ARTIFICIAL INTELLIGENCE AT DLR RESEARCH FOR GERMANY

DLR

DLR plays an important role in artificial intelligence (AI) research. This is made possible by its extensive experience in AI coupled with interdisciplinary expertise, as well as several cutting-edge, large-scale facilities. As a result, DLR is well positioned to contribute to the further research and development of AI, both in Germany and the rest of Europe.

The primary competence of DLR is the well-founded selection, creative and innovative use of and targeted further development of AI methods for various industrial and commercial applications. These include Earth observation, robotics, energy research, the development of assistance systems for air transport, traffic management and automated driving.

Through its unique range of expertise, DLR promotes innovation and contributes to the direct transfer of ground-breaking technologies to industry. It also ensures that data is made usable, and promotes education in the field of AI. All of these activities are aligned with the German national AI strategy.

AI is not a one-size-fits-all solution. The technology enables targeted, smart solutions for many current challenges; DLR is a leader in this field. This brochure gives an overview of AI research at DLR and its fields of application.

Prof. Dr. Pascale Ehrenfreund, Chair of the DLR Executive Board

THE GERMAN AEROSPACE CENTER (DLR)

DLR is the Federal Republic of Germany's research centre for aeronautics and space. The organisation also completes research in the areas of energy, transport, security and digitalisation. Such projects are often completed as part of national and international cooperative efforts.

Acting on behalf of the federal government, the DLR Space Administration designs and implements Germany's space programme, together with national and international partners. DLR is also the umbrella organisation for two project management agencies that promote research.

DLR has approximately 8600 employees at 27 locations in Germany. It also has international offices in Brussels, Paris, Tokyo and Washington D.C.

SPACE
ENERGY
PROJECT MANAGEMENT AGENCY
AERONAUTICS
DIGITALISATION
SECURITY
TRANSPORT
SPACE ADMINISTRATION

Artificial intelligence (AI) is an umbrella term used to describe various computer science methods that can perform tasks commonly associated with human cognitive function. The field of AI research has experienced significant growth in recent years. This is, in part, due to technological advances in computing, which make it possible to acquire and analyse very large quantities of data. These developments are enabling the use of AI in emerging areas of application. **DLR has been working on the development of AI methods for many years.**

SELECTED FIELDS OF APPLICATION AND AI ACTIVITIES AT DLR
AN OVERVIEW

EARTH OBSERVATION

SAFETY-CRITICAL SYSTEMS

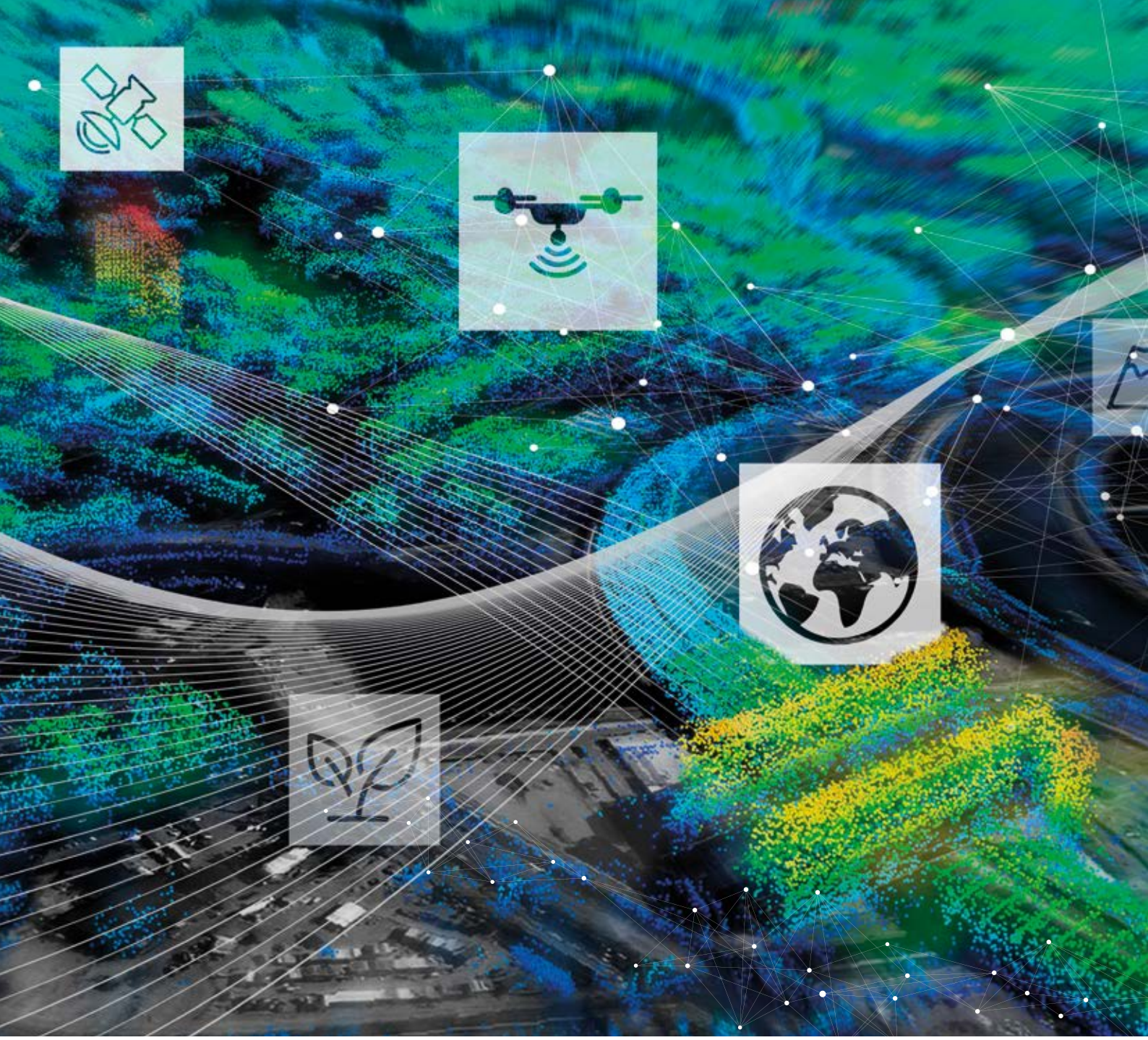
AUTOMATED AND NETWORKED DRIVING

PERSONAL ASSISTANTS AND EXPERT SYSTEMS

ROBOTICS

PRODUCTION

PREDICTIVE MAINTENANCE AND CONDITION MONITORING



ARTIFICIAL INTELLIGENCE FOR EARTH OBSERVATION – MAKING IMPROVED USE OF DATA

Today's new era of Big Data derived from Earth observation activities poses difficult challenges. AI techniques are the only way to analyse the large amounts of high-quality data required to **understand the Earth system** and global change. These data are of **great economic and public value.** Regional and urban planning, agriculture, and resource management are as dependent on information derived from satellite data as security-relevant applications. These include early warning of natural hazards, crisis and disaster management, monitoring the condition of infrastructure and maritime security.

DLR is working on numerous AI-based solutions in these areas, such as geo-databases for planning transport systems and urban areas, as well as remote detection of fires. The mapping of sea ice and forest areas, the development of cognitive radar systems and climate modelling are also part of this AI research programme.

DLR has been intensively involved in the **development of AI algorithms needed to process and evaluate Earth observation data** for many years, and is now internationally recognised as a pioneer in this field. In particular, **machine learning methods involving deep neural networks** have been successfully developed. These address a large number of geo-relevant analysis questions and have received many awards.

With the establishment of its Institute of Data Science in Jena, Germany, DLR is continuing to strengthen its expertise in the fields of data science and data visualisation.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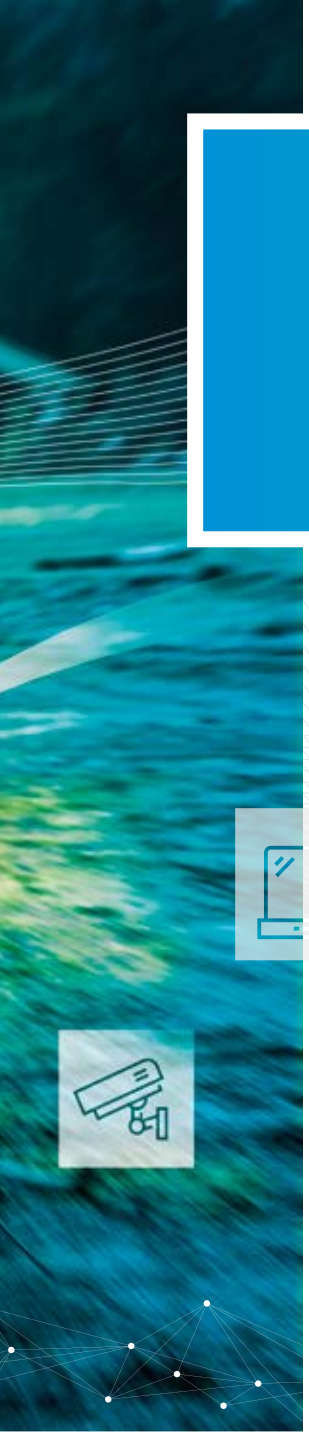

ARTIFICIAL INTELLIGENCE FOR SAFETY-CRITICAL SYSTEMS – DEVELOPING TECHNOLOGY RESPONSIBLY

AI algorithms are increasingly being used in civilian applications. However, their widespread implementation will largely depend on their ability to comply with the same safety and security standards as conventional systems. Such **AI systems must not only operate safely, they also have to be secure against attack.**

Possible application fields include air transport, as well as automated and networked mobility. Industry 4.0 and smart, decentralised energy grids may also benefit. The aeronautics and space industries are highly focused on safety and reliability; for this reason, critical software and hardware systems are comprehensively tested and verified. DLR makes use of its extensive expertise in these fields to ensure AI algorithms are tested in accordance with such standards. Thanks to its experience in the cross-disciplinary fields of digitalisation and security, **DLR is well placed to conduct cutting-edge research into secure AI systems.**

ARTIFICIAL INTELLIGENCE FOR AUTOMATED AND NETWORKED DRIVING – ENABLING SAFER TRANSPORT

Automated and networked driving is transforming mobility. Autonomous vehicles need to analyse their surrounding environment and react accordingly. AI technologies are key to accomplishing this. DLR is developing **intelligent traffic management systems** and conducting research into accurate three-dimensional **digital mapping of roads.**

DLR has **extensive fundamental and application-oriented research experience** at both national and international levels. It is also thoroughly integrated with the automotive sector and its industry bodies. For example, DLR was involved in the BMWi flagship project PEGASUS and the BMBF forward-looking 'Learning Systems' platform.

In addition, DLR operates numerous **large-scale research facilities** for transport research. For example, the Application Platform for Intelligent Mobility (AIM) is used to examine urban transport, whereas the Test Bed Lower Saxony focuses on motorways and main roads. These facilities provide ground-truth data for learning processes and the validation of AI-based components. Therefore, DLR is able to provide reference databases for the training and functional verification of AI algorithms.


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ARTIFICIALLY INTELLIGENT PERSONAL ASSISTANTS AND EXPERT SYSTEMS – STRUCTURING COMPLEX KNOWLEDGE

Supporting people is the primary purpose of Intelligent Personal Assistants (IPAs). To accomplish this, they must be able to understand and process verbal commands, and then act independently or propose solutions. Modern speech recognition methods draw on various approaches from the field of machine learning.

IPA often only form the interface to the underlying technical systems. They are frequently supplemented by **knowledge-based systems** in which human expertise is stored and linked in a logical way for subsequent retrieval. For many years, **DLR has been developing solutions for various application areas,** such as supporting astronauts, pilots and air traffic controllers. The underlying AI technology can also be used in other fields where complex knowledge provides the basis for decision making, for example in medicine.

ARTIFICIAL INTELLIGENCE FOR ROBOTICS – OPTIMISING HUMAN-MACHINE COOPERATION

Robotic systems with certain levels of autonomy are already being used in a number of scientific and industrial applications. However, achieving full autonomy will remain the stuff of science fiction without the availability of AI techniques as enablers.

An important AI research goal at DLR is making robots aware of their own abilities. This approach is also being explored in **service robotics,** an area focused on assisting humans. **Partial autonomy** plays an important role here; the robot recognises the task that the person wishes to perform and helps them achieve their goal. People with physical impairments consider partial autonomy to be much more pleasant than the idea of fully autonomous robots, which are seen as patronising.

DLR has a long history of success in robotics and is considered to be a world leader in this field. Examples of its work are **humanoid robots like Justin and surgical robots,** such as the fully licensed **MIRO.** In order to lay the foundations for **successful human-machine cooperation** in Industry 4.0, as well as in medicine and healthcare, DLR has completed fundamental research in the area of sensitive lightweight robotics. This technology has since resulted in an award-winning spin-off company and successful licensing.


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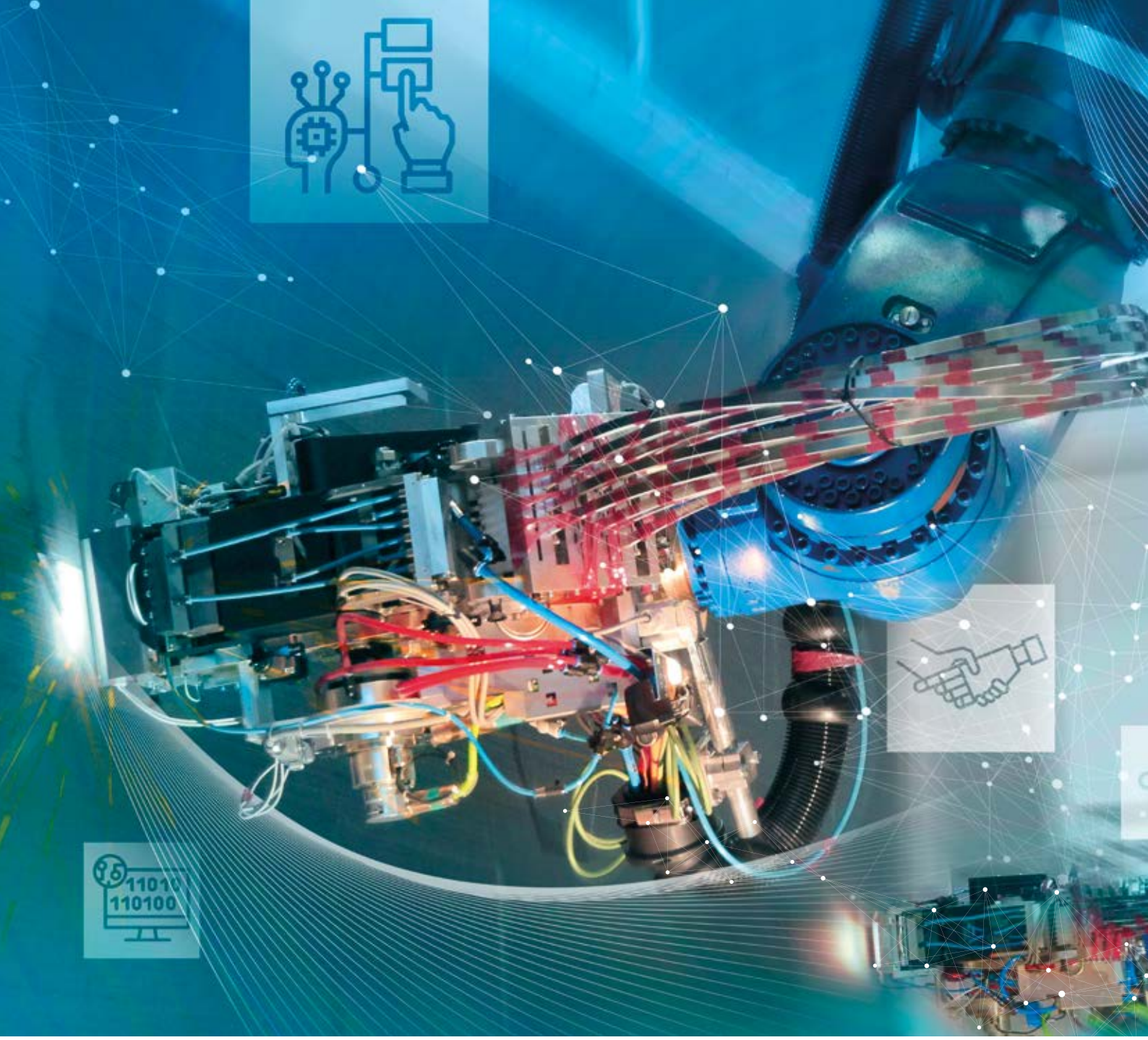

ARTIFICIAL INTELLIGENCE FOR PRODUCTION – ENHANCING CONTROL OF AUTOMATION

Industry 4.0, which builds on the idea of the Internet of Things, incorporates highly automated and networked production. Such technology involves interactions between large and complex systems, which generates enormous amounts of data. These cannot be monitored or checked by humans, and this is where AI becomes necessary. DLR's activities are currently addressing two main areas related to the use of robotic systems in manufacturing: **automatic recognition and position estimation, and the networking of different systems as part of industry 4.0.**

The first allows numerous components to be recognised as quickly and reliably as possible. Such systems can also determine the exact locations of components, which allows a robotic arm mounted on a mobile platform to grasp them. DLR has made considerable progress within this area by implementing a deep learning approach. The robotic system's learning process is completely autonomous.

Regarding the **networking of different systems** – the efficiency and intelligence of human-machine interaction is being improved using DLR's lightweight SARA robot. New application scenarios are also being made possible in networked production. DLR is also using RAFCON software to develop an **open source licensed system** for task programming and semantic logging. The aim here is to offer a free-of-charge platform for robot capabilities.

ARTIFICIAL INTELLIGENCE FOR PREDICTIVE MAINTENANCE AND CONDITION MONITORING – ENSURING OPERATIONAL SAFETY

Predictive maintenance refers to the **proactive upkeep of systems and structures,** such as machinery and buildings, so that they can be serviced before a problem occurs. This makes it possible to keep downtime for machinery, aircraft, satellite-based systems and robots to a minimum.

Predictive and prescriptive maintenance are widely implemented at DLR. Modern commercial aircraft are equipped with **tens of thousands of sensors,** a large proportion of which are designed to evaluate the condition of the aircraft. DLR is researching AI methods which will extract status information from the large quantities of data provided by the sensors. These techniques will make it possible to identify disruptive events and draw conclusions regarding the location and cause of the malfunction. In addition, knowledge-based AI processes can be used to determine **correlations between measurement data and disruptions,** – and to better plan upcoming maintenance tasks.

Several DLR institutes are contributing their expertise and infrastructure to an **in-house cross-sectoral project.** This aims to introduce next-generation condition-based, maintenance procedures for preventing damage to safety-related structures in air transport. DLR is also applying its expertise to other areas, such as rail transport, road vehicles, traffic management and energy systems.

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DEVELOPING TECHNOLOGY RESPONSIBLY
ENABLING SAFER TRANSPORT
STRUCTURING COMPLEX KNOWLEDGE
OPTIMISING HUMAN-MACHINE COOPERATION
ENHANCING CONTROL OF AUTOMATION
ENSURING OPERATIONAL SAFETY

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