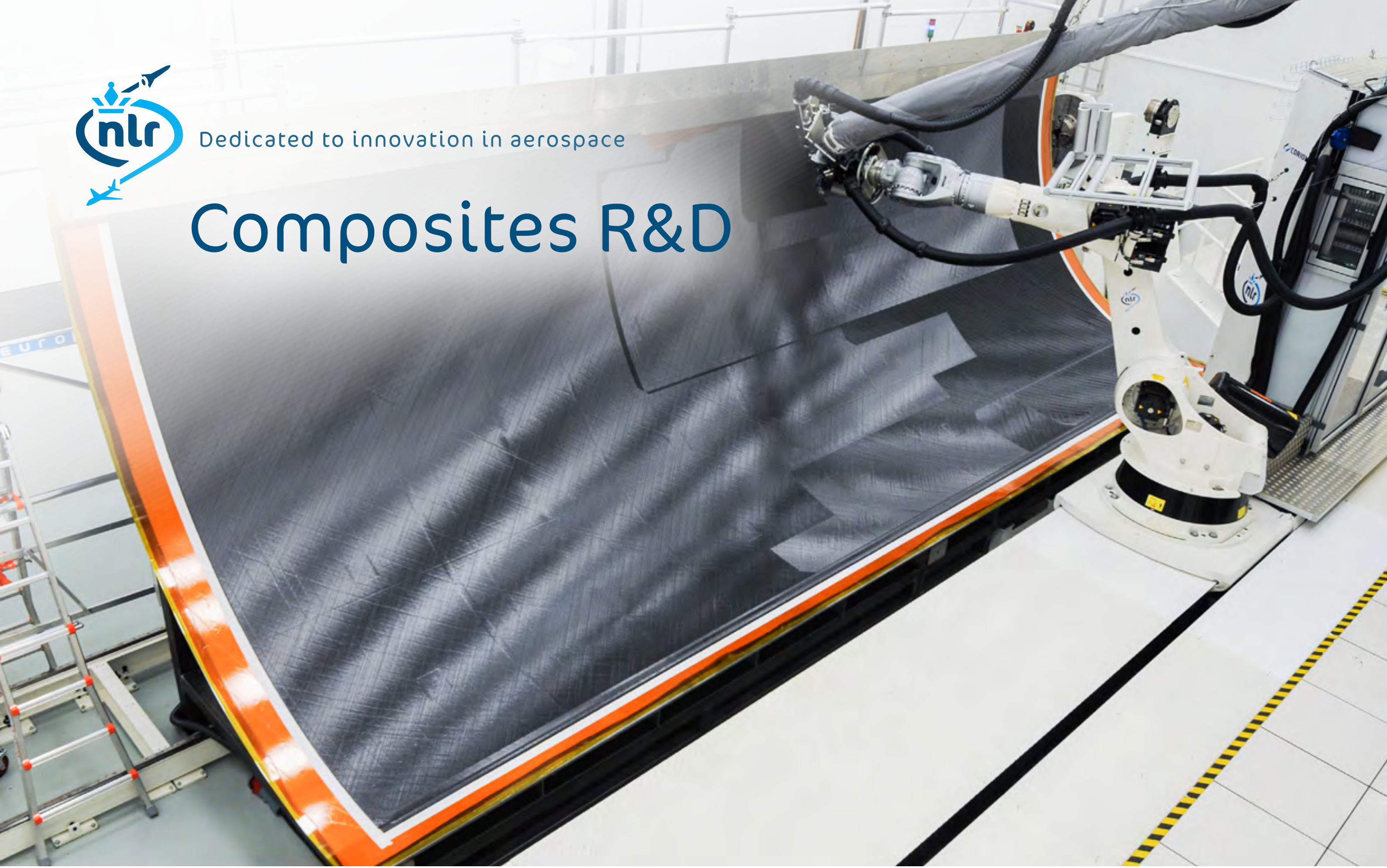
Dedicated to innovation in aerospace

Composites R&D



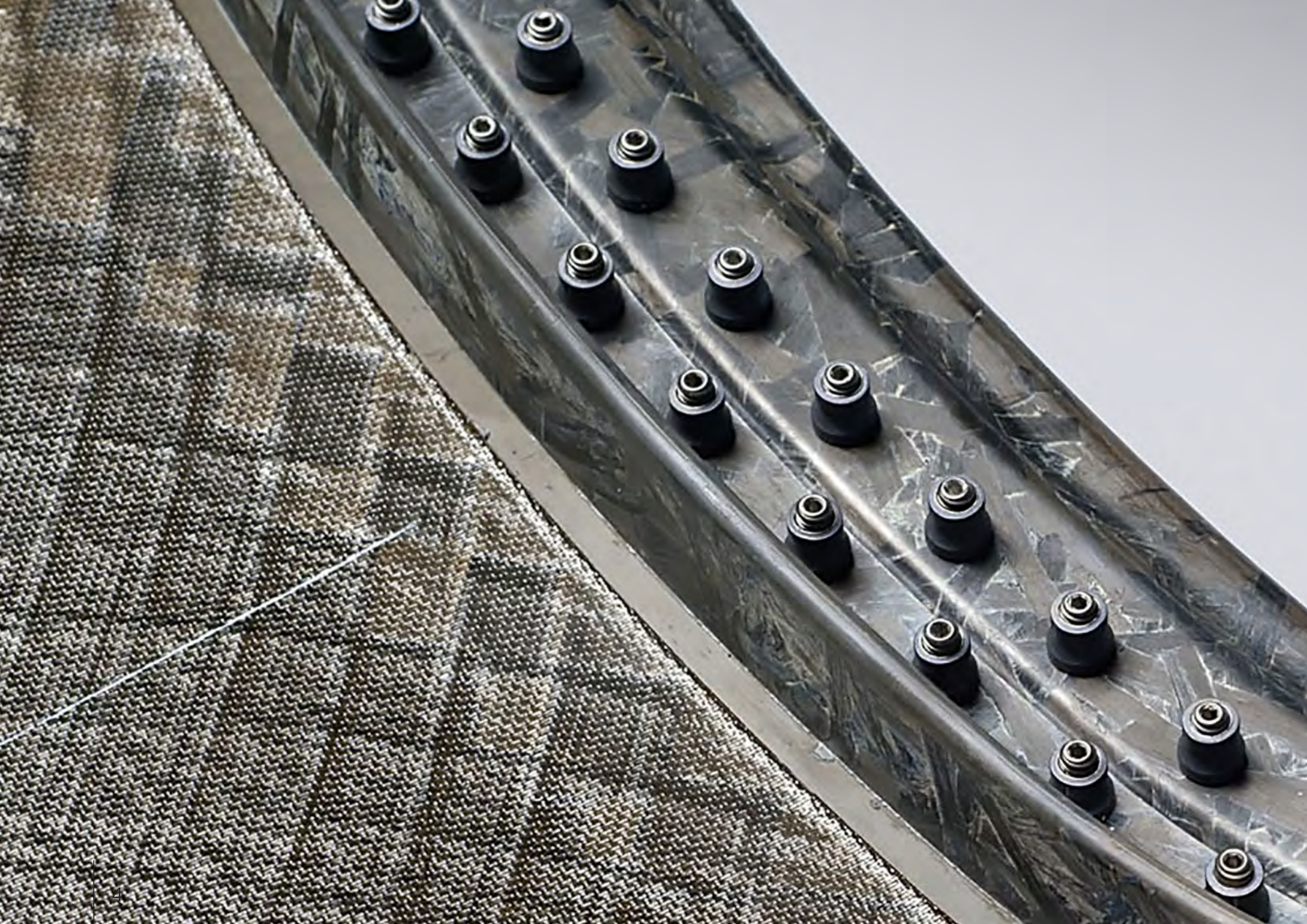
Royal NLR - Netherlands Aerospace Centre

Cover image: STUNNING project

From process optimisation to industrialisation

Efficient, durable and automated

A key objective for more efficient and sustainable aircraft is to make lightweight, durable and affordable parts which are designed for ease of maintenance. To be allowed to use parts made of new materials like composite and metal additive printed components in an industry like aviation, all of the materials must be accompanied by the right certification. NLR takes care of the entire process, from calculation and design all the way through to manufacturing, repair and certification. NLR assesses material properties, develops structural concepts and manufacturing technologies, designs components and builds parts up to the level of full scale prototypes. Spanning the entire spectrum of product development is what makes NLR unique.



R&D for automated composite manufacturing

Automated Composite Manufacturing Technology Centre (ACM Technology Centre)
It starts at the ACM^3 Technology Centre, a facility that addresses research questions at the low to medium Technology Readiness Level (TRL) or levels 3 to 6. In the field of construction technology, NLR develops at almost all TRL levels from 1 to sometimes 8. To be able to implement the processes properly elsewhere, the goal is to work towards generic, flexible systems. A significant portion of the research nowadays takes place virtually using simulations, which speeds up lead time and reduces costs.

TRL stands for Technology Readiness Level, a method of estimating technology maturity of Critical Technology Elements (CTE) of a program (hardware, components, peripherals, etc) to integrate this technology into an operational system or subsystem. TRL 1 is the lowest level, where scientific research begins to be translated into applied research and development (R&D). For NLR, TRL 8 is the highest level, where the actual system is completed and qualified through test and demonstration. TRL 9 is the highest TRL level. In close collaboration with industry, NLR elaborates ideas that are not yet viable or for which the business case is not yet clear, but which have the potential to become really big. Focus of the research is related to high performance fibre reinforced composites (thermoset and thermoplastics) and metal additive manufacturing. Key topics that are being addressed are development of new design, manufacturing and assembly concepts and automation and digitalisation of manufacturing and assembly. NLR does this in a research environment where we can also develop the hardware ourselves.

Automated Composite Manufacturing Pilot Plant (ACM Pilot Plant)
After the ACM^3 Technology Centre phase, it continues to the ACM^3 Pilot Plant for the development of TRL 6 to 8. Within the ACM^3 Pilot Plant NLR uses state-of-the-art equipment . The end-user must be able to do a copypaste, so to speak, the processes and procedures that were developed and start up production in their own facility.

Automated manufacturing and digitalisation

With the increasing penetration of robots in the production process, NLR also meets the demand for automation. The ACM^3 Technology Centre develops a robot-based process for producing composite components. The actual robots are always ‘off-the-shelf’ models to which various end effectors can be fitted. If necessary, NLR develops its own end effector, frequently in cooperation with the robot manufacturer. NLR knows the requirements a certain robot end effector must meet, such as the pressure that must be exerted, its flexibility and so on. This is an important element in the cooperation with SMEs. NLR has the fundamental knowledge and understanding of materials, the manufacturing process and the final products.

Beside automation of manufacturing processes ACM^3 is also active in the field of digitalisation of manufacturing processes (Digital Twin technology). The Digital Twin technology not only speeds up the development phase but also increases the robustness and reliability of the manufacturing process

Detecting and repairing damage of composite parts

Besides the manufacturing industry, NLR is also active for MRO (Maintenance, Repair and Overhaul). There is a lot of MRO work that has to be done because, compared with metals, composites behave differently in the event of damage and maintenance. Knowledge of ageing and repair is becoming increasingly important, particularly with the growing number of composite aircraft parts. The most important question in the aerospace industry is whether it is possible to continue flying after damage has occurred. With an aircraft made of metal there will be a dent, but in composite material you probably won’t see anything, although the part could be damaged all the same. NLR has the equipment and the know-how to inspect such an aircraft and to determine whether the damage has to be repaired immediately or whether it is possible to continue flying.

Certification

When developing a new composite part, certification immediately has to be factored in from the start. NLR is deeply involved in materials research so as to gain a better understanding of what happens to various materials, such as composites and printed parts. NLR ranks among the leaders when it comes to knowledge and certification.

Automated Composite Manufacturing Pilot Plant

The NLR automated composites pilot plant, ACM^3 Field Lab, aims to attract Small- and Medium-sized Enterprises (SMEs). This well-equipped, state-of-the-art field laboratory makes high-tech equipment available for the development of light-weight products.

The purpose of ACM^3 (Field Lab for Automated Composites Manufacturing, Metal Manufacturing and Maintenance) is to support companies in the development of light-weight systems made of composite materials and/or metal. NLR can provide this support in nearly all phases of product development: from concept studies and material screening to preparing detailed designs and creating concepts. Repairs and full-scale prototyping are also carried out in the centre. ACM^3 is optimizing accessibility in various ways. For instance, a 'menu' of the available equipment has been prepared to provide quick insight into the facilities and their operation. This allows companies to discover at a glance what they can do at ACM^3. Users can receive training or hire an NLR operator if the equipment is too complex for unassisted operation. During the production of a pilot run, for instance, users can receive training to ensure that properly qualified personnel is available when actual serial production starts at the customer site.

Affordable prototypes

The centre particularly offers benefits for SMEs. Without any requirement for major investments, they can join forces with NLR and use the equipment available at ACM^3 to work on the development of new light-weight products and the required manufacturing technologies. This process can start with 'proof of concepts' that are eventually developed into full-scale prototypes.

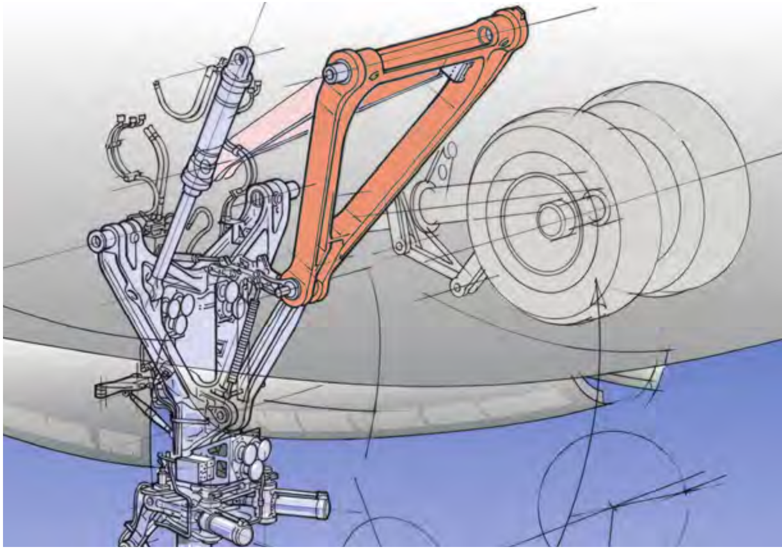
Another benefit is the ability to postpone capital investments until there is more certainty about the commercial potential of the product. The facilities at ACM^3 enable companies to delay the ordering of production equipment until there is greater certainty of a successful market introduction. In order to bridge the intervening period and maintain market momentum, companies can use ACM^3 equipment to produce the initial pilot runs.

One recent achievement illustrating the potential of ACM^3 is the successful development of PAL-V: the world's first flying car production model, equipped with unique collapsible rotor blades. Designs for the composite rotor blades and propeller were developed and tested in the NLR Field Lab. The required manufacturing method was also developed here.


EUROCARBON
MENKENS

Showcases

Development of composite drag stay for Airbus A350-1000



Within the CS2 Systems ITD a CFRP drag stay for the A350-1000 is being developed in the Core-Partner project HECOLAG. The goals for the CFRP structure are a weight saving of over 30% at recurring cost similar to the current aluminium drag stay as manufactured by Liebherr-Aerospace. The CFRP drag stay is designed by Fokker Landing Gear (part of GKN Aerospace) in cooperation with NLR, to requirements set by Liebherr Aerospace. Within the project NLR has focused on automated manufacture of preforms for these types of complex geometries. The present design is optimized for automated preform manufacturing and offers a weight saving of approximately 40%. The tooling for prototype manufacturing is designed and built by Compose Tooling. Functional prototypes are being manufactured by NLR and will be tested in 2019 by Fokker Landing Gear.

Project: HECOLAG
Customer: Liebherr Aerospace
Project partners: Royal NLR, Fokker Landing Gear, Compose

Horizon 2020
European Union Funding
for Research & Innovation

STUNNING:
the world's largest known thermoplastic aircraft structures

The Clean Sky 2 Multifunctional Fuselage Demonstrator (MFFD) with its 8.5 meter long composite-made fuselage section with an approx. 4 meter diameter gives a glimpse of what a next-generation aircraft could be. This typical section of a single aisle standard aircraft fuselage is completely produced from thermoplastic. Now, Royal NLR's STUNNING project is turning heads as the MFFD's largest component, the 8.5 meter long lower fuselage skin, has been manufactured and delivered to the project partners.

THE CHALLENGE

As part of the EU's Clean Sky 2 initiative, the aerospace industry is looking for flight path to sustainability. To deliver a double-digit fuel burn reduction for the Large Passenger Aircraft (LPA) segment next generation fuselage structure concepts are needed in which cabin, cargo and physical system elements are integrated. Its three main and for STUNNING overarching objectives for future Single Aisle Aircraft fuselages compared to the state of the art are:

- Enable a High Rate Production (HRP) of 60-100 shipsets per month
- Reduce weight
- Reduce recurring cost

THE SOLUTION

As part of the MFFD development, the STUNNING project will develop, manufacture and deliver the 180° full scale lower half of the multi-functional integrated thermoplastic fuselage, including cabin and cargo floor structure and relevant main interior and system elements. The STUNNING team will apply advanced design principles, innovative system architecture and advanced materials and processes. Addressed topic are:

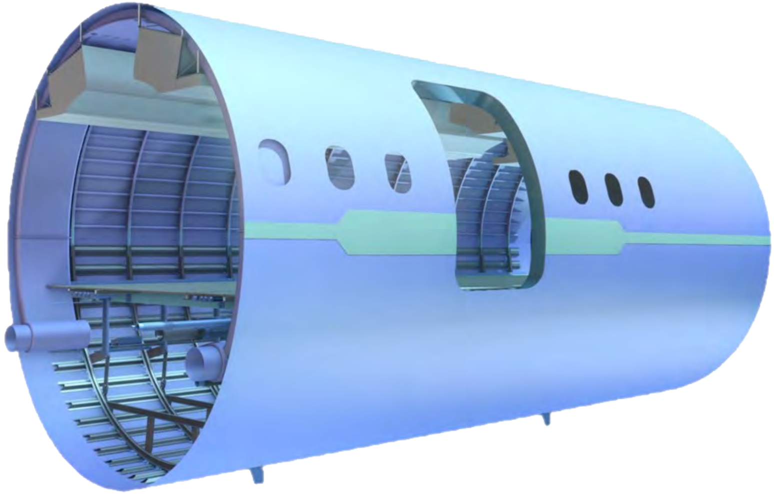
- A 180° full scale multi-functional and integrated TP fuselage shell
- The potential of TP material and its associated manufacturing processes including welding
- The integration of multiple system functionalities
- Industrial Readiness taking in account the requested HRP of 60-100 shipsets per month
- Advanced simulation capabilities

WHAT DID WE DO

NLR developed and applied a competitive manufacturing process using fast AFP layup of two 90° fuselage segments out of thermoplastic TC1225 PAEK/T700 uni-directional carbon fibre material on a layup tool at room temperature. The part was consolidated by the NLR team in an innovative consolidation mould (EMOTION CfP) using the research autoclave at the German Aerospace Centre (DLR) in Stade, Germany. The consolidated 180° fuselage skin was inspected at NLR using Thermography and delivered to the STUNNING partners for the integration of structures, interior and systems installation.

A significant weight reduction resulting from this integrated approach, based on advanced thermoplastic assembly principles like welding, will contribute to the environmental goals. Manufacturing costs and assembly times will be reduced and high production rates can be realized. To achieve the overall goals, ‘beyond state of the art’ technologies are developed and verified in dedicated tests up to TRL6.

STUNNING IS PART OF THE MULTIFUNCTIONAL FUSELAGE DEMONSTRATOR PROGRAMME HEADED BY AIRBUS



Project partners:
Industry (NL) : Fokker Aerostructures
Industry (EU) : Diehl
Research organisations : NLR
Universities : TUDelft, SAM|XL
Start : September 2017
Duration : 6 years

Project partners
Royal NLR (coordinator), DLR, VZLU, CIMNE, Fokker Aero-structures, EVEKTOR, Fokker Elmo, IMST, INVENT, TRACKWISE, L-UP

Start: June 2017
Duration: November 2020

ACASIAS:

Advanced Concepts for Aero-Structures with Integrated Antennas and Sensors

THE CHALLENGE

Aircraft drag reduction is an important issue for cleaner air transport. Up to now, satellite antennas are positioned on top of the aircraft in large protruding radomes. Within the European ACASIAS project, Royal NLR is investigating the possibilities to integrate antennas in the structure to create smoother outer surfaces.

THE SOLUTION

As part of the programme, NLR and the ACASIAS partners have developed new beam forming Ku-band antennas, but also new composite structures with integrated Antennas. The ACASIAS fuselage panel is made with a fibre placement machine, using carbon fibre prepreg. Fibre placement machines are often used for large surfaces with local patches. NLR has now optimised the process for the manufacturing of thin stiffeners. In the crossings of the lattice structure, half of the tapes are cut in one direction and half of the tapes are cut in the opposite direction, so no thickness build up occurs. In the middle of the panel, glass fibre prepreg is used to create a transparent skin for the internal antennas.

By doing so, antennas can be placed on the inside instead of on the top of an aircraft, reducing the total drag of the aircraft.

WHAT DID WE DO

The complete panel is cured on a female mould in an autoclave at a higher temperature and pressure. To support the stiffeners during this process no labour intensive tools were used. Instead of the common used high number of supporting blocks a silicon bag is developed. The silicon bag has the same pattern as the final panel with stiffeners. In this way, an affordable panel was made with integrated stiffeners. No man-hours are required for cleaning of tool blocks, bonding of stiffeners or the installation of fasteners to connect stiffeners.

HORIZON 2020

ACASIAS

Digital Twins:
mastering and optimising highly automated composites manufacturing processes

The aerospace manufacturing and production industries are increasingly challenged to be more competitive, and do more with less. To be able to comply with higher production rates, affordability and constant quality, high levels of automation are required for current-day manufacturing processes. This results in more parts meaning more process data to control and keep track of while the number of operators at the production floor has not grown.

THE CHALLENGE

The challenge is to be able to maintain overview of individual process steps, part quality and status of equipment. Advanced monitoring and inspection of automated processes by a Digital Twin (DT) of the physical manufacturing environment could help an operator to filter all the available data supporting timely detection of production flaws, first-time right production, product quality, and delivery reliability. Additionally, all the collected data can be used for many more purposes:

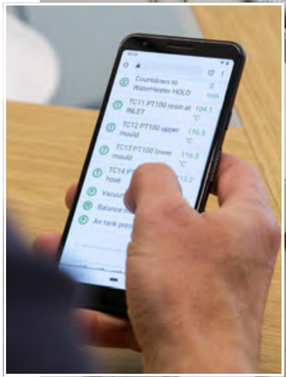
- Design and optimise the production facilities and manufacturing processes
- Optimise maintenance
- Digital threads, digital product passports, and managing data on behalf of certification

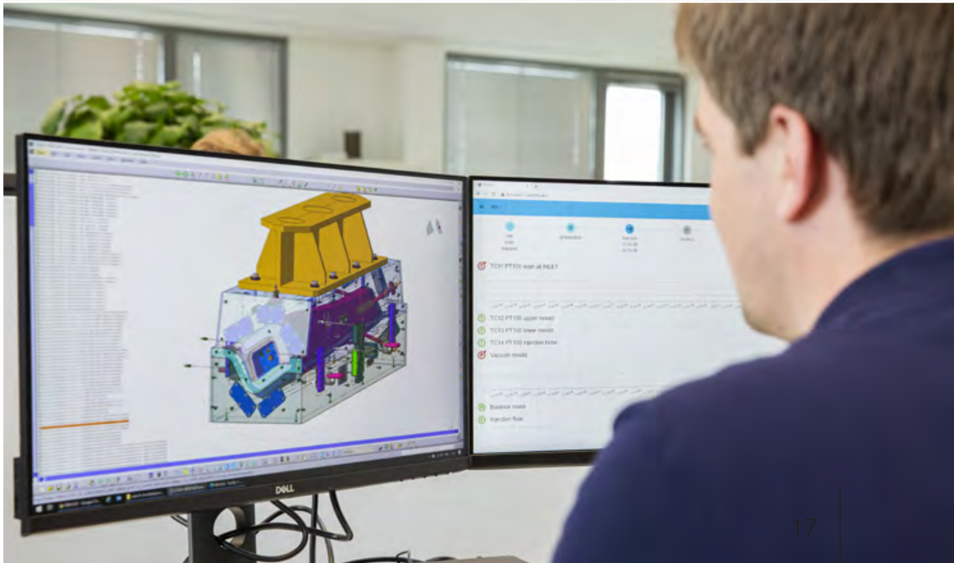
THE SOLUTION

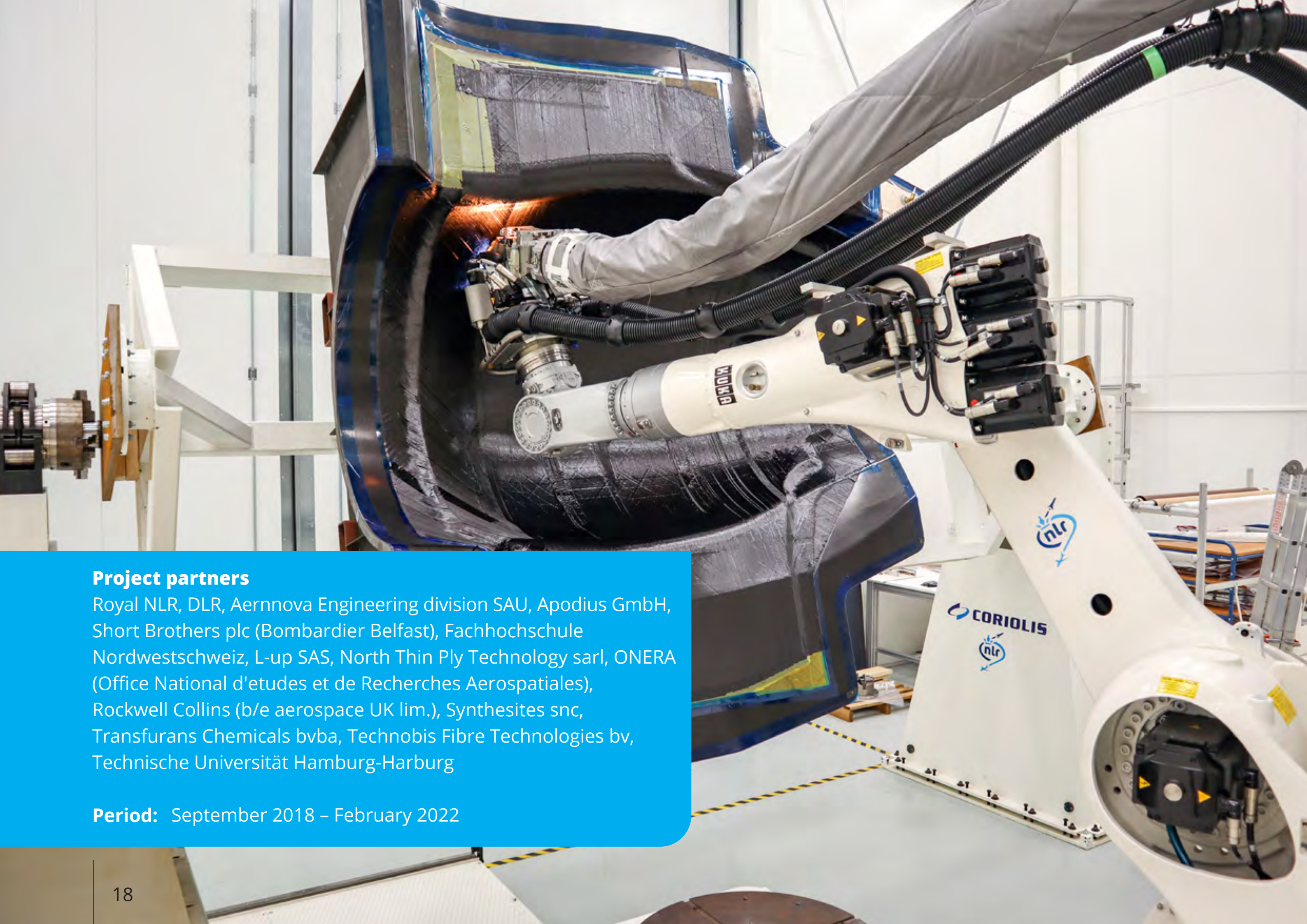
The Digital Twin compares the actual situation, going-on real-time process and product information of the physical manufacturing environment, against the expected and simulated behaviour and properties, thereby signalling deviations beyond thresholds. The DT raises situational awareness through dedicated dashboards and advanced interactive visualisation technology (e.g., VR, AR via handhelds, information projection on PT), enabling and supporting operator and mechanics to monitor, understand, inspect, adjust and repair. A DT can collect and organise data and statistics from processes, detect trends, and analyses data across process runs, to support process optimisation and condition-based predictive maintenance. The Digital Twin facilitates digitals threads and passports of the products and machinery.

WHAT DID WE DO

NLR developed a Digital Twin ecosystem and implemented this as test case on our Resin Transfer Moulding RTM manufacturing environment for validating and testing. By connecting actual live data from the industrial OT/IT technology and machine communication protocols, and a tailored integrated mix of IT technologies (e.g. AI/machine learning, data analytics, big data, cloud, etc.) and data sets, a digital replica (DT) of the physical RTM manufacturing environment was realised. The Graphical User Interface (GUI) of the DT and added handhelds/tablets to the work environment that advises the operator not only when on the production floor but also when the operator is taking a coffee break, have created a powerful "smart assistant". Besides, the Digital Twin is available in any place over the world remotely, in (near) real-time. It only visualises the relevant data in each phase of the manufacturing process and issues alarms or warnings which are triggered based on defined thresholds and predictions by the Digital Twin.







Project partners
Royal NLR, DLR, Aernnova Engineering division SAU, Apodius GmbH, Short Brothers plc (Bombardier Belfast), Fachhochschule Nordwestschweiz, L-up SAS, North Thin Ply Technology sarl, ONERA (Office National d'etudes et de Recherches Aerospatiales), Rockwell Collins (b/e aerospace UK lim.), Synthesites snc, Transfurans Chemicals bvba, Technobis Fibre Technologies bv, Technische Universität Hamburg-Harburg

Period: September 2018 – February 2022

SuCoHS:

Sustainable and Cost Efficient High Performance Composite Structures demanding temperature and fire resistance

The SuCoHS project focusses on new structural concepts with novel multi-material composites to provide high resistivity against thermal, mechanical and fire loading. In order to achieve the project objectives for sustainable and cost-efficient high performance composite structures, the SuCoHS concept focusses on the three main topics: design, manufacturing and operation.

THE CHALLENGE

The main challenge questions for this program are:

- Can we design and develop novel high temperature composite multi-material systems to enable new composite solutions for weight savings up to 15% and costs up to 17%?
- Can we develop new robust sensor systems to increase safety and aircraft availability and to decrease maintenance costs up to 15%?
- Can we demonstrate efficient automated tailored composite manufacturing to reduce time and costs for individual production steps up to 30%?

THE SOLUTION

Develop new materials and efficient manufacturing processes for fire and temperature resistant composites structures. Explore hybrid manufacturing processes, combining different materials and manufacturing technologies as well as sensor- and simulation-based adaptive process and quality control strategies. Perform manufacturing trials and customized material tests to guarantee performance of novel multi-material-systems.

WHAT DID WE DO

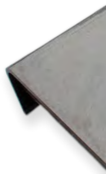
New high temperature and fire resistant composites were developed with improved toughness by making use of effects from resin modification, thin ply technologies and woven fabrics. New manufacturing technologies were developed to provide tailored multi-material preforms with specific functionalities (thermal conductors/ barriers, damage resistance, integrated sensors) to enable efficient manufacturing at minimum waste. New manufacturing technologies with integrated process and structural usage monitoring systems were validated and checked on reliability by manufacturing of representative critical details. All developed methods, designs and technology integrations were validated and demonstrated by NLR on thee use-cases: (1) High temperature nacelle component, (2) Composite aircraft interior shell and (3) Tail cone panel substructure.

This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme EU (Grant Agreement number: 769178)

Thermoplastic upper spar for an aircraft pylon by Automated Fibre Placement

The challenge: to find out whether thermoplastic materials can be used for really thick and large components, for example in aircraft. Parts of the aircraft engine pylon become very hot during normal use of the aircraft. For that reason, the pylons currently used are commonly made of titanium. Most of the parts, such as ribs and spars in the pylon, are made by forging and milling. A reduction of costs might be achievable if the titanium parts can be replaced by composite materials.

As part of a Dutch innovation programme TAPAS 2 (Thermoplastic Affordable Primary Aircraft Structure 2), NLR examined the manufacturing of a large and thick thermoplastic composite part using Advanced Fibre Placement and Cetex, TC1320 AS4D PEKK material of TenCate. Within this programme, a preliminary design was made for a pylon upper spar using finite element calculations. Mechanical tests were conducted with the material at higher temperatures and a first prototype was constructed. The prototype was made by fibre placement on a male mould and subsequently consolidated in an autoclave.



Based on developments in this programme, it was concluded that thick components can be made of thermoplastic materials with an automated manufacturing process, thus reducing weight and production costs. The material is usable at higher temperatures. This innovative process has great potential for thick U-shaped products in the aerospace sector. The technique is also usable as a replacement for a wide variety of products like wing spars, stabiliser spars and floor beams.

Customer: Netherlands Enterprise Agency - RVO
R&D: Royal NLR
Partners: GKN Fokker Aerostructures, TenCate, Airbus

CFRP Vinci Thrust Frame

THE CHALLENGE

The Ariane 6 Launcher will enter a very competitive commercial launcher market. New entrants to this market have reduced the launch price per unit mass payload by half (50%). As a consequence a key requirement for the development of the Ariane 6 is reduced recurring production costs and increased performance. Compared to Ariane 5 the production costs should be reduced by at least 50%. Cost reductions and performance increase (both stiffness and mass) shall be realized in proposed materials, manufacturing technologies, processes, procedures and optimization of the industrial organization.

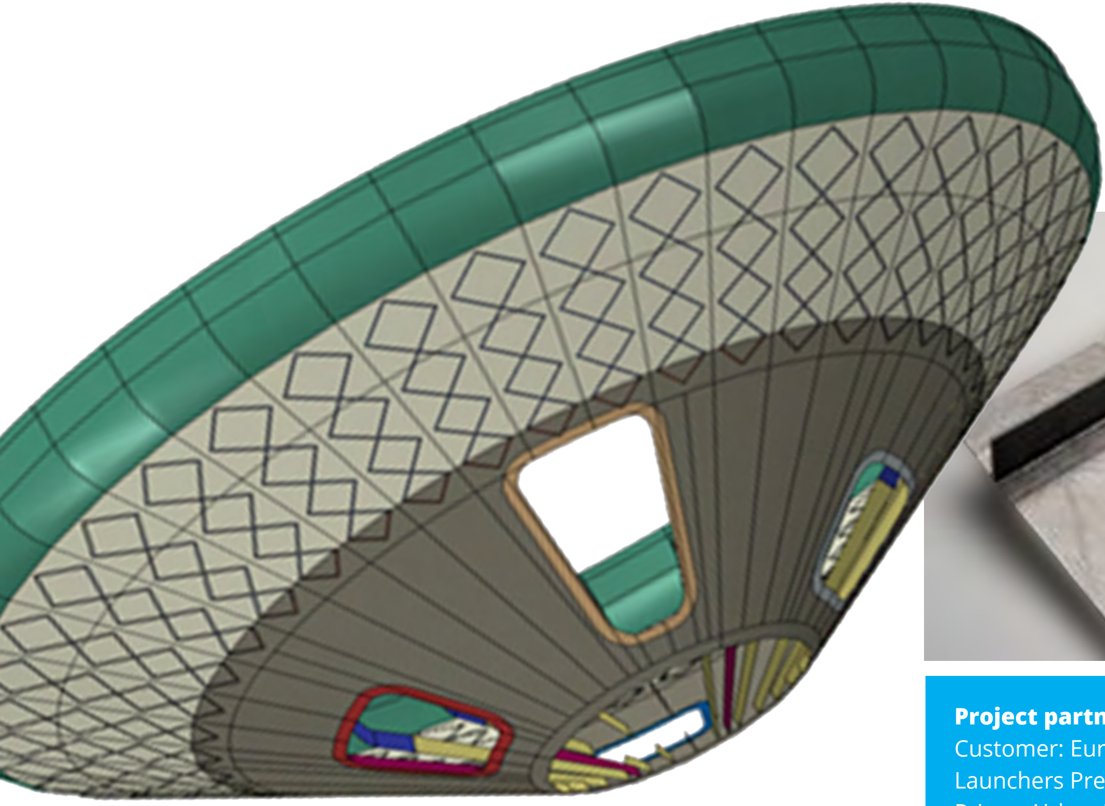
THE SOLUTION

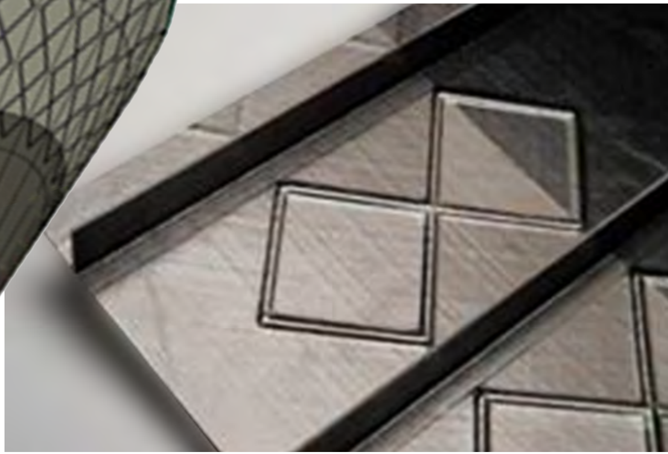
Currently, Engine Thrust Frames for launchers are made from metal. Previous programs showed that cost and weight can significantly be reduced by application of carbon fibre reinforced polymers in tailored ply architectures, processed by the automated fibre placement technology. Based on a reference finite element model provided by Airbus DS NL, NLR developed optimisation to reduce the amount of manufacturing steps and tooling and to create vector fields for the steered plies.

Dedicated local reinforcements are composed by smart overlapping in order to improve the buckling behaviour between the reduced amount of blade stiffeners. This innovative optimisation method in combination with the automated fibre placement technology will lower knock-down factors, reduce weight and minimize scrap material, resulting in reduction of material consumption and processing time in order to save manufacturing costs and increase the payload. In addition, fibre detection methods are integrated by Infactory Solutions into the automated fibre placement technology. Possible material defects like gaps, overlaps or twists are detected, analysed and written to a database. Corrections are applied in order to support first time right production for further cost reductions.

WHAT DID WE DO

This innovative design in combination with the automated fibre placement technology will lower knock-down factors, reduce weight and minimize scrap material, resulting in reduction of material and energy consumption, processing time and increased payload. Together with application of smart tooling, a snowball effect is created to reduce. A detailed track record of each component will be available in a manufacturing database, containing as-built information.





Project partners
Customer: European Space Agency – Future Launchers Preparatory Programme (FLPP)
Prime: Airbus Defence and Space Netherlands
Subs: NLR, Infactory Solutions

Start: 2018
Duration: 2 years

Project partners
Industry: (EU): PBS, MERL/ELEMENT, Piaggio, Grob, Evektor
Research organisations: Royal NLR, CIRA, ILOT, VZLU, INCAS

Start: 2011
Duration: 2016

ESPOSA:

Efficient Systems and Propulsion for Small Aircraft

THE CHALLENGE

Composites offer several advantages over metals to consider them for components in an aircraft nacelle design. The advantages: lower density, higher specific strength and stiffness, better corrosion resistance, better sound absorption characteristics and the possibility to reduce part count by moulding and curing of integrated structures. These advantages have led to increasing application of composites in jet engines over the last decades. However, this involved military and large civil aircraft engines. ESPOSA aimed at small aircraft composite nacelle development targeting:

- Cost reduction by 15%
- Part and weight reduction by 20%

THE SOLUTION

Development of new design approaches aimed at the realisation of advanced, higher temperature capability composite nacelle structures for small aircraft and leading to a cost effective manufacturing solution suitable for this class of aircraft. The advanced composites are to be used for nacelle components which traditionally could only be made using metals requiring significant thermal insulation resulting in a weight and cost penalty.

To achieve this goal several composite technologies were investigated in order to exploit the potential expressed by the most promising emerging materials and processes. Addressed topics:

- Composite materials and processes for high temperature nacelles
- Design engineering approach satisfying design and manufacturing constraints
- Test and validation high temperature performance

WHAT DID WE DO

Royal NLR in association with project partner CIRA and resin supplier Raptor Resins successfully employed a new vacuum resin injection method using the Bismaleimide (BMI) resin system. With project partners Piaggio, MERL, CIRA and GROB, NLR developed and manufactured a Carbon-BMI nacelle for the Piaggio P180 exceeding the targets for cost, part and weight reduction.

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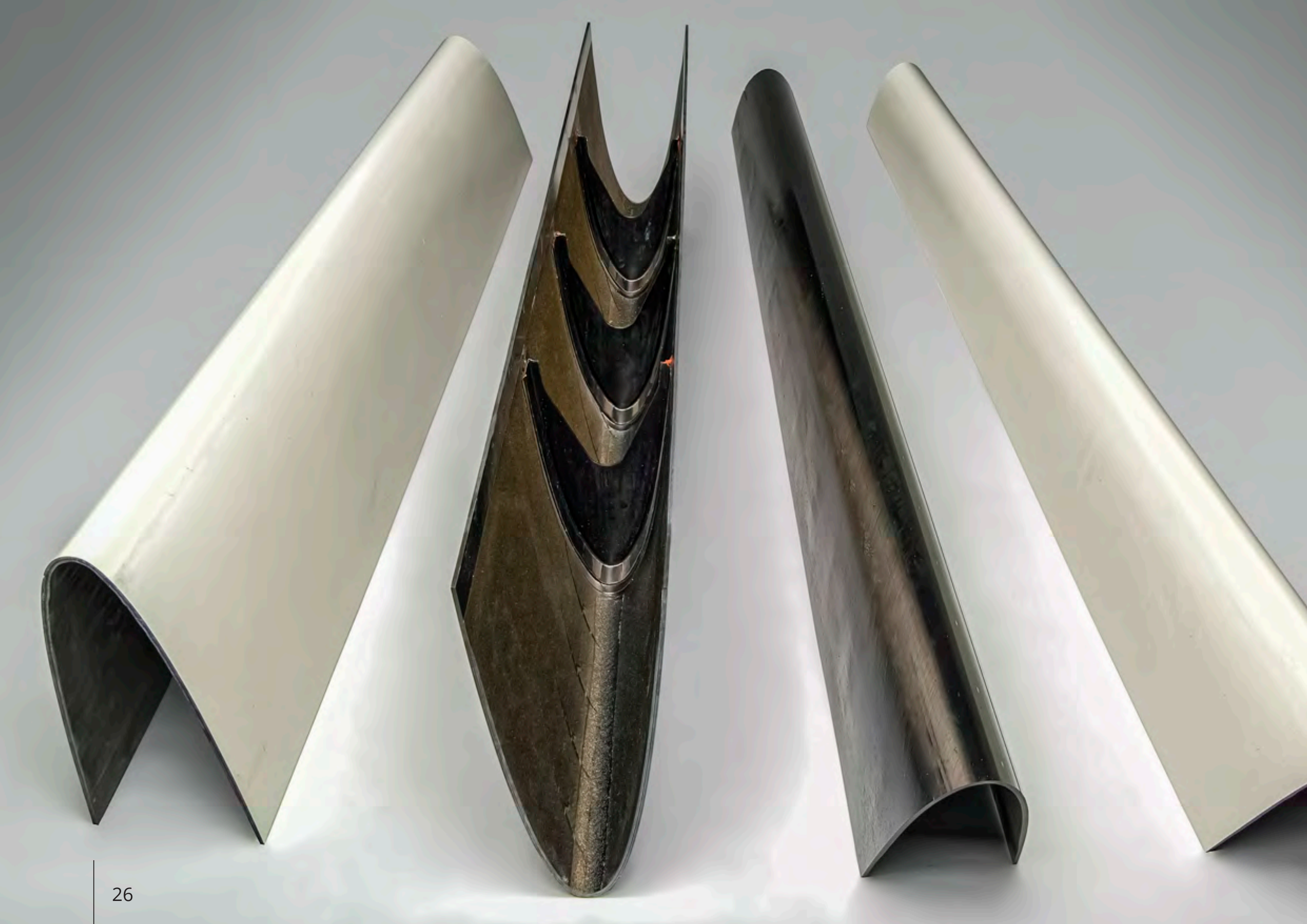


Leading edge manufacturing by fibre placement with dry fibres and with prepregs

THE CHALLENGE

The reduction of the CO2 emission is an important challenge for all industry and transportation sectors. To create a sustainable aerospace, several European research programmes are initiated within the Clean SKY 2 call. One of these programmes is titled Advanced Laminar Flow tAilplane, ALFA. A way to reduce CO2 emissions of aircraft is to lower the drag (the aerodynamic force that opposes an aircraft's motion through the air). This can be obtained by creating a laminar flow over the wing. A very smooth surface is required for a laminar flow.

THE SOLUTION

Within the ALFA programme Royal NLR is investigating different manufacturing techniques to create a leading edge without fasteners. One concept could be to bond the ribs to the leading edge skin. However, a fully bonded connection with fasteners is difficult to certify.

WHAT DID WE DO

Two alternative concepts were developed: a one shot vacuum assistant resin transfer moulding VARTM process and a prepreg autoclave curing process with integrated ribs. For both processes, the preforms were made by advanced fibre placement with respectively dry fibres of prepreg tapes. The ribs were preformed from flat blanks and vacuum press moulded to the desired 3D configuration. To create an anti-abrasive layer at the front of the leading edges, research was done together with Fichtner & Schicht for pre-treatments and electro plating of Nickel Cobalt layers.

Project partners
Topic manager: Dassault Aerospace
Industry: GKN Aerospace Fokker Aerospace
Research organisation: Royal NLR

Start: September 2018
Duration: 2 years

Project partners
Royal NLR

Start:	September 2018
Duration:	2 years

Composite blades for wind tunnel models: design and manufacturing

THE CHALLENGE

Composite materials have proven to be ideal for wind tunnel model blades. It allows to mitigate potential fatigue loading problems and enables extensive instrumentation. Furthermore, composite materials offer the possibility for aero-elastic tailoring, i.e. the structural design can be optimized in such a way that for example blade deformation and blade frequencies are tuned as desired. For rotating systems, it is essential that this aero-elastic behaviour is well understood prior to wind tunnel entry. Advanced FEM models of composite wind tunnel model blades and a good understanding of the complete manufacture process is important in this. How accurate can blade deformation and blade frequencies be predicted? To what extent is the extensive instrumentation influencing the aero-elastic behavior?

THE SOLUTION

Further insight in design and manufacture of composite wind tunnel model blades is developed via NLR and European funded research projects. Material and coupon tests are being performed to validate the basic material properties for the specific manufacturing process used to manufacture the final blades.

Coupon tests are also used to validate the modeling method and material models in an early stage of the design process. In parallel, prototype composite wind tunnel model blades are made with extensive instrumentation included.

WHAT DID WE DO

The test elements and prototypes are subjected to a variety of inspections and typically these inspections are tailored for wind tunnel blades. Geometry inspection, frequency measurement, deformation measurement and structural integrity check are standard procedure. This research will improve accuracy of the predicted aero-elastic behaviour and improves quality of the manufactured composite blades. More extensive instrumentation can be integrated in the blades, like:

- Integrated strain gauges, especially for load monitoring
- Flush mounted embedded pressure sensors,
  for aerodynamic and acoustic measurements
- Flush mounted LED's, for blade deformation measurement during rotation
- Integrated heating system, for laminar-turbulent flow transition measurement

A high rate automated manufacturing process for thermoplastic carbon composite bicycle frames

THE CHALLENGE

Carbon composite bicycle frames are currently manufactured by manual labour. Production in Europe can be more cost competitive compared to cheap labour countries by reducing manual labour as much as possible. An automated production process will lower the recurring cost of the frame production. In addition, the automated production enables a more constant and high quality of the manufactured parts.
Another factor which is influencing the recurring cost is the cycle time of the production process. Traditional thermoset composites take a long time to cure. Thermoplastic material can potentially be processed much faster allowing for high rate production. Furthermore, traditional thermoset composites are quite vulnerable for impacts damages. The newly developed FEATHER material on the other hand offers extreme impact resistance.

THE SOLUTION

FEATHER material is a new composite material technology offering extreme impact resistance, which is a revolution in the composites arena. Bicycle frames with FEATHER technology inside increase safety and reliability beyond what is now available.
Adding a certain percentage of steel to the composite eliminates the sudden, brittle fracture behavior.
NLR developed a dedicated press forming process for the FEATHER material, reducing the recurring manufacturing cost. This includes the design of so called tailored blanks to optimize the press forming process and limit the amount of scrap material.

WHAT DID WE DO

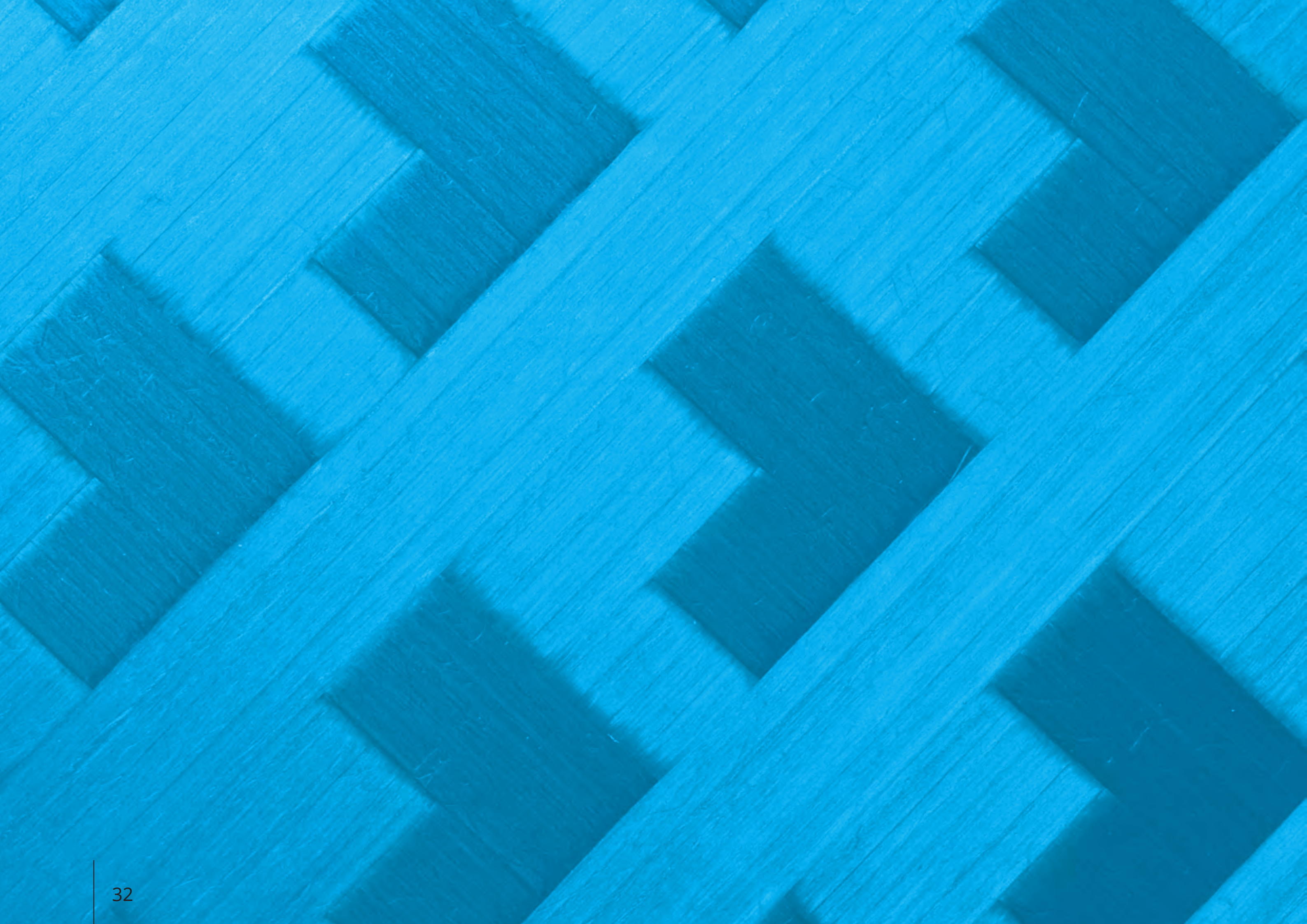
Royal NLR has extensive experience with the development of fast and automated manufacturing processes both for thermoset and thermoplastic composite materials. The press forming process was selected to competitively manufacture bicycle frames in Europe compared to the cheap manual labour production from Asia.

NLR has developed the press forming process and designed the press tooling which is critical for the final product quality. By developing a fully automated production process the manufacturing quality now is at a constant high level. The result of the project is that REIN4ced is now able to realize high rate production of bicycle frames competitively in Europe. Delivery to end customers has started.

REIN4CED
Engineering & manufacturing

Project partners
Industry: REIN4CED
Research organisation: Royal NLR

Start: 2016
Duration: 2020



Technology Readiness Level, R&D and industry

In the field of construction technology, NLR develops at almost all TRL levels from 1 to sometimes 8. To be able to implement the processes properly elsewhere, the goal is to work towards generic, flexible systems. A significant portion of the research nowadays takes place virtually using simulations, which speeds up lead time and reduces costs.

TRL stands for Technology Readiness Level, a method of estimating technology maturity of Critical Technology Elements (CTE) of a program (hardware, components, peripherals, etc) to integrate this technology into an operational system or subsystem. TRL 1 is the lowest level, where scientific research begins to be translated into applied research and development (R&D). For NLR, TRL 8 is the highest level, where the actual system is completed and qualified through test and demonstration. TRL 9 is the highest TRL level.

NLR in brief

One-stop-shop	Global player with Dutch roots	100+ Since 1919	Amsterdam, Noordwijk Marknesse, Rotterdam, Volkel
Innovative, engaged and practical	For industry and government	For fixed and rotary wing	690 employees
€ 91 M turnover	73% Dutch, 23% EU and 4% international	Active in 30 countries	Extremely high client satisfaction

About NLR

Royal Netherlands Aerospace Centre

NLR is a leading international research centre for aerospace. Its mission is to make air transport safer, more efficient, more effective and more sustainable. Bolstered by its multidisciplinary expertise and unrivalled research facilities, NLR provides innovative and comprehensive solutions to the complex challenges of the aerospace sector.

NLR's activities span the full spectrum of Research, Development, Testing & Evaluation (RDT & E). Given NLR's specialist knowledge and state-of-the-art facilities, companies turn to NLR for validation, verification, qualification, simulation and evaluation. They also turn to NLR because of its deep engagement with the challenges facing our clients. In this way, NLR bridges the gap between research and practical applications, while working for both government and industry at home and abroad.

Royal NLR stands for practical and innovative solutions, technical expertise and a long-term design vision, regarding their fixed wing aircraft, helicopter, drones and space exploration projects. This allows NLR’s cutting-edge technology to find its way also into successful aerospace programmes of OEMs like Airbus, Boeing and Embraer.

NLR enjoys working in a challenging and fast-changing field of research every day, assisting a wide range of clients. All of this knowledge benefits companies that are suppliers of large corporations like Airbus and Boeing and SMEs. Much of the knowledge of these new materials is also widely usable in other fields, such as the automotive industry, the maritime sector and the infrastructure, creating numerous spin-offs outside the aerospace industry.

For more information:

ir. H.G.S.J. (Bert) Thuis, Head of Structures Technology Department

p) +31 88 511 46 04

e) bert.thuis@nlr.nl

NLR Amsterdam

Anthony Fokkerweg 2

1059 CM Amsterdam

p) +31 88 511 3113

e) info@nlr.nl i) www.nlr.org

NLR Marknesse

Voorsterweg 31

8316 PR Marknesse

p) +31 88 511 4444

e) info@nlr.nl i) www.nlr.org