



Dedicated to innovation in aerospace

Fully engaged

Netherlands Aerospace Centre



Dedicated to innovation

Aerospace faces a great challenge. How does one accommodate growth without neglecting the conditions required by safety and sustainability? This demands satisfactory solutions based on applied research. NLR's mission is to render aviation safer, more sustainable and more efficient. To achieve this, NLR builds bridges between research and practical applications, and develops applied technology for and with industry and governments.

MULTIDISCIPLINARY

The Netherlands aerospace centre (NLR) is *the independent knowledge organisation in the field of aerospace* in the Netherlands. Since its founding in 1919, NLR has pursued a multidisciplinary approach and close collaboration with government and corporations. A concentration of expertise focused on developing innovative technologies for the aerospace sector. From an initial idea to prototype. With the objective of bolstering the competitiveness and innovative capacities of the government and Dutch industry.

CHAIN APPROACH: ONE STOP SHOP

NLR is engaged in all phases of aircraft and aircraft component development and use, spanning the full spectrum of RDT&E (Research, Development, Test & Evaluation), including all key research stages, from validation, verification and qualification to evaluation. NLR is unique for its chain-like approach, in combination with large facilities, including windtunnels and flight simulators. In this NLR functions as a 'one stop shop' for the aerospace sector: from aerodynamic research to flight operations. From human factors and flight test series to aircraft maintenance. And from policy advice to certified products.

PRACTICAL INNOVATION

At NLR, some 600 people are engaged in every aspect of aviation and space. Whether at work in NLR facilities or elsewhere, our highly educated and committed personnel are 'dedicated to innovation' in aerospace, translating fundamental research into concrete and practical solutions for today and the future. They render knowledge accessible for governments and the corporate sector, from multinationals to SMEs.

FROM SMART IDEA TO SMART MODEL

NLR owes its unique position to our personnel, who possess the latest knowledge and have access to advanced testing facilities. Through an international partnership, NLR operates the DNW German-Dutch Wind Tunnels (an ultramodern windtunnel facility and joint venture with DLR, NLR's German partner institute). Here is where NLR tests the complex aircraft models it has developed in-house. No wonder that Airbus found its way to DNW, with all its various aircraft types in model form. In addition to Airbus, NLR and DNW's client network includes other leading names in the aircraft industry, including Boeing, Lockheed Martin, Bombardier and Fokker.

NLR, A GLOBAL PLAYER WITH DUTCH ROOTS....

Our roots are in the Netherlands, but the world is our playing field. In addition to the countries of Europe, which have historically pursued aircraft development programmes, new players are entering the market. NLR is therefore developing more projects in emerging economies, such as Brazil, China, South Korea and the United Arab Emirates. NLR has for example recently designed and built an advanced wind tunnel model of the KC-390 for EMBRAER, the Brazilian aircraft manufacturer.

EUROPEAN COLLABORATION CREATES ANSWERS

Aviation is a field that transcends borders. Hence, NLR, together with partner organisations, like Air Traffic Control Netherlands (LVNL) and Fokker, participates in major EU projects, including SESAR (Single European Sky ATM-Research) and Clean Sky 2. Clean Sky is focused on rendering European aviation sustainable while maintaining its competitiveness. With the knowledge gained in such programmes, NLR can provide answers to questions posed by government and industry in the medium- and long-term.

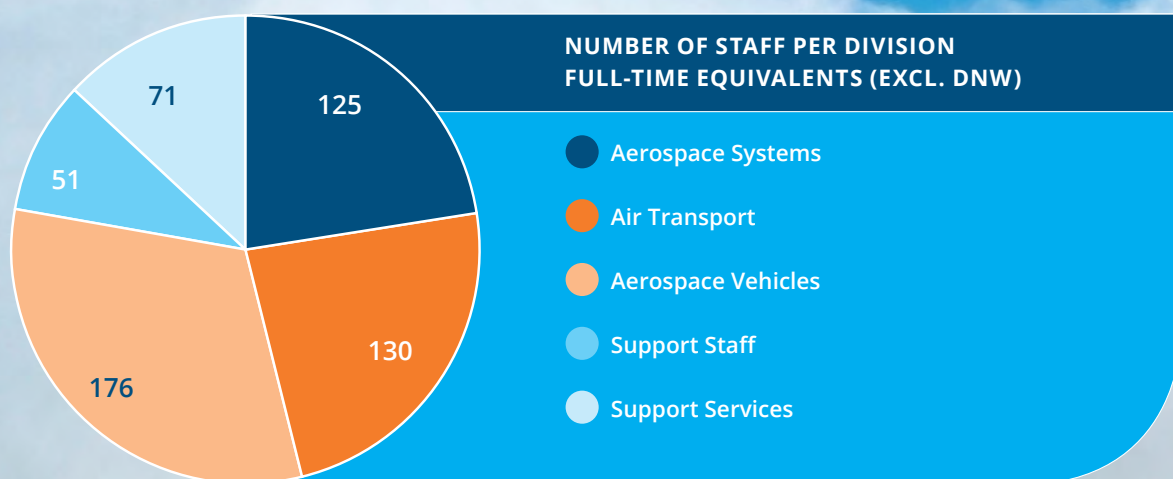
NLR did
wind tunnel tests
and measured wing
deformations
for the A380



Facts and figures

Turnover in 2014 in euros:	73 million	
Contracts	56 million	76 %
Demand-driven programs	17 million	24 %

Breakdown by sector		
Industry	28 million	39 %
Civil Aviation	15 million	21 %
Defence-Government	26 million	35 %
Space Technology	4 million	5 %



Home to many markets

NLR IS ORGANISED AROUND THESE FIVE SECTORS:

CIVIL AVIATION

NLR supports civil aviation organisations that work to increase operational capacity, safety and efficiency, while striving to decrease the environmental impact of aerospace operations. NLR is therefore involved in the development of quieter and more fuel-efficient take-off and landing procedures, cleaner engines, and new approach procedures involving satellite navigation.

DEFENCE AND SECURITY

From policy formation, operational support and consultancy to trainings, NLR conducts various activities related to military defence. NLR thereby contributes to the protection of soldiers during international peacekeeping missions.

DEFENCE AND SECURITY INDUSTRY

The government and the defence industry can turn directly to NLR for assistance with establishing or analysing regulations and the development of technologies for testing, qualifying or certifying products and services.

CIVIL INDUSTRY

NLR also provides support to the civil aviation industry, in research areas that include aerodynamics, aero-acoustics and aeroelasticity, or the design and development of composite aircraft components, such as landing gear. Wind tunnels and flight tests, advising and training... NLR has all these competencies in-house.

SPACE

NLR also serves the space sector with capabilities that include the design of satellites and development of heat transfer systems, or specialist knowledge in the field of earth observation and navigation. In partnership with ESA, NLR is contributing to the development of a European satellite-navigation system.

SAFETY

NLR HAS CONSOLIDATED ITS SAFETY EXPERTISE IN ITS OWN AIR TRANSPORT SAFETY INSTITUTE (NLR-ATSI), AN INTERNATIONAL KNOWLEDGE CENTRE FOR THE FIELD OF AVIATION SAFETY. IN THIS CONTEXT, NLR ENGAGES IN THE INTRODUCTION OF NEW TECHNOLOGIES, THE IMPLEMENTATION OF MODIFIED FLIGHT OPERATIONS, AND THE INTEGRATION OF REMOTELY PILOTED AIRCRAFT IN THE CIVILIAN AIRSPACE.

In addition, NLR also analyses the possible consequences that new high-rise buildings or wind turbines near airports can have for aviation safety. NLR-ATSI moreover provides services in areas ranging from accident investigations, airline fuel efficiency, fatigue risk management and procedure design, to runway safety, safety assessment and safety management.

A passenger airplane is refuelled in the air, this can reduce fuel consumptions and CO₂ emissions



NLR brings the future closer

With technological innovations coming in quick succession, it is better to anticipate than react and to collaborate is more effective than working alone, especially given that new technology is often applicable in multiple sectors. What works in space can also work in aviation, and vice versa. And what is developed for military purposes can also offer solutions for civil aviation.

AERIAL REFUELLING FOR CIVIL AVIATION

The military has used aerial refuelling for many years now. In the European context, NLR is conducting research to determine if civil aviation can reduce fuel consumption and CO₂ emissions on long-distance routes. Pilots were presented with various scenarios during a series of flight simulations. This experiment revealed that a passenger aircraft could indeed be safely refuelled in the air even during turbulence, poor visibility or when an engine failed.

SATELLITE DATA FOR SAFER FLIGHT

Many satellites orbit our planet for the purpose of telecommunications, scientific research, earth observation and navigation. NLR is directly involved with navigation systems, such as Global Navigation Satellite Systems (GNSS), EGNOS (European Geostationary Navigation Overlay System) and Galileo (Europe's civilian answer to the USA's GPS). NLR possesses the expertise required to interpret this data and render it accessible for end users in the aviation and military sectors. This data moreover increasingly finds its way into the railway transport, energy, agro-food and water management sectors.

SAFE FLIGHTS OF UNMANNED AIRCRAFT

How can one safely integrate unmanned flight systems, or 'Remotely Piloted Aircraft Systems' (RPAS), in the airspace? NLR can answer this question, thanks to its comprehensive knowledge of airspace integration and the associated regulatory requirements.

In addition, NLR also has research facilities for Air Traffic Management (ATM), including flight simulators, a research aircraft, and its own RPASs. Commissioned by the Ministry of Defence, NLR for example conducts research focusing on how one can deploy RPASs to collect images during tactical helicopter missions and thus improve the flight team's 'situational awareness' during air operations.

CENTRE OF EXCELLENCE

In December 2013, NLR had the honour of being the first to fly a test route for the European Space Agency (ESA) and Eurocontrol based on the first four operation satellites of the Galileo system. In 2014, NLR's research plane also successfully conducted a new approach procedure based on satellite navigation.



NLR's Pilot Plant:
high tec manufacturing
technologies for
composites

Innovation in practice

Without innovation there is no aerospace industry. This also applies to the highly internationally orientated Dutch aviation industry. NLR is proud to contribute to this industry's innovative capacities. Today's innovations are often not ready for immediate application. Knowledge and expertise are required to convert sophisticated ideas into useful techniques and practical applications.

FIELD LAB FOR APPLIED RESEARCH

NLR's modern facilities serve to contribute to the innovative and competitive capacities of the aviation and aerospace industry. An example of this is NLR's Automated Composite Manufacturing (ACM) Pilot Plant, where research is conducted into automated composite manufacturing technologies. The Field Lab, opened in 2015, is the result of a Public-Private Partnership between Fokker Landing Gear and NLR, in close collaboration with the Ministry of Economic Affairs and regional governments. The Field Lab is thus the epitome of the 'golden triangle' between industry, knowledge organisations and government.

EFFECTIVE TRAINING EXERCISES WITH VIRTUAL OPPONENTS

NLR, together with Airbus Defence and Space, developed an ET-system (Embedded Training) for Lockheed Martin's F-35 Lightning II. This Embedded Combat Aircraft Training System (E-CATS) can simulate virtual opponents and other players during a flight in a training scenario and will become a standard system in the F-35 cockpit. Pilots of fighter aircraft can now practice complex conflict scenarios more efficiently and at a lower cost. In the National Technology Project 'Smart Bandits', NLR developed tactical training scenarios involving virtual and intelligent enemies at NLR's Fighter 4-Ship. This research simulator can simulate collective tactical operations for up to four fighter aircraft.

MEASURING AT THE DECISIVE MOMENT

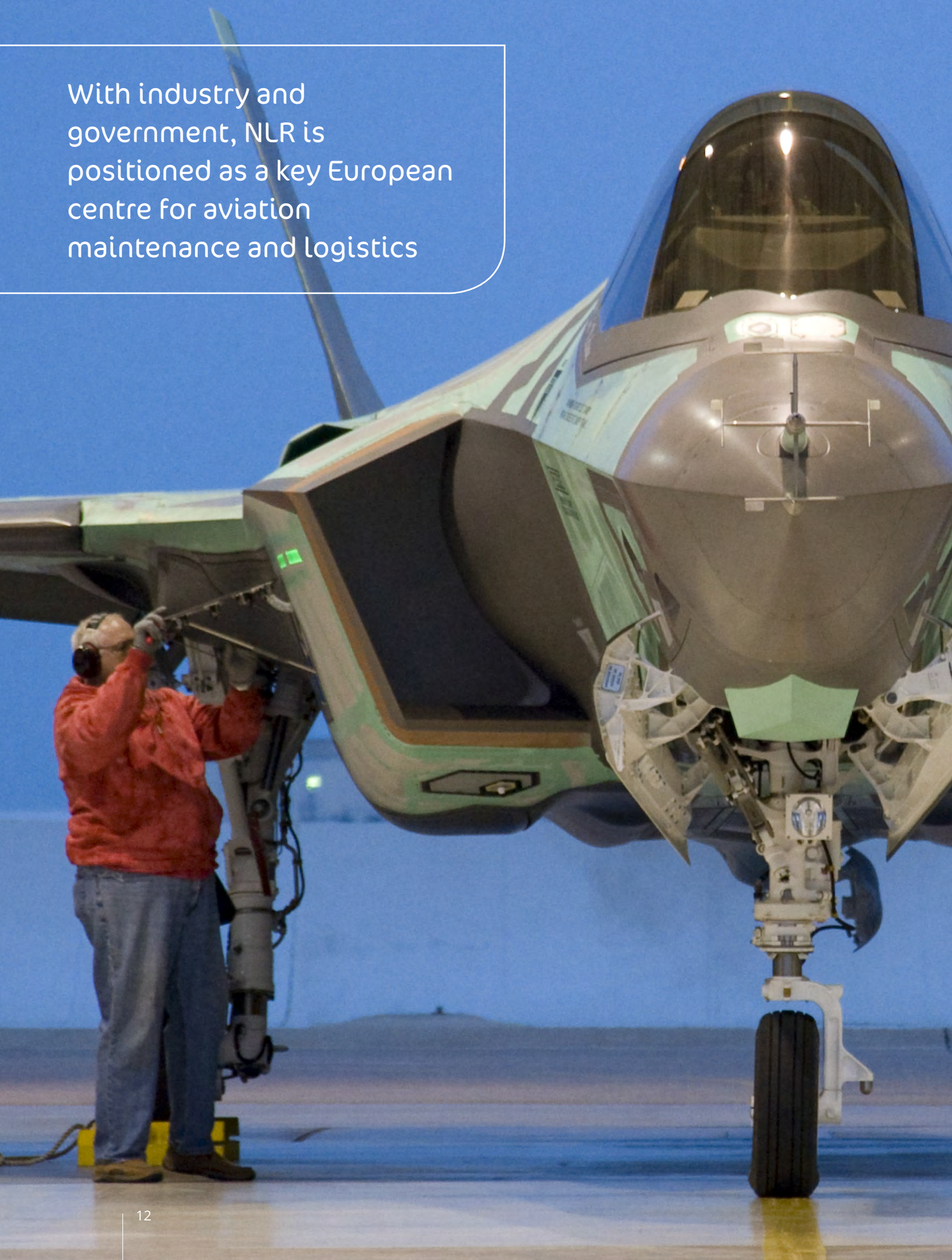
What impact does a lightning strike have on an aircraft?

To research this, Airbus deployed a measuring system, developed by NLR and TU Eindhoven, during flight tests of their new aircraft, the A350 XWB. For this NLR developed advanced measurement electronics that converted electrical signals into digital data. The developers of the instrumentation successfully devised a system that did not fail at the decisive moment, performing accurate measurements during a lightning strike.

3D METAL PRINTING

NLR has an ultramodern Selective Laser Melting (SLM) machine, or 3D-metal printer. SLM is a 3D production method that offers great benefits, such as less waste, weight reduction and greater design freedom. In 2014, NLR initiated a programme for Dutch industry and SMEs to certify metal printed products. This programme, conducted as a Joint Industrial Participation (JIP), adheres to the national government's Top Sector policy.

With industry and government, NLR is positioned as a key European centre for aviation maintenance and logistics



NLR, strategic partner of government and industry

NLR strives to be and remain a strategic partner for the Dutch aerospace and defence industries. NLR and industry work together to infuse knowledge into products intended for the commercial market. For governments, NLR provides the building blocks to render aviation policy safer, more efficient and environmentally friendly.

INCUBATORS

NLR collaborates extensively with companies in the aerospace sector. Consequently, the Dutch company, Airborne Technology Centre, opened an office in the Composites Manufacturing Technology Centre (CMTC) in 2014. This centre, which is part of the CompoWorld Incubators in Flevoland, enables Airborne Technology Centre to produce diverse and highly advanced components for the aircraft industry.

PREPARATION FOR THE ARRIVAL OF THE F-35

In partnership with industry and government, NLR is positioned as a key European centre for aviation maintenance and logistics. With the arrival of the F-35 Lightning II fighter plane, the Ministry of Defence is focused on the introduction and operational deployment of this new aircraft, for which NLR's technical and operational expertise is indispensable. NLR moreover supports the Defence Materials Organisation (DMO) and Air Force Command in areas that include airworthiness, maintenance, training, environment, mission-support and electronic warfare deployment of the F-35. Additionally, NLR is engaged in preparing the F-35's maintenance program, with the tools made for managing the maintenance (Prognostic & Health Management) the first tangible results.

SPECIAL INTELLIGENCE FOR THE NH90 HELICOPTER

In collaboration with Fokker Landing Gear, NLR developed the controller for the NH90 helicopter's nose-wheel steering system. The prototypes were built and qualification tests conducted. Moreover, NLR developed composite components for the NH90's landing gear. The metal trailing arm was constructed with the help of NLR's 'Resin Transfer Moulding' (RTM). With this special production method for fibre-reinforced plastics, complex shapes can be made in just one production step.

ONE STOP SHOP FOR THERMOPLASTICS

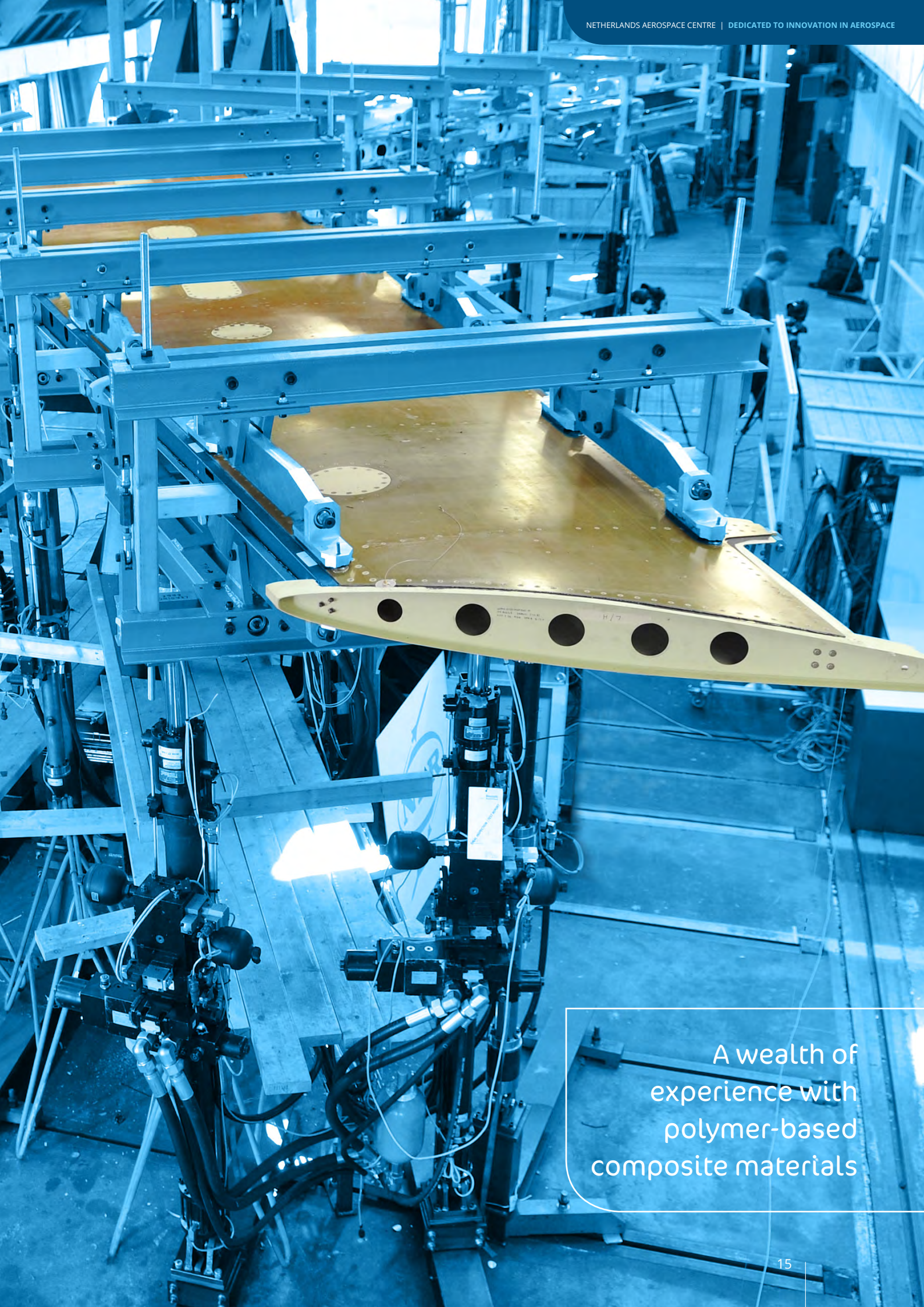
From aerospace, the car industry and maritime sector, to the transport and medical fields, many sectors are searching for lighter and more sustainable materials and a lowering of costs. As part of the TAPAS consortium (Thermoplastic Affordable Primary Aircraft Structure), NLR has a wealth of experience with polymer-based composite materials. In this consortium, Dutch companies and knowledge organisations collaborate with Airbus on the application of thermoplastic composites.

NLR's contributions include the development of a body component, an engine mount and a wet box structure. The latter is part of the horizontal stabiliser, consisting of an upper and lower skin, with front and rear ribbed beams in between that can potentially be filled with fuel. NLR is also developing 'integrated design systems' for the design of structures. NLR subsequently conducted full scale tests on one of the components.

NLR'S SERIOUS GAMES: 'USEFUL FOR LEARNING TO COLLABORATE'

NLR researches the applicability and effectiveness of Serious Games as tools for teaching non-technical skills in the areas of leadership, collaboration and change processes. An example of this is AeroGame, a game that NLR and partners developed for the purpose of rendering the process of change in Air Traffic Management (ATM) more manageable. In 'playing' this game, the participants (involved in ATM) learned how to better prepare for the planned changes to the ATM system that were required to improve the capacity and efficiency of flying.

The first participants in AeroGame were the stakeholders of airports, airport companies and governments. They found serious gaming to be a useful tool for supporting the process of change. The participants had this to say: "It is an innovative way of working together", "It supports motivation", "AeroGame has great potential to get all stakeholders involved in the future development of ATM".



A wealth of
experience with
polymer-based
composite materials



A new technology for cockpit displays provides better contrast and greater clarity

NLR makes more from knowledge

To measure is to know, but what is subsequently done with this knowledge is a step that clients take together with NLR. NLR renders knowledge applicable in both civil and military aerospace. From safe take-off and landing procedures to strategic and technical solutions for the Ministry of Defence, NLR and its multidisciplinary approach offers synergy in many fields.

CLEARER COCKPIT DISPLAYS, EVEN IN BRIGHT SUNLIGHT

NLR and its national and international partners have developed a new technology for cockpit displays. This new technology (based on colour conversion by remote phosphor) provides for better contrast and greater clarity. To test the optical properties of the new display, NLR conducted validation research with its research aircraft, the Cessna Citation. At an altitude of ten kilometres, and in extremely bright sunlight, the displays remained perfectly readable.

DEFENCE AND GOVERNMENT SECURITY

NLR is the most important Dutch knowledge supplier for both civilian and military aerospace. The aim of the long-term, comprehensive collaboration between NLR and Ministry of Defence is to use innovation as a means of achieving the greatest possible operational effectiveness. NLR, with its unique knowledge and facilities, supports the Ministry of Defence in maximising the operational deployment of military personnel and materials, lowering the maintenance and repair costs and reducing the operational costs.

SYNERGY OF SPACE AND AVIATION

Satellite systems play an increasingly important role in the efficient and environmentally friendly operations of civilian and military aircraft fleets. NLR is involved in the development of satellite systems and participates in the Galileo and IRIS programmes. The ESA-initiated IRIS programme is focused on supporting air traffic management (ATM) with satellite communications.

SMART BUYER, THANKS TO NLR

The Netherlands is in need of strategic tanker-transport aircraft, and therefore participates with other European countries in the European Defence Agency (EDA) project: pooled procurement and operation of a common international fleet. NLR's role in this project is to provide the EDA and Defence Materials Organisation (DMO) with independent knowledge pertaining to the technological and operational aspects of tanker-transport aircraft. This will subsequently strengthen the EDA and Ministry of Defence's position as a 'smart buyer'.

MEASUREMENT METHODS ESPOUSED INTERNATIONALLY

NLR also works to improve airport operations through collaborative efforts involving the various parties at an airport, of which a fine example is the agreements reached regarding the schedules for arriving and departing aircraft. In addition, NLR develops computer models that can accurately determine noise disturbance levels. NLR's measurement methods are the regulatory standard for aviation in the Netherlands. Moreover, airports around the world also use these noise and risk contours, including, for example, Indira Gandhi International Airport in New Delhi, where (on behalf of the Indian government) NLR determined the aircraft noise levels for the development of an improved noise disturbance policy and enforcement system.

IN SERVICE OF SAFETY: IN THE AIR AND ON THE GROUND

NLR has everything it needs in-house to develop flight procedures, routes and air space classifications. Using the real-time simulation facility (NARSIM) for Air Traffic Management (ATM), NLR can determine and validate whether the expected benefits are achievable and the solutions feasible from an operational perspective. New flight procedures can then be gradually introduced following a step-by-step plan. Proof of this is for example the 'Runway Incursion Alerting System Schiphol' (RIASS), an important extra safety net for preventing potential collisions from occurring on landing and take-off runways. This unique warning system for Amsterdam Airport Schiphol's air traffic control tower was jointly developed by NLR and Air Traffic Control the Netherlands (LVNL).



Real-time
simulations for
air traffic
management



NLR's ultramodern facilities are open to industry, SME's and government

Facilities bolster innovative strength

NLR has unique, large-scale and strategic research facilities that - together with the knowledge and know-how of our personnel – provide the foundation for the applied research conducted at NLR. Industry and SME's use these facilities, and in this NLR serves to bolster the innovativeness, competitiveness and effectiveness of government and industry.

FLIGHT AND MISSION SIMULATORS, INFUSED WITH KNOWLEDGE

NLR's flight simulators allow new flight procedures for a range of aircraft types to be studied. The simulators have a modular structure, and with all the requisite software available within NLR, the simulations can be rapidly adapted.

AIR-TRAFFIC SYSTEM-SIMULATORS: ATM-system, NARSIM Radar - an air traffic control centre / radar simulator NARSIM Tower.

FLIGHT SIMULATORS AND MISSION SIMULATION FACILITIES: GRACE, APERO, Fighter 4-Ship (F4S), Helicopter Pilot Station (HPS), UAS-lab and Helmet Mounted Display (HMD).

WINDTUNNELS, MORE THAN JUST AERODYNAMICS

Determining the airworthiness properties of aircraft or helicopters, the aerodynamics of cars, trucks or bridges? NLR possesses various wind tunnels, operated by DNW, a joint venture with the German partner institute DLR. This joint venture also provides NLR with access to wind tunnels in Germany.

WINDTUNNELS: Operated by DNW: The Large Low-speed tunnel (LLF), Low-speed tunnel (LST), the High-speed tunnel (HST) and the Supersonic Tunnel (SST).

FLIGHT TESTS

Cessna Citation, NLR's research plane, offers clients the opportunity to test new technologies in practice. NLR has therefore conducted flight tests focusing on sliphook calibration for the Flight Test Centre of a major Chinese aircraft manufacturer.

RESEARCH AIRCRAFT: Cessna Citation II.

FACILITIES FOR NEW MATERIALS

NLR has long distinguished itself in the area of new materials and their product processes. This is manifest in a new programme that allows Dutch industry and SMEs to receive certification for 3D metal print products. In addition, the recently opened composite Field Lab, where the focus is on the research of automated manufacturing processes for composites, is a fine example of how NLR (re)develops technological expertise.

PROTOTYPE MANUFACTURING AND TEST FACILITIES: Tow Placement Robot, Resin Transfer Moulding machine (fibre resin injection), Fibre Placement Machine (thermosetting polymers), Selective Laser Melting Robot (3D printer metal), structural testing facilities (incl. the Test Hall), lifespan monitoring of aircraft.

GIVING SPACE TO SPACE TECHNOLOGY

NLR has comprehensive knowledge of space systems engineering, including mission analysis and satellite positioning and orbiting regulations. NLR can for example deploy this expertise for the development and testing of small satellite platforms. NLR's Space System Simulation Laboratory focuses on simulating space and the development of test systems. In addition, NLR has various test facilities for supporting the development of aerospace systems and components.

AEROSPACE SYSTEMS-FACILITIES: Seeker Test Facility, aerospace- and geo-information, optics, noise- and vibration-tests, eCFD (flow simulation).

AERO-ENGINEERING TEST FACILITIES: Aero Engineering Facility, Electromagnetic quantities lab, precision mechanical devices, environmental testing (high/ low temperature, dampness, salt spray, decompression, altitude, waterproofing).

NLR, a global player
with
Dutch roots





Dedicated to innovation in aerospace

**NLR'S CUTTING EDGE TECHNOLOGY FINDS ITS WAY
INTO AEROSPACE PROGRAMS OF CIVIL AND MILITARY
SECTORS.**

- ATM infrastructure and flight procedures
- Maintenance, repair and overhaul (MRO)
- Structures & materials
- Certification and qualification
- RPAS/Drones
- Satellite navigation
- Earth observation and remote sensing
- Simulation and training
- Avionics
- Helicopters
- Military defence systems
- Safety

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