ISOLATION OF SPACE RESEARCH FROM SPACE INDUSTRY

HOW TO IMPROVE THE RELATIONSHIP BETWEEN BROADER BASIC SCIENCE AND THE SPACE INDUSTRY

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Executive Summary

This study investigates the relationship between academia and the space industry. It responds to the question of whether there is a gap between the two actors and how the relationship can be deepened. The study has been prepared with the support of a team of European experts providing insights from different sectors and perspectives.

A strong and close relationship between academia and the space industry is important for the European space endeavour. This relation is crucial for industry to access innovative ideas and technologies originating from academia that can enhance their international competitiveness. Furthermore, it creates visibility for the universities' research and promotes the capacities of the European science community as a whole.

In this study, the authors did not find any systematic isolation between academia and the space industry. What has changed is the attitude of industry and its willingness to cooperate, and also to apply jointly with academia for public funding. This can be explained by the fact that the space industry has now become technologically much stronger and the largest companies are less in need of close relationships with academic institutions for ongoing business.

Small and medium-sized enterprises (SMEs) are often more in need of close cooperation with academia and many of them therefore have a good working relationship. Today, there are signs that also the large space companies now realize that they stand to benefit from closer partnerships with academic institutions.

As regards such relationships for the science-driven programmes, the ESA mandatory science programme, the programme on earth observation and meteorology provide favourable preconditions. They successfully link the interests of the science community with the needs of industry. We find the relationship excellent, with mutual trust and mutual dependence and clearly respected roles.

The challenge is to increase collaboration for the more commercial and industrially-motivated (non-science driven) space activities like launchers and applications. The authors believe that most ESA member states decide on funding more under the influence of industrial policy and the intention to secure roles for the national industries without looking at the interests of academia. Such policies reduce the potential for stronger links between the space industry and academia.

It is strongly recommended to strengthen the ties and opportunities for cooperation between academia and the space industry. The goal should be to strive for an equally good and mutually beneficial relationship with the industry-driven space activities as well as with science-driven activities.

Our main recommendations are further detailed in the report and may be summarized as follows:

- ESA and its member states should fund the NewPro (New Technology Programme to be decided by ESA Ministerial Council) initiative and use this to intensify the partnership between industry and academia for the advanced technologies needed for future space missions.
- ESA, together with the EU and in close coordination with national funding agencies, should encourage and provide funds for programmes and activities which will create a better partnership between the space industry and academic institutions.
- Such coordination should lead to less duplication and a more effective use of public funds.
- ESA has the genuine competence to lead such coordination efforts due to its long experience and also its knowledge of the total space efforts both within Europe and globally. However, it must work very closely together with the space industry, academic institutions and the national organisations during such coordination efforts.

- The authors believe the most efficient way for industry to reap the benefits of a close relationship with world-class academic institutions is joint research activities. Challenging research should be undertaken at the academic facility with teams composed of senior academic researchers supplemented by industry sending its young and most promising technical staff to participate hands-on in such research. This secondment of industrial staff should last long enough, minimum one year, to allow for the research results achieved to be brought back to the company.
- Industry itself should build up stronger ties to universities by supporting and funding PhD students. The research topic is to be defined in cooperation by the academic institution and the industrial company providing the funding and should reflect mutual interests.
- ESA should strive to include new academic actors. Incentives for a stronger engagement of academia could be programmes to develop more forward-looking technologies, including non-space research. Appealing projects are needed to create the spin-ins necessary for sustainable development of the ESA programmes. Such efforts could help to attract bright young people from different scientific backgrounds.
- Most often, the national support of space industry only moderately considers the interests of academic institutions. Such a splitting of responsibilities prevents cross-fertilization and should be avoided.
- The development of personal relationships and mutual trust is a major factor of cooperation. Contacts among the interested actors (industry and academia) could be established through already existing platforms, such as the European Space Science Committee of the European Science Foundation (ESSC-ESF), the International Astronautical Congress (IAC) or the Committee of Space Research (COSPAR).
- Additionally, professional contact units on the university side are a good means to promote expertise and experience.
- The establishment of truly European world-class universities is a recommended way forward.
- Academia should be attracted by low-cost, high-risk missions to test and use new technologies. Such missions should be supported by government agencies.
- The sensitivity regarding intellectual property rights in industry-university cooperation should be softened by non-disclosure agreements to underline the need for responsible behaviour.

The study includes an investigation of space research funding both at the supranational level and national level. It also includes a description of several national activities and the roles of ESA and EU. Supportive structures for industry-science cooperation have been established as national initiatives as well as on the European level. There is no need to plead for another supra structure. With regard to both the national and European level, the authors' key recommendations are the following:

- A definition of the mutual roles of ESA and EU and a joint procedure for the support of cooperation between science and industry is highly recommended. Besides of a more effective use of resources, such a measure would make the European space level more transparent for both the space industry and the science community.
- Benchmarking between the national strategies could lead to more coherent best practices.

1. Introduction

When the space age began 50 years ago, it involved scientists' contributions in many fields of science and technology development. Strong links were established between science and space activities. Over the years, these links have weakened and space has lost some of its attractiveness to recruit the best scientists and engineers. The purpose of this study is to analyse this presumed isolation of space research from the space industry and in a second step, develop recommendations on how to bridge the potential gap.

This report is a result of desktop studies, and a discussion and brainstorming workshop conducted on March 7, 2008 at the ESPI premises in Vienna. Experts from organizations responsible for the funding of basic science, i.e., research councils and ministries, from universities/research institutes and from the space industry participated in the discussions and contributed their views and experiences on the subject. The outcome of this brainstorming was included in the broader context of the study and a draft of the report was sent out to an enlarged group of contributing experts. The expertise received by circulating the draft was integrated and led to the final study report.

The final report is divided into six parts. After a definition of the term "research", it continues with an analysis of the relation between Academia and the space sector in general in Europe focussing on ESA and European Commission (EC) initiatives. Subsequently, the report concentrates on the relation between basic space research and the space industry. At the centre of our study we ask the questions whether, and why, basic research in science and the space industry have gradually become isolated and which international best practises can be applied to the European situation. For the recommendations, we evaluated possible initiatives at four levels: What can academic institutions, industry, national funding agencies or ESA do to improve the relationship between the broader basic sciences and space industry.

Participants in the workshop of 7 March 2008 at ESPI, Vienna
(for the list of participants see Annex 2a)

2. Definition of terms

The term *research* appears in various forms and must thus be defined more precisely. For the purpose of this study, the authors have used the terms *basic space research* and *space research*.

- ***Basic space research***: is investigation work that does not refer to a specific problem, but which has the potential to contribute to knowledge for future space applications; In this respect basic space research includes as well non-space sciences which might be applicable to space-related issues. Examples for basic space disciplines are astronomy, planetary science, solar physics, etc. Examples for basic non-space disciplines are manifold and broad. They range from natural sciences to human sciences and social sciences.
- ***Space research***: is application-oriented and in our case it refers to engineering and technical sciences; Here again, there is a genuine space science part, including, for example, launcher systems, re-entry systems and propulsion, and a more general science part that includes, for example, electronics, navigation systems, thermal control, etc.

However, there is a need to mention a more general definition of research and its different levels:

Basic research investigates the essentials of phenomena. It has the potential to re-define knowledge, create new explanations, new possibilities and new questions. It can have an important impact on technology and society in re-defining priorities for strategic and applied research. It offers a generic understanding, which is a fundamental "transferable skill" and can be applied to a wide range of circumstances and phenomena. *Strategic research* derives knowledge from basic research and explores ways in which it might be used to solve current problems or create marketable products. *Applied or innovation-engaged research* is driven by market and business considerations. It exploits both basic and strategic research to create innovative products and processes in response to existing market demands or by creating new markets. The practice requires ready access to research and researchers by innovative business and preconditions in which licensing and patenting are rapid and efficient processes.[1]

Space sciences as such are often seen through a three-dimensional approach: as science *of* space (space science, exploration), *in* space (life science, fluids, materials, etc.) and *from* space (earth science).

In our work, we use the terms *academia*, *universities* and the *science community* to talk about the counterparts of industry in our image of the relationships.

University is this context is defined as the institution where teaching and research by professors and PhD students represent the major part of work. In this sense, ***academia*** includes both extra-university research institutes (such as Max-Planck, Surrey Institute or Fraunhofer) and the universities themselves. The ***science community*** refers to all universities and academic institutions as well as to the outside science laboratories.

[1] League of European Research Universities, ed. "The Future of the European Research Area." Aug. 2007. 28 Feb. 2008 <www.leru.org>.

3. Relation between universities/academia and the space sector in general in Europe

Generally, the European space sector as a whole is represented by two institutions: the European Space Agency (ESA) and the European Commission (EC). ESA's competence in the space sector is based on its many years of experience, starting with the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO) in 1964 that merged to form the ESA in 1975. By contrast, the EC is a relatively young actor in the field, having started to become more involved only in the 1990s. The different stages of development and the diverse objectives of these two bodies are the reasons why the amount and distribution of funding varies widely. While ESA is dominant in the field of public funding, EC supports the space sector on a smaller scale.

It also needs to be mentioned that some national space activities are very large in scale, in particular, in France where the national space agency CNES has an annual budget of EUR 697 million.[2] CNES has 2500 employees[3], while ESA counts 4000, including subcontractors. Germany is another major European actor in the field of space and has annual national space expenditures (civil programme) of EUR 290 million[4], Italy spends EUR 349.1 million[5] annually on its national space programme, and the UK allocates an annual budget of EUR 76 million[6] to its national space efforts.

Industry is closely involved in the planning and the programmes of these official key players in the space sector. The involvement of academic institutions is apparently modest in the planning at the European level for the European Space Programme with the exception of the ESA scientific programmes, space science and exploration, Earth science, life, physics, etc.. The same statement applies to the national level and the relations among the national space agencies, national research facilities, university research, and the space industry. It appears that the decisions on space matters, except with regard to the previously mentioned science-driven activities, involve mainly government agencies and industry, with little or modest influence from academia.

2 Lardier, Christian. "Le Cnes fait le plein de programmes." Air & Cosmos 1 Feb. 2008.
3 ESD Partners, ed. "2007: European Space Directory." 22nd Edition.
4 ESA, ed. "European Space Technology Master Plan" ESTMP 5 Dec. 2007.
5 ESA, ed. "European Space Technology Master Plan" ESTMP 5 Dec. 2007.
6 British National Space Centre, ed. "UK Space Activities 2007". 14 May 2008 <http://www.bnsc.gov.uk/assets//channels/resources/publications/pdfs/BNSC%20SpaceActivities_2007.pdf>.

3.1. What do the relations between ESA and academia in the field of research look like?

A distinction should be made between:

1. The science community as a user of space systems for research *of* space (i.e. space science, exploration), *in* space (i.e. life sciences, physics) and *from* space (i.e. earth science); The science community is the driving force here.
2. Academia that provides research to develop non-science-driven space systems and to develop space-based products for the service industry; In this case, academia and research organisations in general are partners and contractors of ESA. For instance, the General Studies Programme (GSP) and the basic Technology Research Programme (TRP) have granted significant allocations to research organisations for basic research; There are also special procurement clauses to support the involvement of research organisations.
3. Education, training; Here ESA has a number of initiatives, not only the official education programme, but also schemes like the Ariadna in the General Studies Programme, the Networking and Partnering Initiative (NPI), etc.

For the purpose of our study, ESA programmes are differentiated as to whether they are science-driven or focused on other (non-scientific) user-driven applications like launchers, telecommunication and navigation.

Apart from the modest degree of commitment in some of the optional programmes, the mandatory Science Programme and the science-driven application programmes allow scientific teams to play a key role in programme design. The strategy is defined by the science community; the programme objectives and the missions are proposed, selected, defined and exploited by the science communities.

In the other optional programmes, ESA focuses first and foremost on launchers and space applications, and the decisions related to funding is influenced considerably by industrial policy and the policy of ESA member states to secure roles for their national industrial companies.

The scientific community is often excluded from the dialogue between government agencies and industry. It can only become involved in programmes in the second phase when the key decisions have already been taken. Still, there are some opportunities for the science community to contribute at a later stage.

In a talk, David Southwood, Director of Science at ESA, stressed that the science programme was well accepted by both scientists and the political institutions funding science. Starting from that statement, we asked the experts participating the ESPI workshop on March 7, 2008 how the successful integration of academia into the scientific programme of ESA could also affect the role of universities in other ESA programmes.

Jörg Wehner, representative of ESA, stated that the strong links of academia to the science programmes (space, earth, etc.) were based on scientific objectives. In such science programmes, research is the key element and the driver. Applying the successful involvement of universities in the science programmes to other ESA programmes would therefore be difficult. Jesús Marcos from Tecnalia Aerospace added in a written statement that the role of universities and the scientific community in ESA programmes was adequate and covered the dual objective of fostering educational objectives and the standing of academia in user development. He provided a valuation of university participation in ESA programmes based on his own assumptions:

- Launchers: 5%; for studies on re-entry aerothermal analysis and particularly for future launcher concepts
- Scientific: 30%; responsible for phase A/definition addressing scientific goals for a mission (exploratory-instruments)
- Earth observation: 15%; particularly on ground applications on GMES development of user databanks
- Telecom: 10%; addresses re-design and simulation models of components (microwave devices, antenna)
- Manned S/C: 20%; mainly for microgravity experiments, but also behind many tools and devices for instruments and life support studies
- Aurora/Exploration: difficult to assess, maybe 30%; preliminary concepts studies and scientific analysis of potential missions

- Generic technology: no more than 20%; lacking funds for breakthrough technologies and barriers to optional programmes for industrial-product validation with national support.

All ESA science programmes, in particular the mandatory Science Programme and the optional Earth Observation Programme are beneficial for all ESA missions due to their demanding need for innovative spacecraft. Some examples are subsystems such as electrical propulsion, advanced space communication systems, on-board data processing and storage and navigation systems for outside earth orbit. There are concerns relating to these technologies that ESA's competitiveness could suffer due to a lack of advanced technologies developed outside the space field. Appealing projects are needed to create the spin-ins necessary for sustainable development of the ESA programmes. Most importantly, bright young people from different scientific backgrounds have to be attracted. ESA states that the main problem is the lack of resources to develop technology beyond the needs of the current candidate missions. What ESA needs to do is to attempt to match scientific and technology breakthroughs. Such technological breakthroughs often come from the non-space sector, and therefore, spin-ins are of major importance.

The European Commission (EC) faces important challenges due to its lack of real experience as a relatively new actor in the space sector. The workshop participants criticised that the concrete drivers for the EC-led programmes were missing and that funds from the Framework Programme are often not focused on a coordinated space strategy and thus at times do not lead to the best possible output. Nonetheless, Galileo and GMES are major contributions from the EC involving both industry and the scientific community. However, only a modest number of space scientists are involved in these two EU-funded programmes.

The following section will take up these points and compare the capacities of ESA and the European Commission in the area of support for space industry/university cooperation through their programmes.

3.2. What is the difference between ESA and EC as regards support for space research?

As ESA has been active in the space sector for more than 30 years and the EC just entered the field of space recently, overlapping structures have raised the issue of a future balanced model to be developed. As already discussed in the previous chapter, ESA involves academia the most in the field of its science-driven programmes. The EC had no real involvement in space related research up to its 6th Framework Programme of Research (FPR). Within the current 7th FPR (2007-2013), the EC provides EUR 1.4 billion to support space. Research activities during the lifetime of FPR 7 will be drawn from space-based applications at the service of European society, exploration of space, and research and technological development for strengthening space foundations.[7] A prerequisite for receiving financial assistance (up to 50% of total joint research costs) for a research partnership is the inclusion of actors based in at least two EU member countries. Industry, universities and research laboratories may participate.

In December 2006, the European Research Council (ERC) was approved and set up within the frame of the 7th FPR. With its seven-year budget of EUR 7.5 billion, the ERC will support investigator-driven frontier research.[8] At the same time the ERC complements other funding activities in Europe such as those of the national research funding agencies. The ERC approach allows researchers to identify new opportunities and directions in any field of research, rather than being led by priorities set by politicians. This approach ensures that funds are channelled into new and promising areas of research with a greater degree of flexibility. As a part of the 7th FPR, it is also the space field which might benefit from this initiative.

ESA representative, Jörg Wehner, stated that the big difference between the ESA and EC approach was the missing knowledge of the latter in terms of managing technology transfer. It was crucial on the EU level to

[7] The FP7 Factsheets. 26 Mar. 2008 <http://ec.europa.eu/research/fp7/pdf/fp7-factsheets_en.pdf>.
[8] European Research Council. 25 Mar. 2008 <http://erc.europa.eu>.

obtain ESA expertise in order to connect the academic programmes with space programmes.
In this respect, it should be mentioned that ESA has tried to participate in non-space Technology Platforms (part of the EU's 7th FPR) so as to spin-in the latest technology for the benefit of space.

Another difference lies in the financial strength and the question of funding of the space sector. As of today, the EC plays only a limited role in space activities representing less than 10% compared to the ESA budget. In addition, the drivers for granting financial support are not the same. ESA is funded by its member states, with a mandatory part consisting mainly of the science programme with a three year funding decision taken by consensus. ESA also has the much larger optional programmes in which each member state decides its own participation according to its priorities and its possibilities for industrial returns. This means that all ESA activities are fully funded either by governments or by third party activities like EUMETSAT, GMES and Galileo. In contrast, the EU's 7th FPR is a means to promote research. Projects within the FPR are only partially funded and typically market oriented. They may be perceived as a helpful addition to the ESA approach. Still, a definition of the mutual roles would be important to proceed coherently and to strengthen the position of space on the European level. If the next steps were to lead in the direction of ESA gradually becoming the space agency of the EU, there would definitely be a major necessity to reconsider the approach taken to the funding of space programmes.

We believe that if ESA were to become the space agency of the EU, the member states would like to preserve the flexibility of ESA in the funding of space programmes. They would also like to see a direct link between each member state's funding and the role it will be given in the programme. Right now, the space funding activities of the EU are viewed as highly unsatisfactory by the member states, whereas the ESA financing mechanism is based on a broad agreement.

Apart from ESA and EC support, a number of programmes for industrial-university partnerships are run by the European states. In the next section, various examples will be discussed.

3.3. What concepts have been developed in European countries to bring government, academia and industry closer to each other?

Governments have promoted and supported research partnerships in order to correct market failures in R&D investment. They aim to speed up technological innovation to increase international competitiveness. Governments try to promote the exchange of technological information among companies, universities and research institutions. In different European states, a number of concepts have evolved to bring academia and industry closer. The experts who participated in the ESPI workshop presented examples from their home countries.

German Aerospace Centre (DLR), for example, has established a platform through which scientists can make proposals for new programmes. Several commissions with individuals from academia, industry and the Centre meet two to three times a year to discuss topics of mutual interest. Still, the forums on space topics have not proven very effective said Irena Bido from DLR. It was especially difficult to include the research community. Gerhard Haerendel from Max-Planck Institute added that the problems of effective integration arose with the appearance of a broad scope of space-related science and the burdens of the reunification of Germany. As of 1989, financial support for space has shrunk, but the science community continues to grow. The situation has only recently started to recover.
Another approach is the German Trilateral Memorandum of January 1999. Its goal is to intensify the dialogue between industry, academia, and the DLR. Scientific programmes will be designed to support closer relations between the three actors. The memorandum was signed by the German Research Foundation (DFG), DLR and DaimlerChrysler Aerospace AG. However, in the space field, the implementation of a closer cooperation between the signatories has not been yet realised, while it is strong in aeronautics.

Radboud Koop from the NIVR (Netherlands Agency for Aerospace Programmes) presented the "Action Plan Space", which aims, among other things, to connect academia, industry and government institutions. Academic freedom is guaranteed for everything within the university programmes. Academia and industry have different objectives and the alignment of these objectives does not seem to be a trivial issue. Today, NIVR is primarily engaged in the industrial side of the space programme, and less in science and research. Recently, the Dutch government expressed its intention to create a space organisation representing all relevant aspects.

An example from Great Britain was presented by Mike Cruise, a physicist from Birmingham University. Universities in the UK receive all of their funding from the government. Applied and basic sciences are very much dependent on each other to produce visible success and create innovative output. In the late 1990s, a report was published stating a positive correlation between investments in basic research and GDP growth. Since then, basic research has had a much better standing in government funding than before. Changes in attitude arose recently leading again to more competition. This underlines the long-term trend, while most UK scientists believe that receiving funding for basic research was easier 35 years ago and has become more and more competitive. Still, the positive relation between economic growth and funding of university-based research is obvious and the UK government tries to extract the value from the recent investments by establishing knowledge exchange and networking initiatives. The NERC/DIUS Centre for Earth Observation Instrumentation promotes collaboration between academia and industry. It aims to position consortia for access to international funding and access to missions, looking for short-term benefits as well as a long-term payoff in space missions.

Another approach is the British Co-operative Award in Science & Engineering (CASE) scheme which promotes partnerships between eligible research organisations and public or private sector organisations. Within the programme, PhD students enhance their training by spending between 3 and 18 months at a workplace outside the academic environment.[9]

In Austria, a dual structure exists for the funding of basic research (FWF - Fonds zur Förderung der wissenschaftlichen Forschung) and applied research (FFG - Forschungsförderungsgesellschaft) that takes into consideration the different role played by industry in the two fields. Harald Posch from FFG stated that the relationship between applied research and industry was automatically one of supply and demand, while basic research and industry stayed further apart. In his view, scientific competition was not a bad approach and necessary to make research visible to the outside. In small countries, a stronger concentration would be needed to stay internationally competitive. Therefore, three competence centres were established in Austria last year. These centres are part of the COMET (Competence Centres for Excellent Technologies) programme which is the follow-up programme of the Austrian competence centre programme launched in 1998. The overall objective is to increase the culture of cooperation between science and industry and to create research competence in both areas. The aim is to increase international visibility and competitiveness.[10]

Following a similar approach, 14 Centres for research-based Innovation (CRI) were established in Norway in 2007. The CRI scheme promotes innovation by supporting long-term research in close alliances between research-active enterprises and prominent research groups at universities and research institutes. The scheme promotes technology transfer, internationalisation and researcher training. The centres are financed by enterprises (min. 25%), host institutions and the Research Council (max 50%). Their annual budgets range from EUR 2.5 to 5 million. Enterprises must participate actively in a centre's governance, funding and research activities. The corporate members constitute the majority of the board members. The centres are established for five years and may be continued for another three years based on a mid-term evaluation.
The centres were selected based on an open call with two main criteria: i) scientific quality and ii) potential for innovation and value creation. Space research has thus far not succeeded in the competition, but fits well into the framework of the scheme.

[9] CASE-studentships. 15 Apr. 2008 <www.nerc.ac.uk/using/schemes/case.asp>.

[10] COMET - Competence Centers for Excellent Technologies. 15 Apr. 2008 <http://www.ffg.at/content.php?cid=715>.

3.4. Conclusion

The European space sector is highly fragmented. At the top is the EC and the ESA. The two organizations have different approaches for including academia in space programmes. Their efforts in this field are not coordinated and both face problems. While ESA has a hard time identifying and attracting the industrial technology research to contribute to their programmes, the EC is still in the definition phase of a coherent future perspective to effectively place its funds and derive the maximum benefits. A definition of their mutual roles and a joint procedure is not only the next logical step for the whole space sector in Europe, but would as well be a good way to make the European space sector more transparent to industry and the science community.

On the national level, numerous different concepts have been established to foster relations between industry and academia. These concepts range from platforms, space action plans, knowledge exchange and networking initiatives to the establishment of competence centres. Some have already proven successful, while others have only recently been established. On the one hand, they are stand-alone concepts of the European national states, and on the other, part of overall European policy. All have the capacity to supplement and improve on the ESA and EC initiatives for stronger industry-science cooperation, representing the genuine European concept of subsidiarity.

In the view of Gerhard Haerendel, the European situation in terms of the integration of science suffers from a lack of efficiency. The European Space Science Committee (ESSC, a committee of the European Science Foundation – ESF) has too little authority to deeply influence the ESA, the EU or the national states. Europe does not have an overarching academic advisory body; there are only national societies such as the Max-Planck Society and the Fraunhofer Society.

In his view, an academic authority will be needed to link the European level in the future, probably taking over the ESF.

Up to now, the interests of industry outweigh on the European scene. The ESA and EC – taking into account their relative assets – involve industry more than science and academia in the space sector. The mandatory ESA Science Programme as well as the optional Earth Observation Programme are science driven. When ESA member states allocate funds to ESA, their funding decision gives more priority to industrial policy than to the interests of academia.

A change in this attitude could be brought about by a new status definition by ESA and EC or by a more active inclination of the European space science community as proposed by one of the experts. However, on the European level, and similarly, on the national level, there are a number of obstacles preventing space research and space industry to deepen their mutual ties.

4. Relationship between basic space research and space industry

In the general theory of the triple helix of university-industry-government relations, an expanding network system of interactive spirals arising from all sides has been identified. Innovation is no longer a function of a single institutional sphere, but a system of innovations and can thus be made subject to a process of dissent and consent formation.[11] A research partnership can be defined as an innovation-based relationship that involves, at least partly, a significant effort in research and development. Research partnerships can be further characterized in terms of the members of the relationship or their organisational structure. These dimensions are not independent. As regards members, it is necessary to identify whether they come from the public sector or the private sector. Given these parameters, the partnerships can be public, private or public/private. In terms of organisational structure, the partnerships can be either based on informal arrangements (short-term project-specific research subcontractor) or on a formal arrangement.[12]

The desired amount of cooperation among industrial players in different fields of action is always based on specific reasons and considerations. The space sector seems to have fewer ties between university sciences and industry than other related fields. What are the obstacles for better cooperation on a regular and mutually beneficiary basis?

In the following is a general overview of the benefits and problems that might arise for both industry and academia from cooperative partnerships.

4.1. General benefits and problems for industry

The incentives to form a research partnership are mainly economies of scale and scope, such as minimization of transaction cost, avoiding costs of internalizing the activity and sharing R&D costs. Companies might pool risks and improve their competitive position. An increase in efficiency through networks and access to complementary resources is very probable. A partnership with academia is a learning vehicle to accumulate and deploy new skills and capabilities, transfer technology and create new investment options. [13]

Problems in cooperation can arise from risks in sharing proprietary know-how, the desire for control by individual partners and the coordination of different time-horizons. Disagreement on design specifications and contrary objectives might pose another obstacle. Missing support from government policies and the effects of a minimum efficient scale in R&D can make the decentralization of R&D both costly and difficult to control.[14]

4.2. General benefits and problems for academia/ universities

The academic segment benefits from the additional revenue for universities and from the faster technological diffusion through two-way knowledge transfer. Lively cooperation with industry might have positive effects on local/regional economic development. Strong cooperation may have both positive and negative effects on the

[11] Leydesdorff, Loett and Henry Etzkowitz. “The Transformation of University-Industry-Government Relations.” Electronic Journal of Sociology 2001. 10 Mar. 2008 <http://www.sociology.org/content/vol005.004/th.html>.

[12] Hagedoorn, John, Albert N. Link and Nicholas S. Vonortas. “Research partnerships.” Research Policy 29 2000: 567-570.

[13] Hagedoorn, John, Albert N. Link and Nicholas S. Vonortas. “Research partnerships.” Research Policy 29 2000: 575.

[14] Ibid.

curriculum. On the one hand, it might become more specialised and attractive because of the proximity to practice. [15]
On the other hand, it might narrow the spectrum and variety of subjects taught at university. A close partnership with industry will probably have a negative impact on the culture of open science. Student/advisor relations and teaching might be affected, as professors' concentration might focus stronger on research. Basic research might fall behind and the types of research questions addressed might change profoundly.[16]

A key question is what the primary purpose of universities is or should be. The answer to this question is somewhere between doing so-called 'blue-sky' research and the full dedication of universities to what industry requests, acting as a laboratory for certain companies. European countries have different approaches for supporting their universities or giving them the freedom to organise and orientate themselves as they want. At the ESPI workshop, several participants emphasized that academic institutions should be respected in their genuine role. It is not in the scope of this study to give an answer on how much autonomy should be given to universities, nor what direction they should take in terms of research and cooperation. We only wish to focus on the problems the space sector is facing in this respect and attempt to provide some useful concepts that might be applied.

In the discussions at the workshop, the focus was on the specific problems of the space sector to build strong partnerships between university science and industry. First of all, we focused on the problems faced by ESA.

4.3. Top-down approach: ESA

It is important to distinguish the following:

1. Scientists as users of space systems for research
   In this case, the scientific community drives the programme, its strategy, the objectives and the missions. The partnership is well organised and mutually respected. Scientists need industry to address the implementation of science ideas, and conversely, industry needs research organisations to define the technical implementation. In early phases, i.e., concept phases, research organisations lead and have industrial partners on their teams. In initial project phases, i.e., phase 0/A/B(1), industry has research organisations on their teams to estimate performance, have the end-to-end view, define observation techniques, etc. This calls for a delicate balance, as partnerships should not drive the programme contents, which should be driven by science.

2. Scientists/research organisations as providers for the development of space systems
   The Agency is aware of the importance of research organisations. A significant part of the GSP and TRP go to research organisations. Special procurement clauses assure the involvement of research organisations. This brings industry and research organisations closer together.

A strong link between the government, industry and academia can be reached either through a bottom-up approach or a top-down approach. Top down means that incentives are given by a superior authority (e.g. government) to foster cooperation.

Nationalized schemes are by their nature more innovation-related. The most effective work can be done within a national or a regional setting, because of their genuine closeness to the actors and the clearer structures. ESA is faced with national network initiatives and is challenged by putting such schemes into a broader international context. Processes in each country are different and the establishment of an overall strategy is difficult, especially in relation to the differences in the contributions to ESA from the member states. Referring to Jörg Wehner, ESA thus tries to bring together universities, research centres and industry. Wherever possible, ESA tries to benefit from national programmes and/or expertise in this domain.

Apart from the heterogeneous national funding and the difficulties caused by the principle of fair-return, the involvement of ESA in innovation support is made harder by the limited resources provided and the difficulty in establishing a dialogue with research groups interested in cooperation.

[15] Poyago-Theotoky, Joanna, John Beath and Donald S. Siegel. "Universities and Fundamental Research: Reflections on the Growth of University-Industry Partnership." Unversity of St. Andrews, ed. Discussion Paper Series No. 0201: Nov. 2001: 31.
[16] Ibid.

Still, a well-proven concept applied by ESA is to gain access to university capacity by funding PhD students in cooperation with space industry. Central to the concept of "co"-funding is to bring together the researcher's interest preserving the freedom of universities and the interest of the space sector in developing new applications.

However, the direct link between academia and industry within the ESA framework is somewhat hard to establish. When it comes to the non-science-driven optional programmes, industry remains passive in initiating new projects in cooperation with academia.

Another problem is that the resources are limited. They are focused on selected missions and typically, only little is left for more prospective technologies as would be appropriate for research organisations and long-lasting partnerships.

The problem is also that the scientific community being aware of the fact that maturity and low risk are criteria for the selection of a project, may refrain from proposing a mission that would demand new technology even if such technology would be naturally developed for other fields.

What is needed is to combine the longer term views of scientists as users with the resources of technology development programmes. This would enable the creation of long-term partnerships between industry and academia and thus make available technologies that are not mature today. In this context, ESA has proposed an in-orbit demonstration strategy following the success of the PROBA, a technology demonstration mission. This is planned to be implemented as an element of the General Support and Technology Programme (GSTP). This could be a way to establish longer lasting partnerships.

ESA fully understands the need for technology spin-ins from outside the space sector. Examples are microelectronics, embedded systems and new materials. Therefore, ESA has initiated several activities like the NewPro (New Technology Program) to be proposed at its next Ministerial Council. If adopted by ESA member states, this will open up more funding for long-lead technology development, and academic institutions from the non-space sector will have new possibilities to partner with industry.

4.4. Bottom-up approach: Initiatives from industry and academia

Bottom up means that individuals and organisations from different institutional spheres interact and build up cooperation through their own initiatives.

Numerous examples of initiatives originating in space industry and academia can be found. Some projects have been implemented successfully. Rob Scott presented the approach QinetiQ described below.

QinetiQ is a publicly-owned defence and security company, but it is expanding into other markets by exploiting capabilities and technologies. The company carries the legacy of the Royal Aircraft Establishment Space Department. The biggest part of the space business is in the civil domain. QinetiQ is a company with 12,000 employees, including subsidies in the US and Belgium. QinetiQ has many contacts with academia and perceives this as an important part of its business. There are direct contacts with university groups to find projects, instruments, technologies, goals and missions of mutual interest. QinetiQ participates in emerging space science consortia preparing mission proposals for Cosmic Vision and Earth Explorers to mention two. Different forms of cooperation have been established, such as individual collaborative agreements with university groups (formal or informal), CASE (Cooperative Award in Science and Engineering) studentships (industrial PhD studentships) or via the academia liaison office within QinetiQ. Additionally, there are visiting fellowships (in both directions) and industrial visiting lectureships/chairs.

In practices, some success has been proven, e.g., the Centre for Earth Observation (industry lead), the UK Penetrator consortium (academic lead) and the Near Earth Objects (NEO) and space science industrial mission studies (both can lead). The Centre for Earth Observation is a national initiative to position UK groups to access international earth observation missions and exploit innovative technologies and capabilities, to form consortia of academia and industry to build instrumentation in response to science needs.

The academic-led UK Penetrator consortium has the goal to develop high-speed landers for in-situ exploration of objects in the solar system. It includes industry partners (QinetiQ, SSTL) for mission involvement and access to technologies. In the NEO and space science industrial mission studies academic input on science case and payload package for a variety of space science and Earth Observation missions is communicated and implemented.

Most of the time it is not clear which approach is predominant. Bottom-up meets top-down in a creative fashion, creating a context for innovation that is broader than would be likely to emerge from either approach in isolation.[17]

4.4.1. View from industry

In practice, various obstacles have been identified that prevent a stronger link between industry and universities. The sensitivity regarding intellectual property rights for commercial exploitation as well as academic publications is one of the inhibiting factors. Therefore, it is essential to elaborate agreements which define how outcomes of activities will be exploited and managed. Similarly, non-disclosure-agreements can serve to underline the need for sensitive and responsible behaviour.

Referring to cooperation on a sublevel, it seems to be extremely hard to match background research as done by PhD students with the necessities that arise at companies.

An obstacle is also time. Sometimes the relationship between industry and academia needs years to become established and time-to-market perception in industry and research centres is completely different than in academia. Spacecraft payloads are also getting bigger and more expensive, and need longer to be developed and carry a higher technical risk. As most of the European space industry is made up of private commercial enterprises, their primary objective is to do business and earn money to survive. Long-term developments with a horizon of 20 to 50 years (which is not unusual in space research) cannot be afforded by private investments where returns are requested on a much shorter timescale. In the end, commercial risk is the responsibility of the private enterprise or industry. In the view of Eberhard Schulz-Luepertz from EADS Astrium only a higher public involvement could improve the situation.

Jesús Marcos from INASMET added some additional obstacles for cooperation. First of all, space industry today is a highly qualified sector, having as a baseline its own research and a relatively low tradition of externalizing R&D. The low rate of return creates difficulties for industry to subcontract and invest in universities in long-time research. In addition, space projects last longer (seven to ten years) than the periods of public funding (mostly a four-year political period) and scientific teams are difficult to maintain due to the high renovation rate of personnel at academia.

Rob Scott stated that he still saw frequent collaboration between academia and industry, but the perception prevails of an exclusive “club” of regular collaborators. The expansion of the club to new partners is limited by commercial constraints and lacking efforts on the part of universities.

4.4.2. View from academia

Similarly, Joran Idar Moen from Norway found that industry was willing to collaborate, especially for recruitment and manpower reasons and the possibility to better access ESA. Thus, the practical background is becoming more and more important for universities to attract industry. It is crucial to close the gap between basic research and applied sciences at universities to stay attractive to industry and to gain outside support. One means to achieve this would be interdisciplinary cooperation within universities. Therefore, the initiating scientists need to offer incentives for all groups of scientists contributing to a defined project. Offering a comprehensive product, including know-how from different science sectors will boost the attractiveness of a university for both industrial cooperation and new students attracted by a challenging and hands-on academic environment.

[17] Etzkowitz, Henry. “The Triple Helix of University – Industry – Government: Implications for Policy and Evaluation.” Institutet för studier av utbildning och forskning, Stockholm, ed. Working paper: Nov. 2002.

In this case of universities developing innovative technologies, one will have to pay attention to the fact that future technologies often do not fulfil the expectations of reliability and security demanded by space mission managers.

A solution to preserve the innovative potential and make use of new technologies could be to build low-cost, high-risk missions supported by government agencies. As soon as proven, such technologies could be applied to "real" missions.

Manfred Steller from the Austrian Academy of Sciences doubted that industry was interested in an equal partnership. Industry regularly bids for a certain contract, and focuses on one special contribution. This makes it difficult to create a steady basis for cooperation.

Mike Cruise identified some more obstacles for universities to cooperation with industry. Quality assessment and management overheads are increasingly important in space industry. These developments are neither reflected nor attractive in an academic environment and the respective demands are difficult to fulfil.

Another problematic issue for universities is the maintenance of patents, because of the high costs. The selling of licences is not so relevant for one-off missions and creating spin-off companies is often not adequate, as a solution to the problems a university is facing.

Apart from taking a long time to become established, patents are expensive and remove the academics from their original profession and from what they know best.

4.5. Conclusion

Bilateral relations between government and university, academia and industry, and government and industry have expanded into triadic relationships among the stakeholders, especially at the regional level. The dynamic of society has changed from one of clear boundaries between separate institutional spheres and organisations to a more flexible overlapping system. The common purpose is to stimulate knowledge-based economic development.[18]

The overall reason for the perceived exclusion of universities from the commercial space sector is to be found in the challenges entailed by the higher complexity of projects. The growing size and scope of missions is forcing academia out of space projects. Academia no longer fits into the new mission structure. The duration of space projects overwhelms the capacity of universities to fund academic staff.

Summarizing the different points the authors find no isolation as such between academia and industry, but a change in their attitude toward cooperation and using supportive (public funding) structures. On the one hand, large space industry companies in Europe have become established through mergers and the direct links to academic institutions have been lost. These so-called "Primes" contact governmental institutions directly and regularly run their own science laboratories or outsource to certain laboratories again preventing the entry of other actors of the scientific community. In their view, there is no need to actively include academia in their programmes and they mostly ignore the opportunities for closer cooperation.

On the other hand, taking opportunity of the still intact links to academia it remains more important for medium and small industries. Although the number of projects has been reduced and the projects last longer, the contacts to university are still there and are good. Medium and small-sized companies can benefit from cooperation and support through public funding in a cooperative structure.

As interest does exist in general, at least on a certain level of company size, platforms to find partners are needed. The International Astronautical Congress (IAC) and the Committee of Space Research (COSPAR) meetings could, for example, be used as a platform to build up partnerships between the space industry and academia. Industry should be more present to find out about opportunities for cooperation and to establish the contact to scientists which may provide new ideas and new technologies for space systems and applications. Very often, personal contacts have already been established, for example, through former university students now working in industry and going back to their educational institutions to cooperate on special projects. No doubt, personal relations play a major role in selecting cooperative networks.

[18] Etzkowitz, Henry. "The Triple Helix of University – Industry – Government: Implications for Policy and Evaluation." Institutet för studier av utbildning och forskning, ed. Working paper: Nov. 2002.

5. Can we understand if and why cooperation between space industry and academia has lost its attractiveness?

In the early days of space, starting with Sputnik 50 years ago, university researchers were deeply involved in most space activities. Industrial development and scientific basic research were much closely connected than today.

Now space industry runs its own laboratories; universities do not seem to be appealing partners for industry to conduct scientific research. In cases in which relations between industry and university have been established, they tend to have an exclusionary effect.

At present, space systems involve a significant portion of routine work that can be better carried out by industry. This is a good development, as it allows one to reduce costs and focus on the challenging part, the payloads.

In a certain sense, it could very well be inevitable that the deep involvement between academic science and industry will be weakened over time. For example, when scientists and/or engineers working in academia see a business opportunity within their research area and start a company they will retain their personal links to their previous academic colleagues for a while. However, as their business grows, the initially strong ties to academia will gradually weaken. As an example, there are many parallels between the space industry and the computer or IT industry. The computer industry in the 1950s and 1960s had most of its basic inventions in, for example, computer architecture, programming languages and operating systems developed by universities both in the US and in Europe. Starting from the 1970s, the computer industry grew very rapidly and started to carry out most of its development work in-house. From that time on, universities became mainly recruitment sources and were used for long-term research, but not needed for the actual products sold.

The space industry, both in the US and in Europe, through multiple mergers and acquisitions, is now dominated by very large industrial companies called "Primes", which in most cases combine space activities with military systems including aircraft. The largest such companies are Thales Alenia Space and EADS Astrium in Europe, in the US they are Boeing, Lockheed Martin and Northrop Grumman.

These very large companies became more and more independent in how they developed the technology they needed for their activities, and like the computer industry, they use universities mainly for recruitment and very advanced forward-looking research.

In the current space landscape, although with fewer large space companies, there are more parties that play a role, more SMEs and more complex national, regional and European funding agencies. The connections between the key players are not as direct as they have been in previous times. In addition, the budgets allocated for research are much higher in these large space companies than any university could match. The projects are growing in size and need more time and special diligence. Security standards and quality testing are a central element of these high-level projects. Overall, more time is needed for implementation. All these recent developments pose significant obstacles for major university contributions to space missions. A critical problem is the lack of resources to undertake breakthrough technology developments, which would force better partnerships between university and industry. This lack of resources to support such partnerships translates into missing science and technology not being developed. Also, the lack of encouragement from many quarters is certainly not helping to create closer relationships.

At the ESPI workshop, another reason was also mentioned for the gradual drifting apart: The management of large space companies, even if such persons come from positions as university professors, will be too focused on the companies' activities and priorities, and over a relative short period typically lose the previous personal contacts with academia. Very seldom do individuals in the management of large space companies teach or work as part-time professors at a university. This is one of the reasons why some small and medium-sized enterprises (SMEs), in particular the SMEs with advanced niche products, often have a much closer contacts and collaboration with academia.

6. Best practice or lessons to be learned from the United States

There is a lot of information available to compare the situation in the US with Europe as regards the relationship between the space industry and academia. In both regions, the policies towards research partnerships were implemented in the early 1980s to arrest the relative decline in international competitiveness of the high technology sectors. The idea to promote cooperative R&D arose in the US and the European Community around the same time. Europe entered the 1980s with increasing anxiety over the loss of competitiveness and the effects of globalization in high-technology industries. In 1981, this led to the establishment of the pilot ESPRIT programme with the endorsement of the twelve largest European producers of electronics. ESPRIT served as the progenitor of the European Framework Programmes on Research (FPRs). FPRs have since then become the vehicle for the implementation of the S&T policy of the European Union. They are the policy umbrella through which the European Commission (EC) supports R&D in particular areas. The EC took the initiative to create a legal basis for central science and technology policy in the Single European Act of 1987 and by institutionalizing a series of 4-year successive Framework Programmes on Research and Technological Development.

The US drove a twin strategy of relaxing its relatively strict antitrust laws and of strengthening its intellectual property rights policy laws. US policymakers put into legislation the Bayh-Dole Act (1980), which allowed universities to own patents arising from federal research grants. The National Co-operative Research Act (NCRA) of 1984 provided additional incentives for firms to engage in research joint ventures (RJVs). During the 1980s, the US National Science Foundation increased funding for Industry-University Co-operative Research Centres (IUCRCs). As a result of the initiatives, almost all research universities in the US have established technology transfer offices to manage the relationships with industry and to facilitate commercial knowledge transfers.[19]

It must be highlighted that academic institutions, in particular universities and publically-funded research institutes in Europe show major differences among the various European countries in their culture and their openness towards industrial cooperation in research. It is therefore not possible to describe a common European form of relations with industry.

However, some general comments are worth mentioning. Universities in the United States typically have a large portion of their academic staff and their PhD students paid for by contract research. Therefore, generally speaking US universities depend much more on doing paid research work than European ones. The US universities therefore are more actively involved in space-related research, both paid for by the space industry and by the US government. The latter includes work both for NASA, NOAA (National Oceanic and Atmospheric Administration) and the military. In the UK for example, university staff is not allowed to work for the government on sensitive topics deemed important for national security, while in the US, the prestigious universities play a very significant role in the development of technology crucial for national security. Some US universities like John Hopkins and MIT (Massachusetts Institute of Technology) have substantial space activities and have laboratories and infrastructure at their universities to do complete space missions, including designing, manufacturing and operating spacecrafts. In a certain sense, these US universities compete with the US space industry, however, this is widely accepted by industry, because it provides industry with already experienced engineers and scientists.

[19] Hagedoorn, John, Albert N. Link and Nicholas S. Vonortas. "Research partnerships." Research Policy 29 2000: 567-586.

It should also be mentioned that many of the staff working on such programmes have non-US passports and often return to their home country spreading the know-how gained to their home universities or industry.

It should be specifically mentioned that the Jet Propulsion Laboratory (JPL) operated for NASA by the California Institute of Technology (Caltech) operates for all practical purposes like a NASA field centre, its staff is full time and very few of them are active teaching professors at Caltech.

There are a few universities in Europe, mainly in the UK and Germany (University of Birmingham, Surrey University, Bremen, Berlin, Stuttgart, Graz) with staff, laboratories, infrastructure to do small space missions including designing, manufacturing and operating small satellites. It is of particular interest to observe how Professor Martin Sweeting at Surrey University was able to develop the company Surrey Satellite Technology Limited (SSTL) into a global leader for affordable small earth observation spacecraft. It has been recently announced that the university has sold its majority stake in SSTL to Astrium UK at a price not yet made public. However, according to the Vice Chancellor of Surrey University Christopher Snowden "[…] this will represent one of the largest cash spin-out from any UK university."[20]

[20] EADS Astrium signs an agreement to acquire Surrey Satellite Technology Limited from the University of Surrey. 7 April 2008.

7. How to improve the relationship between the broader basic science and the space industry

The authors strongly believe and recommend that both academic institutions and space industry should strive to improve and strengthen their relationships. We believe more joint research activities will lead to both better education and new technologies.. This will result in a more competitive space industry and more affordable use of space. The authors make this recommendation and respect the fact that academic institutions – in the same way as any industry – are independent institutions which of course have their full right to decide on the policies which they believe to be in their best interest for their future development based on their mandate and ambitions. It is therefore not necessarily the case that improved relationships are desired by industry or academia. Therefore, the following set of recommendations will have a greater effect if there is a genuine wish to establish closer ties between industry and academia and to exploit the potential of such stronger relations.

The following recommendations reflect the experiences and opinions of the study leader, and also take into account the discussions at the workshop as well as interviews with selected institutions both before and after the workshop as well as the responses received after circulation of a draft text both to the workshop participants and those interviewed.

7.1. What can academic institutions do?

If universities and research institutes wish to become more involved with industrial space companies, a better understanding of the real needs and priorities of their potential partners in industry would be helpful. The authors believe that the large industry Primes are interested in a combination of being able to recruit new engineers and scientists with the best combination of formal education in the relevant academic fields plus relevant research experience.

In the ideal case, these persons were educated at universities doing more advanced research, which industry could benefit from in future programmes but not necessarily in ongoing missions. We believe that advanced research projects at academic institutions using graduate and post-graduate (Master and PhD level) staff, with research topics discussed and agreed with industry, are a recommended way forward. This could be further improved if industry would transfer or second some of their own staff to be part of an integrated team performing the actual research. This is a well-proven method of transferring the results from research into industrial use.

In most European countries the funding of such joint industry/academic research is possible with a combination of total funding from i) government funding agencies like Research Councils or Innovation Funding agencies ii) participating industry and iii) the participating academic institutions themselves. The additional public funding may be attractive for both sides and will often facilitate such joint research.

For SMEs the needs will typically be different from the Primes. SMEs often need the additional expertise and talent from an academic institution to bid for a space contract and if awarded a contract, also to deliver the agreed products and services. This often raises some contractual challenges. Companies expect that their partners and/or subcontractors to accept normal contractual business conditions with guaranteed delivery of the contracted products or services, sometimes with penalty clauses for late delivery and no payment if unable to deliver within agreed specifications. Not all universities are willing to, or allowed to, participate at such terms. Therefore, some universities have set up research companies organized as limited liability companies (ltd) to facilitate partnering with industry.

What most certainly helps both for Primes and SMEs is to develop personal relationships, and over time, to build mutual trust by gaining experience in working together in a way that benefits both sides. Universities might establish professional contact units to promote their expertise and experiences. At the same time, it might be necessary to coordinate the basic and applied sciences to derive the best professional output and to present an attractive offer to potential industrial partners, irrespective of whether Primes or SMEs.

Looking at Europe as a whole, the establishment of truly European universities, holding lectures in English and attracting young capable individuals from all over Europe will lead to greater transparency and to a higher attractiveness for internationally operating industrial companies to enter into cooperation with the academic sector. The International Space University in Strasbourg is a good example providing space studies based education in an intercultural environment.

7.2. What can industry do?

First of all, space industries must decide what kind of relationship they wish to have with academic institutions. Is it mainly for future recruitment, for long-term leading edge research or for partnering with current business? If industry decides it wants to develop a long-lasting relationship, it should try to understand what the academic side wishes to gain from such a partnership. This implies that the senior management of industrial companies must engage in a dialogue with the senior management and key professors/scientists on the academic side to better understand the priorities of each side.

A proven method to increase collaboration is for industry to fund PhD students with industry defining the actual topics involved for the PhD together with the professor and candidates for such PhD funding.

The authors believe the most efficient way for industry to reap the benefits of a close relationship with world-class academic institutions is joint research activities. Challenging research should be undertaken normally at the academic facility with teams composed of senior academic researchers supplemented by industry sending its young and most promising technical staff to participate hands-on in such research. This secondment of industrial staff should last long enough -- minimum one year -- to allow for the research results achieved to be brought back to the company.

7.3. What can national funding agencies do?

In most European countries, the funding of research activities is split between research councils and innovation funding agencies, with the research councils being the most important as regards funding for basic research. It varies from country to country how space is treated by these government agencies. In many countries, funding for space is totally separated from the research councils and/or the innovation funding agencies. This often implies that funding schemes available to bring industries into better partnerships with academic institutions are not available for the space sector. Such partnering for space is only available through the funding mechanisms within the national space agencies or space offices. Most of these dedicated space institutions are dominated by policies to support the national space industry with only a modest regard to the interests of academic institutions. Such a splitting of responsibilities prevents the cross-fertilization of ideas and innovation between the space and non-space sectors.

The space sector is small compared to the sum of all other sectors. It would therefore benefit from cooperation between the space industry and academia if they were allowed to compete in all countries on equal terms for the public funding of joint industry/academic research programmes.

Based on the study leader's own experience as a previous Director General of one of the Research Councils in Norway, he strongly recommends research funding agencies to fund and promote integrated advanced research activities in which researchers and engineers from both industry and the actual academic institution work as an integrated team in performing such advanced research, This is the most efficient way of getting the results from the research, because the team members from industry will go back and take the actual results gained with them.

7.4. What can ESA do?

We will distinguish between the following two categories of ESA programmes: the scientific community as a user of space systems, on one hand, and as providers of technology, on the other hand.

7.4.1. Scientific community as user of space systems

Within ESA there certainly is the experience and know how for activities which have an exceptionally good reputation in promoting the relationship between academia and space industry. We refer to the ESA mandatory Science Programme, regarded as both well managed and linking the scientists interested in the science for the mission with industry building their spacecraft. This is also the case for other ESA scientific programmes, i.e. for Earth sciences, etc. We recommend this to continue.

ESA apparently sees the importance of improving its relationship between academia and space industry and from the ESA document *Agenda 2011* we quote the following as a strategic goal of ESA:

“In order to organise a much stronger synergy among ESA scientific activities, between science and technology and between science and applications, the following actions will be implemented:

- An overall ESA Science Policy will be developed, encompassing common themes among ESA scientific activities such as water in the Universe. A High-level Scientific Advisory Committee will be created to advise the DG on such policy.
- The above-mentioned technology policy and plans will support a stronger synergy between science and technology.
- Stronger links between scientific communities and European industry will be promoted, in order to shorten the transfer of scientific progress to applications.”

7.4.2. Scientific community/research organisations as providers of technology

A quotation from the HISPAC (High-Level Space Science Policy Advisory Committee):

“The development of innovative technologies opens new fields of research and provides to scientists sophisticated new tools. But a conservative approach to technology is too often followed. The scientific community usually hesitates to propose missions relying on not yet fully proven technologies for fear of losing in competitive assessment phases. ESA managers penalize with high contingency budgets the risks associated with new technologies and member states do not invest enough in the development of advanced instrumentation for not yet approved missions. As a result, ESA may have to deal with obsolete technologies in a fast developing field, losing competitiveness and leadership. Europe looks to the Agency for innovation in space, accelerating the pace for scientific discovery through advanced technologies.”

ESA should strengthen its efforts to develop the forward-looking technologies, not only those needed for its current missions. Such efforts have to match the available funds provided for such long-term activities by its member states. It is necessary to propose scientific breakthroughs and matching technology developments. Often such developments will come from non-space research. New and longer lasting partnerships should be opened between industry and research organisations, and new actors not yet involved or not primarily involved in space will become involved. It will be important for ESA to convince its member states that funding for such long-term developments will be advantageous for all future missions. Likewise ESA should promote that an improved and closer partnership between academia and industry is the best way forward to develop such long-term technologies.

At the ESPI workshop, it was proposed that ESA should strive for more publicity in its own name, the same way as, for example, NASA. This will make ESA both better known and more attractive to scientists from the non-space sector to actively associate with ESA.

Annex 1: Programme of the workshop, 7 March 2008

ESPI project workshop

Isolation of space research from space industry.

How to improve the relationship between the broader basic science and the space industry.

I. Dates and Schedule:

The date is 7 March 2008, starting 9:00 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 15 to 18 participants/experts coming from:

- The innovation creators such as universities/academia and research institutes
- The main users and providers of technology innovation like space and space applications industry
- Organizations which facilitate and fund innovation such as space agencies and government innovation departments

IV. Foreseen Topics:

The preliminary topics currently foreseen to be dealt with:

- Relation between universities/academia and the space sector at large in Europe
- Relationship between basic space research and space industry
- Can we understand if and why basic research sciences and space industry have become more isolated?
- Future perspective: learning from international benchmarks, benefiting from a close cooperation of space research and space industry, elaborating an effective strategy

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

V. Workshop Format:

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.

VI. Programme Overview:

- Welcome by ESPI Director, Mr. Kai-Uwe Schrogl and 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 each participant
- Presentation of the workshop programme, key subjects, and discussion of the format by the participants
- Brief introduction on each subject by ESPI team or participants who have been asked beforehand
- Each topic will be discussed independently and in plenary, no subgroups are foreseen

- Each topic might be subject to presentations of the participants (presentation infrastructure on the spot, just USB key needed), to enhance the spontaneous discussion
- Each topic will be ended by a brainstorming through a summary of a previously agreed “rapporteur” providing observations and conclusions

VII. Detailed Programme:

1. Relation between universities/academia and the space sector at large in Europe

From a top view the European space sector as a whole is represented by two institutions: the European Space Agency and the European Commission. Industry is closely connected to the planning and the programmes of these official key players in the space sector. With the exception of the Science Programme of ESA, there apparently is modest involvement from academic institutions in the planning at European level for the European Space Programme. The same statement applies to the national level and the connections between the national space agencies, national research facilities, university research and space industry. The following subjects should be discussed:

- How are the relations between ESA and academia in the field of research?
- How does the EU take advantage of space science as emerging from universities?
- What concepts have been developed in European countries to closer connect government, academia and industry?

2. Relationship between basic space research and space industry

The desired amount of cooperation of industrial players in different fields of action is always based on specific reasons and considerations. The space sector seems to have fewer ties between basic science and industry as other related fields, i.e. the aeronautics sector. What are the obstacles for better cooperation on a regular and mutually beneficiary basis? We would like to discuss this from the following points of view:

- Academia
- Industry
- Government institutions and research funding agencies

3. Can we understand if and why basic research sciences and space industry have become isolated?

In the primary days of space, starting with Sputnik 50 years ago, university researchers were deeply involved in most space activities. Industrial development and scientific basic research were much closer connected than they are today. Now space industry runs its own laboratories; universities don’t seem to be an appealing partner for industry to conduct scientific research. In the cases where relations between industry and university have been established, they tend to have an exclusionary effect. We would like to discuss the following questions:

- How have different sectors of basic space science grown or decreased in importance (in financial support, in numbers of people working in the field, in numbers of university students)?
- How do European examples of cooperation between space industry and space research of universities look like?
- How can these European cases be classified in an international comparison (i.e. USA)?

4. Future perspective: learning from international benchmarks, benefiting from a close cooperation of space research and space industry, elaborating an effective strategy

Is there a way to better connect basic research and industry for the benefit of both? The following questions should be discussed:

- How can academia make itself attractive and more relevant?
- What are the benefits for industry arising from improved cooperation with basic science at university level?
- Is there a best practise or lessons to be learned from the USA, Russia, India, China or Japan?
- How can space attract the best and the brightest among the young students?

- In the US, NASA involves some universities in a major way (like JPL managed by the Californian Institute of Technology). Is this a possible model also for European universities together with ESA and for the European Commission?
- Is it feasible to adapt some practises from the ESA Science Programmes, where engineers and scientists work sometimes in integrated teams?

VIII. 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 7 March and coffee & cookies during breaks. For those participants arriving before 20:00 on Thursday, 6 March, a welcome and get-to-know dinner will be arranged.

If you need assistance with hotel booking, please contact ESPI through:
segolene.vandensteen@espi.or.at

Kind regards,
Rolf Skaar

Annex 2a: Workshop participants, 7 March 2008

Bido, Irena	DLR, German Aerospace Center
Cruise, Mike	University of Birmingham, School of Physics and Astronomy
Haerendel, Gerhard	Max-Planck-Institute for Extraterrestrial Physics (Emeritus)
Kavlie, Dag	The Research Council of Norway
Koop, Radboud	Netherlands Agency for Aerospace Programmes
Moen, Joran Idar	University of Oslo, Department of Physics
Posch, Harald	FFG, Austrian Research Promotion Agency
Scott, Robert	QinetiQ, UK
Steller, Manfred	Austrian Academy of Sciences
Wehner, Jörg	European Space Agency

ESPI

Schrogl, Kai-Uwe	Director
Skaar, Rolf	Study Leader
Stoffl, Katharina	Study Team Member
Baranes, Blandina	Workshop Support

Annex 2b: Contributors to project development and to the final report

Marcos, Jesús	Tecnalia Aerospace
Rycroft, Michael	ISU and Cranfield University (Emeritus)
Schulz-Luepertz, Eberhard	EADS-ASTRIUM
Southwood, David	ESA
Tobias, Alberto	ESA

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Vienna, 30 May 2008

Rolf Skaar
P25 Project leader

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

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