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INNOVATION JOURNAL
TECHNICAL REVIEW

INNOVATION AWARD 2021

the Innovation that kept going in the toughest of times

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LEONARDO

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contents

editorial

Ambassadors and *inspirers.* That is my definition of the 2021 Innovation Award winners and all who applied, regardless of the selection phase outcome. They are ambassadors because their success at the Awards represents their 50,000 colleagues at Leonardo who implement innovation daily, each within their field of activity. I believe this role of theirs is vital because we must not forget that Leonardo's excellence has always been sustained and driven by innovation. The innovation in their submissions strengthens the sense of belonging to the company and the image of excellence our company conveys to the outside world.

The courage and dedication shown by all candidates in proposing and promoting their ideas in which they believed and invested time and resources regardless of the outcome, also makes them inspirational. Courage is the first great distinguishing feature of our innovators. In our company, we need their example. Many people have good ideas, but most let them fall by the wayside. Instead, one must have the courage to convince others and overcome the difficulties that arise from time to time in the development stages. In this transition, the difference lies between the initial, abstract, innovative idea and its final realisation as a true, useful innovation for the company.

We must hope that their example acts as a stimulus to the many people in Leonardo who have good ideas, so they feel themselves encouraged to make that leap, which is helpful to them and of fundamental importance to our company.
Of course, for a good idea to develop well, significant teamwork is required. The submissions for this competition, particularly the winning ones, confirm this. In this respect, we should have no reason for concern. I have always been involved in innovation and, upon joining Leonardo, I was delighted to see how in our company innovation is part of the DNA of every employee.

Even the two years of forced standstill of the Award have become an opportunity to introduce many innovations and make the Leonardo Innovation Award an initiative that involves as many colleagues as possible. We introduced new categories, a more rigorous selection process and the opportunity for finalists to participate in training courses for the presentation of their proposals. We also introduced a pitch day, to get finalists involved by presenting in person their proposals to a panel of in-house experts, as well as the popular jury award. Above all, we wanted to give value to the innovative abilities that Leonardo's 'people' have demonstrated over the last difficult two-year period, by rewarding the ideas that had matured to the point where they had already been implemented in products or company processes.

In continuity with previous editions of the Award, we awarded the best patent, as well. Rewarding a patent is crucial, as we risk giving away to our competitors the innovation not protected by any enforceable patent. Therefore, we must focus more closely on the patentability of what we have conceived and are realising. This year, in line with Leonardo's vision, we assigned a key role to Sustainability, by highlighting and rewarding innovative proposals in this area. Without sustainability, we shall not get any future, as non-sustainable companies will not be competitive.

Therefore, the more we innovate in the field of sustainability, the better we will prepare Leonardo to be a major player in the decades to come. In line with the many innovations introduced in the Innovation Award, the Polaris Innovation Journal also is back to you in a new format that improves user-friendliness, with this issue dedicated to the award-winning proposals.

Recent years have challenged us with increasing constraints in the availability of natural, energy and economic resources. This scenario of the progressive scarcity of resources is made even more dramatic by the increasing consumption worldwide. However, there is one resource that, although not being unlimited, grows along with its increased 'utilisation', and that is the inventiveness of those who come up with innovative ideas. The more we innovate, the more we generate new ideas to grow and develop.

And so, the 2021 edition of the Innovation Award has confirmed how, thanks to the skills of its people and despite the period of great turbulence and hardship, Leonardo can come up with many innovative ideas, from which it was tough to choose those to receive awards. It is specifically on this aspect that I would like to conclude. In a true One Company spirit, colleagues made the final choices from all Divisions. This is another essential and fantastic aspect of this edition of the Award and I would like to thank and congratulate again all participants and winners.

Franco Ongaro
Chief Technology and Innovation Officer

Winner of the
Product Results category

An Innovative Helicopter Tailplane Design: the ORIGAMI Concept

Stefano Melone, Luca Medici, Riccardo Bianco Mengotti, Alessandro Scandroglio, Gabriele Giuseppe Campanardi, James Simon Barber, Pierantonio Andreoli, Marco Bordin, Federico Del Grande, Stefano D'Agosto, Raffaele Marmo

Leonardo - Helicopters Division

The ORIGAMI concept is an innovative design of the helicopter tailplane aerodynamic tips. The driver behind this project is the improvement of stability of the aircraft at high-speed while also paying attention to the low-speed regime characterized by strong interactional phenomena. The design focuses on the horizontal tailplane and, in particular, on its outermost sections: the winglets. The ORIGAMI winglet design is a cluster of features optimized for efficient aerodynamic design and for an easier, more straightforward retrofit solution aimed to replace the conventional tips while preserving the main tailplane body. This is a key design point for the concept's applicability to other helicopter variants, thus avoiding the complete tailplane redesign. After the integrated design phase and the flight test verification, the ORIGAMI design has received the EASA certification and is now installed on all new configurations of the AW169 product line. It is also protected by an International Patent application.

MOTIVATIONS

In a conventional helicopter configuration, the horizontal tailplane is the sole fixed lifting surface (Figure 1). Like on any fixed-wing aircraft, it provides the proper aerodynamic contribution to the longitudinal stability at high-speed both in the case of pilot control inputs and in case of external perturbations (e.g., atmospheric gusts).

Nevertheless, the peculiarity of the helicopters is to spend most of their operative lifetime at very low-speed regimes. At these regimes, the wake shed by the main rotor impinges the tailplane generating a download force that causes an annoying and limiting pitch-up effect (Figure 2), impacting helicopter handling qualities and pilot workload. This characteristic clearly results in conflicting tailplane design requirements: a larger tailplane would improve the stabilization at high-speed.

Similarly, a smaller one would reduce the impact of the interactional phenomena at a low-speed regime. Several complex tailplane design solutions have been approached in the past for some specific helicopter configurations to manage this type of conflict. For example, this is the case of the tiltable tailplane designed for the Sikorsky UH-60 "Black Hawk" helicopter, whose tailplane is tilted upward (in a feathering position) at low-speed regimes, thus alleviating the pitch-up while it is tilted back to the levelled position in high-speed forward flight conditions (Figure 3).

Figure 1 - Helicopter tailplane (AW169)

Despite its aerodynamically simple and efficient solution, the UH-60 posed some issues regarding its tailplane design, installation and control law. In fact, the automatic tiltable tailplane design resulted in a nasty failure of the tailplane actuator in some high-speed flight conditions causing the helicopter to pitch down suddenly. A manual switch on the cyclic stick was added later on to allow the pilot in command to disengage the automatic control of the tailplane in case of a failure, while the pilot not in command was allowed to use a manual control to adjust the tailplane setting angle as the speed changed[1].

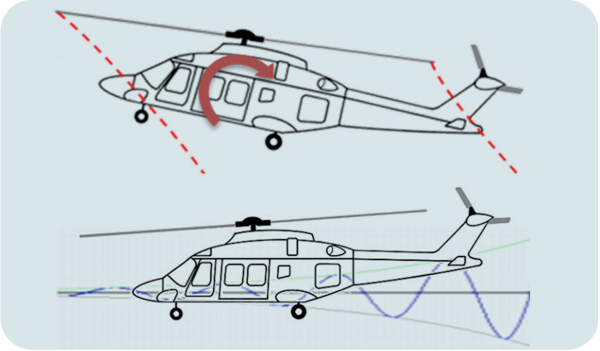

Figure 2 - High-speed stabilization effect (top), low-speed interference effects (bottom)

Besides the complexity of accomplishing both the high and the low-speed requirements associated with a new helicopter tailplane design, another critical aspect to consider is represented by the continuous aircraft upgrades and variants that take place during the typical helicopter lifetime. In reality, helicopters significantly grow depending on the customer/market requirements that push to enrich their initial clean outer aerodynamic shapes with kits or role equipment. The latter can dramatically impact aircraft aerodynamics, especially in the case of dual-use platforms with their weaponry systems. In these cases, stability must be restored to an acceptable level, but the costs and implications of a newly developed tailplane at a later stage would be too high. Aside from the already cited requirements (namely, to improve the high-speed stability and to reduce the detrimental low-speed interactional phenomena), this implies that a third requirement should be considered. It is easy to apply/retrofit to other helicopter variants or configurations without asking for a complete tail redesign.

Figure 3 - UH-60 tiltable tailplane solution: high-speed position (left) vs low-speed position (right)

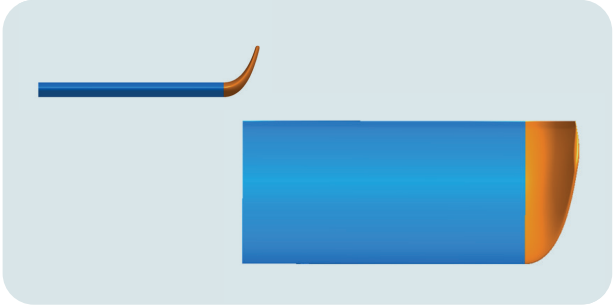

Figure 4 - Leonardo Helicopters conventional tailplane and winglet (AW169)

THE ORIGAMI CONCEPT

Due to its size and position behind the fuselage, the most aerodynamically efficient region of a helicopter tailplane is represented by its outermost sections, where, in conventional Leonardo helicopters, winglets are attached to the tailplane body (Figure 4).
To further improve the helicopter's longitudinal stability, the basic idea could be adding an extra aerodynamic lifting surface to produce the desired additional stabilization contributions.

In principle, this could be done by simply extruding the outer tailplane body section, increasing the overall span and wetted surface. This simple solution would result in an efficient aerodynamic design that easily meets the stability improvement requirement. Still, it would likely fail the requirement to minimize the drawbacks at low-speed regimes.
A bigger planar tailplane would produce a significantly higher download force and its associated pitch-up phenomenon. Moreover, moving further outboard the application point of the aerodynamic forces would further increase the overall loads acting on the tailplane and the tail boom, likely requiring the structural redesign of some components.
The ORIGAMI concept, instead, is an innovative design of the helicopter tailplane aerodynamic tips aimed to improve both high- and low-speed performance while minimizing possible drawbacks. Moreover, it is conceived as a retrofit kit to replace the conventional tips while preserving the main tailplane body. This is a key design point for the concept applicability on various helicopter variants that enables avoiding the complete tailplane redesign and represents the most challenging aspect of the whole design.
The concept bases its foundations and name, on the art of *origami* papercraft that enables one to obtain complex 3D shape by folding a 2D paper sheet. The conventional and simple-shaped tailplane tips are replaced by a more complex aerodynamic surface whose 3D folded shape recalls an *origami* papercraft (Figure 5).

Within the ORIGAMI concept, the additional lifting surface required for stability is designed as a secondary upper surface bending inboard an airfoiled vertical fin attached to the tip of the tailplane body. It also has a forward sweep angle partially overlapping the lower main body, thus creating a proper shadow region when, at low-speed regimes, the induced main rotor wake impinges the upper surface first. The new winglet concept is also fully cantilevered with no struts interfacing with the main tailplane body, thus facilitating the retrofit installation.

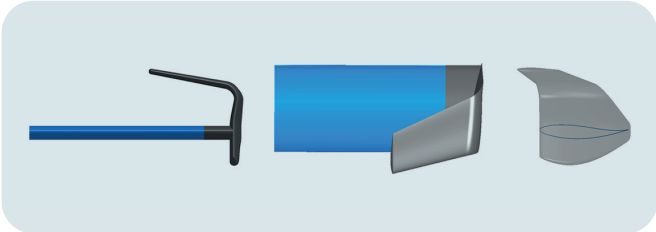

Figure 5 - Leonardo Helicopters ORIGAMI winglet (AW169)

With the largest cabin in its class and a backward Centre of Gravity management, it poses aerodynamic challenges to managing aircraft stability.
Moreover, as we already stated, continuous upgrades and variants (e.g. skids or external equipment) further raise the bar, looking for a simple and effective solution to improve the aeromechanical characteristics with minimal implications on the existing components.

THE DESIGN AND VERIFICATION

This innovative idea has required a strong and solid preliminary verification before moving towards the flight test validation required to account for all non-linearity and interactionality and to provide the final green light to the concept. The ORIGAMI concept is a cluster of aerodynamic features concentrated at the outer/tip tailplane region. Each of them is chosen and optimized to meet a specific driver:

- high-speed stability,
- low speed impingements,
- retrofit,
- low drag,
- better handling qualities.

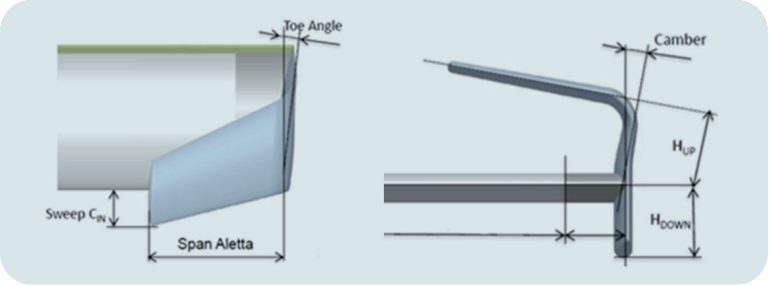

Figure 6 - ORIGAMI geometrical design features

A vertical airfoiled finned surface attached to the tailplane tip interface is bent into an upper horizontal lifting surface designed, in terms of span and taper ratio, to improve the overall stabilization in forward flight. Meanwhile, the pitch-up phenomenon is mitigated through the shadowing effect of the forward sweep.

The missing distance between the horizontal surfaces, with the associated camber, and the toe-angle set for the vertical surface are optimized to minimize the interference effects and reduce cross-flow separations at high-speed (Figure 6).

The entire design was carried out in an interactive and multi-disciplinary process to improve the aircraft performance where required while reducing the drawbacks.
This solution guarantees improved performance while preserving the overall tailplane span and the main body design.

From the draft idea to the final design, the integrated concept has been entirely driven by extensive usage of both Computational Fluid Dynamic analyses and Wind Tunnel tests to converge on the final solution (Figure 7). Wind tunnel tests were all carried out at the open-channel Leonardo Helicopters Bresso Wind Tunnel facility.

Both isolated and installed tailplane investigations were carried out to check the impact of the several geometrical design features introduced by the ORIGAMI concept.
Finally, Flight Mechanics analyses completed the toolchain utilizing aeromechanic comprehensive tools, numerically assessing the flight dynamic stability characteristics of the new tailplane concept.

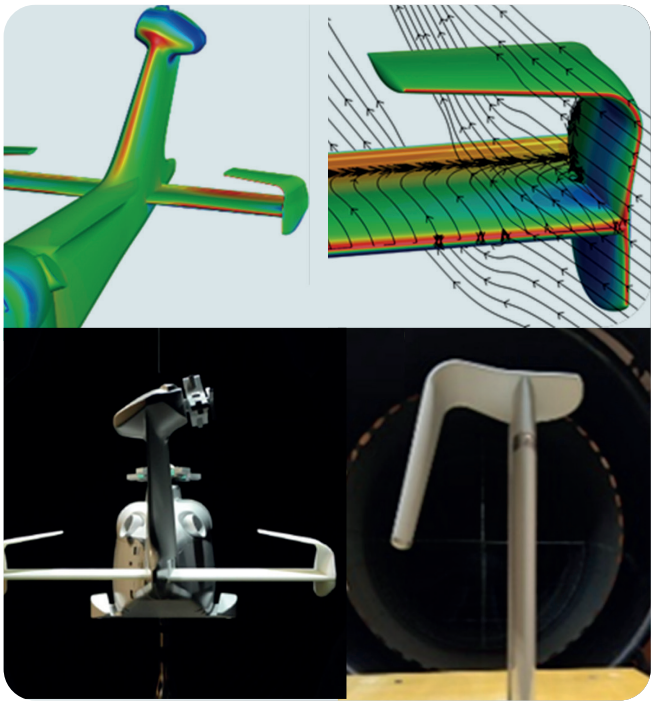

Figure 7 - CFD (top)
and Wind Tunnel (bottom) test activities

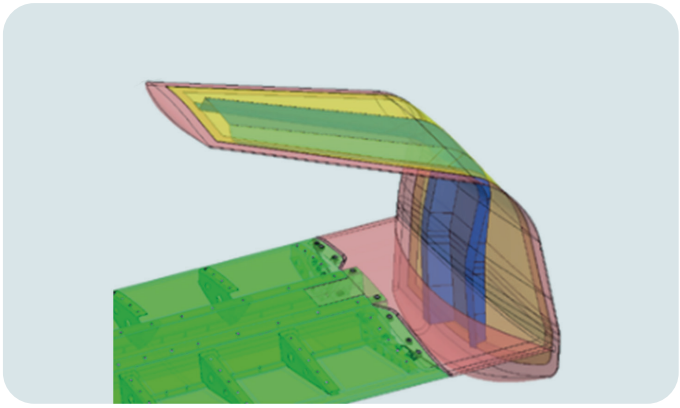

Figure 8 - Structural design

The CFD and the Wind Tunnel did not only serve for the aerodynamic performance characterization of the new design.

They also provided the basis that has supported the winglet structural design (Figure 8) and verification through the definition and application of the proper aerodynamic limit loads. In fact, stringent EASA CS29 rules were used for the prototype design and verification activities. Static and dynamic (flutter) analyses were performed with numerical assessment and experimental verification of bird strike.

Figure 9 - Full-scale prototype manufacturing

Manufacturing the full scale prototype for flight tests was made possible quickly reliably thanks to the support of Dallara Automotive (www.dallara.it).

Its proven expertise in manufacturing complex aerodynamic configurations using composite materials made a flyable full-scale winglet prototype available in a short time and ready for tests (Figure 9).

Flight test activity on an AW169 prototype helicopter (Figure 10) proved the design's effectiveness by meeting the objectives set at the project's launch. The frequency response of the helicopter to the pilot inputs in Auto Pilot OFF and ON has been investigated, resulting in significant improvement of the bare aircraft longitudinal stability behaviour. Also, the flight campaign has shown handling qualities benefits in the event of lateral wind near hover, improving low-speed controllability and reducing the pilot workload.

Once the development and testing phase was completed, the ORIGAMI concept received the green light to proceed with the detailed design and verification phase and also successfully dealt with the demanding certification stage, receiving the EASA approval in December 2021. This significant achievement has made it ready to equip the whole new production AW169 aircraft.

So far, the ORIGAMI concept has successfully been applied to two different AW169 configurations: the wheeled landing gear and the skid landing gear (Figure 11).

It is worth noting that the new tailplane design received positive comments not only during the internal Leonardo flight testing development phase but also later from customers' pilots who had the chance to fly the new concept in advance. Some of their comments further confirm the significant design improvement behind this new tailplane concept.

Figure 10 - Installed ORIGAMI winglet for flight test activity

Although it was developed for the AW169, the ORIGAMI provides a clever modular design solution that can also be fitted on other Leonardo Family Products (e.g. AW139, AW189) if deemed necessary by new configuration requirements.

Since the early design stages and testing, an international patent application (N° 20164164.4) was issued to protect the ORIGAMI solution's Intellectual Property and style.

Figure 11 - The ORIGAMI installed on two AW169 configurations

Finally, while the ORIGAMI concept has been conceived mainly by the LHD Aircraft System Integration department, its development through the maturity stage required the involvement of several other LHD departments (e.g., Flight tests, Structures) and external suppliers (Dallara Automotive).

This clearly demonstrates that if solid synergies and investments are put in place for design and experimentation, challenging goals can be successfully reached.

CONCLUSIONS

The ORIGAMI tailplane concept is conceived and developed to fulfil three main drivers:

1. Improve helicopter longitudinal dynamic stability at high-speed;
2. Improve the low-speed handling qualities by mitigating the interactional main rotor-induced wake effects;
3. Represent a suitable and straightforward retrofit solution aimed to be installed even on other helicopter variants or configurations, with no need for any complete tailplane redesign.

With its 3D complex folded shape, the ORIGAMI demonstrates its ability to meet all the design requirements, thanks to the extensive numerical and experimental activities carried out during the integrated design phase, including flight tests.
Thanks to its modular design solution, this concept also applies to other helicopter configurations.
The design is EASA CS29 certified and is protected by an international patent application.

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REFERENCES

[1]https://www.quora.com/Does-the-tailplane-on-the-UH-60-Blackhawk-and-the-AH-64-Apache-operate-automatically-and-is-it-only-a-function-of-speed-Do-the-pilots-have-any-manual-control-over-it

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Winner of the Technology Category results

Radar Processor on Chip

Francesco Auriemma, Simone Bartolini, Stefano Borra, Emanuele Leva, Giovanni Martino, Maria Francesca Micanti,Gennaro Migliaccio, Marianna Pizzetti, Luisa Posani, Daniela Tedesco, Siriana Vannini

Leonardo - Electronics ITA

Radar Processor on Chip is a radar processing chain mapped on RF-SoC (Radio Frequency System-on-Chip). Its architecture integrates the front end of the Radio Frequencies signal chain on a chip (containing firmware blocks that make the receiving and transmitting chain) and the software processing chain starting from the signal analysis and data extractor to the target tracking and classification.

Such a solution is innovative and flexible. It can be applied to other types of sensors, reducing costs since it is hosted on a single board and simplifies the radar processor architecture, making it more maintainable and testable.

A System-On-a-Chip (SoC) is a microchip that includes all the necessary electronic circuits for a given system. The Radar Processor on Chip is based on RFSoC technology. It is the development of a sensor processing chain with all the components allocated on a single chip.

Its architecture integrates the front end of the RF signal chain on an SoC containing the set of firmware blocks of the receiving and transmitting chain. It also integrates the software processing chain, starting from the signal analysis to the target tracking and classification.

The term RFSoC identifies a device produced by Xilinx that integrates the front end of the RF signal chain on a SoC (System on Chip). The device combines analogue data converters and/or SD-FEC cores with high-performance programmable logic, and the ARM® multi-processing system, to create a comprehensive analogue-to-digital signal processing chain on a single monolithic device. It is divided into two sections: the Programmable Logic (PL) section and the Processing System (PS) section.
The PL section contains all the firmware blocks of the transmitting (for waveform synthesis) and receiving chain, while the PS section contains the entire software processing chain of the sensor that deals with: timing management, bite, signal processing, target extraction, target tracking and classification. Communication between PL and PS takes place via a high data rate AXI Bus. Figure 1 shows an overview of the RFSoC.

The functional allocation between PS and PL is based on real-time requirements.
In the PL section, all the temporally critical programming and events synchronous with Timing are allocated: Range counter of Operative Timing, Transfer in DMA to DAC, Transfer in DMA from ADC, Messages to be sent to the ARTEMIS modules, Status and bite definition, Calibration, TTG, Tap Point for debugging, Programming of the LMK and LMX modules of the PLLs.

In the PS section, the slower and less critical operations are allocated, such as: Initialization Management, Configuration, Logging, Debug, Asynchronous external requests (from config, file, lan, etc.), Signal and Data processing without special latency requirements.

This solution satisfies the SWAP (Size, Weight and Power) requirements. It provides several benefits, as it features compact, light and low dissipation, as the monolithic integration of ADC and DAC converters on SoC eliminates the need for external data converters, thus allowing a reduction of up to 50% in power and footprint compared to a multi-component solution.

It provides also flexibility, as the heterogeneous computing architecture formed by converters, FPGA and microprocessors offers complete analogue/digital programmability, and extreme flexibility. In addition, it features Maintenance and Testability, as much of the RF signal processing has moved into the digital domain.

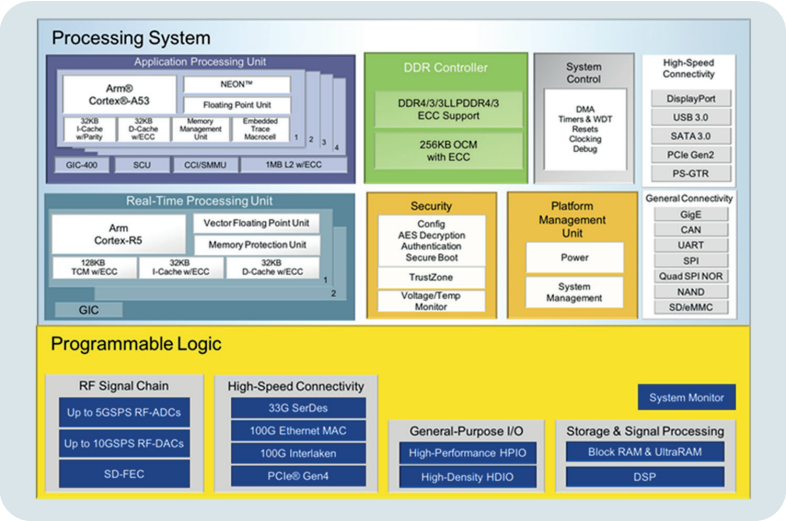

Figure 1-RFSoC Overview

This makes testing, debugging and maintainability easier. We may conclude that the Radar Processor on Chip is an innovative solution suitable to all applications that require low-cost, easily deployable and transportable sensors. The actual solution can be applied to C-band radars, as it features simplified architecture and low product cost, since everything is performed on a single board. This approach also paves the way for the experimentation of innovative solutions for other types of sensors.

It is a sustainable solution featuring relevant reduction of power and of footprint. The solution that we have developed is a new way for an integrated firmware/software design for the efficient implementation of applications.

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Winner of the
People Category

As Simple as Sustain-Able, the First Sustainable Platform in Leonardo

Carmela Esposito, Manuel Fuselli, Francesca Ienca
Leonardo - Corporate

Sustain-Able is a platform that rewards the sustainable behaviour of employees by engaging them in a playful way, with challenges aimed creating a real corporate community. The project's experimentation lasted 12 weeks and involved about 3,500 employees in the Rome area, with the aim of offering them a training and awareness path on sustainability issues and giving them a real perception of how each of their actions can contribute to generating a positive impact for the Planet. A Leonardo web app was created that is dedicated to sustainability issues and is made accessible to all our people, with the aim of teaming up and contributing - together - to the reduction of our Carbon Footprint. Through an easy and fun pathway, people were sensitized and, at the same time, trained on different environmental sustainability topics. In the test phase, colleagues completed an impressive 1995 missions and saved around 3000 kg of CO_2.

MOTIVATIONS

Sustainability means responsibility and competitiveness for the Company, but also the opportunity for its people to evolve and improve their behaviour. All companies will have to demonstrate their concrete impact on sustainability in the near future (SDGs). To make Leonardo's commitment even more effective, we have developed a co-innovation pilot project. The path undertaken by Leonardo with its 2030 Sustainability Plan includes, among various clusters of initiatives, a concrete and constant commitment to environmental sustainability issues, with particular a focus on decarbonisation, reduction of water and plastic consumption, waste management and mobility.

SUSTAIN-ABLE PLATFORM

The Sustain-Able project is conceived as a platform to reward employees' sustainable behaviour by engaging them, through a highly gamified environment, in challenges that aim to raise awareness and create a real corporate community.

Figure 1 – Attendance Certificate

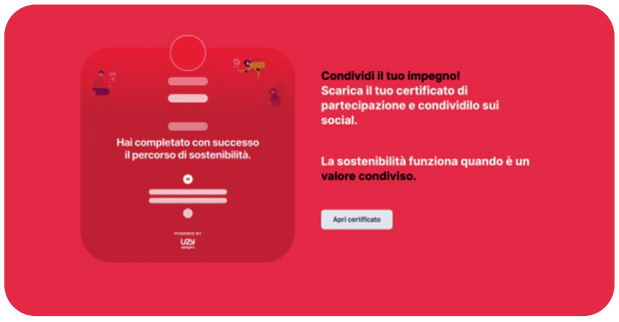

Figure 2 – Mission results

The benefits are manifested in terms of engagement and employer branding, as well as through a real reduction in CO_2 emissions and overall environmental impact through projects on the ground.
The platform is split into three main sections: **Missions**, where employees participate in challenges to minimize their environmental impact and submit 'proof' of their mission; **Rewards**, where employees receive points to spend for each action; **Gamification**, where charts are provided to engage employees through gamification.

Finally, the platform determines the CO_2 emissions avoided through the virtuous actions of colleagues, thus enabling the reporting of participants' efforts.
The project was launched in November 2021 through a web app accessible from any device, customized in accordance with Leonardo's visual identity and meeting the Company's Privacy and SIC requirements.

Figure 3 – Winning teams

We engaged people through challenges in low-impact activities involving five macro themes/missions:

- **Food and Nutrition**
- **Circular Economy**
- **Digital and Technology**
- **Mobility**
- **Green Holidays**

The Proof of Concept of the 12-week project involved approximately 3,500 employees in the Rome area, with the aim of providing them with training on sustainability issues. Colleagues were asked to form their teams and to take part in challenges, quizzes and sustainable missions. The actions of each individual and of the group contributed to creating a positive impact on the Planet. The first engagement phase involved sending out a Survey to test the degree of employees' interest in sustainability issues. Based on the responses obtained from the sample involved, we started with the onboarding phase and the launch of the missions. The platform also became the tool for conveying other activities implemented by the Company in the field of sustainability, thus creating a real community.
Colleagues participated in the challenges, posting photos and videos on the app and describing how do they implement their sustainable actions in their daily lives, **reaching 1995 completed missions and saving around 3000 kg of CO_2.**

CONCLUSIONS

Benefits do manifest both in terms of the employer's branding and Leonardo's reputation, and in terms of the ability to engage our people. Moreover, the measurability of the actions makes it possible to verify the overall environmental impact (actual reduction of CO_2 emitted) and to develop specific projects in the area. The project will see a new edition with the aim of expanding the audience of participants through the development of new app features and new modules such as offsetting. All the CO_2 captured by the projects assigned to Leonardo will be traceable and transparent.

Sustain-able is a great shared project, which starts with each and every one of us!!

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Award for Cross-cutting topic area Best Patent

Mosquito Globetracker Satellite Localization System

Domenico Giancristofaro, Leonardo Mazzini, Lorenzo Simone

Thales Alenia Space Italia

The Mosquito Globetracker is an unprecedented device that, thanks to its systems engineering, opens a totally new field of applications, complementing existing localization solutions that either have a different application target or are much bigger and power-consuming, thus resulting commercially much weaker. For localization, the Mosquito Globetracker relies on Synthetic Aperture Radar Satellites. To be noticed, it uses a specific watermark coding over the Synthetic Aperture Radar (SAR) image, like bills or stamps, that enhance the Mosquito Globetracker brilliance in the SAR image formation, with high energy gain. It uses communications concepts, like paging procedures for the establishment of trusted active-user identifiers that are extremely short in bit count, smartly reusing within the SAR arena some concepts that belong to the telecommunications theory. Furthermore, it can use deep-space modulation and antenna design concepts that produce, overall, an extremely innovative localization solution with a sound, definite return on investment.

THE SYSTEM AND DEVICE CONCEPT

The Mosquito Globetracker was awarded the Thales Alenia Space Italia Radical Innovation prize in October 2017 and was then granted two patents that protect its relevant intellectual property:

- EP3593164-B1 Innovative locator system, related low power consumption regenerative transponder and related localization method and service (Earliest priority date: 2017-03-10)[1];
- EP3881093-B1 Locator System and Related Localization Method and Service with Innovative Time and Frequency Synchronization of Localization Transponders (Earliest priority date: 2018-11-12)[2].

It is an unprecedentedly small and low power device (two-euro coin-sized, see Figure 1) that allows localization services for a large community of users worldwide, being them either commercial or military users. Therefore, it allows a whole set of novel services to burst out, and opens new businesses for Leonardo.

The device concept (and also the said patents) includes a satellite SAR, but it also applies to avionic SAR, as it is also suitable to be hosted on an unmanned aerial vehicle, and it absolutely applies to a RADAR.

Figure 1 - Mosquito Globetracker Device Size

The very low-consumption localization device can be easily hidden and miniaturized. It has an enormous added-value associated with the possibility of locating a very large number of devices attached to humans, for example, one million. It can be used to track animals, objects or vehicles and left for years in very low-consumption mode, which makes the device undetectable and stealthy. The above function is implemented through activation concepts used in the telecommunications links, but the device is uniquely identified and accurately localized with individual recognition through the SAR or a RADAR. Only limited information can pass through the SAR/RADAR channel. Hence, the devices to search, once activated, send only a few bits-3 are enough-on the SAR / RADAR channel and a state of health of the human or the vehicle to be located, if required. This localization system can be very effective in a war theatre. Essentially it is an Identification of Friend or Foe (IFF) device with accurate localization capabilities and close to zero power consumption that can be powered by a small CR2032 battery, like the ones used for a watch or a heart rate monitor.

In order to clarify the difference with all of the existing tracking devices, we include a comparative table of devices for localization or for search and rescue, to which the Mosquito Globetracker plays a winning competition. All of the devices competing with Mosquito Globetracker feature much higher energy consumption.

Recently, more and more solutions have been proposed to locate and track people and/or objects. Many of those solutions are based on the combined exploitation of:

- a Global Navigation Satellite System (GNSS), such as the Global Positioning System (GPS) or the Galileo;
- one or more wireless communication technologies, such as one or more mobile phone technologies (e.g., GSM, UMTS, LTE, etc.);
- one or more short-range wireless communication technologies (e.g., Bluetooth);
- one or more technologies for wireless local area networking (e.g., Wi-Fi) and/or for wireless broadband access to telecommunications networks (e.g., WiMAX).

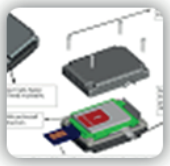
Device Type	Products Aspect	Distinctive Features
Search And Rescue	 	Extremely reliable service for user collaborative safety of life applications, limited battery duration, 5 W RF power required.
Small communications payloads (parasitic on NOAA or Eumetsat satellites)	 	Argos: Miniaturized terminals, solar cells recharged, 600 mW RF. Always transmitting, simplex link toward the low orbit satellites. Big consortium with monthly subscription fees. New 2017 terminals will have 2-way transmission to reduce power usage. Long antennas due to the low RF frequency. Improvements expected in 2017 with duplex link.
Bluetooth Device coupled with Smartphone	  	TrakR, Tile, Lapa 2: based on a 100 m range Bluetooth link with the smartphone, possibly constituting a collaborative users network to track on map other users' devices.
Integrated GPS with GSM	  	Tractive (120 h battery): localization provided via GPS / GNSS and communications of location data via GSM; support services available with a fee. From pets to car/truck localization.

Table 1 - Concurrent Devices and Services Complementary but not Substitutive in Business with Mosquito Globetracker

A brief overview of some of these systems is shown in Table 1. However, traditional localization devices and their corresponding systems suffer from several disadvantages. For example, remote localization requires a considerable amount of power. Thus, the battery life of competing localization devices is often limited. Furthermore, the technology for long-range localization is expensive and often requires sophisticated circuitry to operate.
Some known solutions (e.g. Bluetooth Device coupled with Smartphone, shown in Table 1) can dramatically enhance the potential of those simple devices only endowed with a Bluetooth connection and no GPS, originally intended to find objects within the coverage of a mobile telephone Bluetooth[3]. In fact, collaborative networks of users' mobile telephone devices would allow the localization of a tag when it enters within the Bluetooth range of any of the users mobile phones. The tag is located thanks to the local mobile phone GPS location sharing and is communicated to the tag owner across the internet. Cooperative techniques for localization have been widely addressed[4].

FIELDS OF APPLICATION

Mosquito is extremely small when compared with other localization devices. It can guarantee worldwide localization in critical areas where other services are not available. Some examples of applications follow (also see Figure 2):

- Mosquito can be applied, being it actually stuck and disguised, on a cargo vehicle; it will remain undetectable and stealthy, even if searched with a radiofrequency analyser.

Figure 2-Fields of Application of Mosquito Globetracker

- Non-cooperative soldiers even if injured can be localized thanks to their health status communication; in the emergency mode, the device could also be activated by the soldier himself.
- Camp bases for leisure or military operation, can be localized either wby a user request or without any user device activation.
- Mosquito can also protect personal property, as it can be hidden under the saddle of an expensive bicycle or on board a sailing boat or a windsurf, with or without non-cooperative or injured owners.
- Mosquito can localize cargo containers lost at land and at sea, which is a nightmare for organizations that manage them, for value losses and the harm caused to ship navigation.
- The heft of expensive cars, especially if transferred abroad, can be easily discovered.
- Tracing and localizing can include fixed or moving land masses or even icebergs.
- Animal migration, like small birds, can be monitored, as can valuable animals, including those from circuses or zoos.

This opens a wide range of applications with a sound and guaranteed Return on Investment (ROI).

INNOVATIVE SCIENTIFIC AND INDUSTRIAL VALUE

The Scientific value of the Mosquito Globetracker innovation mostly relies first on smart systems engineering (see Figure 3 for the system architecture) and then on a number of patented key innovations.
Mosquito is so small because it relies on Synthetic Aperture Radar satellites, like Cosmo Skymed (see[5]) or the ESA Sentinels. SAR have huge onboard amplifiers with power in the order of about tens of Kilowatts and extremely large antennas to face the harsh goal they have to accomplish.
They have to hit a point target with an enormous power density, and by receiving only the reflected power, they must be able to localize it accurately and create images of the earth's surface.
They exploit enormous sensitivity algorithms. Synthetic Aperture Radar Satellites are "giants" because the power attenuation law they must face decays to the fourth power of distance between the satellite and the point target, while communications satellites face only a second power law.

In a communications satellite, the sequence of transmission is reversed: ground to satellite and back to ground, but there is always an amplifier onboard. In generating images of the ground, the SAR must face the decay trend of the fourth power law. The re-transmitted power by a one-meter Radar Cross Section (RCS) is 0.1 mW. This is – roughly – the power that the Mosquito must transmit, thus making sure that some signature allows its recognition.

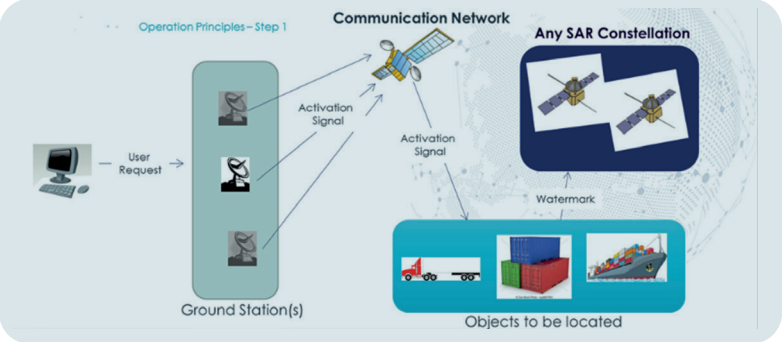


Figure 3 - Mosquito Globetracker System Architecture

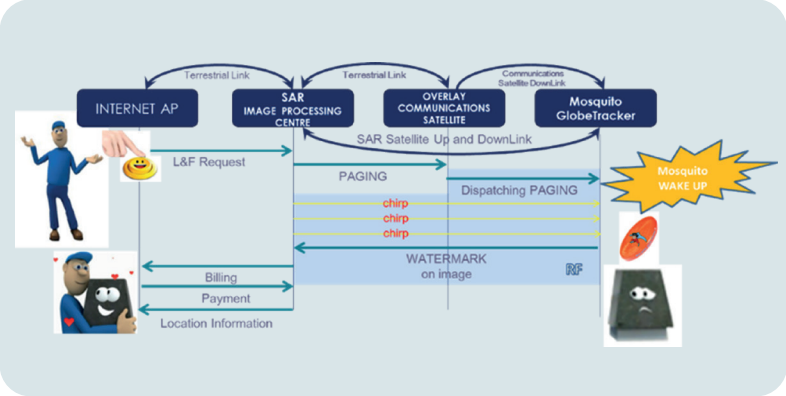


Figure 4 - Mosquito Activation and Operating Procedure

The most crucial innovations introduced in the patent include:

- the systems engineering with the remote activation procedure of the Mosquito device (see Figure 4 for the functional data flow and Figure 5 for the communications overlay system);
- the identifier (ID) data compression;
- the usage of paging and identification information compression by delivering to the paged user a long ID capable of identifying millions of users and a few bits of a long active user ID.

Once the ID data has been strongly compressed, the activated Mosquito expands it with a known code, chirp-to-chirp in the azimuth direction, thus enhancing the target brilliance by watermarking the image with the usage of the spread spectrum.
Finally, thanks to the data compression, the interference caused by Mosquito on the image can be located and reliably cancelled with light processing at the ground SAR image processing centre.

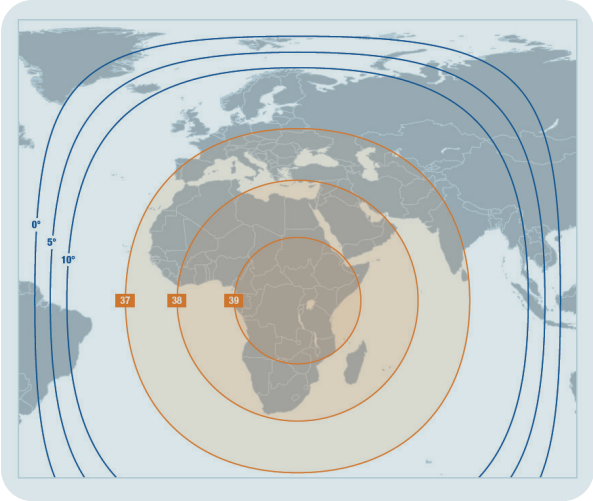


Figure 5 - Communications Satellite Coverage used for activation of the localization devices (possibly X-band for RX complexity reduction). It is possible to use the Italian Ministry of Defense and Italian Space Agency (ASI) SICRAL satellites [6] or commercial XTAR satellites [7]

THE GENESIS OF THE INNOVATION

The idea of the Mosquito Globetracker was generated when some employees of our company, skilled with HW design and telecommunications design expertise, moved to the Synthetic Aperture Radar Department.

There they found there were massive resources available for SAR, namely onboard power, bandwidth and sensitivity that put a communications engineer and a HW designer in a sort of Eldorado, thus allowing them to quickly devise the Mosquito concepts. A very limited R&D funding within the Thales Alenia Space Italia "Innovation Cluster Scheme" has financed the exploratory phase.

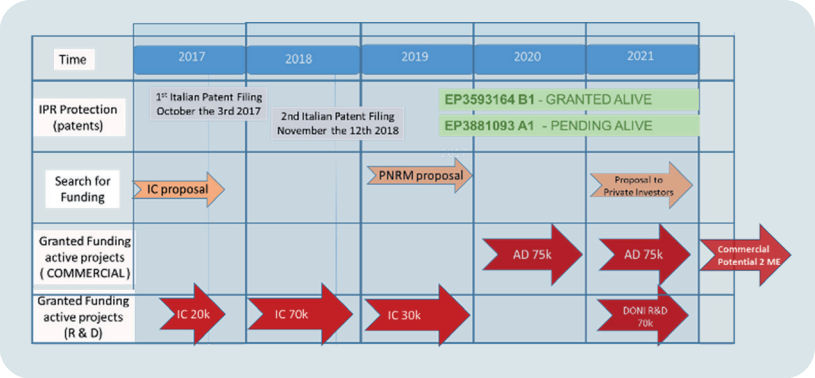


Figure 6-R&D activity: projects, funding and patents. AD Stands for Italian Defense Administration (PNRM). IC stands for Thales Alenia Space Innovation Cluster. DONI for Thales Alenia Space Domain of Observation and Navigation

The flow of the funding for search, projects and patents is shown in Figure 6. Subsequently, a PNRR ("Programma Nazionale di Ricerca Militare, a National Military Research funding scheme") fund has been awarded.

Currently, both Leonardo and some private investors are devising a common strategy for technological finalization and commercial exploitation. The consolidated collaboration of the Space Alliance with Telespazio and e-Geos has created a perfect team organization for application and product-driven systems engineering, as well as for hardware and antenna design.

CONCLUSIONS

We believe that the Mosquito Globetracker System is a good idea and represents an interesting innovation that could pave the way to the development of a new family of products and to brilliant commercial perspectives for Leonardo.

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Award for Cross-cutting topic area Digitisation

MBSE (Model Based Systems Engineering) Winglet Certification through Complex Simulation without Experimental Tests

Gaetano Esposito, Salvatore Russo
Leonardo - Aircraft Division

The latest IT technologies now offer high-benefit process capabilities, able to continuously support the development and management of an engineering product during its entire life cycle, with clear benefits in terms of process efficiency, traceability and time/cost reduction, from its "conceiving" to its use in service. With Model Based System Engineering (MBSE), the logic of standardization, traceability and flexibility provided by digital models is scaled up to a central role in the processes. The predictive capabilities of the models allow design verification before the certification phase, which is achieved by using simulations rather than physical prototype testing.

INTRODUCTION

The MBSE method - Model Based System Engineering - is a "futuristic method" for industrial applications that changes the way of approaching aeronautical design, as the designer defines since the initial stages the entire space of possible solutions by exploiting the company's data and know-how related to projects / activities previously carried out (lessons learned). The use of the MBSE not only minimizes the risks of inoperability or of physical problems, but once the structural part has been produced, it provides faster responses without waiting for test activities.

CONTEXT

The application of the MBSE in the Aerospace, but also to other issues and / or business sectors offers the opportunity to accelerate the digital transformation of our company. In recent years, Leonardo Aircraft has started this digital transformation process by applying techniques and methods for the validation of configurations and architectures for aircraft structures. This article refers to a specific case, in which the MBSE method has been applied in the certification process with the Agency for the approval of major design changes for C27J aircraft winglet.

OBJECTIVE

To improve the aerodynamic efficiency of the C27J, winglets have been added and the structure has been validated following a bird impact, in compliance with the airworthiness requirement CS (Certification Specification) 25.631 Amendment 24 and CRI (Certification Review Item) C-03 (Issue 8) by responding to requests received from the Authority (EASA - European Aviation Safety Agency) to obtain

Figure 1–C-27J Winglet Overview

to obtain the certification approval. The numerical simulations have been performed using an explicit non-linear MSC Nastran solver.

In order to comply with the airworthiness requirement, the aircraft must demonstrate the ability to perform any recovery manoeuvres, continue its flight and land safely in agreement with CS 25.631 Amdt. 24 “Bird strike damage” and CRI C-03 Issue 8 “Bird Strike Interpreting Material”, according to the Certification Programme.

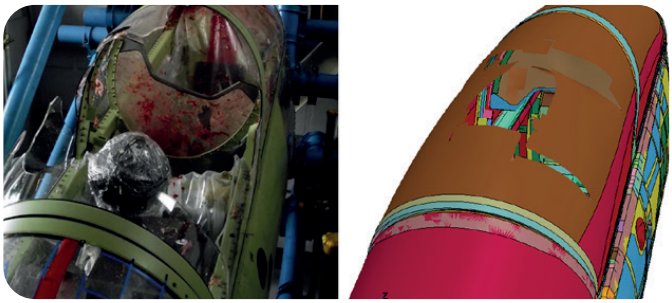

Figure 2 - M345 Blastshield FEM Experimental Test correlation

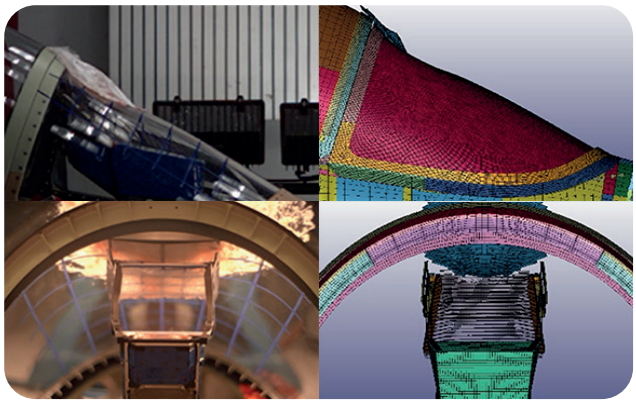

Figure 3 - M345 Windshield FEM Experimental Test correlation

For the winglet certification “No bird penetration has been requested”.
The traditional approach would have required a bird strike test. Over the years, experience in civil and military programs has streamlined the certification procedure of structural parts in relation to the bird strike phenomenon by performing increasingly complex simulations, also thanks to more and more powerful computing machines. In the recent past, for the M345 aircraft,

it was possible to certify all the structural parts involved for bird strike by manufacturing only one certification test article.

Therefore, while in the past it was necessary to manufacture at least two/three test items for development, correlation and certification tests, today, thanks to the validation of MBSE methods, it is instead possible:
- to select and validate the most critical impact locations;
- to avoid development and certification testing.

COMPLEX VIRTUAL SIMULATIONS

Using a Model-Based Systems Engineering (MBSE) approach, verification and validation allow an aircraft and its parts to be virtually visualized and tested before production. The virtual complex simulation and calculation methods have allowed the certification of the component through advanced simulations, without any experimental tests, and rapid identification of criticalities and construction variables to maximize the structural performance for the bird impact application. The complex impact simulations have been performed a different points of the leading edge to verify the integrity of all the structural parts, such as the Skin, Spar and Ribs of the Winglet, validating the design choice.

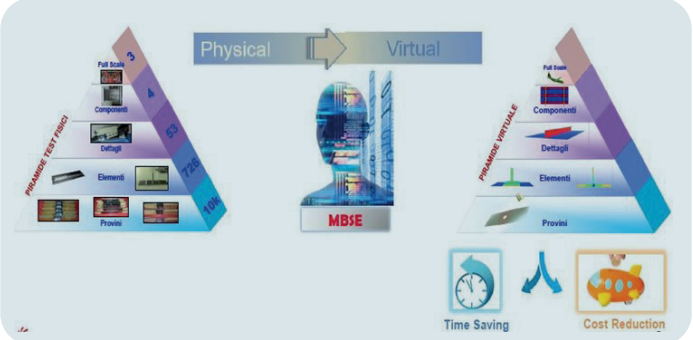

Figure 4 - Virtual certification approach with MBSE - To be

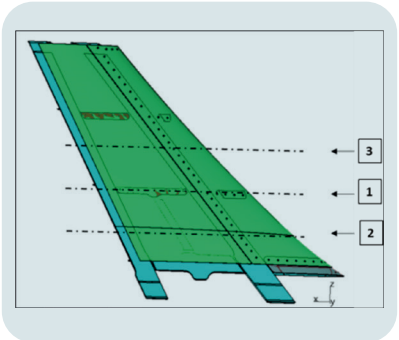

Figure 5 Impact Locations

The simulations have shown that the winglet is minimally damaged by the impact and does not detach from the aircraft. In accordance with the requirements, the impact conditions locations were the following:

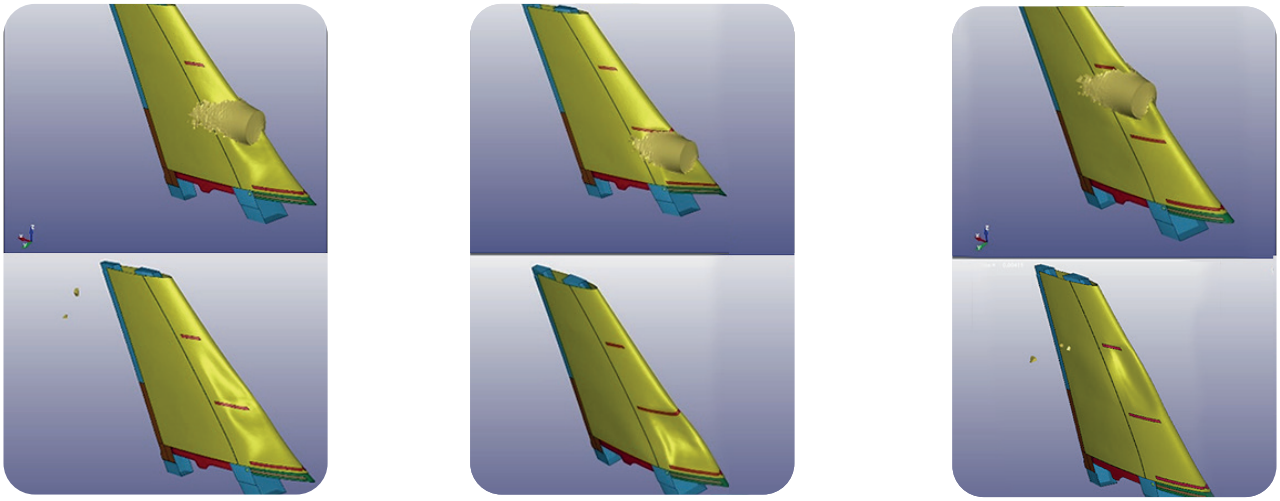

Figure 6 - Impact and No Failure in locations no. 1, 2 and 3

The following table summarizes the results of the simulations.

Impact	Bird weight	Speed	Location
1	4 lb	260 kst	1
2	4 lb	260 kst	2
3	4 lb	260 kst	3

Table 2 - Impact conditions

The failure of the Rib component has been verified in Simulation1-Location1 of Impact analysis, but no penetration of the bird model has occurred.Even if the Rib fails, for the three-impact analysis, the structural integrity has been demonstrated for all other components (Skin and Spar).

The Winglet design complies with the certification requirement CS 25.631 Amdt 24 “Bird strike damage” and CRI C-03 Issue 8 “Bird Strike Interpreting Material”: the aircraft must ensure the ability to perform any recovery manoeuvres, continue the flight and land safely.

CONCLUSIONS

The use of MBSE not only minimizes the risks of inoperability, physical problems and structure redesign if tests fail, but once the structural part has been produced, it provides faster responses without waiting for test activities. The obtained results have provided a solution in compliance with the bird strike airworthiness requirements while respecting the manufacturing and design constraints of the component. EASA accepted the demonstration of compliance only by means of “an analysis”, thus confirming the sustainability and the substantial industrial relevance of the method in terms of cost savings related to prototype manufacturing and experimental verification tests, with consequent improvement in the social impact due to the drastic reduction of equipment and waste materials. For the winglet’s virtual certification, there have been considerable cost savings due to savings in manufacturing and testing components for validation/certification. In a general case of a component for which the dynamic properties of its material are not available, it’s possible to have double cost savings by avoiding manufacturing and dynamic characterization of specific items.

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Award for Cross-cutting topic area Sustainability

St. Lucia GIC: an Early Warning System to predict and manage the Consequences of Extreme Weather Events

Paolo Berardone, Paola Nicolosi, Daniele Pellegrino, Vincenzo Scotti, Dino Quattrociocchi, Carlo Morucci, Domenico Grandoni

e-GEOS S.p.A.

The Geo-Information Centre (GIC), designed and developed by e-GEOS and installed on the Caribbean island St. Lucia, is an advanced system that, several days in advance, can predict the possible impact of an extreme weather event on the territory highlighting the areas at greatest risk of flooding. A forecasting model based on public weather bulletins, estimates the rainfall on the island and maps the areas at greatest risk using an AI-based hydraulic model, which is also fed by rainfall data collected by the client's stations and by data from a meteorological radar included in the GIC. This overcomes the limits of classical hydraulic modelling that would require several hours/days. Using data from the alarms received by the system, the user is then enabled to task input optical satellite/radar image requests through the GIC in a targeted manner to use for post-event damage assessment.

INTRODUCTION

The effects of climate change are progressively bringing attention to the development of tools that prevent and manage emergencies related to extreme weather events.

In 2015 the United Nations General Assembly established 17 Sustainable Development Goals as a universal call to action to protect the planet Earth and the human being[1]. Climate action is one of the topics of the goals, which has as its official mission the statement "Take urgent action to combat climate change and its impacts".

The Geo-Information Centre (GIC) (GIC), designed and developed by e-GEOS for the St. Lucia Government, is a new, cutting-edge solution that aims to contribute to reaching this goal by increasing the alert capacity of local authorities in flood events and by providing tools for a rapid evaluation of damage, once the event has occurred.

Therefore, the GIC helps St. Lucia decision makers, an island particularly prone to hurricanes and tropical storms, to manage the pre-event and post-event phases of the emergency. The GIC takes advantage of a powerful combination of different information sources, both generic publicly available (such as the National Oceanic and Atmospheric Administration (NOAA) bulletins or other international networks and social media), as well as high precision systems (such as local weather radar, rain-gauge stations and optical/radar satellites).

All those data are used by the GIC at different stages of the emergency to predict in a few minutes the moment of the event peak and to generate flood hazard maps that the decision makers can use to organize the civil protection activities properly. The hazard maps also provide essential indications to task the acquisition of images properly for producing the post-event damage assessment maps.

The Geo-Information Center has been built under a cooperation agreement signed in 2018 between the former Italian Ministry of Environment Land and Sea, now the Ministry of Ecological Transition, and the Caribbean Community Climate Change Center (CCCCC) for the development of an Early Warning System for the St. Lucia government. The St. Lucia Meteorological office, where the GIC is installed, will manage the system with the Water Resource Management Agency and the local Civil Protection. For the realization of the system, e-GEOS collaborated with ELDES to provide the weather radar and the department "Civil and environmental engineering" of the University of Rome "La Sapienza" as the scientific contributor for the state-of-the-art of the hydrological and hydraulic models and their surrogate models' design.

The St. Lucia GIC is a particular implementation of a more general e-GEOS product, the Geo-Information Centre. This modular solution allows the customer to have a tailored and comprehensive end-to-end process to generate satellite-based products from multi-sensor data at its premises. The GIC is "modular" by design, as it is based on the composition of Building Blocks through specific workflows, and it has several predefined applications. These can be easily configured for specific needs on multiple application domains based on e-GEOS vertical platforms (AgriGeo, AWARE, brAInt, SEonSE, mapcy, CLEOS).

In the specific case of the St. Lucia GIC, a "mapcy" platform focused on emergency management has been adopted. In 2022, the St. Lucia GIC won the Telespazio Innovation award in the category "product result" and of the Leonardo Innovation award in the transversal theme "sustainability".

THE EARLY WARNING SYSTEM

Pre-event phase

The scope of the early warning system of the GIC is to constantly search for new hurricane meteo data from the configured data sources (NOAA bulletins). When a new hurricane track is forecasted to pass less than 500 km from St. Lucia, the GIC extracts large-scale parameters such as hurricane tracks, tropical storms, and atmospheric circulation patterns from the bulletins. Using a series of statistical downscaling models, it calculates an estimate of rainfall intensity and the probability of distribution over the island. From these downscaling models, some of which use a neural network approach, it is possible to estimate an extreme event's probability and time of occurrence.

The GIC allows obtaining hazard maps concerning the extreme event that is about to take place in a given area of interest, which are based on historical floods. Based on the atmospheric configuration, the system recognizes the alluvial map based on the past most similar to the one about to happen.

Based on the atmospheric configuration that occurs, the GIC system generates three hazard maps. When there are precipitation parameters that exceed a predefined threshold, it generates an alarm.
In correspondence with the warning, the GIC generates a map in which the possible flooded areas are displayed and defines the related forecast of the instant of occurrence.

The alarm is shown in the GIC portal and an email is automatically sent to a predefined recipients list.
After the generation of the alarm, every 6 hours during the pre-event phase of the emergency, the GIC continues to automatically collect the meteorological parameters related to the incoming hurricane from the NOAA web services. In this manner, the hazard map is updated every 6 hours, providing more reliable information as the hurricane gets closer to the island.

Now-casting phase

As soon as the hurricane approaches and enters the area of the meteorological radar coverage, the rainfall data collected from the radar are used as the input to another model, thus drastically increasing the precision and frequency of the output, as the hazard map can be updated every 15 minutes. The GIC is also able to collect data coming from two different rain gauge network stations owned by the customer, and to store them in a database using ETL (Extract, Transform, and Load) procedures to harmonize different and proprietary data formats and to provide a comprehensive situation from the in-situ sensors in real-time. If the rainfall measured by one station exceeds a pre-defined threshold, the GIC sends an alarm to the user.

THE SURROGATE MODELS

One of the most valuable features of the GIC is its capacity to generate one hazard map in a few minutes. In fact, classic hydraulic modelling can take some days and multiple runs to produce such a map. This is clearly not compatible with emergency events, where a flash flood could even be exhausted in two hours.
In order to reduce computational times, a surrogate model based on machine learning (AI) algorithms has been implemented into the GIC.

Surrogate models are simple analytical models that are used to map input data to output data when the actual relationship between the two is unknown or computationally expensive to evaluate[2]. In this case, a Principal Component Analysis (PCA) process [3] has been applied: each image is turned into a set of eigenvalues, both the inputs and outputs, to reduce the excessive computational grid. Based on the eigenvalue sequences and then how the rainfall is proceeding, the AI estimates what the model output should be in the future.

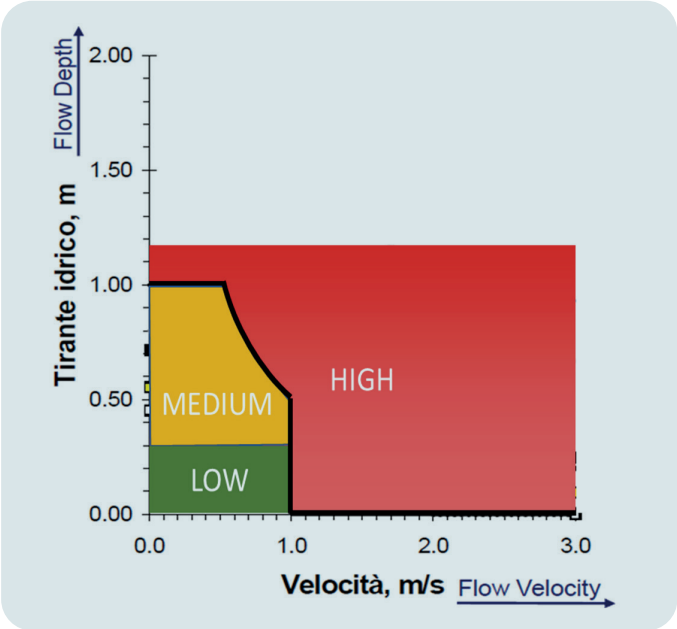

Figure 1 – Flooding hazard level according to the flooding velocity and depth calculated by the model

Table 1 – Main features of early warning system surrogate models

Product	Input	Forecast update	Run Time	Validity
TCR	NHC-NOAA reports Rainfall from Tropical Cyclones	6 h	30 min*	3 d
RADAR	Now-casting radar data	15 min	5 sec*	1 h

**The run time has been calculated using a computer with a .3 GHz CPU and 32 GB RAM*

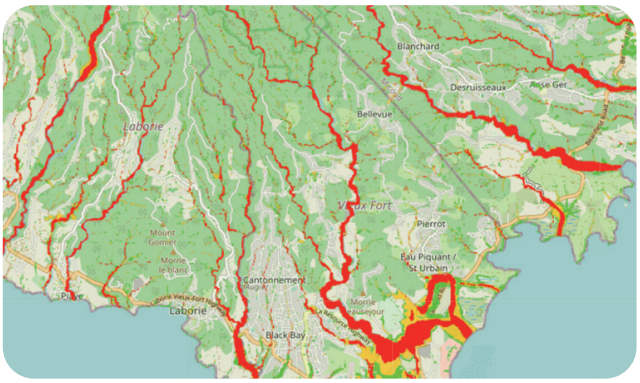

Figure 2 – Example of flooding hazard map

This technique allows for providing real-time scenarios and one-hour flood forecasts using real-time precipitation RADAR data with a good level of accuracy[4]-[6].

The result is a hazard map where each pixel is classified with three levels of hazard (HIGH, MEDIUM, and LOW) according to a combination (Figure 1) of the flow velocity and flow depth obtained as the output of the model. The spatial resolution of the maps is 20x20 meters. The other main characteristics of the models are reported in Table 1.
The hazard maps are generated in ASCII file and then converted in Geotiff format projected in EPSG 32620 (WGS 84 / UTM 20N).

In order to avoid false alarms, the map is automatically overlapped with a land use map, eliminating the areas with no human settlement or significant assets at risk nearby. If the resulting hazard maps contain significant clusters of critical areas, the GIC generates the alarm. It is automatically made available to its Web-GIS interface, where the pixels are represented with different colours according to their hazard level (Figure 2).

THE EARLY WARNING SYSTEM

With the help of the information extracted by the hazard maps, the decision makers can task at any time the acquisition of the Satellite images in a targeted manner to "book" an image acquired immediately after the estimated time of occurrence over the estimated areas of occurrence of the event. This operation can be performed entirely within the GIC by connecting to the e-GEOS online catalogue and its feasibility engine.

According to the time window set by the user, the GIC automatically searches in the archive catalogue (if the dates are in the past) or activates the feasibility engine for new acquisitions (if the dates are in the future).
Table 2 reports the satellite missions that can be tasked from the GIC according to the different products to generate.

The selected images are automatically retrieved by the GIC and are made available to the user or to the automatic processors for feature extraction and for the production of the post-event damage assessment maps. Figure 3 shows an example of a satellite data search result performed by the GIC.

Table 2 – Satellite missions available in the GIC for each product

Product	Sensor Type	Mission	Spatial Resolution
Flooding maps	Radar	COSMO-Skymed	1 - 100 m
		Sentinel-1	5 - 40 m
Damage Assessment	Optical	WorldView	0.3 - 0.5 m
		GeoEye	0.5 m
		Sentinel-2	10 - 60 m
Wind and Wave field	Radar	COSMO-Skymed	1 - 100 m
		Sentinel-1	5 - 40 m

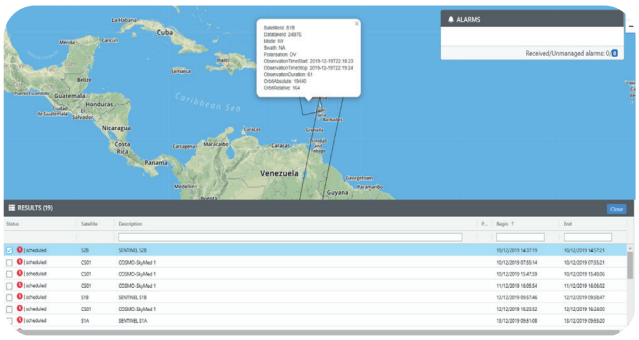

Figure 3 – Satellite images search results from the GIC

POST-EVENT ASSESSMENT

The images acquired are used to produce maps that depict the situation of the territory immediately after the event, in terms of flood extent and infrastructure affected. Such information turns out to be extremely useful for planning fast recovery actions and rescues.

Automatic Flooding maps

The Synthetic Aperture Radar (SAR) images acquired immediately after a flooding event can provide information about the extension of the water [6]-[9]. The GIC is able to automatically generate a flooding map by means of a proprietary algorithm based on deep learning techniques developed by e-GEOS (Figure 4).

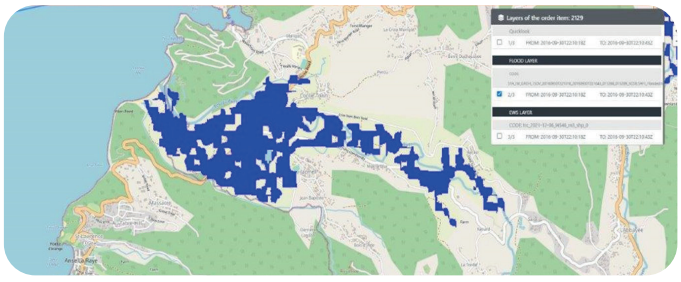

Figure 4 – Flood extension map generated by the e-GEOS algorithm from a SAR image

Enhanced flood footprint

The flooding maps obtained from SAR images and from hydraulic models are both subject to limitations. In fact, the radar satellite images cannot properly detect the flooded areas within the urban areas[10][11], and the hydraulic simulation has limits in calibration and for the morphological complexity to take into account[6].

To overcome the above-mentioned limits, the GIC provides tools for combining satellite images, rainfall measurements and social media markers that allow for generating an enhanced flood footprint map, which is a more accurate flood layer.
It features several advantages, as it is based on the results of robust hydraulic models calibrated on observed flood conditions from SAR satellites (very accurate in suburban areas) and from social media and news that can be assimilated to ground observations.

The social media markers to calibrate the model can be directly filtered and selected within the GIC by means of a specific social media analysis engine.

Damage assessment map

The GIC allows producing post-event damage assessment maps using optical sensor images. The generation of these maps is based on the visual interpretation of two images: one acquired before the event and one acquired after the event. The GIC guides the user in the acquisition of both images and then publishes the final damage assessment layers in its Web-GIS interface (Figure 5).

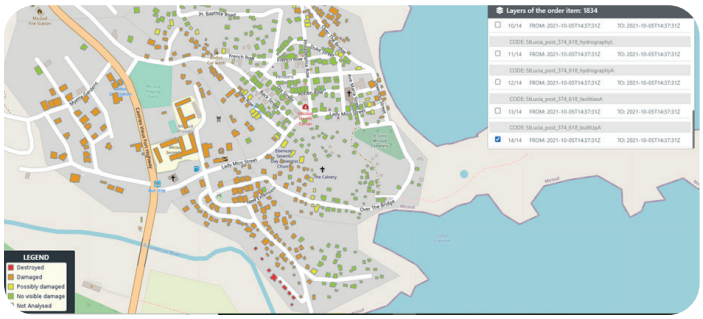

Figure 5 – Example of damage assessment map: this layer reports the status of the buildings (destroyed, damaged, not damaged)

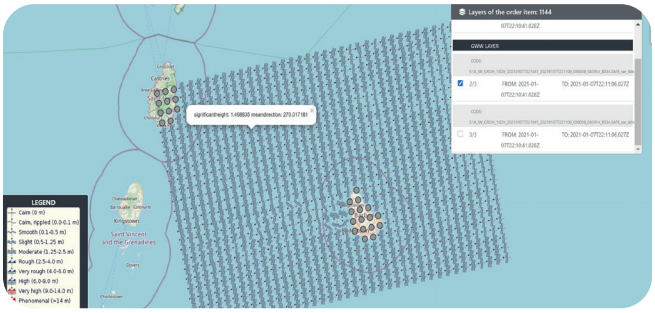

Figure 6 – Example wind filed map generated by the GIC from a SAR

Wind and wave fields maps

The maps of wind and wave fields are automatically generated by the GIC from SAR images, thanks to an e-GEOS algorithm that is triggered by the GIC immediately after the reception of the satellite image.

The wind and wave fields are two separate maps that are generated from one single SAR image and are available in the web-GIS (Figure 6).

CONCLUSIONS

The GIC instance realized for the Caribbean island of St. Lucia is an extremely valuable solution in the sector of flood risk, for the ensemble of services it can provide, the ability to exploit various data sources, the early warning capability, the spatial coverage and the spatial resolution of the risk maps. The GIC is flexible by design. It can be easily configured to intake proprietary rain-gauge networks or other data and can be adapted to local needs.
All these features make the GIC a major innovative industrial product that can be proposed to all the countries prone to extreme meteorological events and/or to insurance companies to help better cope with the effects of climate change and to contribute to saving lives and assets.

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Award for Cross-cutting topic area Digitisation

Colibrì Project

Alessandro Serio, Annarita Boccuni, Paolo Del Giudice, Davide Antonio Stanca, Andrea La Gioia
Leonardo – Aerostructures Division

Innovation means not only devising win-win solutions for the future but also being able to provide responses and technological solutions quickly and effectively during emergencies. This was the "Colibrì Project" vision, a response to the appeal of Isinnova during the Coronavirus emergency. At a time of great need for respirators in Italian hospitals, Isinnova launched a public appeal to receive support for their manufacture using Additive Manufacturing technology. The appeal was for manufacturing two valves made of plastic material (the so-called Charlotte and Dave valves) that would have enabled the modification of a particular model of snorkelling masks, which turns them into respirators intended for sub-intensive care.

INTRODUCTION

The Colibrì Project was started through close collaboration between the Research and Development Department and Production Engineering Department at the Aerostructures Division, Leonardo S.P.A in the Grottaglie Plant.

The COVID-19 outbreak urgently increased the need for breathing devices (Figure 1) for Civil Defence, including national and international entities. During the pandemic outbreak, the two teams joined forces to design and produce Charlotte and Dave valves, breathing assistance devices providing oxygen to patients. Leonardo made available its services and automated equipment such as its 3D printing facility, available continuously and unconditionally. As a result, in April 2020, Leonardo delivered more than 500 Charlotte and Dave valve kits produced with the 3D printing process.

Due to the shortages in the hospitals, at the same time, the Aerostructures Division produced other medical devices, such as face shield masks, crucial for the protection of the front-line workers.

Figure 1-C-PAP modified mask

DESCRIPTION OF INNOVATION

Isinnova analysed the function of a C-PAP mask and developed an emergency C-PAP mask based on the idea proposed by Dr. Renato Favero, a former chief physician at the Gardone Val Trompia Hospital.

The development involved the modification of a standard commercial snorkelling mask and the design of special fittings enabling the connection of the mask to the oxygen regulator.

The modification consists of two fitting valves: the primary one (Charlotte) and the secondary one (Dave); the role of the latter is to connect to the primary fitting (Figure 2).

The main advantage of this development is its compatibility with any snorkelling mask, as the basic fitting needs small adaptation to fit the purpose.

The role of the Charlotte valve is to create a connection between the mask and the oxygen supply, thus allowing a Covid-19 patient to breathe while ensuring controlled air pressure.

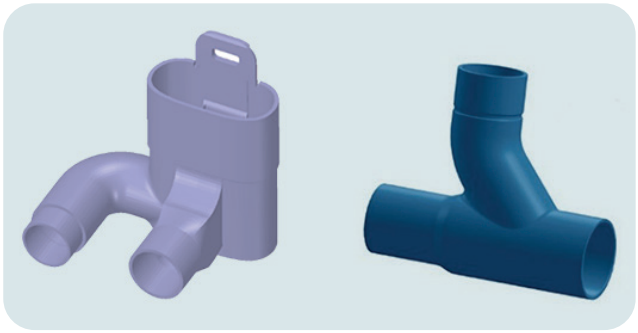


Figure 2 - The Charlotte valve (left) and the Dave valve (right)

The air insufflation system works with an inlet route, through which the oxygen enters the mask, and an exit route, where the exhalation takes place.
The shape of the Charlotte valve can be tailored for each mask model as its geometry and design can be easily adapted when using 3D printing technologies, particularly the Fused Deposition Modelling (FDM) one.One of the driving forces of this project was the rapid fabrication of the required designs and the fast delivery to both nationally and internationally sites.

MATERIAL AND TECHNOLOGY USED

Additive manufacturing, commonly referred to as 3D Printing, is an industrial process used to fabricate objects from computerized 3D models by progressively adding one layer on top of another one. The alternative route would be the use of traditional subtractive machining methods such as milling and lathe machines, where the amount of scrap material is significantly higher than for additive manufacturing. Dedicated software was used to design a digital model for the manufacture of the parts with the 3D printer (Figure 3). There is a wide variety of 3D printers available in Leonardo S.p.A. The FDM technology was chosen for our project.

The FDM process is based on the "additive" principle that releases material in layers. Thermoplastic filaments are ejected from a spool that delivers the material to an extrusion nozzle.
The process flow and the temperature are fully controlled with a G-code. The heated nozzle can be guided on both the horizontal and vertical axes, depending on the required design.
Heated platelets and\or additives are often used to increase the adhesion of a few specific types of material used in the printing process.

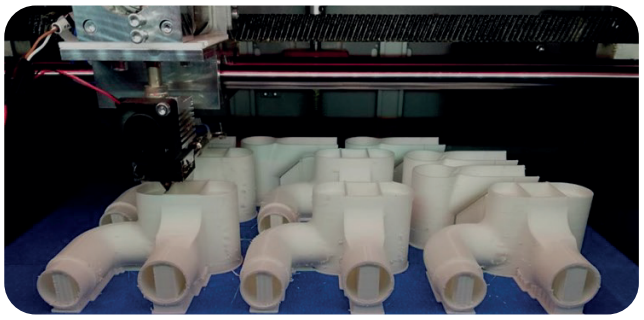
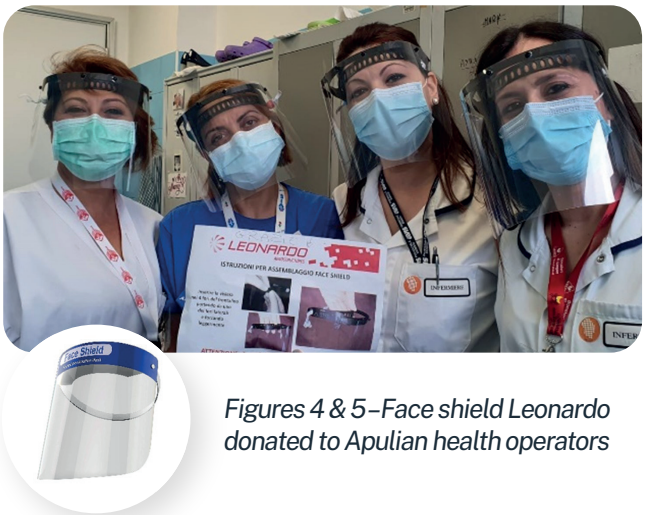


Figure 3 – Charlotte valve in print at Grottaglie plant

The material used for both valves is a polylactic acid (PLA), which is a biopolymer that is derived from hardening the lactic acid produced by the fermentation of natural plants. Common plastics have a life span that is between 100 and 1,000 years, while the PLA has a shorter life span of approximately about four years due to the biodegradation that takes place. In addition to its biodegradability, the odourless PLA system allows patients to breathe air without any inconvenience. Finally, PLA is a flexible material that adapts itself elastically when coupling with other components.



Figures 4 & 5 – Face shield Leonardo donated to Apulian health operators

FACE SHIELD

As mentioned before, besides the said valves, the Aerostructures Division fabricated also face shield masks providing protection from Covid-19 (Figure 4).

In close collaboration with regional health experts and doctors, Leonardo produced lightweight and sanitized wearable masks. Figure 5 shows the donated shield face masks used by healthcare personnel in hospitals in the region of Apulia.

COLLABORATIONS

The project had a strong influence on the national community, with both local and national media reporting and publishing this initiative from the Leonardo S.p.A. plant in Grottaglie. The circulation of the news also reached other Plants and Divisions, which called for collaboration. Alongside, the Leonardo S.p.A. Divisions assisted the local Civil Defence in the regions impacted by high-emergencies at any time.
Working during this emergency allowed the Aerostructure Division to establish a partnership with the Electronics Division that was then leveraged for other corporate Business needs. In addition, it disseminated and exploited the brand of Leonardo S.p.A. worldwide. The Colibrì Project owes its success to those colleagues who accepted the invitation and worked effortlessly towards the common goal.

CONCLUSIONS

The Colibrì Project initiative was named after the fairy tale of a little hummingbird. The story tells of a fire that broke out in the forest. During the fire outbreak all the animals ran away, except for a little hummingbird. He rushed into the river catching a drop of water with his beak and dropping it to the flames countless times. Initially, the other animals mocked him, but eventually, they followed him in his efforts. In the end, operating altogether, they put out the fire and lived happily ever after.

This allegory recalls the societal challenge during the first outbreak when people were disoriented and distant with each other; but at the end of the story, they learned to act like that little Hummingbird, and managed to fight against the pandemic, together.

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Winner of the Popular Jury

SOFIA - Strategic Operational Framework for Intelligence and Awareness

Monica Dubay[1], Marco Clemenzi[1], Bruno Tomaselli[2], Daniele Pallotta[1]
[1]Leonardo - Corporate, [2]Cyber & Security Solution Division

SOFIA is an intelligence tool designed to facilitate the search for information and to promote the sharing of knowledge about the markets served. SOFIA is a platform developed entirely in-house, in which data flows into specialized repositories with continuous automatic feeds. Its powerful search engine allows the time required for scouting information to be reduced.
SOFIA provides users with information, news, documents and data from internal and external sources, thus facilitating their work by sharing its output and making it available in a simple, user-friendly way.

The SOFIA project started from an idea of the Strategy & Market Intelligence Department of Leonardo Corporate to equip the company with a state-of-the-art tool that enables sharing the information within the various organizational units of Leonardo. This would have also overcome the limits of "vertical" solutions based on third-party platforms or news aggregator sites.

Figure 1 – SOFIA logo

The initiative led to the creation of a platform called SOFIA (Strategic Operational Framework for Intelligence and Awareness) that, in June 2021, was activated for Corporate and was subsequently extended to the Cyber Division and the Electronics Division with a shared roadmap for further extension to the whole company.

SOFIA was designed and built to meet a series of requirements:
- it allows sharing of information sources that were previously accessible to a very limited number of users;
- it is internally built and hosted, thus guaranteeing the possibility to share internal documents while safeguarding the confidentiality of both the documents and the searches being carried out;
- it makes it possible to have constantly and promptly updated information, through secure links that automatically feed the platform from databases and external sites;
- it allows publishing information from, and carrying out research on, documents from multiple information sources, which would be impossible to do on platforms of external suppliers;
- it identifies and selects contents based on Leonardo divisions' specific interests, thanks to the possibility of configuring appropriate taxonomies.

SOFIA is conceived and designed to be a real user-friendly tool, as it gives users the possibility to identify the information sought in a very simple manner through multiple access points, such as:

- a home page that summarizes the most recent updates, with a section dedicated to the news of the day, cloud tags with the most recurring themes on the web and the latest documents uploaded to the platform from selected sources, both internal and external;
- a powerful search engine that helps to analyse, with incremental refinements, all the content of the platform, whose databases are fed on a daily basis with the relevant news and reports for the Aerospace & Defence sector, selected through specialized taxonomies from open sources and info providers;
- thematic dashboards structured by competitors, geographic areas and business segments, with sections automatically updated with feeds from various sources to provide a complete picture of the requested topic;
- the internal document repository that collects, in a folder structure, all the available documentation, providing also sharing and collaboration tools;
- a finance section that reports quarterly updated financial data of the main competitors, both in tabular and graphic form.

Each Division is provided with its own SOFIA tool, with customized content and taxonomy, in order to adapt it to information needs specific to the Division itself.

The project has been developed in collaboration between Leonardo Corporate Strategy & Market Intelligence (project owner), Cyber Division (managing implementation) and Leonardo Corporate IT (managing infrastructure). The creation of SOFIA has allowed the Cyber Division to consolidate its know-how on strategic intelligence solutions. The project has been then included, among other Leonardo platforms, in the National Cyber Security Perimeter, thus confirming its strategic importance.

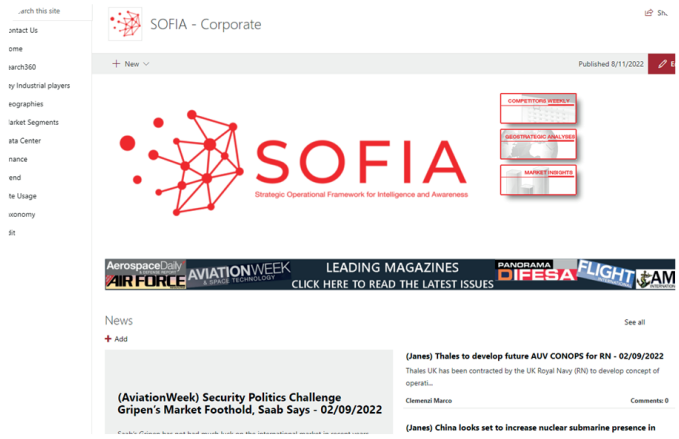

Figure 2 – SOFIA Home Page

From a technical point of view, SOFIA is built on the innovative open-source Kubernetes "containerized" cloud platform, which hosts modular services, each with specific functions. The MongoDB database is the solution selected for data management because of its ability to manage large quantities of documents with fast search capabilities through cognitive text analysis. Finally, the user interface is ensured by Sharepoint, with modules developed in Javascript technology for viewing and searching for data, and by PowerBI, for reports and graphs.
SOFIA is increasingly confirming itself as the company tool of excellence for sharing and disseminating information on our markets, competitors and clients, with the aim of continuously improving its function with new innovative tools for semantic text analysis, artificial intelligence and new algorithms for research.
For the first time, the company has at its disposal a tool that triggers a virtuous process of information sharing, which is not only useful to everyone in their daily work but can support a concrete evolution in the corporate culture.

Stay tuned for new and exciting features in the near future... see you in SOFIA!

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Honourable Mention in the Product Results category

Multi Vector Heterogeneous Network Solution for Secure Communications during the FIS Alpine World Ski Championships 2021 in Cortina d'Ampezzo

Marco Cecchi, Giovanni Borghero, Sergio Galizia, Fabio Gloter, Roberto Maccioni, Carla Miccinesi, Gabriele Pierozzi, Marco Ravasio, Riccardo Riccitelli, Roberta Rossetti, Serena Sabatini

Leonardo – Cyber & Security Solutions Division

For the FIS Alpine World Ski Championships 2021 held in Cortina d'Ampezzo (Italy), the team designed and set up a dedicated mission-critical Professional Communication Network[1] for the police forces aimed at ensuring the protection of athletes and the local community. Moreover, the project included the implementation of an Inter-force Operations and Control Room used by all the police forces involved during the event for coordinating safety and security services[2].
The solution is based on a Multi Vector Heterogeneous Network (RIM)[3], one of the pillars of the Cyber & Security Solutions Division strategic plan, which is conceived for the evolution of Secure Communications towards broadband, as it is capable of integrating narrowband (TETRA and analogue) and broadband (4G/LTE) radio communications networks[4].

The Leonardo team operated in close proximity with the Police and Emergency Forces alongside the ski runs, in order to make the specific features of each communication technology [5][6] available to the users, also supporting the various requests from the Operational Departments of the Police, Carabinieri and Guardia di Finanza engaged on the field.

In particular, not only Mission Critical narrowband voice communication features were required, but also the messaging (chat), GPS localization, radio terminal presence (e.g. active, busy, on call, disconnected) and multimedia data (e.g. photos and video streaming) that were necessary, for example, for an efficient mobile video surveillance service operated by the Forensic Science Police.

Figure 1- Multi Vector Heterogeneous Network Solution for Secure Communications during the FIS Alpine World Ski Championships 2021 in Cortina d'Ampezzo-Italy

The RIM solution deployed in Cortina is based on expertise that is now made available to customers to fulfil their requirements for similar missions.

It is composed of:

- 1 Data Centre, housing the system servers and the user database;
- 9 TETRA Radio Base Station Sites, which offered extensive radio coverage for the province of Belluno (Italy);
- 1 LTE Radio Base Station Site, which made it possible to offer broadband services both in the heart of Cortina d'Ampezzo city and on the ski runs designated for the competitions;
- 1 Inter-force Operations and Control Room with 6 operator terminals;
- over 500 avionic, vehicular, portable and desktop terminals;
- training, 24-hour Monitoring and Assistance services for the whole event.

Figure 2 – Police Forces End Users (Polizia, Carabinieri, Guardia di Finanza)

The RIM implemented for the event features highly innovative content, so far unique in the international scene, because it represents the only solution capable of fully integrating the networks and user databases belonging to narrowband and broadband voice and data communications technologies in a real operational scenario. The RIM Solution represents an innovative aid for emergency services, law and order, highway police, traffic monitoring, escorts, criminal laboratory departments, mobile video surveillance and special forces thanks to its capacity of supporting Operational Services with highly heterogeneous requirements (voice, chat, data, video, localization).

The first priority during the event in Cortina was Safety, not only for the athletes, but also for the operators, community and territory where the event occurred. It was a team game where Leonardo values for excellence, technological innovation, ethics and respect for rules, international presence, and competition aimed at continuous improvement were in complete harmony and fully reflected the values conveyed by the sporting event.

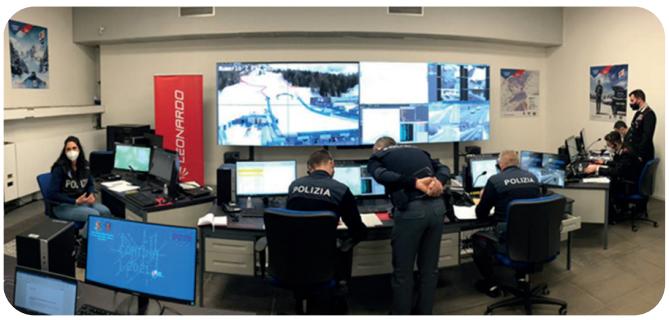

Figure 3 – RIM Inter-force Operations and Control Room

The event was a success, both from a sportsmanship viewpoint and in terms of customers' appreciation of the technological solutions provided by Leonardo[7], as well as in terms of commercial benefits gained and valuable feedback on product and feature development.

Specifically, a project like this was part of an international event with more than 500 million television viewers and 5 million views on social networks and in the press.

Therefore, the success of the project has brought benefits for the promotion of the company's image, which also led to business opportunities such as a new contract to provide a RIM solution for the G20 economic meeting in Venice[8] and a competitive advantage for both the Olympics to be held in Milan and Cortina in 2026 and for the evolution towards the RIM of the National PIT Programme.

At the FIS Alpine World Championships 2021 held in Cortina d'Ampezzo, Leonardo's team consisted of people belonging to almost all the functions of LoB and of the Division, who came from different sites (Firenze Campi Bisenzio, Cagliari, Genova, Roma Laurentina, and Abbadia San Salvatore).

Together with the National Alpine Ski Teams, Leonardo deployed its additional team along the ski runs, which demonstrated to be successful in achieving a unique and innovative solution in a real and very complex scenario, also thanks to the passion, expertise and teamwork of the people involved, before and during the event.

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Honourable Mention in the Technology Results category

Crop Circle Mitigation

Haiying Liu, Steve Marteney, Chris Reed, Kevin Macauley, Eric Minner, Christopher Parten, Beth Findley, Rusty Allred

Leonardo DRS - Electro-Optical and Infrared Systems

In some infrared imaging systems, microscopic blemishes in or on detector windows result in small circular patterns in the output video. Due to their shape and the mystery surrounding their appearance, before the root cause was understood, these patterns came to be known as crop circles. Since these crop circles tend to be more prominent in smaller detectors, Leonardo DRS' industry-leading 10 µm bolometer-based uncooled infrared camera modules are particularly prone.

Unfortunately, traditional calibration and non-uniformity correction techniques are not foolproof in resolving them since crop circles show up dissimilarly in different environments or thermal conditions. Ambient temperature, scene temperature, camera focus and camera warm-up time are all known to change the nature and appearance of the crop circles. Although they do not appear at all in many cameras and they are faint and relatively unobjectionable in many others, in some cameras, the effects are harsh enough to temporarily obscure targets or other important background information.

In recent years, the increasing adoption of uncooled infrared cameras into mission-critical military systems has led to increasingly stringent customer image performance requirements. These stringent requirements initially led to decreasing factory yields of these sensors, leading in turn to the need to develop an algorithm to mitigate them.

The Crop Circle Mitigation algorithm (CCM) was developed using a clever and sophisticated mathematical model that uses the most recent shutter frame from the camera's non-uniformity correction apparatus, along with each real-time video frame.

Although the foundational model is sophisticated, the resulting algorithm is implemented at a low computational cost. Requiring only a single frame for initialization, it generates a compensation frame that instantly eliminates crop circles in each image frame while preserving content.

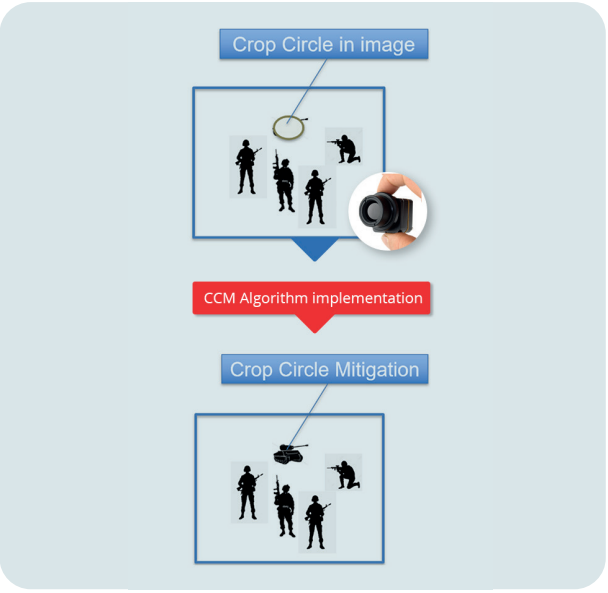

Figure 1 – Cartoon example of Crop Circle Mitigation in Action

That is, CCM is not a patch that artificially reduces the visible effects of crop circles but a true correction that restores the actual content that had been obscured. This is done without introducing latency or suffering from such common processing artifice like burn-in or ghosting. As a beneficial by-product, CCM even removes lens vignette artifice typically found at the edges of infrared images.

The first implementation of CCM in production hardware recovered around 80% of the Leonardo DRS Tenum 640 infrared camera modules that otherwise would have failed acceptance tests due to crop circles. Since that first implementation, the algorithm has been further refined and proliferated to additional Leonardo DRS products. Now a baseline element of the processing in Leonardo DRS' family of uncooled infrared cameras, this algorithm will continue improving performance and boosting production yields for the entire product line.

Figure 2 – Before and after pictures of the CCM Algorithm implementation

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Honourable Mention
in the people Category

Enabling our employees with a disability and neuro diversity to succeed

Mark Hartree, Mark Conn, Beverly McBride, Bethany Colburn, Jo Meek, Kirk Mayes
Leonardo UK Ltd

People with a disability make up around 18% of the UK population, and one in seven people are neuro-diverse. If Leonardo was representative of UK Government statistics, we might have over 1,000 people in these categories in the UK. Similar proportions are likely in other Leonardo-based countries.

Under the Leonardo UK strategy to improve Inclusion and Diversity, the Enable Network Group was formed to represent the interests, needs and support of employees with disability, both visible and invisible, and those who are neuro-diverse. This is transversal across functions, the Electronics, Cyber and Helicopter business units, and in our partnerships and supply chains.
The Enable Group's aim is for everyone in Leonardo with a disability or neuro-diverse way of thinking to succeed. Enable is open to everyone, whether they have a health condition or impairment or not and is proactive in developing our open and inclusive culture, extending our links and influence to partners, suppliers, families and friends.

Since its formation, Enable has developed a strong multimedia presence to support others.
A multi-pronged approach sought to raise awareness at all levels and all areas of the business, including the Senior Leadership Team, Joint Consultative Committees and Trade Union representatives. A number of engagement sessions have focused on equipping leadership, managers and colleagues to create a more inclusive working environment through training, which reached over 150 employees transnationally.

Enable has created training in Autism awareness, partnering with Auticon UK and has also worked with Into-Work to train HR and Line Managers in supporting colleagues who are neuro-diverse. Enable hosted the author and personality Alex Manners, who spoke about living with Aspergers

Enable has reviewed and advised on updates to the company website, recruitment policy and leadership material to better reflect those in the Enable fold and help show that the Leonardo Culture is more accepting of diversity.

This included advising the media team about the dangers of flashing imagery in video content to the neurodiverse and collaborating with the HR department to improve digital access to certain company web tools. These new formats will help improve the interaction between all colleagues by understanding the effects on those with different needs. Externally, activities are promoted via channels such as LinkedIn and Glassdoor.

Working with Leonardo Global Solutions, who are responsible for the Company's site facilities, Enable has raised awareness of diversity needs with initial focus on the Yeovil site.

Through collaboration, we developed and agreed on seven "Enable Programme – Infrastructure Guiding Principles" between LGS and the Enable team, who are now being consulted on other areas of planned site development.

These improvements to common areas ensure a consistent approach to accessibility across all UK sites with long-term plans for site improvement.

As part of the Company's commitment to creating the best environment for all our people, in 2021, Enable signed up for the Disability Confident scheme, meeting a set of criteria that tested the business against a set of statements about employing disabled people.

This achieved the second level, and the team is working on consolidating our values from recruitment through to our supply chains, customers and peers. In the UK, the Ministry of Defence scores the importance of Disability Confident under social values as a measure in evaluation of bids. Leonardo aims to be one of the first defence companies to reach Leader at Level 3.

The Enable network group has become the vehicle through which changes will improve the Company and draw from the widest possible pool of talent while securing, retaining and developing our disabled and neuro-diverse staff who bring extensive skills, loyalty and innovation.

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