PART III. INNOVATION
TECHNOLOGY POWERING SAFRAN

Stéphane CUEILLE (PhD)
Safran Tech Managing Director
An increased R&T effort directed towards clear business drivers

**Aerospace**
- Environmentally friendly propulsion and critical systems
- Optimized energy systems, more electric and hybrid networks
- Secure embedded systems and data analytics based services

**Defense**
- Armed forces “sensor to shooter” capabilities in a network-centric environment
- Autonomous systems and vehicles for military use

**Security**
- Physical & digital security technologies to secure identities & transactions
- Security of human and goods flows at borders, harbors, airports

**450M€ (+50M€)**
Self-funded R&T in 2016*

**2,300 technologists**

**900 patents filed in 2015**

**350M€**
Safran businesses R&T

**100M€**
New corporate research center

---

CMD’16 | March 14, 2016
This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran.
SAFRAN TECH: A TECHNOLOGY BOOSTER

A new Corporate Research Center

- 400+ Technologists
- 150+ PhDs
- 25 nationalities
- Headquartered at Paris-Saclay*
- New state of the art facilities

ECOSYSTEM:

- Academic research
- Labs / universities

TECHNOLOGIES

- Energy & Propulsion Architectures
- Electrical Systems
- Advanced materials & processes
- Numerical modelling
- Image, signal, data processing
- Sensors and applications

* Paris-Saclay is one of the most important research clusters in Europe

Preparing today key technologies for the future

Paris - Saclay is one of the most important research clusters in Europe.
3D COMPOSITES
PUSHING FORWARD OUR COMPETITIVE ADVANTAGE

Polymer Matrix Composites

\[ \rightarrow 230^\circ C \]

A KEY TECHNOLOGY FOR LEAP AND BEYOND

\[ \rightarrow 1,100 \text{ pounds}^+ \]
weight saving per engine

Ceramic Matrix Composites

\[ 800^\circ C \rightarrow 1,450^\circ C \]

- Reduced weight (divided by 2 to 4)
- Reduced cooling
- Allow higher temperature

Safran flying first civil aviation certified CMC part on a commercial Air France flight (A320 aircraft)
Advanced Turbine Airfoils Research Center

Objective: +100°C turbine inlet temperature

BENEFITS:
- Route to 15% lower specific consumption
- Higher durability

MATERIAL
- New generation of super alloy: Improved creep life for high durability

COOLING
- Integrated optimized design of cooling circuit: Aerothermal – mechanical casting and machining

THERMAL BARRIER COATING
- New generation of thermal barrier coating
- Lower conductivity
- More durability

INSPECTION
- Computed tomography system
Driving cost, agility & performance improvement for aerospace applications & mission critical systems

LIFTING OFF WITH FIRST SUCCESSES
- 25+ Machines
- 700 p. directly involved
- 70 people full time

FIRST CERTIFIED PARTS

ACCELERATING AND SCALING UP
- Material/powders & process maturity
- Productivity & modelling
- Critical parts design & modelling
- Mindset & new design freedom
- Supply-chain development

IN A VERY DEMANDING CERTIFICATION ENVIRONMENT

MASSIVE USE
- Original equipment
- Spare parts
- Repair
- Services
- Toolings & fast prototyping

NOW 2018 2020
ADVANCED IMAGE PROCESSING
FROM ACQUISITION TO DECISION

Enhanced 3D perception
Image & video improvement

Deep Machine Learning & Pattern Recognition
Sensor & Data Fusion

A key Safran technology differentiator

DEFENSE SYSTEMS
IDENTITY & SECURITY
DIGITAL FACTORY & SERVICES

Superior performance of optronic payloads
Advanced biometrics and video analytics
Higher productivity
e.g. Inspection time divided by 3 on LEAP composite fan blade

CMD’16 | March 14, 2016
This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran.
ADVANCED NUMERICAL MODELLING

Mastering complex physics all along products lifecycle

Research

In service

Design

Production

Certification

Massive high performance computing

Crack propagation

Welding

Injection

Heat treatments

Forging

Combustion

Multiscale modelling

Complex fluid dynamics

SAFRAN
SMALLER, CHEAPER, SMARTER: MEMS

Smaller size generates wider range of users for inertial navigation systems, incl. dual use

Inertial sensor performance for high-end mission navigation

Miniaturization towards portable, individual geolocation service

Market

Size & Cost

A joint lab working on sensor technologies
CEASAR Lab

SAFRAN
Colibrys

SAFRAN
AEROSPACE DEFENCE SECURITY

March 14, 2016

This document and the information therein are the property of Safran. They must not be copied or communicated to a third party without the prior written authorization of Safran.
ADVANCED PROPULSION & ENERGY

Looking Ahead: Equipment Technologies for new Eco-friendly Architectures

Optimized Energy and Power
- More electric equipment
- Multi-source power
- Fuel Cells
- Generator/motor technologies

Ultra-Efficient Propulsion System
- Propulsion-Airframe integration
- Advanced architectures and technologies
- Buried/distributed propulsion
- Hybrid-Electric Power

First practical step of hybridization

Electrical network tech.
- Modular Power Electronics
- High voltage technologies
- Health monitoring

Micro-Hybridization
‘ECO mode’ propulsion concept for helicopter

CO₂, NOₓ, dB

-60% -85% -55%

ACARE Year 2035

Year 2035

11
HELICOPTER TURBINE TECHNOLOGY

Bruno EVEN
CEO, Turbomeca
OUR AMBITION, OUR ROADMAP

To be the world’s preferred helicopter engine manufacturer

- Enlarge activity within portfolio

- Innovate and develop new engines and variants including high-power engines

- Strengthen our leading position in growth markets

- Develop customer satisfaction and loyalty
INNOVATION ROADMAP

**EIS 2016 / 2018**
Baseline engine
On-going maturation of new technologies

RTM322 (existing)
TS2500 (FETT April 2016)

**EIS 2020+**
10 to 15 % sfc reduction
+20% power-to-mass ratio
Power growth to 3,000 shp
- Cutting edge compressor
- New materials to sustain higher temperatures
- Light high-performance power turbine
- Additive manufacturing

Tech 3000 demonstrator (FETT 2016) → 3,000 shp production engine (2022)

**EIS 2025+**
25 % sfc reduction
Hybridization
2015: proof of concept
2020: first flight

RTM322 (existing)
TS2500 (FETT April 2016)
Tech 3000 demonstrator (FETT 2016) → 3,000 shp production engine (2022)
PIONEER IN ADDITIVE MANUFACTURING

➔ Well suited to Turbomeca engine
  • Functional integration → complex parts
  • Small size engine → small components
  • Large diversity of product → need for flexibility

➔ World’s first serial components (fuel injector nozzle) certified for helicopter engine
  • Selective Laser Melting (SLM)
  • Investment in 3D metal printing machines
  • Support of Safran Tech

➔ Focused on high value components
  • Heat resisting alloys
  • Complex parts

➔ Boosting competitiveness: industrial processes, maintenance, inventories…

Benefits: cost reduction of 30% and production cycles reduced by 50%
HYBRIDIZATION PROJECTS

→ Helicopters require high power level at takeoff, during few minutes…
  • … rest of the time engines are used at low power far from the best efficiency point

→ Helicopter missions are highly variable
  • Engine design is currently a compromise

→ Hybridization allows to optimize the power available with the mission profiles
  • ECO/sleep mode
  • Ultra-fast reactivation system using an innovative electric power generation system

→ Concept for twin engine helicopters
  • Capability to fly on one engine, using the engines at their best efficiency
  • Significant cuts in fuel consumption (-15%)
COMBINING EXPERTISE WITHIN THE GROUP

- A “more electric” aircraft research

- Hybrid system to rapidly reactivate an engine to its full power
  - High power density super starter
  - Compact and highly reliable power electronics
  - High power density electric storage
  - Smart integration on the helicopter

- Key technologies demonstrated in 2015

- Combine the expertise and resources of Safran

Safran is ready to address the need for greater performance and reduced environmental footprint of new-generation rotorcraft
SAFRAN’S DIGITAL VISION

Ghislaine DOUKHAN
Executive Vice President, Safran Analytics
Our products are born digital and generate data throughout their lives.

**Design:**
Through 3D mock up

**Development and Test:**
More than 700Tb of data recorded

**Manufacturing:**
Thousands of machines generating data to track quality

**Operations:**
Embedded sensors for health monitoring

**Support and maintenance:**
Regular feedback on product behavior
WHAT WILL IT TAKE TO REMAIN A LEADING INDUSTRIAL COMPANY IN THE FUTURE

➔ Just like yesterday:
  • Good products
  • Advanced technologies
  • Competitiveness
  • Customer satisfaction

➔ But need to go further:
  • Understanding our customers and their use of our products better
  • Tracking the behavior of our product in real conditions
  • Developing customized services answering/anticipating customers needs
  • Constantly improving our internal performance
  • Being agile

Analytics can help do all this
SAFRAN’S ANSWER: SAFRAN ANALYTICS

➤ Creation on January 1, 2015

➤ One mission: create value for Safran based on Data

➤ Two main axes:
  • Improvement of internal performance
  • Development of new services based on a better understanding of our customers

➤ 60 data experts in 2016:
  • Identifying use cases
  • Collecting and cleaning corresponding data
  • Defining and applying the right algorithms
  • Industrializing the analytic solution

➤ Assets:
  • Data available
  • Capacity to link facts and figures with “physics”
INTERNAL PERFORMANCE IMPROVEMENT

Scrap rate reduction in production: Beyond Lean/6 Sigma actions

MRO shop performance improvement: Shop flow optimization to reduce TAT

360° engine: User friendly view of each engine life in operation to answer customers’ questions
NEW SERVICES

SFC02: Fuel efficiency improvement

BOOST:
Web-based application, highly secured for real time fleet management (Electronic Engine Logbook, Interactive Electronic Technical Publications, Electronic Configuration Manager)

Predictive Maintenance:
On wing maintenance, quick turns
WHAT ELSE?

Massive data sets accessible: let’s imagine new use cases

Extended Enterprise
(data exchange, supplier situation, risk management)

Airplanes, helicopters
(cycles, usages)

Events
(Weather, local events)

Customer Support

Manufacturing

Finance

Geospatial
(location, flightplans)

HR

Test bench

Airlines
(Fleet, fuel consumption)

Marketing

Maintenance & Services

Airports
(taxiing, safety, passengers)

Social Networks
(customer sentiment, flight experience)

Regulations

Competition
(situation, strategy)
SAFRAN: A DIGITAL INDUSTRIAL COMPANY

Seizing the potential of data!