SAFRAN

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one

TEAM – BUSINESS – FUTURE

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ONE TEAM

ONE BUSINESS

Top: A LEAP® low-pressure compressor (Safran Aero Boosters, Belgium).
Bottom: Engine borescope inspection and parts inventory.

ONE FUTURE

This issue's photos were taken before the Covid-19 pandemic.

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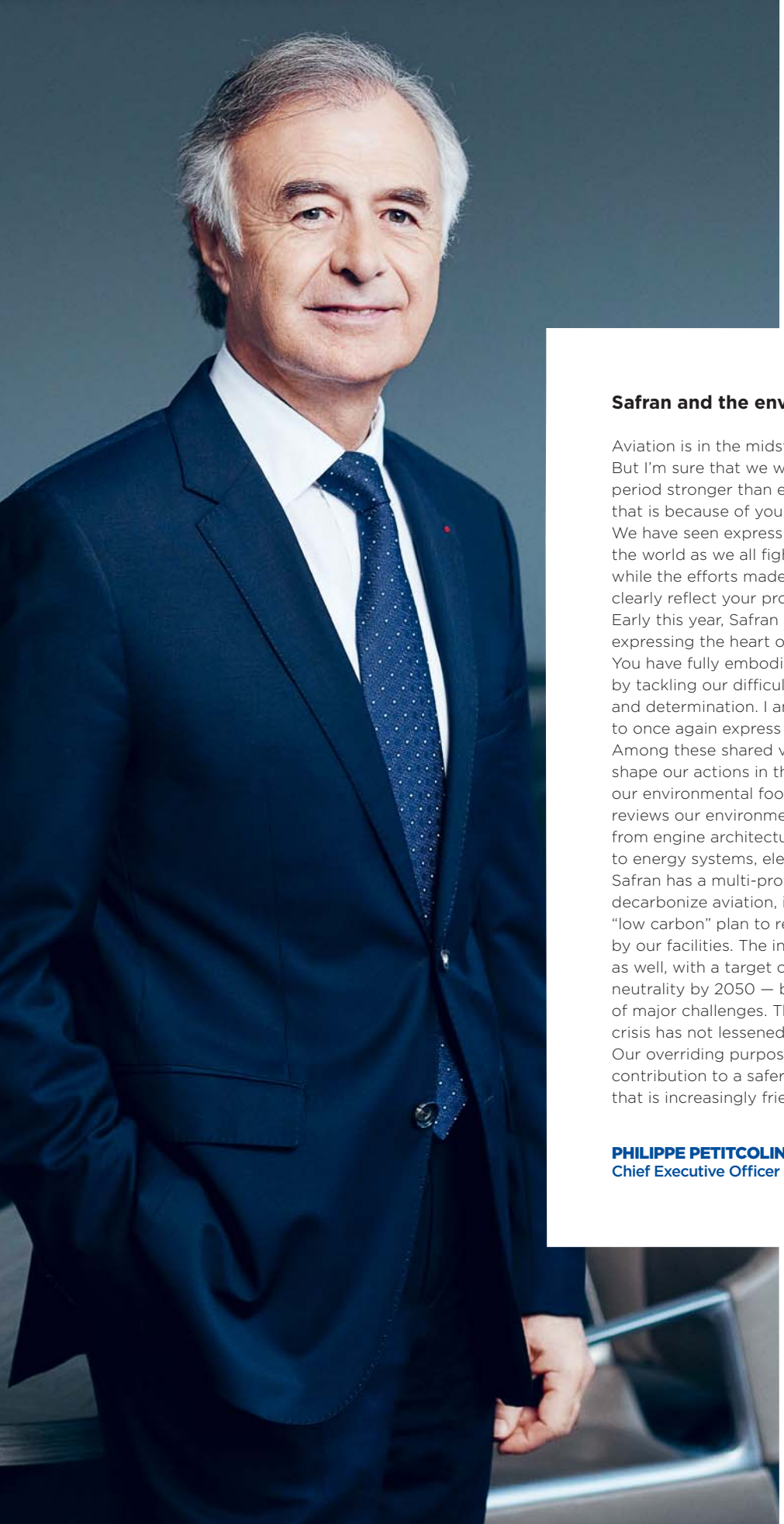


Safran and the environmental challenge

Aviation is in the midst of the worst crisis in its history. But I'm sure that we will emerge from this strenuous period stronger than ever. The main reason I believe that is because of your remarkable attitude.
We have seen expressions of solidarity around the world as we all fight the global pandemic, while the efforts made to sustain Safran's business clearly reflect your professionalism and commitment.
Early this year, Safran published its core purpose, expressing the heart of our commitment and values. You have fully embodied these values in recent months by tackling our difficulties with admirably clear heads and determination. I am taking this opportunity to once again express my sincere thanks.
Among these shared values, one in particular will shape our actions in the coming years: reducing our environmental footprint. This issue of *One* reviews our environmental policy, spanning areas from engine architectures and alternative fuels, to energy systems, electrification and weight savings.
Safran has a multi-pronged strategy to help decarbonize aviation, including an ambitious "low carbon" plan to reduce CO_2 emissions by our facilities. The industry timetable is ambitious as well, with a target of achieving carbon neutrality by 2050 — but this entails a number of major challenges. The global coronavirus crisis has not lessened our convictions.
Our overriding purpose is still to make a sustainable contribution to a safer world, with air transport that is increasingly friendly to the environment.

PHILIPPE PETITCOLIN
Chief Executive Officer of Safran

ONE TEAM

ALEXANDRE KANTOROW WINS CLASSICAL MUSIC AWARDS

The highly talented 22-year-old pianist Alexandre Kantorow, who was supported by the Safran Foundation for Music in 2016, won two prizes in the 2020 Victoires de la Musique Classique awards: one for best solo performance and another for best recording. Among the nominees were two other young virtuosos who received aid from the Foundation : violinist Théotime Langlois de Swarte and soprano Elsa Dreisig.

500

The 15th Safran Innovation Day held in February 2020 attracted 500 people with an exciting lineup of workshops, pitch sessions and the inauguration of Aerogarage, our new creativity space. The event culminated with the Safran Innovation Awards ceremony, which saw six prize-winning teams. The 2021 awards will feature a low-carbon category for the first time.

MOROCCO

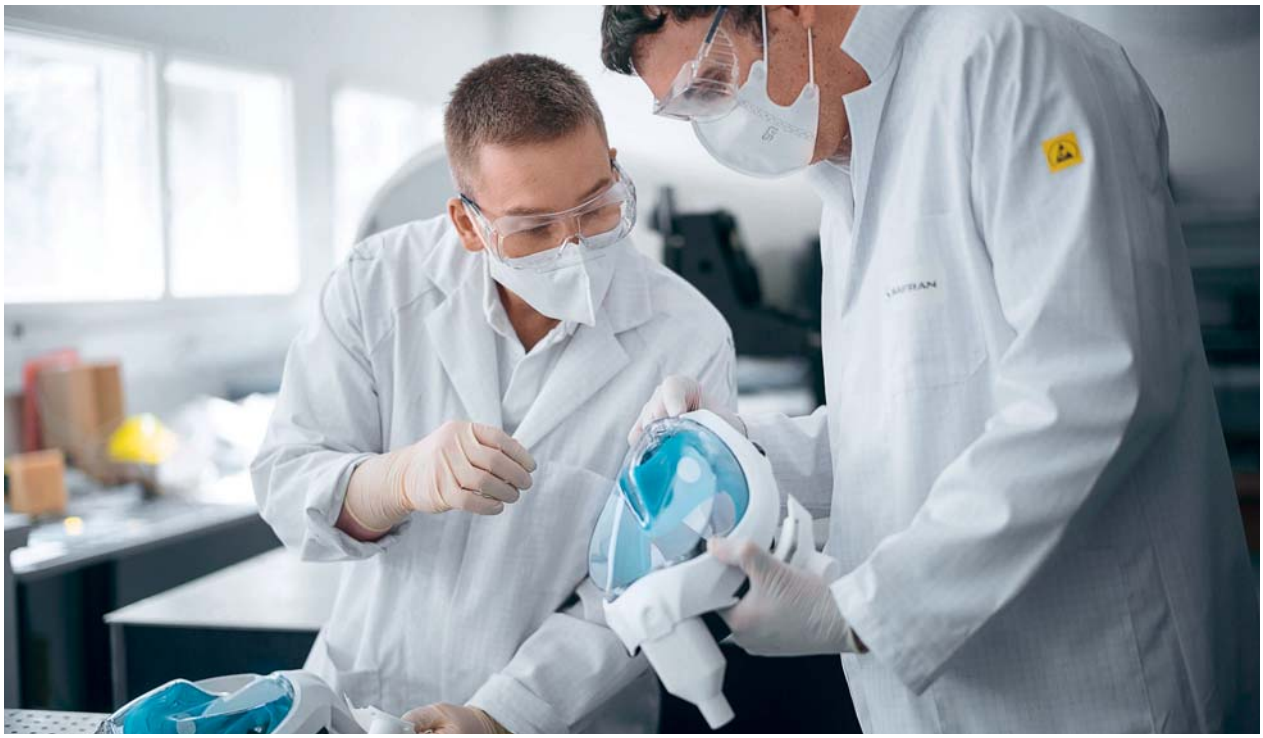
Launched in France in 2016, the Women@Safran sessions continue to gain momentum. Some 30 female employees gathered at the Matis Aerospace site in Casablanca, Morocco, to listen to Saloua Karkri Belkeziz, head of GFI Informatique's Moroccan subsidiary.

CULTURAL INCLUSION

In 2018 Safran Aerosystems introduced an inclusive hiring program targeting people from the Rarámuri indigenous community in Chihuahua, Mexico. The policy has been a terrific success, with 20 employees now fully integrated into the workforce. It has also marked a cultural shift, as these employees are allowed to wear their traditional clothing to work.

SAFRAN VS. COVID-19: THANKS FOR YOUR COMMITMENT

While the Covid pandemic has dealt a severe blow to the aviation sector, the commitment, solidarity and ingenuity of Safran's people has enabled us to maintain our essential operations and apply our know-how to help combat the virus. We take a closer look at some of the most notable initiatives.



Safran engineers adapting Decathlon's Easybreath snorkeling mask for medical usage.

SYLVAIN GUIHENEUF
SVP, Risk Management and Insurance, Covid-19 crisis management unit coordinator

"The Safran crisis management unit was set up in late January and fully activated in mid-February. Our priority was to ensure the continuity of essential operations by providing employees with a safe work environment. The mobilization of our teams in China really helped us extend the initiative to Europe, then to other parts of the world. The unit included representatives of all key functions and helped us stay one step ahead of the crisis and be better prepared for developments. Another important mission was to make decisions to protect Safran's interests, often within a very short timeframe." ■

12
companies in 10 countries were actively involved in the "Safran anti-Covid" task force.

1,000
ventilators produced by Safran in Chihuahua, Mexico.

20+
projects conducted and a dozen devices patented and deployed.

10,000
face shields 3D-printed from March to June and delivered to caregivers.

One of the most direct consequences of the Covid-19 pandemic for our industry has been the drastic drop in air traffic, which has affected the entire aviation value chain. Yet thanks to the unprecedented commitment and organizational skills of employees, management and occupational health staff, all Safran companies have been able to maintain their essential production and service activities, helping mitigate the impact of the pandemic.

Safran's customer support teams have continued to operate 24/7 on site and remotely to support the airlines still flying as well as those whose fleets have been grounded, when planes need to be protected from weather conditions, corrosion, sand and more.

Safran Aircraft Engines, for example, has provided masks, wipes and sanitizer for all Safran facilities in France and various sites abroad through its Villaroche commercial engine distribution center, so they could keep operating. Similarly, a Safran Purchasing team at Safran Aircraft Engines in Suzhou, China, has coordinated procurement of all necessary personal protective equipment (PPE) as Safran employees around the world returned to work. Hard hit by the drop in passengers, airlines have turned to freight as a source of revenue. Here, Safran Seats has been providing vital support to help maximize cargo space on passenger planes.

MANAGING HEALTH & SAFETY

Public-service and military helicopters powered by Safran Helicopter Engines have been performing a vital role for the health authorities - transporting patients and delivering vital equipment. Because of their busy flight operations, our company needed to maintain its essential activities as well as provide ad hoc services, such as implementing disinfection procedures and fitting screens to isolate the flight deck from the passenger compartment.

Protecting the health of our people has been a top priority and a challenge, both during lockdown and once sites started reopening. At the start of the

SYLVAIN FAURE
Senior Vice President, R&T Projects for Safran Electronics & Defense, coordinator of the Safran anti-Covid working group

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"From March, a whole host of initiatives began to emerge in France, other European countries and then in North and South America. We quickly realized a cross-company task force was needed to coordinate all of these actions. Safran anti-Covid was created to help focus the various efforts, pool resources, share information about latest advances and share skills to help everyone respond more effectively to needs on the ground. We rolled out a series of tools to help us meet three priorities: protect medical teams in contact with patients, reduce aerosolization risks (the virus spreads through air droplets) and deliver oxygen ventilation equipment for patients. Some projects are still continuing, like the R-Safe reusable protection mask, and several teams are already preparing for air transport in the post-Covid world, especially aircraft interiors going forward." ■

›

pandemic, company medical officers at all Safran sites relayed corporate guidance so they could implement effective health protection measures, identify and isolate contacts for 14 days and advise higher-risk employees to work from home. They worked with the Health, Safety and Environment (HSE) department throughout the lockdown to make all the necessary arrangements for sites to reopen and answered questions from managers about how to coordinate this transition period. The fantastic collaborative effort by the HSE department, facilities management and company medical staff also enabled sites to reopen after disinfection with all the required conditions in place to keep employees safe. All these actions were guided by the dual objective of protecting everyone's health and Safran's future. Once again, they reflect Safran's agility and ability to adapt to its environment.

SOLIDARITY IN ACTION

While supporting our customers, Safran was also on hand to assist the medical sector, which has been busy dealing with the public health crisis. From the start of the lockdown implemented by many countries in March, we set up a multi-company task force called "Safran anti-Covid".

Its mission was to offer solutions based on Safran products and resources to help combat the pandemic, with a special focus on adapting existing equipment for medical use. All entities manufactured and donated PPE. With the support of "Additive manufacturing against Covid-19" volunteers, instructions were posted on Insite about how to quickly 3D print templates for face shields, no-touch push buttons, elbow-operated door openers, ear protectors and more.

At the initiative of employees, most companies also 3D printed thousands of face shields for hospitals. And the upholstery technicians at Safran's textile workshops, who usually make cabin equipment, life vests and parachutes, turned their expert hands to making a huge number of masks and gowns.

Safran Seats introduced a product line this summer called "Travel Safe by Safran Seats", providing social distancing without impacting seating density, contactless interactions and virus-free surfaces.

All Safran facilities have been organized to foster social distancing and protect employees, such as this Safran Electrical & Power plant at Villemur-sur-Tarn in southwest France.

INNOVATIVE DEVICES

In addition to these initiatives, the Safran anti-Covid teams also mobilized to adapt existing products. Working with the IRBA, Armed Forces Biomedical Research Institute in France, Safran anti-Covid acted quickly to adapt the popular Easybreath snorkeling mask from sports retailer Decathlon. The new mask, called Healthybreath, meets the requirements of caregivers and patients on ventilators. *"On June 24, 2020, we received special dispensation from the ANSM, France's national drug and health product regulator, stating that use of the Healthybreath mask is in the interests of public and patient health,"* says Sylvain Faure, coordinator of the Safran anti-Covid task force.

"That meant we could formally roll out this protective device to hospitals — a real triumph of teamwork." The Mistral mask, developed by Safran Electronics & Defense as part of the FELIN soldier modernization system for the French army, has also been approved with the help of the IRBA. *"It allows caregivers to breathe filtered air only, even when their heart rates are higher, such as when moving patients or equipment,"* says Sylvain Faure. A dozen military hospitals have benefited from this protective device, designed for healthcare staff in direct contact with patients. The Safran anti-Covid task force has been demobilized, but in the face of the ongoing public health crisis Safran employees have demonstrated their sense of solidarity and engagement in very practical ways. During her visit to our Éragny-sur-Oise facility in France on May 25, French armed forces minister Florence Parly learned about the many employee-led initiatives to help protect caregivers and patients from Covid-19. ■

FIVE YEARS OF INNOVATION AT SAFRAN TECH

Safran's Research & Technology (R&T) center recently celebrated its fifth anniversary, an excellent occasion to review its vocation and research focal points.

Vincent Garnier, Managing Director of Safran Tech, addresses his colleagues on January 27 during the center's fifth anniversary celebrations.

560
employees, including 70 doctoral candidates.

1/4
of Safran's R&T investments.

5
facilities: Gennevilliers, Itteville, Le Haillan, Paris-Saclay and Toulouse.

500+
patents in its portfolio.

Paris-Saclay (greater Paris area), January 27, 2020: Some 350 employees of the Group's Research, Technology and Innovation department, along with R&T correspondents from all Safran companies, celebrate the fifth anniversary of Safran Tech. Managing Director Vincent Garnier reminds them of the challenges that led to the center's creation: "*Safran has always invested heavily in building solid foundations for the future. To go even further and faster, we had to pool our efforts within a single entity, allowing us to more effectively share and circulate knowledge.*" Five years on, Safran Tech's objective remains unchanged: to share expertise and foster the development of new technologies for the benefit of the entire Group, alongside our companies' own R&T efforts.

MATERIALS, ENERGY, DIGITAL

Reflecting structural trends in aerospace, Safran Tech channels its efforts into three main areas: materials, energy and digital. Its teams are organized in research groups, focusing on innovative concepts, and technology platforms, which mature technologies all the way through the construction of prototype demonstrators. Safran Tech now has 500 employees at five facilities in France *(see opposite for locations)*.

Safran Tech's capabilities are built on the excellence of its researchers and state-of-the-art facilities, of course, but also its close ties with Safran companies. According to Pierre Cottenceau, Chief Technical Officer at ›

SOPHIE SENANI
Coatings research engineer, Safran Tech

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"At Safran Tech, for the last two years I've been working on a leading edge for the LEAP® fan blade, using a thermal spray coating directly on this composite part. At the same time, I'm developing a coating using the sol-gel method to ensure the high-temp protection of titanium alloys on future engines from Safran Aircraft Engines and Safran Helicopter Engines. I'm also studying an anti-lightning coating for Safran Nacelles that would save weight on nacelles by replacing the metallic parts with composites, as well as assessing various antiviral adhesives. In 2021, I hope to start work on new high surface energy materials for aircraft, which recover or generate energy to reduce our environmental footprint. Day after day, my goal is to develop the disruptive technologies that make our products stand out in the aerospace market." ■

NAWAL JALJAL
Head of aircraft architecture, Safran Tech

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"I'm working on aircraft hybrid electric propulsion systems in our Energy & Propulsion research group. In particular, I'm involved in the "Short Medium Range 2030" project, along with Safran Aircraft Engines and Safran Electrical & Power, to optimize the overall energy system on mainline single-aisle commercial jets. By working jointly with the Electrical and Electronic Systems research group, we identified the technologies where Safran needs to ramp up its expertise to radically improve aircraft propulsion systems by 2030." ■

Safran Nacelles, *"I'm a firm believer in cross-fertilization between our staff and their counterparts at Safran Tech. This approach has already produced an outstanding achievement in infrared thermography, with close support from Safran Composites at our UK and French factories, in Burnley and Le Havre, respectively."* Another example of this productive collaboration is the creation of an autonomous vehicle lab along with Safran Electronics & Defense. *"It's a striking success, with the entire team sharing the same ambitious objectives,"* explains Jean-Paul Trabis, the company's Chief Technical Officer.
Safran Tech Managing Director Vincent Garnier sums up the center's shared objective: *"These partnerships ensure that the issues we address will help Safran meet the challenges ahead."* ■

JENNIFER VANDONI
Deep Learning research engineer, Safran Tech

"My specialty is the automatic learning algorithms that machines use to teach themselves how to process large volumes of heterogeneous data, mainly for autonomous aircraft and drone systems. One of our main challenges is to interpret aerial images to detect other vehicles, determine their trajectory, etc. Group companies send me very specific data, which is an invaluable aid in conducting my research. For instance, with the help of Safran Electronics & Defense, I delivered a first device that identifies aircraft by using an onboard infrared imager to analyze the trajectories of other aircraft and identify possible collision paths." ■

At the Electrical and Electronic Systems lab, a research engineer develops, tests and validates the E&E building blocks for propulsion systems on tomorrow's more electric aircraft.

AROUND THE WORLD OF SAFRAN

Introducing a team and different individuals from Safran companies, for a quick look at their career paths, areas of expertise and vision of Safran.

A fresh start

Safran Electrical & Power, United States

Seven women from the Bradenton Bridge Community Release Center were accepted into the Bridge to a New Life program at Safran Electrical & Power's plant in Sarasota, Florida, in 2019. Chosen for their potential to succeed, these women are now involved in the production of electrical power distribution components. Other career opportunities are also open to them, such as industrial painting and logistics analysis.

“Customers expect a fast turnaround, calling for a high level of responsiveness. My role is to make sure this happens.”

Sammy Yassine

Head of production and supply chain management, MRO (maintenance, repair and overhaul), Safran Transmission Systems, France

“I plan all the work done by our MRO shop, whose job is to restore customers’ power transmission systems to optimal working condition. Customers expect a fast turnaround, calling for a high level of responsiveness. My role is to make sure this happens. The job spans everything from internal logistics to outsourcing and inventory management, and carries a lot of responsibility. Every day, my team must ensure the shop has all the parts needed to restore equipment such as accessory gearboxes (AGB) and transfer gearboxes (TGB) to perfect working order. We have to stay sharply focused at all times to keep to our delivery commitments.”

Florelle Rousse

Color, material and finish designer,
Safran Seats, France

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"I design and develop different combinations of colors, materials and finishes to create a harmonious look and feel to seats and a distinctive ambiance for cabins. I've been doing this job for three years now and I've seen how the needs of airlines have evolved. Increasingly, the focus is on more compact, lightweight seats without sacrificing perceived quality, comfort or technical performance. Ticking all these boxes is a real challenge! My job at Safran Seats is like no other. I love the diversity and creativity of projects; it makes me constantly seek new inspiration. The seat is one of the first things passengers look at when they come on board. It's my job to ensure we make a good impression!"

"The ultimate aim is to strike a perfect balance between good design and quality and reduced weight and costs."

Cassie Collman

Executive assistant,
Northwest Aerospace Technologies,
Safran Passenger Solutions,
United States

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"I began here in 2011 as the assistant to the head of the Engineering department. In 2016, I was appointed executive assistant to Jim Moore, the company's president. A crucial part of my job is to listen closely to the needs of employees. As executive assistant, I provide support for all executive committee members. No two days are the same in my job, which is what makes it so interesting. I have to be highly organized and pay meticulous attention to detail. My motto is to make life as easy as possible for my colleagues."

"My motto is to make life as easy as possible for my colleagues."

PROJECT MANAGEMENT: MORE PROFESSIONAL, MORE EFFICIENT

Safran invests hundreds of millions of euros every year in complex projects. Successful delivery of these projects calls for keeping development costs under control, harmonizing project management practices and enhancing professional skills. In 2018, Safran rolled out One Safran Project Management (One Safran PM), aimed at increasing the professionalism of project management, training staff and standardizing methods and processes at all Safran companies. As a result, project management has come into its own and more and more companies have adopted the associated tools. We spoke to five key stakeholders.

JEAN-PAUL ALARY
CEO of Safran Aircraft Engines, at the time CEO of Safran Landing Systems and One Safran PM project sponsor

"Safran develops innovative new products and services to offer customers ever more value. Project management must play its part by constantly striving for excellence when it comes to quality, cost and delivery. So we've rolled out the One Safran PM initiative to scale up the professionalism of project management across the Group. The initiative focuses on three core aspects: strengthening skills (through training and our PM experts stream), defining standards and fundamentals, and installing a unified PM tool called oSmoz (based on the Planisware integrated PM solution). oSmoz was rolled out at Safran Nacelles, Safran Aircraft Engines and Safran Helicopter Engines in 2019. Other companies will be joining them between now and 2022." ■

PASCAL CHEVALOT
In charge of engineering and project management systems, Safran Nacelles

"We integrated One Safran PM soon after its launch in 2018. We were among the first to implement the new Project Management stream and Project Management Office. The stream now counts 60 designated employees from Engineering (including R&T), Programs, Production, Purchasing and Customer Service. One Safran PM has enabled us to strengthen management of the technical and financial aspects of our projects. By managing all project deliverables, both our KPIs and cost estimates are now much more reliable. oSmoz, the project management application, was implemented in May 2019 and is now used by more than 1,000 employees at Safran Nacelles." ■

TWO TYPES OF TRAINING

Set up in 2018, Safran University offers both common core and specialized learning programs. Common core courses in the fundamentals of project management are mandatory for project managers and Project Management Officers (PMO). Specialized programs, meanwhile, are intended to strengthen skills in specific areas, such as costs, project planning and risk and opportunities management.

MYRIAM PACOT
Focal Point France, PMO, Safran Engineering Services

"Safran Engineering Services has played a central role in Safran's project management initiative since 2018. To start with, we're a key partner to Safran University, working with them to develop and deliver PM training programs. Our aim is to help all Safran companies strengthen their people's skills so that we can achieve excellence in project management across our entire organization. We drew on a network of 80 experienced employees around the world to provide effective support to the corporate Quality and Performance department for the deployment of the oSmoz application. We also work alongside Safran and its companies as part of cross-functional projects (sales, acquisitions, transformation, implementation of the European REACH directive on chemical substances, etc.) and on operational projects, sharing our expertise in methods and tools." ■

FRANÇOIS BASTIN
Vice President, Commercial Engine division, Safran Aircraft Engines

"We actively supported the One Safran PM initiative as soon it was introduced by systematically applying its standards. Having a recognized project management function has stepped up professionalism, and we've designated around 120 PMOs since 2018. Deployment of the oSmoz application in mid-2019 has also helped raise skills levels for some 1,300 employees, including program, project and work package managers, management controllers and resource managers. All of this amounts to highly effective resources for successfully managing our programs and meeting our RTDI (research, technology, development and production engineering) objectives – on time and to budget. What's more, we believe that project management excellence will be more crucial than ever as we work to deal with the current crisis and seize new opportunities that lie ahead." ■

FRANCK DELORAINE-COLLET
Vice President, Operational Excellence for Development, Safran Seats

"The aircraft seat market is braced for rapid change as development schedules get shorter and features ever more numerous. Succeeding – which ultimately means satisfying our customers – calls for nothing less than excellence in project management. By bringing us the benefits of proven practices and standards, One Safran PM will speed up the changes required in seat engineering. This will put us on track to quickly meet our commitments to customers, teams and management as we pursue the transformation underway at Safran Seats. And it's even more strategically important right now, as a dozen new major projects are set to kick off this year in our various engineering departments. For example, one area where tangible improvements are expected is the reliability of work schedules with regard to flexible staffing." ■

YOUR CONTACTS

BERTRAND CARETTE
Head of One Safran PM deployment

ALAIN PERBOS
Head of the project management stream

M88 MAINTENANCE

Didier DELORME

Field Technical Representative and Instructor

Didier Delorme is an instructor at Safran Aircraft Engines. He worked with Franck Monnier to train 12 Indian Air Force mechanics in maintenance procedures for the M88 engines powering their new Rafale fighters.

Early morning briefing in the classroom on a specific maintenance operation. The training course blends classroom instruction and hands-on practice to maintain a balance. We use different educational methods over the six-month training to clearly explain each task.

9:00 AM

The Indian Air Force mechanics are fully invested in the training process and pay close attention throughout. If any instruction isn't clear, we read the technical documents together, line by line, so they fully understand each step.

9:50 AM

We employ a virtual reality headset to realistically simulate the repair procedure and repeat the actions needed until they're clear.

11:00 AM

2:30 PM

Two trainees carry out a maintenance operation, while their colleagues study the technical documents on a large touch screen.

ISTRES TRAINING CENTER AT A GLANCE

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- **December 2019:** Inauguration of the training center, just eight months after construction started.
- **12 Indian Air Force mechanics** completed the training program.
- **Six months** of training with four instructors, blending classroom and hands-on instruction.

4:00 PM

MAY 6

Above: The training center in Istres, southern France. Despite restrictions because of the Covid-19 pandemic, we finished the training program on May 6 with a "graduation" ceremony.
Left: All training was carried out using equipment acquired by the customer, including engines, stands and tools.

ONE BUSINESS

33,000 SQ M

Safran Helicopter Engines' new CAP 2000 industrial campus in Tarnos, southwest France, was inaugurated in February 2020 by Florence Parly, French Minister of the Armed Forces. In September, Alain Rousset, President of the Nouvelle-Aquitaine Regional Council, visited the facility, confirming its status as a global center for the management of helicopter engine maintenance and after-sales support. Spanning some 33,000 square meters (356,400 sq ft), it's also the Group's center of expertise in these services.

Proud!

Collins Aerospace has chosen Safran Electrical Components in Santa Rosa, California to design and manufacture the landing gear wire harnesses for the Boeing T7-A Red Hawk military training aircraft.

15

The number of nacelles delivered by Nexcelle, the 50/50 joint company between Safran Nacelles and MRAS (part of ST Engineering), to CFM for flight testing of Chinese planemaker Comac's new C919 single-aisle commercial jet. This airplane is also equipped with an O-duct thrust reverser designed by Safran Nacelles and featuring an innovative design that improves aerodynamic performance and fuel consumption. It's controlled by the electrical thrust reverser actuation system (ETRAS), designed and integrated by Safran Nacelles in conjunction with Safran Electronics & Defense and Safran Electrical & Power. The sixth test aircraft made its first flight on December 27, 2019, marking the start of deliveries for production-standard equipment.

EMERGENCY FLOTATION SYSTEMS

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Safran Aerosystems has signed a 5-year maintenance contract for the flotation systems on 98 HH-65 Dolphin helicopters deployed by the U.S. Coast Guard. In case of a forced landing at sea, these systems allow the helicopter to stay afloat long enough for passengers and crew to evacuate. Safran Aerospace Services Americas (New Jersey) will handle maintenance work at the Coast Guard's various bases and MRO facilities.

SAFRAN REOSC, A STELLAR PERFORMER

What does making mirrors have to do with uncovering the deepest secrets of the Universe? They come together in the Extremely Large Telescope (ELT), and Safran Reosc is a major contributor to this astronomy instrument as a supplier of high-performance optics. Safran calls on its state-of-the-art production facilities to make the ultra-precise mirrors that are critical to the observation of stars.

State-of-the-art production machinery.

On February 4, 2020, Safran Electronics & Defense inaugurated a new plant dedicated to production of the M1 mirror segments for the Extremely Large Telescope, developed by the European Southern Observatory (ESO). Located in Saint-Benoît, near Poitiers in mid-western France, this factory features state-of-the-art production technologies – a must for this new high-performance telescope that heralds a significant improvement in scientists' understanding of astrophysics.

BIGGEST AND BEST

ELT will be the largest and most powerful optical telescope in the world, four to five times larger than any current model. The telescope which will be operational in 2025 will be able to detect stars 26 times dimmer than currently possible, and even track organic molecules. The ultimate goal is to expand our knowledge about the origin of galaxies, by conducting stellar archeology, discovering and characterizing exoplanets in orbit around stars similar to the Sun, observing black holes and dark energy, and even locating water on small exoplanets.

ADVANCED OPTICS TO EXTEND OUR VISION

What role does a telescope's size play in determining its detection ability ? The telescope's primary mirror collects light from space and uses an optical chain of several mirrors to focus it on a point — the focal point — where we can place a detector such as a photographic sensor. The larger the mirror, the more light it collects, which means it can reveal very dim objects, invisible to the naked eye, such as distant stars and even planets.

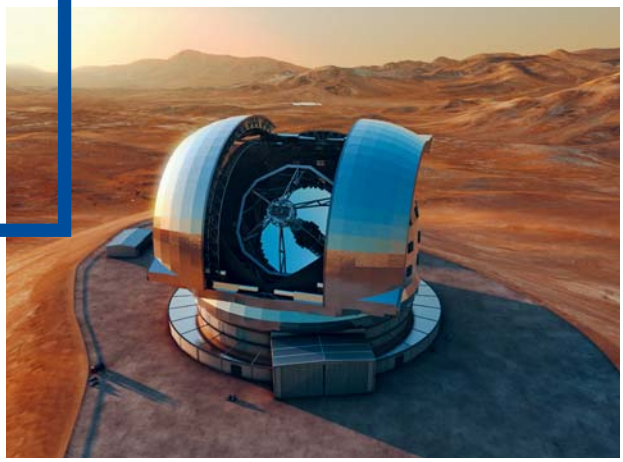
In short, giant mirrors are essential for astronomy. And that's where Safran Reosc comes in. The company is a long-standing world leader in this field, based on its expertise in the design, production and integration of high-performance optics for›

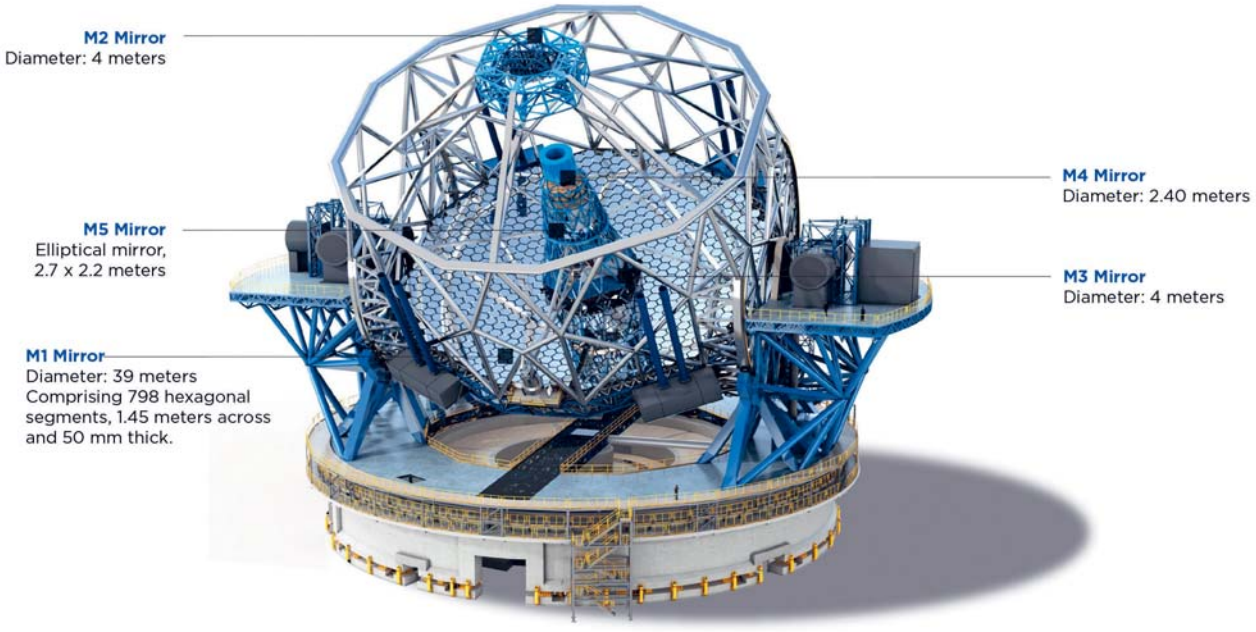
2025 IN SIGHT

The Extremely Large Telescope (ELT) is under construction in Chile, on the Cerro Armazones mountain at an altitude of 3,046 meters (9,993 feet). Prime contractor is the European Southern Observatory. The cornerstone was laid in 2017, and it is expected to collect its first light in 2025.

Top: Artist's impression of the ELT in Chile.

Bottom: The positions of the five ELT mirrors.





Start of a polishing operation by robotized machinery to ensure surface quality to within a nanometer.

› astronomy. Created in 1937, this Safran Electronics & Defense company supplies optics for space, high-power laser, semiconductor and astronomy applications. It has won a long string of contracts for the ELT mirrors: the M4 in 2015, M2 in 2016, M3 and M1 in 2017 and M5 in 2019.

But along with this business success comes a daunting array of technical and industrial challenges. According to ESO Director-General Xavier Barcons, ELT will be the most impressive telescope of its type ever built. For example, the M2 secondary mirror, 4 meters (13 ft) in diameter, will be the largest single-piece convex mirror ever. The M1 primary mirror, concave and aspherical, will measure 39 meters (128 ft) in diameter and will comprise 798 hexagonal segments, each one measuring 1.45 meters (4.8 ft) across. These off-axis aspherical segments will be organized in 133 families of six identical segments. The shape of each type of segment will depend on its location in the mirror. Assembly will have to be extremely accurate, while also being strong. The position of the segments will be controlled in real time by actuators that adjust the overall shape of the mirror to account for wind and mechanical constraints.

EXCEPTIONAL OPTICAL QUALITY

These mirrors have to be polished to a degree of precision that allows the telescope to capture light from stars thousands of light-years away. On the M1 mirror, for instance, each segment has to be polished so accurately that any defects would be smaller than a ladybug if the segment were the size of France.

Polishing is an extremely meticulous procedure, and a long-standing area of expertise at Safran Reosc. In this case, however, minute attention to detail has to go hand-in-hand with large-scale production. The M1 mirror contract alone requires three years to polish the 931 hexagonal segments (including 133 spares) to the required smoothness, or about one per workday. This is a tremendous production challenge, given that completing just one mirror demands 60 different operations and takes about 500 hours.

A PURPOSE-DESIGNED PLANT

Safran Reosc didn't have the production resources needed to handle this output, so in 2018, Safran Electronics & Defense provided the company with an entire building at its facility in Saint-Benoît. *"We chose this site because it already has experience in optics and volume production,"* explains Martin Sion, CEO of Safran Electronics & Defense. *"And that's the exact thing we're looking for here, very-high-quality mirrors, produced*

in series. We'll be able to capitalize on the expertise available at Saint-Benoît."
No less than 5,000 square meters (54,000 sq ft) will be devoted to making M1 mirror segments in this new building, which is also geared to future industrial needs.
A number of revolutionary digital solutions will converge in the new plant: the Internet of Things to connect machines and objects, the "dataization" of production, dynamic processing of huge streams of information, robotics, advanced human-machine interfaces, a 3D digital twin of all installations, digital simulation of flows, virtual reality to simulate workstation ergonomics and more. These technologies will transform all aspects of conventional industrial facilities, from production itself, to control, logistics and staff training.

The upshot is a "Factory 4.0" designed around people, who are at the heart of operations. Machine operators' skills and knowledge are evolving, and the way they work with machines as well. A supervisory system automates data transmissions between machines and ensures the consistency of all information to guarantee the requisite quality for each mirror.
Safran teams will soon be working night and day, five days a week, in this state-of-the-art plant, to make the mirrors that will allow us to discover parts of the Universe that were previously in the dark. ■

"We chose Saint-Benoît because it has experience in optics and volume production."

MARTIN SION
CEO of Safran Electronics & Defense

FROM POITIERS TO THE FURTHEST REACHES OF THE UNIVERSE

The plant inauguration ceremony on February 4, 2020 welcomed VIPs including Sacha Houlie, member of the French parliament for the Vienne department, Dominique Clément, mayor of Saint-Benoît, and Alain Claeys, president of the greater Poitiers urban community, reflecting Safran Electronics & Defense's important role in the city and region. Bernard Uthurry, vice president of Nouvelle-Aquitaine, also reminded guests of the company's role in the region's economy. Safran is a major employer, contributing to the vitality and dynamism of a high-tech industrial and scientific ecosystem — with high-performance optics at its core.
By supplying mirrors for the ELT, the company is contributing to a vital program. As Xavier Barcons, Director-General of ESO, noted, *"It will give us clues to where life might exist outside our Solar System!"*

AN EXEMPLARY MAINTENANCE CONTRACT

The through-life support (TLS) contract awarded by the French government to Safran Helicopter Engines is the largest helicopter engine support contract ever signed by Safran. Running for over 18 years, it covers 550 helicopters and 1,600 engines, which to date have clocked up more than 3.5 million flight-hours. We take a brief look at this model contract.

French government helicopters enjoy a serviceability rate of 100%. Here, an ALAT AS532 Cougar.

A BENCHMARK CONTRACT

The through-life support (TLS) contract is a model for performance and cost control. Safran Helicopter Engines applies this model in the form of a Global Support Package (GSP) type contract for other government customers around the world, such as Brazil, Denmark, the United Kingdom, Malaysia and Portugal.

100% SERVICEABILITY

For almost 20 years, Safran Helicopter Engines has maintained the engines on the French government's helicopters, under the terms of a through-life support (TLS) contract. Renewed every 10 years, it ensures a high level of engine performance and availability, all within a tightly controlled budget. One indicator of this success: for the last 12 years Safran Helicopter Engines has fulfilled all service contract terms covering all 1,600 helicopter engines operating in metropolitan France, overseas territories and in foreign theaters. This is a key advantage for our wide-ranging clientele, including the French army aviation arm (ALAT), the French air force and navy, Civil Defense, Customs, the French defense procurement agency (DGA) and the National Gendarmerie.

AVAILABILITY AND RESPONSIVENESS

Each year, the National Gendarmerie alone flies some 22,000 missions, equivalent to around 19,000 flight-hours. It deploys a fleet of 56 Airbus Helicopters of three different types: 26 AS350 Ecureuils, 15 H135s and 15 EC145s. The National Gendarmerie Air Force Command (CFAGN) performs one mission every 20 minutes on average, day and night. With the TLS contract, French government users enjoy an immediate response to their requirements. *"The TLS contract with Safran Helicopter Engines ensures extremely high levels of availability, and we're very satisfied with it,"* says Captain David M., head of the airworthiness section of the National Gendarmerie air force. *"We carry out a wide variety of missions, so it's vital the engines on our helicopters are operating optimally at all times. Law enforcement, local area control, road safety, criminal investigation, counter-terrorism and mountain and maritime search & rescue are just some of the key roles we perform every day."*

FOCUS ON TARNOS 2020

"A team of 23 people is working exclusively on this contract at our support entity," says Frédéric Fourciangue, CEO of Safran Helicopter Engines Support France in Tarnos, southwest France. *"We handle the logistics, technical and business aspects as well as quality and the contracts for this fleet, working closely with the French armed forces aircraft maintenance department (DMAé) and the DGA."*

Tarnos is the company's main MRO (maintenance, repair and overhaul) center and recently received a €50 million investment as part of the CAP 2020 modernization project. The goal is to boost productivity and reduce MRO cycle times by 30%. Two years ahead of the 10-year renegotiation, the recognition conveyed by French armed forces minister Florence Parly during her visit to Bordes after the Covid-19 lockdown, coupled with the new helicopter orders included in the aviation recovery plan, are promising signs that the contract will be renewed. ■

SIMULATED CRASH TESTS

All seats go through a series of crash tests before they can be certified. It's a huge workload for Safran Seats – but it's about to get easier thanks to Certification by Analysis (CBA). We look at this major advance, which will speed up certification, reduce costs and boost the company's competitiveness.

"This year, we're doing our first Certification by Analysis, or CBA," says Florent Massé, structural design engineer at Safran Seats in Issoudun, France. *"Our aim is to achieve maturity in digital simulation, so it can replace some of the physical tests in the near future."* Actual testing is a lot of work, and the prototypes, dummies and measurement instruments are costly. One seat may require up to 15 dynamic tests, which are the most expensive, and each test can take a day to set up. That does not include all the work to prototype the seat.

GOING DIGITAL

Digital simulation has been helping solve technical issues for a decade, but it wasn't part of the certification process submitted to the authorities. For the company to stay competitive, development programs need to be shorter. However, physical testing can lead to significant delays… which explains the move to digital with CBA. There's a big challenge ahead for the teams involved. After the pilot project currently underway at Issoudun, and once the authorities have approved it, the process will be rolled out to other Safran Seats facilities in the United Kingdom and United States.

IN THE FOREFRONT

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Safran Seats will be the first manufacturer to certify its seats by analysis since the regulatory authorities allowed this method. This will enable us to shorten certification times and reduce costs, giving us a significant competitive edge.

ISSOUDUN PILOT UNIT

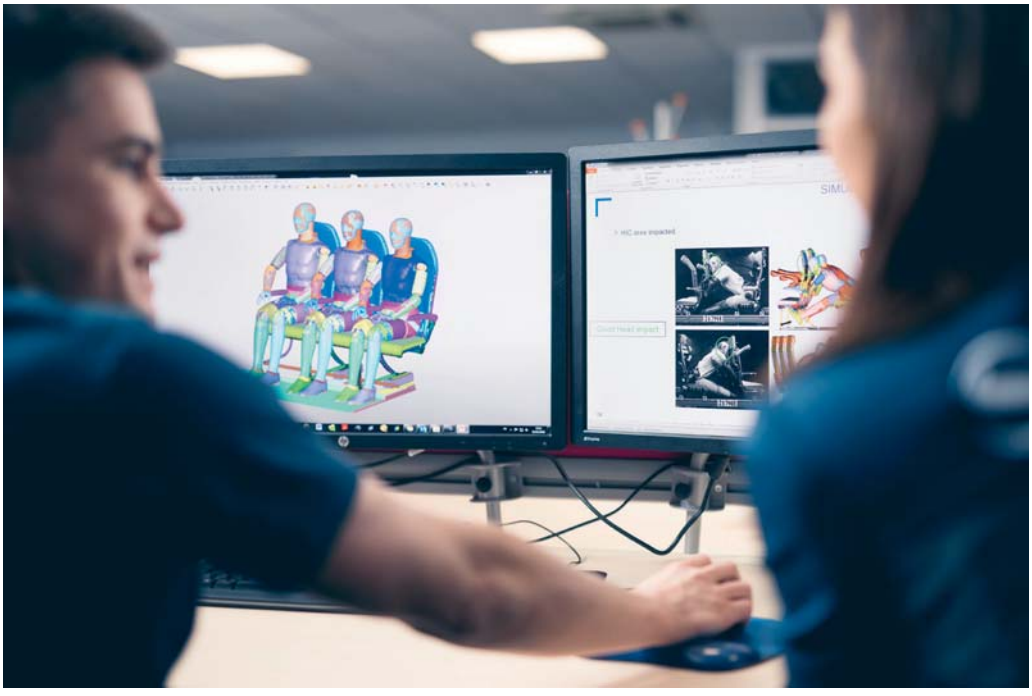
The newly adopted method works like a pyramid: samples of the various materials are verified digitally and physically, followed by whole parts and subassemblies, and then the final product. *"The first pilot CBA will be conducted alongside a conventional certification process to avoid any risk on the first program chosen,"* says Florent Massé. *"The conclusions will tell us where we need to focus our efforts to achieve the requisite level of maturity and ultimately sign off on the test method."* In the most critical cases, the results of the complete simulations will be compared with physical tests. *"This pilot project will be a success if the analysis corresponds to the physical tests on all criteria and, of course, if the authorities approve the new method,"* concludes Massé. ■

CRASH TESTS

As in the automotive industry, aircraft seats are subjected to dynamic testing, more commonly known as crash tests. Seats and test dummies are catapulted forward at different speeds to measure their strength and crashworthiness, i.e., their ability to protect passengers from the physical impact of an accident. Costly and time-consuming, these tests are now being replaced by Certification by Analysis at Safran Seats.

Left: Safran Seats Issoudun teams strap a dummy into a seat for a crash test.

Right: Digital simulations save time and are far more efficient than physical tests.



"BEST" IS A GAME-CHANGER

From guidelines and indicators to action plans and more, the tools we use to manage quality are many and varied. Yet, customer satisfaction doesn't always follow. Safran Landing Systems has therefore launched Best (Bring Excellence to cuSTomers) — a transformation project set to revolutionize our approach to quality.

The Safran Landing Systems
Best project team.

TANGIBLE RESULTS

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- **Non quality exported to customers reduced three-fold.**
- **Number of airline customer complaints halved.**
- **Complex parts "right first time".**
- **150 employee initiatives.**

As the global leader in landing and braking systems, Safran Landing Systems is determined to stay one step ahead by becoming the preferred supplier of its customers. The key is increasing customer satisfaction. *"Technical performance isn't enough,"* explains Richard Masson, Best project manager. *"Our customers want reliable, dependable products that ensure business continuity. Hence the importance of quality. We have everything to gain because by producing defect-free parts, we will increase our competitiveness and employee motivation."*

A NEW PARADIGM

Safran Landing Systems has been committed to quality for many years, but the Best project approaches it from a new angle — a collective dynamic and a desire to achieve it. *"We have the tools and processes, but are we making best use of them?"* notes Richard Masson. *"What's different with the Best project is we're rethinking how we understand and practice quality. We did not change anything except for the mindset ! And that's a major step forward."*

Since the project was launched in 2018, the transformation has taken in three phases. First, putting poor quality in the spotlight. *"You can't improve what you don't know is there,"* says Richard Masson. *"That's why it's so important to talk about problems and understand why they're happening and their impact so you can avoid them in the future."* Second, fostering initiatives in order to show that world-class quality is possible. And third, making quality just naturally "what we do" by building it in from the start of the product lifecycle — from the design phase of new programs and across the production line for volume-produced parts. Examples include utilizing more appropriate and effective tools, or implementing Poka Yokes, Japanese for "inadvertent error prevention", which are simple mechanisms, such as asymmetric parts, color coding and marking, designed to avoid production errors. Supporting these actions, an offbeat communication campaign has reached over 3,000 employees at 20 sites worldwide, challenging preconceived notions and inspiring engagement.

ENGAGING WITH SUPPLIERS

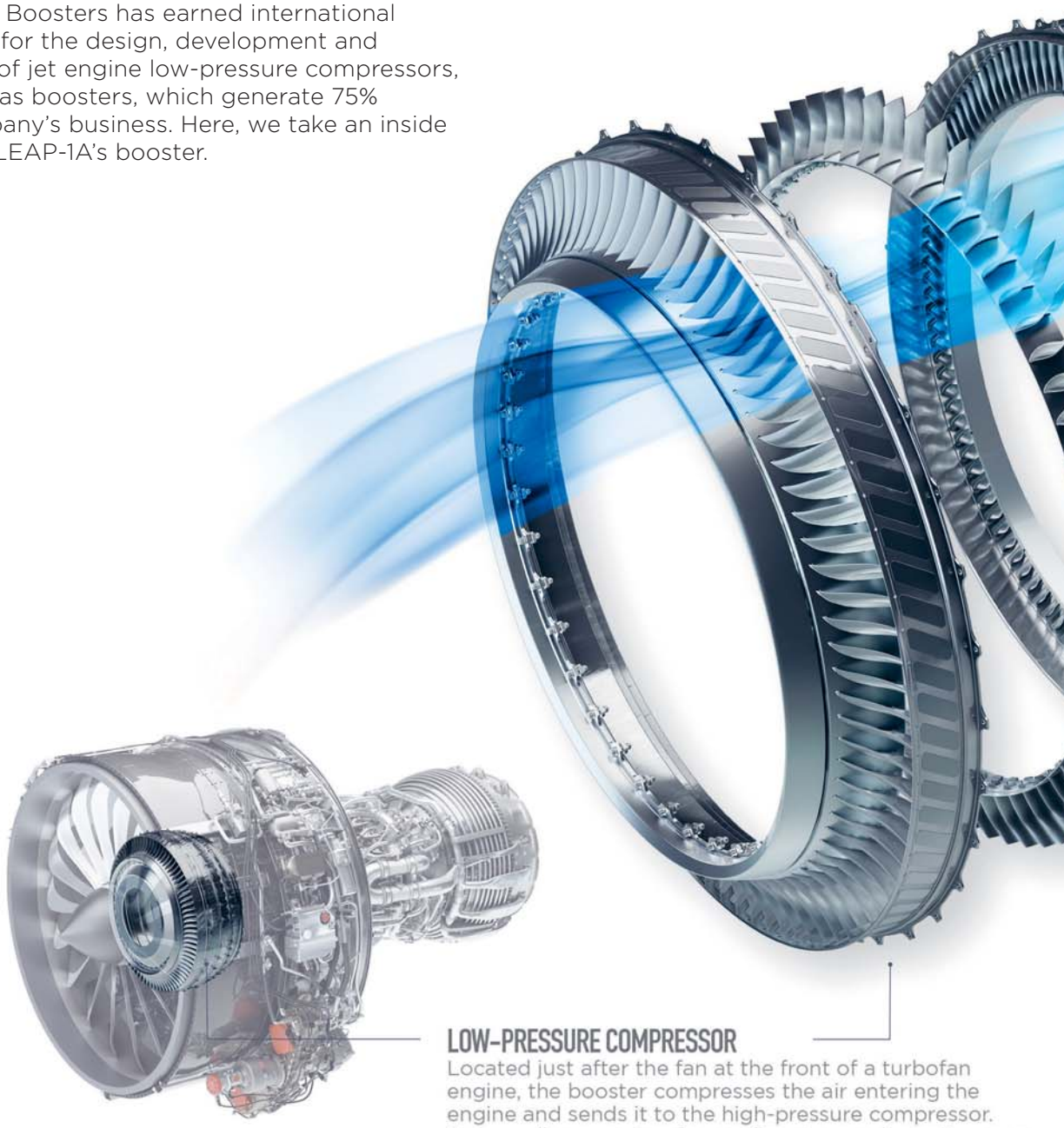
Two years down the line, the project has proved highly effective. *"The level of poor quality exported to customers has been reduced three-fold, and the number of complaints halved,"* explains Yannick Bonnaire, Vice President for Quality at Safran Landing Systems. *"Customer satisfaction has been significantly improved, as has employee satisfaction, with people expressing their pride in a job well done. We've also moved forward in terms of team spirit – quality is now everyone's business."*

Building on these initial in-house successes, Safran Landing Systems has started sharing this approach with suppliers. Once again, the idea is to think outside the box and foster engagement. The first seminar in January 2020 was a chance for promising discussions, with numerous suppliers eager to get involved and roll out innovative best practices.

Additionally, other Safran companies have expressed their interest in this unusual and constructive project. ■

AT THE HEART OF TOP-FLIGHT COMPRESSORS

Safran Aero Boosters has earned international recognition for the design, development and production of jet engine low-pressure compressors, also known as boosters, which generate 75% of the company's business. Here, we take an inside look at the LEAP-1A's booster.



LOW-PRESSURE COMPRESSOR
Located just after the fan at the front of a turbofan engine, the booster compresses the air entering the engine and sends it to the high-pressure compressor. It generally comprises four or five stages, alternating rows of rotors (moving blades) and stators (stationary blades).

ROTORS

The rotating blades are mounted on a drum, and the consecutive stages are used to accelerate the airflow.

GUIDE VANES

The guide vanes are fixed airfoils held between inner and outer metallic rings. They diffuse the airflow and further compress air between each stage of the rotating blades.

Safran Aero Boosters supplies these low-pressure compressors for most commercial aircraft engines, covering the entire thrust range.

RESEARCH & TECHNOLOGY

We're also building foundations for the future, through developments such as the "bladed drum" (BluM®), a unique lightweight booster that has blades friction-welded directly to the drum, and high-speed boosters designed for new-generation single-aisle jets.

ONE FUTURE

FCAS

READY FOR TAKEOFF

The Future Combat Air System (FCAS) took a decisive step forward in February 2020 with the kickoff of the demonstrator phase. Prime contractor Safran and its partner MTU Aero Engines can now start development of the engine for the Next Generation Fighter (NGF).

GEARED FOR LOWER NOISE

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Safran Landing Systems, supplier of the Boeing 787 landing gear, outfitted the 2020 ecoDemonstrator with landing gear noise reduction devices at the end of August. The aim is to reduce noise by over 20%.

SAFRAN AND PARTNERS BOOST SUSTAINABILITY

Safran, Airbus, Air France, Suez and Total have issued a call for expressions of interest to accelerate the use of sustainable aviation biofuels. Safran's aim is to set up a long-term, financially viable supply system in France — a key challenge that is part of the Group's roadmap for technological innovation.

Safran Engineering Services brought together employees from around the world in 2019 for a major Innovathon. The three winning international teams have now been merged to work on an ambitious project. Their innovative approach is designed to speed up the processing of parts defects and waivers, using advanced data analytics and artificial intelligence.

CLIMATE CHALLENGE: A LOW-CARBON PLANE BY 2035?

Faced with the challenge of climate change, Safran is pursuing a technology roadmap to “decarbonize” aviation by actively leveraging two approaches: aircraft energy efficiency and low-carbon fuels.

Fuel consumption
per passenger-kilometer has fallen by 80% since the 1950s.

COVID-19 AND THE CLIMATE

According to the first available studies, the Covid-19 crisis is expected to reduce the sector's CO_2 emissions by 15 to 30% in the short term (2020 to 2024), as well as over the longer term (2035-2050). As a responsible corporate citizen, Safran has decided not to factor this decrease into calculations for its technology roadmap, and to maintain its unprecedented investment in improving environmental performance.

Through the Air Transport Action Group (ATAG), the global aviation industry has committed to halving its CO_2 emissions from 2005 to 2050. However, Stéphane Cueille, Safran Senior Executive Vice President, Research & Technology, Innovation, warns that *"given the expected growth in air traffic — which remains high in the long term, despite the current impact of Covid-19 — it means the global fleet will have to be 90% more energy efficient. In other words, we'll need to replicate the progress achieved by civil aviation between 1950 and 2020, but twice as fast."*

While actively supporting this objective, Safran is going even further, with a realistic innovation strategy designed to achieve total carbon-neutrality starting in the 2050s.

With the natural cycle of fleet replacement since the 1950s, fuel consumption per passenger-kilometer has been reduced by 80%. From 2009 to 2017 alone, it improved on average by 17%, or more than 2% a year. And Safran believes the introduction of new aircraft — like the Airbus A320neo and A350, and the Boeing 737 MAX, 787 and 777X — will automatically lead to a 1% to 2% annual reduction in CO_2 emissions per passenger-kilometer over the next 15 years. These are considerable gains, but still not enough.

AIMING FOR ULTRA ENERGY EFFICIENCY

To deliver on its commitments, industry will need to develop ultra-energy-efficient aircraft. *"Our R&T strategy,"* explains Stéphane Cueille, *"is designed to give aircraft manufacturers the technologies they need to introduce planes starting in the 2030s that use 30% less fuel than current fleets. About half of this progress will be achieved by new engine architectures, the other half by making aircraft systems and cabins lighter, combined with optimal use of onboard energy."*

On the propulsion front, Safran has already proved with its Open Rotor demonstrator that it's possible to reduce fuel consumption of thermal engines by 15% to 20%, thanks to an innovative architecture with two counter-rotating, unshrouded fans and advanced technologies on various systems. The electrification of propulsion, and especially hybrid propulsion, is another way forward, but several major technological hurdles mean its impact on CO_2 emissions will be limited in the near term.

Conversely, significant weight savings can be made to aircraft with the kinds of high-performance materials Safran Composites is developing, coupled with advances in additive manufacturing, which could potentially reduce the weight of an engine by 25%. Likewise, Safran can leverage the synergies between Safran Cabin and Safran Seats to develop more fully integrated products based on lighter materials, such as organic matrix composites.

Safran is also a leading player in the drive for more-electric aircraft. Through Safran Electrical & Power and Safran Aerosystems, the Group covers

›

› the entire range of aircraft electrical systems and can integrate products designed to reduce overall weight.

HOW DO WE REPLACE JET FUEL?

Another significant R&T lever is to replace jet fuel by lower CO_2-emitting alternatives. Technologically, the most easily achievable solution is "drop-in" fuels, which can be mixed with conventional jet fuel on existing aircraft. With available technologies, it's already possible to add up to 50% biofuel, derived from biomass, and Safran is working to maximize their scope for use.

Another drop-in option is synthetic fuels. *"Instead of refining fossil resources,"* says Nicolas Jeuland, a Safran expert on alternative fuels, *"this involves producing power-to-liquid fuels using a virtuous electrosynthesis process that removes carbon from the atmosphere. It opens up the prospect of a completely emission-neutral fuel."* These kinds of refineries are still experimental, but they're already operating on a small scale. Yet the potential is there: with enough investment, power-to-liquid could emerge as a highly efficient, large-scale ecosystem from 2030.

In the quest to find a substitute for jet fuel, Safran is also studying the direct use of hydrogen in engines. Nicolas Jeuland explains: *"We're talking about a quantum leap in technology, which involves huge challenges. Hydrogen would have to be stored in liquid form, i.e., cryogenically at -253°C, as it is for rockets, and we'd have to develop a complete supply chain adapted to these conditions."*

This concept is now being matured as a core part of the French government's plan to support the aviation industry's recovery. It's also being studied as part of Europe's Clean Aviation program, which will announce its findings by 2027. Safran is already working on this initiative to help customers meet their ambitious objectives, and has initiated several studies with industry counterparts, including ArianeGroup, Airbus and the French aerospace research agency Onera.

MASSIVE INVESTMENTS

Safran believes that climate-neutral aviation is within reach. It has formally defined a credible and cohesive strategy, showing that gains in energy efficiency, coupled with the ramp-up of alternative fuels, will pave the way to low-carbon aviation towards 2030-2035 as a necessary milestone on the path to zero emissions.

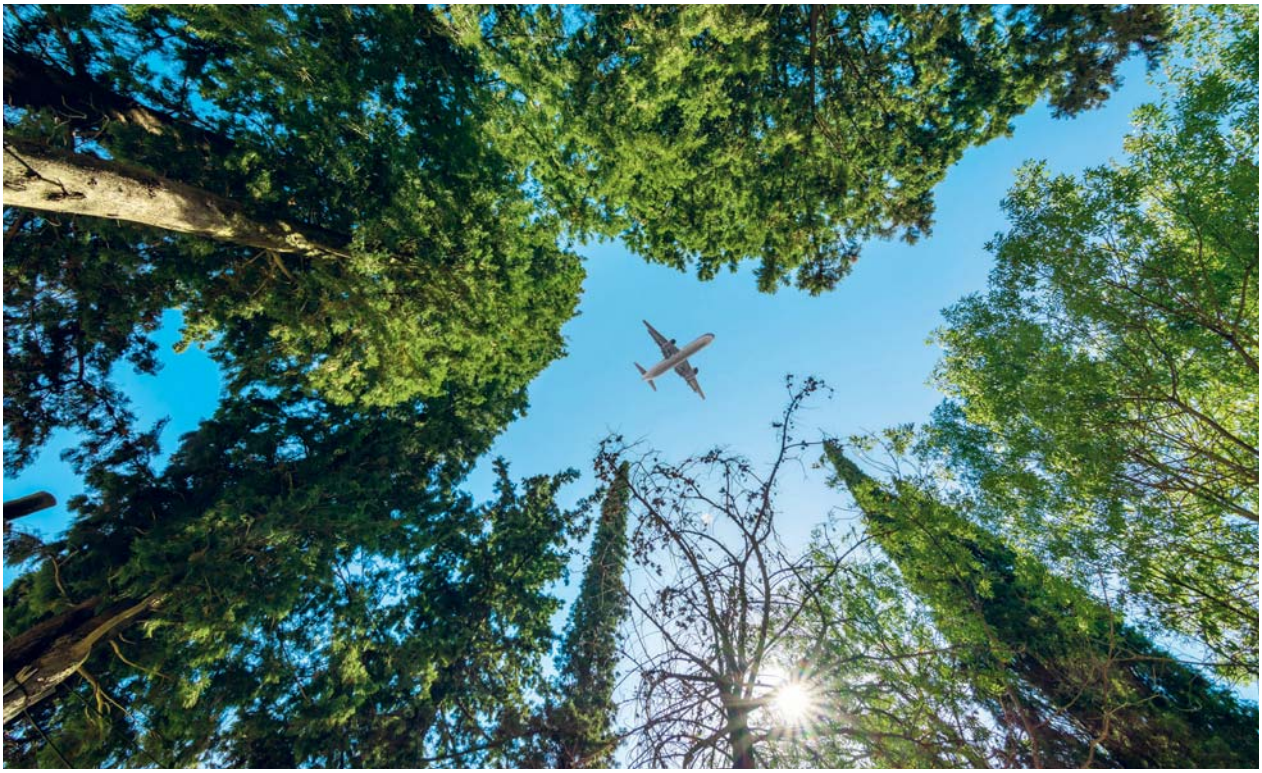
However, this is a major transition, calling for massive investments and a common strategy pursued by the entire sector. *"The effective transformation of aviation calls for collaborative innovation, greater interaction between everyone in the industry and government support,"* concludes Philippe Petitcolin, CEO of Safran. *"We're only one of the players in this movement. However, with our market positions spanning most aircraft systems, including all the energy systems, we have a key role on the technology side of the equation. And we'll be fully playing our part in this necessary transition."* ■

75%
of the Group's R&T investments are focused on reducing its environmental footprint.

15%
lower fuel burn between the last-generation CFM56® and its successor, the LEAP®.

X 2
Excluding the impact of Covid-19, the global commercial fleet is expected to more than double by 2038, from about 23,000 aircraft today to almost 48,000.

Jet fuel alternatives like biofuel, synthetic fuel and hydrogen will be viable if everyone in the sector coordinates and commits to substantial investments.

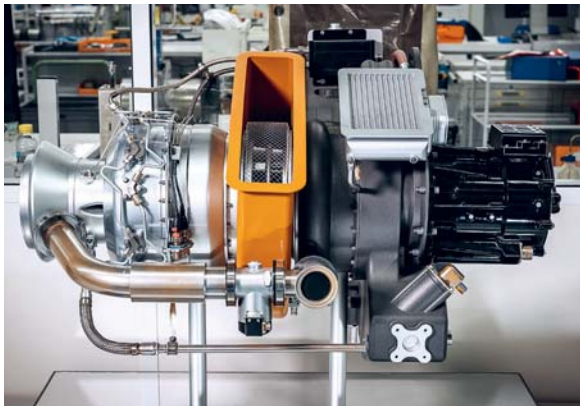


CLEAN SKY: A PUBLIC-PRIVATE PARTNERSHIP

Set up in 2008, Clean Sky is a research program funded by the European Commission and industry. With a budget of €4 billion, it involves 900 entities in 27 countries. Its objective is to develop technologies limiting CO_2 and other greenhouse gas emissions as well as noise caused by aviation. Safran is actively involved in the program, which has been renewed to 2024 (Clean Sky and Clean Sky 2).

ENHANCING ONBOARD ENERGY EFFICIENCY

Safran is applying its expertise spanning the entire range of aircraft electrical systems to help reduce aircraft weight and fuel burn. The PODS (Power On Demand System) concept is a prime example. This smart auxiliary power unit activates automatically whenever it's better for the aircraft to tap power from the APU instead of its main engines.



FRUGAL INNOVATION TO THE FORE

Frugal innovation is all about improvising an effective solution with few resources and a lot of ingenuity. A team at Safran Nacelles has stepped up to the challenge and demonstrated the potential of a new thrust reverser concept.

Safran's initiatives to support innovation encourage everyone to come up with clever new ideas. If their relevance and value is confirmed, funds can be released to turn them into reality. But how do you get to that stage with limited resources?
"The more disruptive the innovation, the trickier it is to convince people, so you have to show a bit of resourcefulness, flexibility and perseverance," says Stéphane Tirel, industrial projects and transfers manager at Safran Nacelles in Le Havre, France. He invented a new thrust reverser concept based on a flexible membrane, but he had to be especially creative to prove its feasibility.*

MOBILIZING SUPPORT

The project team built several models of the concept but then came up against an unknown: how the membrane would actually behave. *"We needed to conduct a test, but we didn't have the budget to book a conventional wind tunnel and the waiting times were extremely long,"* he recalls. *"So, we decided to develop our own test rig."* The team contacted AFPI — a training center operated by France's UIMM metallurgy industry and trade federation — and asked a group of the students to build the central core section of the test bench, in exchange for permission to use it for their own lab work. The upstream part of the bench, together with the air feed pipes and valves, were designed by local companies in the Le Havre area, while the handling dolly and the airflow generation system were built in-house. *"Working under tight constraints makes you more imaginative,"* says Jean-Paul Rami, an innovation engineer at Safran Nacelles and member of the project team. *"We turned the lack of resources into a chance to innovate differently, by capitalizing on our ingenuity, along with a little help from our friends."* After several months of work, the team tested a model of the reverser on its own bench, which they dubbed Speed Air. A few tests later, the membrane's strength and effectiveness were confirmed and the concept was validated.

"As a member of the Safran Experts network, I'm promoting Speed Air to our other companies so they can use it for their projects."

PATRICK GONIDEC
Nacelle architect at Safran Nacelles and senior Safran expert in aerodynamics

GROUP-WIDE

Today, the idea is patented and testing is continuing. *"From the outset, we designed Speed Air as a scalable bench, so it can be used for preliminary tests then subsequently uprated for*

This Safran Nacelles team developed its own wind tunnel.

more advanced trials," adds Stéphane Tirel. *"We also wanted it to be reusable for other concepts, for both Safran Nacelles and fellow Group companies."*

In fact, Safran Aircraft Engines and Safran Aero Boosters, which specializes in test benches, faced the same difficulties as Safran Nacelles for early-stage testing of their innovations. When they heard about Speed Air, they were keen to use it for some of their developments. ■

** Read the full article on Insite.*

DOING BETTER WITH LESS

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Frugal innovation first came about in emerging countries in the 2000s. It's inspired by the Indian concept of "Jugaad", which roughly corresponds to "resourcefulness". The idea is to find a simple and effective solution to an identified need using existing technologies and local resources. It highlights people's inventiveness and flexibility.

ELECTRIC MOTORS PUT TO THE FLIGHT TEST

ENGINeUS™ motors from Safran Electrical & Power are now being put to the test in novel aircraft projects developed by startups like VoltAero, and legacy players like Bell. Initial tests have proven conclusive.

In October 2019, the French startup VoltAero installed twin ENGINeUS™ 45 motors on the flying testbed for its Cassio hybrid electric aircraft. This brand-new family of aircraft, also capable of flying in all-electric mode, will be available in four, six and ten-seat versions, for private owners, air taxi/charter companies, commercial and utility (cargo, postal delivery, Medevac) applications. The flight tests showed excellent performance with the twin Safran Electrical & Power ENGINeUS™ 45 motors in tractor position at the front of the wings. A few months earlier, Bell's new helicopter demonstrator, the 429 with electric tail rotor, performed flight tests in Canada. According to Florent Nierlich, technical director in the company's Power division, *"The conventional tail rotor was replaced by four tail rotors with electric motors derived from our ENGINeUS™ 45 motors delivered to Bell."*

Safran Electrical & Power supplies the entire Electrically Distributed Anti-Torque (EDAT) system for the Bell 429 demonstrator, including control electronics, generator, conversion and distribution equipment, etc. *"The different components were designed in our plants at Pitstone in England and Réau and Villemur-sur-Tarn in France, and everything was completed in nine months,"* notes Nierlich.

QUIET POWER

"ENGINeUS™motors produce remarkable power, with no vibration and very little noise," explains Didier Esteyne, Technical Director at VoltAero, following the first flights of the experimental aircraft. On the Bell helicopter, the electric solution offers certain advantages, in particular reducing noise from the tail rotor, one of the noisiest parts of a rotorcraft. It's also more reliable, since the single tail rotor is replaced by an array of redundant motors, and it's less expensive to produce and service. Safran is now working with Bell to mature the solution, improving performance and making sure it can be produced in volume. This project paves the way to similar applications on both civil and military helicopters, and heralds the inevitable shift to greener and quieter rotary-wing aircraft. ■

"ENGINeUS™ motors produce remarkable power, with no vibration and very little noise."

DIDIER ESTEYNE
Cassio program Technical Director, VoltAero

The VoltAero demonstrator is powered by ENGINeUS™ electric motors from Safran Electrical & Power.

FLORENT NIERLICH
Technical director, Power division, Safran Electrical & Power

"Our electric motors have passed the test. Flight tests with the VoltAero and Bell 429 demonstrators show that our ENGINeUS™ 45 motors generate the power needed by this type of hybrid electric aircraft.
We're currently working on certification of the ENGINeUS™ and GENeUS motors, as well as on electrical protection for the complete powertrain (GENeUSGRID™).
Our modular approach allows us to consider applications in the 500kW class for a hybrid setup with thermal engines on commercial aircraft, based on the building blocks brought to maturity in the current range.
A hybrid propulsion system for commercial airplanes is a major goal for the next five years. We have also started to design the automated production lines capable of meeting requirements for the entire product range."

The ENGINeUS™ 45 electric motor has integrated electronic controls. Two of these motors are used on VoltAero's flying testbed for Cassio, and four derivatives were used on the Bell 429 demonstrator.

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