

FACTS & FIGURES

1.4 billion euros Safran's R&D expenditures in 2007

60% of Safran's research is self-financed

450 doctoral scientists work for the Group

Safran invests heavily in R&D to meet tomorrow's challenges.

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SAFRAN: BUILT ON RESEARCH

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PANORAMA. In any high-tech group such as Safran, research is a strategic core activity. Safran invests considerable human and financial resources in research to build solid foundations for the future.

SHAPING THE FUTURE THROUGH RESEARCH

Research, technology and development activities are a significant part of Safran's overall business. Safran invests some 1.4 billion euros in RT&D annually, including 60% self-financed, with 20% of its employees working on these tasks. These hefty percentages clearly reflect the importance of building solid foundations for the future and developing new programs.

The Research & Technology (R&T) portion itself covers initial

design studies, research and technology demonstrators, spanning the areas of expertise that will enable Safran to develop new products at minimal risk, cost and lead-times (see graph on next page). It precedes the actual Development phase, which encompasses detailed product design, prototype production, development testing and qualification.

Understanding the market's expectations

"The principal technological objec-

tives reflect the Group's strategy and market expectations," explains Michel Laroche, Senior Vice President, Research & Technology at Safran. "One of our primary objectives is the development of more fuel-efficient and environmentally-friendly turbine engines, to meet ACARE* objectives for 2020." Among the targets set by ACARE are a 20% reduction in fuel consumption, and a 50% reduction in noise (see Safran Magazine No. 4, September 2008).

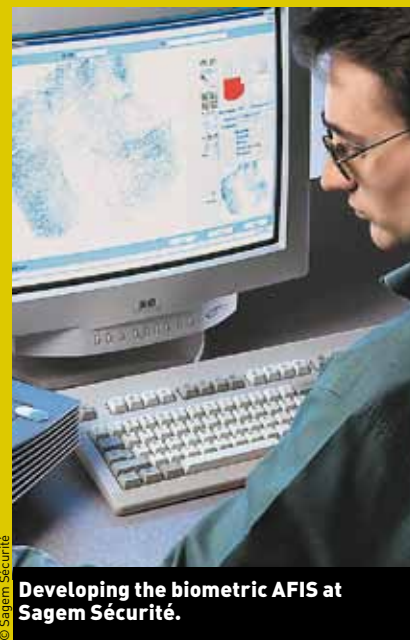
Safran is also carrying out exten-

FRANÇOIS RIEUL,
DIRECTOR OF THE RESEARCH
& TECHNOLOGY UNIT, SAGEM
SÉCURITÉ, SAFRAN GROUP

STUDYING THE HUMAN BODY

"The human body is wonderfully diverse. Biometrics exploits this characteristic and provides a sure, ergonomic way of authenticating a person's identity. Some 80 top engineers and researchers at Sagem Sécurité's R&T Unit (including doctoral candidates) are already working on new applications. For instance, the development of recognition technologies for the three main biometric

characteristics, fingerprints, face and iris; algorithms for vehicle recognition; security and encryption issues concerning identity management (with or without smart cards); development of new methods of image acquisition and processing. For its research work, Sagem Sécurité collaborates with innovative small businesses and labs from outside the company, through a number of joint research projects in France and throughout Europe: 3D Face (three-dimensional facial recognition); BACH and Turbine (interactions between biometrics and cryptology); SIC (development of equipment for the security of critical infrastructures)."



Developing the biometric AFIS at Sagem Sécurité.

VIEWPOINT



DANIEL VERWAERDE,
DIRECTOR OF MILITARY APPLICATIONS,
CEA (FRENCH ATOMIC ENERGY
COMMISSION)

Safran, a favored partner of the CEA

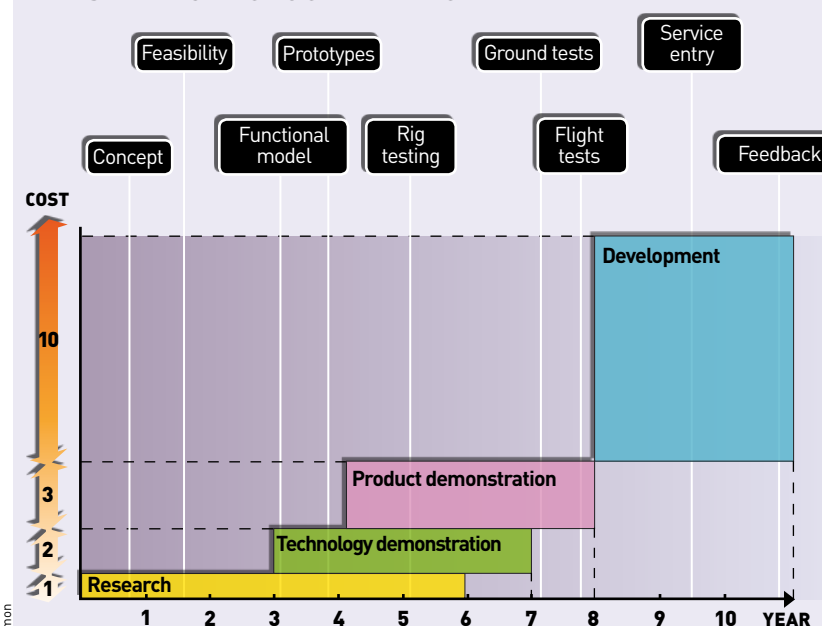
"French atomic energy commission CEA has formed a number of alliances in academia, but Safran is the only industrial company with whom we have developed such an extensive, high-quality partnership. It employs seasoned, world-class engineers, who work on the technical specifications based on our definitions. In addition to an exemplary collaboration on thermostructural composites, through the LCTS

lab, we are also working on two major long-term programs. One involves research into the materials used in atmospheric reentry vehicles. These are the heat shields that have to stand up to temperatures reaching 4,000°C during reentry, while keeping the electronics inside at no more than 50°C! The second program involves the Megajoule laser, in which Group company Sagem plays a leading role."



Framework for the pre-amp modules on CEA's Megajoule laser, used to recreate the conditions involved in nuclear fusion. Sagem is a partner in this program.

PHASED TECHNOLOGY DEVELOPMENT



sive research on biometrics (see box on previous page), as well as pioneering research into onboard energy systems, using electricity to replace traditional hydraulic and pneumatic drives. Tomorrow's "more electric" airplanes will lower the airline's total cost of ownership, enhance propulsion efficiency and reduce environmental impact.

Michel Laroche sums up the Group's strategy: "We're focusing on the development of 'smarter' engines and equipment. Work is already well under way on sensors, cognitive algorithms, transmission techniques, new system architectures, and integrated operations and maintenance. All Group branches are involved in these research efforts."

* ACARE: Advisory Council for Aeronautics Research in Europe.

CROSS-FUNCTIONALITY. The breadth of the Safran Group and its diverse markets are a significant competitive advantage in terms of fostering innovation and research synergies.

LEVERAGING SYNERGIES

Safran covers a wide spectrum of technological expertise, enabling it to meet the needs of many different markets: military or civil, large or small production runs, air, land and sea. This broad range has fostered the development of diverse yet complementary approaches, forming a powerful instrument to address emerging market needs by leveraging group-wide synergies.

One of the leading research priorities at Group level is numerical simulation and other powerful modeling techniques, used to study equipment behavior in depth before launching production. For instance, the Maia initiative brings together some 150 researchers from eight Safran companies and university labs to investigate advanced mechanical engineering methods.

"The close collaboration between Group companies Snecma and

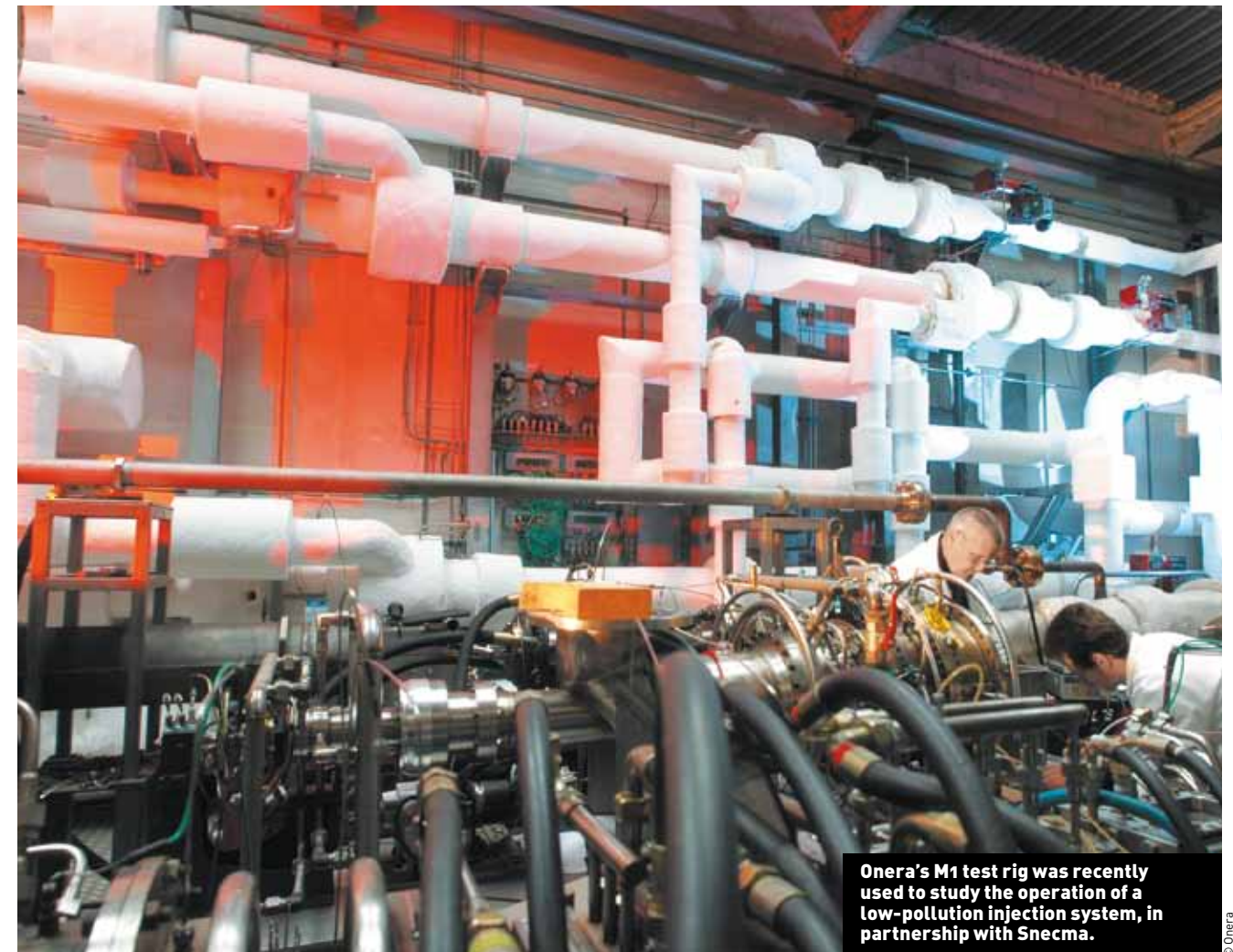
Snecma Propulsion Solide on composite materials has generated an innovative solution based on 3D weaving of these materials," notes Michel Laroche, the Group's Senior Vice President for Research & Technology. "We can now make certain critical parts using woven materials,

since this sophisticated structure increases resistance to stress in all three dimensions." The best example of this new technique is a woven carbon composite strut on the Boeing 787 landing gear, a world first. Another major application is on aircraft engine fan blades. ■

DEVELOPING SYNERGIES THROUGH FIVE CENTERS OF EXPERTISE

Each center of expertise brings together a network of Safran companies, with one acting as leader. The centers may also call on outside partners, whether research centers or academic labs.

- Acoustics (airframe, landing gear, engines): six companies, led by Snecma.
- SPEC (Safran Power Electronics Center, for "more electric" aircraft): 11 companies, led by Hispano-Suiza.
- Thermostructural composites (engine parts): five companies, led by Snecma Propulsion Solide.
- Monitoring (remote surveillance of engine equipment): 11 companies, led by Snecma.
- SEED (Safran Embedded System Engineering): five companies, led by Sagem.



Onera's M1 test rig was recently used to study the operation of a low-pollution injection system, in partnership with Snecma.



Composite exhaust assembly on a CFM56-5C engine.

MARC MONTAUDON,
DIRECTOR OF THE AERONAUTICS AND COMPOSITES DIVISION
AT SNECMA PROPULSION SOLIDE, SAFRAN GROUP

THERMOSTRUCTURAL COMPOSITES: FROM SPACE TO CIVIL AVIATION

"Ceramic matrix composites were originally developed for space applications. Because of their strength and lightness, they were subsequently used in military aircraft, for example on the Rafale's M88 engine. A civil aviation research program, dubbed ARCOCE [see Safran Magazine No. 1, June 2007], is aimed at demonstrating the feasibility of a composite exhaust system for the LEAP-X engine, which will replace the CFM56 turbofan towards 2016. The major technical requirement in this market is longevity. While a rocket engine only burns for one to ten minutes, and a military aircraft engine operates for several thousand hours between overhauls, a commercial aircraft engine stays "on wing" for tens of thousands of hours."

PARTNERSHIPS. Any research at Safran would be unthinkable without its external partners, from public research organizations to academia, not to mention fellow manufacturers.

EXPANDING RESEARCH HORIZONS

In a group like ours," notes François Christin, head of thermostructural composites research & technology (R&T) at Snecma Propulsion Solide, "the complementary interactions between scientists and engineers through research & technology herald exciting new prospects. Academic research actually facilitates contacts with researchers from areas other than those traditionally called on by the aviation industry." For example, studies on the formation of nacre (mother of pearl) in shellfish helped underpin new concepts for self-healing composite materials, now under development at Safran. This is just one example of why Safran has always kept its doors open to the larger research community, and why it has always associated



© Studio Paris
Studying a ceramic matrix composite at the Thermostructural Composites Lab (LCTS).

its own R&T work closely with public laboratories.

Partners across the board

Safran has long-standing partnerships covering all key aerospace disciplines, not only in France, but elsewhere in Europe. In addition to France's own

aerospace research agency Onera, a pivotal partner for the aerospace industry, Safran has developed a rich panoply of research partners, including CERFACS (European Center for Research and Advanced Training in Scientific Computation), which also encompasses EADS,

EDF, Météo France and Total, the University of Sheffield in the United Kingdom, Virginia Tech in the United States, and other partners worldwide, especially in China and Russia.

Networked research

Safran invests heavily to give scientists a greater role in the actual technology development process, more specifically for technology demonstrations. That was the aim of certain previous initiatives, such as the creation of the Ecole de Mines de Paris engineering school's materials center at the Snecma plant in Evry, near Paris, and the LCTS thermostructural composites lab in Bordeaux (see box).

Several new research programs, all given nicknames based on Native American tribes (see Safran Magazine No. 1, June 2007), were recently launched to foster the multidisciplinary work needed to address complex problems involved in reducing the environmental impact of aviation. The Inca advanced combustion initiative brings together 15 laboratories and has generated about 40 doctoral theses (completed or under way). Fifty labs are participating in the Maia project (advanced mechanical engineering methods), focused on structural design methods. The Iroqua project (research

initiative for optimized aeronautical acoustics), dedicated to noise reduction, was created in 2005 in conjunction with about thirty research labs, plus Airbus, Eurocopter and Dassault Aviation.

Attracting talented people

"We never forget that a company's openness is also measured by its ability to attract talented people," adds Michel Laroche. "We are convinced that the quality of our research is based on the creativity of the people involved. Our

DEVELOPMENT AND COLLABORATION

SAFRAN SCIENCE BOARD

Safran has created a Science Board, comprising internationally known specialists from disciplines underpinning Group products, to anchor its position as a major player in research and strengthen its partnerships. These disciplines are: physics, solid and fluid mechanics, materials, automation and numerical simulation. The chairman of the board is Georges Charpak, a French physicist who won the Nobel Prize for Physics in 1992. The board will include eight eminent scientists, including Mathias Fink, a professor at the Paris institute of industrial physics and chemistry.

VIEWPOINT



DENIS MAUGARS,
CHAIRMAN AND CEO OF ONERA,
THE "FRENCH AEROSPACE LAB"

A dynamic partnership

"Onera was founded as a research establishment to underpin future development of the aerospace industry, but our work only takes on meaning if it results in concrete programs or technologies. This philosophy is reflected in the Onera slogan: "Return on Innovation". From this point of view, we have established an exemplary relationship with the Safran Group. For instance, in conjunction with Sagem, we operate the "Busard", a flying lab that tests potential payloads for the drones used to monitor risks in the environment. Together, we won a contract from the European Defense Agency to study "see and avoid" technologies. With Snecma, our partner for the last thirty years, we have developed three single-crystal superalloys for turbine blades, used on Turbomeca helicopter engines and the Rafale's M88 engine. Another success story is

the AM1 alloy, recently used in the SaM146 engine developed by Snecma in conjunction with NPO Saturn of Russia. We have also carried out joint aerodynamic studies leading to an eight-point increase in the efficiency of commercial engine fans. Today, we're working on the open rotor engine concept, and more specifically on its acoustic characteristics, which are very difficult to model. In fact, as a long-standing partner to the entire French aerospace industry, we have a broad vision of the issues involved, plus proven multidisciplinary skills and extensive expertise in a dual research approach combining computation and experimentation. That gives us the ability to anticipate the solutions to difficulties that could face engine and aircraft manufacturers in the future."

ALAIN COUTROT,
DEPUTY DIRECTOR OF R&T
AT SAFRAN, AND CHAIRMAN OF
THE SAFRAN-RUSSIA SCIENTIFIC
AND TECHNICAL COMMITTEE.

FRENCH-RUSSIAN RESEARCH

"The Safran-Russia scientific and technical committee, comprising representatives from Safran and Russian aerospace research organizations, aims to bolster ties between the Group and Russian academic research concerning space technologies, aircraft engines and materials. In particular, it calls on the extensive test facilities available in Russia. Safran Group company Techspace Aero and the Central Institute of Aviation Motors (CIAM) in Moscow recently carried out a series of tests of a low-pressure compressor, within the scope of the European research program Vital."

recruitment strategy, carried out in conjunction with corporate human resources, seeks to diversify our candidate profiles and hire more young graduates with scientific degrees from universities and technical institutes, with experience in research. This diversity is a real advantage for our Group."

Safran now hires about thirty doctoral scientists a year. Its overall workforce includes some 450 of these scientists with PhDs, of which 20% are women, as well as about one hundred doctoral students. ■

THERMOSTRUCTURAL COMPOSITES: JOINT CNRS-SAFRAN-CEA LAB CELEBRATES 20th ANNIVERSARY

The Thermostructural Composites Laboratory, known by its French initials LCTS, is one of the world's largest research centers dedicated to ceramic matrix composites. Created in 1988, LCTS is a joint research unit founded by French national scientific research agency CNRS (Centre National de la Recherche Scientifique), the University of Bordeaux I and Snecma Propulsion Solide (SPS), joined in 1999 by French atomic energy

commission CEA. It is based at the Pessac-Talence-Gradignan university campus near Bordeaux in Southwest France. "LCTS was founded to develop the scientific knowledge needed to create materials offering higher performance, greater durability and lower cost, based on ceramic matrices and fibers, such as carbon or silicon carbide," explains François Christin, thermostructural composites R&T manager at Snecma Propulsion Solide, and LCTS scientific delegate. "The lab conducts research on ceramic matrices and fibers so we can expand the envelope of operability in terms of temperature and durability." LCTS employs a diverse team of about 80 people:

research professors from the University of Bordeaux I, CNRS researchers, research engineers seconded by SPS and CEA, doctoral students and interns. Over the past 20 years, they have generated 23 patents and about one hundred doctoral theses. "The advantage of a joint unit such as LCTS," notes Christin, "is that it fosters better understanding of industrial problems by researchers, and a greater involvement by industry in high-level scientific research. For a high-tech group such as Safran, this fundamental research plays a critical role in building solid foundations for the future and opening new markets."