



PROFILE & HIGHLIGHTS



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Innovation Powerhouse

We are Austria's largest Research and Technology Organisation (RTO) and play in the world's premier league on many infrastructure topics. This makes us a powerful development partner for industry and a top employer in the international scientific scene.

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Today, AIT is at the very forefront in many areas.

Peter Schwab,
Chairman of the AIT Supervisory Board,
member of the Management Board of
voestalpine AG

For 15 years, the AIT Austrian Institute of Technology has been a true success story. Thanks to its consistent strategic orientation towards central research topics from the areas of infrastructure and the major challenges of the future, in particular digitisation and decarbonisation, the Institute has grown to become a constant in research, technology development, and innovation, as well as an important partner for business in Austria and Europe. Today, AIT is at the very forefront in many areas – with research being already at the top or very close to it.

AIT sees itself as a partner of business and industry to drive innovation. Since the complexity of the topics and the rich variety of the disciplines in industry nowadays are very high, conventional methods quickly reach their limits. Problems must be considered in depth and the fundamentals must be understood thoroughly in order to find solutions. Industry needs this input and access to new methodology from the outside – and AIT is the best partner for this.

A case in point: At voestalpine, it is often a matter of very precisely con-

trolling highly complex processes with very many influencing parameters. This can only be done with scientific methods and procedures. To achieve this, the company needs a research institute like AIT that has been conducting in-depth research on these topics for years and at the same time aims to implement the findings – and that also commands the necessary critical mass.

With the current AIT Strategy 2021+ "Research and Innovation for a Sustainable and Competitive Position in the Digital Age", AIT is positioned perfectly. Infrastructure, climate change, resource conservation, digitisation, sustainability, safety, health, and more: AIT's research activities are playing out in these big topics, where we're all going to need a lot more progress. AIT has an impact in all these fields of action; AIT offers new solutions. This in turn makes AIT even more attractive for researchers: When you work in these areas, you help make our world a better place. You are part of the solution.

AIT thus also makes an important contribution to the business location: Austria is a high-price and high-wage

country. This means that you need a corresponding performance that justifies the high wage costs – this is only possible through innovation. We have a great many medium-sized companies in Austria that are world market leaders in their field. These companies can only get to the top and stay there if they constantly innovate. If you don't, others will overtake you. In a way, you're doomed to innovate and do research – but that's actually the wrong way to put it, because innovation is motivating and innovation is fun!



THIS IS AIT

The AIT Austrian Institute of Technology is the largest non-university research institute in Austria, leading the way in innovation and playing a key role at a European level as the research and technology institute that focuses on the major challenges of the future, such as decarbonisation and digitisation, as well as on the key infrastructure topics of the future.

Seven specialised Centers conduct research in the fields of Energy, Low-Emission Transport, Health & Bioresources, Digital Safety & Security, Vision Automation & Control, and Technology Experience. These research areas are complemented by expertise in the field of Innovation Systems & Policy.

A strategic priority is the development of a climate-neutral, digitised, competitive, resilient economy and the infrastructures and systems required for this.

As a national and international hub at the interface between science and industry, AIT enables innovations thanks to its scientific and technological competencies, experience in markets, close connection to its clients, and an excellent research infrastructure.

As an Ingenious Partner to industry and the public sector, AIT plays a central role with regard to advising on future challenges and developing disruptive technologies. In doing so, AIT pursues a research approach that is based on comprehensive knowledge at system level. We not only want to understand systems, but actively design them.

Around 1,400 employees throughout Austria conduct research on the development of the tools, technologies, and solutions for Austria's economy which will keep it fit for the future according to our motto: Tomorrow Today.



On the Way to a Climate-Neutral Future

Leonore Gewessler, Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)

With climate neutrality by 2040, we are pursuing a clear and ambitious goal. This is a necessity, and we are reminded of the urgency of becoming climate-neutral every day by the climate crisis and by Russia's war in Ukraine. We need to work vigorously to end our dependence on Russian gas and fossil fuels altogether, we need to push ahead with the energy transition and must take decisive action to stop climate change. This applies to us here in Austria, in Europe, and the world.

The AIT Austrian Institute of Technology supports business and society in the sustainable design of the green and digital transformations. As the largest non-university research institution in Austria, AIT is a central institution when it comes to researching the big questions of our future. In close collaboration with businesses and society, solutions are being developed for the mobility and energy transition, for the design of climate-neutral cities and communities, and for competitive industry. AIT's specialisation in the field of secure and resilient infrastructures plays a special role here. New challenges in the areas of digitisation, cybersecurity, and virtual networking are addressed at an early stage and in European co-

operation as part of research and development activities.

An ambitious innovation, climate, and energy policy contributes to strengthening Europe as a research and innovation location. To this, AIT makes an important contribution as an innovation driver and as a central link between research and application. With innovations and future technologies, we will successfully master our path to climate neutrality in 2040.

I would like to thank everyone very much. Thank you for your future-oriented spirit in the fight against the climate crisis. Thank you for your research for a livable future on behalf of next generations as well.

AIT: Important strategic partner for the great transformation of the coming decade

Isabella Meran-Waldstein
Head of Research, Technology & Innovation
Federation of Austrian Industries (IV)



Like nearly all other countries in the world, Austria is facing major transformations that are both challenging and full of opportunities and have been massively accelerated by multiple crises. These challenges are reflected in the ever-increasing digitisation of all areas of life, from health via education to mobility. The digital transformation is also having a particular impact in the area of production, where it is leading to major changes in existing value creation processes and value chains, and where it is spurring the development of new, data-based business models.

At the same time, the green transformation, which defines climate and nature protection as well as the transition to a resource-efficient and competitive economy as a clear goal, poses challenging tasks for us that can only be solved together. In addition, the global technology race is seeing a significant intensification. The access to and a pioneering role in key technologies are increasingly crucial for Austria's and Europe's technological sovereignty.

The essential basis for solving these challenges is formed by research, technology, and innovation. By combining research, demonstration, and production in Austria and Europe,

our resilience and competitiveness in strategically important areas can be improved. At the same time, the opportunity arises to bridge potential bottlenecks in value chains, to expand key technologies, to increase resource efficiency, and to benefit from the advantages of digitisation. Furthermore, highly innovative, technology-based and digitally active companies can strengthen their own competitiveness – and thus that of the research location – through the development of technologically sophisticated products and innovative services.

In order to best utilise the existing potential, decisive action is required now more than ever. On the political side, a clear frontrunner course must therefore be pursued with investments in our future, ranging from Austria's participation in important EU initiatives, first and foremost in the new Horizon Europe research framework programme, to the expansion of national RTI funding. What is needed is a consistent and ambitious implementation of the "technology offensive" anchored in the RTI strategy and RTI agreements, which will make Austria a key player with visible technological competence, as well as the fast and smart implementation of the climate and transformation offensives. At the same time, the application and

intelligent use of digital technologies, such as Artificial Intelligence and data technologies, should be pushed more strongly as an additional innovation driver for Austria as a production location.

The AIT Austrian Institute of Technology has been a key strategic partner of innovative Austrian industry for many years. Through its manifold bridging functions between science and industry, research and education, AIT is an indispensable lead partner in Austria as well as in Europe. In particular when it comes to successfully mastering the twin transition as a research and production location in Austria on the way to more resilience, more competitiveness, and more technology sovereignty.

TRANSFORMATION, SOVEREIGNTY & RESILIENCE

Decarbonization and digitalization are two central cornerstones of the work at the AIT Austrian Institute of Technology. A new strategy is regularly developed for the continuous further development of the research topics and the organization.



Alexander Svejksky, the "Managing Director Finance, Processes, Administration", is responsible for all business management matters, real estate and digital infrastructure and is also the interface with the public sector.

Alexander Svejksky (50) has been CFO of AIT for many years and has a wealth of experience and deep knowledge of the domestic RTI scene, which he has built up over many years. At the same time, he has distinguished himself at the institute by handling many projects – such as the end-to-end digitalization of all of the company's business processes.

As "Spokesperson of the Management Board," **Brigitte Bach** assumes responsibility for the strategic positioning of the research institution as well as for external relations and the product portfolio.

Brigitte Bach (57), a physicist, is currently a director at Salzburg AG. Previously, she was in charge of telecommunications, electromobility and new business areas at Wien Energie. From 1999 to 2018, Brigitte Bach was instrumental in the development and strategic positioning of energy research at AIT, most recently as head of the Center for Energy.

Andreas Kugi, the "Managing Director Scientific Excellence" shapes the scientific profile in the research focus areas and is responsible for the successful positioning in research and technology development at the top international level.

Andreas Kugi (55) is Professor of Complex Dynamical Systems at the Automation and Control Institute (ACIN) of TU Wien and, together with Andreas Vrabl, headed the AIT Centers for Vision, Automation & Control from 2017. Kugi is a member of the Austrian Academy of Sciences (ÖAW) and the German Academy of Science and Engineering (acatech).

The major challenges of our time are climate change and digitization. As Austria's largest research and technology organization, our goal is to make substantial contributions to solving these challenges for business and society on the basis of our research, development and technology expertise. We take this task very seriously. On the basis of the AIT's successes to date, we also have the best prerequisites for successfully further developing the AIT together as an authoritative Austrian research institute at a top international level. This will only succeed with an open culture of innovation, a clear commitment to excellence in all areas from research and development to customer projects and internal processes, and motivated and satisfied employees.

New Strategy 2024–2026+

To make this possible, a new AIT strategy is regularly formulated. Currently, the development of a strategy for the years 2024 to 2026 "Research on systems and key enabling technologies to master accelerated transformations, secure technology sovereignty and enhance resilience" is underway. In the first half of 2023, key milestones for the development of the AIT in the coming years were elaborated in the document "AIT Strategic Framework and Initiatives 2024-2026+"; in the second half of the year, strategies for the seven AIT centers will now be defined.

Excellent evaluation results

The basis for the creation of the strategy is, on the one hand, an extensive evaluation of the seven centers by 38 international experts, which was completed in spring 2023 - with an excellent result. On the other hand, the strategy is based on the "Shareholder Vision", in which the owners of the AIT - the Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology (BMK) and the Association for the Promotion of Research and Innovation (VFFI) in the Federation of Austrian Industries - formulate their expectations of the AIT.

Shareholder Vision 2030

1.) AIT is the leading Austrian research institute at the highest international level, geared towards technology developments in the "grand challenges" with a focus on infrastructure topics of the future. AIT supports the economy and society, in particular with technological competences as well as research and development in the areas of climate protection and digitisation. From the owners' perspective, strategic priorities are

- developing a climate-neutral, digitised and competitive, resilient economy and the infrastructures and systems required for this
- expanding the global market positions in the innovative areas of strength of Austria as a business location, as well as the development and expansion of Austrian technological competence in performance areas of the highest relevance
- securing system-critical competences to strengthen European technological sovereignty and societal resilience

2.) As a research institute, AIT identifies key technologies in the strate-

gic priorities (Strategic Foresight) and builds up corresponding technological competencies. In these fields, AIT conducts independent research and cooperative research with national and international partners (especially companies, universities, and non-university research institutions). This research is further developed into innovations in close cooperation with companies and society. Contract research is seen as an important metric of the portfolio's attractiveness and relevance.

Als Forschungsinstitut identifiziert das AIT Schlüsseltechnologien in den strategischen Prioritäten (Strategic Foresight) und baut entsprechende technologische Kompetenzen auf. In diesen Bereichen betreibt das AIT eigenständige Forschung und kooperative Forschung mit nationalen und internationalen Partnern (insbesondere Unternehmen, Universitäten und außeruniversitären Forschungseinrichtungen). Diese Forschung wird in enger Kooperation mit Unternehmen und der Gesellschaft zu Innovationen weiterentwickelt. Auftragsforschung wird als wichtiger Gradmesser für die Attraktivität und Relevanz des Portfolios gesehen.

3.) Thanks to its high level of technological expertise and the system knowledge it has acquired, AIT, together with its clients and partners, is able to analyse and exploit the potential of new technologies for innovation and sustainable transformation in/of socio-technical systems with a focus on infrastructure systems.

4.) To implement its strategy and as a basis for its cooperation with companies, AIT is investing in high-quality research infrastructures.

5.) With its strong roots in European institutions and its international activities, AIT also acts as a "door opener"

for international RTI cooperations of Austrian companies.

6.) AIT pursues an active strategy for the exploitation of research results, including an IPR strategy, and implements it in cooperation with companies and other partners.

7.) The continuous further development of the AIT portfolio in the strategic priorities builds on the critical mass already achieved in the performance areas of the highest relevance, with the aim of establishing its position among the absolute research leaders in these fields of technology for the long term.

8.) AIT maintains its scientific performance in comparison to its international peers.

9.) AIT is expanding its position as a system-relevant partner for technology leaders in the economy. Piloting and demonstration will be pushed in interaction with business and society.

10.) In view of changing value chains and geostrategic interests, the creation, development, and transfer of system-critical technological competencies (key enabling technologies) is becoming ever more important. AIT is strengthening its profile in the fields of

- autonomous systems & assistance systems
- emission-neutral mobility
- sustainable use of resources
- quantum technologies
- integration of renewable energy and sector coupling (lab infrastructure and simulation expertise).

11.) AIT is intensifying its activities for exploiting research results, including through the establishment of start-ups and spin-offs, and has holdings in companies that support the company's purpose.

TOP KNOW-HOW AND IDEAL INFRASTRUCTURE

AIT offers researchers attractive working conditions and unique research infrastructures for cutting-edge research in order to support industry and the public sector in the best possible way when it comes to innovation and transformation processes.

AIT's strategy is future-oriented and addresses the topics that concern us all. These include, first and foremost, climate change and decarbonisation and, secondly, digitisation and Artificial Intelligence – in addition to areas such as resource conservation, innovative mobility solutions, health technologies, automation, human-centred technologies, and innovation research.

Investments in strategic future fields

AIT offers researchers attractive working conditions and unique research infrastructures for cutting-edge research. In order to support industry and the public sector in the current transformation processes, AIT sees the need to combine a high level of expertise in concrete applications and technologies with comprehensive systems knowledge and cross-sectoral systems competence.

Research and technology development at AIT is organised in seven Centers, which cooperate in numerous areas and develop interdisciplinary solutions for the challenges that lie ahead.

An essential basis for AIT to be able to compete in the league of the best and to be a strong partner of industry and the public sector in innovation and transformation processes is the unique research infrastructure with its strategic focus areas that's competitive on a European level. These facilities are constantly being expanded. For example, in energy research: For

years, AIT has been operating laboratories that are unique in Europe for the development and testing of components and networks, such as the SmartEST lab or the high-current lab. These have recently been expanded to include a direct current (DC) lab, which is a high-quality infrastructure for the further development of DC systems; DC is becoming increasingly important for areas such as photovoltaics, electricity storage, electric vehicles, and data centres.

Another case in point is the Battery Lab, which is developing more powerful and safer batteries of the future as well as environmentally friendly manufacturing processes. This lab, which includes facilities for materials research and a research pilot line, is currently being expanded to include a "Solid State Batteries Lab". Future solid-state batteries will no longer require liquid electrolyte; this should increase safety and age resistance in a few years.

Research at the LKR Leichtmetallkompetenzzentrum Ranshofen is also significantly strengthened, where high-strength aluminium and magnesium alloys that meet the highest stability requirements as well as efficient, sustainable manufacturing processes are being developed. Special wires are made from these materials, which can be processed into light metal components in a 3D printing process with the help of an adapted welding robot. Ma-

job investments are also being made in the Seibersdorf Laboratories subsidiary. In this context, the electromagnetic compatibility (EMC) lab, which is already one of the leading laboratories of its kind in Europe, is being expanded. The very successful radiopharmaceuticals area is also being expanded through a new building and new lab infrastructure.

Know-how expansion

Based on the excellent lab infrastructure, the approximately 1,400 AIT employees, who come from more than 45 countries, produce scientific top results. This is very clearly shown in the "Scientific & Performance Indicators", which are collected annually. For instance, the impact factor of scientific publications by AIT researchers has recently risen significantly to a new record value (1,348). This is the result of a significant increase in the number of publications in scientifically referenced journals with an impact factor, as well as a further increase in the impact factor per publication. Another very pleasing aspect is that the number of patents granted (35) has remained at a very high level for years. The same applies to the number of habilitated staff at AIT (currently 33).

Promoting the best talents

In order to continue this positive development in the future, AIT is constantly strengthening itself with new compe-



tences. In the global competition for the best talents, the institute has, for example, set up a new PhD programme to offer talents the best conditions and stimulating mentoring. Currently, around 180 young researchers are working on their doctoral theses at AIT, of whom almost half come from the international arena. In addition to an attractive framework programme of training, mentoring, and networking events, key elements of the PhD Programme are the establishment of the PhD Coordinator and the Thesis Committee, which is made up of AIT and university supervisors and enables joint and regular monitoring of the participants' progress.

The constant efforts to create optimal working conditions for doctoral students in cooperation with leading universities are paying off more and more: For example, there are very close contacts and joint work programmes with

TU Wien, the Technical University of Munich, the Université Gustave Eiffel (Paris), and Tufts University in Boston (USA). The list of cooperations is continuously being expanded. One example of this are two new PhD programmes at the AIT Center for Energy: Together with Graz University of Technology, innovative hydrogen technologies are now being developed with a focus on reversible high-temperature electrolysis. And together with Delft University of Technology, AIT focuses on the transformation of the energy system: With the help of Artificial Intelligence (AI), innovative methods are being developed for the planning and operation of future sustainable energy systems.

Variety and diversity

When it comes to attracting and retaining excellent research personalities at AIT, an ambitious gender and diversity management is equally important. The

objective is to significantly increase diversity and the proportion of women at all levels. This is not only a question of equal opportunities, but also of AIT's capabilities: For one thing, no one can afford to underutilize half the pool of talent anymore. On the other hand, diversely composed teams increase the innovative strength immensely.

Startup initiative

In order to make a positive contribution to Austria as a business location, AIT pays particular attention to the practical exploitation of research results. In addition to the implementation with partners and patenting, spin-offs are playing an increasingly important role. The intensified start-up and entrepreneurship initiative – with the establishment of a "Start-up Coach", with trainings, consultations, and support for AIT researchers – is now increasingly bearing fruit. One example is the

company CellEctric, which allows a much faster and easier diagnosis of sepsis (blood poisoning). The founder, Klemens Wassermann, began developing the technologies more than ten years ago as a doctoral student at AIT. Following its spin-off in 2020, the company has already been awarded numerous prizes. Two more recent examples: VIRIDAD offers a digital platform for the assessment and application of sustainability criteria from the EU taxonomy; and ENSEMO develops methods for treating seeds with microorganisms or metabolites that provide a biological alternative to the use of chemicals in agriculture.

Strong foundation

AIT is built on a strong foundation of two strong owners: The BMK (Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology) and the VFFI (Association for Research and Innovation of the Federation of Austrian Industries). The interaction with the owners, their vision, the strategy pursued, and the management is regulated in a sound governance process that ensures quality assurance as well as the necessary autonomy and independence of the institute.



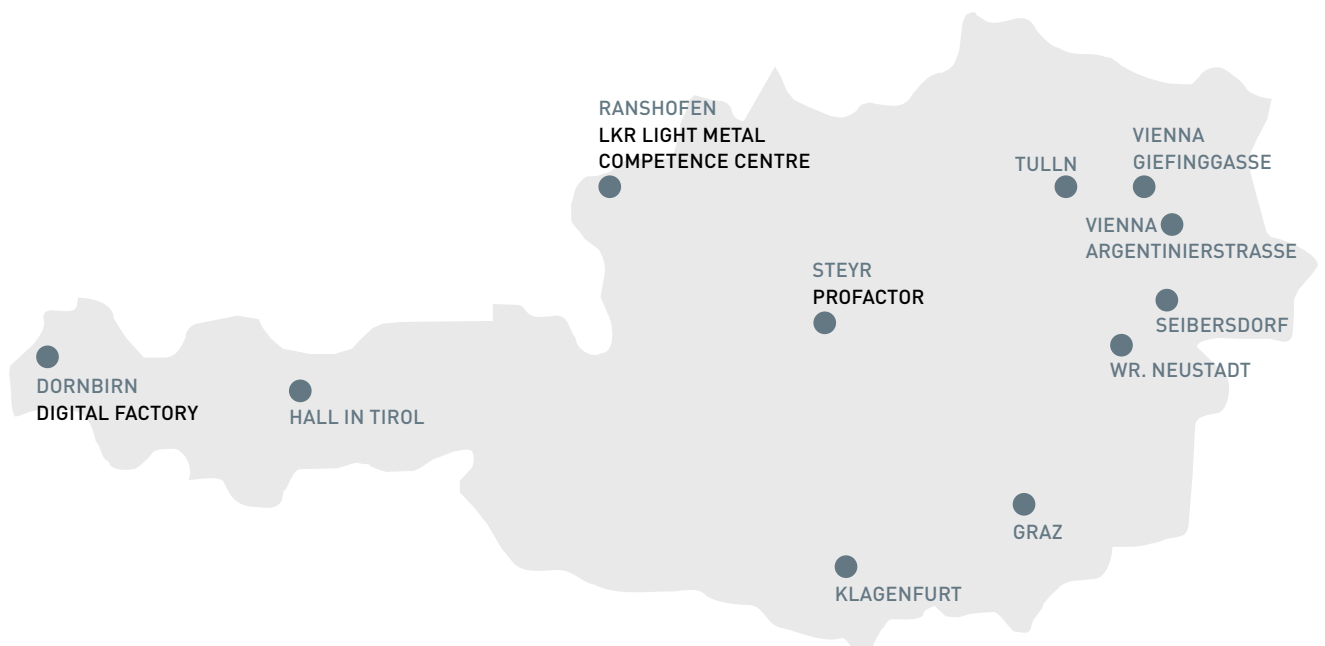
SUSTAINABILITY @ AIT

The basic values of sustainability are the responsible use of resources and good corporate governance. They are an integral part of AIT's self-image and are firmly anchored in all business areas and processes. Building on the current strategy "Research and Innovation for a Sustainable and Competitive Position in the Digital Age", sustainability and corporate social responsibility play a central role in all phases of AIT's service delivery. This ranges from the content of research projects via Human Resources management and gender & diversity activities through to compliance, which ensures adherence to important standards and rules of the company. This is made possible by the established, closely coordinated system of structures, processes, and policies at AIT. Moreover, the idea of sustainability also extends to supporting

processes and measures. Sustainable procurement is carried out in accordance with the relevant guidelines of the BMK (Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology). In the area of building and lab infrastructure, a cross-organisational planning process that transparently addresses the ideas of sustainable building development, energy issues as well as renovation issues was developed. Optimised land use, the best possible avoidance of land sealing and the ecologisation of green spaces are of great importance in this context, especially at the Seibersdorf site. AIT's mobility management includes travel guidelines, fleet management (electric vehicles with charging facilities at the sites) and advising employees regarding their choice of mobility options.

A STRONG NETWORK FOR AUSTRIA

Over the past 15 years, the AIT Austrian Institute of Technology – starting off from the original location in Seibersdorf – has developed a strong network of other locations with a focus on Vienna – in each case in the vicinity of universities or clients. Through new partnerships, in addition to the established locations, further locations were set up or expanded in Lower Austria (in Tulln and Wr. Neustadt), in the “Industrieland Oberösterreich” [industry state of Upper Austria] (Profactor in Steyr and LKR in Ranshofen) and in Vorarlberg (Digital Factory). AIT also conducts further activities in Carinthia, Tyrol, Salzburg, and Styria.



STRATEGIC RESEARCH TOPICS

Energy

- Electric Energy Systems
- Integrated Energy Systems
- Energy Conversion and Hydrogen
- Digital Resilient Cities
- Sustainable Thermal Energy Systems

Low-Emission Transport


- Electric Vehicle Technologies
- Battery Technologies
- Transportation Infrastructure Technologies
- Light Metals Technologies Ranshofen

Health & Bioresources

- Medical Signal Analysis
- Bioresources
- Digital Health Information Systems
- Molecular Diagnostics

Digital Safety & Security

- Security & Communication Technologies
- Sensing & Vision Solutions
- Data Science & Artificial Intelligence
- Cooperative Digital Technologies



Seven Centers conduct networked research and innovation in central, strategic research topics of infrastructure and the major challenges of the future, such as decarbonisation and digitisation. With this clear positioning, AIT is striving for research and technology leadership in these areas. There are many forms of cooperation among the Centers, utilising synergies and establishing comprehensive systems competence.

Vision, Automation & Control

- Assistive & Autonomous Systems
- Complex Dynamical Systems
- High-Performance Vision Systems

Innovation Systems & Policy

- Innovation & Industrial Dynamics
- Transformation Governance

Technology Experience

- Experience Contexts and Tools
- Experience Business Transformation

PERFORMANCE & OUTPUT

The AIT laboratories use state-of-the-art technology and equipment and form an essential prerequisite for successful applied research and development. Here, the foundations for products, services, and solutions for tomorrow are laid, tested, and brought to series production readiness. The so-called “Large Research Infrastructure” is one of AIT's major unique selling points and provides added value for customers and partners.



Search for biomarkers in plants

In the AIT labs in Tulln, the most important molecular biological and protein/enzyme-based biochemical techniques can be performed. Genetic marker systems are developed using state-of-the-art technologies (genomics, transcriptomics, phenomics) together with subsequent integrative bioinformatics data analysis. These methods allow e.g. working with an intersection of genotype and phenotype. This allows also those genes to be identified that are associated with certain traits (characteristics). The markers developed in this way are used for a wide variety of genotyping purposes and inquiries. A DNA bank with an integrated data management system is available for long-term storage of biological material at the AIT site in Tulln (www.dnabank.at).



City Intelligence Lab – digital urban planning

The City Intelligence Lab (CIL) has been an integral part of AIT's expertise in the field of “Digital Resilient Cities” for several years now. The lab is an interactive platform for the holistic consideration of the effects of various measures in urban and neighbourhood planning on mobility, energy, and climate issues. Complex interrelationships of urbanisation and climate change are visualised in real time using Artificial Intelligence (AI) methods and prepared for the co-creative process with stakeholders and citizens in a target group-specific manner. On the one hand, existing designs can be evaluated extensively, on the other hand, numerous automatically created design approaches can be compared performantly by means of key performance indicators (KPI) via a parametric design. This new digital process enriches the traditional urbandevelopment process in all planning phases.



Test site for autonomous machines

The automation of working machines such as cranes or forklifts is a strategic research goal of the AIT Center for Vision, Automation & Control (VAC). In the future, machines will take over repetitive and dangerous tasks. On the one hand, this serves to protect and upgrade workers, and on the other, it is intended to counteract the shortage of skilled workers. The automation of working machines requires research into many complex aspects, ranging from environmental recognition and interpretation to machine control and human-machine interaction. The Large-Scale Robotics Lab in Seibersdorf is set up to test and validate automated and autonomous working machines.



NEFI – New Energy for Industry

NEFI – New Energy for Industry is part of the "Energy Model Region" and pursues the approach of decarbonising the industrial energy system with the help of key technologies "made in Austria". The NEFI innovation network has formed around a consortium consisting of the AIT Austrian Institute of Technology (coordinator), Montanuniversität Leoben, the OÖ Energiesparverband and the Upper Austrian location agency Business Upper Austria, and brings together the experience in the field of energy research and project implementation. In its first 24 projects, the continuously growing consortium with currently more than 125 companies, research institutes, and public institutions is developing technological and systemic solutions for the implementation of the energy transition in industry. The Climate and Energy Fund supports the NEFI projects with a total of 30.2 million euros, endowed with funds from the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK).

www.nefi.at



EU missions in Austria

The EU's five "Mission Areas" – Cancer, Climate, Ocean, Cities and Soil – strive to find solutions to some of the greatest challenges of our time. A study conducted by AIT together with Joanneum Research has surveyed the starting position of the Austrian RTI landscape in terms of mission-oriented research. The results confirm that Austria has connecting points for positioning itself at the European level in all five missions. An above-average positioning has already been achieved in the missions Cities, Climate, Cancer, and Soil in HORIZON 2020. At the same time, the survey revealed that the environmentally oriented missions have potential for synergy.



Biometrics for a secure digital identity

At the AIT Center for Digital Safety & Security, systems for personal identification and access control are developed that use state-of-the-art technologies to ensure fast and secure access and border controls. For example, a contactless fingerprint biometrics for e.g. mobile use via smartphones has been successfully developed – a globally unique system for the rapid and highly precise assessment of identity, which is marketed worldwide via an Austrian SME. In addition, AIT researchers lead and coordinate large national and international projects in this field. All of them share a particular focus on the EU's high data protection requirements. Privacy protection and responsible use of these new systems is also a core aspect of AIT's cooperation with the United Nations in this field.

Infrastructures for RTI policy

RISIS ("Research Infrastructure for Research and Innovation Policy Studies") is a pan-European research infrastructure for the support of empirical innovation research. It increases the quality of the design and evaluation of policies in the areas of research, technology, and innovation (RTI) in Europe through a radically improved information base. RISIS is highly relevant for research, design, and evaluation of the RTI policy in Europe. AIT is a core partner of RISIS, which is currently in a second development phase and continues to be supported by the EU Research Framework Programme. RISIS II focuses on new functionalities and services in harmonized databases on RTI activities, such as by means of address-based geocoding, or the ability to apply own thematic classifications to the data sets through semantic techniques.



Bioaerosol lab

The bioaerosol lab at the AIT site in Tulln is equipped with a unique bioaerosol chamber that enables the creation and maintenance of a controlled environment of airborne microorganisms in defined numbers and uniform distribution. In this way, e.g. sampling devices and methods can be reproducibly tested and validated. During the COVID-19 pandemic, scientists are placing a particular focus and emphasis on the detection of airborne viruses. Furthermore, detection methods for biological particles from the air – pollen or plant material, fungi, bacteria, spores and viruses – are being developed. The EU project InChildHealth is currently researching determinants of indoor air quality and their health effects on children.



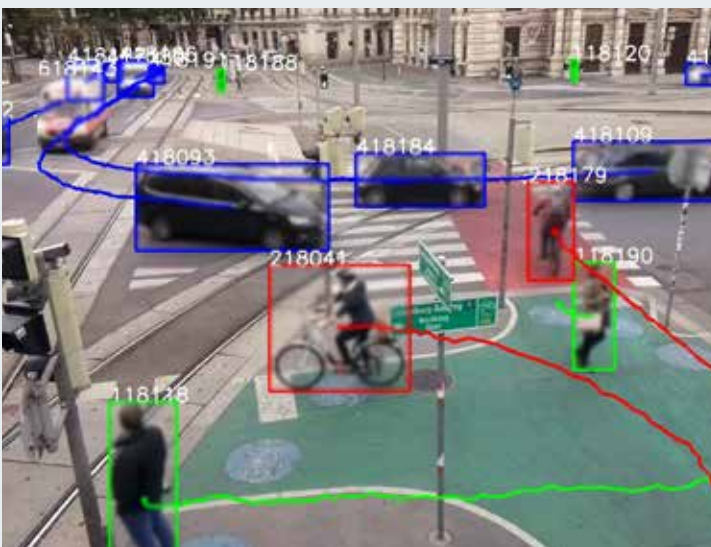
Machine Vision Lab

To achieve the highest performance of vision systems, image acquisition, illumination and algorithms have to be perfectly aligned. At the Machine Vision Lab, test setups are quickly created from a variety of available components so that the suitability of different solution ideas can be tested. In this way, both the latest research ideas can be implemented for the first time and the development of prototypes for industry can be realized.



Environmentally friendly and safe batteries

AIT is one of the few research institutions worldwide that can cover the entire value chain from battery research to battery production under one roof. In the state-of-the-art "Battery Lab" with a research pilot line and a drying room, the AIT experts are able to manufacture lithium-ion pouch cells with regard to industrially relevant processes. A strong focus here is the environmentally friendly production of (co-balt-free) batteries and the development of new battery types. The high degree of expertise in this area makes AIT a much sought-after partner for large EU research projects (such as BatWoMan, 3beLiEve or HighSpin) as well as for industry. The Battery Lab is now being expanded to include a lab for solid-state batteries.



Objective measurement of traffic safety

The AIT Mobility Observation Box films the traffic situation with a camera – in compliance with restrictive data protection and privacy requirements. After data collection, different road user groups (pedestrians, cyclists, cars, trucks, e-scooters, etc.) are automatically recognised, classified, and their behaviour evaluated using Machine Learning. This makes it possible for the first time to measure safety according to objective criteria and thus make it comparable. The better understanding of causes of accidents helps to improve safety measures – especially for vulnerable and non-motorised road users.



Technology Experience Lab

The AIT Technology Experience (TX) Lab is a flexible laboratory environment that enables holistic user experience investigations. The TX lab was modernised in 2020 and adapted to cope with future challenges. The lab was expanded and restructured: The Context. Lab offers the possibility to evaluate products and interaction concepts in simulated contexts. With the XR.Lab, a dedicated space was created to design and investigate extended reality projects. The Idea.Lab accommodates focus groups and co-design workshops in a pleasant atmosphere. The Maker.Lab is a creative area for building prototypes. The Office.Lab is a "classic" usability and user experience lab for evaluating systems. Apart from the spatial expansion, the lab was also strategically supplemented: A multi-level measurement infrastructure and know-how enable a holistic TX measurement.



Fighting together against fake news

The dissemination of disinformation is a serious threat: At AIT, media forensic tools are being developed that are based on Artificial Intelligence and allow users to make an assessment of the credibility of text, image, video, or audio material found on the Internet. Together with the Austria Press Agency (APA), AIT now represents Austria in the German-Austrian Digital Media Observatory (GADMO). This EU-funded initiative to combat misinformation is the largest association of fact-checking professionals and researchers in the German-speaking world. The dpa Deutsche Presse-Agentur, the Agence France Presse (AFP), the research network Correctiv and numerous academics are also represented in the initiative, which is led by TU Dortmund.



Telehealth solutions for chronic diseases save lives

The Digital Health Information Systems Competence Unit of the AIT Center for Health & Bioresources is a specialist in telehealth applications for chronic diseases (such as cardiovascular diseases or diabetes). For example, the telehealth service HerzMobil is managed in cooperation with the AIT spin-off company TELBIOMED: via this platform, patients suffering from heart failure regularly enter vital data, which is regularly monitored by medically trained staff. According to recent clinical studies, this can greatly reduce the risk of patients being readmitted to hospital or even dying.



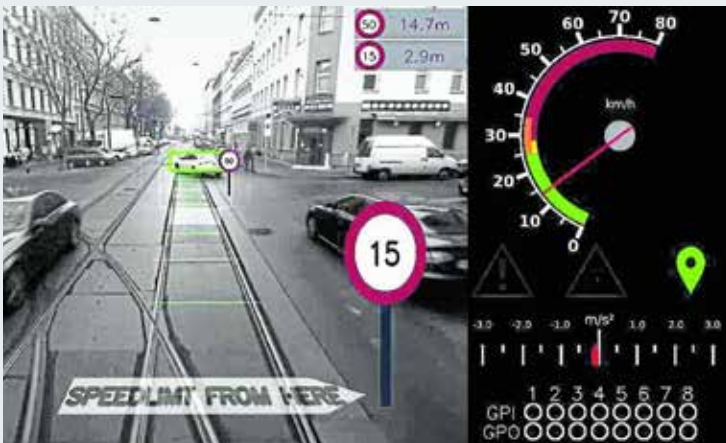
Additive Manufacturing Lab

So-called "Wire-Based Additive Manufacturing" is considered one of the most promising methods of 3D printing with light metals. In the Additive Manufacturing Lab at the LKR Leichtmetallkompetenz-zentrum Ranshofen, new alloys for welding wires are being developed, and welding equipment is adapted in such a way that it enables component manufacturing by direct metal deposition from welding wires at comparatively high buildup rates and theoretically unlimited component sizes. The Additive Manufacturing Lab – which is constantly being expanded – is the basis for numerous cooperation projects with industry, including the COMET project We3D. The objective is to find new applications for this technology, e.g. in the automotive sector, aerospace, or mechanical engineering.



The microbiome of plants

Plants are associated with microbial communities, called microbiomes, which interact closely with their host plant. In AIT's labs, these microbial communities are studied by microbiome, genome, metagenome, and transcriptome analyses including bioinformatics and statistical evaluation. This makes it possible to explore the molecular mechanisms of the interaction between microorganisms and plants. Also, high-resolution microscopy methods are used to study the microbial colonisation behaviour of plants. In order to develop specific microbial applications to improve plant traits, extensive plant trials are also conducted in climate chambers, glass and wire houses under (semi-)controlled conditions. Where field trials are necessary, local plots are available through partners.



Smart tramways

Similarly to cars, tramways are also equipped with driver assistance systems which serve road safety. At AIT, systems have been developed to help drivers avoid dangerous overspeeding and to warn them of obstacles via a stereo camera. These have already been deployed internationally. Building on this, a system has been developed in the INTELLiTRAM project that uses Artificial Intelligence (AI) to learn to understand traffic situations predictively.



Aerial Systems Lab

In the Aerial Systems Lab, experts from the Center for Vision, Automation & Control are developing technologies for automated aviation. These range from autonomous, unmanned aircraft via air traffic management, the development and operation of various flight platforms, all the way to flight simulators for collision avoidance systems. In addition to outdoor test environments, there is also an indoor flying area with a safety net and a high-performance development infrastructure. The focus of the work is on the autonomy of future unmanned aircraft and their integration into civil airspace, air traffic management, the protection of critical infrastructures against threats from the air, as well as other airborne applications – such as for forestry and agriculture and, with real-time situation image capturing and evaluation, for crisis and disaster management.



Direct current in the lab

Direct current (DC) is playing an increasingly important role in many areas – e.g. in photovoltaic systems, storage systems, batteries for electric vehicles, or in the long-distance, low-loss transmission of electricity from offshore wind farms via high-voltage DC lines. By expanding the Center for Energy's lab infrastructure for DC currents on the order of 100 kA, AIT has created an efficient and high-performing validation platform for manufacturers of DC components and DC systems. The DC Lab is the largest lab of its kind in Austria. This lab infrastructure is particularly important for European developers and manufacturers of power electronic components. The construction of the plant involved the use of 30 tonnes of steel and over 50 tonnes of copper. The switchgear contains four special transformers that can be connected for various test scenarios.



Innovative diagnostics with novel biosensors

The focus of the work in the Molecular Diagnostics Lab is on non- or minimally invasive diagnostics – i.e. primarily analyses in body fluids (liquid biopsy) for point-of-care solutions in human and veterinary medicine. Based on comprehensive know-how in physics, chemistry and biology as well as in micro- and nanotechnologies, photonics, nanomagnetism, and electronics, new concepts for biosensors are being developed. Great progress is currently being made e.g. in "lateral flow tests" which allow for low-cost detection of inflammation biomarkers. In the EU project IMPETUS, a test strip was developed to distinguish between bacterial and viral infections.



Quantum encryption: AIT makes Nobel Prize-winning findings usable in practice

What was once a mere theoretical exercise by quantum physicists is now becoming reality: Around 25 years ago, the Viennese quantum physicist Anton Zeilinger – who was awarded the Nobel Prize in Physics in 2022 for his work – showed that confidential information can be exchanged with the help of so-called “entangled particles”; should someone “eavesdrop” on this communication, it is noticed immediately. Researchers from AIT have been involved in Zeilinger’s experiments from the very beginning: They put quantum cryptography into practice in the form of real terminal devices and have since been coordinating large EU research networks such as UNIQORN, CiViQ oder OPENQKD in order to make the technology suitable for everyday use and to establish a secure network for quantum communication in Europe. The aim is to create small and compact devices that can be easily utilised by all users who have a fibre-optic connection – similar to the way a modem is used today to access the Internet from a computer. For instance, a miniaturised QKD transmitter with a photonically integrated chip carrying all components such as lasers, modulators, and attenuators was recently presented at Europe’s largest IT security trade fair “it-sa”. As part of the EU-wide EuroQCI initiative (European Quantum Communication Infrastructure Initiative), a European cybershield based on a quantum communication infrastructure is to be established over the next ten years. This is an essential contribution to Europe’s data sovereignty.



Use of waste heat from industrial processes

Nearly two thirds of the industrial energy demand in Europe is used to provide process heat – e.g. in syntheses in the chemical industry, in forming metals, in firing bricks, or in drying agricultural products and food. Of this, 77 per cent are currently covered directly by fossil fuels. At the same time, industrial processes also generate a great deal of waste heat. However, using this is not easy because the temperature is too low for many applications. This has changed now: As part of the EU research project DryFiciency, high-temperature heat pumps were developed, commissioned, and tested in industrial environments under the leadership of AIT. In doing so, the focus was on industrial drying processes that require process heat of up to 160°C. Three demonstrators (in Austria and Norway) were developed together with partners. In comparison to natural gas, industrial heat pumps thus have the potential to increase energy efficiency by up to 80 per cent, reduce CO₂ emissions by up to 80 per cent, and cause up to 20 per cent lower production costs. The technology is attracting keen interest from industry and is being further developed in new research projects.

TOMORROW TODAY WITH YOU

As an expert and knowledge organisation, AIT strives to attract the best minds and to keep them at the Institute. A central focus of the corporate strategy is the promotion of diversity and equality.



In order to consider and integrate all facets of a development at an early stage, mixed teams are needed – interdisciplinary, international, and intercultural, with different genders and people from all generations.

Gender equality is firmly anchored in the company's understanding and is expressed in the claim to particularly promote women and support them in their personal advancement across all career paths.



Employees are the most important resource in any organisation, especially during times of immense international competition for the best talents. This is all the more true for a research and technology organisation that assumes a prominent role on the international innovation stage.

Science and technology development is becoming increasingly multidisciplinary in the face of increasingly complex challenges to overcome. It thus requires interdisciplinary teams with different approaches and needs to consider and integrate all facets of a development at an early stage and find creative solutions. This is only possi-

ble in mixed teams – interdisciplinary, international, and intercultural, with different genders and people from all generations. This is why the topic of Gender & Diversity has been firmly anchored at AIT for years.

Gender equality is an integral part of the AIT strategy

Diversity is an enrichment for the company and the teams, it is a central component of AIT's corporate culture and strengthens AIT's position as an Ingenious Partner for industry and the public sector. That is why diversity is highly valued at AIT, and all employees are encouraged to treat others with

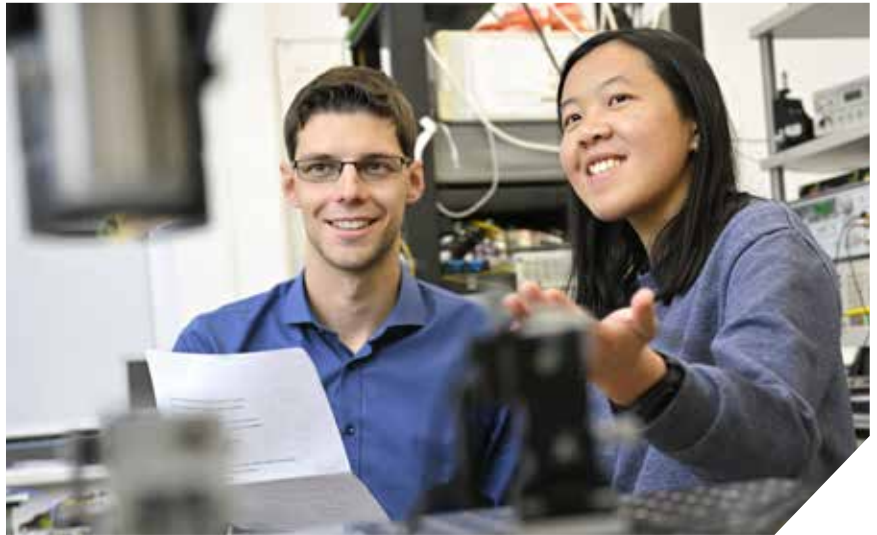
acceptance, respect, appreciation and tolerance.

Equality of all genders has a fixed place in the company's self-understanding – as an organisation in which equal opportunities, fairness, communicative openness, empowerment, and committed participation in the design of processes and structures take on a corresponding importance. AIT strives for a balanced ratio of women and men for all career models, career paths, and stages of life. It is a clearly defined objective of the Institute to provide special support for women and to assist them in their personal advancement. It is seen as a manage-



Last year, AIT launched a programme to promote female managers: 19 participants train their leadership skills, network, and receive impulses for their development from external experts.

People from more than 50 different nations are employed at AIT, which is why English is the company's second language.



ment task that is supported across all hierarchical levels. For purposes of implementation of the Gender strategy, the Gender Equality Officer is appointed by the management from among the management/line function for two years at a time. Sandra Schneider (International Relations) was first, followed by Helmut Leopold (Head of Center for Digital Safety & Security), Elke Guenther (Head of Center for Health & Bioresources) and Manfred Tscheligi (Head of Center for Technol-

ogy Experience). The Head of Recruiting & HR Development (Marie-Theres Raberger) is the deputy to ensure continuity.

A Gender Office and an AIT Gender Task Force were established as well. AIT provides the necessary resources. The focus of the various formats and measures is always on the participation of all company units and employees. The integration of gender dimensions is now also an obligatory part of research projects.

Gender dimensions in research

Thus, gender aspects are incorporated into the conception, description and implementation of research projects – particularly in the composition of project teams and the orientation of project goals. The concrete composition of teams – both in terms of the absolute number of women and men in the team as well as their hierarchical positions and income – is an increasingly important criterion in the evaluation of submitted projects. AIT



Diversity at all levels forms the basis for an ongoing dialogue and permanent exchange of knowledge that enriches and inspires everyone – and makes working at AIT even more exciting.

also takes gender dimensions into account when it comes to the content of research projects, e.g. in the areas of technology experience, molecular diagnostics (diabetes), data science for public security (e-commerce) or integrated mobility systems. The inclusion of gender dimensions in research and innovation content promotes the development of new ideas, eliminates gender bias, and increasingly integrates societal needs.

International team from more than 45 countries

At AIT, we are proud of the diversity in our teams – from nationality to academic and social background through to specialist disciplines and career stages. This unique mix makes AIT a very special place to work. We welcome colleagues from around the world. People from more than 45 different nations are employed at AIT, which is why English is the company's second language. As an internationally oriented company, we offer German courses to colleagues from other countries and thereby help them to settle in Vienna more easily.

Cooperation between the generations

At AIT, employees of all career levels collaborate in a diverse and dynamic work environment. Whether interns, Master or PhD students, scientists, research engineers, technicians or support colleagues, whether career starters or management personnel: They all make an important contribution to our success. This diversity at all levels forms the basis for an ongoing dialogue and permanent exchange of knowledge that enriches and inspires everyone – and makes working at AIT even more exciting.

Further information about the Gender & Diversity Initiative can be found at www.ait.ac.at/en/career/diversity



The concrete composition of teams – both in terms of the absolute number of women and men in the team as well as their hierarchical positions and income – is an increasingly important criterion in the evaluation of submitted projects.

Ingenious Partner @ AIT

The optimal development of talents and skills of our employees is of particular importance. A career model that complies with international standards allows for the targeted development as well as individual career paths – and does so in various job profiles and levels:

- Management
- Research Engineering & Expert Advice
- Science
- Support
- Technical Services



More about this: <https://www.ait.ac.at/en/career/workait>

COMMITTED TO EXCELLENCE

Current scientific papers show the high research competence at AIT.



Hannes Hübel
Center for Digital Safety & Security

As a result of the UNIQRN project in the European Quantum Flagship programme, chips with integrated photonics for quantum communication applications were developed. This involves the use of three different integration platforms for the production of components and subsystems on chips for quantum communication devices – namely monolithic indium phosphide-based integration, hybrid polymer-based integration, and a CMOS-compatible silicon platform. The selection of the different platforms was made in order to use the best features of each platform for the planned quantum communication device. So the indium phosphide platform was used to produce a transmitter chip for the distribution of quantum keys with lasers, modulators, and attenuators.

A. Trenti, M. Achleitner, F. Prawits, **H. Hübel** et al.: **On-chip quantum communication devices**, IEEE/OSA Journal of Lightwave Technology, 30506-2022. R1, doi 10.1109/JLT.2022.3201389



Bernhard Dachs
Center for Innovation Systems & Policy

More than half of Austria's economic output (GDP) is generated abroad. However, relatively little was known about the exporting companies until now. A joint study by the Vienna Institute for International Economic Studies (wiiw) and the AIT Austrian Institute of Technology (AIT) on behalf of the BMAW (formerly BMDW) has now provided a remedy: Robert Stehrer (wiiw), Bernhard Dachs (AIT) and Maria Yoveska (Vienna University of Economics and Business) analysed 5,000 manufacturing companies, of which around 3,500 also sell their products abroad. "Companies that export are much larger, more innovative, more productive, and also more profitable, they pay higher wages, invest more, and also do more to protect the environment," the researchers conclude.

R. Stehrer, **B. Dachs**, M. Yoveska: **A Snapshot on the Characteristics and Dynamics of Austrian Exporting Firms**, wiiw Research Report 462, Sept. 2022; Download: wiiw.ac.at/p-6308.html



Tilman Barz
Center for Energy

Latent heat storage systems with solid-liquid phase change materials (PCM) are characterised by high energy densities and, in the ideal case, by the isothermal nature of the storage process. Economical storage concepts are based on compact gas-liquid heat exchangers in which the gas side is filled with PCM. These highly optimised devices are used as standard, e.g. in air conditioning and engine cooling. Together with industrial partners, AIT is developing storage prototypes and design models for heating and cooling applications in buildings. Commercially available paraffins that exhibit a strongly non-ideal phase change behaviour are used as PCMs. It has been possible to develop and validate efficient data-based numerical models for predicting the complex phase change behaviour.

T. Barz, J. Emhofer: **Paraffins as phase change material in a compact plate-fin heat exchanger-Part I & Part II**. Journal of Energy Storage, 33 & 34 (2021), 102128 & 102164



Thomas Maier
Center for Health & Bioresources

Lateral flow devices (LFDs) enable cost-effective decentralised testing with a short time to result and are therefore an indispensable tool for point-of-care diagnostics. At AIT, a novel LFD device with electrochemical readout was developed for the quantitative detection of CRP (C-reactive protein) in filtered human saliva. CRP is a known biomarker for inflammations. The detection of CRP is made possible by a sandwich assay with specific antibodies. The subsequent enzymatic reaction leads to a product that can be oxidised by an electrochemical sensor placed on the LFD strip, generating a concentration-dependent and analyte-specific electric current. Through optimisation of the system, detection limits of 3 and 25 ng/ml were achieved in buffers and filtered saliva, respectively. Finally, a sensor with four different channels was introduced for testing simultaneous multi-channel measurements.

L. Petruzzi, **Th. Maier**, P. Ertl, R. Hainberger, **Quantitative detection of C-reactive protein in human saliva using an electrochemical lateral flow device**, *Biosensors and Bioelectronics*: X, 10 (2022) 100136, -doi: 10.1016/j.biosx.2022.100136



Tanja Kostic
Center for Health & Bioresources

Microbiomes (communities of all microorganisms in a given habitat) play a crucial role in the life and health of plants, animals and humans. Microbiomes can also be used specifically for innovations, e.g. to produce goods more sustainably. In order to drive research and innovation in this field, a number of powerful international consortia with AIT participation have been established in recent years. Together, a recommendation for measures was developed to exploit the potential for microbiome innovations as fully as possible. Suggestions include more interdisciplinary research, stronger international cooperation, the creation of "Microbiome Centers" as new research infrastructures, long-term investments, clear legal regulations and increased communication between research, politics, authorities, industry, and users in order to increase public trust and acceptance of the new technologies.

K. D'Hondt, **T. Kostic** et al: **Microbiome innovations for a sustainable future**. *Nature Microbiology* 2021 Feb; 6(2):138–142. doi: 10.1038/s41564-020-00857-w



Tobias Glück
Center for Vision, Automation & Control

Solenoid valves are used for power distribution in hydraulic drive systems for commercial vehicles. These are generally subject to manufacturing tolerances and thus large parameter fluctuations. The adaptive control aims to achieve a high control performance even with fluctuating, uncertain or unknown system parameters. No manual adjustment of the controller parameters is required in the process. A new current control method for solenoid valves developed at AIT consists of adaptive, model-based feedforward and feedback control. The system parameters are estimated using a recursive least squares method. This solution differs from existing approaches in the adaptive feedforward control and the way parameter estimation is performed. The results were compared with two control methods known from the literature: Both were outperformed by the proposed AIT control concept.

M. Schwegel, **T. Glück**, V. Shaferman, L. Zaccarian, A. Kugi: **Adaptive Two-Degrees-of-Freedom Current Control for Solenoids: Theoretical Investigation and Practical Application**, *IEEE Transactions on Control Systems Technology*, 2022, doi: 10.1109/TCST.2022.3211457



Ivan Barisic
Center for Health & Biosources

As part of the EU MARILIA project to develop innovative testing methods for pathogenic microorganisms in food and beverages, a powerful software was developed which can predict the structure of large molecules. Tools available so far have weaknesses and were not comprehensive enough for the concrete task in the MARILIA project. The newly developed CATANA system includes a tool for three-dimensional modelling and manipulation of complex biomolecules in real time, as well as visualisation at multiple levels of detail – down to the atomic level. Also integrated was "AlphaFold", an Artificial-Intelligence-based tool that predicts the exact three-dimensional structure of a protein on the basis of the amino acid sequence with unprecedented quality. CATANA is designed as a web-based application, the software itself runs on a server at AIT and is freely accessible to scientists all over the world as an open source solution.

<http://catana.ait.ac.at/>

D. Kutak, **I. Barisic** et al: **CATANA: an online modelling environment for proteins and nucleic acid nanostructures**. *Nucleic Acids Research*, 2022 1, <https://doi.org/10.1093/nar/gkac350>



Philip Leopold
Center for Low-Emission Transport

Landslides are a natural hazard that pose a great risk to buildings and infrastructure (such as roads or bridges), especially in a mountainous country like Austria. However, they are difficult to predict because it depends on a great many factors whether a slope starts to slide during heavy rain or not. This includes the type and intensity of precipitation, soil moisture, and land use. Add to that the fact that all these factors are changing due to climate change. A group of researchers with AIT participation has now found that global warming is leading to a massive increase in landslide risk: In a scenario with a temperature increase of four degrees, the risk of landslides could increase by 45 percent. If global warming is limited to the Paris targets, the increase in risk is ten percent. In part, this risk can be compensated for by creating or maintaining resilient and climate-adapted protective forests.

A. D. Maraun, **Ph. Leopold** et al.: **A severe landslide event in the Alpine foreland under possible future climate and land-use changes**, *Nature communications earth & environment* (2022) 3:87



Markus Makoschitz
Center for Energy

Photovoltaic, wind power or battery storage systems are typically operated in partial or low load conditions (weather conditions, surface contamination, etc.) for a certain period of time. Therefore, minimizing electrical losses under various load conditions helps improve the average overall energy performance. The paper evaluates different types of circuit enhancements based on wide band gap semiconductor technologies (silicon carbide SiC, gallium nitride GaN). It could be demonstrated that for an inverter with an additional low-load SiC MOSFET or GaN transistor power stage, the semiconductor losses of the overall system can be significantly reduced in the low-load range up to no-load operation. Furthermore, it was shown that the clock frequency of the optional circuit expansion can be selected independently of the switching frequency of the main converter. This results in an additional degree of freedom in circuit design.

M. Makoschitz, S. Biswas: **Light Load Efficient Silicon Power Converters Based on Wide Bandgap Circuit Extensions**. *Applied Sciences*, 10 (2020), 4730.



Quynh Ngyuen
Center for Technology Experience

Virtual Reality (VR) training has become increasingly important for police first responders. To further improve the training experience, VR systems must be able to simulate the experiences of police officers "in the field". This can be done by adding reality-based stressors. In order to include stressors in VR, the concept of so-called stress cues is introduced. Given the complexity of the field of work, a co-creation process was chosen that allows us creative and cooperative collaboration with people from police organisations. The stress cues give trainers new opportunities in VR training, e.g. by actively intervening in the training. The trainee experience is enhanced through customisable trainings based on real-time stress measurements and additional information for training feedback.

Q. Ngyuen, E. Jaspaert, M. Murtinger, H. Schrom-Feiertag, S. Egger-Lampl, M. Tscheligi (2021) Stress Out: Translating Real-World Stressors into Audio-Visual Stress Cues in VR for Police Training. In: Ardito C. et al. (eds) Human-Computer Interaction – INTERACT 2021. Lecture Notes in Computer Science, vol 12933. Springer, Cham. https://doi.org/10.1007/978-3-030-85616-8_32



Laurin Ginner
Center for Vision, Automation & Control

Today, inline inspection for industrial processes where parts move continuously in a production line is more and more becoming an indispensable tool for industrial quality inspection. However, the desired acquisition speeds and the requirements for high-precision imaging often reach the limits of what is physically feasible - for instance, a large field of view with high spatial resolution. At the AIT, a novel light field and photometry system has been developed that resolves this conflict of goals by combining microscopic imaging with a specialized projection optics to create a parallax effect. Experiments, e.g. on a test banknote provided by OEBS (Oesterreichische Banknoten und Sicherheitsdruck GmbH), have shown that scanning speeds of up to 12 mm/s at a depth resolution of 2.8 µm and a lateral scanning of 700 nm/pixel can be achieved in this way, a performance appropriate for inspection in the high-precision manufacturing industry.

L. Ginner, S. Breuss, L. Traxler: Fast Inline Microscopic Computational Imaging, Sensors 2022, 22, 7038 <https://doi.org/10.3390/s22187038>



Johannes Österreicher
Center for Low-Emission Transport

With the increasing importance of Li-ion batteries, the analysis of lithium content in samples is becoming more and more important. However, this measurement is not possible using conventional methods (energy dispersive X-ray spectroscopy/EDS), in part because the characteristic X-rays emitted by lithium under an electron beam are low energy and are absorbed by the windows of conventional detectors. A team led by Johannes Österreicher (LKR Leichtmetallkompetenzzentrum Ranshofen) has now discovered a new method that allows much more accurate measurement of low lithium contents. Here, conventional EDS is combined with the so-called "Quantitative Backscattered Electron Imaging" (qBEI) method, which measures the backscattering of electrons: The combination of these two detection methods now allows the quantitative and spatially resolved detection of lithium. A patent application has been filed for the process.

J. A. Österreicher, C. Simson, A. Großalber, S. Frank, S. Gneiger: Spatial lithium quantification by backscattered electron microscopy coupled with energy-dispersive X-ray spectroscopy, Scripta Materialia, 194 (2021), 113664

INGENIOUS PARTNER

The research services of AIT experts meet with great international recognition. This is reflected by numerous awards, distinctions, and functions in important committees. This also contributes to AIT being a first point of contact in major multilateral projects.



AIT coordinates Gaia-X Hub Austria

The European Gaia-X initiative is dedicated to building a transparent, trustworthy, and secure data market in Europe. In March 2022, the Austrian Gaia-X Hub was launched on the initiative of the Federal Ministry of Finance (BMF), the State Secretariat for Digitisation, and the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). Helmut Leopold, Head of the AIT Center for Digital Safety & Security, was appointed Chairman of the Gaia-X Hub Austria. Gaia-X Hub Austria plays a central role in mediating and coordinating the various initiatives at the Austrian and the European level. After focusing on creating a common understanding and broad distribution of information and strategies around the creation of data ecosystems in the start-up phase, the focus is now on strategic and technical support for concrete implementation projects in the Austrian economy.

www.gaia-x.at/en



6G network: Safe, Reliable and Energy-Saving

The mobile network connection of people, but also of machines and physical objects (Internet of Things – IoT) is irresistibly advancing. In order to sustainably provide highly reliable communication for industrial control systems, robots, autonomous systems, etc. in the course of the digitisation of our society, further technological developments are required. In order to research the next generation of mobile communications, a new 6G research focus was established at AIT in the Center for Digital Safety & Security. With the appointment of Thomas Zemen as Principal Scientist, AIT has entrusted an internationally renowned expert with the further development in this future-critical research field. The aim is the development of communication systems with short latency (maximum 100 microsecond delay) and high reliability (over 99.999%). 6G systems also reduce energy consumption and increase competitiveness. Zemen graduated with honours in electrical engineering/communications engineering from the Vienna University of Technology in 1998, followed by a doctorate in 2004 and habilitation in 2013. In 1998–2003, Zemen worked at Siemens Austria, and until 2014 he headed the “Signal and Information Processing” department at the FTW Research Center Telecommunications Vienna. Zemen has been conducting research at AIT since 2014 – since 2020, as Principal Scientist.



AIT researchers win Ö3 Traffic Award

Great success for the AIT road safety team around Anna Huditz, Peter Saleh, and Michael Aleksa: The “Mobility Observation Box”, an AI-based system for recording and objectively assessing traffic infrastructure and conflict situations, has won the Ö3 Traffic Award in the category “Idea of the year”. The AIT researchers received the prize at a gala event attended by Climate Protection Minister Leonore Gewessler, Minister of the Interior Gerhard Karner, ORF Radio Director Ingrid Thurnher and Ö3 station head Georg Spatt. The AIT Mobility Observation Box had previously won the prestigious German DEKRA Award 2021 in the category “Safety in Traffic”.

Dirk Holste heads EARTO Working Group Healthcare

Dirk Holste (AIT Center for Health & Bioresources) has taken over the chair of the EARTO Working Group “Emerging Technologies for Healthcare”. It consists of more than 30 active experts in applied research in medical technology, biotech & digital health tech. The working group represents the interests of health-related research and technology organisations (RTOs) in Europe to ensure that EU research and innovation programmes are optimally aligned with the core competencies of RTOs as technology enablers for health system innovation. Prior to his chairmanship, Dirk Holste was an active member of the working group for two years, with the goal of raising the profile of RTOs as key players and promoting their specific and innovative technologies.

www.earto.eu



eAWARD for the VR training system SHOTPROS

Action forces are often confronted with situations in which they have to make decisions in a matter of seconds under stress. In order to be able to practise such operations in a realistic way, an innovative virtual reality (VR) training system was developed in the three-year project SHOTPROS (funded by the EU HORIZON 2020 programme) by research institutions in cooperation with police institutions and police officers from all over Europe. The police officers wear high-tech VR suits and use deceptively real-looking weapons and equipment. Moreover, a mobile multi-sensory platform developed by the AIT Center for Technology Experience can be used to convey authentic impressions such as wind, temperature, water spray, or small electrical shocks during VR training. The training solution for police training developed in SHOTPROS, already presented in several EU countries, was awarded the coveted eAward. VR training offers enormous advantages, because a wide variety of operational scenarios can be trained and analysed under realistic conditions at different levels of difficulty.



Angela Sessitsch is among the "Highly Cited Researchers".

Already for the fifth year in a row, Angela Sessitsch, Head of the Competence Unit Bioresources at the AIT Center for Health & Bioresources, is among the most frequently cited researchers worldwide. She is one of 46 research personalities working in Austria on this list – and one of only two women. Scientific papers published and cited between 2011 and 2021 were used for the analysis by the data company Clarivate Analytics. Sessitsch has been researching microbiomes – the entirety of all microorganisms at a given location – and their interactions with plants. One of the aims is to make plants more resistant to climate change.



Winfried Neuhaus is researching alternatives to animal testing

AIT Principal Scientist Winfried Neuhaus was appointed to Austria's first professorship for alternatives to animal testing, which was established at Danube Private University (DPU) Krems in autumn 2022. Neuhaus heads also the Biological Barriers Group in the Competence Unit Molecular Diagnostics (Center for Health & Bioresources), he is President of EUSAAT, the European Society for Alternatives to Animal Testing, and acts as coordinator of the European 3R Centers EU3Rnet. 3R stands for Replace (replacement of animal experiments), Reduce (reduction in the number of experiments), and Refine (improvement of experiments). Neuhaus also coordinates the EU COST Action "IMPROVE" in this area.



AIT research you can touch at the Long Night of Research 2022

Decarbonisation and digitisation were the central topics with which the AIT Austrian Institute of Technology participated in the "Long Night of Research 2022". In the end, 135,000 visitors were counted at 2,500 stations at 280 locations. In Vienna's CAPE 10, AIT showed innovative methods of urban planning of the future for making cities more resilient, gave insights into current battery research, and proved that waste heat from industry or geothermal energy can be used sensibly with heat pumps. At the AIT site in Tulln (Lower Austria), it was demonstrated how important microorganisms are as helpers for plant growth and how important diversity is. In addition, AIT experts presented methods for increasing digital security and invited the visitors to become active as "makers".



AIT Poster Award for battery research

Christiane Groher from the Center for Low-Emission Transport won first place at the AIT Poster Award 2022 for her work on the service life of lithium-ion batteries (LIB). Lukas Neidhart, also from the Center for Low-Emission Transport, who is working on improving the electrodes in LIB, took second place. The third place winner is Daria Liakhovets, who does research on the topic of "Hate Speech" at the Center for Digital Safety & Security. The AIT Poster Award, which has been held annually since 2010, aims to raise awareness among young scientists that innovative research is not an end in itself, but also requires an economic exploitation potential in order to benefit the public at large.



Lower Austrian Science Prize for Bernadette Fina

Prestigious award for Bernadette Fina, researcher at the AIT Center for Energy, for her work on the topic of energy communities: In the course of a gala in Grafenegg for the awarding of the Lower Austrian Science Prizes 2021, she was awarded a recognition prize. In her research, she deals with the topics of the economic efficiency of energy communities in individual multi-apartment buildings as well as between several buildings. This specifically involves the optimisation and optimal dimensioning of photovoltaic systems and other technologies. Furthermore, the researcher's work sheds light on the impact of external financing of renewable generation plants.

Martin Czuka: Managing Director of the OeGA (Austrian Acoustics Association)

Martin Czuka, Scientist at the Center for Low-Emission Transport, was elected Managing Director of the Association and thus also to the Board of the Austrian Acoustics Association (OeGA). Czuka addresses the question of how transport infrastructure can help reduce noise emissions. The focus is on the acoustic properties of road surfaces and tire-road interaction. In addition to Czuka, Manfred Haider, Senior Research Engineer and thematic coordinator in the field of acoustics at AIT, has also been active in OeGA for many years.



Matthias Weber in the Productivity Council's expert pool

The Productivity Council is part of the EU-wide economic policy coordination mechanisms. Its primary task is the systematic analysis of the development of domestic productivity and competitiveness. The five independent members have appointed 19 proven experts from science and research to advise them in an expert pool. Among them is also Matthias Weber, Head of Center for Innovation Systems & Policy. The Productivity Council makes recommendations to the Federal Government and reports annually to the National Council.



TOMORROW TODAY

Our partners and customers benefit from conferences and events which AIT (co-)organises and complements with top-class contributions. In this way, it is possible to extend the knowledge lead.



What makes the approximately 3,300 start-ups in Austria tick

Where do most startups get launched? How are they financed? What is the composition of the startup ecosystem in Austria? These and many other questions are answered in the annual Austrian Startup Monitor. "The Austrian Startup Monitor helps to collect and continuously analyse information on the development of Austrian startups," explains AIT project manager Karl-Heinz Leitner. The 2022 edition showed that the proportion of startups with at least one woman on the founding team increased from 36 to 39 percent compared to the previous year. 25 percent of startup founders have a migrant background – this corresponds to the proportion in the Austrian population as a whole. Every second of the more than 3,300 startups pursues overarching corporate goals in the areas of ecology and/or social concerns. This share has grown in recent years.

<https://austrianstartupmonitor.at/en/>

AI5production: Know-how for companies

In November 2022, the new European Digital Innovation Hub (EDIH) "AI5production" began its work. It is intended to support domestic manufacturing companies with up to 3,000 employees in all aspects of digitisation. The AIT Austrian Institute of Technology is also involved – together with 15 other partner organisations – with the Center for Digital Safety & Security (coordinator at AIT), the Center for Technology Experience, the Center for Vision, Automation & Control and the LKR Leichtmetallkompetenzzentrum Ranshofen. As Manfred Tscheligi, Head of the AIT Center of Technology Experience, emphasised in his keynote speech at the kickoff event, people must always be at the centre of all automation. "The move towards Industry 5.0 brings a new understanding of roles for workers, but it is always important to pay attention to safe and inclusive work environments and Human Centered AI." This includes a focus on the necessary abilities and digital skills of the employees as well as on the usability and acceptance of new technologies.

www.ai5production.at



<https://austrianstartupmonitor.at>, Getty Images



AIT at the Berlin Science Week

Artificial Intelligence (AI) methods are permeating more and more areas of our life and work.

A panel discussion organised by the AIT entitled "AI-enabled Automation: How Intelligent Machines Support Humans" as part of the "Berlin Science Week 2022" identified a number of application areas where intelligent machines can help us meet future challenges. The panel included: Martin Kugler (moderator, AIT), Andreas Kugi (Vienna University of Technology, AIT), Elisabeth André (University of Augsburg), Manfred Tscheligi (University Salzburg, AIT), Lydia Kaiser (Technical University Berlin), Johannes Winter (L3S), Matthias Scheutz (Tufts University, AIT), and Wolfgang Knoll (AIT Managing Director) (from left to right).

Blackout training for critical infrastructure sectors

Regardless of whether they are companies, authorities or emergency organisations: The topic of blackout, a failure of critical infrastructure, concerns every institution in Austria. Together with AIT and the Federation of Austrian Industries (IV), the Competence Center Secure Austria (KSÖ) organised a blackout simulation in November 2022, in which the first hours and days after a blackout, triggered by a technical incident in a transformer station, were realistically simulated. On the basis of the AIT Cyber Range Training Platform and through use of state-of-the-art digital simulation systems, it was possible for the first time to simulate concrete effects for the whole of Austria. This makes it possible for different stakeholders from the public sector, operators of critical infrastructures, and companies to gain essential insights in order to define and implement the measures required to sustainably ensure the highest possible availability of our critical infrastructures. A total of nine teams fought against the blackout and its consequences.

Security at the Highest Level

Together with its partners, AIT presented exciting innovations at the "it-sa" trade fair in Nuremberg, Europe's largest trade fair for IT security. In addition to news from the areas of quantum communication, fake news detection, and secure data storage and forwarding, the Sec³ Secure Cloud Connecting System, which offers maximum security for machines and IoT devices according to the principle of "Security by Isolation" (SBI), attracted great interest in the area of "Industry 4.0": It prevents a single successfully attacked IoT device from mutating into an attack vector against all devices connected to the cloud.



AIT: Hotspot of image processing

Under the slogan "From Sensor to Decision", AIT scientists presented at the VISION - the world's leading trade fair - four innovative approaches in automated surface inspection.

The inline 3D microscopy method (ici:microscopy) is suitable for inspection tasks with extremely high resolutions (up to 700 nm) and large inspection areas. Using the TinyScan360°, a miniaturized 3D stereo

scanning system, the smallest cavities can be measured and exact digital replicas created. The strength of exposure:photometry lies in the reliable detection of defects at very high inspection speeds, even for difficult surface properties. ICI:inspect combines light field and photometry and mimics human inspection such as tilting the object and changing the viewing perspective. In this way, even the most subtle changes in the surface are detected and evaluated with intelligent algorithms.

With its open booth design and live demonstrators, the AIT booth attracted more than 120 different companies. The fact that AIT is now a key player is also shown by the visitor statistics.



INTERNATIONAL DIGITAL SECURITY FORUM VIENNA

www.idsf.io

The International Digital Security Forum brings the digital community together

From 31 May to 2 June 2022, Vienna's MuseumsQuartier became an international stage for digital security topics. Organised by AIT in partnership with the ARGE Sicherheit und Wirtschaft (ASW) of the Austrian Federal Economic Chamber, the "International Digital Security Forum" (#IDSF22), certified as a "Green Event", offered a three-day programme with more than 100 renowned speakers from all over the world. Following the motto "Secure Digitalization for a Safe, Green and Sustainable Future", more than 250 people attended the conference on-site, and over 500 from 41 countries participated online. "It's about mastering our technologies in a responsible way. A global, sustainable dialogue between research, industry, and authorities is a necessary basis for shaping digitisation in such a way that it also corresponds to our goals and values," explained Helmut Leopold, Head of AIT Center for Digital Safety & Security and initiator of the IDSF. 15 sessions and ten keynotes were dedicated to a wide range of R&D topics in conjunction with the policy design of digital security. The next date has already been set: 19–21 September 2023. www.idsf.io

Highly successful Light Metal Days 2022

How can lightweight construction contribute to making mobility more sustainable? What possibilities are there to minimise resource consumption in the aluminium industry by means of recycling and circular economy approaches? And what will the "Green Foundry 4.0" of the future look like? These and many other questions were the subjects of the 12th Ranshofen Light Metal Days 2022 which took place at the University Mozarteum Salzburg under the title "Green Processes & Sustainable Materials". Three keynotes, 18 presentations from research and industry, a panel discussion as well as a pitch and a poster session made the Light Metals Days one of the most high-profile events in the light metals sector. In an accompanying industrial exhibition, renowned companies from industry, research, and testing technology presented the latest trends and technologies. And in a poster exhibition, young scientists provided an insight into current research results.

www.lmt.ait.ac.at



Above: The traditional AIT garden party in Alpbach.

Below: RTI Talk with Florian Tursky (BMF), Martin Polaschek (BMBWF), Leonore Gewessler (BMK), Moderator Gerald Gross, Martin Kocher (BMAW), and Christoph Neumayer (IV)



Technology & Innovation

@ European Forum Alpbach 2022

We currently have to cope with many crises – the Ukraine war, the climate and energy crises, the consequences of the pandemic. Many of these current problem areas were discussed at the European Forum Alpbach 2022 at the end of August. "The talks revealed that we have a certain chance of coping with the challenges," summed up Wolfgang Knoll, Scientific Managing Director of the AIT Austrian Institute of Technology. "The consensus is that we need a deeper scientific understanding that is translated into new technologies and into innovations," said Knoll at the end of the meeting of the technology community, which has been organised by AIT and ORF Radio Ö1 in the tried and tested form for more than 30 years. The more than 20 Plenary and Content Partner Sessions with more than 40 hours of a high-calibre programme as well as many opportunities for networking met with very high interest from the technology community – almost like before the Corona crisis. "There is an urgent need for personal exchange," says Knoll.

www.ait.ac.at/en/efatec

CENTER FOR DIGITAL SAFETY & SECURITY

More than 200 experts at the Center for Digital Safety & Security work on key technologies of digitisation in order to build the most modern information and communication technologies in an energy-efficient, highly secure and reliable way and to use them according to a wide range of requirements.



Digitisation has changed the rules of the economy and many mechanisms of our society at an impressive pace. This transformation process is gaining further momentum through the networking of numerous physical objects (Internet of Things). These developments unlock huge potential for new applications, business models, and added value streams. At the same time, however, we have all already become dependent on technology platforms to such an extent that our economy, our social life, and our government administration have become

unthinkable without functioning digital infrastructures.

Strong international networking

Mastering digital technologies has therefore become a fundamental requirement for business and society. Digital technology must be developed and designed with the highest possible availability, with the best possible security against the most diverse threat scenarios, with the lowest possible consumption of resources, and with a focus on data protection in the service of people.

The Center's research activities build on strong networking and close collaboration with globally leading universities and research institutions, but also with international organisations such as the United Nations or the International Atomic Energy Agency IAEA, as well as with the European innovation system (EU Commission, EU agencies, and authorities in the EU member states). Furthermore, AIT with its Center for Digital Safety & Security is the national coordinating body of the Gaia-X Hub Austria and thus also acts as an effective link for Aus-

"A secure digital technology is the foundation for our social and business life."



Helmut Leopold,
Head of Center for Digital Safety
& Security

trian industry and public authorities to the European Gaia-X Initiative as well as to the international innovation ecosystems.

Organisation and focal points

The research agenda of the Center is organised in four Competence Units: The Sensing & Vision Solutions area addresses next-generation sensor systems for the protection of critical infrastructures and works on biometrics technologies for future digital identity management.

The Data Science & Artificial Intelligence area focuses on Artificial Intelligence (AI), Big Data and data science, as well as blockchain technologies.

This concerns e.g. how decisions made by an AI system can be explained – an important prerequisite for being able to use AI-based technologies in a sensible and safe manner.

In the Cooperative Digital Technologies area, AIT experts work on future IT architectures and technologies – with a focus on distributed and virtualised IT systems, data ecosystems, the Internet of Things and smart applications for the environment, e-government as well as for public safety and crisis & disaster management.

The Security & Communication Technologies competence area focuses on the one hand on central requirements for the reliability and security of digital technologies for the operation of

critical infrastructures and production systems, cybersecurity systems and state-of-the-art encryption technologies; and on the other hand on new Enabling Digital Technologies such as hardware-related software development, photonic semiconductor technologies, radio systems of the future (6G), and quantum technologies. In the latter area, the findings of Nobel Prize winner Anton Zeilinger regarding quantum encryption are being put into practice – AIT is a leading technology supplier and coordinator of major European projects to help translate research results into industrial solutions and market applications.

Data protection and digital sovereignty for users

All these activities are strongly focused on data protection and privacy. With the great expertise in the development of methods, architectures, tools and technologies, the Center for Digital Safety & Security makes an important contribution to European data sovereignty, in order to ensure the highest possible protection of data in technical solutions through "security and privacy by design" approaches. For instance, smart encryption methods are being developed to prevent the misuse of personal data. The latest AI methods are being used to protect online users from abuse – for example, to detect disinformation campaigns on

the Internet that endanger democracy or to protect consumers from online fraud.

Safety & Security by Design

As digitisation progresses, the topic of security becomes a fundamentally essential issue. Especially in the industrial sector, reliability and operational safety have always been important design criteria. This is now being increasingly complemented by cybersecurity. Methods and tools are being developed at AIT to already take safety and security requirements into account in the design phase ("Security & Safety by Design").

In order to actively participate in creating important framework conditions for future digital technologies, the constant exchange with users and authorities as well as the active discourse with the public are an essential guiding function for the Center – so that technology acceptance, legal requirements and ethical guidelines can be taken into consideration in the technical system design from the very beginning.

CENTER FOR HEALTH & BIORESOURCES

The mission of the 200 researchers in the fields of health and bioresources is to improve the quality of life and make the environment more sustainable against the backdrop of demographic changes, dwindling of resources, cost pressure, and changing lifestyles.

The activities of the Center for Health & Bioresources, which has developed into a renowned partner at the regional, national, and international level in the fields of health and bioeconomy in recent years, are guided by the motto "One Health". This motto illustrates the claim of not considering human health alone, but rather in conjunction with the health of plants, animals, and the environment. The "One Health" concept has gained much importance recently, since the interactions between humans, animals, and the environment have changed due to a variety of factors such as population growth, aging societies, climate and environmental changes, and the ever-increasing mobility and spread of people, animals, plants, food and feed. These developments have also favoured the emergence or re-emergence of many infectious diseases. There is therefore a great need for the development of appropriate systemic solutions and strategies at the interface between the fields of health, environment, and bioeconomy in order to address these global challenges.

By linking the health sector with bio-economic aspects under the umbrella of "One Health", we are addressing not only human, animal, and plant diseases, but also their general health status – and not only the improvement of individual plant systems, but also the

quality and safety of food and feed within the framework of an organically based and circularity-oriented economy.

Within this framework, we see our task in improving the quality of life and the environment in the face of demographic change, the growing world population, the limitation and increasing scarcity of resources, as well as the increasing individualisation of consumers and patients and a changing lifestyle.

With our scientific reputation, our technological expertise, our deep understanding of system interrelationships and partner requirements as well as of the necessities for implementing our solutions in practice, we contribute to the "Grand Challenges" and/or missions and the "Sustainable Development Goals" set by the EU and the WHO. Together with our partners and clients, we want to make an impact-oriented contribution to the development of relevant tech-



"In biomarker research, AIT is among the leading RTOs in Europe."



Elke Guenther,
Head of Center for Health
& Bioresources

nological and scientific solutions to improve the health status of the population and make better use of biological resources.

Plants and microorganisms

In the area of bioresources, the focus is on the transformation from a fossil-based to a biobased resource-conserving economy. A current research focus is the microbiome – the community of all microorganisms in a given habitat. The focus is on the colonisation of plants with beneficial microorganisms and their mutual interactions (holobiont). The growing understanding of the interconnectedness of microbiomes in environmental and food systems has the potential to support the sustainable production of food, feed, and biofuels and at the same time to promote the principles of the circular economy.

Digital technologies play an important role in the research and application of this knowledge – e.g. for a circular agriculture or improvements in food production.

Health according to the "4P" principle

Digitisation is also one of the cornerstones of the Center's activities in the health sector: Cases in point comprise the development of telemedicine systems for different indications, such as for people with cardiac insufficien-

cy or people who, for example are in home quarantine due to an infection. Key research areas are the search for biomarkers, the development of biosensors, and decentralised "point-of-care" solutions for diagnostics as well as research into biological barriers and the development of AI-based algorithms for the analysis of biological signals in neurological and cardiovascular diseases. The task is to rethink health systems and to make the transition from reactive to active health care. Our research approaches are based on the "4P" concept, which includes the following aspects:

- preventive: Regular monitoring of the health status can prevent the outbreak of diseases through timely intervention.
- predictive: With the help of big data analyses and modern diagnostic methods, situations with significant health risks can be predicted.
- participative: Systems are being developed that make patients active participants in healthcare.
- personalised: Therapies are adapted to people's individual needs – e.g. by developing specific biomarkers.

Integrated into large European networks

The AIT Center for Health & Bioresources has also been a member of two of the nine innovation communities of the European Institute of Innovation & Technology (EIT). One of these is EIT Health, which aims to leverage the innovation potential of cutting-edge research for health technologies for health care, diagnosis, and prevention and to implement it for rapid market entry. The innovation hub "EIT Health Austria" was founded on the initiative and under the coordination of AIT for the regional anchoring of the European network. On the other hand, AIT is also active in the EIT Food innovation network, which is Europe's leading innovation and technology initiative in the agricultural and food sector, and is committed to more sustainable, healthier, and more trustworthy food.

CENTER FOR LOW-EMISSION TRANSPORT

At the Center for Low-Emission Transport, fundamentally new technologies for sustainable vehicles and transport systems are being developed. The focus is on electric drives, battery research, lightweight construction, and efficient use of the transport infrastructure.



The Center for Low-Emission Transport occupies a leading position in the Austrian innovation system and a key role in Europe as an RTO focusing on the key transport infrastructure issues of the future. The Center realises fundamental innovations for the next generation of sustainable transport technologies through research and technology development in combination with a high-quality research infrastructure. The Center's unique selling point is its holistic approach to low-emission transport technologies for people and goods – from sustainable and energy-efficient manufacturing via low-emis-

sion usage and maintenance all the way to aspects of the circular economy comprising transport vehicles and infrastructure. The Center's approximately 180 employees cover a wide range of research competences.

Technologies for electric vehicles

Research in the Electric Vehicle Technologies Competence Unit focuses on the development of innovative methods, models, and tools for the construction of efficient and reliable electric powertrains. A case in point: research is being conducted on the simulation of vehicle systems (e.g. to improve energy and heat manage-

ment), and on components and control algorithms for power electronics. By combining many competencies, the overall system of energy storage and energy consumers and their interaction can be better addressed. Recently, some purely electrically powered vehicles have been developed – such as the EMPA-TRAC, an innovative commercial vehicle with a modular structure; or, in collaboration with KTM, a two-wheeler for urban areas. A further focus is on the development of methods for purely electric and hybrid aircraft that can be powered by both combustion fuels and electric energy. And in the area

"In our battery research, we cover the entire system chain from battery development via materials research all the way to battery production."



Christian Chimani,
Head of Center for Low-Emission
Transport & Managing Director LKR

of environmental simulation and battery testing, comprehensive testing of components for electrically powered vehicles, battery systems, and other components is taking place.

Environmentally friendly and safe batteries

A key research area in the Center is battery research. The experts have a state-of-the-art battery lab at their disposal for developing the next generation of batteries, including a research pilot line. The focus here is on three areas of research: Firstly, new battery materials are being developed that might replace lithium in the future. Secondly, together with renowned partners from industry, efficient and sustainable production methods are being developed for cobalt-free batteries that do not require toxic solvents. And thirdly, the researchers are working on future-oriented solid batteries that no longer require liquid electrolytes, with benefits in terms of storage density, ageing resistance, and safety. For the purpose of further development, the Battery Lab is now being expanded to include a Solid State Lab.

Innovative light metals

The work in the Light Metals Technologies Competence Unit at the LKR Leichtmetallkompetenzzentrum Ranshofen revolves around the devel-

opment and processing of lightweight high-performance materials for vehicles and aircraft of the future as well as the design and production of prototypes and components. Lighter vehicles consume less energy, cause lower emissions and increase the range. Using highly specialised material characterisation and simulation, the researchers are investigating and developing new types of light metal materials (such as aluminium, magnesium and titanium alloys) as well as methods for their shaping. A separate research area is "wire-based additive manufacturing", which is one of the most promising methods of 3D printing with light metals. The special feature of this Competence Unit is that it covers the entire process chain: from developing high-quality light metal alloys via their sustainable and efficient processing all the way to developing functionally integrated components and their recycling.

Secure and efficient infrastructure

In accordance with the Center's research approach, the Competence Unit Transportation Infrastructure Technologies also has a great deal of experience in modelling and simulating transport infrastructures, combined with experimental sensor technology and characterisation in order to capture and understand all

interrelationships and interactions in this important area. The focus here is on decarbonising the transport system, extending the life cycle of infrastructure facilities, and increasing road safety.

For example, measurement methods for noise and vibration effects are being developed for monitoring the transport infrastructure (roads, railway networks, bridges, buildings) in order to ensure a highly resilient, resource-efficient, and safe transport network. A fleet of measuring vehicles (RoadSTAR, RoadLab, and Motorcycle Probe Vehicle) regularly check the condition and safety of the Austrian road network. And the award-winning "AIT Mobility Observation Box" is able to conduct objective analyses of dangerous situations, e.g. at intersections.

CENTER FOR VISION, AUTOMATION & CONTROL

The mission is the sustainable industry: With the goal of protecting people and the climate, the researchers are developing sustainable digitisation and automation solutions. While production costs are to be reduced and resource efficiency increased, machines and production processes are to become more flexible, adaptive, and resilient.

In view of the many challenges such as shortage of qualified staff, volatile energy prices, supply bottlenecks, the need for more flexibility in production processes and, last but not least, the demand for resource-efficient and sustainable production, the pressure on industry to invest more in digitisation and automation is increasing. Automation is one of the key technologies to achieve the two top priorities of the European Commission: On the one hand, the EU economy is to be made sustainable (Green Deal), and on the other, Europe is to be made fit for the

digital age. The Center for Vision, Automation & Control supports industry with customised, intelligent automation solutions in this endeavour.

From sensor to decision

Around 120 experts at the Center are researching autonomous commercial vehicles (e.g. for logistics and transport, for agriculture, forestry, and construction), assistance systems (e.g. for tramways, rail vehicles and aviation applications), optical high-performance measurement and inspection systems (e.g. for quality control in the

metal and electronics industries and in security printing), intelligent production systems (e.g. for reducing energy consumption and emissions while simultaneously increasing quality) as well as in mechatronics and robotics. In addition, advanced automation systems are expected to make an important contribution to the circular economy and bring parts of the value chains back to Europe. The vision is to support people in their work through modern automation concepts and to help to design the industrial future.



The requirements of the market and problems of the industry are systematically incorporated into the research programme of the Center from the very beginning. With this, we support our industrial partners to consolidate and expand their position on the market. In this process, a close synergetic linkage of in-depth scientific methods and technological expertise is pursued. The portfolio of the Center encompasses the entire spectrum from consulting via medium- and long-term strategic research cooperation all the way to the development of prototypes and the support of industrial implementation and application.

Three research groups – one goal

With its scientific and technical know-how, the Center covers all areas of industrial automation: from capturing information by means of sensor systems via sensor fusion, the combination of physics-based models with Machine Learning and data analysis concepts, using this information for fault detection and isolation, real-time optimisation and control, all the way to high-level decision-making in components, systems, and processes. In short: from the sensor to the cognitive decision of an autonomous system. The Center is organised into three research groups that work hand in hand depending on the task and research question.

The Assistive & Autonomous Systems research group deals with sensing, navigation and decision-making functions for assistance systems and for the autonomous operation of vehicles, machines, and aircraft. These are based on sensory perception, perceptual and environmental modelling, Machine Learning for object recognition and scene understanding, as well as scenario-based simulations and tests. The scientists in the Complex Dynamical Systems research group work on intelligent mechatronic drive systems that can be easily commissioned, re-configured, and adapted to changing operating conditions. Moreover, they are also researching the automation of commercial machines and vehicles as well as the real-time optimisation and control of continuous production systems.

The core competence of the High-Performance Vision Systems research group is the holistic design of robust image-processing-based sensor systems for real-time inspection and inline quality assessment. These systems are characterised by top performance in terms of speed, resolution, and capturing complex shapes and difficult surface properties.

AI-enabled automation and human-machine collaboration

The Center has established a number of key partnerships with scientific

institutions, e.g. in form of a PhD programme with the Tufts University, USA. Moreover, there is a close connection with the Automation and Control Institute (ACIN) of TU Wien. In addition, the researchers are working across Centers and together with industry partners on selected topics of AI-based process automation for sustainable production, synergetic cooperation between humans and robot systems, and the development of assistance as well as autonomy functions of working machines and commercial vehicles. Future automation systems should be designed to serve and support workers in the best possible way and adapt to their needs. For this reason, a close partnership was established with the Center for Technology Experience in order to systematically take the users' perspectives into account.

"Our intelligent automation solutions serve people and the environment. They increase resource and energy efficiency and ensure a high product quality."



Andreas Vrabl
Head of Center for Vision, Automation and Control

CENTER FOR TECHNOLOGY EXPERIENCE

The users of digital technologies take centre stage: The Center for Technology Experience focuses on the interaction between humans and technology, the human-centred design of systems and the design of advanced human-machine interfaces.



We humans do not just use technology, we live with it. More than ever before, digital technologies affect us on an intellectual, but also on a sensual and emotional level. Due to the rapid spread of digital technologies – such as artificial intelligence, robotic systems, and extended reality (XR) – it is becoming increasingly important to consider a human-centered view on technology (Human Centered Design).

Successful digitisation must support people. An essential prerequisite for successful innovation is an optimally designed interaction between people and technology. The needs of people must be taken into account in all steps of the value chain. This approach poses many challenges for the successful design of new products, technologies, and services.

The Center for Technology Experience focuses intensively on interactions between humans and machines, on the interfaces between them and on the so-called "user experience", the experience of using technologies. In order to achieve this, numerous new methods and processes are being developed along the entire value chain, which are being applied systematically and methodically in various contexts

and technology fields. This ranges from autonomous driving through to collaboration between people, machines, and robots (Industry 5.0), from the design of innovative learning and training environments (e.g. with the help of XR) through to e-commerce experience or human-centred entertainment concepts. The Center is the leading institution in the field of "Human Centered Design" in Austria and partner of many renowned companies. The researchers are supported in their work by a unique Technology Experience Laboratory (AIT TX Lab).

Methods for measuring the experience

The Competence Unit Experience Contexts and Tools researches contextual and situational phenomena as well as innovative methods and tools for the provision of appropriate solutions. In the research field Experience Measurement, methods are being developed for measuring, modelling, and optimising the experience and use of technologies. An important goal is to gain a deep understanding of human diversity (e.g. for people with visual impairment) so as to be able to realise diversity-conscious human-centered design. The research area Capturing Experience is concerned with in-

novative examination methods and solutions that enable a responsible human-machine relationship. What is being sought is an interaction framework for improved cooperation and coordination between people and technology, in particular in the context of automation.

Designing digital transformation processes

The Competence Unit Experience Business Transformation focuses on new concepts and strategies for supporting organisations in digital change processes and on the transformation of business cases by using future interaction concepts. The research field Human Centered Business Innovation is to create foundations for the development of new digital ecosystems. The focus on users and customers enables their integration into the development of new digital solutions (co-creation) as well as the successful and sustainable introduction of innovations. The research area Future Interface Design is particularly concerned with the development of optimised interfaces that increase the usability of new types of technologies for non-tech-savvy people and help users solve their daily challenges conveniently. The basis for this is to more or less "humanise" the

increasingly complex technologies and interactions through novel interfaces and design strategies.

Next-Generation Human Centricity

The current research work at the Center can be summarised under the keyword "Next-Generation Human Centricity". This means that the latest findings of basic research, which today looks at the human condition much more closely than ever before, are processed in a structured way and channelled into a methodology so that they can be applied. This concerns, e.g., the economic and social framework conditions under which technologies are developed, such as people's changing value orientation (e.g. with regard to sustainability or diversity) or new communication, working, and learning environments.

"The human experience is a key factor for the quality and success of digital solutions."

Manfred Tscheligi,
Head of Center for Technology Experience



CENTER FOR INNOVATION SYSTEMS & POLICY

How do innovations come about? How does this change societies?
And how can we already actively participate now in shaping future changes?
The Center for Innovation Systems & Policy provides answers to these questions and develops future scenarios – and it is an important think tank and advisor for government, companies and research institutions.

The Center for Innovation Systems & Policy is a leading institute in Europe for innovation and policy research. It is particularly concerned with the analysis of research and innovation activities and with the design of policies and strategies for social and technological change. In doing so, it is important to harness the potential of emerging technologies (e.g. digitisation and Artificial Intelligence) to address societal challenges (such as decarbonisation, pandemics, or positive socio-economic development).

The key tasks of the Center are, on the one hand, providing constructive, science-based advice and support for RTI-related (RTI = research, technology, and innovation) policy-making and strategy development in Austria and Europe, as well as for other research and innovation stakeholders. On the other hand, transdisciplinary transformation processes with the inclusion of a wide range of players and stakeholders (e.g. companies or cities) are to be accompanied and supported. Moreover, the Center contributes to the further development of knowledge in the field of innovation studies and policy research at the highest scientific level.

Innovation dynamics, digitisation, and decarbonisation

The research field Innovation Dynamics and Modelling deals with the quantitative analysis and modelling

of innovation systems. The data infrastructure required for this is established at the Center and further developed in close cooperation with European partners.

Research focuses on collecting, maintaining, and processing new types of data on RTI activities (micro-level structured data, unstructured data from the Internet), on the development and application of new network-based indicators for tracking and evaluating system transformations, and on advanced methods of modelling, simulation, and visualisation. The research results flow directly into projects for national and European clients.

The research field Innovation Systems and Digitalisation deals with new patterns of innovation and challenges in industrial transformation resulting from new technological opportunities (digitisation, AI) and demanding societal requirements (such as decarbonisation). Research focuses on the impact of this on innovation practices, business models, new production models (e.g. circular economy, value chains) and new industrial dynamics (e.g. green startups). A major topic here is the relationship between social responsibility and industrial strategies – in other words, how social and ecological ambitions can be integrated into RTI processes at an early stage.

Insights into possible futures

The Societal Futures research field addresses the increasing need for ethical and social engagement in the context of emerging technologies and a growing awareness of uncertainties and disruptive events. This involves, e.g., observing emerging developments with foresight projects and researching the longer-term transformation potential for society resulting from advances in science and technology (such as quantum communication or personalised medicine) or new social developments (e.g. divisive social fragmentation and polarisation). Building on research into how technologies interact with society and lead to social and ethical debates and conflicts, procedures, protocols or guidelines are developed for dealing with them.

Finally, the Innovation Policy and Transformation research field promotes the understanding of political instruments aimed at accompanying transformative systemic change. The scientific foundations for a future-proof design of RTI policy and related policy areas are being developed in the process.

This includes, e.g., the design of a policy mix of instruments for a mission-oriented RTI policy. Another focus is on monitoring, evaluating, and steering longer-term policy initiatives as well as newer and more agile prac-

“The achievements of AIT contribute to pursuing strategic and visionary paths into the future and thus shaping the future.”



Matthias Weber,
Head of Center for Innovation
Systems and Policy

tices to increase the chances of success of ambitious political goals.

Numerous partners at home and abroad

This type of research is in high demand both among clients from industry and the public sector, as shown, for example, by a long-term framework contract with the European Commission for the provision of "Foresight on

Demand" services. Furthermore, the starting position of the Austrian RTI landscape in terms of mission-oriented research in Europe was surveyed together with partners. And the Center is also a leading partner in the preparation of the annual Austrian Startup Monitor. Close contacts and cooperation with universities at home and abroad are maintained in all research areas.



AIT/Bösendorfer (2)

CENTER FOR ENERGY

More than 270 experts are working on the energy system of the future at the Center for Energy. The range of topics is oriented towards three central future fields: Public energy supply systems, industrial energy systems, and cities and the built environment.

The Center for Energy develops solutions for the innovative energy supply of tomorrow. The energy sector is undergoing a drastic process of change that requires a cross-sectoral approach. Innovations for the sectors of industry and commerce, the built environment, and mobility play a central role on the path to climate neutrality.

Research and application

The increased integration of renewable energies, the decarbonisation of industrial processes and plants as well as innovative technologies and solutions for resilient cities and urban resilience are the key research fields in the Center. Furthermore, new and alternative forms of mobility, electrification of road transport, and the optimised use of transport infrastructure are important elements for decarbonisation.

The strengths of the Center are based on its high level of research and application expertise: Many years of experience, scientific excellence and worldwide networking of experts as well as the high-quality laboratory infrastructure create clear competitive advantages for our clients and partners such as industrial companies, energy suppliers, technology providers, regions, cities and municipalities as well as research and technology institutions.

High quality lab infrastructure

AIT's SmartEST Lab (Smart Electricity Systems and Technologies) and the High Power Laboratory provide a laboratory infrastructure for electrical energy technology components that's unique in Europe. Since direct current will also become increasingly important at the medium and low-voltage level in the future (photovoltaics, storage systems, batteries for electric vehicles, etc.), the research infrastructure was expanded with the new DC Lab for DC currents in the order of 100 kA.

The City Intelligence Lab, an international flagship lab for the urban planning practice of the future, is an interactive platform for exploring new forms and technologies for urban planning practice and follows the approach of a co-creative development, i.e. the joint creation of new knowledge. In this lab, Artificial Intelligence and Machine Learning methods can be used to simulate, e.g., real time climatic influences in urban planning or mobility aspects. The Industrial Energy Systems domain will be further strengthened with a planned "Virtual Industry Lab" in which industrial energy systems can be simulated and visualised in real time. The first use cases demonstrated the planning support at location level, the model representation of plants (e.g. an industrial belt dryer) including mea-

surement data for monitoring as well as the plant control.

Public energy supply

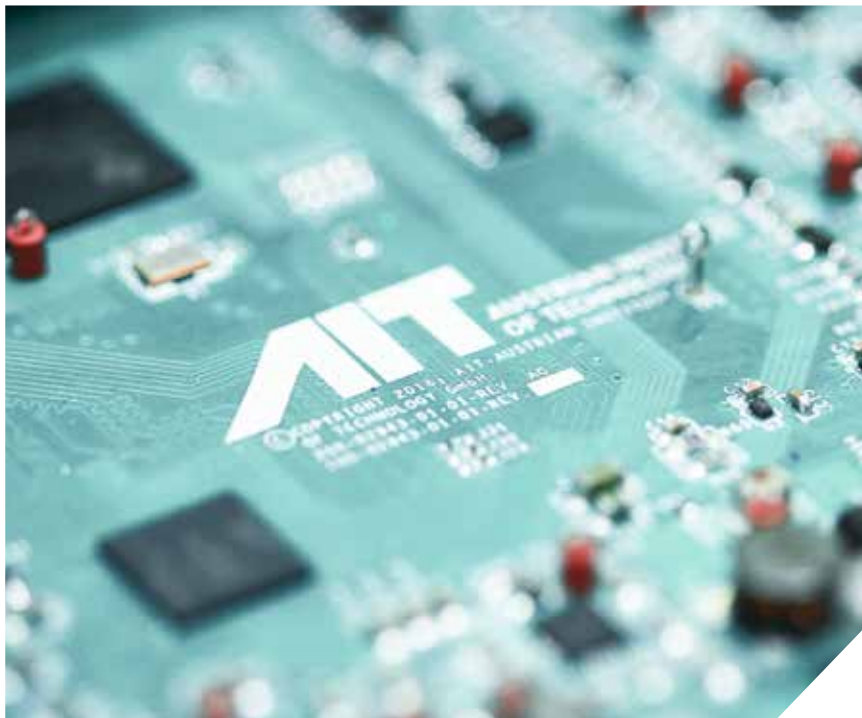
The Center has built up in-depth expertise in energy system modelling for a sustainable transformation of our energy supply. A basic model of the Austrian energy system is used, e.g., for long-term forecasts of energy prices and the development of technology and decarbonisation scenarios. An integrated approach to the different energy sources electricity, heat, and gas is indispensable here in order to ensure an optimised and efficient operation of the energy system of the future in terms of supply security.

Furthermore, technologies for sector coupling are needed. In the Competence Unit Energy Conversion & Hydrogen (ECH), building on many years of extensive know-how in selected energy conversion technologies (e.g. solar cells, OLEDs, etc.), research is being conducted together with strategic partners on hydrogen technologies in the context of sector coupling. The topic covers a broad spectrum of activities and is oriented towards two central focal points in the Center: On the one hand, it is about the integration of hydrogen technologies and synthetic gases in the energy infrastructure for efficient sector coupling, taking into account energy industry aspects. On the other hand, the material and en-

"With our high-quality and specific lab infrastructure, we offer our partners innovative and applied research services."



Wolfgang Hribernik,
Head of Center for Energy



companies. As part of the innovation network NEFI – New Energy for Industry, key technologies such as heat pumps for waste heat utilisation, innovative storage technologies, and new solutions for the use of renewable energy in industry are being developed and scientifically accompanied in numerous application-oriented projects.

Cities and the built environment

Climate change and its adverse effects on cities and their mobility systems have become a global challenge. An understanding of climate change, such as the impacts, risks, and effects of countermeasures, is essential for sustainable urban and infrastructure planning. In the area of Digital Resilient Cities, solutions are being developed to strengthen the resilience and adaptability of cities and their infrastructures, as well as the optimised use of energy for significantly decarbonising the mobility sector. Another focus is the decarbonisation of the building sector. In order to increase the share of renewable energy in buildings, the building technologies for heating, ventilation, and air conditioning are being investigated, and corresponding energy concepts are being developed.

ergetic use of hydrogen in industrial processes is being researched for the decarbonisation of industry. The Center's technological know-how can also be deployed for the decarbonisation of the transport sector. A high-performance infrastructure for ultra-fast charging of electric vehicles is being developed as part of a scientific pilot project. For the first time in Europe, a demonstrator is being developed here for a multi-megawatt fast charging station that is directly coupled to the medium-voltage grid.

Decarbonisation in Industry

The Industrial Energy Systems domain deals with the transformation of the industrial energy system and the integration of renewable energy sources into the existing power and heat system of the process industry. An important research area is industrial heat pumps which can be used to convert low-temperature waste heat back into usable process heat of significantly more than 100°C. To this end, several innovative demo systems were designed and installed in industrial

KEEP YOU INFORMED

The AIT Austrian Institute of Technology is Austria's largest non-university research facility and is present on many media channels and platforms on a daily basis.

AIT BLOG: RESEARCH EXPLAINED FOR ALL

The AIT Austrian Institute of Technology has been running a research blog for several years. AIT is thus expanding its communication mix and addresses a broad public in order to convey the topics of research, innovation, and technology development in an exciting and understandable way. Currently, two to four blog articles per month are published, in which the work and services of the highly qualified AIT experts are described in a tangible way.

Moreover, the AIT research blog is intended to illustrate the particular benefits of industry-related research for society. The spectrum of topics ranges from climate protection and innovation to digitisation and decarbonisation.

Link to AIT Blog: www.ait.ac.at/blog



THE MAGAZINE FOR PARTNERS AND CLIENTS

The Magazine for AIT Partners and Clients is published three times a year and addresses decision-makers from research, industry, and education. It addresses all key stakeholders of the Austrian innovation and knowledge system.

THE PROFILE & HIGHLIGHTS

The AIT yearbook, which presents and showcases current research highlights and issues, vividly presents a representative cross-section of AIT research topics and developmental focus areas.



TECHNOLOGY @ FORUM ALPBACH

For many years, the AIT Austrian Institute of Technology and ORF Radio Ö1 have jointly organised a programme for the technology community at the European Forum Alpbach. "The Review" summarizes the most important statements, content sessions, and topics of the Alpbach Technology Symposium.

At www.ait.ac.at/en/efatec, you will find a compact review of the talks of the year 2022 and the Yearbook "Discussing Technology" for free download – 2022 on the topic of "Applying Artificial Intelligence", 2023 on the topic of "Shaping the green and digital transformation".

FOLLOW US ON FACEBOOK, TWITTER & CO.

In social media, too, AIT is considered one of the appreciated addresses for all those interested in RTI. Current topics and the researchers working on these issues at AIT are presented in the form of information prepared in a popular science format.

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Anmeldung zum
AIT-Newsletter



Mehr über das AIT
auf www.ait.ac.at

ARTTEC – THE ART PROGRAMME OF AIT



With the ART PROGRAMME ARTTEC, the AIT Austrian Institute of Technology is investigating interfaces between art, technology, and science. "In doing so, we rely on appropriate professional curation and mediation and cooperation between established institutions such as Ars Electronica Linz, the MAK – Museum of Applied Arts, and the University of Applied Arts," says Michael H. Hlava, Head of Corporate Communications and Project Manager ARTTEC. Since 2018, ARTTEC has been taking place in the foyer of the headquarters at Giefinggasse 4 in Vienna. Under the name ARTTEC @ AIT, creative and interdisciplinary exhibitions with artists in residence broaden the perspective of employees and guests at the location.

Berlin-based mixed-media artist Chris Noelle was the first artist-in-residence at AIT. Under the title "Deceleration", he used spirography to address the constant changes in society and technology. Concurrently, the video project ONE was realised: In a one-minute clip for each, Chris Noelle interpreted the research of the various

AIT Centers in an artistic way. The second artist-in-residence, Judith Fegerl, focuses on the topic of energy. In the installation "reservoir", she showed the traces left by electric current on the materials in batteries. In the "capture" project, she chased lightning bolts and arcs through lightning conductors and through various sand mixtures in the high-voltage lab of the AIT Center for Energy – the intense heat caused the sand to melt and solidify into jagged pipes called fulgurites.

Since 2022, the third artists-in-residence are Martin Grödl and Moritz Resl from the Viennese artist duo Process Studio. They cooperate in particular with the AIT Center for Vision, Automation & Control (Competence Unit Complex Dynamical Systems). The artists use Artificial Intelligence as a tool for their work, e.g. in their sculpture "Tokens for Climate Care". "With ARTTEC and the focal points ARTTEC Talk and ARTTEC Visit, the AIT Austrian Institute of Technology is a pioneer in the integration of art and science and technology," Hlava emphasises.

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