**Nationaal Lucht- en Ruimtevaartlaboratorium**

National Aerospace Laboratory NLR

# NLR Annual Report **2008**

***NLR** - Dedicated to innovation in aerospace*

## WHAT IS NLR?

- The National Aerospace Laboratory (NLR) is the key center of expertise for aerospace technology in the Netherlands;
- NLR employs around 700 people, including 300 with a Master degree and 150 with a Bachelor degree;
- NLR's facilities include wind tunnels (for testing aircraft produced by Airbus, Lockheed Martin and others), simulators (for testing the safety of new flight procedures, among other things), and a laboratory aircraft;
- NLR's revenue amount to € 74 million, with contracts accounting for € 54 million.

AMREF FLYING DOCTORS
betere gezondheid in Afrika

NLR supports AMREF Flying Doctors

INDUSTRY

MOBILITY

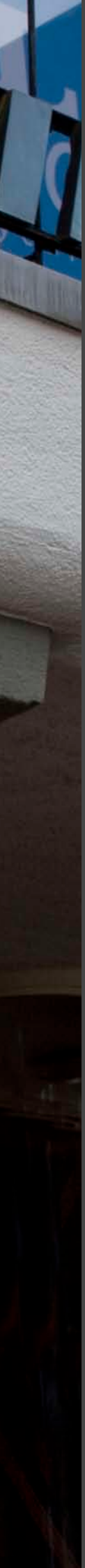
SAFETY

ENVIRONMENT

DEFENSE & PEACEKEEPING MISSIONS

ARIE KRAAIJEVELD – CHAIRMAN OF THE SUPERVISORY BOARD

*"It is our duty to ensure that we make our knowledge and testing facilities available to the Dutch aviation sector in a cost-effective manner"*



# FOREWORD

Aviation policy is increasingly shifting towards the international arena. NLR has in recent years intensified its participation in European programs and further strengthened its European partnerships. But we can and must do better. How can we integrate our knowledge even more effectively and utilize our costly facilities more efficiently within the European context? To ensure that the Netherlands gains maximum benefit, NLR and the Dutch Ministry of Transport, Public Works & Water Management must stand shoulder to shoulder as they make their way from The Hague to Brussels. This demands continuous coordination of our efforts.

In the past year, we took a major step forward in the cooperation between NLR and the Ministry of Transport, Public Works & Water Management, resulting in frequent consultation at the executive level. NLR staff have been seconded to the Ministry, and we discuss with the Ministry their need for knowledge development at NLR. This close cooperation resulted in, among other things, strong ministerial support for NLR's participation in European programs such as the Single European Sky ATM Research program SESAR.

There is ongoing pressure from society to reduce environmental impact resulting from air transport. That is why NLR is actively involved in European programs, such as Clean Sky, that aim to achieve cleaner and more efficient air traffic. In the past year, our institute also supplied important material for the Alders Commission's report on noise abatement around Amsterdam Airport Schiphol. We also researched the issue of noise resulting from the deployment of AWACS aircraft, and we are doing more and more research for other airports. In short, noise is our area of expertise.

In 2009, the Knowledge and Innovation Agenda for Air Transport will be presented under auspices of the Ministry of Transport, Public Works & Water Management, working in close cooperation with the Ministries of Economic Affairs, Defense, and Housing, Spatial Planning & the Environment. The aviation sector will formulate innovative projects for this agenda, which will be partly funded by the parties themselves. NLR is playing a crucial role in this process, because it is our duty as a Major Technological Institute to ensure that we have the best possible knowledge and testing facilities, and that they are made available to the Dutch aviation sector in a cost-effective manner.

Internally, NLR has its house in order. Our works council has been further professionalized, and employment terms and conditions have been further improved. Externally, we are also on the right track. Our efforts to become a more market-driven organization have resulted in even greater client satisfaction, which is becoming increasingly important. And this will certainly apply in the coming years, when our sector is likely to be faced with the consequences of a stagnating economy.

In 2009, I will also be actively seeking a suitable successor for Fred Abbink, who will retire as general director of NLR at the end of the year.

Amsterdam, June 2009

Arie Kraaijeveld
Chairman of the Supervisory Board

# INTRODUCTION


FRED ABBINK – GENERAL DIRECTOR

*"We convert money into knowledge, and knowledge into money"*

# COOPERATING FOR SAFETY, SUSTAINABILITY AND COMPETITIVE CAPABILITY

**NLR is dedicated to helping the Netherlands achieve greater safety, sustainability and competitive capability in its civil and military aerospace industry. NLR researches, develops, tests, validates and evaluates on behalf of many Dutch and international organizations. We offer excellence in these activities, according to an independent International Knowledge and Technology Audit conducted in 2008.**

We served more than 200 different clients in the governmental and industrial sectors in 2008. Our governmental clients included the Dutch Ministries of Transport, Public Works & Water Management, Defense, Economic Affairs, and Education, Culture & Science. Our industrial clients are mainly active in the Dutch and European aerospace industry. We derived three quarters of our revenue in 2008 from these contracts. In our increasingly competitive market, we are becoming more and more succesful in offering the best product at a competitive price. As a result, we once again ended the past year with a positive result.

NLR has been assigned a key role in aerospace in the Netherlands. Twenty-five percent of our revenue in 2008 derived from demand-driven program's funded by the Netherlands government. These programs are used to improve NLR's expertise and our research and testing facilities in such a way that we can continue to offer our stakeholders and clients tailored services at a competitive price.

Through knowledge accrual, technological development and product innovation, NLR supports Dutch society and the economy. We convert money into knowledge, and knowledge into money. We do not do this alone, but in collaboration with institutions and businesses in the Netherlands and elsewhere in Europe.

## COOPERATION IN THE NETHERLANDS

On ratification of the Kyoto and Lisbon Treaties, the Netherlands explicitly expressed its ambition to pursue a sustainable and eco-friendly knowledge economy.

In line with this ambition, the Ministry of Transport, Public Works & Water Management and the Ministry of Defense drafted their 2008 Strategic Knowledge Agendas containing guidelines for knowledge development in the years ahead.

The Ministry of Transport, Public Works & Water Management outlined concrete objectives for greener aviation – specifying a "green mainport" and "green aircraft." While the Ministry of Defense stated in its Agenda that knowledge development is of great importance to the activities of the armed forces. Furthermore, the Minister of Transport, Public Works & Water Management Camiel Eurlings initiated the drafting of a "Knowledge and Innovation Agenda Aviation." He did so in consultation with the Minister of Economic Affairs, the Minister of Housing, Spatial Planning & the Environment, and the State Secretary of Defense. In addition to a cohesive aviation policy, said Minister Eurlings, it was necessary to pursue a strong knowledge and innovation program to ensure that the different policy objectives are really achieved.

In 2008, a wide variety of NLR projects were prompted by these strategic agendas. Commissioned by the Ministry of Transport, Public Works & Water Management, Amsterdam Airport Schiphol, and Air Traffic Control the Netherlands, NLR conducted research into the possibility of capacity expansion at Schiphol, within existing safety and environmental restrictions. Our work for the Ministry of Defense focused, among other things, on research in relation to the replacement of the F-16 fighter and the acquisition of new Chinook and NH-90 helicopters. And of course NLR also did its utmost to ensure the safety and efficacy of various peacekeeping missions involving units of the Netherlands Defense Force.

At first glance, our work for Dutch industry and business seems dominated by major clients such as Stork, for whom we developed advanced manufacturing technology for the production of composite components for aircraft. However, an increasing number of smaller industries are calling on NLR for support. This includes industries that form part of the supply chain of major aircraft and engine integrators (such as Airbus, Boeing, and Lockheed Martin), as well as organizations in the fields of air traffic control and airport development.

In short, NLR is all about developing innovative technology. Our clients use this technology to create new and competitive products, thus converting knowledge back into revenue. NLR thus converts money into knowledge, and knowledge into money. We do so in collaboration with Dutch government and industry.

## INTERNATIONAL COOPERATION

International contracts and partnerships increase our knowledge base, enabling us to serve Dutch government and industry even more efficiently and effectively. Moreover, contracts from abroad ensure that our major research and testing facilities are better utilized, which means they remain affordable for Dutch and international clients.

**EU Framework Programs**

Since 1992, NLR has participated in the European Union's Framework Programs. Key areas of attention include Accessibility, Safety, and Sustainability. Cooperation within Europe enables NLR to participate (often in direct partnership with Dutch industry) in major technological development and testing programs that would be unfeasible at a national level.

NLR uses knowledge and technology gained via these programs to further strengthen the position of the Dutch industry and its ability to supply globally competitive products.

In the longer run, participation in European programs will help stimulate high-quality job opportunities in the Netherlands. But also in the short term, Dutch organizations participating in EU programs benefit directly from the knowledge they gain. In other words: partners must join forces at the European level to be competitive in the global arena.

It is also of direct public benefit that air traffic over the Netherlands is as eco-friendly and safe as possible, and that standards are laid down and technology is developed and adopted to ensure this at a European level.

European and national policy are increasingly running parallel. This is borne out by the European cooperative projects NLR contributed to in 2008. This included the Joint Technology Initiative (JTI) CleanSky, which aims to make air transport more eco-friendly, silent, and economical. Furthermore, flying could be safer and more efficient, which is the objective of the EU program Single European Sky ATM Research (SESAR) that aims to achieve optimum utilization of the single European sky and all airports. New technology must be developed to achieve these broader European societal objectives. This is important for the Netherlands, for Amsterdam Airport Schiphol, for Air France-KLM, and for Dutch industry and their suppliers. In short, Europe is a logical platform for NLR.

**ESA**

NLR has a duty to actively participate in European space programs. At the ESA Ministers Conference, held in The Hague in November 2008, decisions were taken on ESA priorities and programs for the 2009-2013 period. The average Netherlands contribution is set to increase during this period. The TROPOMI program will be the most prestigious scientific space exploration project that the Netherlands will contribute to in the coming years.

**DNW**

And last but not least, German-Dutch Wind Tunnels (DNW), in which NLR holds a 50% share, contributed significantly and successfully to a number of European, American and Chinese aircraft and engine development projects in 2008. DNW also devoted all of its advanced expertise and technology to the EU project Validation of Radical Engine Architectures (DREAM), dedicated to reducing noise and fuel consumption in aircraft engines. All these projects are beneficial for the utilization of our wind tunnels and beneficial for our knowledge development. They are also beneficial for our airports, which will profit from cleaner and more silent aircraft. By pursuing better integration and joint management and exploitation of European wind tunnels, these facilities remain affordable. This ensures that everyone gains maximum benefit from the important research and test results generated in these facilities.

## COOPERATION WITHIN NLR

**International Knowledge and Technology Audit**

In 2008, NLR asked twelve international experts to conduct an independent assessment of our technology position and market attractivity, as well as the "technology maturity" of our 12 main knowledge areas. The outcome of this International Knowledge and Technology Audit was highly positive: we are in excellent shape and we have a broad and satisfied client base. The auditors' report also indicated that, to maintain its standards in future, NLR must pursue sufficient long-term studies as well as investment in research and testing facilities. Other action items listed in the report are the "graying" of our workforce and the aging of our buildings.


LEO ESSELMAN – FINANCIAL DIRECTOR

*"NLR is in excellent shape and has a broad and satisfied client base"*

These are issues that we will definitely take into consideration when drafting our plans for the coming years.

**Public relations**

NLR continues to invest in extending its renown among government officials, business partners, and the broader public. In 2008, the institute welcomed leading officials from ministries that are important to NLR, as well as Dutch and European parliamentarians, high-ranking military officers, and CEOs of Dutch and foreign business partners. NLR was also present at numerous events, such as the open days of the Royal Netherlands Air Force and at various symposia organized by universities and branch organizations. This included the "Dare to Imagine" symposium organized by VSV Leonardo Da Vinci (a society founded by students of the Aerospace Engineering Faculty of the Delft University of Technology) and the 'Veiligheid Bedrijven' symposium on corporate security, organized by the Netherlands Defense Manufacturers Association (NIDV).

**Recruitment**

Our people are still our primary asset, our knowledge base. We recruited new colleagues in 2008. Because NLR sets high standards, it can be difficult to find the right candidates. To improve our chances in the labor market, we last year devoted extra attention to our ties with universities (of technology) and colleges, giving lectures and presentations, offering post-grad positions and internships, organizing workshops, and participating in business fairs and symposia.

**Employee satisfaction**

Recruiting new staff may be difficult, but it is also a challenge to keep them on board. We have been measuring employee satisfaction since 2004. This has improved gradually in recent years. In 2008, a comparative survey of more than 300 businesses and organizations revealed that we ranked among the best employers in the Netherlands. That is good news, but there is room for improvement. NLR therefore distilled five focus areas from the survey recommendations, which we further detailed in consultative sessions involving the board, management, and employees. In 2008, this led to concrete activities to improve our efficiency, to offer greater insight into our output, and to improve our communication. Although these areas of attention may differ, they are all of great importance to ensure a smooth-running organization where people take pleasure in their work. This is something we need to work on together continuously.

In 2008, we made the terms and conditions of employment more clear and simple. Issues such as training and career development are now a standard aspect of a balanced employment contract. In our covenant with the works council, we chose to continue following the guidelines laid down for governmental personnel. We hope to have rounded off this process in late 2009.

**Training**

Since last year, not only managers but also employees working in the field have been urged to attend external commercial courses or training. We are proud of our work, but effective communication with our customers is not just a question of demonstrating how good you are. One of the action items raised by the 2007 NLR Customer Satisfaction Survey was to pay better attention to the wishes of our customers. We therefore urge staff at all levels of our organization to attend courses in customer contact skills. And our recruitment criteria now also stress the importance of good social and communication skills, as this is important within our organization, but also in our communication with customers.

## NLR – 90 YEARS AND BEYOND

What are the prospects for NLR? It is hard to predict to what extent we will be affected by the ongoing financial crisis. The International Air Transport Association (IATA) has projected a further decline in passenger and cargo traffic by air in 2009. This will have a global impact on the development, manufacture and deployment of new aircraft.

Nevertheless, the prospects for 2009 as sketched by the Dutch Ministries of Defense and Transport, Public Works & Water Management are not unfavorable. The Policy Paper on Aviation of the Ministry of Transport, Public Works & Water Management (as well as the related Knowledge and Innovation Agenda Aviation) will offer further impulses for innovation within the Dutch aviation sector. This will steer development, maintenance and operations within the aviation sector and is likely to generate a great deal of research assignments for NLR.

In 2009, we will present our new Strategy Plan 2010-2013, outlining focal points for knowledge and technology development, for investments in research and testing facilities, and for national and international cooperation. This new NLR Strategy Plan is based substantially on the outcome of the International Knowledge and Technology Audit conducted in 2008, but also on consultation with the Dutch government regarding our buildings and investments.

The year 2009 marks NLR's 90th anniversary, which we will of course be celebrating in appropriate fashion. One of the events on our anniversary calendar is an international symposium where local and foreign experts will give there vision on the development of aviation in the coming 25 years. This is a highly appropriate theme, because NLR's rich history derives, in part, from our desire to keep a constant eye on the future.

Fred Abbink and Leo Esselman,
The Board of Directors

# POLITICS & MEDIA

## NLR CONSULTS WITH OFFICIALS AND POLITICIANS

In 2008, NLR once again strove to strengthen its ties with officials and politicians. NLR organized a special aviation seminar for its key stakeholders, as it did in 2007. In the past year, numerous European and Dutch parliamentarians as well as provincial and municipal officials visited the NLR establishments in Amsterdam and Flevoland. Similarly, the Geomatics Business Park (GBP) in Flevoland, in which NLR is actively involved, was host to a number of politicians. Several members of parliament attended the "Down to Earth" Geomatics Dinner at 'Nieuwspoort'.

## NLR IN THE MEDIA

In 2008, NLR featured in all of the larger national newspapers, including NRC Handelsblad, De Volkskrant, Het Parool, de Telegraaf, and Trouw, and in various (popular) scientific journals, including De Ingenieur (The Engineer), Technisch Weekblad (Technology Weekly), and the Technologiekrant (Technology News). The articles in question related to topics such as $CO_2$ reduction in the airline industry, de F35 ('JSF'), the noise regulations for Schiphol, and the noise issues in relation to AWACS operations in the Dutch province of Limburg.

NLR also featured in various radio and television programs, including Nieuwslicht (VCNS noise simulator), AT5 (aircraft and ATC simulators), Klokhuis (wind tunnels), TV Limburg (cooperation between Limburg University and NLR), and Radio 2 (VCNS noise simulator).

NLR also strove to gain further exposure in other ways. Fred Abbink was one of the speakers for the symposium "Dare to Imagine" organized by VSV Leonardo da Vinci. NLR also contributed to the traveling exhibition "50 Years Aerospace in the Netherlands," which was opened by Minister Maria van der Hoeve in early 2008.

# **2008** Visits & Events

### January 16
Visit by L. van Nistelrooij,
Member of European Parliament

### March 6
Visit by Lt-Gen R. L. Zuiderwijk,
Commander of the Royal
Netherlands Navy

### March 3
Opening of the NLR
simulator Fighter 4-Ship

### May 14
Visit by J. de Vries,
State Secretary of Defense

### June 10
Visit by Tj. Joustra,
National Coordinator
for Counter-Terrorism

JANUARY FEBRUARY MARCH APRIL MAY JUNE






### March 6
Visit by a mayoral delegation of
the Council of Haarlemmermeer

### March 13
Farewell reception at NLR for
General D. Berlijn as Chief of the
Netherlands Defense Force

### April 15
Visit by B.J.A.M. Welten,
Head of Police of the
Amsterdam-Amstelland region

**August 27**
Visit by Lt-Gen F. Meulman, Deputy Chief of the Netherlands Defense Force

**November 6**
NLR presentation at NIDV Symposium

**August 22**
Visit by E. Cramer, Member of Parliament for the ChristenUnie

**December 16**
Opening of the NLR Assembly, Testing and Integration Facility

JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER






**August 25**
Visit by R. Knops, Member of Parliament for the CDA

**August 28**
Visit by Lt-Gen J. Jansen, Commander of the Royal Netherlands Air Force

**November 12**
Visit by European Management Authority (EMA)

**October 7**
Opening of the milling hall by Andries Greiner, representative of the Province of Flevoland

**September 1-3**
International Knowledge and Technology Audit

Chapter 1:

# AN OVERVIEW OF NLR PROJECTS IN 2008


Knowledge and innovation are cornerstones of the Dutch economy. They are not only key assets for the present, but also hold great promise for the future. As markets become increasingly competitive, scientific research and technological innovation are of paramount importance in achieving distinction.

The Dutch aerospace industry plays an important role in this process. The Netherlands, with its important aviation industry, leading airlines and key airports, supported by eminent research and academic institutions, has its own critical mass within the European aerospace sector. A sector which has for decades been an important driving force for innovation, benefiting a broad array of economic sectors.

Naturally, the Dutch government wishes to retain this status and consolidate it wherever possible. NLR strives to achieve this objective with applied research into design, systems, procedures, and prototypes. These products and activities lie at the cutting edge of technology. They support the innovative capability of government and industry, thus making a substantial contribution to the retention of high-grade job opportunities.

# INDUSTRY

Virtual testing

Faster airworthiness testing

Composite components
for rotor head

More efficient wiring for
greener aircraft

Flawless planning in space

# VIRTUAL TESTING

**The testing of aircraft prototypes costs a great deal of money and time. NLR has achieved savings on both counts by using virtual models.**

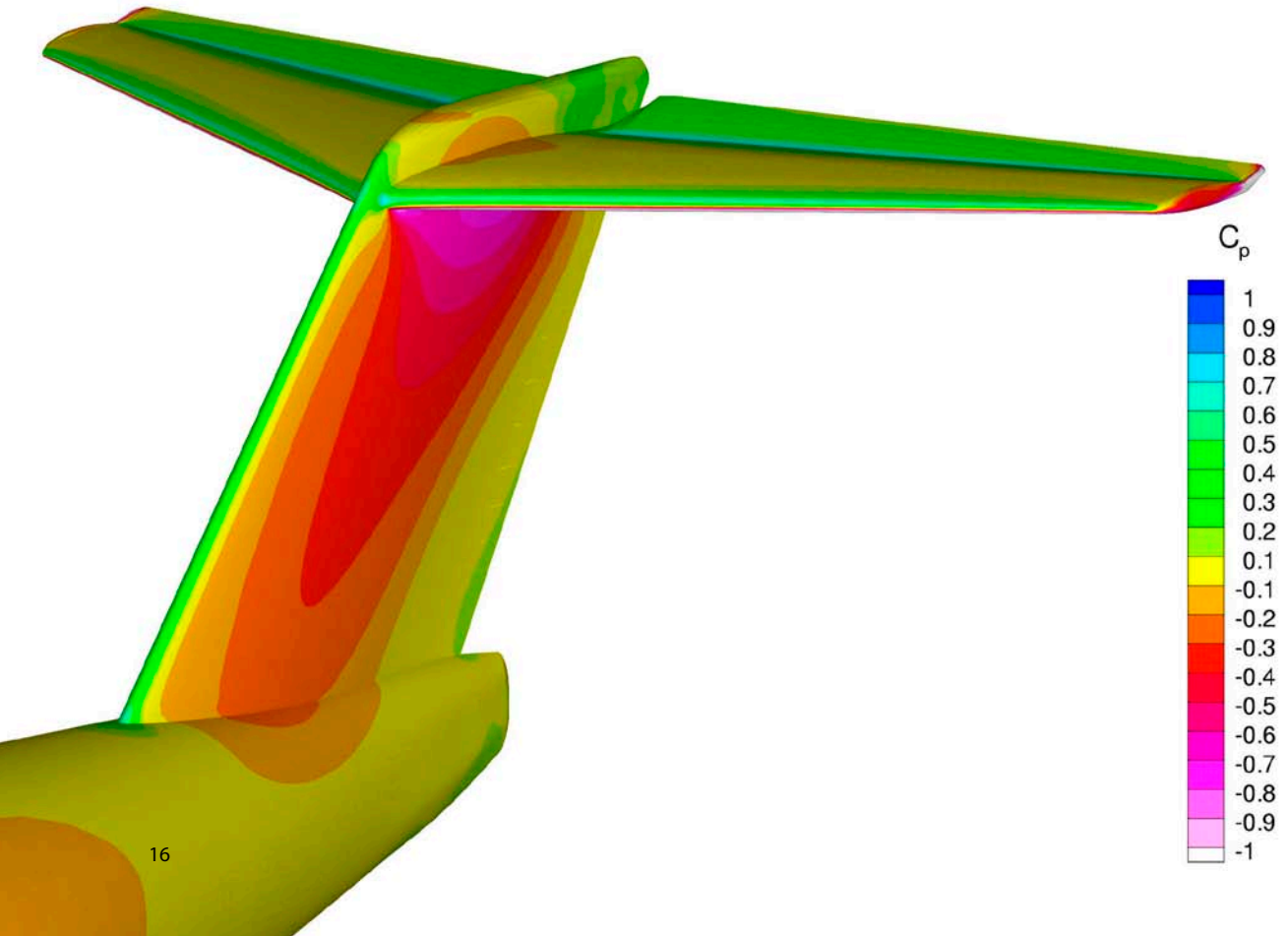
The physical characteristics of aircraft materials and components must meet the required standards. This is a crucial for airworthiness and air safety. It is a costly and time-consuming business to assess whether physical characteristics are within the stipulated values. NLR is therefore increasingly making use of virtual tests, for which the available data on materials is converted into numerical models. Virtual testing has already proved to have major cost-saving potential, which could very well enhance the competitive strength of aviation-related industries in the Netherlands.

Virtual testing is currently largely restricted to models of so-called coupons; i.e. relatively simple sections of materials. These models provide basic insight in the materials' characteristics, such as their rigidity, elasticity and failure behaviour. However, numerical models are also compiled for components with a complex geometry. These models are then validated with physical tests on the real materials or components.

One area in which virtual testing is especially beneficial is in the preparation of physical tests. Because the characteristics of the test bench are known, as are the general characteristics of the component to be tested, virtual testing can be used for the purpose of fine-tuning the physical test. This substantially reduces the time-consuming fine-tuning of the test bench.

NLR has in-house expertise to convert components of prototypes, or whatever other test articles, into numerical models. The institute has access to a wide range of physical and quantitative knowledge of relevant materials, including composites.

2008 saw major advances in the reliability of NLR's models. In addition, NLR made models for virtual testing of the tail section of the NH-90 army and navy helicopter. This demonstrated that the through-put time required for physically testing this component can be substantially shortened, resulting in major savings.



INDUSTRY
**Gulfstream**
Commissioned by
**Stork Fokker AESP B.V.**


# FASTER AIRWORTHINESS TESTING

**NLR is testing the innovative tail section of the new Gulfstream G650 business jet.**

Stork Fokker AESP developed and built a tail section for the new Gulfstream G650 business jet. NLR is conducting the airworthiness tests for this section of the jet.

The innovative tail section is made of carbon composite, a light and extremely strong and rigid material. However, not all of its characteristics have yet been tested under all conditions. Strength and rigidity are of prime importance for this particular aircraft, because the G650 will be the world's fastest business jet, traveling almost at the speed of sound. That means the carbon composite will be subjected to extreme forces. The material must also withstand extreme temperatures ranging from -55 to +80°C.

NLR engineers conducted so-called "coupon tests" in 2008 to determine the physical characteristics of the carbon composite material. Static pressure tests were subsequently conducted on various panels of the tail boom, reinforced with ribs, to establish the onset of panel deformation. An optical measurement system registered three-dimensional deformation.

Stork is using the test data to improve its own computer models. Stork engineers were on site to observe the tests, enabling speedy analysis and adjustment of the production process.

In the future, the methodology will be further improved by applying virtual testing, in which reliable computer models will replace some aspects of material testing as well as test preparations. This will further reduce the cost of developing and testing aircraft components.


# COMPOSITE COMPONENTS FOR ROTOR HEAD

**A new experimental cross between a plane and a helicopter is exploring the limits of weight and power. NLR is researching the possibility of using composite alternatives for the metal components of the rotor head of this new tilt-rotor aircraft.**

Helicopters are relatively slow, but they can take off and land almost anywhere. Fixed-wing aircraft are ideal for rapid transport, but they require relatively long runways to do their job. New tilt-rotor aircraft combine the best features of helicopters and fixed-wing aircraft. A tilt-rotor aircraft has engines that can rotate from a vertical to a horizontal orientation, allowing it to operate like a helicopter and like a plane.

The potential of tilt-rotor aircraft for civil aviation is currently being studied in the European Union's Novel Innovative Competitive Effective Tilt Rotor Integrated Project (NICETRIP). For this project, NLR is researching the possibility of using a composite for various components that make up the tilting rotor head. In 2008, the institute completed research on various technologies and production methods.

The research focused on three components: the yoke, to which the rotor blades are attached; the combiner plate, which allows the rotor blades to tilt; and the combiners, which connect the rotor blades to the combiner plate.

To manufacture the composite yoke, NLR researchers came up with a pressing process for the fibers and matrix that together form the composite. This process prevents the formation of shrinkage cracks, which are a common drawback, especially in relatively thick composite components, such as those required for the rotor.

NLR also completed a feasibility study for the development of a new production method for the combiner plate. The method in question, known as dry fiber placement, proved to be suitable. This method involves fibers placed in a specific mould, after which the matrix is injected.

Because the combiners must be extremely stiff, NLR in 2008 conducted a preparatory study for the production of these components and the selection of a suitable composite. Results revealed that thermoplastic technology would be the most suitable. In this case, subcomponents of fibers and matrix are joined together by means of heating, which is relatively simple compared to the dry fiber placement process. In addition, the design of the combiners was optimized.

# MORE EFFICIENT WIRING FOR GREENER AIRCRAFT

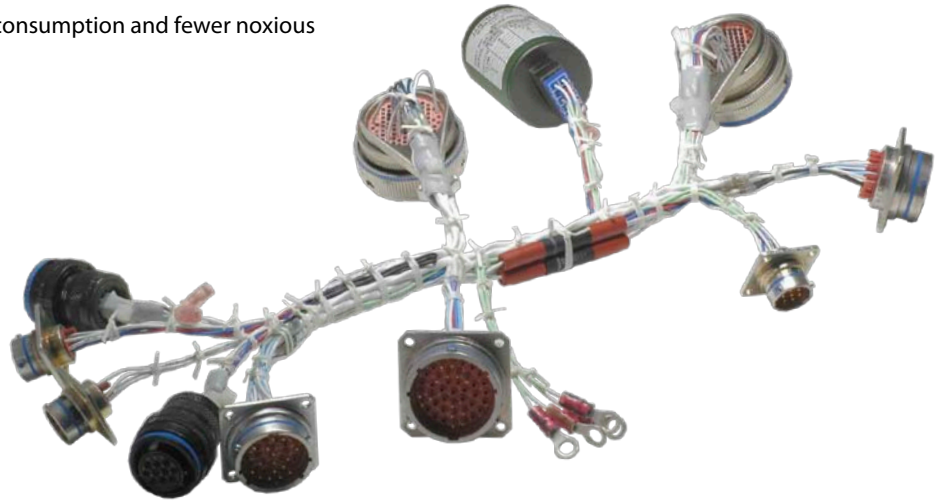
**By combining two important functions of aircraft wiring – power supply and data transport – aircraft could be made more sustainable.**

Modern aircraft contain more and more wiring. On the one hand, more and more hydraulic and pneumatic systems are being replaced by electrical systems. On the other hand, all sorts of systems are being added; for example, for inflight entertainment. Because weight reduction is becoming an increasingly important factor in the design of new aircraft, the European program Transmissions in Aircraft on Unique Path wirEs (TAUPE) is conducting a study into wiring that combines different functions. This would reduce weight, contributing to lower fuel consumption and fewer noxious emissions.

A regular passenger aircraft such as a Boeing 747-400 requires almost 300 kilometers of wiring, while the new Airbus A380 SuperJumbo contains no less than 500 kilometers of wiring. For the larger part, this wiring contains copper and is therefore relatively heavy. In the TAUPE program, NLR and its European partners are seeking smart ways of combining the functions of wiring, with data communication and electric current using one and the same set of wires.

However, it is crucial that this should not jeopardize reliability. Two different techniques are being combined, PowerLine Communication (PLC) and Power-over-Data (PoD). In addition to saving weight, the project should also reduce maintenance costs.

NLR is responsible for verification and validation of the new technologies being introduced in this project, based on two existing avionics systems. One is the Cabin Lighting System (CLS), which is a non-critical system as far as air safety is concerned. NLR will also be demonstrating the safe functioning of a flight-critical system, namely the Cockpit Display System (CDS). The tests are conducted in two mock-ups; the Cabin Mock-Up of EADS Innovation Works and the 'Copper Bird' of Hispano Suiza. The latter is the result of a previous EU program and will mainly be utilized to determine the electrical characteristics of the wiring network. The Cabin Mock-Up tests will focus on assessing the functional requirements of the technologies.



# FLAWLESS PLANNING IN SPACE

**NLR is operating key experiments aboard the Columbus module of the International Space Station – an operation requiring flawless precision.**

NLR's space activities passed a milestone on February 11, 2008, when the European space module Columbus docked on the International Space Station (ISS). From then on, NLR was responsible for two important experiment facilities, one on the inside and one on the outside of the module.

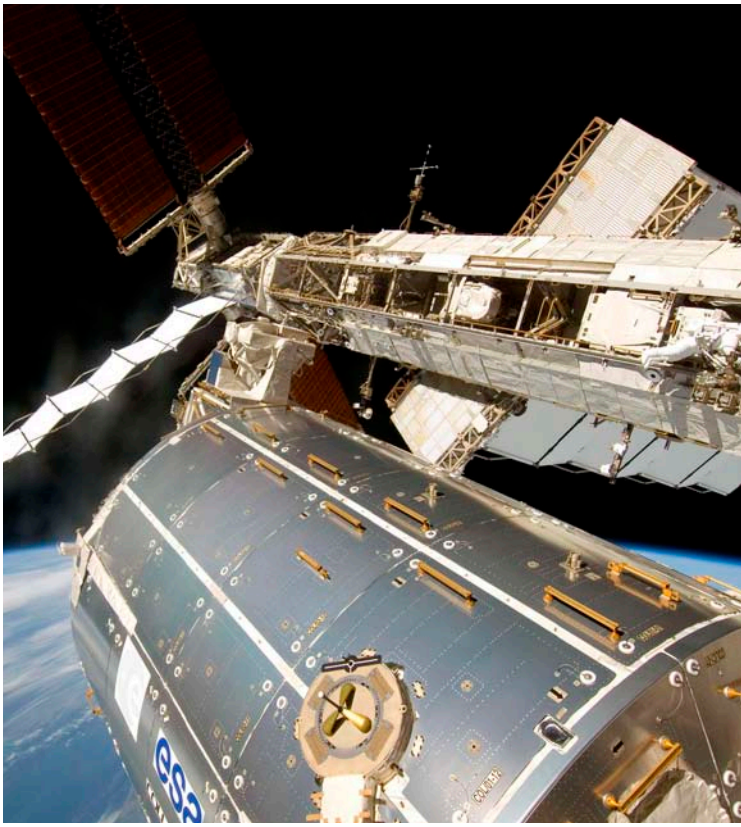
The experiments were operated from the Erasmus User Support and Operations Centre (USOC) in Noordwijk, the Netherlands. Together with the Belgian company Space Applications Services, a team of 15 experts controlled the experiments around the clock.

NLR supported the development of the USOC concept over a period of 20 years, aiming for distributed ISS experiment operations control from several European centers. Since 1998, NLR and other partners have jointly developed the Erasmus USOC, which is a component of a broader program.

The European Drawer Rack (EDR) is one component of the Columbus module. The EDR is sub-divided into seven compartments for smaller experiment modules, allowing different types of experiments to be conducted simultaneously. The EDR is suitable for physical, chemical and biological experiments, all of which can be fully automated or conducted with the help of astronauts on board or from the ground. There are standard facilities for supplying and removing water, nitrogen, and gas.

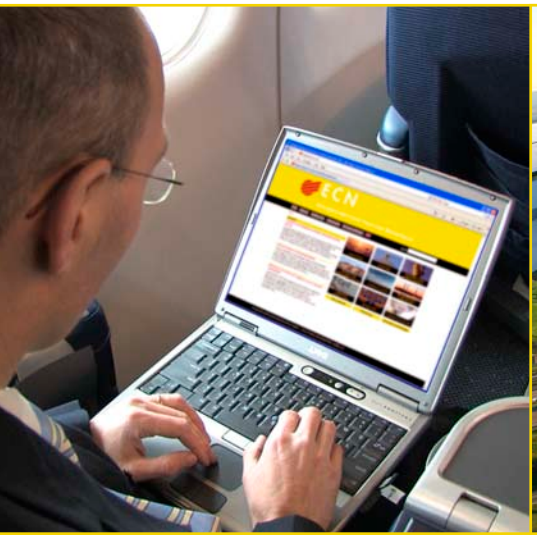
The EDR facility includes the Protein Crystallization Diagnostic Facility, an experimental module analyzing crystallization of organic macromolecules. Due to the low-gravity environment, the crystallization process is highly stable, producing much purer crystals.

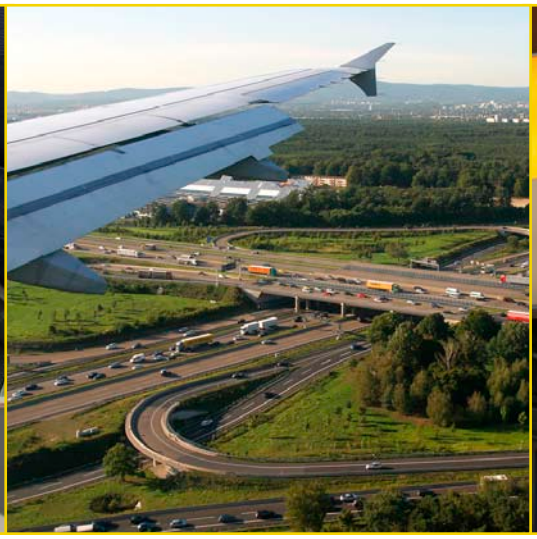
The Erasmus USOC in Noordwijk is also responsible for operations involving the European Technology Exposure Facility (EuTEF). This is a platform mounted on the outside



of Columbus that is used to study, among other things, radiation and particles in outer space. The platform serves as a base for nine instruments. One of these is the Material Exposure and Degradation Experiment (MEDET). This monitors the extent of damage to the ISS caused by ultra-violet radiation and the continuous bombardment by atomic oxygen, micrometeorites, and minute fragments from previous space missions and rocket launches. In addition, the Exposure Experiment (EXPOSE) studies the effects of cosmic radiation on biological materials. This could well yield important information for the safety of future space missions.

Experiment results are relayed to USOC while the mission is underway. That means data analysis can begin immediately, without the intervention of an astronaut. To date, EuTEF has been available 99% of the time.







An endless stream of goods and people crisscrosses Europe every day. Mobility is becoming increasingly important – on the ground, but certainly also in the air.

But how can Europe prevent its airports and skies from becoming congested? And how can the Netherlands ensure that Amsterdam Airport Schiphol and the surrounding area remain accessible and retain their status as a key international transport hub?

NLR conducts research in logistics and planning that improve the flow of passengers and goods – by arranging check-in and check-out more efficiently; by applying new security technology and procedures; by better coordinating airport processes such as catering, cleaning, and air traffic control; by finding ways for aircraft to take off and land parallel to one another or at shorter intervals; but also by reaching agreements at the European level and participating in projects that facilitate the flow of international air traffic.

# MOBILITY

Exchanging information for more efficient departure times

Zapping and surfing at high altitude


More punctual and eco-friendly landings

Expansion of Lelystad Airport with minimal nuisance


# EXCHANGING INFORMATION FOR MORE EFFICIENT DEPARTURE TIMES

**If all parties at an airport exchange their information, aircraft could be prepared for takeoff more rapidly. NLR designed a simulation tool.**

A series of activities must be completed before an aircraft can depart. It must be refueled and cleaned, catering supplies must be loaded, and passengers must board the aircraft. Once pilots have completed their pre-flight checks, the doors are closed and they ask air traffic control for clearance to depart.

It would be handier if air traffic control was to know well in advance when a pilot is ready to depart. This would allow for better planning and enhance traffic throughput to the runway. That would avoid unnecessary waiting times. Although various parties have information on aircraft readiness, this information should be more effectively shared. At Schiphol, this is set to change.

NLR has many years of experience with development of planning techniques, information exchange, and Collaborative Decision Making (CDM). That is why we were contracted by KLM Royal Dutch Airlines, Amsterdam Airport Schiphol and Air Traffic Control the Netherlands (LVNL) to supervise the development of a Collaborative Pre-Departure Sequence Planning (CPDSP).

NLR reached agreements with all relevant parties on which information they were able to share. For instance, it was decided that ground handlers and airlines will inform air traffic control of their expected aircraft ready time around twenty minutes beforehand. Air traffic control then informs the pilot when he can expect to receive clearance to depart.

The exchange of information not only ensures better planning, but also lets pilots know how long a delay is going to last, so that they can inform their passengers better. Research has shown that passengers experience a delay as being shorter if they know how long it is going to last.

NLR developed a simulation tool that provides good insight into how CPDSP will work in practice. This simulation program will be expanded with various scenarios in 2009, including one involving poor weather conditions.

# ZAPPING AND SURFING AT HIGH ALTITUDE

**New antenna systems will enable airline passengers to watch TV or check their e-mail when cruising at high altitude.**

Many air travelers would like to have the same broadband connectivity as they have in their homes, or perhaps zap through a wide range of TV channels during a long flight. However, a satellite dish on top of an aircraft is not an option, as it would cause to much air resistance and it would be impossible to continually steer the dish towards communications satellites.

NLR and several Dutch partners have joined forces in the FLYSMART project to develop a special broadband antenna system for airborne satellite reception. This flat antenna system is only a few centimeters thick and measures one square meter. It is shaped to follow the contours of the fuselage so that it does not interfere with the aircraft's aerodynamics.

Since the 1960s, NLR has been involved in the development of antenna technology and the modeling of electromagnetic waves. Owing to this expertise, NLR was asked to develop this broadband antenna system, together with the Dutch company Cyner Substrates. The system consists of around 1,600 antenna elements that each have 2 gigahertz bandwidth. The signals produced by the elements are combined to produce a directional antenna. The system can adjust the direction in which the antenna receives and transmits signals.

The system makes use of optical technology jointly developed by the University of Twente and the Lionix company. Optical delay lines ensure that antenna signals are delayed with great precision to allow in-phase combination.

In 2008, the partners constructed the first small prototype of the antenna system and demonstrated its feasibility. In 2009, FLYSMART will be followed up by the EU project SANDRA, which will demonstrate the new system's airworthiness, testing its ability to withstand extreme temperatures and pressure at high altitudes, among other things. Project SANDRA will also work on integrating the optical and antenna technology so that the system becomes even more compact.

# MORE PUNCTUAL AND ECO-FRIENDLY LANDINGS

**Landings could be more simple and eco-friendly if pilots are guided into an optimal flight path and speed at an earlier moment. This method was successfully tested in 2008.**

Long before an aircraft begins its landing at Amsterdam Airport Schiphol, Air Traffic Control the Netherlands (LVNL) determines which runway it is to land on, and the moment it must pass over a specific beacon, the Initial Approach Fix (IAF). Once it has passed the IAF, an aircraft enters the Terminal Maneuvering Area (TMA), the airspace close to the airport in which aircraft landing and taking off are separated. The actual moment when an aircraft passes over the IAF can deviate from the stipulated time by as much as two minutes. KDC wants to reduce this deviation to no more than 30 seconds, without compromising traffic safety and without increasing the workload of the air traffic controller and the pilot.

It would be highly beneficial if aircraft pass over the IAF exactly at the stipulated time. This would ensure a more stable traffic flow in the TMA, making it simpler for air traffic control to guide aircraft down to the runway. It is even possible to have pilots follow a prearranged route, resulting in better control over noise production and in lower fuel consumption.

To improve the punctuality of aircraft arrival at the IAF, LVNL developed an algorithm called "Speed and Route Advisor" (SARA). Well before the aircraft reaches the IAF (sometimes even before it enters the Dutch airspace), SARA issues a speed and route recommendation to the air traffic controller. SARA takes into account the speed profile, route, specific aircraft characteristics, and weather conditions. The air traffic controller passes the recommendation on to the pilots. If the deviation tends to exceed the limit of 30 seconds, SARA issues a new recommendation.

Based on the SARA algorithm, NLR developed a series of software prototypes, which were installed on NLR's air traffic control research simulator NARSIM-Radar. In August 2008, a real-time simulation was conducted to assess the SARA operational concept. NLR invited eight air traffic controllers and eight test pilots from LVNL and Maastricht Upper Area Control Center (MUAC) to take part in the simulation. The study proved that the SARA algorithm is well-worth developing into operational software. A pre-operational trial will take place at LVNL in 2009, when SARA will be used on real air traffic.

# EXPANSION OF LELYSTAD AIRPORT WITH MINIMAL NUISANCE

**Lelystad Airport wants to expand. NLR is researching what impact this will have on local residents and wildlife sanctuaries. The institute studied three alternative flight routes.**

Amsterdam Airport Schiphol wants to handle more scheduled services. That would be possible if, for example, more charter flights were operated to and from Lelystad Airport, which would consequently grow. The Flevoland provincial authorities would also like to expand the airport, as this would generate new job opportunities. But the province also wants to make every effort to ensure that the additional air traffic has minimal impact on local residents and nature reserves. NLR was asked to advise on this matter by the Province of Flevoland, together with Staatsbosbeheer (the national forestry authority), and the Municipalities of Harderwijk and Nunspeet.

NLR researched the possibly of restricting noise nuisance by, for instance, opting for alternative flight routes or by having aircraft turn away either closer to or further from the airport. Staatsbosbeheer asked NLR to primarily focus on devising flight procedures ensuring that aircraft do not fly below 3,000 feet (approx. 1 km) when passing over the Oostvaarderplassen nature reserve. Aircraft flying above that altitude hardly disturb birds and other wildlife. Air Traffic Control the Netherlands (LVNL) is currently unable to offer guarantees in this regard. The reason being that air traffic to and from Lelystad is not permitted to interfere with air traffic at Schiphol. As a result, flights departing from Lelystad sometimes cannot climb as quickly as is desirable.

Within the stipulated flight routes and procedures, NLR spotted two possibilities to shift routes in such a way that they would meet the wishes of Staatsbosbeheer. These routes have now been submitted to LNVL for closer scrutiny. At the request of the Municipalities of Harderwijk and Nunspeet, NLR also studied alternative routes that would reduce noise nuisance in these residential areas.

The debate on future flight routes and procedures stands to benefit if all those involved have insight into relevant considerations. This ensures that decisions are made on the basis of solid arguments. A new Environmental Impact Report will be presented in 2009, assessing the effects and viability of the alternative flights routes suggested by NLR.


The aviation industry has more safety regulations than any other. And rightly so, because the safety of airline passengers and people living near airports must be assured, even if air traffic increases.

NLR contributes by developing new cockpit systems that provide pilots with the latest, integrated information on weather, obstacles and other aircraft; by improving ground-based conflict detection for aircraft; by improving security at airports and on board to prevent terrorist attacks; and by determining the causes of human error via simulations, in order to develop systems and procedures that can help prevent such errors.

Continuous research and active innovation are required to improve safety standards, even as the number of flights increases and environmental regulations become more stringent. That is why NLR continuously collects data on the causes of incidents in air transport and compiles risk analyses for airports and their surroundings. NLR also regularly contributes to new concepts that improve safety for airports and aircraft, for passengers and residents.

# SAFETY

Supporting development of a helicopter simulator

Hong Kong detects turbulence

Data-based helicopter design

Safely avoiding thunder storms

# SUPPORTING DEVELOPMENT OF A HELICOPTER SIMULATOR

**NLR's expertise is in demand worldwide. Last year we helped a South Korean client develop a simulator for a fire-fighting helicopter manufactured in Russia.**

NLR developed a simulation model for the Russian Kamov Ka-32T helicopter. This was commissioned by NLR's counterpart the Korea Aerospace Research Institute (KARI). The Korean Forest Aviation Office operates several dozen Kamov helicopters. NLR successfully completed this complex project in 2008.

In first instance, a model was developed for the helicopter's flight movements. KARI supplied NLR with the technical data required. To assess whether the model was realistic, South Korean pilots conducted test flights with NLR equipment under supervision of specialists from NLR and KARI.

NLR was able to draw on its extensive experience gained with the helicopters of the Dutch defense force. NLR has, for instance, conducted extensive studies of navy helicopters operating off the flight decks of naval vessels. NLR also certified self-protection equipment on combat helicopters, and advised on missions involving transport helicopters. In addition, NLR has extensive expertise in the development of simulators for helicopters, having produced such systems for the Chinook transport helicopter, the Apache combat helicopter, and the NH-90 navy helicopter.

The maneuvers involved in fire-fighting also had to be integrated into the simulator. The Kamovs are equipped with a 3,000-liter water tank, which is filled via two hoses that the pilot can lower into a reservoir. This extra weight affects the helicopter's flight characteristics. The same applies in connection with the capability to release the water over a blaze either at intervals (a salvo drop) or gradually (a trail drop).

The great distance between the Netherlands and South Korea played a role in the organization of the project. Visits by NLR technicians had to be prepared in detail beforehand, because a quick trip back to pick up extra equipment in the Netherlands was unfeasible. The Russian technology presented an additional logistical challenge, because specific components had to be obtained via a network of contacts.

# HONG KONG DETECTS TURBULENCE

**Hong Kong International Airport experiences a lot of turbulence and windshear. Smart software will improve forecasting, allowing pilots to better anticipate wind variations.**

Hong Kong International Airport is located in a mountainous area, where wind direction and speed are subject to rapid change. Hong Kong Observatory (HKO) provides pilots with detailed weather forecasts, which include the risk of wind shear – sudden, very local, shifts in wind. Nevertheless, pilots are still often confronted with unexpected wind changes and turbulence.

HKO commissioned NLR to develop software to compare the actual situation during landings with the forecasts. This helps HKO improve its weather and wind forecasts, enabling pilots to better anticipate turbulence in due course, ultimately benefiting the safety and comfort of passengers.

NLR developed the computer program WINDSTURB to calculate the actual wind shear and turbulence experienced during a flight, based on data measured by aircraft flight data recorders. At HKO's request, airlines supplied data on course, speed, air temperature, accelerations, control surface movements, and the air flow angle during their flights. WINDSTURB uses this data to calculate the relative speed and direction of the air flow around the aircraft. By computing the wind speed in three different directions, the degree of turbulence can be ascertained (the so-called Turbulent Kinetic Energy and Eddy Dissipation Rate).

HKO has already analyzed almost 200 flights using the WINDSTURB program. The focus was on flights operated by Cathay Pacific, the key operator at Hong Kong International Airport, with a fleet of A320s, A330s, and B747-400s. The results have proved so valuable that HKO has requested NLR to expand the tool to include the Airbus A321.

# DATA-BASED HELICOPTER DESIGN

**NLR is building a comprehensive aerodynamic database for an entire helicopter. In 2008, a scale model of such a helicopter was successfully tested in the German-Dutch Wind Tunnels (DNW).**

Helicopters can encounter a wide variety of flight conditions. During a tail shake, for instance, the tail boom vibrates due to vortices (of vortical structures) caused by the main rotor. The tail boom must be able to withstand this vibration. Using advanced mathematical methods, NLR has recently succeeded in simulating flight regimes such as these. Computational Fluid Dynamics (CFD) was used to calculate pressure, density and velocity components in three directions around the helicopter. This allows engineers to determine which forces are exerted on specific helicopter components.

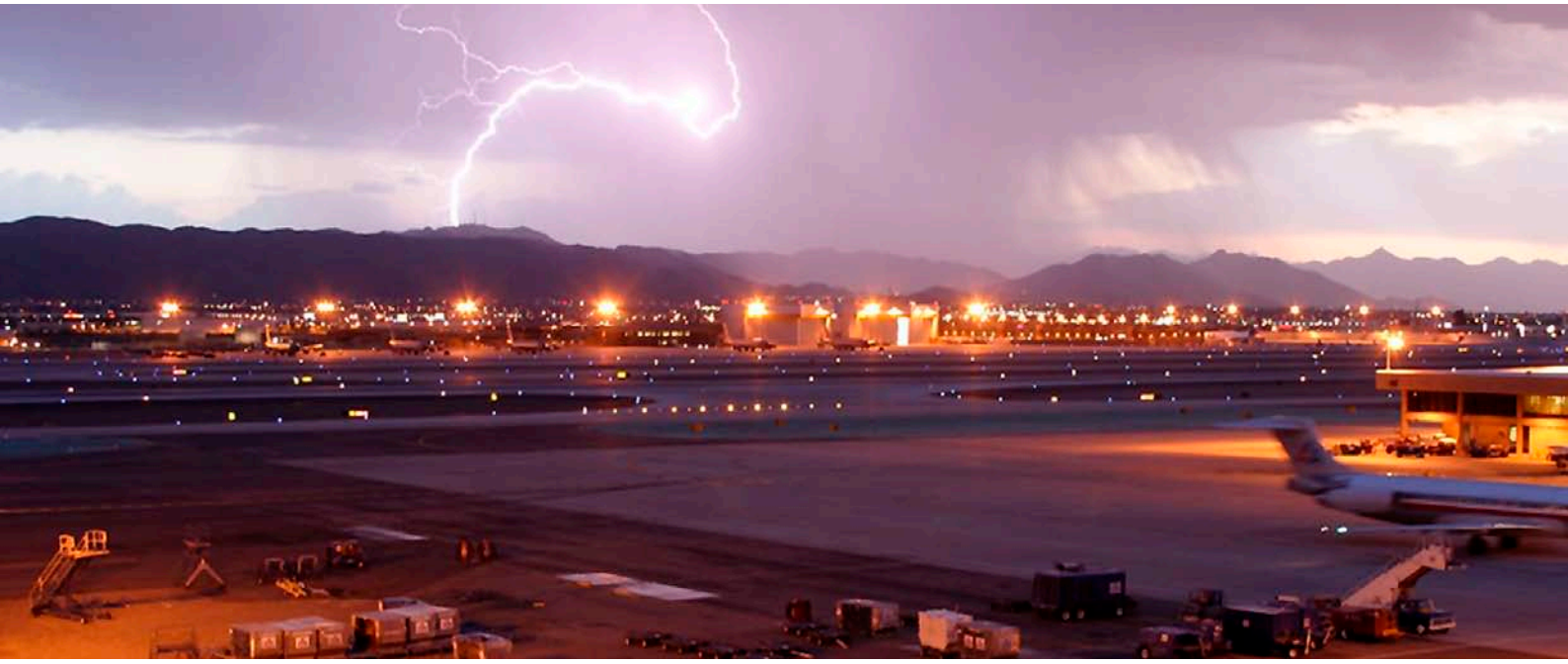
These new simulation methods must be validated with great care. Until recently, there was insufficient suitable experimental data for this purpose. Existing databases available from helicopter manufacturers are mostly based on measurements of a specific rotor or fuselage with main rotor, and rarely on a complete helicopter.
NLR is therefore working in the European research consortium GOAHEAD on building a database containing the aerodynamic characteristics of an entire helicopter. To contain project costs, the 15 GOAHEAD partners constructed a helicopter model from existing components. A 1:4 scale model of the NH90 helicopter was used for the fuselage. The blades of both main and tail rotors were developed for previous measurement programs.

In 2008, researchers tested this helicopter model in a wind tunnel for five different flight conditions. One of the conditions tested by the consortium was the tail shake condition. 2008 saw the completion of the blind test phase, in which simulations are made even though the results of the wind tunnel tests are as yet unknown. In 2009, these simulations will be validated with the data generated by the wind-tunnel tests. NLR will then be able to adapt and upgrade its simulation methods.

Thanks to the GOAHEAD partnership, NLR now has access to a database that it could never have compiled on its own. That means NLR will be able to conduct helicopter simulations under a wide variety of flight conditions. In addition, wind-tunnel and other tests, which are relatively costly, can be conducted more efficiently and safely.

# SAFELY AVOIDING THUNDER STORMS

**Adverse weather conditions pose a risk for flight operations around airports. New information systems improve pilots' overview of the situation.**



In 2008, NLR's Metro II laboratory aircraft regularly went in pursuit of thunder storms. Ice and storm-related data were relayed to the aircraft from ground stations via a satellite data link. On board, this data was then merged with data from a new type of weather radar. Pilots could then view the combined results on a display.

This is the first time meteorological data have been accessed, processed and presented in this manner on board an aircraft. This enables pilots to better perceive thunder storms. They are also much better able to see what is behind the storm. Is there another storm cloud? How fast is it developing? And to what altitude? These questions cannot be answered by existing radar systems aboard aircraft.

NLR operated the test flights as part of the European Union's Sixth Framework Program FLYSAFE. This program involves 36 partners under the leadership of Thales Avionics, with a budget of EUR 53 million. FLYSAFE aims to raise the situational awareness of pilots by better integration and presentation of data in the cockpit, allowing pilots to better anticipate dangerous situations. The better a pilot understands where he is and how weather is going to develop, the better his ability to make the right decisions.

During the FLYSAFE project, cockpit systems were designed that will reduce the risk of accidents. This includes collisions with other aircraft and ground objects (such as mountains), as well as accidents caused by poor weather. The test flights conducted by NLR in 2008 pertained only to weather-related aspects.

NLR conducted the test flights for FLYSAFE and developed the experimental simulator tests. In addition, NLR created the environment simulations and developed the training material required to teach pilots and traffic controllers how to operate the new systems. In 2008, NLR also completed studies of the architecture required to install the new systems in new and existing aircraft.

With 16 million people inhabiting an area of just 35,000 square kilometers, the Netherlands is one of the world's most densely populated countries. It is therefore hardly surprising our country is among the global frontrunners in the development of environmental policy and eco-friendly technology.

NLR contributes by producing aerodynamic aircraft designs, developing lightweight and sustainable materials, and designing more economical and silent engines. We also advise on flight paths and take-off and landing procedures that are more fuel-efficient and have less impact on the community.

NLR also produces independent studies supporting constructive debate on the development and enforcement of noise standards. Clear and objective facts serve as the basis for well-founded choices regarding the complex balance between environmental objectives, safety, and air traffic capacity.

# ENVIRONMENT

Wind speed measurements off the coast of Lisbon

Low-noise landing gear

A new generation of fuel-efficient aircraft engines

New enforcement system for aircraft noise around Schiphol

Geodata tackles oil spills at sea

## WIND SPEED MEASUREMENTS OFF THE COAST OF LISBON

**In 2008, the NLR laboratory aircraft Citation could be seen flying at low altitude (150 meters) off the coast of Lisbon. Wind speeds and other parameters were measured. The data was for Portuguese biologists studying explosive algae growth in coastal waters.**

Northerly winds along Portugal's coast create turbulent airflow over the sea, affecting ocean currents. The subsequent mixing of warm and cold ocean layers, which are rich and poor in nutrients, can cause explosive algae growth. This has a major impact on the environment and fish stocks in coastal waters.

To gain insight into the algae growth, Portuguese biologists require data on wind direction and speed as well as air temperature along their coast. To map out this data, NLR's laboratory aircraft Citation conducted flights off the coast of Lisbon at an altitude of just 150 meters. This was done at the behest of IPIMAR, the Portuguese institute for fisheries and marine research. The institute received a grant for these flights from the European 6th framework project EUFAR (EUropean Fleet for Airborne Research). The NLR Citation is part of EUFAR's pool of laboratory aircraft equipped for atmospheric research.

The measurement flights generated a wealth of data for IPIMAR. The Portuguese scientists require the data to validate a model describing how wind and ocean currents interact. Participation in the EUFAR project allows NLR to broaden its scope to include atmospheric research and earth observation. EUFAR will run a follow-up project in 2009. NLR will be involved once more, but this time the Citation will be joined by NLR's other laboratory aircraft, the Metro II.

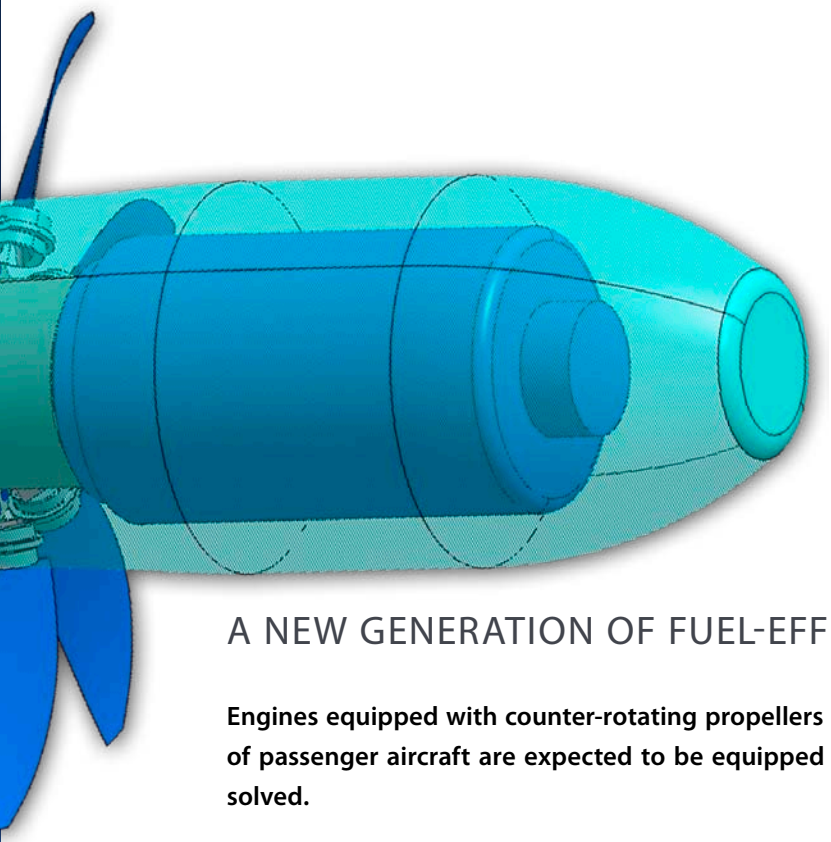
# LOW-NOISE LANDING GEAR

**As aircraft engines steadily become more silent, researchers' attention is shifting to other noise sources. NLR is currently working to reduce noise caused by landing gear.**

Air traffic noise is a major factor affecting responsible growth of airports, especially in densely populated areas such as the Randstad conurbation. In recent decades, a lot of hard work has been done to reduce noise generated by aircraft engines. The civil aviation industry, supported by NLR, has been successful in this area. However, this success makes the noise produced by other parts of aircraft relatively more prominent.

NLR is studying ways of reducing noise generated by landing gear. In 2008, NLR constructed a wind tunnel model of a simple nose wheel, based on an existing nose wheel of a helicopter. This generic landing gear can be used to develop and validate computation models. These can be used to determine how much noise this nose wheel generates. The computation models can then in turn be used to improve the design of new landing gear.

The geometry of the landing gear is not the only factor. Replacement of some metal components of landing gear with composite equivalents is also an option. Composites are not only lighter but also stronger than the steel traditionally used for landing gear. The use of composite components presents opportunities to produce lower-noise designs than is possible when using metal. Composites also have potential benefits in terms of resonance and maintenance. NLR's research is focusing specifically on a composite drag brace, which is the section that lowers and retracts the wheel, and braces it when landing.



# A NEW GENERATION OF FUEL-EFFICIENT AIRCRAFT ENGINES

**Engines equipped with counter-rotating propellers are more fuel efficient. In the future, large numbers of passenger aircraft are expected to be equipped with such engines. But only if the noise problem is solved.**

High fuel prices are putting pressure on airline operating margins. More fuel-efficient engines are therefore becoming more important. The current design of engines for civil aircraft leaves little room for any substantial improvement in fuel efficiency. One new concept is the Counter Rotating Open Rotor (CROR). NLR has since 2007 conducted extensive multidisciplinary studies of this innovative engine type. In 2008, NLR constructed two CRORs, mounted them on a model of a medium-haul commercial jetliner, and tested them is several wind tunnels.

The CROR is the golden mean between propeller and jet engines. The first are relatively fuel efficient, but they can only achieve limited speed. Exactly the opposite applies for jet engines.

The CROR offers an average 20% improvement in fuel efficiency. This is achieved in various ways. For example, the rotor blades are highly curved and counter-rotating, which leads to higher rotation speed and therefore greater thrust and speed. The fan blades are also adjustable, in contrast to ordinary jet engines, which have fixed fan blades. CROR fan blades can be adjusted to the most fuel-efficient position, depending on the speed of the aircraft.

Unfortunately, the CROR also has inherent disadvantages. The open rotor blades produce more noise than regular jet engines, as they do not have noise-reducing cowling around their fast-rotating parts, as is the case with jet engine fans. However, the noise can be reduced substantially by adjusting the form of the propeller blades and by using different diameter blades for the propellers placed one behind the other.

It would also be better to mount the CRORs above the horizontal stabilizer, instead of under the wings, as is usually the case with jet engines. Potentially, this location could better shield the noise generated by the engines than, for example, the traditional rear mounting on either side of the tail under the horizontal stabilizer.

NLR is the only European aerospace laboratory that can manufacture carbon composite rotor blades for jet engines. This material is light and strong and, because carbon fibers can be oriented in any direction, it can be shaped to ensure that it produces less vibration than traditional metal blades. NLR also has extensive expertise in the development of rotating balances, which are highly accurate sensors that can measure the forces exerted in a running engine. These balances are also highly useful for testing the specifications provided by engine manufacturers, as they can measure both power consumption and effective output.

# NEW ENFORCEMENT SYSTEM FOR AIRCRAFT NOISE AROUND SCHIPHOL

**In 2008, NLR conducted an analysis of a new enforcement system to regulate aircraft noise around Amsterdam Airport Schiphol**

Local residents, the aviation industry and government officials find the current enforcement system too complicated. That is why a new system is being considered by the Alders Table, a consultative platform that is advising the Dutch cabinet in its effort to strike a balance between the growth of air transport at Schiphol, noise abatement, and the quality of life in the region. This advice extends to policy for the short term (through 2010) as well as the mid-to-long term (2018-2020). At the request of the Ministry of Transport, Public Works & Water Management, NLR supported the Alders Table by analyzing three alternative enforcement systems that could, in due course, replace the existing system for aircraft noise.

The existing enforcement system for aircraft noise makes use of maximum noise limits that are set for 35 enforcement points around Schiphol. Annual noise levels are calculated at these points. This ensures that noise levels in local residential areas and elsewhere do not exceed predetermined values. The Dutch Lower House has demanded a new enforcement system, because the current system is too complex and lacks transparency.

NLR assessed three alternative systems, calculating their effect on the environment and their impact on the area surrounding Schiphol. To do so, NLR analyzed more than 20 scenarios for each alternative, based on aircraft movements over an entire year, under various weather conditions (i.e. different wind directions, visibility and precipitation). The results of these analyses were reported to a taskforce that supports the Alders Table.

The NLR report helped the Alders Table achieve consensus on a system called “Flying as Agreed,” in which agreements are made on the noise-preferential utilization of the Schiphol runway system. The Polder and Kaag Runways are high on the noise-preferential list, because their respective flight paths affect fewer people than the flight path of, for instance, the Buitenveldert Runway. In short, runways causing less noise nuisance will be first in line for utilization. Runways causing noise nuisance for more people will still be used, but only under specific circumstances, for instance when there is a strong westerly wind. The strict preferential utilization of runways may cause higher local noise levels in some locations and lower levels in others. Overall, however, fewer people will experience high levels of noise nuisance.

The new system will be tested in 2010. NLR has already been approached to advise on practical implementation of this system.

# GEODATA TACKLES OIL SPILLS AT SEA

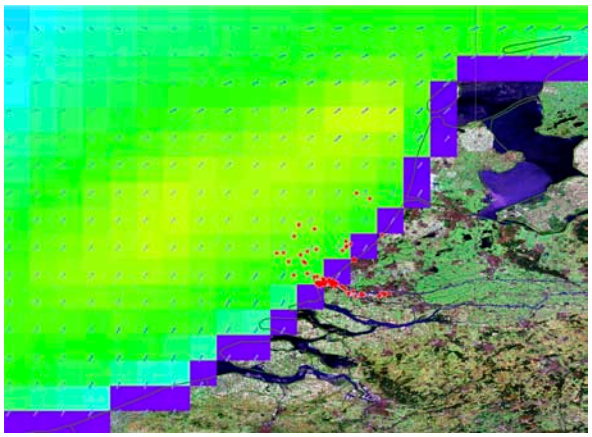
**Oil spills and the ships responsible for them can now be tracked down fast by combining data from various sources.**

Prevention of oil spills in the North Sea has never been easy, because it is difficult to track down polluters. In 2008, NLR teamed up with several Dutch partners, including companies in the Geomatics Business Park, to study a means of more swiftly detecting oil spills and their perpetrators. This was achieved through smart combination of geographic information, currently scattered across national databases, and recent information on shipping and local maritime conditions. NLR headed this project, commissioned by the Netherlands Agency for Aerospace Programmes (NIVR).

The different data sources were linked at a Geospatial Data Service Center (GSDC), focusing specifically on the North Sea. The center combined data on wind and waves with current data on maritime shipping, supplied by the Automatic Identification System (AIS). This data originates from satellites and transponders aboard the ships. Data was also obtained from TNO's Ships Radar (SHIRA) system. Oil spills can be detected because oil on the surface of water causes subtle changes in wave patterns. These variations can be detected by radar.

The team spent a month tracking oil. The information itself was relatively easily available on request. The greatest challenge proved to be the technology for merging the different data streams.

The movement of the oil spills could be followed live, even allowing their probable direction and drift speed to be forecast. The latter could be important for re-routing shipping and directing clean-up teams to beaches threatened by a spill.



# DEFENSE &

Times are changing – and this certainly applies for the Dutch armed forces. Dutch troops operate far beyond NATO territory, in countries such as Afghanistan and Angola. This imposes extreme demands on equipment.

NLR helps the Dutch armed forces deploy planes and helicopters safely and efficiently. Which missiles are likely to be deployed against Dutch aircraft in operational areas? Which protective measures are most effective? How can pilots best be prepared and trained? And what additional materials are required to ensure safe operations?

NLR also supports the Dutch armed forces in its choice of operational equipment and the maintenance thereof. Humidity, desert sand and intensive use take their toll. By closely monitoring the wear and tear of helicopters and planes, the Dutch armed forces can anticipate essential maintenance and optimize deployment of equipment.

# PEACEKEEPING MISSIONS

New high-tech helicopter

Secure exchange of
sensitive information

Flight testing with
military aircraft

Maintaining the JSF

Collective mission simulation

# NEW HIGH-TECH HELICOPTER

**NLR assists in the procurement of new Chinook transport helicopters for the Royal Netherlands Air Force.**

Military operations are all about logistics. The reason is simple: the success of such operations depends largely on the efficient transport of military personnel and material. This also applies to peacekeeping missions. Transport helicopters proved highly important in recent Dutch peacekeeping operations. This was a key factor in the decision to procure six new Boeing Chinook CH-47F helicopters in 2005. The Royal Netherlands Air Force (RNLAF) already operated earlier types of Chinook. The Defense Material Organization (DMO) contracted NLR to provide support in the procurement and introduction of this new equipment.

An introduction of this kind is a complex operation. The Ministry of Defense therefore established its own Military Aviation Authority (MAA) several years ago, which issues certificates of airworthiness for new equipment. NLR draws up the relevant requirements in consultation with this body, and is involved in the ground tests and test flights that are part of the airworthiness certification process.

The process of ordering helicopters is also complex. The standard version of the CH-47F did not fully meet Dutch demands. The package of requirements for the new Chinooks also took into account recent operational experience in Iraq and Afghanistan. The helicopters, for instance, must be suitable for the deployment of special forces. That means they need an infrared sensor and heavier than usual armament. Another requirement was the permanent display of all relevant flight data. This stems directly from two accidents that occurred with Dutch Chinooks in Afghanistan.

Like the old Chinooks, the new helicopters have a so-called "glass cockpit," in which most flight functions and mission equipment are controlled via multi-function displays. Because of updated equipment requirements, the old cockpit was no longer available. This presented yet another problem: the helicopter pilots should not need to deal with a cockpit layout that differed greatly from that of the older Chinooks. The same applied for the actual operation of the equipment itself. Differences between the two types had to be minimized for the pilots. This was particularly important in view of the limited number of pilots, making it unfeasible to have a separate group who would only pilot the new type.

Construction of the new Chinooks is now underway. Software requirements were formulated between 2006 and 2008, and a test bench with the selected equipment is scheduled for 2009. The DMO project team includes an NLR specialist, making it relatively simple to incorporate NLR's expertise. Apart from participation in the DMO, NLR also works in close cooperation with helicopter manufacturer Boeing and with avionics manufacturer Howeywell. NLR is both directly and indirectly involved as a team player in the design and testing phase of the cockpit modernization.

# SECURE EXCHANGE OF SENSITIVE INFORMATION

**It is essential that organizations and companies involved in defense projects are able to share data rapidly and securely. That is the purpose of the worldwide network TSCP.**

Most aviation and defense industry projects involve a large number of participants, including government authorities, companies and organizations from various countries. These parties must have a way of rapidly sharing protected data relating to designs, for example. Such data may be sensitive for commercial, technical or military reasons. Normal channels such as email are unsuitable for this purpose, because they offer insufficient security. Another issue affecting data exchange is the need to safeguard intellectual ownership, notably where competing companies are obliged to collaborate. In addition, most countries have laws restricting the export of defense materials. Also, the use of couriers – a tried and trusted security system – is much too slow.


The Transglobal Secure Collaboration Program (TSCP) is designed to resolve all of these issues. The international TSCP taskforce aims to enable secure collaboration through a standardized framework based on mutual trust. The program has been in operation for some years and is supported by companies like Boeing, Airbus, Lockheed Martin, Northrop Grumman, BAE Systems, and Rolls-Royce. The US, UK and Dutch governments are also actively involved. The Netherlands Ministry of Defense has been a member of the TSCP since 2007. Together with the Ministry of Defense, NLR promotes the interests of Dutch government and industry within TSCP. NLR is also studying the potential of TSCP for applications within the Dutch government and defense industry.

TSCP is working towards a more flexible system, with scalable solutions. Security is not only an issue of technology, but also requires a system of procedural agreements. One example is agreements on user identification procedures. That involves legal issues: which legal entities are allowed to identify themselves as user? The current focus of research is the application of the TSCP Secure Email standard. Secure Email uses proven technology such as the Public Key Infrastructure (PKI), which enables participants to exchange confidential data using digital certificates and digital signatures.

TSCP is still in the full flow of development. In collaboration with the Ministry of Defense, NLR will be testing relevant developments for the Netherlands.

# FLIGHT TESTING WITH MILITARY AIRCRAFT

**Mobile measuring equipment facilitates faster introduction of new systems.**

The Royal Netherlands Air Force (RNLAF) pursues the highest standards of safety and efficiency, even on demanding peacekeeping missions. Technological development in the area of weapons systems and protection systems against enemy missiles is a continuous process. New systems cannot simply be installed in planes or helicopters. They must first be checked to ensure that they operate correctly and to assess whether they negatively affect the characteristics or lifespan of the aircraft or helicopter in question. The required data is collected with the aid of measuring equipment during flight tests. Data analysis then reveals whether the new system works properly.

In the case of the F-16, such tests occur so frequently that the RNLAF has installed a permanent measuring system in an F-16B, a two-seat fighter, for use in all such tests. The need is less pressing for transport planes and helicopters, which is why RNLAF commissioned NLR to develop a mobile measuring system. The Generic Instrumentation System (GIS) was officially taken into operation in 2008. GIS records the readings of cockpit instruments and, in exceptional cases, records data on vibration, stress, temperature and the like. That means the system conducts more and better measurements than the standard crash recorder installed aboard most military aircraft. The measurement data are stored in a solid-state memory. Immediately after the flight, the data are downloaded and processed by computer. This allows analysis of test results shortly after completion of the test flight. GIS can be quickly and simply installed in helicopters, even in the confined cargo bay of the Apache attack helicopter.

GIS is also used to rapidly investigate failures. GIS is designed to minimize the impact of failures of aircraft and helicopters, thus benefiting operational availability. RNLAF technicians install and operate the system, even during operations abroad.

The system has been deployed in Apache and Chinook helicopters on a number of occasions. It was used, for instance, to test the effects of the Apache Modular Survivability Equipment (AMASE) with which helicopters are equipped to protect them from guided missiles. The pod containing warning sensors as well as chaff and flare holders that divert missiles weighs hundreds of kilos and is mounted on the tips of the helicopter's short wings. GIS recorded vibrations and stress exerted on these wings. The data was then used to check for excessive stress or unacceptable levels of vibration during various maneuvers.

# MAINTAINING THE JSF

**Intelligent diagnosis would ensure more efficient and safer deployment of future Royal Netherlands Air Force fighter jets.**

The American aircraft manufacturer Lockheed Martin commissioned the Dutch PHM Consortium (DPC) to design a maintenance system for the F-35 Lightning II, better known as the Joint Strike Fighter (JSF). Formed and coordinated by NLR, DPC also includes the Netherlands Organization for Applied Scientific Research TNO, Perot Systems, and Sun Electric Systems.

Using NLR's systems expertise, DPC successfully completed development of this Prognostics and Health Management (PHM) system in 2008.

Part of the process was to develop a failure resolution system, which allows technical problems to be identified and analyzed as soon as the fighter returns from a mission. In many cases, the aircraft's onboard software has already pinpointed the fault. After landing, however, ground personnel connect the aircraft to the failure resolution software, which has much greater capability, allowing swift diagnosis of the problem.

During system design, the greatest possible use was made of technology that was already commercially available, with a view to minimizing production costs. Cost considerations were also a major issue in the development of the PHM software, which was a reason for paying the greatest heed to procuring commercially available technology.

The project also included work on software for Fleet Life Management, which monitors the availability and life cycle of the entire fleet. Aircraft almost due for maintenance are, for instance, less suitable for challenging operations. A commander using the system can see at a glance which aircraft are mission capable. For example, fighters due for heavy maintenance within a couple of months are less suitable for deployed operations.

NLR previously developed similar systems for Orion maritime patrol aircraft and for the F-16 multi-role fighter. These systems are also of interest to clients outside the Netherlands.

# COLLECTIVE MISSION SIMULATION

**Nothing can match the touch and feel of an actual combat exercise, but collective mission simulation using smart linking of different simulators comes close to the real thing.**

Since the Cold War, there has been increasing cooperation between different parts of the Dutch defense force. Not only with each other, but also in the international arena. The Dutch navy supported the army by landing tanks on the Netherlands Antilles, while air force helicopters are used to deploy Dutch marines in Afghanistan. Joint operations such as these are complex and training is required, preferably taking advantage of simulators for reasons of cost efficiency. Although simulators are already widely used for training with individual aircraft and helicopters, collective mission training is still relatively uncommon.

For the past ten years, NLR has researched how Royal Netherlands Air Force simulators can be linked for training purposes. Technical success with linking has already been demonstrated nationally with the ULT-JOIND air and ground combat readiness network, and internationally with the NATO exercise First WAVE. NLR's simulators and expertise were a key factor in both these projects. Currently, NLR and the TNO research institute are collaborating on research aimed at combining air, land and sea systems effectively to allow realistic mission training. In this project, NLR is responsible for the air domain, the airborne systems, and all that is related to these systems.

It is a technological and operational challenge to interlink systems and harmonize the virtual environment. It not only involves all sorts of cable and wireless connections, but also the alignment of simulation models and operational concepts. For instance, the radio range of an aircraft or the weaponry of the F-16 simulator must match those in the other simulators. The same goes for the technical parameters of armored vehicles, marine helicopters, and anti-aircraft batteries.

Enemy weapons systems also play a role in collective simulations. NLR is helping the Ministry of Defense establish a central library containing all current and relevant data relating to these weapons systems. These are used to brief pilots ahead of missions, such as in Afghanistan. NLR is currently developing tools that allow this data to be used in simulators, thus enabling pilots to prepare effectively for realistic threats.

NLR is also working on a means to ensure that the simulated environments of the interlinked simulators are compatible with each other. Cloud cover can, for example, interfere with laser functioning. If cloud cover in the F-16 simulator differs from that in the simulator of a ground based observer (Forward Air Controller), the laser action in these simulators will also differ. That is unacceptable in an interactive scenario.

**NLR conducts research in the aerospace sector, although our knowledge is regularly applied in other sectors, and our facilities are also used for research in other fields. One example is NLR's expertise in the area of sustainable composite materials, which is now also being put to good use in the Dutch shipbuilding industry. Our wind tunnels have welcomed skaters, cyclists and bobsleigh teams seeking the most aerodynamic posture. With the aid of its milling machines, NLR creates ingenious chassis for racing cars designed by students at the Delft University of Technology. Spin-off activities of this kind give some indication of the breadth of impact of aerospace research – ranging from the public to the private sector, from major aircraft industries to smaller specialized businesses, from aviation to shipping, and from welfare to sports.**

## EYE-TRACKING HELPS KEEP BUS DRIVERS AWAKE

**Commissioned by Royal Beuk**

NLR has teamed up with the Royal Beuk touring coach company to experiment with a system that warns drivers for sleepiness. On long touringcar rides over quiet country roads, sleepiness is a risk to the driver as well as passengers and other motorists. Beuk therefore approached NLR to come up with a solution for this problem. NLR has gained extensive experience with eye-tracking, which is used, among other things, to register what pilots and air traffic controllers actually see during simulations. The same technology can also be used to measure how long a person's eyes remain open and closed. Sleepy people blink more often or keep their eyes closed longer. During a 2,800-kilometer bus trip from the Netherlands to Croatia, NLR constantly registered drivers' visual behavior and their blink patterns. During this extended trip, it was demonstrated that sleepiness could be accurately measured and used to set off an acoustic alarm to warn the driver. The company Seeing Machines saw this study as a further impulse to develop an experimental system that can be installed in vehicles and automatically does what is required. Beuk purchased this DriverStateSensor (DSS) and became the first touring coach operator in the world to use this fatigue detection system. The company has contracted NLR to assist in gaining further insight. Over the past year, Beuk and NLR gave a series of successful demonstrations at the Dutch Ministry of Transport, Public Works & Water Management and elsewhere.

# SPIN-OFFS

## MEASUREMENTS ALONG NEW RAILWAY

**Commissioned by ProRail**

The infrastructure manager ProRail is equipping the new Betuwe Line with 25,000-volt line voltage. The heavy freight trains that will use the line need more power than the 1,500 volt currently used on the Dutch railway network. The new electrical system is already used in France and elsewhere, but because circumstances are different in the Netherlands, ProRail contracted NLR to assist in an extensive measurement program guaranteeing the safety and reliability of rail traffic under extreme conditions, even if the electrical systems short-circuit.

Since 1999, measurements of the 25,000-volt system have already been underway on a trial section on the Maasvlakte. From 2007, the integrated systems of the entire Betuwe Line were put to the test. Measurements usually took place at night, when the section in question was free of ordinary rail traffic. The experiments paid special attention to possible interference with the existing railway network, which sometimes crosses or runs parallel to the Betuwe Line. The connections with the existing network, via so-called "voltage interface areas," were also closely scrutinized. In these areas, the train driver switches the locomotive supply voltage from 25,000 volts to 1,500 volts, or vice versa. A complex protection system ensures that there is no damage or danger if an error is made during this switch. This prevents disruptions and therefore delays.

NLR designed the measurement system and conducted the actual measurements together with ProRail and other parties. ProRail specialists are analyzing the measurement data. NLR is contributing to these analyses its extensive experience in the instrumentation of experiments for the aviation industry. The institute gained this experience in collaboration with customers such as the former Fokker Aircraft, for which it handled instrumentation of prototypes. Such complex measurements go hand in hand with high costs, demanding high levels of reliability. Similarly, the ProRail measurements were too costly to risk having to redo them. Sometimes more than 50 people were actively involved in each test. Vast quantities of measurement data had to be recorded without a hitch.

NLR is also providing expertise for measurements along the new High-Speed Railway. The experience gained along the Betuwe Line will certainly come in handy.

## TREATING CANCER WITH RADIO WAVES

**Commissioned by Erasmus MC**

The Erasmus Medical Center in Rotterdam treats cancer of the head and neck by heating tumors with the aid of radio waves emitted by 12 antennae arranged in a circular array around the patient's body. By creating phase differences in the signals, the electromagnetic field can be focused on the tumor. NLR contributed to an electronic system that continually monitors the signal phases of the antennae during treatment, so that healthy tissue is not harmed. The system ensures that the heat treatment is fully stable.

NLR developed the basic technology for integration of smart antennae into vibrating aircraft structures. The technology was developed, in part, for the ISAAC project, which was commissioned by the Dutch Ministry of Defense and completed in 2008. This project also involved an array of antennae elements. The phase differences had to be carefully controlled to guarantee communication without interference. Several years ago, researchers from the two projects met at a scientific congress in Germany and decided to put their heads together. In the years that followed, this resulted in the development of electronics for the HYPERcollar Hyperthermia Applicator. This technology is currently used in standard treatment at the Erasmus Medical Center, in combination with radiotherapy.

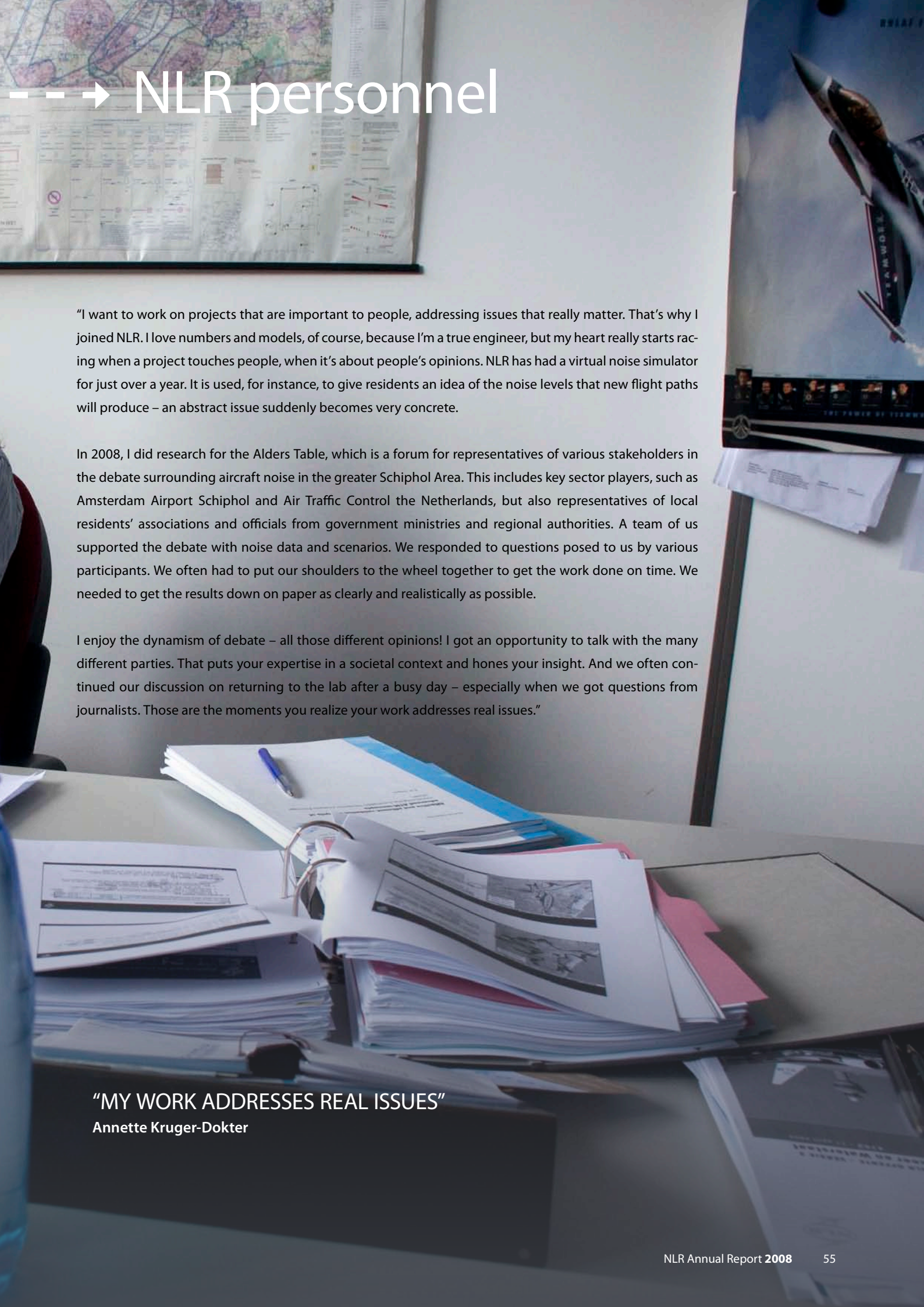
Chapter 2:

# PEOPLE, FACTS & FIGURES

This chapter features a series of portraits of NLR employees, in which they discuss their working ambitions and motivations. You will also find information on NLR's organizational structure, our workforce, the Supervisory Board, the Advisory Board, the Advisory Committees and the additional functions of the Executive Team. The chapter ends with a summary of our financial results for 2008.


# Portraits of

# - - → NLR personnel



"I want to work on projects that are important to people, addressing issues that really matter. That's why I joined NLR. I love numbers and models, of course, because I'm a true engineer, but my heart really starts racing when a project touches people, when it's about people's opinions. NLR has had a virtual noise simulator for just over a year. It is used, for instance, to give residents an idea of the noise levels that new flight paths will produce – an abstract issue suddenly becomes very concrete.

In 2008, I did research for the Alders Table, which is a forum for representatives of various stakeholders in the debate surrounding aircraft noise in the greater Schiphol Area. This includes key sector players, such as Amsterdam Airport Schiphol and Air Traffic Control the Netherlands, but also representatives of local residents' associations and officials from government ministries and regional authorities. A team of us supported the debate with noise data and scenarios. We responded to questions posed to us by various participants. We often had to put our shoulders to the wheel together to get the work done on time. We needed to get the results down on paper as clearly and realistically as possible.

I enjoy the dynamism of debate – all those different opinions! I got an opportunity to talk with the many different parties. That puts your expertise in a societal context and hones your insight. And we often continued our discussion on returning to the lab after a busy day – especially when we got questions from journalists. Those are the moments you realize your work addresses real issues."

## "MY WORK ADDRESSES REAL ISSUES"

**Annette Kruger-Dokter**

## "WE'RE ALWAYS READY, EVEN ON CHRISTMAS EVE"

**Paul Dujardin**

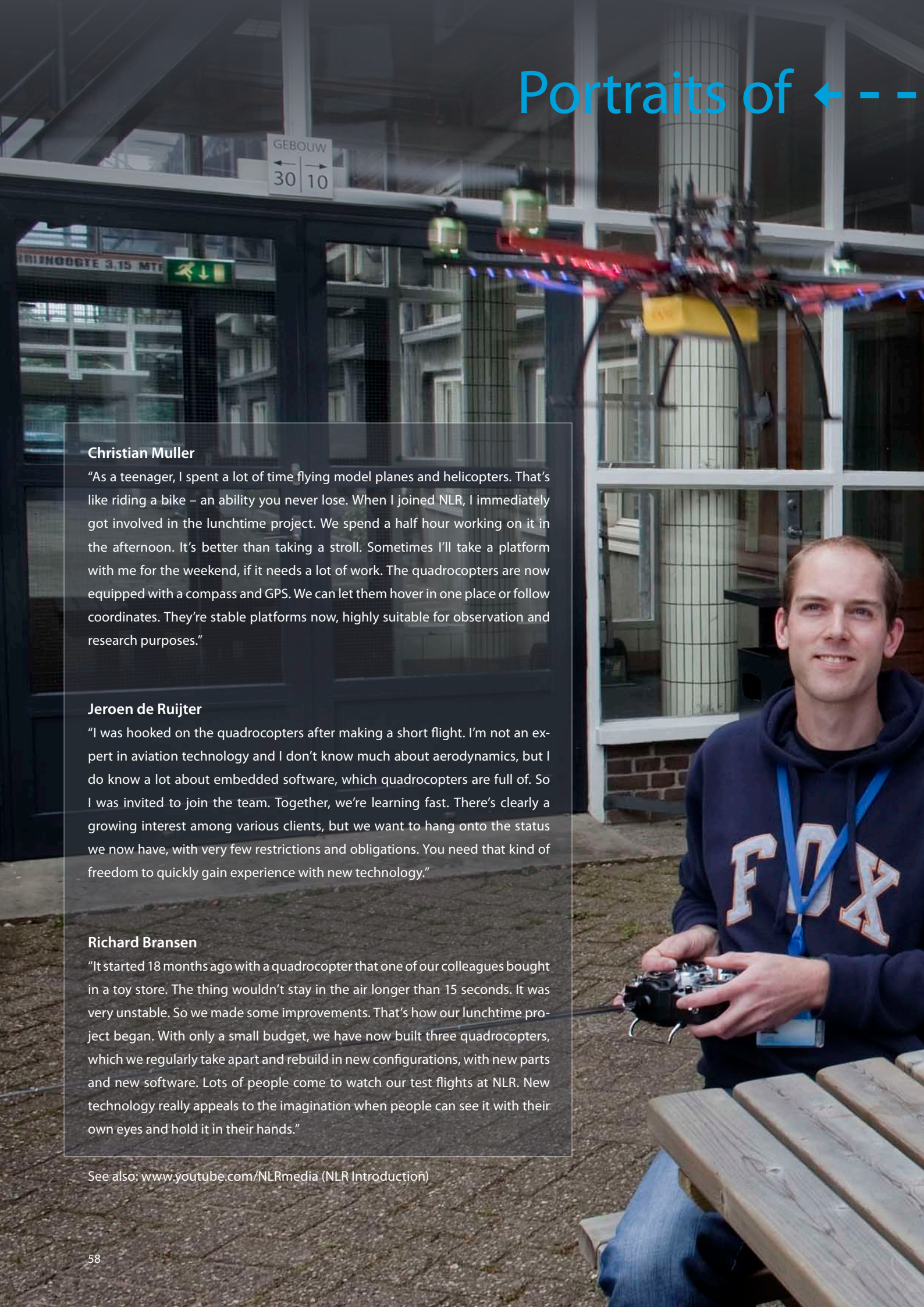
"February 7, 2008, saw the launch of the Columbus Module, the European section of the International Space Station. That was an exciting moment for the operating team. Our task was to keep a 24-hour watch on nine experiments on the EuTEF external platform for a total of 18 months. Since March 2009, we've also monitored an experiment in the European Drawer Rack.

We work in shifts at the Erasmus USOC in Noordwijk, which is even staffed at Christmas and New Year. We have two operators on site during office hours, and one after hours in the evening and at night. My personal preference is the command shift from 14.00 in the afternoon till 22.00 at night. That coincides with the working day of the astronauts on board, which means there's a lot of activity. But the other shifts are also important. If something goes wrong, you have to take action immediately. A couple of times a month, on average, we have to take action during the night shift.

I've been involved in the Erasmus USOC project from the very beginning – from the first designs and prototypes, right through to the installation of ground infrastructure and experimental platforms, and the validation of procedures. It's great to be operational and I'm more than willing to put up with the irregular working hours. I'll never forget the moment in 2008 when the European Drawer Rack was unpacked in space and installed according to the procedures we had designed and tested. We supervised the NASA astronaut, giving instructions from Erasmus USOC, and within a couple of hours the rack was up and running."

# - - → NLR personnel

# Portraits of




**Christian Muller**

"As a teenager, I spent a lot of time flying model planes and helicopters. That's like riding a bike – an ability you never lose. When I joined NLR, I immediately got involved in the lunchtime project. We spend a half hour working on it in the afternoon. It's better than taking a stroll. Sometimes I'll take a platform with me for the weekend, if it needs a lot of work. The quadrocopters are now equipped with a compass and GPS. We can let them hover in one place or follow coordinates. They're stable platforms now, highly suitable for observation and research purposes."

**Jeroen de Ruijter**

"I was hooked on the quadrocopters after making a short flight. I'm not an expert in aviation technology and I don't know much about aerodynamics, but I do know a lot about embedded software, which quadrocopters are full of. So I was invited to join the team. Together, we're learning fast. There's clearly a growing interest among various clients, but we want to hang onto the status we now have, with very few restrictions and obligations. You need that kind of freedom to quickly gain experience with new technology."

**Richard Bransen**

"It started 18 months ago with a quadrocopter that one of our colleagues bought in a toy store. The thing wouldn't stay in the air longer than 15 seconds. It was very unstable. So we made some improvements. That's how our lunchtime project began. With only a small budget, we have now built three quadrocopters, which we regularly take apart and rebuild in new configurations, with new parts and new software. Lots of people come to watch our test flights at NLR. New technology really appeals to the imagination when people can see it with their own eyes and hold it in their hands."

See also: www.youtube.com/NLRmedia (NLR Introduction)

# - - → NLR personnel

"IT'S BETTER THAN A LUNCHTIME STROLL"

# Portraits of ← - -

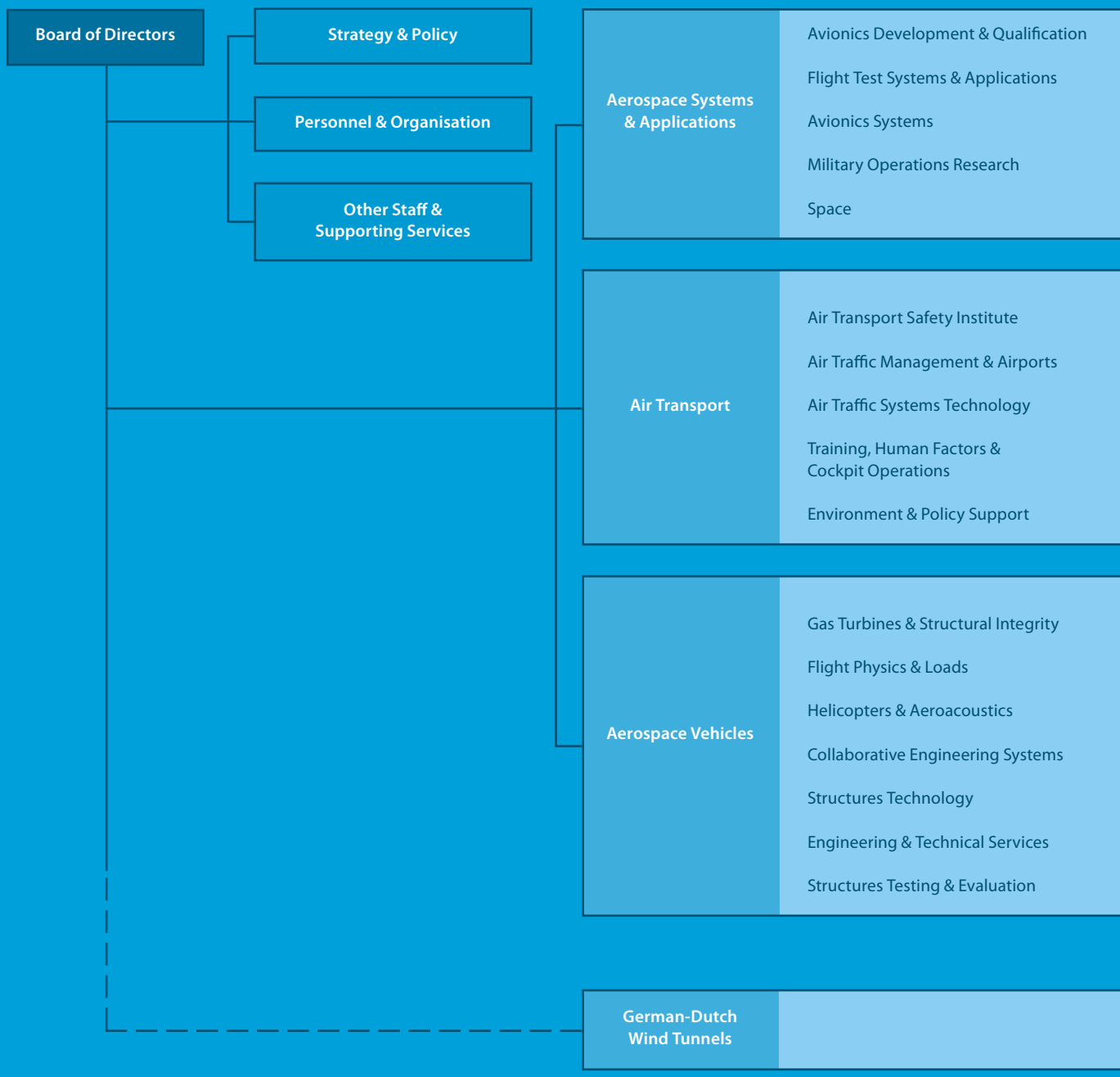
# - - → NLR personnel

"When we're measuring in the wind tunnel, the working day never ends at five. We regularly make adjustments in the evening, so that we can get back to measuring at eight the next morning. If necessary, we work till eleven at night, or even later. It's a lot easier to ask that of your colleagues if you work overtime yourself. We get things done together, which gives a great deal of satisfaction. I like the challenges and diversity – my work is never the same. When one customer walks out the door, the next is often already waiting. Sometimes we spend weeks cooperating intensively with research teams – with Britons, Americans, Chinese, Koreans, Spaniards, Brazilians. They want to get the most out of the available measuring time. They work on their wind-tunnel models in the evening, so that they can measure even more efficiently the next day. I often stick around. We'll chat. They'll tell me how the measurements contribute to their research, and I'll give them my thoughts. I think this degree of involvement is important. It gives me insight into our role in the broader program. Sometimes we have a meal together or a drink in the café. I got on very well with a visiting Brazilian team. Before they left, we all went skating together."

## "MY WORK IS NEVER THE SAME"

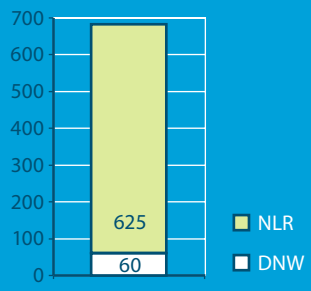
**Koen Artois**

# I) ORGANIZATIONAL STRUCTURE

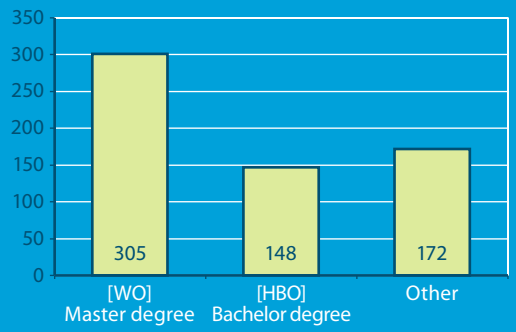



# II) NLR STAFF ON DECEMBER 31, 2008

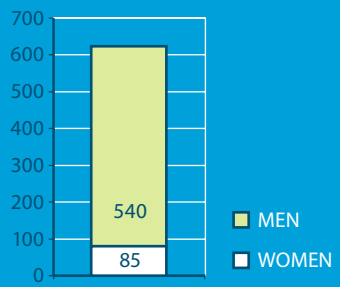
**Number of staff (total = 685)**



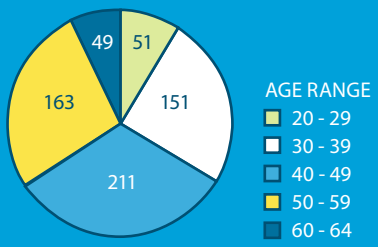

**Educational level of staff (excluding DNW)**



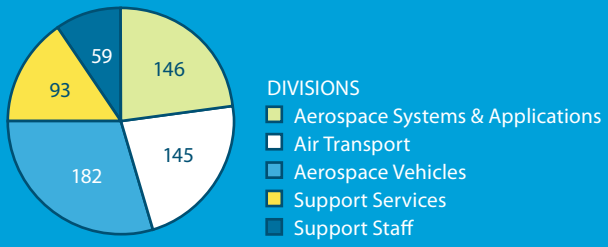

**Gender division (excluding DNW)**




**Age breakdown (excluding DNW)**




**Number of staff per division (excluding DNW)**



## III) THE SUPERVISORY BOARD ON DECEMBER 31, 2008

| | | |
|---|---|---|
| Drs. A. Kraaijeveld | • | Chairman |
| Drs. A. de Ruiter | | |
| Ir. C.A.M. de Koning | | |
| Prof.dr.ir. M.P.C. Weijnen | | |
| A. Schot RA | | |
| Ir. A.C.J. Besselink | | |

## IV) THE ADVISORY BOARD

| | | |
|---|---|---|
| Dr.ir. A.W. Veenman | • | Chairman |
| Drs. E.A. Bien RC | • | Ministry of Transport, Public Works & Water Management |
| Ir. P.J. Keuning | • | Ministry of Defense (DMO) |
| Cdre M.M.C. Spit | • | Ministry of Defense (CLSK) |
| Drs. A.A.H. Teunissen | • | Ministry of Economic Affairs |
| Dr. J.T.M. Rokx | • | Ministry of Education, Culture & Science |
| Prof. B.A.C. Droste | • | NIVR Netherlands Agency for Aerospace Programs |
| Y. de Haan | • | KLM Royal Dutch Airlines |
| Ir. P. Riemens | • | LVNL Air Traffic Control the Netherlands |
| A.P.J.M. Rutten | • | Amsterdam Airport Schiphol |
| Ir. H. Buthker | • | Stork |
| Ir. J. de Jong | • | Stork |
| Ir. H.J.D. Reijnen | • | Dutch Space |
| Prof.dr.ir. H. Tijdeman | • | Chairman Advisory Committee Aerospace Vehicles |
| Prof.dr.ir. G. Ooms | • | Chairman Advisory Committee Aerospace Systems & Applications |
| Prof.dr.ir. M.J.L. van Tooren | • | Chairman Advisory Committee Air Transport |

## V) THE ADVISORY COMMITTEES

| | | |
|---|---|---|
| Prof.dr.ir. M. van Tooren (Chairman) | • | Delft University of Technology / Faculty of Aerospace Engineering |
| Drs. M. van Dorst | • | KLM Royal Dutch Airlines |
| Prof.dr. P.T.W. Hudson | • | University of Leiden / Faculty of Social Sciences |
| Ir. G.C. Klein Lebbink | • | NIVR Netherlands Agency for Aerospace Programs |
| Ir. R.J. Karelse | • | Ministry of Defense / Simulation Expertise Center |
| Kol.drs. R.H. Kramer | • | Ministry of Defense / Staff Support Group CLSK |
| Dr.ir. A.C.A.P. van Lammeren | • | Ministry of Transport, Public Works & Water Management / DGLM |
| Prof.dr.ir. J.A. Mulder | • | Delft University of Technology / Faculty of Aerospace Engineering |
| J.M.P. Noordeloos | • | Amsterdam Airport Schiphol |
| Ir. H.A.J.M. Offerman (Vice Chairman) | • | LVNL Air Traffic Control the Netherlands |
| Prof.dr.ir. J.L Simons | • | University of Groningen / Faculty of Business Management |
| Prof.dr. P.J.M. Stallen | • | University of Leiden / Faculty of Social Sciences |
| Prof.dr.ir. H. Tijdeman | • | Emeritus Professor of the Twente University of Technology |
| Dr.ir. H.G. Visser | • | Delft University of Technology / Faculty of Aerospace Engineering |
| Ing. J.H. Wilbrink | • | Ministry of Transport, Public Works & Water / IVW / TL&L |
| Kol.ir P.J.H.H. de Witte | • | Ministry of Defense / DMO / WS / RLu / HBTH |

## AEROSPACE SYSTEMS & APPLICATIONS

| | |
|---|---|
| Prof.dr.ir. G. Ooms (Chairman) | • Delft University of Technology / J.M. Burgercentrum |
| Ing. P. van Dooren | • KLM Royal Dutch Airlines / Engineering & Maintenance |
| Ir. H.M.P. Förster | • NIVR Netherlands Agency for Aerospace Programs |
| Lt-Kol T. Haringa | • Ministry of Defense / CLSK / DML / H-AORE |
| Cdre b.d. A.P. Hummel | • Thales Nederland B.V. |
| Kol.ir.ing. J.W.E.N. Kaelen | • Ministry of Defense / Logistics Center Woensdrecht |
| Lt-Kol dr.ir. T.W.G. de Laat | • Netherlands Defense Academy / Faculty of Military Sciences |
| Drs.ir. H.J.M. van Leeuwen | • NIVR Netherlands Agency for Aerospace Programmes |
| Kol. P.E. Mulder | • Ministry of Defense / CDS / BS / DS / DOBBP / H-BKLu |
| Prof.Dipl.-Ing. H. Stoewer (Vice Chairman) | • Space Associates GmbH, St. Augustin/Bonn |
| Ing. T. Tetteroo | • Fokker Elmo B.V. |
| Prof.dr.ir. P.J.G. Teunissen | • Delft University of Technology / Faculty of Aerospace Engineering |

## AEROSPACE VEHICLES

| | |
|---|---|
| Prof.dr.ir. H. Tijdeman (Chairman) | • Emeritus Professor Twente University of Technology |
| Prof.dr.ir. R. Benedictus | • Delft University of Technology / Faculty of Aerospace Engineering |
| Lt-Kol ir. G.J. Beuker | • Ministry of Defense / Volkel Airbase / PCOOD |
| Dr. ing. G. Eitelberg | • DNW German-Dutch Wind Tunnels |
| Ir. H.M.P. Förstert | • NIVR Netherlands Agency for Aerospace Programs |
| Ir. N.J. Fraterman | • Stork Fokker AESP B.V. |
| Ing. H. Hendriks | • Ministry of Defense / Royal Netherlands Air Force Command |
| Prof.dr.ir. A. Hirschberg | • Eindhoven University of Technology / Faculty of Applied Physics |
| Prof.dr.ir. H.W.M. Hoeijmakers | • University of Twente / Faculty of Mechanical Engineering |
| Lt-Kol H.J. Koolstra | • Netherlands Defence Academy, former lecturer on Air Power |
| Drs.ir. H.J.M. van Leeuwen | • NIVR Netherlands Agency for Aerospace Programs |
| Ir. A.J.A. Mom | • Dutch Gas Turbine Association |
| Ir. A.R. Offringa | • Stork Fokker AESP B.V. |
| Lt-Kol ir. F.H.M. Schuurman | • Ministry of Defense / Command Staff / Military Aviation Authority |
| Prof.dr.ir. P. Wesseling (Vice Chairman) | • Emeritus Professor of the Delft University of Technology |
| Prof.dr. ir. S. van der Zwaag | • Delft University of Technology / Faculty of Aerospace Engineering |

# VI) ADDITIONAL FUNCTIONS OF THE EXECUTIVE TEAM

## FRED ABBINK

| | | |
|---|---|---|
| International Council of Aerospace Sciences (ICAS) | • | Past President & Member Executive Committee & Programme Committee 2009 |
| Association of European Research Establishments in Aeronautics (EREA) | • | Vice Chairman Board 2009 |
| EEIG AT-ONE | • | Supervisory Board |
| DLR-NLR Joint Executive Board | • | Member |
| NIVR Raad van Advies | • | Member |
| European Aviation Safety Training Organisation (EASTO) | • | Board member |
| Raad van Advies Kon. Ned Vereniging voor de Luchtvaartd (KNVvL) | • | Member |
| Duits Nederlandse Windtunnels (DNW) | • | Vice Chairman Board |
| EU Transport Advisory Group | • | Member |
| NL Transport Advisory Group | • | Member |
| Advisory Council for Aeronautical Research in Europe (ACARE) | • | Member |
| Academie Nationale de l'Aeronautique et de l'Espace (ANAE) | • | Member |
| AIAA International Activities Committee | • | Member |
| European Transonic Windtunnel (ETW) | • | Chairman 2009 |
| Stichting Nederlandse Industrie voor Defensie en Veiligheid (NIDV) | • | Deputy member of the Board |
| Netherlands Academy for Innovation and Technology (AcTI) | • | Member |
| Flight Safety Nederland (FSN) | • | Board member |
| Von Karman Institute (VKT) | • | Board member |
| Kenniskamer Min VenW | • | Member |
| Kenniskamer Min Defensie | • | Member |

## LEO ESSELMAN

| | | |
|---|---|---|
| KennisKring Amsterdam (KKA) | • | Board member |
| Ondernemers Vereniging Regio Amsterdam (ORAM) | • | Board member |
| Duits Nederlandse Windtunnels (DNW) | • | Board member |
| Aero Testing Alliance (ATA) | • | Board member |
| Stichting Pensioenfonds van NLR | • | Chairman Board |
| Ondernemingsvereniging VNO-NCW | • | Member |
| Koninklijk Nederlands Instituut van Registeraccountants (NIVRA) | • | Member |

## ERNST FOLKERS

| | | |
|---|---|---|
| Association of European Research Establishments in Aeronautics (EREA) | • | Member General Assembly / Treasurer |

### MICHEL PETERS

| | |
|---|---|
| AT-One alliance with DLR | • Director |
| European ATM Research and Development Association (EATRADA) | • Board member |
| Coordination Committee FAA/Eurocontrol MoU | • Active member |
| FAA/Eurocontrol ATM conferentiecommissie | • Member |
| Eurocontrol Control Group (ECCG) | • Member |
| Knowledge Development Center (LVNL) Management Team | • Member |
| Eurocontrol Advisory Group for Research (AGR) | • Member |

### EDDY PIJPERS

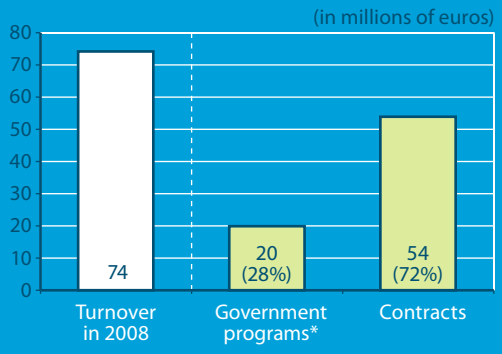
| | |
|---|---|
| Aerospace Software and Technologies Institute (ASTI ) | • Board member |
| Geomatica Business Parc | • Board member |
| KIVI-DV (Defensie en Veiligheid) | • Board member |
| Regiegroep Geomatica - Prov. Flevoland | • Member |
| UVS International | • Member |
| NATO Research & Technology Board | • NL representative |

### BAS OSKAM

| | |
|---|---|
| Group for Aeronautical Research and Technology in Europe - Executive Committee (Garteur EC) | • Board member |
| NATO Applied Vehicle Technology panel(NATO-AVT panel) | • Member |
| NATO-RTO AVT Panel Technical Committe on Performance, Stability & Control and Flight Physics (NATO-AVT panel TC) | • Member |
| Fibre Metal Laminates Centre of Competence (FMLC) | • Chairman |
| Advisory Committee German Dutch Wind Tunnels | • Chairman until the end of 2008 |
| Airbus and Netherlands Aerospace Cluster on SRP projects in the thematic area “Future Technologies” (NAG Stork Aerospace) | • Single PoC |
| AirTN Board, European Research Area Net on Air Transport | • Member |
| AirTN Management Committee | • Member |
| NLR-DLR Programmatics Committee | • Member |
| DLR-NLR Joint Executive Board | • Member |
| Raad van Advies Maritime Research Institute Netherlands (MARIN) | • Member |

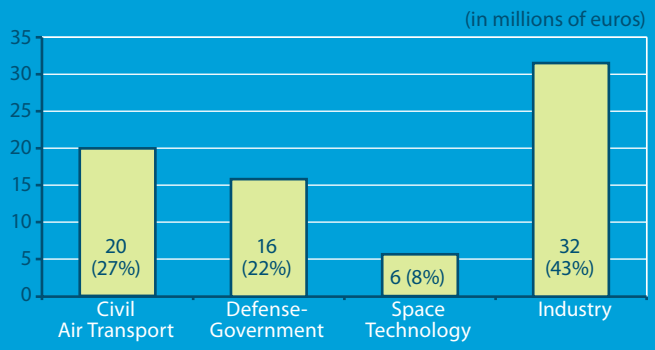
# VII) FINANCIAL DATA

**Turnover in 2008:**




* Excluding 3.2 million investment contribution

**Breakdown across sectors:**



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