THE EUROPEAN SPACE TECHNOLOGY STRATEGY AND HARMONISATION PROCESS

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Abstract

In this paper we describe the process developed by the European Space Agency (ESA) to coordinate all European space technology R&D activities. The process involves all existing national European space agencies, industries and research centers. In the paper, the various elements of the process are described, together with the results achieved in a specific technology area, thus clearly demonstrating that the process developed is practical and does indeed deliver measurable benefits to the European space community.

1. Introduction

The European Space Agency (ESA) was established in 1975 by merging two preexisting organisations, namely, the European Launch Development Organisation (ELDO), and the European Space Research Organisation (ESRO). The objectives of the Agency were formalised in the ESA Convention [1] where we read that "The purpose of the Agency shall be to provide for and promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications." ESA has currently 15 member states, and one associate member (Canada). As we can see from the list of ESA member states in Table 1, membership in ESA is not related to membership of the European Union (EU). In fact, when ESA was established, it was not conceived as a part of the EU but was designed as an independent organisation [2]. During the years of his existence, ESA has indeed accomplished his task of fostering space activities in Europe, as demonstrated by the many achievements both in commercial and scientific space applications [3].

At the time when ESA was established, the movement toward the economic and political integration of Europe was not as strong as it is today. Furthermore, several European countries already established (or were planning to establish) their own space agencies to serve their own national policies (See Table 2 for a list of existing entities). In addition, space activities in general where not initially considered to be of key relevance to the EU policies. However, a concrete indication of a change in general attitude can be found in a communication from the European Commission (EC) to the Council and the European Parliament [4], where it is concluded that urgent action was needed to establisha proper environment in Europe for the development of space technologies and applications, involving ESA, the EU and all the National Space Agencies already existing in Europe.

Following this change, the initial steps for the development of a joint ESAEC Strategy for Space were taken [5]. Furthermore, activities were initiate in ESA to develop a more efficient management process to coordinate all space activities in Europe [6].

The objective of this paper is to describe the space technology R&D management process developed by ESA. In this paper, we first outline the mandate of ESA in the context of space Technology R&D. Next, we describe in detail the global management process developed. The paper is concluded by reporting the result produced by the process in a practical example thus confirming the validity of R&D management process developed and its usefullness in delivering value to the European space community.

2. ESA R&D Management Process

The management process created by ESA to coordinate all technology R&D activities pertinent to space in Europe is described graphically in Fig. 1. Its basic objectives are:

Table 1

ESA Member States

Austria	Netherlands
Belgium	Norway
Denmark	Portugal
Finland	Spain
France	Sweeden
Germany	Switzerland
Ireland	United Kingdom
Italy	Canada (associate member)

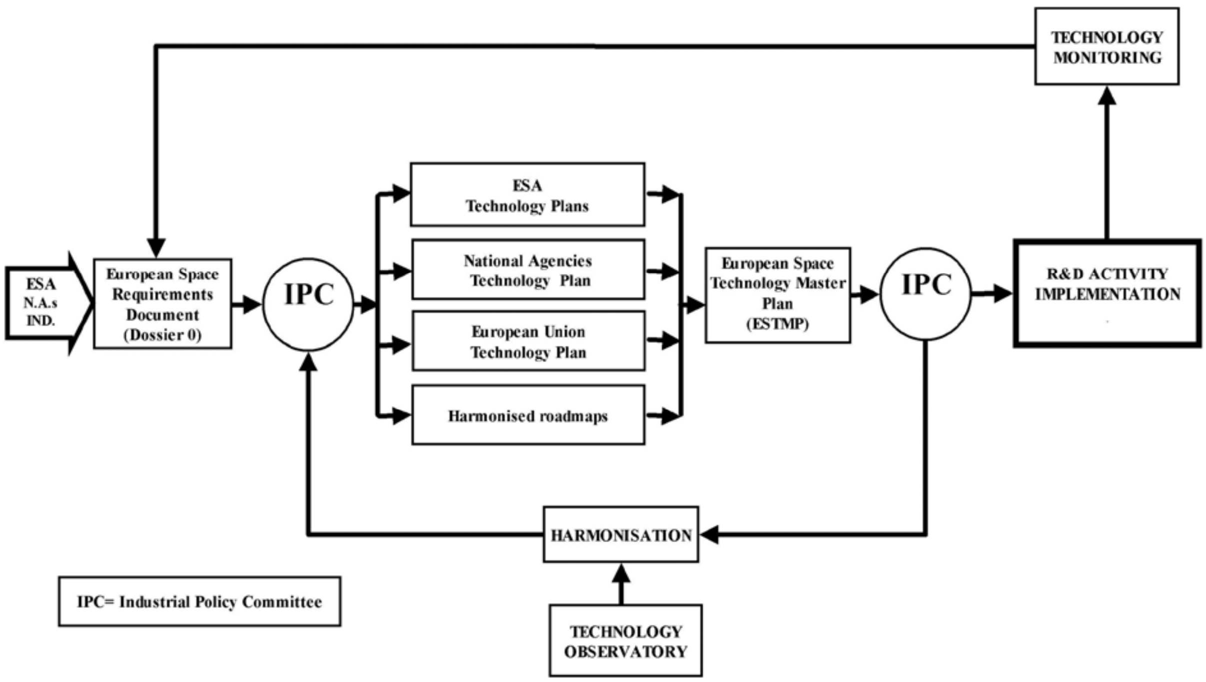

Fig. 1. Graphic description of ESA management process for European space technology R&D

Table 2

European National Agencies involved in space R&D activities

Austrian Space Agency (ASA)	(AU)
British National Space Center (BNSC)	(UK)
Center for the Development of Industrial Technology (CDTI)	(ES)
Finnish Space Technology Development Center (TEKES)	(FI)
German Aerospace Center (DLR)	(D)
Italian Space Agency (ASI)	(I)
National Center for Space Studies (CNES)	(F)
Norwegian Space Center (NSC)	(N)
Netherlands Agency for Aerospace Programmes (NIRV)	(NL)
Office for International Relations in Science and Education (GRICES)	(P)

- Optimise public fund investments in Space Technology R&D
- Arrive at a coordinated and committed European Space Technology Policy and R&D Programme
- Fill strategic gaps and reduce unnecessary duplications
- Specialise skills and strengthen industrial cooperation
- Determine R&D priorities to satisfy European Space ambitions
- Involve Industry and users in the definition of the technology programmes
- Ensure a fair role to each player
- The basic elements of the process are:

1. European Space Technology Requirement Document (Dossier 0)
2. European Space Technology Master Plan (ESTMP)
3. Harmonisation process
4. Observatory
5. Monitoring process

One additional important element of the process is the Industrial Policy Committee, indicated with the acronim IPC in Fig. 1. The IPC is the board that approves all technology R&D expenditure in ESA. The members of the IPC are appointed by the National Delegations with the function of ensuring consistency between the ESA technology policy and the respective national policies. The IPC is the official board where the ESA executive has a formal dialogue with all ESA Member States for space technology issues.

In the following sections each individual element of the management process in Fig. 1 will be described in detail. To start, however, it is important to first clearly define the mandate of ESA in the context of space technology R&D.

2.1 The Mandate

The mandate for ESA to coordinate and harmonise the European strategy and policy for space technology development has been stated by the ESA Ministerial Council in November 2001 [7]. The basic guiding principle of the document was that space could now be considered a part of the global European infrastructure at the service of the European citizen. In this context, ESA was invited to:

- Pursue the programmatic coordination and harmonisation of technology programmes in Europe and prepare the European Space Technology Master Plan (ESTMP).
- Define roadmaps and harmonised implementation schemes for the development of critical technologies, involving industrial funding as appropriate.

From this mandate, it is therefore clear that ESA was given the central coordinating role for all space R&D activities in Europe. However, it is also clear that since the ESA budget for technology R&D only accounts for about half of the total European spend in space technology (see Fig. 2), coordination could only be achieved through consensus.

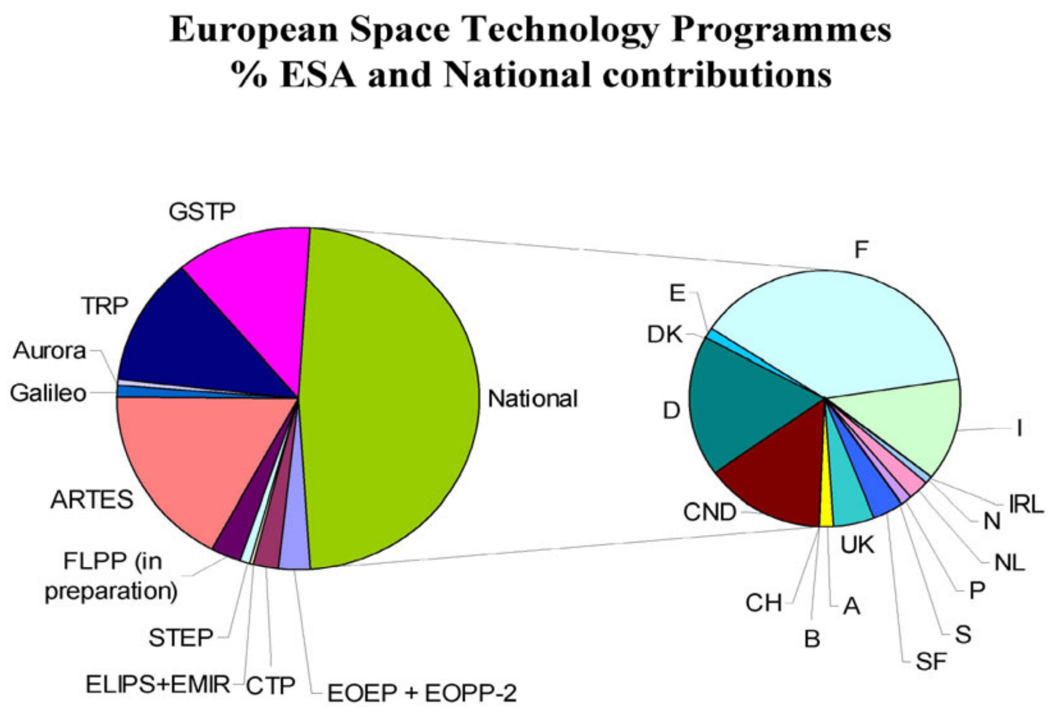

Fig. 2. European contributions to space R&D

In this context, therefore it was necessary to build a management platform that could directly involve from the beginning all of the players. Take into account all space related technology requirements, and be able to reach a consensus on future R&D activities, including funding and sharing or responsibilities.

2.2 European Space Technology Requirements

The initial concept in terms of space technology requirements [6] was to create a document, the European Space Technology Requirements Document (in short Dossier 0) where all envisaged European space missions and technology requirements could be collected. Dossier 0 was envisaged to be the common starting point for the generation of all technology R&D plans. Contributors to Dossier 0were intended to be all parties involved in space technology R&D, namely ESA, National Agencies and Industry. Once created the Dossier 0 was distributed by ESA and the IPC to all European Parties involved in space technology R&D.

The first version of Dossier 0 was issued in 1999 but, although it was immediately recognised to be a very usefull document, it only had a very limited scope. The document was arranged in terms of ”Service Domains” (Eart Observation, Telecommunications, Launchers...) and within each service domain, both missions and technology requirement where listed in tabular form. The first update of the document was initiated in 2001, and the updated document was issued in 2002 with a much increased scope and content. From this experience, two lessons were quickly learned. The first was that the technology requirements needed to be structured in order to produce a more coherent document. The second was that if the Dossier0 was to become an effective instrument, its update process needed to be very substantially reduced.

To address the first issue, ESA initiated the development of a Technology Tree Document where all know how available in ESA could be classified in terms of Technology Domains (TDs), Sub Domains and Groups [8]. Twenty six TDs where identified, and for each

TD one TD Responsible (TDR) was nominated. As a result, the technology requirements could now be groupped in terms of the TDs, and their review and consolidation could be carried out much more efficently.

The second issue was addressed by creating a World Wide Web based application (D0WA) to collect, process and distribute the complete set of information. This effectively transformed the Dossier 0 into a database accessible via the internet for both data contributors and general users (http://dossier0.esa.int).

The introduction of the D0WA effectively reduced the 2003 update cycle to approximately two months. This important time reduction makes it possible, as originally intended, to update the complete database on a yearly basis.

2.3 European Space Technology Master Plan (ESTMP)

The next element of the global process is the European Space Technology Master Plan (ESTMP). The ESTMP is based on the ESA Technology Master Plan, the Technology Plans of the ESA Member States, and on the R&D plans of the EC that are relevant to space. The objective of the ESTMP is to provide the European parties involved in space activities with a synthesis, overview and analysis of all planned European institutional space technology R&D activities. The intended function of the document is to become a common reference tool for the definition of space technology strategy and policy at ESA, National and European level.

In the document, the content of the R&D plans is compared with the top-level requirements of Dossier 0. In particular, detailed information are provided in order to:

- Map the National, ESA and EC technology activities and budgets
- Analyse the content of the planned activities in relation to the mission requirements reported in Dossier 0
- Identify potential complementarities, overlaps and gaps
- Identify the key persons and potential Partners within the different Organisations

The ESTMP was first issued in 2002 and distributed to ESA, National Delegations, the EC and to European industries involved in space activities. The main difficulties encountered in the creation of this document were the definition of a common format for all data required, and the adaptation of all parties involved to a new level of interagency communication that did not exist before. From the first issue, the ESTMP has been updated regularly on a yearly basis.

The document itself is composed of two parts. A paper document that outlines the structure and the global technology strategy of all participating Agencies, and a separated database that contains the detailed information concerning the technology activities being funded. With every subsequent update, the document part is revised as necessary, and additional activities are added to the database.

2.4 Harmonisation

The objective of the Harmonisation process is to analyze in full detail the situation of a specific space technology area and arrive at a consensus with respect to future actions. The process started in 2000–2001 with 3+3 pilot cases, and has now reached a stable rithm with 8 cases per year.

The process itself is based on a 16month overlapping cycle, repeated every year. Each year is split into 2 semesters of activity, in each semester 4 technologies are discussed. Two meetings are dedicated to each subject, namely a Mapping Meeting, and a Road-Map Meeting. The main steps in the Harmonisation process are:

1. Subject identification (yearly work-plan)
2. Preparation of background information (Technical Dossiers)

3. Share, discuss and consolidate the information (Mapping Meetings)
4. Decide on the best course of action (Roadmap Meetings)
5. Conclusions and agreed Roadmaps endorsed by IPC
6. Provide documentation of the entire process (Proceedings)
7. Monitor the implementation of the RoadMaps

The identification and selection of the harmonisation subjects is based on:

- Technology Domain Tree Dossier 0
- The ESTMP
- Reccommendations from ESA Directorates, Industry, National Delegations.
- Revisiting periodically previously harmonised subjects

The selection of the subjects proposed is made in continuity with the harmonisations conducted in the past, and respecting the need to address new technologies. The criteria used in the selection are:

Table 3

Examples of harmonisation subjects in the 2000–2003 period

Electrical Propulsion Synthetic Aperture Radars AOCS Sensors On Board GPS receivers Thermal SW tools Microprocessor and microelectronics Mechanisms and Motors On Board Computer and Data Systems Solar Cells Cryogenics Robotics Aerothermodynamics simulation tools Energy Storage (Batteries) Chemical propulsion Ground Systems Software On Board Payload data processing systems

- Technology maturity
- Strategic relevance for Europe
- Missions needs and market potential
- Existing gaps or duplications

The themes proposed for the subsequent harmonisation cycle are submitted to IPC for approval. The cycle is kicked-off upon the IPC approval of the proposed themes. Table 3 gives some examples of the subject harmonised so far.

2.5 Monitoring

The objectives of this element of the technology management process are to monitor (or evaluate) the output of the technology R&D activities carried out by the Agency, and to evaluate the effectiveness of the overall R&D strategy. This element of the process is not currently fully developed, however, a pilot phase has already been initiated. The (pilot) monitoring activity has essentially two dimensions, namely direct R&D output and global industry performance.

The direct output of the technology R&D activities sponsored by the Agency is evaluated in terms of the direct value generated in industry. To carry out this evaluation a questionnaire has been developed. Typical areas explored are:

- Space applications of the technology developed
- Heritage generated
- Publications and patents
- Technology licensing
- Non-space applications

Questionnaires have been sent to Industries on average three years after the start of the R&D activity so that time is given to complete the project and to exploit the results in applications.

The global industry performance is also evaluated with a questionnaire with the objective colleting information about the overall business performances of the surveyed companies. Typical areas explored are:

- Overall sales
- Commercial sales
- Institutional sales
- Sales to ESA
- Exports

The information collected has been processed in orer to identify the most important enabling factors that contributed to the achievement of outstanding business performances, thus allowing a global evaluation of the R&D strategy implemented.

2.6 The Observatory

The final element of the process in Fig. 1 is the Observatory. The function of this element is to observe technology developments both inside and outside Europe that are relevant to, and in support of, the establishment of a global European Space Technology Strategy. Areas of activity are:

- European industrial capability mapping
- Space technology watch outside Europe
- Non space technology tatch in Europe
- Identification of strategic space technologies
- Identification of long term technology trends

The findings of these activities are again summarised in reports that are then distributed to all European parties involved in space technology R&D.

3. A Success Story: Solar Cells

The solar generators are key elements for satellites because they convert the light coming from the sun into electrical power, which is then collected, regulated, stored and distributed to the satellite subsystems and to the payloads.

While in the USA the space photovoltaic technology has known a very fast evolution in the last 10–15 years, in Europe the transition to the new generation of solar cells has started with a persistent delay and with a slower pace due to a more conservative approach. Only in the late nineties, when the gap between the American and the European new generation solar cells became more evident, the need for an independent and competitive European source of advanced solar cells was unanimously recognized.

The complexity of the advanced solar cell technology, the high level of investments needed and the difficulty to cope with a discontinuous market demand required synergy to make the development efforts more effective.

The need for cooperation among the European actors together with the necessity of a coordinated development plan made the Solar Generators a good candidate as one of the first cases for the Technology Harmonisation process that was initiated in 2000.

Two harmonisation meetings were held in the year 2000, with the participation of ESA, the Delegations and the Industries

It was recognised that the high efficiency ("III-V multi-junction") solar cells would still represent the main space photovoltaic technology for several years and it was agreed that Europe needed to invest in multi-junction cells, in order to provide European primes with a competitive source, in terms of performance, price and delivery schedule. It was further recommended to concentrate the resources into a common development programme, aiming at a large-scale production capability, which would respond to the needs of future European high power array requirements.

In the year 2000, the gap between the III-V multi-junction cell development in the USA (triple junction) and in Europe (double junction) was still 20% in terms of cell performance.

Following the harmonisation meeting recommendation, an ESA funded activity for the "Development of advanced GaAs based triple junction solar cells" was initiated in 2001, in coordination with concurring German national program ("Triquas") and Italian and Belgian activities, with the industrial team led by RWE Solar (the major space solar cell company in Europe) and composed by all other relevant companies and research centers. As a result of the harmonized development effort, in March 2003, RWE Solar succeeded in realizing triple junction cells with a minimum average efficiency of 26.8%. The technological gap with the American companies has been reduced from 20% to less than 5%, in terms of cell performance.

The first high efficiency IIIV multi-junction solar cell completely produced in Europe is now under qualification, and has been already selected for several space missions, namely, for the complete solar arrays of Aeolus (an ESA Earth Observation satellite), for Pleiade (a satellite from CNES), and for one section of Herschel (an ESA Scientific satellite).

The good results in the III-V multi-junction solar cells in Europe were in large part due to the coordinated synergy of conspicuous company investments (in terms of facilities and human resources) and of continuous institutional support from ESA and from the National Agencies, both initiated supported and coordinated by the management process created by ESA to coordinate all technology R&D activities pertinent to space in Europe.

4. Conclusion

In this paper we have outlined the Europen end-to-end space technology R&D management process developed by ESA. The process described is based on voluntary contributions and consensus generation, and involves the European Space Agency (ESA) and all other European National Space Agencies. The various elements of the process have been described, including the outcome of a concrete case, clearly demonstrating that the R&D management process developed is practical and does indeed deliver value to the European space community.

Acknowledgment

The authors would like to acknowledge the contributions of the members of the Industrial Policy Committee of the European Space Agency, and of all other parties involved from ESA, European industries, Eurospace, academia and research centers to the success of the process described in the paper. The authors would also like to acknowledge in particular the contribution given by Marco Freire, Luca Maresi, Rui Meneses, and Edmund Williams to the development and implementation of the process, and Carla Signorini for the material on solar cells. Finally, the authors would like to acknowledge the strong encouragement and support from Dr. Hans Kappler during the development and the implementation of the process described in the paper.

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[8] *ESA Technology Tree Document, IMTTHS/4760/ MG/EW/ap* Figure 1: Graphic description of ESA management process for European space technology R&D