offs

This ESPI study report does not focus on spin-offs as such. Spin-offs correspond to the use of space technologies outside the space sector.

During the Apollo programme with its

large funding there was many spin-offs from Space and from the Apollo programme to other fields. These two examples are mentioned, the first mini-computer built with integrated circuits (1964) and the first Database Management System (IBM).

Both NASA and ESA have established Technology Transfer Programme offices which support spin-offs and help transfer space technologies to other sectors. While this is a well received effort supported by ESA Member States, it does not provide any meaningful additional funding for space agencies which then could be used to finance new innovation programmes.

1.3. Some comparisons with U.S. technology

Mainly because of the U.S. Government very large investments in space systems for the military and homeland security needs, the United States have available for their space efforts more advanced components and technologies than Europe. Two examples are shown because of their importance:

- a) For communications satellites the U.S. military through its Spaceway programme has space qualified ASIC (Application Specific Integrated Circuits) components with 0.16 micrometer, 180Mhz clock rate and 7.1 million gates pr ASIC. The most advanced ASIC chips available for European suppliers are U.S. based with 0.65 micrometer, 80Mhz clock rate and 2.7 million gates pr ASIC.
- b) In computer processors the time-gap between the United States and Europe is around 4-5 years for space qualified radiation hardened microprocessors, equivalent to at least 5 times more performance for the U.S. industry.

1.4. Non-dependence for space components

European space industry, for all its most successful space businesses like the Ariane 5 launcher and the communication satellites from Thales Alenia Space and EADS Astrium, are dependent on the use of components only manufactured in the United States, even Galileo depends on the use of U.S. made components. (It needs to be mentioned that Thales Alenia Space has recently put on the market an "International Traffic in Arms Regulations (ITAR) free" communication satellite which is not dependent on any U.S. components.

The May 2007 European Space Policy stresses the need for non-dependence from the U.S. for selected critical components. Such non-dependence is deemed essential for the European space programme to be elaborated in full European autonomy, in particular with regard to strategic decisions and systems and with regard to international cooperation. Furthermore European industry will gain better global market penetration with reduced dependence from controlled export components and equipment. It must however be remembered that the best components and technologies are not always for sale. Therefore when discussing stimulating technology innovation for the space sector in Europe, this must support the gradual improvement in non-dependence of critical space components.³

³ Quote from ESA EUI-AH/5040/MG/EW/AP/ap (Feb 2006): "Non-dependence" refers to the possibility for Europe to have free, unrestricted access to any required space technology. On every European satellite a significant share of components and equipments are procured outside Europe, primarily from the United States, but also from Japan and Israel. US supplied components, parts and equipments are used in all spacecraft subsystems, platform as well as all payloads institutional and commercial. In the 1999 Department of Defence Authorization Bill, the U.S; Congress transferred responsibility for satellite technology to the State Department from the Commerce Department. With this step a number of important exemptions such as Fundamental Research Exclusion under the National Security Directive 189 were abandoned. Virtually all procurements for satellite parts are now subject to the International Traffic in Arms Regulation (ITAR). Affected are members states' national programmes, primes, equipment suppliers, SMEs and universities/institutes.

1.5. Launchers's need for innovation

The need for technology innovation for launchers poses some dilemmas. For the existing European launchers, like Ariane 5 and Soyuz from Kourou, it may be argued that stable production of identical launchers increases reliability, and any change to a well proven design should be avoided (this has *de facto* been the strategy for Soyuz).

On the other side, there is a need for a reignitable second stage for Ariane 5, both for the launching of Galileo and for bringing Geostationary communication satellites directly to their final orbit (instead of a Geostationary Transfer Orbit (GTO) launch as currently only way of using Ariane 5). To make Ariane 5 reignitable is more a question of ESA Member States agreeing to its funding. There is available expertise and technology in Europe to do such an upgrade.

However, there is a major need to reduce the cost of access to space. The current most serious challenge to the strong position of Arianespace with its Ariane 5 dual-launch capability is the Falcon 9 under development by the privately funded company SpaceX in the United States. This development is supported both by NASA and DARPA. It may result in a significant reduction in

Even if an export license is obtained, it may induce costly delays into a project. Prominent examples are the difficulties that Europe faces in the field of electronics components. On a typical ESA satellite programme approximately 60% of the EEE components procurement costs correspond to procurement of components from the USA, about 35% in Europe and the remaining 5% in other countries outside the ESA Member States. This has led the ESA Director General to propose and start the European components initiative (ECI) in 2004. The ultimate objective of this Europeanization activity is to reduce substantially (if not eliminate) the dependence on non-European procurement sources, particularly those that might be subject to United States export restrictions (ITAR Certificate) and for which the availability is not guaranteed. In this context, it is important to note that ITAR is not only limited to space. Electronic components, but it does also mention explicitly components or subassemblies such as propulsion systems, AOCS, antennas, TT&C, cryptography etc.

In this situation, it is therefore clear that not pursuing any actions to correct the dependence situation would lead to a serious loss of competitiveness and effectiveness of the European Space industry.



the cost of access to space. This is particular the case for the U.S. Government which is not allowed to use low-cost launchers from Russia or Ukraine.

The reduction of the cost of access to space requires real innovation, and even more so, the smart use of existing technology. There are two very different

ways to really reduce the cost of access to space, either by investing a lot of money up front for a reusable or partly reusable or refurbishable launcher, or by developing like SpaceX a design which gives a cost, competitive enough for each launcher if more of them are sold. Europe has a lot to loose if it refuses to participate in the competition of reducing the cost of access to space.

2. Key challenges for sustaining technology innovation

Access to technology innovation is vital for space and for space industry to survive and prosper. In this chapter we will discuss how technology innovation is stimulated and funded and look into the future challenges.

2.1. Funding fragmentation

ESPI is aware of the initiative and activities of ESA and Eurospace for a coordinated European space policy within the Technology end-to-end process and the technology harmonisation rounds. ESA also introduced in 2005 the NewPro, responding to the Resolution of the ESA Council at Ministerial level of Berlin in 2005. NewPro is a complement to the current technology programmes of ESA, addressing new aspects such as non-dependence, multiple use, and, introduced in 2007, in-orbit validation. The revised and expanded Newpro is to be presented to the ESA Ministerial Council in November 2008. ESPI has been given full visibility into these activities and key individuals from ESA and Eurospace participated in the ESPI workshop.

This report has a long term focus to reach beyond the next ESA Ministerial, however it hopefully will be of use both in the current planning phase and long-term.

Space technology development in Europe is carried out under contracts financed by ESA, countries, and other public entities (e.g. European Commission, Eumetsat), and is also funded internally by industry:

1. ESA and the major national space agencies (such as CNES, DLR etc.)

have specific programmes devoted to technology development activities. These programmes can be generic (such as ESA's TRP and GSTP programmes) i.e. targeted at developments with potential use with a wide variety of space applications. Together ESA and national agencies budgets for space technology development are in the range of 200 Million euros a year. This represents roughly 5% of ESA expenditure for programmes. The European Commission with the FP7/Space Foundations programme also provides support to technology development for space science, space transportation and space components, with an average budget of 30 million euros a year.

2. The European space industry also invests in technology research and development in particular areas of strategic interest with an annual investment in the range of 150 million euros a year.

The European space companies have their own Research and Technology (R&T) Departments with large number of scientists and engineers which both do in-house development and coordinate collaboration activities with academia and other industrial companies. In the case of large groups with dedicated space units, these R&T centres are fully devoted to space-related developments, but core and common research centres also carry out R&T activities promoting interdisciplinary (e.g. defence and space, aeronautics and space, etc.). Industry does this both in order to stay competitive in their commercial space business, (which in Europe is their largest business) and to be able to successfully bid for the complex missions



ESA and national governments are procuring. According to Eurospace, approximately 1/3 of their total R&T effort budget is funded internally, the rest is funded mostly as part of their contractual work and by access to national and ESA technology funding. Compared to other advanced industries, like IT and telecommunication industries their own funding of 1/3 is very modest.

A main reason for this is, that as seen from a pure business perspective, investing in space business has a very occasional pay back scheme (since most

3. National funding

In most ESA Member States the national Space Agency/Space Office use technology funding programmes to support both their national space ambitions and their space industry. In some medium and small ESA Member States these national funding programmes are the key tool to support their industry in their ability to win ESA contracts and thus allowing the country to reach its fair geographic contribution according to the ESA rules. These programmes are decided nationally, and there is always the risk that several countries will support the same technological development, resulting in government money being used with no business won. ESA is through its Technology Master Plan (ESTMP) and its harmonization activities trying to coordinate such national initiatives, however ESA can not direct a Member State national priority. In particular, the large ESA Member States, France, Germany and Italy use substantial amounts to stimulate space technology innovation in their own countries and use the resulting technology both for their own national programmes and for participating in both ESA and global programmes like the International Space Station (ISS). These large ESA Member States have the choice of whether to support technology innovation through ESA or nationally. Their choices will for example in a significant way influence the ESA NewPro initiative and its total funding.

developments are mission-specific and only seldom are able to support the establishment of a recurrent business), very high barriers to entry and many kinds of risks. This is probably also the main reason for the lack of new entrepreneurial companies entering space business in Europe. In the United States entrepreneurial companies are now challenging the establishment by their development of new launchers, commercial high resolution optical Earth observation satellites and also by giving birth to space tourism.

4. Specific ESA Technology Funding Programmes

ESA probably has the best complete picture of the needs for technology innovation for the future space activities of Europe. ESA works closely with both national Space Agencies and space industry to steer the technology developments in the direction of the total needs and tries to avoid any missing technology elements. ESA has currently at its disposal the following key funding schemes for technology innovation (it must not be forgotten that almost every ESA mission includes a significant amount of technology innovation). (For a more complete picture of ESA programmes with a strong Research and Development component see attachment # 5.)

a) TRP Basic Research Technology Programme

TRP is mandatory and is part of the ESA General Budget. TRP budget for 2008 for industrial contracts is around 42 million euros. The priorities are set by ESA, and its proposals are open for competitive bidding among all Member States. TRP is typically used for long lead technology needs.

b) GSTP General Support and Technology Programme

GSTP is an optional programme; ESA and Member States will typically work closely together to coordinate the use of

ESA Technology Programmes vs. TRL

source: ESA/C/WG-M(2005)7 issue 1,2

TRL	2	3	4	5	6	7	8	9
Programme								
TRP								
CTP								
GSTP								
EOEP								
ARTES								
Galileo								
FLPP								
Aurora								
STEP								
ELIPS								
focus								
potential extension								

this programme. Available funding is approximately 40-50 million euros per year. Some countries will use GSTP as a funding source for its national space ambitions and getting ESA support for such.

c) ARTES Advanced Research for Telecommunication Systems

ARTES is an optional programme with approximately 217 million euros for 2008 budget, out of which around 60 million euros is for technology. Member States and ESA will together coordinate the use of these funds which may be used both for the space segment and the ground segment of a complete satellite communication system. ARTES have played a key role in the success of European Satellite Communication Industry and have significantly contributed to the fact that European Primes are competitive in the market for geostationary communication satellites.

d) FLPP Future Launcher Preparatory Programme

FLPP is also an optional programme, budget for 2008 approximately 89 million euros. ESA and some Member States will in this programme coordinate the technology innovation needed for

next generation launchers.

e) ITI Innovation Triangle Initiative

ITI is a new initiative from ESA providing a fast lane for innovation in space applications. It also opens up for new actors to enter space by bringing the INVENTOR, a DEVELOPER and a CUSTOMER together in a close collaboration supported by ESA.

2.2 Coordination issues

The fact that funding for technology innovation is fragmented implies several challenges. Most of the funding is *de-facto* determined nationally regardless if funding is through ESA or not. Technology innovation which does not have a visible potential or a business case, as seen nationally, therefore runs the risk of not being funded. Examples are development and space qualifying components through spin-ins of available commercial technology which could lead to both lower mass, higher performance, and future lower costs, might not be funded because the business case as seen from the electronic component industry is not attractive.

To illustrate the complexity in the space



industry, a representative from industry stated at the ESPI workshop:

“Space systems are launched with yesterday’s technology for today’s requirements at tomorrow prices.” The timing to introduce new technology is critical, not too early, not too late and knowing the risks involved either way.

2.3. Standardization issues

In commercial businesses, including commercial satellite communication, technology innovation is key to increase competitiveness through typically a combination of higher user value and lower production costs, resulting in more units being sold.

Institutional space business is rather extreme by typically having very few identical units being procured and very high non-recurring costs for the development of the first unit. To make space activities more affordable and thus increase total space business it would make sense to encourage higher production rates of each system or subsystem or even a complete satellite bus or in some cases offering identical satellites for different but missions with some similarity. A good example is the reuse of parts of Mars Express, platform/avionics as well as instruments, for Venus Express stemming from Rosetta, where the cost for this first Rosetta ESA spacecraft was around 230 million euros, and by smart reuse the cost of Venus Express spacecraft was around, 70 million euros.

It is therefore recommended that ESA uses its influence as customer to force some more standardization of spacecraft architecture allowing more common use of subsystems for more missions and using competitive bidding for such subsystems. If ESA had more missions it could promote more systematically reuse approaches at component, equipment and system level, thus achieving a higher level of spending effectiveness and more competitive systems.

Just as an example, almost every spacecraft use a star-tracker as its 3-axis position keeping sensor. The interface between the star-tracker and the spacecraft bus could be standardized and resulting in an incentive to use modern components to reduce size, mass and power consumption, and its development costs could be shared among a much higher number of units compared to today situation where there is no standard interface.

Such more standardized architecture needs to be developed in close coordination with space industry, in particular with the main space companies, however with a final say for ESA. Such standardization should include innovative concepts and a willingness to try new ideas coming from outside of ESA.

3. Key issues on how to foster and stimulate innovation

3.1. The Need for technology maturity and in-orbit demonstrations

Today's most funds associated to technology development programmes in ESA, National agencies and the European Commission, target early stages of technology development (from early concept investigation to breadboard models, i.e. up to TRL 6-7). Later stages of development (all validation and demonstration phases, where less innovation occurs and higher costs are incurred) are still insufficiently covered. As a result, European space applications (the programmes) are often required to support the additional development and validation costs, or to choose risking the implementation of unproven technologies, or accept de facto dependence situations from non-European sources (and the associated regulatory risk). The ESA NewPro has as one of its key objectives to fill the "TRL-gap". We support this and hopefully NewPro will be able to close the gap between TRP funded activities and the need to reach a reasonable TRL level (5-6).

An important step of the space innovation cycle is the in-orbit test and validation phase, where new components, sensors, subsystems or even more complete assemblies are eventually qualified for use in space. In order for innovative technologies to be actually used, both space agencies and space industry will require both testing and space qualification to include actually flying in space of the hardware involved. To use dedicated launchers for such in-orbit testing is very expensive and in Europe almost never done.

In this report we propose that the ESA programme EGAS, European Guaranteed Access to Space, which provides Arianespace with yearly funding to allow Arianespace to better compete with Russian/Ukrainian launchers for the commercial launch services market of communication satellites to GTO (Geostationary Transfer Orbit), is amended to include a piggy back opportunity for space qualifying of hardware.

The marginal cost for Arianespace for providing such a service is very low compared to a dedicated small launcher. Arianespace may therefore as an act of goodwill to ESA and its Member States who fund EGAS, either provide such piggy back test flights for free or at its marginal production cost and without any profit.

Such piggy back test flights could be flown frequently and allow much shorter delays for space qualifications of important space innovation technologies. It is worth mentioning that such an arrangement existed for Ariane 4. This was called ASAP (Ariane Structure for Auxiliary Payloads) and permitted up to 50 kg of piggy-back load on what was called "A children ticket price" of 500.000 euros to be shared among the number of small satellites. With 6 satellites as used on one of the Ariane 4 missions, the cost for each was less than 100.000 euros.

The author has learned that Arianespace also for Ariane 5 offers the A5 ASAP, however at a price of 5 million euros for a payload of 50 to 150kg.



3.2 Using Prizes to stimulate Innovation

Prizes to stimulate innovation and exploration have a long history starting with the "Longitude" Prize from 1714 and Prizes which helped advance both the automobile and airplane at the beginning of the 20th century. Prizes may provide significant stimulation to innovation, helped in many cases by bringing in new actors.

Probably the most influential space related prize is the Ansari X-Prize won by Mojave Aerospace Ventures (Burt Rutan and his partners) for the successful, twice within 14 days, of manned rocket flight to more than 100 km altitude. It was really this Prize which gave birth to space tourism. The winners Burt Rutan and his financial backer Paul Allen from Microsoft invested around 27 million U.S. dollars to win the 10 million U.S. dollars purse of the Ansari X-Prize. NASA and the U.S. Air Force cost models have estimated that if the development of Space Ship One were performed under typical contractual arrangement, it would have cost the U.S. Government between 600 million and 1300 million U.S. dollars. (Some would argue that the safety considerations might be different if this was a Government financed development).

The use of Prizes to stimulate innovation was discussed at the ESPI workshop, it was agreed that using Prizes to stimulate innovation would be a recommended supplement to the existing innovation stimuli, but cannot be seen as a driving force by itself.

It was recommended that the target for such Prizes would not be the large space companies, but a combination of risk willing entrepreneurial companies and universities/research institutes. For the on-going prizes, such as the recently announced Google Lunar X-Prize, several European groups are participating, typically involving young people at universities and often able to secure additional funding from outside the university. Small and Medium size

companies have also demonstrated interested in such alternative way of financing R&D activities with limited cost of entry and little bureaucracy .

The ideal situation would be to have large Prizes, in 1-5 million euros range, and coming from European wealthy philanthropists with support from ESA, as a tool to increase Europe's competitiveness, and eager to see major changes and new businesses arising based upon their offering of a Prize to stimulate entrepreneurship and creativity.

A major benefit with use of Prizes is their ability to give the smartest engineers and scientists real hands-on experience and thus becoming an important recruitment tool for attracting young talent to space.

In Attachment # 3 is shown the viewgraphs from the workshop at ESPI prepared and presented by Nicolas Peter Research Fellow at ESPI that worked in 2006 with the X Prize foundation on a study for NASA leading ultimately to the Google Lunar X-Prize announced in September 2007.

The author would like to propose the following challenge for an ESA sponsored Prize related to combining these 3 challenges:

1. Close distance formation flying
2. Fully automatic docking in orbit
3. Use of current COTS computers and mobile phones in space to test if they work, or how long they function.

With a reference to a previous study by the same author: "Commercialization of space and its evolution; will new ways to share risks and benefits open up a much larger space market? And by taking an idea from the current Apple laptop computer, the MacBook, with its magnetic connector to its power cord to connect power, this is the proposed Prize winning challenge:

Demonstrate close distance formation flying by two objects, and demonstrate that one object can be

able to provide power to the other. These two objects to use modified COTS units, including either an Apple MacBook computer with its magnetically connected power cord in the one object or any other equivalent suitable computer, and a solar panel unit attached to a mobile phone with Bluetooth, WiFi or WiMax communication as part of the other object.

It is left to the award seekers to seek possible collaboration, including grants, from the mobile phone industry and/or from the computer manufacturers. If desired the challenge could be much less demanding by allowing a tether connecting the two objects limiting the maximum distance between the two objects to the length of the tether which could be the maximum distance for Bluetooth, WiFi or WiMax communication. This challenge is ideal for testing on the ground.

3.3. A European DARPA

At the ESPI workshop a brief introduction of DARPA (Defense Advanced Research Projects Agency of the US Department of Defense) was given in form of viewgraphs prepared and presented by Ms Charlotte Mathieu, now at ESPI, who worked with DARPA for 2 years. These viewgraphs are found in attachment 4.

DARPA's mission is radical innovation for national security.

However, DARPA is not only about funding, it is also about:

- the ability to create multi-disciplinary teams with people from academia, industry and large research laboratories
- easier financial and contractual procedures
- very focused in terms of mission
- very user-oriented with close relationships with users
- failure and risk acceptance

DARPA is also multi-disciplinary in terms of activities, not only space, and they do benefit from this cross-fertilization effect and their systems tend to be integrated with other non-space-based systems.

During the workshop, it was discussed whether there is a need for radical innovation, as opposed to incremental innovation, for space in Europe and therefore a need to fund high-risk, high-reward research. The relevance of setting up an organization like DARPA was then discussed.

Would such an institution be of strategic importance, as it is in the United States?

The workshop participants were somewhat reluctant to the radical innovation strategy which is a major priority for DARPA. In Europe incremental innovation and spin-ins seems to be preferred. This is cheaper, less risky and acceptable by the customers.

DARPA is another example of the huge difference between the United States and Europe as regards funding available for technological innovation. The yearly DARPA budget is more than 3 billion U.S. dollars and as such completely impossible to envisage for Europe.

There was a clear consensus at the ESPI workshop that the practical way for Europe to increase funding for technological innovation for space and to get some of the benefits which DARPA provides to the United States, like developing complete new launchers (Falcon family of launchers from Space-X) and in-orbit demonstration of new satellites and new subsystems, would be to further strengthen the existing technology innovation stimuli at ESA, including the creation of a new programme dedicated to radical innovation and to encourage further collaboration and partnership between ESA and EC.

It was felt that for example a "DARPA light" new programme funded and managed by EC would most likely lack the very close coordination with ESA that would be needed, and therefore such new initiative is not recommended. Any contribution from the EC should be based upon a partnership with ESA and coordinated.



DARPA is financed by the US DoD, and its large budget is based upon its potential impact on U.S. Military and Homeland Security needs. If the European Defence Agency (EDA) should decide to have a DARPA Light type activity, it is again recommended that its space element is to be coordinated with ESA. ESA has the best understanding of which technologies is most needed for European space activities, and these needs are basically the same for the pure military and security needs as for the advanced ESA Earth Observation or Science missions.

3.4. Importance of globally competitive European space systems and industrial supply chain

Technology and innovation: at the core of industry competitiveness

The space sector is highly dependent on technology, and given the high technological constraints of space systems the European space industry is one of the most RTD-intensive sectors in Europe. RTD is carried out under contracts financed by ESA, countries, and third parties (e.g. European Union, Eumetsat), and is also funded internally.

In space, technology is a critical essential dimensioning factor. Since operational space programmes require proven technology for implementation, technology evolution and validation programmes are an essential enabling factor for new space applications.

Space technology cycles are longer than the average high-tech cycles. From concept validation to actual implementation, climbing the 9 levels of the technology readiness scale to reach full qualification in orbit may take, in some cases, 10 years and more. This implies very high technical risks that the private sector cannot bear alone, especially since most of the technological

developments are driven by the requirements of institutional customers.

Space technology and innovation are at the core of the sector competitiveness, with state-of-the-art systems being at the edge of market penetration and customer requirements.

Competitiveness and market penetration

The satellite communication market with its geostationary satellites is the largest civilian market for satellites. It is commercial, global and highly competitive and provides also the largest market for the large launchers to take these heavy (2.5-6 tonnes) satellites to their final orbit.

The two European Primes Thales Alenia Space and EADS Astrium compete mainly with the United States based Primes Boeing, Lockheed Martin, Space Systems/Loral and Orbital Sciences. These two European Primes have in the past been competitive and together hold more than 50% of the non-military order book for geostationary communication satellites.

In contrast to the U.S. industry who benefits from large advanced technologies developments funding from the DoD, The European industry has developed its capabilities in the satcom area mainly through its participation to civil co-funded technology demonstrator programmes (e.g. the ESA Alphabus programme for platform development). The increasing share of commercial market-driven developments (in the broadband and mobile domains particularly) led to a re-assessment of civil programmes in the satcom domain, with the increase of co-funding mechanism, such as implemented in the ESA ARTES 3, 4 & 8 programmes. As a result, the existence of a sizeable and addressable market for any new technology is an essential pre-requisite for developments to occur. Otherwise, European companies likely chose to procure commercial technologies, often

imported from the United States. U.S. solutions (in the processor, antenna, optical technologies for example) are all covered by ITAR and generate dependence. A dependence level that can be acceptable to serve commercial customers, but that may be felt very differently by the military.

In the launch services market European companies have been doing very well too. The European Launcher company Arianespace with its Ariane-5 (soon to be complemented with Soyuz from Kourou and Vega) has more than 50 % of the global launcher market for communication satellites.

Even with the current strength of the euro versus the U.S. dollar (from 0.80 to 1.47 (84%) since the Euro replaced some national currencies in Europe) and the strong support from the U.S. DoD for technological development for their next generation satellites, the European Primes are able to compete.

It is very important that European systems are able to be globally competitive on the commercial market. If this no longer would be the case, the lack of competitiveness and loss of business would have a devastating effect on all European space activities. The cost of the complex ESA science and Earth observation missions would be much higher with fewer satellites to cover all the necessary fixed costs of the industrial sector. This could result in a negative spiral with fewer institutional satellites being procured at even higher costs.

All European programmes, ESA, EC and national to stimulate technological innovation must therefore also support the future competitiveness of the European supply chain for the commercial market.



4. The relationship between Space industry and Academia

In most European countries there is a good working relationship between academic institutions like universities and research institutes and space industry. It has been argued that such good working relationship only applies to the small portion of the academic world which may be regarded as being part of the space family (or Space Cluster), and thus in some ways isolating parts of the academic world.

This theme was discussed at the ESPI workshop and it can be observed that the relationship between the academic world and space activities is different in each European country depending among other things on variation in academic funding, academic culture and the relationships built up over time. The representatives from the two large European Primes (Thales Alenia Space and EADS Astrium) strongly argued that both in its recruitment policy and in seeking academic collaboration it was important to reach all of academia, and not only those used to work on space related matters.

The funding for space related academic work is limited in all European countries, and therefore those academic institutions which have established a partnership with space industry sometimes would like to keep potential new funding to themselves, and do not open up for widening of space academia. Probably this is a significant barrier for new academic players to enter into space related work.

For the ESA science missions there is a long tradition of involving universities and research institutes in a major way in providing instruments and sensors for the spacecraft and to receive the data from which the science will be done. This deep involvement has not resulted in

much entrepreneurial efforts and not many companies being founded due to such involvement of a highly technical nature. Only in the UK, through the pioneering efforts of Sir Martin Sweeting and his team, have a university been able to create a significant space industrial company, Surrey Satellite Technology Limited (SSTL). SSTL, owned mainly by the university and SSTL management has around 200 employees, and has become a global leader in small Earth observation satellites. The Technical University of Berlin and the University of Stuttgart also have developed on its own small, very capable satellites, however no industrial activity outside the University has developed. In the United States universities like the Massachusetts Institute of Technology (MIT), the University of California in Los Angeles (UCLA), the California Institute of Technology (Caltech) and the John Hopkins University all have very large roles in NASA and other U.S. space missions.

It would be very advantageous for innovation in the space sector if more would follow the example of Surrey University, and support the creation of commercial activities organized as companies. It would also help if ESA and national space Agencies would be willing to give the best universities a larger role outside the science program.

ESA noted the gaps and set up the Networking and Partnering initiative with Universities and Industry to co-sponsor PhD research. This initiative started three years ago and the number of scientists and engineers involved is growing.

A separate ESPI study is planned for 2008 called "Improving and benefiting

from the relationship between basic science and space industry". Because of this planned new study this report is limited to technology innovation and the role of academic institutions in such.

To improve and benefit from the full potential of academia in technology innovation, it is strongly recommended that initiatives for closer collaboration should come mainly from space industry and from space agencies, including ESA.



5. Recruitment and Generation Change issues (succession planning)

In the beginning of space activities 50 years ago, space was enormously attractive for young students. As just an example, it was the dream and desire of the author of this report, and after listening to Yuri Gagarin who visited his University, to seek space job opportunities in the United States, preferably in the Apollo programme. This did not happen, however a large number of young engineers and scientists entered space in the 1960's and early 1970's and are now reaching their retirement age. This is creating a challenge both for the space industry and for space agencies when they need to replace very senior and very experienced staff with new recruits. This is both a challenge and an opportunity. The latter coming from the fact that new recruits with a more recent education, will bring with them new knowledge and new methods of working. Often they are more trained and better prepared in the use of advanced Information Technology products, including simulation and advanced design methods. The recommended way is to have sufficient overlap between the really experienced staff nearing retirement age and allowing the young ones to work closely with the most experienced (and often bypassing some hierarchical levels in between).

One should not underestimate the capabilities of the young ones, compare the average age of those who made Apollo moon landing possible with the average age of let us say the Aurora programme of ESA.

The real challenge in recruiting for space is that the smartest candidates from higher education are too often more attracted by working in the City of London for financial institutions as opposed working with space matters at ESA ESTEC.

The author believes that by far the best way to make space jobs attractive for the best future space engineers and scientists is to give them as early as possible true hands-on experience with space activities. It is therefore strongly recommended to continue and enlarge activities related to student satellites, to Young Engineers Satellite (almost 500 students participated on their latest tether experiment satellite YES2), to student rockets and to national or international space camps, or any activity which will lead their attention to space when they are young, and the younger the better.

Annex 1



Participants list

ESPI Workshop

“Stimulating and sustaining technology innovation in the space sector.”

on 19 October 2007 from 09:00 to 16:00.

Organism	Name
NSC	Mr. Geir Hovmork
Finland, Department of Industry	Mr. Antti Joensuu
Thales Alenia Space	Mr. Erick Lansard
The Netherlands, Department of Economic Affairs	Mr. Johan Lindeman
Eurospace	Mr. Pierre Lionnet
Tecnalia Aerospace	Mr. Jesus Marcos
ESPI	Mrs. Charlotte Mathieu
EADS Astrium	Mrs. Marie-Catherine Palau
BNSC	Mr. Andy Payne
ESPI	Mr. Nicolas Peter
Thales Alenia Space	Mr. Jean Portier
FFG	Mr. Harald Posch
Galileo Avionica	Mr. Giampaolo Preti
ESPI	Mr. Kai-Uwe Schrogl
EADS Astrium	Mr. Eberhard Schulz-Luepertz
QinetiQ	Mr. Robert Scott
ESPI	Mr. Rolf Skaar
ESA	Mr. Alberto Tobias



Annex 2



European Space Policy Institute

Vienna, 10 October 2007
ESPI (2007)#449 RS/svds

Invitation to a workshop

Title: “Stimulating and sustaining technology innovation in the space sector.”
(P 14)

I. Dates and schedule:

The date is 19 October 2007, starting 09:00 and finishing at around 16:00.

II. Venue:

The venue for the workshop will be at ESPI premises in the centre of Vienna, Austria.

III. Participants:

around 16 (15-17) participants/experts coming from

- i) the main users and also providers of technology innovation like space industry and space applications industry,
- ii) the innovation creators like Universities/Research Institutes and highly innovative smaller organizations,
- iii) organisations facilitating and funding innovation like Space Agencies and Government Innovation Agencies.

IV. Foreseen topics:

The preliminary topics currently foreseen to be dealt with:

- Challenges for increased technology innovation in space
- New funding mechanisms of activities to stimulate innovation in space
- Diffusion of innovation. Is the Space Cluster in industry and academia too isolated and thereby limiting diffusion of new ideas and entry of new companies?
- Succession planning, recruitment and generation change issues

Please note that there might be changes reflecting the discussions at the beginning of the workshop.

V. Workshop format and programme :

The format of the workshop is a round table of experts, each participant sitting around a horseshoe shaped table with access to presentation and IT infrastructure on the spot.

The workshop programme:

- Welcome by SG of ESPI Prof Dr Kai-Uwe Schrogl
- Introduction by the ESPI project leader, Mr. Rolf Skaar, describing the purpose of the study as well as the purpose of the workshop and the desired output.
- Presentation of the workshop program with the blocks of key subjects involved.
- Discussion on proposed workshop format by the participants
- For each subject there will be a brief introduction either by the ESPI team or by some of the participants which have been asked beforehand to give such an introduction.
- Each topic is to be introduced (ESPI team or participant) and discussed one by one by the experts/participants (no parallel subgroups foreseen)
- Each topic might also be subject of presentations by the participants (Presentation infrastructure on the spot, just USB key needed), to further enhance the spontaneous discussion.
- Each topic will be ended by a brainstorming through a previously agreed “rapporteur” which will give a brief summary of the most important observations and conclusions

The more detailed programme is as follows:

- **Challenges for increased technology innovation in space.**
Space Agencies and space industry are conservative and do everything they can to avoid failures. They will normally only fly already space qualified components and systems. This has led to a time gap between the technologies available for space and the ones available for other commercial markets. For the very fast changing technologies like computers and other electronic components the time gap results in a major handicap for space systems compared to non-space systems. It is proposed to brainstorm on how to mitigate this situation and the following ideas are put forward:
 1. Increasing the funding for space qualifying of critical components needed for many space systems.
 2. Smart use of COTS. Can highly redundant system design combined with screening and shielding of COTS components reduce this time gap and allow space systems to reliably use modern commercial components?
 3. Making more space flights available for qualifying components and subsystems.
 4. Increasing the use of spin-ins and facilitate such spin-ins from the non-space sector.
- **New funding mechanisms of activities to stimulate innovation in space.**
There is a large gap between the US and Europe both in funding and in available funding mechanisms to stimulate technology innovation in space. It can also be argued that innovation for space does not necessarily have to be expensive and risky. It is proposed to brainstorm on ways to improve the situation and the following ideas have been put forward:
 1. Is there a need also in Europe for high-risk, high-reward type funding for space innovative concepts and technologies (for example modeled after DARPA, the US Defense Advanced Research Projects Agency)? If so, where should it belong? (EC, EDA (Europe Defense Agency) or ESA). A brief introduction of how DARPA works will be given by an ESPI staff member who used to work for DARPA.
 2. Should ESA prepare for its next Ministerial Council a proposal for a dedicated Technology Innovation Programme? This could for example provide some of the benefits DARPA gives to the US. What should be the activities in such a possible programme? Both ESA and Eurospace are involved in such early planning of a candidate for this and their work will be briefly presented.



3. Should also Europe use prize awards (like for example the Anzari prize or the Google Moon prize) to stimulate innovation? Who should be the sponsors? Who would be eligible?
- **Diffusion of Innovation. Is the Space Cluster in industry and academia too isolated and thereby limiting diffusion of new ideas and entry of new companies?**
Space activities typically involve both academia (Universities and Research Institutes) and industry (Primes, sub primes and SME's). Over the years strong relations have been developed with selected academic institutions and space industry forming a kind of a Space Cluster. It is proposed to brainstorm on whether the current structure is optimal and if not, how could it be improved? Some topics to discuss:
 1. Is the diffusion of new ideas at the academic level between space and non-space good enough?
 2. Are space-related academic works open enough for new entrants and new ideas?
 3. Is the current industrial structure in space industry too closed and thereby limiting access for new companies with other ideas?
 - **Succession planning, recruitment and generation change issues.**
Have space lost its ability to attract the best and the brightest young students? How to cope with the succession planning of retiring experienced engineers and scientists? How to renew the attractiveness for space in the engineering and scientific population?

VI. Participation and conditions

Each invited participant is assumed to take charge for his travel and accommodation (special rates by ESPI possible) through his sending entity/employer.

ESPI will provide lunch on 19 October 2007; coffee & cookies during breaks, for those participants arriving before 20:00 on Thursday October 18th, a welcome and get-to-know dinner will be arranged.

If you need assistance with hotel bookings, please contact ESPI through:

segolene.vandensteen@espi.or.at

Kind regards,

Rolf Skaar

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ANNEX 3

ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
"Inducement prizes to foster space technology achievements and breakthroughs in Europe: Challenges and Opportunities" Nicolas PETER

ESPI
European Space Policy Institute

Inducement prizes to foster space technology achievements and breakthroughs in Europe: Challenges and Opportunities

Nicolas PETER
Research Fellow ESPI

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ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
"Inducement prizes to foster space technology achievements and breakthroughs in Europe: Challenges and Opportunities" Nicolas PETER

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Outline

- Background
- Prominent technology prizes for technological innovation
- Space prizes
- Harnessing the power of prizes in Europe
- Questions to be considered

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ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
"Inducement prizes to foster space technology achievements and breakthroughs in Europe: Challenges and Opportunities" Nicolas PETER

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Background

- What is an inducement prize?
 - Mechanism that specify a **desired outcome** and a **cash prize reward** for obtaining it in order to **incentivise innovation**. The prize is awarded to a team or individual meeting the **criteria set out in the initial prize offering**
 - Distinction between **objective-specific prizes** and **competition prizes**
- Inducement prizes have **several comparative strengths** when compared with **traditional public policy instruments**:
 - Ability to **attract a broader spectrum of participants and ideas** by **reducing the costs** and other **bureaucratic barriers to participation** by individuals or firms
 - Identify and **engage non-traditional participants** in industry, academia and the "public", as well as **unorthodox approaches** to challenges (tap into the hitherto **neglected intellectual capital**)
 - Stimulate **nascent** or "**stalled**" technologies
 - Address **neglected** or seemingly intractable **societal problems** (human ingenuity is bottomless)
 - Potential for **leveraging the financial resources** of sponsors
 - Capability for **educating, inspiring** with respect to particular scientific, technological and societal objectives

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* "New products, business process and organic changes that create wealth or social welfare" - OECD

ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
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Prominent technology prizes for technological innovation

- 1714 Longitude Prize
- 1775 Alkali Prize
- 1795 Napoleon's Food Preservation Prize
- 1823 Turbine Prize
- 1895 Chicago Times-Herald Prize for Motors
- 1900 Deutsche Prize
- 1909 English Channel Crossing Prize
- 1909 Rheims Airshow Prizes
- 1910 Milan Committee Prize
- 1913 Daily Mail Trans-Atlantic Prize
- 1919 Orteig Prize
- 1948 Wolfskehl Prize
- 1959 Feynman Prizes
- 1959 Kremer Prizes
- 1997 Budweiser Challenge
- 2000 Goldcorp Challenge
- 2003 DARPA Grand Challenge
- 2005 Gainger Challenges

Geodesy-related prize
Chemistry-related prize
Food industry-related prize
Automotive-related prize
Engine-related prize
Aviation-related prize
Mathematics-related prize
Natural resources-related prize

Widespread application of prizes


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ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
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Space prizes

- Centennial Challenges is NASA's programme on prize contests to stimulate innovation and competition in **solar exploration** and **on-going NASA mission areas**
- Established in 2004



Current NASA Centennial Challenges programmes

- Astronaut Glove Challenge \$400 K - purse won in 2007 \$200K
- Beam Power Challenge \$500 K – 1 German and Spanish team
- Lunar Lander Challenge \$2M
- MoonRox Challenge \$1M
- Personal Air Vehicle Challenge \$300K - purse won in 2007 \$250K
- Regolith Excavation Challenge \$750 K
- Tether Challenge \$500 K

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ESPI Workshop "Stimulating and sustaining technology innovation in the space sector" 19 October 2007
"Inducement prizes to foster space technology achievements and breakthroughs in Europe: Challenges and Opportunities" Nicolas PETER

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Space prizes

- The X PRIZE Foundation creates and manages prizes
- Established in 1996



Ansari X PRIZE - \$10 M prize won by Mojave Aerospace Ventures

- 26 teams from 7 countries (with a few others that pulled out along the way) 3 from Europe (2 teams from the UK, 1 from Romania)
- Winning team spent about \$27M
- All teams together spent between \$100M and \$150M
- NASA / USAF cost models for "SpaceShipOne" type development programme range between \$600M and \$1.3 billion

Google Lunar X PRIZE - \$30 M in incentives

Within first month (September) received:

- 260 requests for registration of the first 175 potential teams to submit a request for registration material AND indicate what country they are from, 30 came from Europe (not counting ESA partners like Canada).
- Requests from: Belgium, Finland, France, Germany, Greece, Italy, the Netherlands, Poland, Romania, Spain, Sweden, UK, Ukraine
- 9 Letters of Intent (with fee) - 3 from Europe (Romania, UK, Italy)
- Teams submitting Letter of Intent expect to spend much more than the prize purse (~\$100M)



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Harnessing the power of prizes in Europe

- Prizes can **complement government's** existing **approaches** to **inducing innovation** such as procurement contracts and peer-reviewed grants etc.
 - Inducement prizes **cannot substitute** for robust **long-term funding**
- Contest rules should be **simple, fair** and **unbiased** etc.
 - Procurement policy problem in Europe (i.e. geo/fair-return Vs EU or national procurement rules)
- Promote **European sponsored prize** programme would allow a **paradigm shift** as winners will be **determined by actual achievements not proposals!**
 - Don't pick the winner
- Prizes can **increase Europe's competitiveness** and can help to cross/leapfrog the "Valley of Death" of innovation
- An **old idea whose time has come again for Europe!**
 - Proven European interests for space prizes

Questions for debate


- What type of prize?
 - Target
 - The current European industrial base and/or the future space entrepreneurs?
 - Education oriented – Universities and/or general public?
 - Goals
 - Add **technology breakthroughs**
 - Utilitarian orientation – climate change?
 - Inspirational orientation – space exploration?
 - Would should initiate it?
 - Space agencies?
 - Foundations or venture philanthropists?
 - Size of the purse?
 - Hundred thousands of euros?
 - Millions of euros?

ANNEX 4

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"DARPA", Charlotte Mathieu

The Defense Advanced Research Projects Agency (DARPA)



Charlotte Mathieu
Research Fellow - ESPI

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DARPA

- The central R&D organization of the US DoD
- Founded in 1958 in response to Sputnik
- Original mission
To prevent technological surprise
- Today's mission
*Radical innovation for national security
Turning innovations in technology into new military capabilities*

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Strategy

Priority

- Flexibility and ability to quickly exploit emerging situations and new opportunities

Strategy

- Constantly searching worldwide for revolutionary high-payoff ideas (i.e. finding great ideas upon which to build new programs)
- And then sponsoring projects that bridge the gap between fundamental discoveries and the provision of new military capabilities

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Operations

- Large budget - *3.1 billion dollars in 2007*
- Flexible and responsive structure and decision-making process
- Small organisation with flat structure
 - 240 people (incl. 140 scientists and engineers)
 - One level of management between the director and program managers
- Highly flexible contracting and hiring practices

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Entrepreneurial environment (1)

- No permanent technical workforce
- Program managers (PMs) hired for 4-6 years
 - => *Constantly bringing new ideas*
 - => *Minimizing institutional interests*
 - => *PMs are willing to pursue high-risk technical ideas*

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Entrepreneurial environment (2)

- Proactive PMs with the goal of developing a new capability
- PMs have both technical and fiscal flexibility
- PMs can decide to fund studies (or "seedlings") as initial research to determine if a more formal program is appropriate
- Regular review processes - performance rewarded with increased funding

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An investment agency

- Not a R&D lab - No facilities and very limited overhead
- Invests 97% of its funds outside of the agency
- Contracts with industry, laboratories and universities to accomplish its work
- Combines investment in basic and applied research with investment in development and demonstration
- Set of very strict investment criteria – Seven questions
- Adaptation of the Agency's portfolio of investments with changing military needs and technological advances

Multidisciplinary

- Multidisciplinary projects
- Multidisciplinary agency – Open to new fields of activity
- Facilitated by the flexibility of the Agency's structure and the diversity of background of the PMs coming from industry and academia
- Accomplished through the teaming of universities, laboratories, small businesses, large industry, etc.

User-oriented R&D

- Very strong connection with the user community
- Tight feedback loop between technology developers and technology users
- PMs need to ensure a market pull for their technology
- Methods developed to transition technologies to the warfighter depending on the technology

ANNEX 5

The following table provides summary information on the ESA programmes with a strong R&D component:

<i>Programme</i>	<i>Objectives</i>
TRP	The Basic Technology Research Programme provides technologies of potential interest for all the ESA Programmes, assuring long-term technical capabilities. TRP focussing on research and feasibility demonstration. Mission specific technology elements are covered by the dedicated technology activities of Optional Programmes.
GSTP	The General Studies Technology Programme provides technologies of potential interest for all the ESA Programmes, bridging the gap to user programmes, developing generic cross-cutting technologies, elements for scientific experiments and pilot projects. GSTP also might cover themes not supported by other optional programmes, e.g. activities in the field of Reusable Space Transportation and Atmospheric Re-entry Technologies are performed in the GSTP ITE (Interim Technology Effort). Contracts may also be awarded on the basis of co-funding by Industry awarded on the basis of co-funding by Industry up to a maximum of 50%, especially in case of market oriented activities.
CTP	The Science Technology Programme CTP is dedicated to critical development technology activities of scientific missions, aiming at developing engineering models tested in relevant environment.
EOEP	The Earth Observation Envelope Programme has a development and exploitation component covering pre-development of technology, in particular technology instrument elements specific to Earth Observation.
ARTES	The ARTES Programme includes a line of Satellite Telecommunication Products Development to maintain competitiveness and innovation at supplier level. ARTES-1 supports preparatory activities to grow the knowledge base. ARTES-3 continues developments in the field of application and equipment for multimedia satellite communications. ARTES-4 is a programme element in support to specific precompetitive development of equipment and products. ARTES-5 covers the early stages of development of new and promising technologies, once specific opportunities have been identified. ARTES-8 includes all activities related to the definition of a large platform mission. Contracts under ARTES-3 and -4 coverage are awarded on the basis of 50% co-funding by the Contractors.
GalileoSat	Some user equipment and application developments have been initiated in the GalileoSat programme, as the tight programmatic aspects of the Galileo Project did not allow for early technology developments in a preparatory technology programme of the Application Directorate.
ELIPS	The objective of programme is to achieve scientific results in the area of Life and Physical Science and applications, as part of the International Space Station ISS exploitation: ELIPS includes also other carriers, e.g. sounding rockets and unmanned orbital elements, for the execution of the experiments.
STEP	The objective of STEP is the improvement of existing ISS services, the reduction of the ISS operational costs and the preparation of future infrastructure capabilities.
FLPP	Addresses system studies and technology developments for the Next Generation Launcher (reusable or expandable) and the evolutions of current European launch vehicles. Situation as of June 2003: Member States approved initiation of the new programme with a financial envelope of € 24 million. Subscription is open until the end of the year.
Aurora	The programme is set to pave the way for human exploration of Mars, the Moon and the Asteroids. The exploration will be conducted starting in 2005 with robotic in-situ exploration and sample return and leading to the decision in 2015 to proceed with an international mission to land a human crew on Mars by 2025-2030.
PRODEX	The PROgramme de Développement d'EXperiences scientifique is dedicated to the development of flight hardware elements for scientific instruments or experiments dedicated to Science, Life and Material Science and Earth Observation, which exceed the TRL 4 or 5 considered in this document. The budget is assigned upon identification of appropriate flight opportunity: therefore, the flight hardware development activities start with the Phase B.

source: ESA



Mission Statement of ESPI

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

Through its activities, ESPI contributes to facilitate the decision-making process, increasing awareness on space technologies and applications with the user communities, opinion leaders and the public at large, and supporting students and researchers in their space-related work.

To fulfil these objectives, the Institute supports a network of experts and centres of excellence working with ESPI in-house analysts.

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