

R&D ACTIVITIES FOR ASTRONOMY AND ASTROPHYSICS IN FRANCE

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Abstract. This report provides the output of a survey performed in 2010 on the R&D activities for Astronomy and Astrophysics. This prospective exercise ended by a national Symposium that gathered all the actors of the discipline in Grenoble for 4 days in May 2011. This report gives also the main conclusions issued from the working groups of the Symposium.

Keywords: R&D, R&T, instrumentation, technology

1 Introductions: Outlines

After its 2009 prospective exercise, the division Astronomy/Astrophysics of CNRS/INSU * requested a review of the R&D activities in the laboratories of the discipline. R&Ds provide very efficient supports to the instrumental developments performed in France. Instrumentation is one of the domains of excellence of the French astronomy highlighted by the very strong French presence for the design and the construction of ground based and space borne instruments dedicated to the major European observation facilities.

R&D is also a real research topic from which emerges innovations sometimes published in international peer reviewed journals of the corresponding discipline. The French R&D activity has a strong international profile.

The requested review work was carried out in two stages, first by means of a survey conducted in 2010 among all the involved laboratories and then through a Symposium held in Grenoble (May 9 to 13, 2011).

The investigative work and the organization of the conference was made by a group of twenty scientists and engineers, with representatives of all laboratories, of each R&D theme and some representatives of the national agencies such as CNES, the national technology platforms as RENATECH (see <http://www.rtb.cnrs.fr>) or CEA/LETI and OPTITEC/POPSUD as a competitive cluster.

This work involved the R&D teams from the laboratories. Their contributions were solicited through the survey that was coordinated at the laboratory scale by their technical managers. This survey gathered answers from more than 20 laboratories, describing their R&D actions. As a final event of this exercise more than 220 people attended the R&D Symposium over 4 days (see <http://ret-d-insu-2011.obs.ujf-grenoble.fr/>).

These two exercises provided a comprehensive overview that highlights the wealth of the activities, of the results and the interdisciplinary collaborations with laboratories outside of the discipline or with industrial partners.

2 The survey of the R&D in the laboratories

The survey was managed at the laboratory scale by the technical managers in two steps, an initial one to identify all the actions and a second one to homogenize the data returned in the answers, in order to obtain comparable informations.

We present here the information gathered over a period of almost 4 years:

- **21 laboratories** answered to this survey, and **140 actions** are identified.
- More than **400 scientists, engineers, and technicians** are involved in all laboratories.

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* INSU: Institut National des Sciences de l'Univers see also <http://www.insu.cnrs.fr>

- This corresponds to an overall budget of **7.5M Euros /year** with a support of almost **125 FTE/year**.
- **63 academic partners** contribute to these actions, including **25 foreign partners** (UK, Italy, Germany, USA, Netherlands, Spain, Australia, ...).
- **61 industrial partners** are identified, some of them contributing to several actions.
- **Access to technologic platforms** outside of the laboratories is required for more than 36 actions.

Indeed the final application of most of these R&Ds is related to **instrumentation for astrophysics**, but some **valorizations** succeed to bring the developed technology to other field of science (medical, aeronautics, laser, biology ...).

2.1 Domain of investigation

The graph of Fig. 1 presents the domains of investigation of the all the actions, reported in number of actions (and not in overall budget). For the analysis we use the domains corresponding to the main technics used for astrophysical investigations. The optics domain cover the largest part of the developments. Detection is also a large domain of investigation covering all the wavelengths from high energy to radio wavelengths.

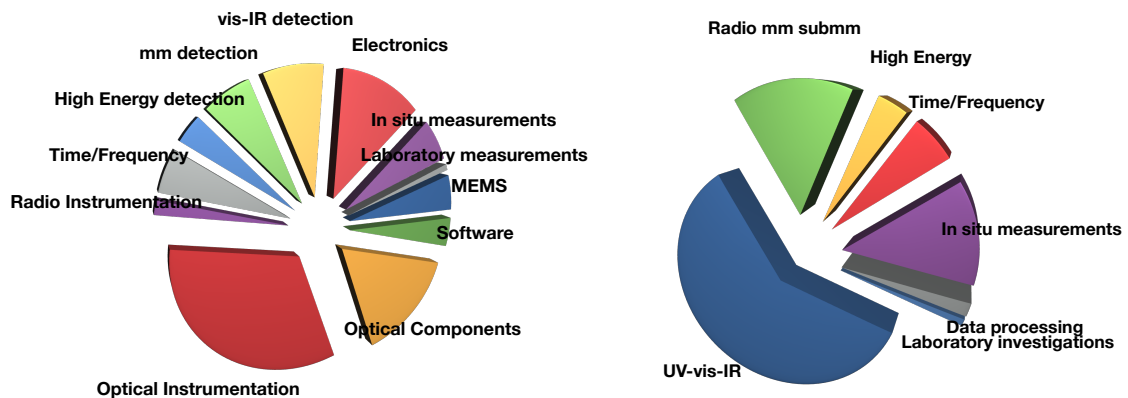


Fig. 1. Repartition of the actions in the various thematics (**left**) and domains (**right**)

2.2 Manpower

We identified more than 400 persons involved in R&D actions, a large part of them being engineers and technicians. It corresponds to an effort of 500 FTE on the period of analysis (125 FTE/year).

Many R&D activities are also carried by PhD students. 71 PhD thesis are identified with various supports from Universities, CNES, CNRS, and Industrial partners. Co-funding are required for CNES and CNRS. CIFRE supports allow PhD directly hired by the companies. More and more PhD supports are coming from EU programs or ANR. A few PhD supports are provided by ESO. Indeed in many cases, PhD thesis are a good way for the investigation of new technologies. It allows a well defined effort on a 3 years time scale.

The repartition according to staff's position is summarized in Fig. 2.

2.3 The partners

More than half of the actions is carrying in collaboration with industrial partners, large groups, SMEs or spinoffs.

More than one third of the actions involves academic partners outside of INSU in France including ONERA and CEA. Collaborations with foreign partners are also a significant part. Indeed the collaborations with academic partners are more often devoted to initial developments.

A large dozen of actions is supported by RENATECH through a RTB funding. RENATECH is the French network of the large technologic facilities supported by CNRS (PTA/Grenoble, LAAS/Toulouse, IEF/Orsay, LPN/Nozay, IEMN/Lilles, FEMTO-ST/Besançon) and LETI (MINATEC/Grenoble) (see <http://www.rtb.cnrs.fr>).

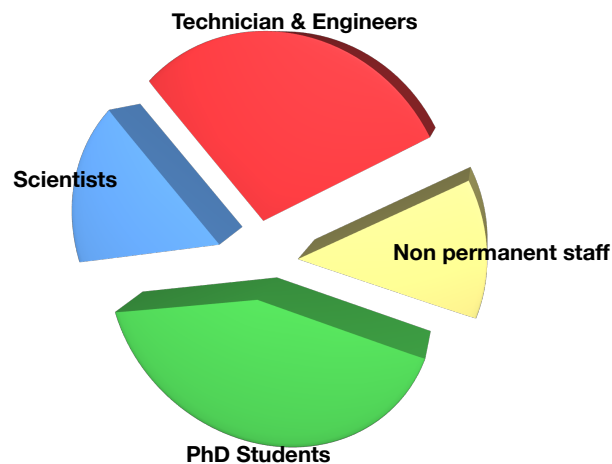


Fig. 2. Staff involved in the R&D in the laboratories

2.4 Synergies with other application domains

For a long time astrophysics has been benefiting from the technological efforts made by other disciplines: this applied to military optronics in the eighties mainly for detection and adaptive optics more specifically for the IR domain. It applied also to optical telecom in the nineties especially for optical interferometry using integrated optics technology.

In an other hand the developments done by the discipline allow fruitful transfers toward other domains of applications: Ophthalmology from adaptive optics, optics manufacturing, Time/Frequency measurements, Spectroscopy and more recently aeronautics through the valorization of a high speed detector.

2.5 Localization on the national area

Fig. 3 presents the repartition of the R&D actions in the French laboratories. The major actors are the laboratories involved in the realization of the instrumentation for the large telescopes and for space missions. Indeed it corresponds often to the preparation of future programs on a top-down process, but it corresponds also to bottom-up developments where new ideas arise from the instrumental groups, including developments not directly linked to well identified instrumental programs.

We keep here both descriptions in term of number of actions and in term of budgets, to avoid the bias of very expensive developments like for instance the new detector developments.

The analysis shows also that R&D activity has been growing in several places since a few years. It is identified in several laboratories as an essential support to instrumental activities including information services.

2.6 Funding

In the recent years there has been a diversification of sources of budget as for other research domains. Apart the usual funding coming from space agencies (CNES and ESA mainly) or INSU, several new tools were provided to the teams to fund there research: ANR, FUI (Fond Unique Interministériel), EU Framework Programs (FP7 currently until 2013). This diversification induces a difficulty to manage the R&D programs at the national scale, and to focus it mainly in support to the large instrumental programs. Forthcoming new tools of "initiatives d'excellence" will even reinforce this effect. It underline the importance of an efficient animation by INSU, to keep the best coordination between the laboratories and to provide the right support to the main projects of the discipline. Fig. 4 presents the fundings that have been used for the R&D actions reported by the survey. The main funding devoted to R&D programs are the following:

- R&T CNES 2011: 2,394 M€
 - Astronomy Astrophysics: 0,88 M€
 - Planetology: 0,4 M€

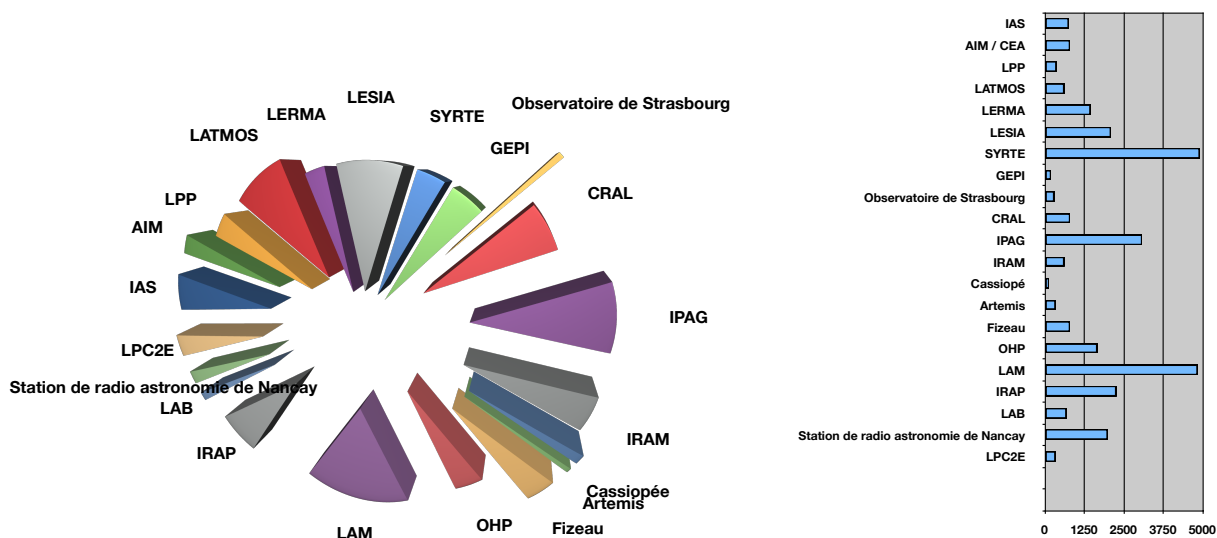


Fig. 3. Repartition of the R&D actions in the French laboratories reported to the number of actions (left) and to the considered budget (right).

- Fundamental Physics: 0,45 M€
- Solar Physics: 0,29 M€
- Exobiology: 0,245 M€
- R&D INSU AA (R&D + ELT/SKA + VLTI) (2010/2011): 400k€/ 200k€
- ANR (20 actions mentioned) and FUI (4) corresponding for both cases to allocations of 2,9M€.
- ESO and ESA Contributions, Projects. As a reminder the French contributions to the agencies (info prospective INSU) are ESA/65M€ for the mandatory program, ESO/20M€, CNES/62M€,
- EU FP7 budget for the 2003-2009 period (actions related to Astronomy and Astrophysics) is almost 50M€.

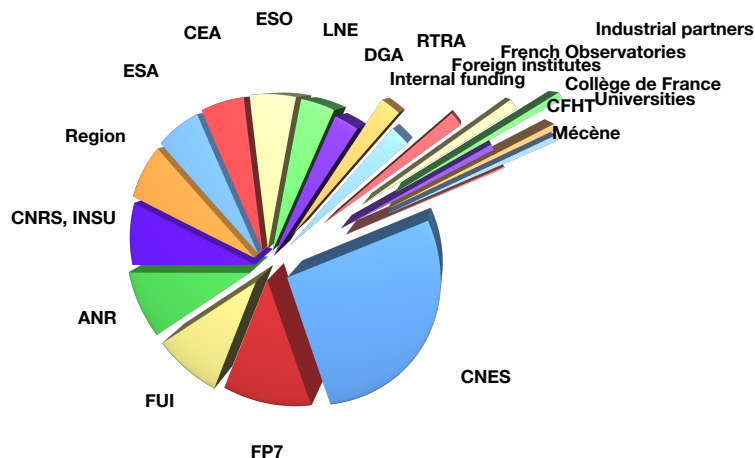


Fig. 4. Funding supports

3 The Symposium

3.1 Attendees

More than 220 persons participated to this four day Symposium. It includes representatives from:

- the laboratories of the disciplines (most of the INSU/AA laboratories were represented),
- the main organism partners (CEA, LETI, ONERA)
- the agencies (CNES, ESO),
- the technologic facilities, mainly RENATECH
- industrial partners from main groups, SME and spinoffs.

3.2 The program of the Symposium

The detailed program of the whole Symposium is reported in Table 1. The program during the 4 days included:

- A first half day of presentation of the instrumental needs. It addressed ground based facilities (ESO), space program needs (CNES), a reminder of the conclusions of the INSU-AA prospective exercise.
- One day for a full review of the R&D programs for all instrumental themes, done mainly by the members of the scientific committee via 20 keynote presentations.
- At the end of the second day, a presentation of the national means available for technological realization.
- A full day of workshops addressing the organization of the R&D in Astronomy, with four groups, each addressing one of the following themes:
 - Organization within the laboratories
 - Technologies means available inside and outside of the laboratories
 - International collaborations
 - R&D and large instrumental programs
- The last day was devoted to the relations with the industrial partners, through keynote presentations (Large groups, SMEs, Spin-offs) and round table: (1) common projects and answers to agencies call for tenders, (2) common research through PhD, (3) transfers of technologies and knowledge).
- This last day ended by a concluding talk that summarizes the conclusions of the 4 workshops of the wednesday, and drew some first recommendations.

3.3 Wednesday Workshop

The four workshops were organized by a team of a few engineers and scientists from the organization committee with additional persons when necessary to complete the expertise.

The conclusions of these workshops were presented in a plenary session during the last day of the workshop. It was discussed from the **top down R&Ds** generated by the main instrumental programs as well as the **bottom up R&Ds** that arise from the research teams. These two processes must be supported since they are both essential for the discipline, the efforts must not be centered only on program driven R&Ds. Agencies and laboratories must keep availability and funding for up stream developments in order to anticipate long term programs.

Some specific recommendations were issued from each workshop:

1. Programs impact:

Jean Gabriel Cuby (LAM), Thomas Foujols (LATMOS), Martin Giard (IRAP), Michel Piat (APC)

- Need to bring out the observational barriers in each scientific theme. Such concerns could be addressed via the INSU/AA national programs.

Table 1. Detailed program of the Symposium

Introduction of the Symposium		
Instrumentation priorities INSU/AA prospective	Martin Giard	IRAP
R&D in the laboratories main numbers	Pierre Kern	IPAG
ESO/VLT and ELT instrumental requirements	Norbert Hubin	ESO
Space programs and CNES R&T	Pierre Gilles Tizien	CNES
Thematic survey		
Optical Telescopes	Marc Ferrari	LAM
Planetary exploration	Sylvestre Maurice	IRAP
Gamma nuclear astronomy	Peter Von Balmoos	IRAP
radio mm/sub-mm R&D	Michel Guélin	IRAM/LERMA
Optical Interferometry	Denis Mourard	OCA
Signal processing software	Eric Slezak	OCA
Time-Frequency	Noel Dimarcq	SYRTE
Ondes gravitational waves	Hubert Halloin	APC
Optical Spectroscopy	Jean Gabriel Cuby	LAM
Radio telescope Back-end	Marc Torres	IRAM
Adaptive Optics	Gérard Rousset	LESIA
High dynamic Imagery	Pierre Baudoz	LESIA
Virtual Observatory, inter-operability, new interactions user/data	Françoise Genova	Observatoire de Strasbourg
Gamma high energy-very high energy astronomy	Pascal Vincent	LPNHE
BF Radio-astronomy	Steve Torchinsky	Station de Nancy
Astronomy X	Olivier Limousin	CEA
Heterodyne mm detection	Yan Delorme	LERMA
UV-Vis-IR detection	Philippe Feautrier	IPAG
mm direct detection	Michel Piat	APC
Cryogeny for detection	Philippe Camus	Institut Néel
Presentation of the national technology facilities		
General presentation of RENATECH	Michel de Labachellerie	FEMTO-ST
The platforms of the RENATECH network	Hugues Granier	LAAS
Examples of developments for INSU/AA programs		
- Arrays of bolometers at LETI	Louis Rodriguez	CEA
- UV Filtres at FEMTO-ST		IAS
- Nano-technologies for submm detection at LPN	Roland Lefevre	LERMA
IRAM: a dedicated platform	Karl Schuster	IRAM
GDR CNRS Micro Nano Systems	Jean-Louis Leclercq	ECL
Industrial partners		
Air Liquide	Sébastien Triqueneaux	
CILAS	Jean Jacques Roland	
SAGEM REOSC	Roland Geyl	
SESO	Gilbert Dahan	
SODERN	Roland Legoff	
μQuanS	Bruno Desruelle	
THALES	Jean-Jacques Juillet	
ONERA	Vincent Michau	

- Need technology demonstrators before the main programs. It concerns ground based instruments, balloon as well as space missions. The difficulty has been identified on the CNES side, a working group is constituted.
- Increase the coupling between the CNES thematic groups and R&D, with suitable comments on actual relevance.
- Need of feedbacks from proposal and/or from the competitive phases A toward required R&D.

2. Organization

Françoise Genova (observatoire de Strasbourg), Guy Guyot (INSU), Pascal Jagourel (GEPI), Roger Pons (IRAP)

- The volume of activities in the laboratories is varying depending on project activities. The dynamic between R&D programs and project activities must be balanced accordingly.
- The organization of R&D within the discipline must be improved:
 - At the local level, laboratories must define their strategy for R&T.
 - The definition of a national strategy seems all the more necessary as funding opportunities become more and more diverse.
 - An overall coordination of INSU R&T in addition to the INSU/AA coordination mentioned above could be useful.
- The organization of such a R&D Symposium before the next INSU/AA prospective is requested as an input to the prospective exercise (skills, highlights, strategic lines would be defined at the Symposium)
- Then such Symposium must remain recurrent.
- R&T Actions:

Actions must be quickly known in laboratories. They must have an appropriate project structure: definition of the objectives, milestones, regular reflection on their pursuit (decision to end, realization phase, valorization outside of Astronomy, ... and confrontation with project / laboratory / national strategy). The special conditions of different types of funding must be taken into account.
- Staff:

This activity is performed by "instrumentalists" researchers AND engineers/technicians specialists, as well as PhD students. If the laboratory wishes to retain the expertise after the projects at least one permanent scientist or engineer must follow the activity.

Regarding to the staff careers, the criterion "project management" should not be the sole criterion for promotions of the engineers and technicians. The difficulties for the careers of engineers and technicians are specific and the R&D activity must be taken into account. It must be noticed that instrumentation is a **Researcher profiles** for Astronomy and Astrophysics.

3. Technology facilities:

Marc Ferrari (LAM), Louis Rodriguez (SAP/CEA)

The teams involved in technology developments for Astronomy and Astrophysics use either national facilities as the one of RENATECH/CNRS network or MINATEC/LETI or the means (pooled or not) of INSU laboratories.

A lack of knowledge of the capacities and capabilities of the existing facilities was observed. The situation was already known, but strongly arose from the discussion. It was suggested to:

- Provide an information about these facilities, mainly in INSU laboratories, but also about the national Centrals
- Maintain a national census of the proximity platforms.
- Setting up a network / forum about technology means.
- Centralize the information at CNRS / INSU level through a dedicated and unique website.

The need for recognition of the technical staff of the technology centers was also underlined. The support to R&D or community is poorly (or not!) recognized, in particular when it is performed for other institutes. We need to find another measure of the impact of the activity that the publications in peer review papers.

The difficulties to maintain the manufacturing processes was also identified. Is it the role of technology centers to maintain the technologies required by astronomical instrumentation? The question is to identify

if it must be done by the INSU laboratories themselves using dedicated means. For most of the cases this support is too expensive for INSU.

Another point is to define the boundary between laboratories and national platforms means. We must keep the critical steps and key technologies in the labs to ensure the product realization for incoming large projects.

The need of a new job was identified: "technology project manager". It must probably be supported at the INSU level in order to insure the legitimacy with respect to Renatech. Such people will insure multi-lab and multi-core role.

Finally one identified that two operation modes are used by the technology platforms: "Do it Yourself" or "Do Not Touch Anything". Necessarily an intermediate mode is often necessary for a suitable operation for INSU developments, in order to associate researchers/technologists from INSU laboratories for the developments.

4. International

G rard Beaudin (LERMA), Marc Ollivier (IAS), Denis Mourard (OCA), G rard Rousset (LESIA)

- Observations

European Union tools are important sources of funding for R&D. FP7 EU programs are well suited to prepare the positioning for the construction and access to the instruments. The international positioning is one of the criteria for the evaluation of the laboratories.

Throughout the difficulties we identified:

- Regarding to responses to EU call for tenders (CFT) rules are numerous and the structure is complex.
- Heavy project management,
- Regarding to the intellectual property, special attentions should be given to the dissemination of ideas.
- EU tends to focus on targeted call for tenders
- France is misplaced in the European lobbying
- International activities are not well recognized for the career progression.

- Recommendations:

It is essential to insure the sustainability and to capitalize the experience by a permanent staff especially for administration AND project management. A strengthening of the support by CNRS regional delegations will be invaluable.

International collaboration require to sign:

- a confidentiality agreement from the beginning of the project preparation,
- a Memorandum of Understanding (MoU) for the responses to the CFT,
- a consortium agreement for the realization.

Laboratory staff must be encouraged to become "expert" to understand the logic of the EU CFT and to increase the chances of success

We enjoin CNRS to support white programs of the EU in order to stimulate new ideas.

Mount specific training for the preparation and the management of international projects:

- Ongoing training for the laboratory staff
- University education for future research players

4 Conclusions of the discussions during the Symposium

The following conclusions were issued from the works of the 4 workshops and of final discussion within the organization committee.

R&D is an essential element of the activity in Astronomy, for the preparation of future projects to push the technologies to their limits, and enable technological breakthroughs. It exist an actual virtuous circle between the scientific needs, instruments realization, and R&D activities. Instrumental research is one of the strengths

of French research in astronomy. Large sectors of R&D excellence includes many domains (components, test benches, system analysis, simulations, software ...)

It is necessary to maintain a coordinating role to INSU.

The diversity of funding tools increases, including for phase A studies devoted to space missions and ground based instruments, in particular to remove the technological show stoppers. These new fundings authorize R&D programs that could not be possible 10 years ago. In essence R&D activities are not supposed to succeed in all cases (which are not necessarily failures). The role of the partnership with the main agencies is essential especially CNES and INSU for space. The integration in European programs is excellent (EU, ESA, ESO).

The group underlines the interdisciplinary of the activities including with industrial partners. The rich relationships with industry is far from a simple delivery service. It must be considered to use alternate indicators able to put a better emphasis on this efficient partnerships beyond the usual indicators of the social and economic impact. R&D provides a good potential for use outside of the discipline. Concerning the signal processing, a structure must be created, especially for the dissemination of the knowledge in the community (creation of a CNRS/Specific Action)

5 Conclusions

The Symposium responded to a strong demand of the community. The last Symposium organized by INSU on this subject was in 1999 in Boussens. Most of the laboratories answered to the survey, and send several representatives to the Symposium. The high quality of the talks and of the associated posters was emphasized by the attendees. The Symposium provided also an excellent occasion for multiple discussions between various teams that are not usually meeting since they are not working in the same domain.

The strong evolution of the national landscape was enlighten by the exercise. Especially the support is now coming from a much larger number of funding partners and agencies. It is essential to take the best benefits of this evolution whereas we maintain the main objectives of INSU/AA missions.

This overall R&D survey brings a first step toward a better organization at the national scale, through the potential of INSU and its laboratories.

The main support of the Symposium was provided by CNRS (Formation Permanente) and by INSU. Additional supports were also given by CEA/Sap, CEA/LETI, CNES, Thales, POPSud, Université Joseph Fourier.