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- ▶ **SAFRAN** is an international high-tech group, organized in four business branches: Propulsion, Communications, Equipment, Defense Security.
- ▶ The group has 56,200 employees in more than 30 countries, with sales **exceeding 10 billion euros in 2004.**
- ▶ Comprising a number of companies with prestigious brand names, SAFRAN holds world or European leadership positions in its markets, working alone or in partnership.
- ▶ For all of these reasons, 500 airlines, the armed forces of 90 countries, 2,000 helicopter operators and a number of government agencies place their trust in aerospace and defense solutions from SAFRAN, a full-fledged partner in their success. SAFRAN also provides advanced communications solutions to more than 100 operators worldwide.

Business branches and main companies

▶ **Propulsion**

- Snecma
- Snecma Services
- Turbomeca
- Microturbo
- Snecma Propulsion Solide
- Techspace Aero

▶ **Communications**

- Sagem Communication
 - Broadband Communication
 - Mobile Communication

▶ **Equipment**

- Aircelle
- Labinal
- Hispano-Suiza
- Teuchos
- Messier-Dowty
- Messier-Bugatti
- Messier Services

▶ **Defense Security**

- Sagem Défense Sécurité
 - Navigation and Aeronautical Systems
 - . Sagem Avionics
 - Optronics and Air-Land Systems
 - . Vectronix
 - Security
 - . Sagem Monetel
 - . Sagem Morpho



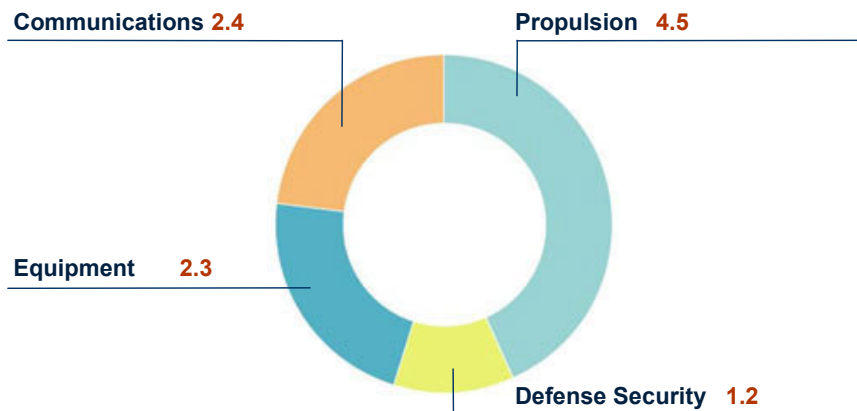
SAFRAN GROUP: KEY FIGURES

- ▶ 2004 sales ⁽¹⁾ **10.4 billion euros**
- ▶ Operating income ⁽¹⁾ **717 million euros**
- ▶ Net financial position ⁽²⁾ **496 million euros**

(1) Non-audited, pro forma figures, French accounting standards

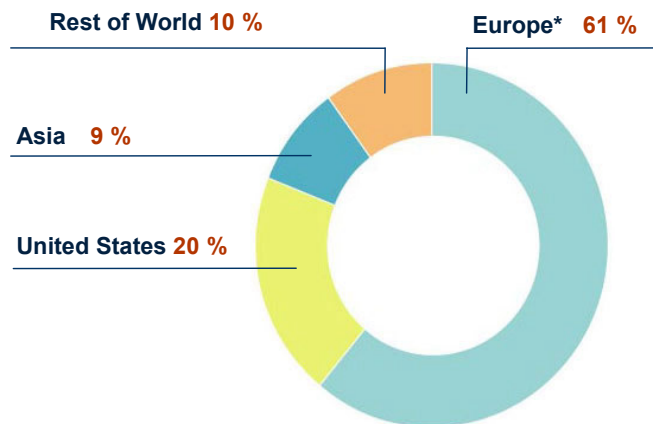
(2) Non-audited, pro forma figures, French accounting standards, excluding financing of Sagem's exchange/cash offer for Snecma

• 2004 sales by branch (billions of euros)



* Non-audited, pro forma figures, French accounting standards, after elimination of inter-branch sales

• 2004 sales by region



*Mostly re-exported by prime contractor customers

• Workforce

At March 31, 2005, SAFRAN had **56,200 employees**, including more than **15,000 outside of France**.

Propulsion branch

2004 sales: 4.5 billion euros

▶ **Snecma**

Snecma is one of the world's leading makers of aircraft and rocket engines, with a wide range of propulsion systems. These include commercial aircraft engines renowned for their performance, reliability, economical operation and environmental friendliness, plus world-class military engines. Snecma develops and produces rocket propulsion systems and equipment for launchers, satellites and space vehicles.

Civil Aviation:

CFM56 engines through CFM International, an equally-owned subsidiary with General Electric,

SaM146 engine through PowerJet, an equally-owned subsidiary with NPO Saturn,

Large commercial engines (CF6, GE90, GP7200), in partnership with General Electric.

Military aviation:

M88 (Rafale), M53 (Mirage 2000), Larzac® (Alpha Jet, MiG-AT, HJT36) and, through the European consortium EPI, the TP400-D6 (A400M).

Propulsion spatiale : HM7B, Vulcain® 2, Vinci® cryogenic engines (Ariane 5); PPS® 1350 plasma thruster.

▶ **Snecma Services**

Snecma Services offers a full range of engine support services to airlines, operators and armed forces around the world: on-wing and off-wing MRO, technical assistance, repair solutions, engine leasing, tools, fleet management, documentation, training, etc. Through various joint ventures and a subsidiary in Belgium (Snecma Services Brussels), Snecma Services provides aftermarket support for the entire CFM56 engine family. It also provides MRO services for other engines.

▶ **Turbomeca**

Turbomeca is the world leader in the design, development and manufacture of turbine engines for helicopters, including world leaders such as Eurocopter, Sikorsky, Agusta, Denel, Kamov and HAL. It has also earned recognition for jet engines powering training and support aircraft, as well as for land and marine turbines. Since the company was founded, more than 50,000 Turbomeca engines have been produced around the world. Today, these engines – Arrius, Arriel, Makila, TM-333, Ardiden, RTM322 (with Rolls-Royce), MTR390 (within MTR consortium) – power helicopters for 2,000 customers in 140 countries. Turbomeca operates worldwide through 14 facilities and three major subsidiaries.

CGTM, also a Turbomeca subsidiary, specializes in flight testing and maintenance services



Branche Propulsion

(suite)

▶ A Turbomeca subsidiary, **Microturbo** is the leading European maker of jet engines for missiles and target drones. Most new-generation airplanes and helicopters built in Europe are fitted with Microturbo auxiliary power units (APU).

This Turbomeca subsidiary also produces starting systems for aircraft.

▶ **Snecma Propulsion Solide**

Snecma Propulsion Solide designs and produces solid rocket motors for Ariane 5 and Vega (via Europropulsion, an equal joint venture of SAFRAN and Avio), M45 and M51 ballistic missiles (via G2P, owned 75% by SPS and 25% by SME), and tactical missiles. It is also specialized in the design and production of thermostructural composites for the aerospace and manufacturing industries.

▶ **Techspace Aero**

Belgian company Techspace Aero designs, produces and repairs components and subassemblies for aircraft and rocket engines. It has considerably strengthened its design capabilities, making it a major partner to the world's leading engine manufacturers. Techspace Aero's scope of business extends from military engine maintenance, to the design and construction of high-tech test facilities. The company is jointly owned by SAFRAN (51%), the Walloon region of Belgium (28.37%), Pratt & Whitney (19%) and the Société Fédérale d'Investissement (1.63%).

Communications branch

2004 sales: 2.4 billion euros

The SAFRAN Communications branch groups all activities related to telecommunications: mobile phones, printing terminals residential terminals, digital TV, broadband networks and optics. It also provides cables, fiber optics, printed circuits and electric meters.

The branch is made up of Sagem Communication and its subsidiaries.

▶ Sagem Communication

Sagem Communication has two core businesses: mobile communications and broadband communications.

For the former, the company makes mobile phones, accessories and radio-communications modules, etc.

The Sagem mobile phone brand boasts a strong global presence, due to innovative solutions based on new communications technologies. The company has also formed industrial and commercial partnerships with other players in the telecom industry, such as Bird in China and Gradiente in Brazil, to access new markets.

In the broadband sector, Sagem Communication designs, develops and produces a complete range of products that meet demand in the high-growth markets of broadband, video and printing: fax and multifunction machines for consumers and professionals, video-projectors, photo printers, HDTV, digital TV set-top boxes (satellite, cable, ADSL), digital terrestrial television (DTT) receivers, DECT wireless phones, ADSL WiFi routers, electronic meters, corporate networks, infrastructure and broadband, Internet access, power cables and telecom cables.

Its proven capability for innovation has driven breakthroughs in highly competitive markets. Sagem Communication deploys a dense European sales and marketing network called the National Sales Organization (NSO), to distribute Sagem brand products to all major European retailers.

Equipment branch

2004 sales: 2.3 billion euros

▶ **Aircelle**

Aircelle designs, produces and markets nacelles for commercial aero-engines, and provides MRO services for its customers and users of its products. It is the No. 1 European manufacturer of aero-engine nacelles, and a world leader.

Aircelle offers a complete product line, with nacelles for engines ranging from business aircraft to the latest A380 super-jumbo.

▶ **Labinal**

Labinal is one of the world-leading supplier of wiring systems and engineering services for the civil and military aerospace industry. It has over 80 years of experience in working with the world's major aircraft manufacturers.

▶ **Hispano-Suiza**

Hispano-Suiza is specialized in complete control systems and equipment for commercial and military aircraft engines. Operating worldwide, it offers a complete line of optimized solutions, from design and development to integration and support.

More than 20,000 engines are equipped with Hispano-Suiza products, logging over 300 million flight-hours to date.

▶ **Teuchos** is a consulting and engineering services company, working for the aerospace, defense, automobile and rail industries. It primarily provides support in the development of systems and products.

In particular, Teuchos has carried out studies for the Airbus A380 and A400M, Dassault Falcon 7X and Ariane 5.

Equipment branch

2004 sales: 2.3 billion euros

▶ **Messier-Dowty**

Messier-Dowty is the world's leading maker of landing gear, spanning design, development, manufacture and support. These landing gear now equip over 19,000 civil and military aircraft, and chalk up more than 30,000 landings a day. Messier-Dowty has plants in France, the U.K., the United States, Canada, Singapore and China.

▶ **Messier-Bugatti**

A systems engineering and integration company, Messier-Bugatti has established leadership positions in wheels and carbon brakes, braking control systems, monitoring systems (tires, landing gear, brakes) and electrohydraulic systems. Through these complementary activities, Messier-Bugatti offers airlines and aircraft manufacturers (Airbus, Boeing, Dassault Aviation, etc.) a complete package of products and services.

Messier-Bugatti also offers advanced electrical actuation systems for passenger seats, dubbed SeatNet™.

▶ **Messier Services**

Messier Services, the joint subsidiary of Messier-Bugatti and Messier-Dowty, provides maintenance, repair and overhaul (MRO) services for the landing, braking and hydraulic systems produced by its parent companies and other manufacturers.

Defense Security branch

2004 sales: 1.2 billion euros

The Defense Security branch covers three main areas:

- navigation and aeronautical systems;
- optronics and air-land systems (technological programs and simulation, sights/displays, air-land combat);
- security (government solutions, terminals and secure transactions).

The branch is made up of Sagem Défense Sécurité and its subsidiaries.

▶ **Sagem Défense Sécurité**

Sagem Défense Sécurité develops and markets key technologies in electronics, micromechanics, optics, and information processing and transmission.

The company is a worldwide specialist in gyroscopic solutions, ranging from the small vibrating gyroscope for light vehicles and weapons to the "star in a bottle" quality gyroscope enabling precision navigation for nuclear submarines.

This solid technological background has enabled Sagem Défense Sécurité to cover a very wide range of applications for all types of vehicles (land, navy, aircraft, helicopters, drones, missiles and guided weapons) and to progress from equipment to system supplier, taking the entire on-board avionics system into account, particularly with modernization.

This system expertise extends to information and communication systems such as those enabling mission planning for fighter aircraft (e.g. Rafale fighters), on-board information systems for civil aircraft (e.g. the A380) and airbase management-planning systems.

The optronics department offers a whole range of performances and applications. Optronics are used in the fields of air-land defense (civil defense, helicopters and the "network centric warfare" military concept), naval air defense (ships, submarines, aircraft carriers, mainly for tracking and defense), ground defense (all civil and military vehicles, particularly for surveillance), aerospace (on-board optronics on military aircraft and missile homing devices), space (systems for mirrors in very large telescopes).

In the security sector, Sagem Défense Sécurité is the world leader in biometrics. The company started with digital fingerprint technology, and is now developing a range of multi-biometrics solutions, including facial and iris recognition systems.

Building on these technologies, Sagem Défense Sécurité expanded its scope of business to include information and communications security solutions: production of non-falsifiable ID and health documents; the fight against delinquency (secure payments, transactions and games); developing infrastructures with public key identification/encryption (PKI); access control (buildings, airports, borders) and IT security (data, communications, etc.) and, more generally, homeland security.

Defense Security branch

2004 sales: 1.2 billion euros

▶ **Sagem Monetel**

Sagem Monetel is a subsidiary of Sagem Défense Sécurité, specialized in electronic payment solutions. Its products and solutions feature cutting-edge technologies such as GSM, GPRS, biometrics and secure transmission. With over 20 years of experience in secure transaction terminals, Sagem Monetel has built up a solid reputation for reliability and quality.

Sagem Monetel is also a major supplier of smart card terminals (chip-capable), with over one million sold worldwide.

▶ **Sagem Morpho**

A subsidiary of Sagem Défense Sécurité, Sagem Morpho, Inc. develops and manufactures biometric identification systems, which incorporate multiple biometric technologies including fingerprint, iris and facial recognition products and services. Sagem Morpho Inc. is the world leader in this field, with solutions for a number of applications: law enforcement, healthcare, airport security, national security, population management, etc. Its systems are currently used by a number of government agencies, including the FBI and the New York Police Department in the United States. Dedicated consumer systems are in operation in New York, Texas, Arizona and other states.

▶ **Sagem Avionics, Inc.** is the American subsidiary of Sagem Défense Sécurité, covering both the civil and military sectors. With operations in Texas and Washington State, it handles marketing, sales and support for Sagem Défense Sécurité's avionics product line, as well as development and production of cockpit display systems and satellite communications systems. Sagem Avionics Inc. also carries out helicopter retrofits. It has earned FAA certification for a number of different helicopters, including the Bell 407 and 427, Eurocopter AS350, EC120, EC130 and AS355, plus STC (supplemental type certificate) for the Air-Crane Erickson S-64 helicopter.

▶ **Vectronix AG** is a Swiss defense optonics company. It designs, develops and produces observation, positioning and range-finding equipment and systems for five main applications: night vision, rangefinding, target observation and acquisition, military topography and positioning-orientation. It integrates cutting-edge technologies such as digital electronics.

SAFRAN and the Airbus A380

Ten group companies deploy their technological expertise on the Airbus super-jumbo jet

▶ **Snecma**

Working for the Engine Alliance GP7200 engine (an equal joint venture of General Electric and Pratt & Whitney), Snecma is in charge of the design, development and production of most of the 9-stage high-pressure compressor (10% of the engine program).

▶ **Techspace Aero**

Techspace Aero designs, develops and manufactures the low-pressure compressor and forward bearing supports (7.5% of the engine program). It also manufactures the fan disk and, through Cenco International (test cell engineering), it provides equipment for the GP7200 test cells at General Electric and Pratt & Whitney (engine cowls, variable nozzles, engine mount).

▶ **Aircelle** designs, develops and supplies the two types of aircraft's nacelles (with and without thrust reverser) for the two engines on offer, the GP7200 and the Rolls-Royce Trent 900.

▶ **Hispano-Suiza** develops and produces, in partnership with Honeywell, the first electrical thrust reverser actuation system (ETRAS), which will equip the nacelles made by Aircelle for the A380. Hispano-Suiza is responsible for electrical system architecture, and development of electrical and power electronics components, while Honeywell handles the development of mechanical parts and system integration.

▶ **Messier-Dowty** designs, produces, tests and supports the nose landing gear. The design of this forward-retracting gear involves new technologies, namely the use of 350-bar (5,000 psi) hydraulic pressure, never before used on a large jetliner, as well as the high velocity oxygen fuel (HVOF) surface treatment procedure, instead of Chrome plating.

▶ **Technofan** produces the brake cooling system, the avionics bay ventilation systems and cabin ventilation equipment.

▶ **Labinal** makes about 80% of the electrical wiring on the plane, and offers two noteworthy innovations: the use of aluminum cables, and innovative mechanical and electromagnetic cable protection. It develops and produces electrical wiring for the wings, the entire fuselage, including the fin as well as the specific wirings required for flight testing.

▶ **Sofrance** provides filtration systems for the hydraulic circuits (main, braking and flight control) and avionics (electronics cooling), as well as engine lubrication and fuel filtration. It is the lead filtration company on the A380.

SAFRAN and the Airbus A380 .../...

▶ **Messier-Bugatti** supplies five systems on the A380:

- Full-brake-by-wire braking system for 20 wheels, including a backup circuit using decentralized hydraulic generation for considerable overall weight savings.
- Steering system for the nose wheels and central bogies to give the aircraft maximum maneuverability.
- Tire pressure, brake temperature and landing gear monitoring systems (TPMS NG, BTMS and OPMS).
- Mini-pumps for the electrohydraulic actuators (EHA) on the secondary flight controls.
- Components for the distribution and filtration system on the hydraulic circuits.

▶ **Sagem Défense Sécurité** supplies:

- Onboard information system, the secure Network Server System (NSS). Connected to the aircraft's avionics, it collects extensive data, including flight parameters. The NSS also supports specialized applications, such as online documentation, maintenance information, etc.
- Secondary fly-by-wire flight control system, large environment accelerometer unit (LEAU).
- Various flight control components and sensors: backup yaw damper sensors, backup control module (BCM), backup power supply (BPS).

▶ **Snecma Services**

- This engine MRO specialist provides support for most of the GP7200 core (aircraft installation, tools, documents, logistics, etc.).
- On behalf of the Engine Alliance, Snecma Services is gearing up for core MRO services, including setting up a special maintenance and repair shop in early 2006.

▶ **Aircelle** is the sole supplier of nacelles for the two engines being offered, the Trent 900 and the GP7200.

It has to meet three technological challenges: materials, control system, and weight and acoustic requirements.

SAFRAN and the 787 Dreamliner

- ▶ **Messier-Dowty** is responsible for the design, development, testing, production and assembly of the main and nose landing gear.
- ▶ **Messier-Bugatti** supplies the two nose wheels and eight main wheels, along with eight electric brakes and control units. These control units are developed in conjunction with Sagem Défense Sécurité.
- ▶ **Labinal** was selected to design, produce and qualify electrical wiring systems.
- ▶ **Techspace Aero** works in partnership with General Electric on the GENx engine. It is responsible for the design, development and production of the guide vanes for the low-pressure compressor.
- ▶ **Fadec International**, an equal joint venture of **Hispano-Suiza** and BAE Systems, was selected by General Electric Aircraft Engines (GEAE) to design, produce and support the full authority digital engine control (FADEC).
- ▶ **Cenco International** supplies the cowls for the GENx development tests.

SAFRAN and the longer range 777

Boeing launched the “longer range” 777 program to give airlines a modern jetliner with greater non-stop long-distance capabilities.

The 777-300ER (extended range) entered service a year ago, and the 777-200LR (longer range) is now under development, with service entry planned in early 2006.

▶ **Snecma** has a 23.5% stake in the GE90-115B, the exclusive powerplant for the longer-range 777s, with responsibility for the design, manufacture, assembly and support of the low-pressure compressor, and most of the 9-stage high-pressure compressor.

It is also involved in manufacture of the composite fan blades through C-Fan, its equally owned subsidiary with GEAE.

Snecma carries out development and certification tests for the GE90.

▶ **Hispano-Suiza** provides the FADEC 3 control system, built in collaboration with BAE Systems. It also supplies actuators for the GE90-115B, designs the wiring harnesses, and the speed and displacement transducers.

▶ **Techspace Aero** is in charge of the lubrication system and the oil reservoir.

▶ **Sofrance** supplies filters for the lubrication circuit on the GE90-115B engine.

▶ **Messier-Bugatti** provides the wheels and brakes for the 777-300ER and 777-200LR. This means, for each aircraft: the two nose wheels, 12 main wheels and the 12 brakes made of Sepcarb III OR (oxidation resistant). Messier-Bugatti also provides the tire pressure monitoring system (TPMS) and the brake temperature monitoring system (BTMS).

SAFRAN and the Russian Regional Jet (RRJ)

- ▶ **Snecma** is developing the SaM146 engine in partnership with NPO Saturn (through their joint venture PowerJet), to power the Russian Regional Jet (RRJ) built by Sukhoi Civil Aircraft.
- ▶ **Hispano Suiza** designs and manufactures the complete engine control system. It is prime contractor for 43 components and subassemblies on the SaM146, including the FADEC, fuel metering unit, actuators, harnesses, etc.
- ▶ **Techspace Aero** designs and manufactures the engine's lubrication system.
- ▶ **Aircelle** is responsible for the complete nacelle, including the butterfly-type thrust reverser.
- ▶ **Cenco International** designs and manufactures the open air test cell for the SaM146 in Rybinsk, Russia.
- ▶ **Messier-Dowty** is in charge of coordination, design and manufacture of the integrated landing system for the RRJ.

SAFRAN and Rafale

Dassault Aviation's Rafale is a modern multirole fighter with low radar signature and capable of a wide range of all-weather, day/night missions. Made in both naval and air force versions, it can operate from aircraft carriers, as well as on short runways.

- ▶ **Snecma** makes the M88-2 engine which powers all versions of the Rafale. It has delivered 90 engines to date.
- ▶ **Hispano-Suiza** provides the complete control and power transmission system for the M88-2. In addition it produces the accessory gearbox for the Rafale and the flex drive shaft.

The company also developed or specified a number of other systems and components:

- Electrical: FADEC, harness, actuators, speed transducers.
- Mechanical: engine accessory gearbox, flex driveshaft and aircraft-mounted accessory drive.
- Hydromechanical: main and afterburner fuel pumps, fuel metering units, lubrication units, injectors, actuators.

An upgraded version of the FADEC control unit, the M88 Type 3, was developed to meet requirements for enhanced safety and lower operating costs. Qualification tests kicked off in late May 2005.

- ▶ **Snecma Propulsion Solide** handles assembly of a module for the M88-2 nozzle, and also produces the secondary flaps using ceramic matrix composites – an area of expertise at the company.
- ▶ **Messier-Dowty** supplies the landing gear for the Rafale M carrier-borne version – the most advanced landing system of this kind. Compared with the air force Rafale B and C versions also provided by Messier-Dowty, the main and nose gear on the naval version have been strengthened to withstand the demanding conditions of carrier-borne operations.
- ▶ **Messier-Bugatti** supplies:
 - wheels and brakes
 - brake-by-wire braking control system
 - nosewheel steering system
 - landing gear extension/retraction system
 - hydraulic generation system (5,000 psi/350 bar)
 - brake temperature monitoring system (BTMS).
- ▶ **Labinal** provides all electrical wiring, and is also in charge of installation of wiring harnesses on the assembly lines.

SAFRAN and Rafale .../...

▶ **Sagem Défense Sécurité** provides:

- inertial navigation system, hybrid GPS unit
- OSF infrared frontal imaging system
- Samir missile warning detector
- Gerfaut helmet-mounted display
- gyros for the fly-by-wire controls
- mission planning
- weapons control units.

▶ **Sofrance** produces filters for the main hydraulic circuit, the fuel circuit, and also air filters for the avionics suite.

▶ **Technofan** supplies components for the air conditioning system.

SAFRAN and the A400M

- ▶ **Snecma**, through the Europrop International (EPI) consortium, has a 32.2% stake in development of the TP400-D6, a triple spool turboprop engine rated at 11,000 shaft horsepower.
- ▶ **Techspace Aero** has a 4% share of the TP400 engine. It is responsible for the lubrication system, production of the outer housing for the combustor and the high-pressure turbine disk, as well as part of the development engine assembly and testing.
- ▶ **Hispano-Suiza**, in partnership with MTU Aero Engines, is responsible for design and integration of the engine control system.
- ▶ **Sofrance** is responsible for the filters on the engine's fuel and lubrication lines.
- ▶ **Microturbo** provides the engine starter.
- ▶ **Cenco International** is adapting a test cell for development tests of the TP400-D6.
- ▶ **Messier Dowty** is responsible for the integrated landing gear system.
- ▶ **Messier-Bugatti** was selected as supplier of carbon brakes and systems integrator on the A400M. In addition to wheels and carbon brakes, Messier-Bugatti will supply the "SLK" system, for the steering, landing gear extension/retraction and the innovative aircraft kneeling/hiking functions.
- ▶ **Sagem Défense Sécurité** supplies the inertial navigation system and hybrid GPS unit.
- ▶ **Labinal** was selected to develop, engineer, manufacture, test and delivery electrical wiring harnesses and flight test installation harnesses for the A400M nose.
- ▶ **Technofan** provides cabin ventilation equipment.

SAFRAN and the NH90

The NH90 is the first helicopter to feature fly-by-wire controls.

- ▶ **Turbomeca** supplies the two RTM322 engines (within RRTM, an equally-owned company with Rolls-Royce).
- ▶ **Techspace Aero**, through Cenco International, is participating in the modernization of the production RTM322 test cells for Rolls-Royce Deutschland and Patria of Finland.
- ▶ **Technofan** provides the remote accessories gearbox (RAGB), as well as all fans for avionics and air conditioning.
- ▶ **Sofrance** supplies the filters for the gearbox lubrication system and engine and avionics air filters.
- ▶ **Sagem Défense Sécurité** supplies:
 - Navigation system: inertial navigation unit, hybrid GPS, air data unit, Doppler sensor
 - Flight control system, for stabilization and guidance
 - Avionics assembly for FBW controls
 - Multispectral optronics pod.
- ▶ **Aircelle** designed and produces the engine cowls.
- ▶ **Messier-Bugatti** provides the uplock actuator, giving the helicopter deck landing capability during naval missions.
- ▶ **Labinal** developed and produces avionics bays as well as electrical wiring for the cockpit and cabin, on behalf of Eurocopter and Agusta.

SAFRAN and Ariane 5

- ▶ **Snecma** is prime contractor for the HM7B and Vulcain® 2 cryogenic engines on Europe's Ariane 5 launcher. It is also in charge of development of the Vinci® engine.
- ▶ **Techspace Aero** designed and manufactures the cryogenic valves for the Vulcain® 2 and Vinci® engines, and the hot gas valves for the Vulcain® 2.
- ▶ **Snecma Propulsion Solide** is in charge of the design, development and production of the MPS solid rocket motors, through Europropulsion. Snecma Propulsion Solide makes the nozzles for the MPS motors and is developing new nozzle versions.

In addition, SPS provides the pressure sensors for the cryogenic systems on the Vulcain and HM7, as well as the starters and igniters for these engines.

Selected programs

SAFRAN invests heavily in research, technology, development and engineering. For example, about 10% of SAFRAN revenues go to self-financed R&D. In addition to the research & technology activities by group companies, SAFRAN participates in a number of joint research programs.

1 – International research programs

TECH56

The TECH56 program is designed to lay the groundwork for future generations of CFM56 turbofans, by tackling all major aspects of aircraft engines. Primary objectives are to improve fuel consumption, efficiency, environmental-friendliness, maintenance costs and reliability. This research is validated by engine demonstrations under actual conditions. The first phase kicked off in 1999 and finished in 2004. A follow-on program, TECH56-2, is being launched this year and has even more ambitious objectives, especially in terms of reducing specific fuel consumption.

Partners: Snecma and General Electric Aircraft Engines (GEAE)

Term: TECH56-2, 2005 to 2009

► **Snecma's role:** development of a new-generation fan; evaluation then demonstration in conjunction with General Electric of an engine concept based on a counter-rotating fan and turbine.

SILENCE (R)

This is a European Union program, organized within the scope of the second call for bids for the 5th PCRD (R&D framework program), concerning aircraft noise. Its objective is the large-scale experimental validation of noise reduction technologies concerning the engine, nacelle and aircraft.

- Engine: aeroacoustic design, active technologies
- Nacelle: aeroacoustic design, innovative acoustic treatment, active noise control
- Aircraft: primarily wing and landing gear noise (aeroacoustic design, fairings, innovative acoustic treatment, active noise control).

The program will also evaluate the acoustic performance of future-generation engines, such as those studied within the scope of the EEFAE program (including the CLEAN program).

Partners: Over 50 companies (including Airbus Industrie, Rolls-Royce and MTU Aero Engines), research centers and universities. Participating group companies are Snecma, Messier-Dowty and Aircelle.

Term : 2001 to 2005

▶ **SAFRAN's role:** program coordination and management, and development of key technologies.

Other group companies involved: Aircelle, Messier-Dowty, Turbomeca.

CLEAN

“CLEAN” was one of the two test platforms in the European Commission's Efficient and Environmentally Friendly Aero Engine (EEFAE) program (5th PCRD). It aimed to reduce polluting emissions and fuel consumption on civil aircraft, based on a redesigned combustor. A demonstrator was built and tested on the ILA test rig in Stuttgart. It featured an axially-staged combustion chamber with LMP (lean, mixed, prevaporized) type main stage, a high-pressure compressor with active surge control, a high-speed low-pressure turbine and a heat exchanger designed to evaluate the “intercooled

recuperative aero-engine” concept. Testing was completed in 2004, generating conclusive results.

Partners: Snecma, MTU Aero Engines, Avio, Volvo Aero Corporation.

Term: completed in 2004

▶ **Snecma's role:** joint program management with MTU Aero Engines, and development of key technologies.

VITAL

Also an EC program, part of the second call for bids in the 6th PCRD. Vital will evaluate technologies for low-pressure modules on future very-high-bypass engines, designed to reduce fuel consumption and noise in line with objectives set by ACARE. In particular, it is studying new fan architectures, including a stator-less fan with two counter-rotating stages, as well as shaft and structural technologies, and low-pressure turbines. The CIAME research center of Russia has joined Snecma in design and testing of fan models, marking the first significant collaboration by a Russian research

center in European aeronautical programs.

Partners: Snecma, Techspace Aero, Rolls-Royce, MTU, ITP, RR Deutschland, Avio, Airbus.

Term: 2005 to 2008

▶ **SAFRAN's role:**

Snecma: program coordinator, development of technologies for counter-rotating fan, aircraft installation.

Techspace-Aero: booster module.



POA - POWER OPTIMIZED AIRCRAFT

POA is also a European Commission program, and one of the nine technology platforms in the 5th PCRD, focusing on the development of “more electric” aircraft. It aims to replace hydraulic power sources by electrical power on an Airbus

A330 class aircraft, optimize energy management and validate innovative architectures.

Partners: 43 laboratories and companies, including seven from the SAFRAN group.

Term: 2002 to 2006.

SAFRAN's role: each of the seven group companies is working on a key part of the program:

- **Hispano-Suiza:** responsible for test aspects of the project, in charge of the aircraft test rig (engine plus a half-A330), and design and production of a distributed system (all-electric control), including FADEC and fuel system.
- **Aircelle:** electric thrust reverser control.
- **Labinal:** optimization of electrical distribution and power management.
- **Messier-Dowty:** feasibility study and integration of all-electric landing gear.
- **Snecma:** integration of electrical devices in a turbofan engine.
- **Technofan:** ventilation systems.
- **Techspace Aero:** engine lubrication system with electric pumps.

TPTECH/TPX – FUTURE TURBOPUMP

Technology demonstration programs financed by French space agency CNES, designed to lay the groundwork for a hydrogen turbopump on a future-generation engine. The TPTECH technology demonstrator resulted in conclusive tests on a component test bench. It will therefore shortly be followed by TPX, a Vulcain-scale turbopump featuring a simplified architecture and lower-cost components (open impellers, fluid bearings, blisk type turbine rotor, etc.). The technologies validated in this program will also be a critical part of the hydrogen turbopumps on tomorrow's reusable rocket engines.

Partners: Snecma, Volvo Aero Corporation, IHI (Japan).

Term: 2001 to 2007

► **Snecma's role:** program prime contractor, in charge of design, production and testing of demonstrators. Development of the turbine section for the TPX is assigned to Volvo Aero Corporation, according to technical specifications provided by Snecma. IHI participated in tests of the fluid bearings.

GGP8 – FUTURE GAS GENERATOR

The technology demonstration program designed to support the development of a gas generator for new rocket engines was successfully carried out on the Franco-German P8 test rig at the DLR in Germany. The injector technology validated through these tests is slated for use on the pre-combustion chamber in future-generation staged-cycle reusable engines.



RESEARCH, DEVELOPMENT AND ADVANCED TECHNOLOGIES

Partners: Snecma, DLR.

Term: completed in 2004

- ▶ **Snecma's role:** design, manufacture and program coordination.

FLPP - Future Launcher Preparatory Program

Snecma is leading European partners in this ESA program to foster the technology developments needed for propulsion systems on reusable launchers. The main areas of research are: staged combustion using LOX-LH2 and LOX-CH4 propellants, turbopumps and monitoring.

Partners: Snecma, Techspace Aero, DLR

Term: first phase from 2005 to 2007.

P80

The P80 is a demonstrator program for a new-generation solid rocket motor with 80 metric tons of solid propellant. It is being built by a European team, with ESA as program manager. The P80 program is designed to qualify technologies offering excellent cost reduction potential for use in future launchers or derivatives of Ariane 5. Snecma Propulsion Solide is developing the nozzle, and SAFRAN is involved in overall design and testing through Europropulsion, its joint venture with Avio. The Vega small launcher will be the first application.

Partners: Europropulsion (filiale 50/50 SAFRAN-Avio), Avio, Snecma Propulsion Solide

Term: 2003 to 2007

2- JOINT PROGRAMS IN FRANCE

SAFRAN is currently involved in over 100 R&T programs with 60 French labs at the CNRS (national scientific research agency), CEA (atomic energy commission), ONERA (aerospace research agency), etc. Some of the major joint initiatives are listed below.

INCA

SAFRAN faces three major imperatives in developing next-generation combustion systems: failsafe operation, minimal environmental impact (reduction of NOx, CO2, soot, etc.), and competitive costs. To meet these challenges, SAFRAN, ONERA and the CNRS have launched major research programs to foster continuous improvement and also identify innovative, even "disruptive" technologies. To make their collaboration even more effective, they have pooled their skills within the INCA Advanced Combustion Initiative. Its overall goal is to leverage French combustion expertise, and ensure that SAFRAN is a top-tier player in all related technologies.

Partners: Snecma Propulsion Solide, Snecma, Turbomeca, over 30 CNRS and ONERA labs; support from the French defense procurement agency DGA, civil aviation program directorate DPAC, space agency CNES and the Ministry of Research.

Term: 2002 to 2007





MAIA

The Advanced Mechanical Engineering Methods initiative (MAIA) aims to support the design of lighter, higher-performance, lower-cost, less polluting and high-reliability components for aeronautical systems developed by the group. The founding partners in this initiative are French research agencies ONERA (aerospace) and CNRS (science); MAIA brings together over 100 engineers and scientists from eight group companies, along with the public laboratories. They will be working on developments in robust computation, vibrations, transient dynamics, modeling of composite materials, lifespans of structures and contact mechanics.

Partners: Hispano-Suiza, Aircelle, Messier-Bugatti, Messier-Dowty, Snecma Propulsion Solide, Snecma, Techspace Aero, Turbomeca, three ONERA departments, 22 CNRS laboratories, 2 CEA (French atomic energy commission) laboratories, three Belgian labs, an American lab, and support from defense procurement agency DGA, civil aviation program directorate DGAP, French space agency CNES and the Ministry of Research.

Term: 2003 to 2008 .

IROQUA

Following in the footsteps of previous initiatives, CNRS, ONERA, Airbus, Dassault Aviation, Eurocopter and SAFRAN have launched a similar initiative, IROQUA, this time intended to reduce aircraft noise.

The Advisory Council for Aeronautics Research in Europe (ACARE) has set noise reduction targets for 2020, including a decrease of 10 decibels in noise around airports, or a ten-fold decrease in sound power – which means cutting perceived noise in half. This objective is all the more ambitious, since previous scientific and technical studies have already reduced noise by about 20 decibels since the 1980s. Researchers will focus on two approaches: the first is to reduce noise at the source wherever possible, by working on the shape and configuration of airframes, engines, equipment and materials. For example, they will be studying nozzles, turbine speeds and combustion rates that foster noise reduction. This facet is the focus of the IROQUA program.

The second approach concerns low-noise flight procedures and paths. People are not disturbed to the same degree if aircraft are flying overhead once an hour or once every ten minutes, not to mention during the day or at night. The perceptions of neighboring populations will be taken into account to orchestrate aircraft movements around airports.

This research will help contain noise around airports, as recommended by ACARE. In this case, noise is considered to be a disturbance when it exceeds a level of about 65 decibels, or the noise a car makes at 130 kilometers/hour.

Partners: CNRS, ONERA, Airbus, Dassault Aviation, Eurocopter, and within SAFRAN, Snecma, Snecma Propulsion Solide, Aircelle, Messier-Dowty, Turbomeca.

Term: 2005 to 2010

AEROSPACE RESEARCH FOUNDATION

SAFRAN is a founding member of the Aerospace Research Foundation along with EADS, Thales and Latécoère. This foundation became an officially state-approved entity on April 1, 2005. According to its bylaws the aim of the foundation is to define, promote and finance, for a minimum period of six years, joint research programs, in particular public-private partnerships, for the aerospace sector. These programs will concern the basic issues of sustainable development, security, safety and the environment.

Specific objectives include:

- air transport safety and security;
- development of environmentally-friendly technologies;
- the overall efficiency of the air transport system;
- the development of space applications to support risk management and sustainable development;
- an expanded scientific and technological base to support the strategic independence of aerospace industries.

3 - SAFRAN's in-house programs

Here are just a few of the many R&T programs now being conducted within the SAFRAN group.

SCORES – Efficient, silent RTM composite fan (Snecma, Aircelle)

SCORES, the French abbreviation for efficient, silent composite fan using RTM (resin transfer molding), aims to demonstrate the validity of composite blades made from a woven carbon fiber preform, molded via RTM. This process offers a significant reduction in parts costs compared with the layup and autoclave curing process now generally used. The demonstration is being carried out at the scale of the largest engine now in service, the GE90-115B, and includes bird ingestion tests and longevity tests for the critical areas such as blade roots. Initial results in early 2005 were positive, demonstrating enhanced resistance to ingestion, and confirming this technology's potential for future engines. The program is now exploring its possible extension to medium-power engines.

DEM21 – COMMERCIAL CORE ENGINE (Snecma)

This program aimed to apply the technologies developed by Snecma to a new-generation core for a commercial jet engine. The core is sized for the regional jet class. Used in conjunction with a low-pressure section incorporating proven advanced technologies, the DEM21 core is designed from the outset for certification of a commercial jet engine. It comprises a compact 6-stage compressor with a high pressure ratio, a low-emissions combustor and a single-stage, high-temp turbine. These latter two components use technologies directly derived from the PHT program, among others. The DPAC supports this program, including funding of the compressor, turbine and core tests.

Initial tests in 2002 demonstrated very satisfactory performance, meeting or exceeding expectations.

DEM21 is the basis for the core on the SM146 engine from Snecma and NPO Saturn, chosen for the Russian Regional Jet family being developed by Sukhoi, with support from Boeing.



ECO, reduced cost-of-ownership combat aircraft engine demonstrator (Snecma)

Based on the Rafale's M88 engine, ECO is a demonstration program that aims to reduce cost of ownership by extending time between inspections, while also expanding the performance envelope to increase the engine's versatility and keep pace with evolving mission requirements. The improvements designed to ensure world-class performance focus on the HP and LP compressors, HP turbine, afterburner, nozzle and control system. The program is supported by French defense procurement agency DGA. Tests kicked off in 2004 and were successful.

ATHENA (Turbomeca)

Athena is an exploratory development program, supported by the DPAC, and mainly aimed at the technological development of a single-stage, cooled, high-pressure turbine for helicopter turboshaft engines. Launched in 1999, it is a follow on to the Vesta program, but with more ambitious objectives. In 2003, the new HP turbine stage underwent testing in a gas generator, along with a two-stage centrifugal compressor. The program culminated in 2004 with testing of a complete engine, including a low-speed two-stage power turbine, and an innovative inter-shaft rear bearing

technology. Blades for the HP turbine are cast by Snecma' Gennevilliers foundry.

CERAMIC MATRIX COMPOSITE COMPONENTS FOR AIRCRAFT ENGINES (Snecma, Aircelle, Snecma Propulsion Solide)

Reducing engine weight is a critical factor in helping reduce aircraft noise and pollution. Ceramic matrix composites can play a major role in this endeavor, since they combine light weight with excellent temperature resistance. However, innovative solutions are still needed if these composites are to offer the required service life of thousands of hours, plus acceptable cost. Research is now under way at Snecma, and at the LCTA joint laboratory (CNRS-University of Bordeaux-CEA-SAFRAN). It has already achieved significant results, including decisive demonstrations of nozzles on French and American military engine.

Other areas of research include combustors and mixers on CFM56-class commercial engines.

TITANIUM MATRIX COMPOSITE PARTS (Snecma, Turbomeca, Messier-Dowty)

Rotating parts for aircraft engines

The Epicur program, funded by the DGA, involves the development of an integrally bladed disk, or blisk, made of a composite material with a titanium matrix and silicon-carbide (SiC) fibers. Considered a disruptive technology, this material will cut weight in half. The innovative, low-cost production process (high-speed coating) allows a variety of matrices to be used, unlike conventional coating processes. The concept has been tested for mechanical strength.

The program will continue with the development of a mixed impeller for turbine engine compressors (Turbomeca).

Titanium matrix composites for landing gear (Snecma and Messier-Dowty)

Building on Snecma's extensive expertise in titanium matrix composites, Messier-Dowty has launched a program to adapt this technology to landing gear. Research is focusing on performance, especially a significant lightening of the parts concerned, and reducing the production costs for this technology.



SAFEE

A European Commission program within the scope of the 6th PCRD framework R&D program, SAFEE is examining aircraft security in the future European environment. It was launched to meet the need for greater civil aviation security, in light of hijacking and other terrorist attacks. The project focuses on a wide range of threat detection systems, along with the development of corresponding measures to counter physical or electronic threats. One of the keys to this project is the integrated information system, based on a secure communications link. Four sub-projects have been defined to meet the general goals:

- Detection of onboard threats: an integrated threat detection system based on a number of information sensors is installed on the aircraft. A prototype will be built and tested.
- Assessment of the threat and response generation system: a decision-aid tool that will give pilots real onboard crisis management support.
- Recovery of aircraft control by automated systems, with or without human intervention. Secure communications on the aircraft and with the ground.

- Assessment of the economic impact and compliance with national laws.

Partners: over thirty partners, including Airbus, BAE, Thales, EADS, nine smaller businesses, and several research labs and universities.

Term: February 2004 to December 2007

- ▶ **Sagem Défense Sécurité's role:** project coordination and head of 4th sub-project.

TATEM

A European Commission program for the 6th PCRD, focused on aircraft MRO. The main aim of this project is to improve the efficiency of maintenance, repair and overhaul (MRO) operations, which account for 20% of airlines' operating expenses. For instance, unscheduled maintenance can lead to costly flight delays and cancellations, if the problem cannot be resolved in time. The Tatem integrated project team aims to validate technologies and techniques that would make maintenance operations more effective, and especially to change unscheduled maintenance into scheduled maintenance. It is focusing on the following areas:

- Onboard sensors to group data from different aircraft systems (avionics, flight control, engines, structures, landing gear, hydraulics, fuel, etc.).
- Maintenance-free avionics.
- Signal processing (for example, fuzzy logic, neural networks, etc.) to transform raw data into pertinent information on system health.
- Diagnostics methods to identify and locate failures and malfunctions, thus reducing the cases of undetected failures.
- Prediction methods, to support preventive maintenance.
- Decision aids for maintenance crews, including process-oriented information and advice.
- Man-machine interface technologies suited to the needs of maintenance teams.

Partners: over 30, including Airbus, EADS, Alenia and Eurocopter.

Term: March 2004 to March 2008

- ▶ **Sagem Défense Sécurité's role:** coordinator of the sub-project "Data management".

PIBRAC

A European Commission program (second call for bids, 6th PCRD) focusing on reducing braking system costs. In particular, the project aims to show how the promising technology of piezo-electric motors could be applied to braking actuators to reduce weight, power consumption and maintenance costs.

The Pibrac program is taking two approaches, studying a rotary configuration in the medium term, and a linear configuration in the long term. The research work should culminate in a technology demonstrator, based on the rotary configuration.

The program will conclude with a technical-economic assessment of these new products. The main points to be developed are as follows:

- architecture of the actuator driven by a piezo-electric motor;
- surface coating for the piezo-electric components;
- elimination of mechanical disturbances in case of motor failure;
- electrical power consumption;
- control of the piezo-electric motor;
- prototype manufacture and testing.

Partners: ten, including Airbus, BAM, Messier-Bugatti and Noliac, plus other small businesses and universities.

Term: January 2005 to January 2008.

- ▶ **Sagem Défense Sécurité's role:** project coordination.

ISCAPS

A European commission program within the scope of the PARS initiative for preliminary research on security, concerning the detection of abnormal and suspect behaviors in a crowd, generally in a train station or airport. Research is focusing on three types of zones:

- open zone, with numerous entrances and exits (airport, train station, etc.);
- channeled zone, with limited number of entrances and exits, but not allowing individual control methods (shopping center, street, etc.);
- restricted zone, where the entrance/exit points can use biometrics and other individual control methods (e.g., entrance to a stadium).

The project is divided into four main sub-projects:

- Study of scenarios for behaviors to be detected, and selection of scenarios.
- Development of appropriate technology.
- Integration of this technology in a demonstration system, to be used on the scenarios selected.
- Definition of a road map setting out further research objectives.

Partners: ten, including BAE, CEA, ELSAG, SNCF, etc.

Term: February 2005 to February 2007.

► **Sagem Défense Sécurité's role:** coordination of project, definition of demonstrator specifications, selection and customization of sensors, analysis of overall project results.

SAFRAN IN-HOUSE RESEARCH PROGRAMS

GRH (Sagem Défense Sécurité)

Hemispheric resonator gyros (GRH in French) provide a real “disruptive” technological advance for inertial systems. This type of technology offers not only a wide range of performance, but also reduced size and volume, to make these units appropriate for many different applications.

In this type of gyro, a hemispheric resonator is fixed along its axis, and is excited and controlled by a capacitive effect, initially provided by two concentric hemispheres. This structure enables controlling the deformation of the resonator according to the air gap, but production and assembly is meticulous and costly.

R&D work has resulted in a number of patents filed over the last ten years. The patents mainly concern the architecture of the inertial sensor, especially the replacement of the conventional spherical air gap by a flat gap which is less costly to produce, along with signal processing electronics and manufacturing procedures.

Tests have validated this research, and results match expectations. Production of a high-performance inertial reference system was recently launched, and will be used for tactical missions on a variety of platforms.



RESEARCH, DEVELOPMENT AND ADVANCED TECHNOLOGIES

Image processing for defense and security applications (Sagem Défense Sécurité)

Image processing is a core discipline for Sagem Défense Sécurité's optronics and biometrics businesses. It involves a variety of functions: image stabilization, tracking via visible and infrared imagery, multispectral image fusion, detection, recognition and identification of targets on fixed or moving images, in visible and IR wavelengths, recognition of digital fingerprints, irises and faces, etc.

Sagem Défense Sécurité has participated in a number of advanced research projects for French defense procurement agency DGA, concerning or including target identification and classification functions, in terrestrial or aerial environments.

The company has been carrying out contract or independent research for a dozen years, calling on collaboration with major research organizations such as Inria and CNRS, as well as universities.

Sagem Défense Sécurité is a member of the ISIS research group, and is participating in the Techno-Vision program launched by the ministries of research and defense through the Robin project.