Research and Technological Development in France



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technologies

France, with all its talents and passion, participates in the Europe of science, a decisive element in the cohesion of our continent and its opening to the rest of the world.

This science not only seeks and innovates, but above all, is able to provide meaning. It can be summed up in three major challenges. First of all, there is the need for shared knowledge, as the balances which govern the workings of our world are so fragile. Then there is the moral imperative of responsibility that makes every researcher, in public institutions as well as private firms, a committed citizen in assessing risks and in seeking the common good. Lastly, we must take into consideration the rights of the individual, a fundamental challenge the importance of which we can measure in the ongoing discussion about human embryos.

At a time when questions are arising about being able to replenish the present body of researchers, the appeal of some countries for our scientific elites, the sharing and consequences of progress, it is an absolute necessity to place science at the heart of society. To do so we must help our fellow citizens to become aware of the challenges that science represents and the prospects that it opens. We must liberate initiatives, make results more visible, provide support to the desire and pleasure of undertaking new projects.

The XIXth century was the century of heavy industry, the XXth century the century of transportation and electronics, and the XXIst century will be the century of economies based on knowledge. Science is at the heart of our future. It combines intelligence, excellence and responsibility in building a piece of the destiny of humankind.

Claudie Haigneré
Minister for Research
and New Technologies

SOMMAIRE

THE PRIORITIES OF FRENCH RESEARCH

At the Lisbon summit in 2000 France, along with its European partners, stressed the central position of knowledge in the future of the most competitive economies of the 21st century.

Knowledge, in particular scientific knowledge, is one of the key factors in the evolution of our societies. It is by sharing knowledge and adapting scientific culture that we create value not only on the economic but also the human level.

A NECESSARY INTERNATIONAL COOPERATION

In order to meet the great challenges in environmental protection, health, new technologies, and more generally quality of life, one country alone is not enough. In all these areas greater cooperation is necessary between different partners in the future European research community and in an increasingly open world community. Knowledge can only be enriched by such cooperation, which does not exclude the fact that each country is engaged in a logic of competition that encourages emulation and therefore the pursuit of excellence.

HIGH QUALITY BASIC RESEARCH

In order to meet these challenges the ministry in charge of research plans to maintain a pillar of high quality basic research. Who can say today what great problems will have to be solved tomorrow? It is essential to preserve the continuity between science and industry in the different aspects of research, whether basic or applied, public or private. This synergy is beneficial to all, and opens the way to answers relevant to the questions when the time comes.

MORE SPECIFICALLY TARGETED PRIORITIES

For the ministry in charge of research and new technologies, maintaining a pillar of basic research goes hand-in-hand with specifically targeted initiatives. Certain priorities have been defined by the President of the Republic and the French Government. These priorities guide the missions of the ministry and answer the concerns now shared by most of the countries in Europe and the rest of the world: sustainable development, the energies of the future, the fight against cancer, the digital society, space...

■ Meeting the challenges of sustainable development requires placing man at the heart of our concerns while respecting present and future generations. The emphasis put on renewable energies in the framework of vast international programmes of new energy technologies as well as research in the fields of non-polluting transportation and environment-friendly production methods are all part of this vision of a modern and realistic ecology.

■ ITER, the international experimental thermonuclear reactor project offers us a new vision of our planet's future as it promises a clean and practically unlimited source of non-polluting electricity within two generations, thanks to the energy of nuclear fusion.

■ Public health, in particular the fight against cancer which has become a symbol, now mobilises new synergies in the live sciences, from physiology to genomics as well as fields other than biology, the humanities and social sciences. It will now be possible to view a disease in a broader way and to transfer the results faster toward clinical and industrial applications.

■ The digital society is now revolutionising our means of communication and information exchange. Research in this area must lead not only to the creation of new technologies, but also to their protection, the broadening of their access to as many as possible, and the dissemination in society of new contents of knowledge.

■ Space policy, in view of the know-how acquired by France and Europe in this field, must be radically changed. It must evolve and become stronger in order to enter the new territories of the future and play the key role there to which it is destined by history.

Devote 3% of the GDP to research

To meet these challenges of knowledge, we have provided ourselves with prospects and indicators. The President of the French Republic has set the objective of devoting 3% of the GDP to research and development, and thus of moving from a rate observed in 2001 of internal expenditures on R&D of 2.2% to a rate of 3%. This objective was also adopted by all the heads of State and Government of the European Union in Barcelona in 2001. This requires large-scale mobilisation, alongside the ministry in charge of research, of everyone working in research, whether public or private. In cooperation with European institutions a vast plan in favour of research and innovation is now underway. France is one of the European countries with the highest share of the government budget devoted to research. France will pursue its efforts aimed at economic growth, creation of jobs, and social progress.

Research is above all a question of human resources

Research will adapt to today's new time frames, which have become considerably shorter, through more fluid organisation. The slowness of certain systems can no longer be allowed to hinder the process that changes an idea into a product. To achieve the objective of 3% of the GDP, Europe must, for example, recruit 500,000 researchers by 2010, who will be added to the some 800,000 researchers now working in Europe. How can we attract new generations of students? How can we encourage them to pursue scientific studies and keep them in our research institutions without organising research mobility, creating bridges and facilitating recruitment?

The central administration of the ministry has understood the need to adapt and has acquired a capacity for scientific expertise with the creation of a scientific, technical, and educational mission. This mission gives science all the weight it requires within the administrative system. Two divisions coordinate all the research and technological development, and the research institutions define the avenues of work that determine the financial resources granted to them. This contractual approach must be broadened.

A new research culture

Our research must be structured, our talents must be mobilised, our knowledge must be shared and the entrepreneurial spirit must be stimulated around a true culture of projects, which complements the notion of programme and encourages us to take into account concrete objectives in priority areas.

Along with their partners, institutions and companies must unite today to provide solutions to the great problems of our time.

ENERGY, TRANSPORTATION, AND SUSTAINABLE DEVELOPMENT

The President of the Republic and the French Government have placed the question of sustainable development at the heart of their action, and Europe has decided to strengthen its efforts in this area. Research plays a major role in this perspective. It opens transdisciplinary programmes in two essential fields: transportation and energy. This is carried out in coordination with major European and international programmes, and the idea is to engage the responsibility of France in the field of environment and cooperation with the countries of the south.

Research and action in sustainable development

For French research, sustainable development represents both an area of research and a principle of action. The approach of French research seeks to accelerate the convergence between environment and development, local and global action, private initiative and public action. French research takes on a concrete form in its contribution to international conventions on climatic change or biodiversity. It is concerned with solidarity and the development of the countries of the south, as it seeks to improve the immediate environment of citizens through the reduction of pollution and risk prevention.

A more harmonious organization

To develop these programs, research tends to harmonize more effectively shared and pluridisciplinary projects, methods and tools of integration in technical and socio-economic fields.

The Institute of Sciences of the Universe and the Environment will handle the coordination of research in these areas. So projects related to water resources or sustainable food systems are carried out in common by research bodies specialized in the knowledge and use of living resources for agronomy and halieutics. Other interdisciplinary projects concern the relationship between the environment and health and pathologies due to climate change.

Research on governance

Research develops models and methods of knowledge and assistance to decision-making useful to expertise and governance in the context of sustainable development. For example, research projects are aimed at societies and cultures, governance and regulation, methods of analysis and sensors, new depollution procedures or the management of ecosystems.

Energies and climate change

The Kyoto protocol constitutes an initial stage toward the objective of reducing greenhouse gas emissions. New non-harmful production technologies must be designed by developed countries in the context of increasing worldwide energy demand by around 5 to 10% per year. In France public research devotes about 1.2 billion euros per year to the energy question. Its priority objectives aim at creating procedures for reducing energy consumption and polluting gas emissions and improving performances and safety in the nuclear sector. These objectives focus on the efficiency of renewable energies, in particular the photovoltaic battery and biofuels. They also aim at perfecting all the clean, economical, and non-polluting processes for the optimisation and improvement of energy efficiency and the control of greenhouse gases.

Research in different forms of energy

■ In France 77% of all electricity production comes from nuclear energy. Research in this area tends to increase safety, reduce waste and improve storage and transportation. This research also prepares the so-called 4th generation systems: more economical gas reactors which produce less waste. Six designs of these reactor systems are part of the international research being conducted in view of industrial use around 2030.

■ Research is also being developed in the field of photovoltaic cells (solar energy), in particular with new nanostructured materials like organic cells.

■ Biofuels open up interesting avenues of research in preparing the non-fossil fuels of tomorrow. Research focuses on improving their productivity and performances to meet the needs of new automobile technologies.

■ Research in hydrogen and fuel cells deals with the entire sector, from the initial energy to the fuel supplied. It considers components, assemblages and complete systems.

A technological network to prepare the transportation of tomorrow

Transportation is responsible for 28% of greenhouse gas emissions, and for a very large share of the consumption of oil products. A 40% increase in traffic is predicted by 2010, so Europe must think about perfecting clean means of transportation. French public research devotes around 300 million euros per year to the question of transportation, which mobilises 1,500 scientists. In private research, 7,500 scientists work on these questions with a budget of 2.6 billion euros.

Public research, private companies, and agencies with specific objectives like the Agency for the Environment and Energy Control (ADEME), or the National Agency for the Use of Research (ANVAR) cooperate within a technological network, the Programme of Research and Innovation for Land Transportation (PREDIT), which receives 300 million euros in public funding. Research is active in the design of mobility, energy impacts, safety, and economical and non-polluting technologies. Technological objectives take into account the consequences for all types of transportation, energies, and vehicles.

ITER*. RETHINKING THE FUTURE OF THE PLANET

The consumption of energy necessary to satisfy the needs of mankind could triple by the year 2050, and during the same period world population will have doubled. Today two billion persons still do not have access to electricity. Fossile fuels cannot be a durable solution, or the only one. It is therefore vital to explore the potential of other sources of energy, whether renewable or nuclear.

It can be predicted that fossile fuels will become scarce around 2040-2050, and their abusive use has a heavy impact on our environment. Awareness of this urgent question, in a logic of sustainable development, is one of the strong messages expressed by Jacques Chirac, President of the French Republic, at the recent Johannesburg summit. In the context of these concerns, the international ITER* experimental thermonuclear reactor project seeks to produce energy while preserving the environment.

Thermonuclear fusion, the source of solar energy

In addition to fission energy, which already has a long history, fusion energy represents a great hope, namely the hope of providing a clean and abundant source of energy. In a manner similar to what happens in the sun, energy is produced through the fusion of deuterium and tritium atoms, two isotopes of hydrogen, which are available in great abundance. This reaction produces helium, a perfectly inert gas of no danger to human health or the environment. Whereas the production of energy now based on the nuclear fission of uranium atoms produces a set of light atoms, some of which emit dangerous radiations for millenia, the fusion process has no impact on the greenhouse effect, and its short-lived waste is easy to manage with present know-how.

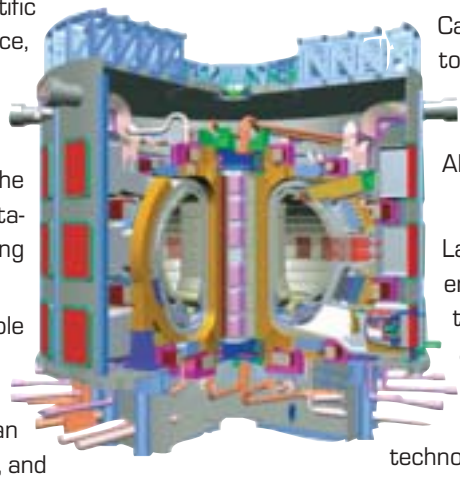
Experiments with the reactor of the future

The elements consumed by the production of fusion energy come from ocean water. They therefore exist in practically unlimited quantities. A litre of water contains 34 mg of deuterium, i.e. the energy equivalent of 300 liters of gasoline. The oceans, seas and lakes could supply thousands of reactors for millions of years.

Current experimental reactors are not large enough to validate fully the scientific and technical feasibility of a technological demonstration reactor, and then the feasibility of an industrial prototype producing electricity. So it is necessary to build a new and much larger experimental reactor. The scope of this project, at an initial cost of 10 billion euros over 30 years for a reactor of a diameter and height of 25 meters requires large-scale international cooperation. If this technology proves its worth, it will benefit the entire planet.

France and Provence offer to host ITER*

In January 2003 the Prime Minister of France announced his country 's decision to be a candidate to host the ITER* project. France expressed its desire to offer Cadarache, in the Provence region, as a European site for the construction of this world-grade reactor. This project would include, for the first time, the world scientfic community (the European Union, Russia, Japan, Canada, China, and the United States are all participating). Four sites have been deemed suitable to be candidates according to the final report of the International Scientific Evaluation Committee: Cadarache in France, Clarington in Canada, Rokkasho in Japan, and Vandellos in Spain. International negotiations are underway to determine the location of the reactor, the status of the organisation responsible for the implementation of ITER*, the functioning, and the funding of the project.



France is determined to win this formidable challenge with its partners. France is offering at the same time its best expertise and its territory to serve this ambition, an unprecedented one for science, our planet, and future generations.

Cadarache, a French site with many advantages

France has developed a reputation of excellence in the field of nuclear energy, in particular through the activities of the Atomic Energy Commissariat (CEA). This long scientific, technological and industrial experience, which led to France's independence in the electricity sector, allowed early awareness of the challenges of fusion and the hopes that it provides.

France offers many advantages: the excellence of its world-famous research teams; the French culture of safety in energy production; its experience in carrying out major technological projects. Indeed, France has proved on its own territory that it is capable of hosting researchers and engineers from all over the world to build and develop ambitious projects: the successes of the Laue Langevin Institute and the European Synchrotron Research Facility, located in Grenoble, illustrate this. The installation of the reactor at Cadarache will benefit from strategic synergies between research activities of the Atomic Energy Commissariat on thermonuclear fusion, all grouped together at Cadarache, and the ITER* reactor, which is planned to be located nearby. Moreover, the choice of Cadarache is supported by the population of the region and the local authorites of the Provence–Alpes Côte d'Azur region.

Lastly, the Provence art of living, the sociocultural environment, the quality of educational opportunities, the French system of social protection, care and health are all suited to meet all the demands of the engineers and researchers who will choose to participate, in France, in this scientific and technological adventure of the XXIst century.

Today, the international scientific and technical community knows that if it wants to succeed it must be united. It is not only a question of financial or human resources. We know that the future of our planet in terms of our energy needs depends on our capacity to be together and do together. ITER* represents an unprecedented challenge for humanity. It is up to the international community to decide upon its construction.

**ITER : International Thermonuclear Experimental Reactor*

THE LIVE SCIENCES, RESEARCH FOR LIFE

It is in the sciences of living matter that the expectations of the population are the highest, especially because of their direct applications in the field of health. These sciences are now witnessing an acceleration in the production of results and a rapid change in their very foundations. New technologies, deriving in particular from nano-biotechnologies, make it possible to multiply data even more while reducing the invasive character of explorations, and for the first time beginning to open the way to a systemic biology with real predictive capacity. Along with widespread dissemination of genomics tools, the sciences of living matter focus on major challenges like the fight against cancer, one of the priorities of the President of the French Republic, and against infectious diseases. The lively ethical controversies around these sciences show how much they are at the heart of contemporary thinking.

GENOMICS, NEW BASES FOR THE SCIENCES OF LIVING MATTER

Genomics is a new field in biology which aims at complete molecular and functional analysis of the hereditary material of living organisms. With this more exhaustive vision, biology will be able to enter its mature stage rapidly, which chemistry or physics have now reached. France wishes to encourage the development of this research and its biomedical, agricultural-alimentary and environmental applications. National efforts focus on two national centres for sequencing both in genotyping and genopoles spread over French territory. These centres possess efficient platforms in the field of large-scale biology. This effort is coordinated within the National Consortium of Genomic Research, which closely brings together the four major research institutions in the field of living matter: the National Agronomic Research Institute (INRA), the National Centre for Scientific Research (CNRS), the National Institute of Health and Medical Research (Inserm), and the Atomic Energy Commissariat (CEA). In the short term, emphasis must be placed on assistance to bioinformatics and its capacity to exploit the immense volume of data produced by genomics, and on the emergence of proteomics, which sheds revolutionary light on the normal or pathological functioning of cells.

A NATIONAL INSTITUTE AND CANCER CENTRES TO AMPLIFY THE FIGHT AGAINST CANCER

The growing rate of cancer in the population, in particular in France, has led the Government to strengthen research in this essential field of health. All persons working in this area are mobilising in the framework of a plan to fight cancer, launched by the President of the Republic. A national cancer institute will be

assigned to the task of encouraging and coordinating upstream biology research programmes, clinical research and research in human and social sciences so as to accelerate the transfer of diagnostic tools and innovative treatments to diseases and take into account more fully the disease as a whole and its consequences. Research will be concentrated in cancer centres, which are research centres linked to recognised clinical centres, where the synergy of resources and scientific and clinical talents will make it possible to conduct, with a true ambition to succeed, projects of an international dimension in the service of patients.

Infectious diseases, a threat that is changing and worsening

Infectious diseases like AIDS, malaria or tuberculosis tend to spread in developing countries. In France, these diseases, including AIDS and viral hepatitis, represent a threat in addition to resurgent infections like tuberculosis, other more common but persistent diseases, and new pathologies linked to changes in life styles. A national research programme launched in 2003 by the ministry in charge of research integrates basic research in these very open fields which will have to answer tomorrow still unknown questions. It is in this context and according to its traditional principles of solidarity with the countries of the south that France is actively participating in the creation of a European platform of clinical tests on contagious diseases related to poverty.

Rediscovering the central role of physiology

The mastery of the complexity of biological systems, the objective of physiology, will lead to the greatest progress in the sciences of living matter. This notion must be reexamined at a time when new fields of investigation are being opened in biology. The ministry in charge of research wished first of all to support initiatives in favour of the physiology and biology of development, on the one hand, and some aspects of the neurosciences on the other. The modernization of facilities with the creation of functional exploration platforms (imaging, electrophysiology, etc.) will continue this effort, which can be adopted in the future to other types of facilities. There will also be action programmes that deal more generally with the integrated functioning of complex organisms.

The French position in bioethics

Research in the sciences of living matter is unthinkable without giving a special place to considerations about ethics. The debate has been opened all over the world about bioethics, in particular about the question of embryo research. The French government has reasserted its position in the framework of the revision of its law on bioethics and before the international community: to make possible, in a strictly defined framework, research on the embryo and embryonic stem cells while maintaining the prohibition on human cloning, regardless of its purpose.

INFORMATION TECHNOLOGIES, DEVELOPMENT OF THE DIGITAL SOCIETY

The Ministry for research and new technologies has a twofold task in the field of information and communication technologies: research in this area and dissemination of these technologies among the general public.

Indeed, leading-edge research should be ensured in the field of information technologies pertinent in many industrial and scientific fields.

In parallel, an educative and pedagogical mission should be carried out with respect to the general public to disseminate these technologies and promote the use of Internet by everyone.

Research in the Sciences and Technologies of Information and Communication

This field is transversal by nature, and the Ministry supervises the activities of the research institutions concerned, mainly the CNRS (the Sciences and Technologies of Information and Communication branch) and the INRIA.

The Ministry also carries out incentive initiatives related to key sectors: scientific computing of high power (university computing and research in applications of quantum physics, meteorology, geology, bio-computing, etc.), computer security, masses of data, grid computing.

It provides support to nanosciences and nanotechnologies through the Micro- and Nanotechnologies Network and the programme of support to four major French nanotechnological centres in the framework of the programme launched in 2002.

Renater, the national network of telecommunications for education and research

The Ministry actively supports the Renater network, which was created in 1993. With the support of data gathering networks of local authorities, this network with a high technical level has linked all French universities and research centres with a bandwidth of 2.5 GBIts since the launching of Renater-3 in October 2002. Its scope of action has recently been expanded to major hospitals and cultural institutions, which make large-scale use of electronic data transfer.

Renater is linked to Giant, the European research network, and has special ties with other national research networks (South Korea in particular).

Renater is also at the cutting edge in Europe in research and creation of new internet protocols (Ipv6). Since the beginning of 2000 it has hosted the French (Ipv6) task force, supported by our Ministry.

Major technological projects in fields of information and communication technologies

The Ministry provides financial support to the major technological programmes combining public laboratories, large companies as well as small and medium size industry: RNTR (National Network of Research in Telecommunications), RNTL (National Network of Software Technologies), RIAM (Network of Audiovisual and Multimedia Innovation).

The Ministry also supports application programmes in fields where these technologies are particularly useful: PREDIT (research and innovation in land transportation), RNTS (National Network of Technologies for Health). Two national priorities are very relevant to these programmes: road safety for PREDIT, and disabilities for RNTS.

Finally, it ensures the follow-up of European projects linked to the information society (e-Content, 6th PCRDT via 2 IST priority).

Legislative and community measures on the information society

The Ministry participates in the policy of digital development of the French territory, with legislative measures and financial support in this area (participation of local authorities in telecommunications networks, liberalisation of wireless technologies like the Wi-Fi, a support fund to alternative technologies, Wi-Fi, satellite Internet, on-line carrier currents).

We actively help transpose European directives into French law: the Directive on e-commerce ("Law on Trust in the Digital Economy"), Directive on "copyrights and related rights in the information society", "telecom packets" Directives organising the second phase of the deregulation of telecommunications in Europe.

In the same way, we participate in the policy of governance of the Internet in Europe: Ipv6, domain names, addressing...

The Ministry is supported in its participation in the policy of national development and legislative measures by the CSTI (Strategic Council of Information Technologies), built on the model of the American PITAC, which reports to the Prime Minister, and which is attached to our Ministry as well.

Dissemination and adaptation of new information and communication technologies by the general public

The Ministry assumes an interministerial mission on this subject, and it works in this mission with other Ministries to promote the use of the Internet for all. The mission gives priority to public uses of the Internet for purposes of education, training, electronic information services, health, cultural information, and information on transportation.

The Ministry closely links this policy to local authorities, in particular through the MAPI (Mission of Public Access to the Internet), which reports to the Prime Minister and which is attached to our Ministry as well.

The introduction of information technologies into schools and universities through policies of digital knowledge centres or digital campuses is a key element in this initiative within the Ministry of Youth, Education, and Research.

SPACE POLICY: EUROPE IN SEARCH OF A NEW APPROACH TO SPACE

Europe has succeeded in developing the resources for sure and autonomous access to space so as to guarantee its development and independence. France, through its Space Agency (CNES) has played a major role for this purpose. If this access is to be permanent, the capacity to deploy spatial infrastructures is necessary as is the mastery of technologies related to their functioning and use, like television or meteorology. The European approach has been based on the close link between space challenges and scientific challenges. This ambition is included in the bye-laws of the European Space Agency (ESA), and the desire to develop a space community of knowledge and technology in a balanced and interactive manner has been one of the drivers behind its achievements. Europe must now find a new impetus in defining a common space policy involving all participants, public or private, to adapt to a fast-changing international context.

From exploration to day-to-day application

Space constitutes an extraordinary field for human and technological adventure. It offers a unique vantage point on our planet, opens matchless prospects for interplanetary exploration, and favours progress of knowledge about our universe and its history. Space has concrete uses in our daily lives like television, satellite telecommunications, weather forecasting, positioning on land, sea or in the air, or satellite images.

Space is also at the heart of strategic challenges. At the military and political level it opens up access to crucial information in times of crisis, as the recent conflicts in the Balkans and the Middle East have shown. In a more general way, it concerns all the challenges related to the lives of citizens and companies, whether they be national or European: independent access to information, defence security policy, autonomy of applications of our sector-wide policies and development of economic activity.

European priority to scientific programmes

In forty years Europe has proved that it is capable of achieving great successes in this field. Europe holds a prominent position in the major areas of knowledge of the physical world and earth sciences. From now on the objectives of space policy and the conditions under which they are implemented deserve to be discussed more broadly and to be better known by European citizens.

A less favourable international situation

The present situation is undergoing great changes. Strategic ambitions have led an increasing number of countries to an unprecedented level of investment. Technologies, in particular launcher technology, face a highly competitive situation and a temporary downturn in the telecommunications sector.

In order to meet the need for both independence and excellence, space requires heavy investments that demand a long-term commitment from States as well as businesses in the sector. For example, building a satellite and putting it into orbit represent an investment of several hundred million euros. This investment cannot be made by only one country like France or any other European country. Only all of Europe is capable of offering the critical size needed to optimise its scientific potential and become industrially competitive.

Renewing Europe's space structures

It is particularly urgent to redefine a space policy as several important dates have been scheduled: the framework agreement between the European Union and the European Space Agency (ESA) now being negotiated, the ministerial meeting of the ESA at the end of May 2003, the response expected in June 2003 to the questions raised by the green book of the European Commission entitled "the future of Europe in the field of space", which is the precursor of a white paper expected at the end of 2003, the preparation of a new Treaty of the European Union in 2004 with the prospect of including a spatial competence.

The purpose is to provide Europe with new institutional structures. In France, the idea is to offer a forum for discussion on space policy, and at the European level for a discussion on the definition of spatial competence at the level of the European Union.

Thus, the reform of existing structures is necessary. In France a renovation of the legal framework of the National Centre of Space Studies (CNES) must be accompanied by a thorough revision of its organization. At the European level, the concept of a network of centres must be strengthened, and a reform of the ESA to optimise public funding, at a time when the now mature space industry does not face the same demands, should lead to better management of operational systems. The relations between public institutions and the space industry must also change and move toward a better distribution of tasks, greater rationality, and a clear definition of responsibilities.

This reform will provide the organization necessary to encourage the development of services and better answers for the communities of users (ministries, local authorities, professional organizations, etc.) by being integrated as much as possible into the international context.

SYNERGY BETWEEN PUBLIC AND PRIVATE INVESTMENTS: A FORM OF LEVERAGE

Even though the share relative to private financing of research has increased, France still has to make efforts to reach levels comparable to those observed in other industrialised countries. To that end, France is implementing a support plan for research and innovation, a general reform of corporate sponsoring and foundations as well as initiatives aimed at cooperation with European organisations.

In order to increase the percentage of the GDP devoted to research by 2010, in France and Europe, research must be supported by private initiatives. French companies must thus increase their research efforts to reach 66% of the overall objective in 2010. The exploitation of the synergy between public and private research, between public and private funding will be the real leverage to move closer to this objective.

New impetus to private funding of research

In the share of worldwide expenditures devoted to R&D, the European Union, with 26.2% of the total, is the second largest investor after the United States (39.4%, much of which is devoted to defence). France now invests 2.2% of its GDP in R&D, but France is one of the countries in Europe with the largest share of public expenditure allocated to research. So French research policy must stimulate R&D in private companies: in-house research in company laboratories, but also external research in partnership with university laboratories. This requires an increase of 40% in present research expenditures of companies over 8 years in order to meet the objectives set.

In cooperation with the European organisations, the ministers respectively in charge of industry and research presented a plan for support of research and innovation. A large-scale national survey was then launched of everyone working in research before the drafting of a bill and the implementation of the incentive measures it proposes.

Reforming corporate sponsoring and foundations

The funding of research by not-for-profit associations and institutions is very weak in France by comparison with Europe or America. Whereas American foundations provide about 4% of all research expenditures, in France the figure is less than 0.1%. A general reform of corporate sponsoring and foundations, to which the ministry in charge of Research greatly contributed, should reverse this trend. A series of legal and fiscal measures will motivate individuals and companies to make more donations. These measures will make it easier to create foundations, and as of 2003 they will modernise the rules governing the monitoring, transparency, and management of foundations. The setting up of " research foundations " will allow funding of research in different sectors, in the service of all, through actions of individual citizens. These measures will have a decisive impact in increasing research expenditures in the private sector, i.e. in increasing the share contributed by all companies and all citizens concerned by the progress of research and science.

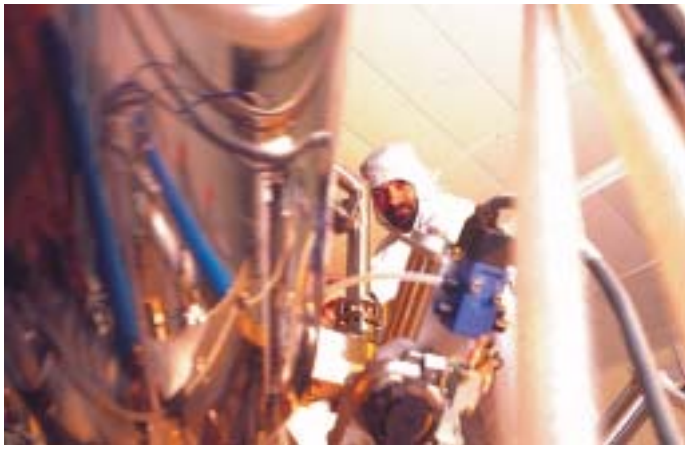
Optimising the funding of European research programmes

A true research policy is possible today only at least at a European level. France optimises the funding of its research by exploiting in particular the opportunities offered by the community programmes of the 6th master programme for R&D. France wishes to take advantage of its position as president of Eureka in 2003 to improve the management of Eureka, boost Eureka's capacity to finance research projects, and facilitate access for small and medium size companies, young innovative companies, and public research laboratories. France also would like a study to be conducted aiming at better use of the funding provided by the European Investment Bank. Indeed, it is in this European framework of consistency between public and private funding that research will receive a new impetus and will play its role in world development.

The research policy launched by France and its partners aims at economic growth, job creation and social progress. It therefore consists in sparing no effort to dynamise its research system and produce scientific excellence.

INNOVATION – A NEW ENTREPRENEURIAL SPIRIT IN RESEARCH

Innovation offers great potential. In cooperation with European institutions, France implements a vast plan in favour of research and innovation. A true national and European strategy to promote innovation should encourage all concerned parties to proceed on the road to success. France pursues its effort with the aim of economic growth, creation of jobs, and social progress.



Creating value through innovation

Innovation that derives from research and development is essential to our future. It consists in creating value on the basis of our knowledge, value in the economic sense of the word, but also in the ethical sense. If innovation is to be developed, companies and academic research must be encouraged to work together. The ambition of the government is to create in France one of the European environments most favourable to investors and young entrepreneurs, and to distribute research on a competitive basis between small and large companies. This is the purpose of the Plan for support to research and innovation, prepared jointly by the ministers for industry and research.

Tax incentive measures

In the framework of this plan, tax incentive measures encourage companies to use innovation more readily. A legal and fiscal tool for " business angels " enables them to support innovative companies more effectively. The " young innovative companies " benefit from reductions on taxes and social security charges if they are recent enough (less than 8 years old) and if they have been regularly active in R&D. Companies also benefit from new tax reductions on their investments in R&D (professional tax, accelerated depreciation on diminishing values). All companies that invest in R&D also benefit from the powerful renovation of the research tax credit.

Bridges between businesses and universities

The youngest students learn the entrepreneurial spirit in elementary schools, secondary schools, and institutions of higher learning in partnership with the ministry of National Education. Many agreements have been reached to facilitate exchanges between universities and companies. Their resources have been increased, for example the Industrial Agreements for Education through Research (CIFRE), or training periods for doctoral candidates to learn about the functioning of companies.

Bridges between research and the business world

Everything that can help develop the culture of projects and evaluation in research institutions is strengthened. A systematic awareness campaign aimed at providing information about registering and managing patents has been launched in every public research institution. Financial measures, in the form of bonuses, have also been taken to encourage scientists to register quality patents. Incentive for scientists in the form of income from patents has been increased.

Scientists in the public sector now have more opportunity to help create innovative companies, and public nurseries, places that welcome young entrerpreneurs with plans to set up companies, are refinanced after their expertise and performances are fully evaluated. At the same time their missions, status, long-term commitment as well as the professionalisation of the nurseries, openess to the private sector and access to start-up funds are studied. An additional budget is provided by the Caisse des Dépôts et Consignations for the launching. The National competition for business creation in innovating technologies provides funding, advice and backing to young entrepreneurs and new projects. All these measures constitute a major effort to encourage the creation of new innovative companies.

Innovation open to Europe

Research and innovation are European priorities. This dynamic process has begun, and the European Commission has welcomed the initiative taken by France with the 2003 plan in favour of innovation. France also participates in all the organisations that can provide impetus to research and innovation. Solidarity is necessary in this complex area so as to exploit the technological potential that make it possible to use the results of research and to support growth and employment.

THE MOBILITY OF RESEARCHERS, TO BUILD THE EUROPE OF TOMORROW

The importance of international cooperation in research, the participation of France in many European programmes, the exchanges between laboratories and research centres all place mobility at the heart of research professions. Whether this mobility is functional, thematic or institutional, it is also a form of knowledge sharing and opening to a world that is increasingly becoming a community of different types of knowledge.

Three types of mobility seem to cover the current practices of researchers in both the private and public sectors as well as research fellows. The distinction between these forms of mobility allows us to better understand their motivations but also to include different types of assistance to mobility in the actual conditions of research professions.

The policy in favour of the mobility of researchers, implemented by the ministry in charge of research, encourages all three forms of mobility at once – functional, thematic, and institutional. Almost every researcher and research fellow must at one point in his career benefit from all of them.

Functional mobility, a form of knowledge-sharing

Functional mobility is both a sign and a commitment. It proves the capacity of the researcher to integrate himself or herself into his environment in an effective and useful way. This type of mobility is reflected in the researcher's contribution to creating knowledge, his capacity to convey knowledge to his students in universities, his pedagogical sense when dealing with a broader public, or the economic and social use of the results of his research. This form of mobility is a global commitment at the human and social level. In practical terms, it reflects the conviction that for a researcher the creation of knowledge requires the sharing of knowledge.

Thematic mobility and intellectual openness

Thematic mobility is the natural expression of a certain intellectual agility. It is the fruit of the fertility of research work, and leads to the discovery of new types of knowledge. The average time between the beginning research and finding the answers varies according to specialisations and themes, but it sometimes covers decades. Full-time research activity leads most researchers to deal with several themes during their career.

Institutional mobility

Institutional mobility is a form of flexibility granted to the researcher to make his activity more effective. During his career he may change his field of activity or his position to adapt to changes in his field. For example, he may move from a position as researcher in a public institution to that of a research fellow in a university or an engineering school, or he may become the director of a department of the ministry in charge of research or the head of a research project in a private company...

Greater career fluidity

This capacity to be mobile, this long-term versatility, which reveal openness and intellectual curiosity, is a characteristic encouraged by those in charge of research in France. This capacity derives from a true "culture of mobility", which must become widespread and extend to all research structures. At the level of the European research community, this mobility should make it possible to free initiatives and creativity, to build a Europe of knowledge, and to strengthen the values that unite this Europe with those regions of the world that need Europe's knowledge.

In France,

320,000 work in private or public research:

- **178,000 persons (including 81,000 researchers) conduct research in a company.**
- **142,000 persons (including 88,000 researchers and research engineers) work for public research, the main employer being universities, with nearly 32,000 research fellows.**

In the field of research in companies, one out of every five researchers is a woman.

In public research, one out of every four researchers is a woman (with considerable differences depending on the organisations due to specialisations in different fields).

A PROJECT AND EVALUATION-ORIENTED CULTURE, VIEWING RESEARCH AS USEFUL KNOWLEDGE

A project-oriented culture entails two questions raised by the scientist: one question relates to the interpretation of the world, the other relates to action to change the world. This type of culture is increasingly part of the real activities of research professions.

In a very open international context, research themes must include an explanation of their aims as answers to these initial questions. The ministry in charge of research provides support to this project-oriented culture, and combines it with ideas on project evaluation.

The "how?" and "for what purpose?" of the researcher

The social and cultural roots of research in France have long kept the French scientific community away from the question of the use and economic exploitation of knowledge. The globalization of exchanges and cooperation, which has been accelerated by the speed of electronic data transfer as well as by the support of the European Union to R & D projects, has changed this tradition. To the "how?" of the scientist, another question is added: "for what purpose?" To the question that comes naturally to the researcher about the character of his research subject, a second one is added - the uses and purpose of his work. This change is a source of intellectual, social, and economic wealth. Due to the close relationship of sciences like law, economics, or social sciences to society and its functioning, they have been far ahead in this respect of the so-called "hard" sciences like physics and chemistry.

Freedom and projects

Is there a danger that a project-oriented logic limits the scientist's freedom? A project-oriented approach by no means seeks to weaken the initial and essential phase question asked by the scientist, in which his freedom is a basic asset. The point is to define in which framework the scientist's activity is conducted and the possible uses of his work. The scientist engages his own responsibility and also that of a human community. He is necessarily part of a continuum which, from science to innovative technology, contributes to the well-being of society. The notion of project gives a concrete form to this approach in the different contemporary research programs.

Increased support from the authorities: the National Science Fund and the Research Technology Fund

The ministry in charge of research has strongly shown its attachment to basic research to help meet the specific but essential challenges in the fields of sustainable development, health, new technologies, or space. This ministry wishes to complement this action with increased support to the project approach. Large-scale financial resources have been made available to scientists like the action fund - National Science Fund (FNS) and Research and Technology Fund (FRT) - which enable laboratories, through calls for projects in addition to usual types of assistance, to obtain funding on the basis of proposed projects. Moreover, research laboratories have been adopting this project approach with private partners like companies, semi-public organizations, or local authorities.

Evaluation and prospects

The growing impact of this project approach highlights the need for independent and transparent evaluation of the project after it has been completed, even more than the traditional system of regular allocations of resources does. This requires permanent availability of effective tools for evaluating structures and projects.

The ministry in charge of research is opening discussions and action on the question of evaluation in 2003, in close cooperation with the persons involved, for the purpose of greater visibility, consistency, and clarity.

BUDGET: RESEARCH FINDS THE RESOURCES TO ACHIEVE ITS OBJECTIVES

The 2003 research budget seeks to mobilize all available resources in order to meet the objective set by the President of the French Republic, namely to increase the share of the Gross domestic product (GDP) devoted to research from 2.2% in 2001 to 3% iin 2010. All the countries of the European Union have supported this objective since the European Council of Barcelona in 2002.

Funding and execution of R & D in France (Source : MJENR-DPD/C3)

	In millions of euros and %	2000	2001(e)
FUNDING OF RESEARCH	**National R & D Expenditures**	31 438	32 654
	Share of R&D in GDP in %	2,22	2,23
	Annual growth rate in volume [%]	4,4	2,4
	Funding by administrations (1)	14 272	14 871
	Funding by private firms	17 166	17 783
	Funding by administrations R&D expenditures in %	45,4 %	45,5 %
EXECUTION OF RESEARCH	**Internal R&D Expenditures**	30 954	32 227
	Share of R&D in GDP in %	2,19	2,20
	Annual average growth rate in volume [%] (2)	1,2	2,6
	Execution by administrations (1)	11 605	12 105
	Execution by private firms	19 348	20 122
	Execution by private firms R&D expenditures in %	62,5 %	62,4 %

(1) Public and private administrations (State. Institutions of higher learning and not-for-profit institutions).

e : estimate

France devotes 2.2% of its GDP to basic or applied research and to technological development. The budget devoted to these areas, 32.7 billion € in 2001, makes France number four world-wide for this type of investment. Administrations, mainly under the auspices of the State, which finances about 45% and private companies around 55%.

The State finances basic research as well as technological research and military research for defence purposes. Private firms receive funding to support future innovations in the fields of both products and procedures.

CIVILIAN BUDGET FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT

State funding is allocated to the major fields that make up research in France.

■ Public research in various bodies and administrations

This research is funded mainly from the civilian budget for research and technological development. It totals 8.8 billion euros in 2003, including 6,1 billion euros from the budget of the ministry for research, and includes funding from bodies under the supervision of this ministry and the bodies and research departments under the supervision of other ministries (2.7 billion euros).

■ University research

Research conducted in universities and elite educational institutions is partly financed from the civilian budget for research and technological development (0.5 billion euros), and mostly from the budget of the Ministry of National Education (salaries of university research fellows, construction of universities, etc.)

■ Defence research

The Ministry of Defence evaluates current gross military development research at 3.4 billion euros.

■ Research incentives

These incentives may take various forms : from subsidies to organizations, universities or companies to loans to be reimbursed granted to companies that participate in the civilian budget for research and technological development.

■ International bodies and European framework programmes (PCRD)

Participation in this funding can be evaluated annually at 1.5 billion euros provided partly by the civilian budget for research and technological development and by the Ministry of Foreign Affairs. The tax credit for research, which is an incentive for companies, is not budget financing, but it accounts for a half a billion euros of the State budget.

Development of incentive tools

In addition to research bodies and universities, the State also possesses incentive tools like the National Science Fund and the procedures of the Ministry in charge of industry. These tools enable the State to guide research practically in real time, to support certain initiatives, to launch new programs, and to meet unpredictable events which call for immediate action

■ National Science Fund (FNS) : 217 billion euros in 2003

The increase in assistance to the major programs of the sciences of living matter is more than 42%: in genomics, for genopoles and centers specialized in cancerology, microelectronics and nanotechnologies with the launching of a 3-year program mobilizing 100 million euros, in the sciences and technologies of information and communication, and in the environment. These additional resources provide support to open multi-partner technological platforms and encourage the emergence of new research teams. They also provide assistance to young researchers and incentive actions in human and social sciences or microbiology.

■ Technological Research Fund (FRT): 197 million euros in 2003

This fund strengthens the partnerships between university laboratories and private companies, in particular in the framework of projects related to priority fields.

The main fields of the civilian budget for research and technological development (BCRD)

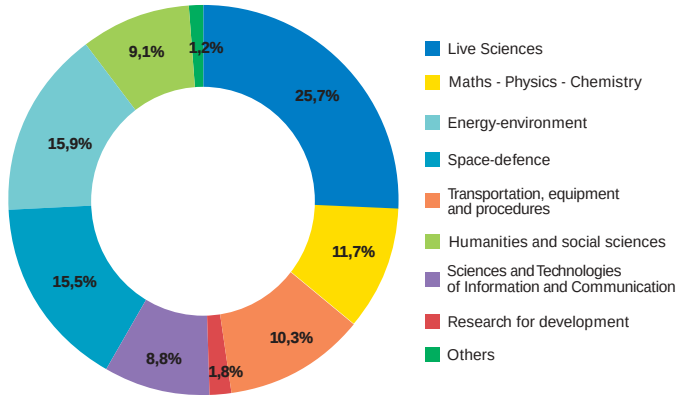
Every year France presents its budget effort for research in a framework harmonized with European and OECD levels.

Breakdown of BCRD in 2002

	En M€	En %
Live Sciences	2 325	25,7%
Energy-environment	1 434	15,9%
Transportation, equipment and procedures	929	10,3%
Space-defence	1 396	15,5%
Maths - Physics - Chemistry	1 053	11,7%
Humanities and Social sciences	825	9,1%
R&D for development	167	1,8%
Information and communication technology	795	8,8%
Others	107	1,2%
Total BCRD	**9 031**	**100,0%**

Breakdown on the basis of the 2002 budget

Breakdown of the civilian budget for research and technological development by major scientific fields



THE MINISTRY IN CHARGE OF RESEARCH AND NEW TECHNOLOGIES

The ministry for Research and New Technologies prepares and implements the major orientations of national policy. This light adminstrative structure of about 400 persons, installed in the former buildings of the Ecole Polytechnique in the heart of the Latin Quarter, is divided between administrative and scientific personnel. The ministry in charge of research has been from the very beginning an administration with a specific mission focused on preparing policy and evaluation rather than on management. It is a preview of what central administations will become in the framework of the modernization of the State. On the basis of a renovated and motivated organization, Claudie Haigneré, minister for research, wishes, to take advantage of French research potential and make it a growth engine in a context not only of active international cooperation but also of strong competition.

THE FUNCTIONS OF THE MINISTRY IN CHARGE OF RESEARCH

(EXCERPT FROM THE DECREE OF JULY 4, 2002 AND JULY 12, 2002)

By delegation of the ministry of youth, national education and research, the minister in charge of research proposes and, in cooperation with the other related ministers, implements the policy of the Government in the field of research, technology as well as the policy in favor of the use and dissemination of new information and communication technologies. It is competent in the field of space policy. It prepares the decisions of the Government related to the civilian budget for research and technological development (BCRD. For this purpose the other ministries present their research credit proposals.

Coordinating the research budget

The ministry does not carry out research itself. Research depends on universities and public and private institutions. The ministry defines scientific priorities, which are approved by the Government at interministerial Councils of scientific and technical research (CIRST). In order to put these priorities into practice it has an original financial tool: the civilian budget for research and technological development (BCRD). This budget includes all credits for public research in France, regardless of which body or ministry will manage them. The ministry for research is thus provided, thanks to this policy tool, with the resources for true research coordination. The ministry determines the credits each year that all participants in research use in keeping with the major national policy priorities.

A bipolar public research organization

The organization of public research in France is structured around two main groups of bodies and institutions.

- Research bodies including public institutions of a scientific and technical character (EPST), the personnel of which are civil servants: the CNRS for basic science, the INSERM for health, the INRA for agronomy are some examples*. They also include public institutions of an industrial character (EPIC), the personnel of which are employees under private law, like the CEA for atomic energy and the CNES for space*. France is characterized by these large organizations, of a general or specialized nature, and they are highly visible internationally.

- Institutions of higher learning are institutions of a scientific, cultural and professional character, and have the exclusive right to award doctoral degrees. These institutions of higher learning include the country's 85 universities, the Collège de France, the

Institutes of Political Studies, the elite Ecoles Normales supérieures, the French schools abroad... Nearly 3,000 teams or research laboratories are attached to them, including 1,500 shared by research bodies in the form of mixed units or federative research institutes.

The ministry for research supervises all these research institutions, but can share this supervision with one or several other ministries.

A CONTRACTUAL RELATIONSHIP LINKED TO PROJECTS

Research activities are carried out long-term. This fact is taken into consideration through pluriannual contracts signed with universities, the EPSTs and the EPICs. These contracts define the broad outlines of scientific policy and their main financial consequences. These commitments are negotiated, and they offer those involved in public research the time they need, beyond the limits dictated by the annual character of the budget, depending on their objectives and a true project approach. This contractual policy constitutes a renovated and effective form of relations with institutions under the supervision of the State, and it now tends to become more widespread in the French administration.

THE ORGANIZATION OF THE CENTRAL RESEARCH ADMINISTRATION

An autonomous mission and two divisions, one for technology and the other for research, structure the central research administration.

■ The scientific, technical, and pedagogical mission is a tool for guidance and coordination. It focuses on the functions of expertise and evaluation in higher learning, and technology and research divisions.

Within the ministry in charge of research, two divisions handle the coordination of all research and technological development.

■ The technology division prepares the technological development and innovation policy. It determines the procedures of public funding for industrial research as well as the procedures for support to innovation. It defines the ways to use the results of public research and technological cooperation with companies, and it also supervises the main EPICs.

■ The research division prepares policy in the field of research, education through research and scientific employment, and also monitors the implementation of policies. In every scientific field it carries out prospective work on the developments in research and coordinates the activities of different organizations. It also supervises the main EPSTs.

■ The communication department guides and coordinates the institutional communication of the ministry in cooperation with these two divisions. It is responsible for documentary resources and keeping the archives of the ministry.

* See the list of the main research bodies in the appendix.

APPENDIX

Major French Research Institutions in France

ADEME: Environment and Energy Research Agency (EPIC*). Provides funds for research conducted by other institutes for the promotion of renewable energies, clean and economical technologies, waste reduction, and the prevention of air and soil pollution. Staff: about 80 persons.

ADIT: Agency for the Dissemination of Technological Information (EPIC*). Staff of 35, and a network of 10,000 experts.

ANDRA: French National Radioactive Waste Agency (EPIC*). Staff: 360.

ANRS: National Agency for AIDS Research (GIP*). Staff: 39.

ANVAR: National Value Added Research Agency (EPIC*). Provides funding and advice to small and medium size companies, laboratories and innovative entrepreneurs all over France. Staff: 434.

BRGM: French Geological Survey (EPIC*). In charge of mobilizing Earth Sciences to provide knowledge, relevant data and expertise to the State and territorial bodies. Staff: about 860.

CEA: Commissariat for Atomic Energy (EPIC*). Nuclear energy, industrial innovation, defence, basic research in the sciences of matter, biotechnologies. Staff : about 16,000.

CEE: Employment Studies Centre (EPA*). Staff : about 100.

CEMAGREF: Rural, Water and Forest Engineering Centre (EPST*). Agricultural and environmental engineering. Staff: about 900.

CIRAD: International Agronomic R&D Cooperation Centre (EPIC*). Agronomic research applied to warm regions, tropical and subtropical countries. Staff: about 1,800.

CNES: National Space Research Centre (EPIC*). Participation in programmes of the European Space Agency (ESA), the Ariane programme, observation of the Earth (Spot). Staff: about 2,500.

CNRS: National Scientific Research Centre (EPST*). Basic research in all areas of knowledge, from physics to human and social sciences. 25,285 persons work with the CNRS.

CSI: City of Science and Industry (EPIC*). Staff : about 1,000.

CSTB: Building Science and Technology Centre (EPIC*). Staff: about 600.

IFREMER: National Institute for Oceanic Research (EPIC*). Staff: about 1,700.

INED: National Demographic Studies Institute (EPST*). Study of all aspects of populations. Staff of about 170.

INERIS: National Industrial Environment and Risks Institute (EPIC*). Staff: about 450.

INRA: National Agronomic Research Institute (EPST*). Staff: about 8,600.

INRETS: French National Institute for Transport and Safety Research (EPST*). Staff: about 414.

INRIA: French National Institute for Research in Computer Science and Control (EPST*). Staff: about 2,200.

INRP: National Institute for Educational Research (EPA*). Staff : 280 in addition to 1,550 associates.

INSERM: National Health and Medical Research Institute (EPST*). Basic and clinical research. Staff: about 5,000.

INSTITUT CURIE: Curie Radiation Studies and Therapy. Staff: about 1,500.

INSTITUT PASTEUR: private non-profit foundation, officially recognised as an organisation benefiting the public, for the fight against infectious diseases; public health services. Staff of 2,500 of all nationalities.

IRD: Research Institute for Sustainable Development (EPST*). Research on sustainable development in the intertropical zone. Staff: 2,300.

IRSN: Institute for Radiation Protection and Nuclear Safety (EPIC*). Staff: 1,500.

LCPC: Central laboratory for Roads, Bridges, Public Works (EPST*). Civil and urban engineering. Staff: about 600.

ONERA: National for Aerospace Research (EPIC*). Staff: about 2,000.

*EPA : national public institution of an administrative character.
*EPIC: public, industrial and commercial institution.
*EPST: institution of a scientific and technical character.
*GIP: public interest organization.