UiO : Department of Technology Systems
The Faculty of Mathematics and Natural Sciences

Summary of the Institute for Technology Systems' strategy for the period 2021-2025

ITS's role, direction, and ambitions for the period will be as follows: ITS works to develop a leading academic community for technology systems that inspires and attracts well-qualified and highly motivated employees and students. The department further develops UiO's technological university environment at Kjeller, with a focus on future technologies in a scientific, industrial, and societal context. The UN's sustainability goals are central to the scientific activity. ITS further develops close collaboration with the Kjeller environment, external actors nationally and internationally, and internally at UiO. ITS's activity shall maintain a high international standard. ITS has a clear ambition to grow in the period within research, education, and innovation. To strengthen the scientific activity, ITS strives for a good, open, and trust-based culture of cooperation, internally and externally, within both research, education, innovation, and dissemination. ITS addresses both national and international challenges, including addressing the societal aspects of technologies.

The research at ITS shall mainly have a practical and applied approach and system perspective. ITS prioritizes a limited number of thematic areas within future technologies represented in the research communities at Kjeller. ITS's priority fields of study are autonomous systems and sensor technologies, renewable energy systems, space technology, and security and trust in the digital world. The mainstay of research activity lies in the middle part of the Technology Readiness Level (TRL) scale. ITS emphasizes interdisciplinary research, with a strong anchor in the disciplines. ITS shall further develop an attractive technological educational environment at Kjeller. The education shall be closely linked to the research and innovation performed at ITS, in the Kjeller environment, and with collaborating businesses and the public sector. Currently, education at ITS is primarily at the Master and PhD levels, but the department also wishes to develop education at the bachelor's level. ITS's objectives for educational activity are:

- ITS graduates are attractive for research, business, and public administration.
- ITS graduates are skilled problem solvers in a digitized society, with a focus on the UN's sustainability goals.
- ITS contributes to lifelong learning. ITS shall contribute to **innovation** by utilizing new and existing knowledge. ITS emphasizes the demonstration of research results in a system or subsystem context, highlighting and **communicating the value** of innovative research for society.
- ITS facilitates the Center for Research-driven Innovation "Center for Space Sensors and Systems" (CENSSS).
- ITS emphasizes long-term research and development cooperation with the Kjeller Institutes, businesses, and the public sector, contributing to idea development and utilising research for sustainable social benefit innovation, product, and service development.
- ITS actively communicates knowledge and research results.
- ITS conducts activities for young people in school age, with the aim of contributing to recruitment to STEM subjects and a more gender-balanced recruitment.

ITS shall be an attractive, secure, and developing workplace for all employees and students, professionally and personally. ITS emphasizes being a department where its administrative and scientific staff and students work seamlessly together to solve the department's societal mission. ITS facilitates professional development and career development for its employees and students. ITS allows for the development of new ideas and concepts. ITS strives for gender balance when recruiting students, employees in scientific, management, and administrative positions, ensuring equal opportunities and fair treatment for all.

1 ITS – Strategy for the period 2021-2025

1.1 ITS role, direction, and ambitions

ITS works to develop a leading academic community for technology systems, which inspires and attracts well-qualified and highly motivated employees and students.

• ITS will further develop the technological university environment at UiO on Kjeller.
• ITS focuses on future technology in a scientific, industrial, and societal context, including the UN's Sustainable Development Goals.
• ITS will develop close collaboration with the research and development community at Kjeller ("Kjeller community"), other external actors nationally and internationally, and internally at UiO.
• ITS has a clear ambition to grow within a limited number of selected areas. • The activities of ITS shall maintain a high international level.

The UN's Sustainable Development Goals are central to the strategies of both UiO, MN, and ITS. ITS and the Kjeller community work with technologies that address several of these goals.

ITS is committed to addressing both national and international challenges, including addressing the societal aspects of technologies.

As a small institute, it is particularly important for ITS to strive for a good, open, and trust-based culture of collaboration, both internally and externally, in both research, education, innovation, and dissemination. ITS will contribute to good cooperation between the Kjeller community and UiO in general, in addition to developing its own collaborations with the business community and public actors both nationally and internationally. ITS will facilitate as seamless and predictable a system as possible for collaboration between students, employees, and external actors that safeguards everyone's interests, including through a common approach to health, safety and security, and physical and information security. Shared use of research infrastructure and research and teaching laboratories for the institutes at Kjeller is desirable. It is also important for ITS to exploit opportunities for synergies internally.

It is important for ITS to be able to take advantage of the human and material resources at Kjeller. This will enrich both UiO and the Kjeller community. Parliament granted money to UNIK at the time precisely because research activity at Kjeller was expected to benefit university education to a greater extent. At the same time, it is important for ITS to develop its own independent and robust activities with an open, academic culture in both research and education. This way, ITS can develop into an even more attractive study and workplace and be an attractive and long-term partner for the Kjeller institutes, the business community, and others.

1.2 Research

• The research at ITS should mainly have a practical and applied approach and a systems perspective.
• ITS emphasizes interdisciplinary research with a strong foundation in disciplines.
• ITS prioritizes thematic research areas within future technologies represented at Kjeller.

An important role for ITS within UiO is to be more system- and application-oriented, compared to other MN activities. The bulk of ITS' research activities will be in the middle of the Technology Readiness Level (TRL) scale. The interdisciplinary research at ITS will have a strong foundation in disciplines. This means that research will be based on in-depth knowledge in the

subject areas included in the thematic areas. Such in-depth knowledge will be found both internally at ITS, at UiO in general, and externally. ITS will also be able to work on developing such depth knowledge on areas that are essential to the application areas and system solutions that the institute works on where appropriate. ITS will work to ensure that its staff succeed in applications and implementation of externally funded research projects from financing sources such as the Norwegian Research Council, the EU, and others. Externally financed research is an important tool for ITS' growth strategy. Cooperation with the Kjeller environment represents significant opportunities for joint applications across a wide range of topics. Important thematic focus areas at ITS are Autonomous systems and sensor technologies, Renewable energy systems, Space technology, and Security and trust in the digital world (in alphabetical order). These are discussed further in Chapter 2.

1.3 Education
MN and ITS vision: Our graduates will succeed professionally and academically

• ITS will further develop an attractive technological education environment at Kjeller.
• Education will be closely connected to ITS research, the Kjeller environment, and collaborating businesses and public sector partners within the thematic areas that ITS is engaged in.
• Education at ITS will primarily be at the master's and PhD levels, but the institute also aims to develop education at the bachelor's level.

ITS students should experience added value by being present at ITS/Kjeller. We will involve master's students in ITS and Kjeller research and offer assignments with collaborating partners at Kjeller, in industry, public sector, and other places.

ITS will further develop student-active teaching methods and actively follow up on feedback from students. We will build on long-term experience in distance education and be at the forefront of digital education, preferably in combination with physical education. ITS will further develop the education programs that it already has responsibility for or collaborates on, according to national and international developments in relevant areas.

The institute aims to increase the number of graduates with master's degrees. Education at ITS should also be relevant in a lifelong learning perspective. ITS will develop collaborations on educational programs at other institutes where appropriate. ITS has ambitions to increasingly involve itself in teaching at the bachelor's level at UiO. This is both to strengthen the recruitment basis for its research and its own master's programs and to contribute to the quality and breadth of the bachelor's education at UiO/MN. This can be achieved in several ways:

i) ITS employees give guest lectures in relevant existing Bachelor's courses at other institutes, ii) ITS staff take responsibility for one or more Bachelor's courses at other institutes, iii) ITS establishes its own ('TEK-4000') courses that are also offered as Bachelor's courses in programs at other institutes, iv) ITS creates a course group ('minor') within a relevant Bachelor's program at another institute, or v) ITS establishes its own (possibly several) Bachelor's programs (on Blindern or on Kjeller) in collaboration with other institutes.

ITS aims for its educational activities are:

• ITS graduates are attractive in research, business, and public administration.
• ITS graduates are skilled problem solvers in a digitized society, with a focus on the UN

Sustainable Development Goals.
• ITS contributes to lifelong learning.

1.4 Innovation and Dissemination

• ITS will contribute to the implementation of new and existing knowledge.
• ITS emphasizes demonstrating research results in a system or subsystem context and highlighting their usefulness for society.
• ITS facilitates the establishment of the Centre for Space Sensors and Systems (CENSSS), a Centre for Research-Driven Innovation.
• ITS will be active in disseminating knowledge and research results and will use our research as a theme in initiatives for young children to contribute to the recruitment of young people to STEM subjects, as well as a more gender-balanced recruitment.

ITS emphasizes long-term research collaboration with the institutes at Kjeller and will contribute to developing ideas and utilizing research results for innovation and new products and services that society needs. Innovation is often associated with starting new businesses by entrepreneurs. ITS aims to offer space at ITS for its own employees and students who wish to test and develop ideas towards commercially-oriented products and services, to the extent that available space allows.

Demonstrating research results in a system or subsystem context and highlighting their usefulness for society is important both for profiling the institute and for achieving a strong connection to innovation.

ITS has ambitions to increasingly apply to the Research Council of Norway for innovation projects in collaboration with industry, start-ups, or potential entrepreneurs. Relevant arenas include the User-Directed Innovation Arena (BIA), Innovation Projects for Businesses, Industry PhD and Public Sector PhD schemes. In addition, competence projects with industry and the public sector, as well as the Centres for Research-Driven Innovation (SFI) and the Centres for Environment-Friendly Energy Research (FME) schemes, will be important.

It is important for ITS employees to participate in public debate and knowledge dissemination. As part of this, the institute will support writing opinion pieces in daily newspapers, creating popular science articles, and participating in lectures and presentations in appropriate forums, both digitally and in person.

The institute will use our research as a theme in initiatives for young children to contribute to recruiting young people to STEM subjects. ITS will work to support the faculty's efforts to recruit good and motivated students.

1.5 Putting people at the center

• ITS aims to be an attractive, safe, and developmental workplace for all employees and students, both academically and socially.
• The institute will facilitate professional development and career advancement for its employees and students, and provide room for the development of new ideas and concepts.
• ITS emphasizes being an institute and a cohesive workplace. Our permanent and temporary scientific staff, administration staff, and students work seamlessly together to fulfill the institute's societal mission. The university's most important resource is its people - all our employees and students. ITS will work systematically to create a safe, inclusive, and positive working and learning environment. We will encourage collaboration and development of each

employee and student, including facilitating increased interaction in the academic communities and stimulating creative work. All employees should be given the opportunity to develop their skills and creativity. ITS will strive for a better gender balance among scientific staff, leadership positions, and study programs, and ensure equal value, equal opportunities, and fair treatment for all. Recruiting the best candidates of both genders, regardless of ethnicity, religion, disability, sexual orientation, socio-economic background, etc., is important for developing the institute in a sustainable direction.

The institute will prioritize sound and secure financial management, and strive for a good balance between permanent and temporary scientific staff. Currently (December 2020), the institute differs from most other institutes at the Faculty of Mathematics and Natural Sciences (MN) by having almost no postdoctoral researchers, but a large number of scientific staff in adjunct positions. ITS aims to increase the number of postdoctoral researchers and researchers within the institute's thematic areas. The institute will still have a significant number of adjunct staff and scientific staff with shared positions between ITS, the Kjeller environments, and the business sector, which is important for both the scientific community at ITS and external collaboration.

2 Thematic Focus Areas

This chapter describes the thematic and academic focus areas of ITS moving forward. *These focus areas are (in alphabetical order): Autonomous Systems and Sensor Technologies, Renewable Energy Systems, Space Technology, and Security and Trust in the Digital World.* There is significant academic overlap between these thematic areas. This means that the work of individual researchers and research groups at ITS may fall under multiple focus areas.

The research at the Kjeller Environment spans much broader academic and thematic areas than the mentioned thematic focus areas at ITS. Through our close and flexible collaboration with the Kjeller Environment, the institute can offer research-based education and guidance outside of its own focus areas at all levels.

2.1 Autonomous Systems and Sensor Technologies

In recent years, there has been significant development in autonomous systems, both in autonomous control of industrial processes and infrastructure, and in autonomous vehicles on water, land, and in the air. This development is expected to continue as the availability and quality of computing power, sensors, navigation, and miniaturized communication devices increase in the future.

Cybernetics and sensor technologies are central disciplines within these "cyber-physical systems." At the same time, machine learning and artificial intelligence have evolved and gained increasing importance in such systems. Large and complex systems that interact with the environment and evolve over time make these types of systems complex.

ITS works within a range of disciplines and topics within these types of systems, such as cybernetics, machine learning, sensors, communication, and complexity. This thematic focus also has a connection to the faculty's focus on data science and computational science. Autonomy and autonomous systems are important elements within the other three thematic focus areas at ITS, and through them, also within several of the United Nations Sustainable Development Goals. It is therefore important to aim for synergies with these focus areas.

2.2 Renewable Energy Systems

Sustainable societal development will require fundamental transformation to renewable energy supply and a dramatically reduced environmental footprint. There is broad agreement that urgency is needed to achieve the overall goal of the Paris Agreement to keep global warming to below 2°C and thus avoid dangerous climate change.

Research at ITS includes modeling and simulation of renewable energy systems in realistic scenarios, as well as research on key components of energy systems and how they interact in local and global systems and networks. In particular, this includes energy conversion and storage in the form of hydrogen. Solar power, battery and hydrogen systems are important topics with significant activity in the Kjeller Environment as a whole. In collaboration with others, we are also interested in how renewable energy can be introduced in a socially acceptable, just, and democratic way in society, as well as the energy behavior of the population, the possibilities for energy efficiency, and low-emission solutions for industrial processes.

ITS assumes that the introduction of increasingly cheaper and time-varying solar and wind power will lead to a great need for different autonomous systems, and that such systems will constitute critical infrastructure for these renewable technologies. Two of our other focus areas: autonomous systems and sensor technologies, and security and trust in the digital world, therefore have strong links to renewable energy systems.

ITS' work on renewable energy systems addresses many of the United Nations Sustainable Development Goals, including 7 Clean Energy for All, 8 Decent Work, and Economic Growth, 9 Industry, Innovation, and Infrastructure, 11 Sustainable Cities and Communities, and 13 Climate Action.

2.3 Space Technology

In 2020, ITS was awarded a Centre for Research-based Innovation (SFI); Centre for Space Sensors and Systems (CENSSS). CENSSS is funded by the Research Council of Norway and UiO for 5+3 years. The center aims to stimulate the participating user partners in the space industry to further develop their expertise, innovation potential and competitiveness in an international market. An integrated part of the center will be guidance of master and PhD students to increase recruitment to the space industry.

CENSSS focuses on sensors and sensor systems, including small satellites and systems for Earth observation, and technology for studying ice and water on the Moon and Mars. These will provide new information on the development of climate on Mars and how ice came to the Moon. This will also provide new methods for studying changes in permafrost on Earth as a result of changes in the Earth's climate.
CENSSS addresses, among others, the United Nations Sustainable Development Goals 11 Sustainable cities and communities, 14 Life below water, and 15 Life on land, as well as national and societal needs. It is also a goal for CENSSS to attract more externally funded projects in space technology and related areas, based on the SFI.

2.4 Security and Trust in the Digital World

The digital development is a crucial part of our value creation and growth. Digital services must be sufficiently secure, reliable, traceable, and have trust among users and authorities. Businesses and individuals must have confidence that the systems are accessible, functioning properly, and safeguard the privacy of each individual. A prerequisite for this is that information and actions are understandable.

Digital systems are increasingly made up of complex autonomous systems. This means that it becomes more difficult to assess whether a digital system behaves correctly, both according to expectations and ethics. The composition of components in digital systems also varies dynamically, making the assessment of "correct" behavior more challenging. Research at ITS focuses on trust in digital systems and how complexity in systems affects robustness and anomaly detection. The focus is initially on critical infrastructure and the Internet of Things (IoT). Wireless communication, often in the context of sensor networks and socially safe technology, are relevant fields of study.

Security and trust in the digital world are a prerequisite and catalyst for achieving several of the United Nations Sustainable Development Goals, including 3 Good Health and Well-being, 4 Quality Education, 8 Decent Work and Economic Growth, 9 Industry, Innovation and Infrastructure, and 10 Reduced Inequalities.

3 Background and premises for the strategy

The ITS - Strategy 2021 - 2025 describes the role and profile of the Department of Technology Systems within the University of Oslo (UiO) and the Faculty of Mathematics and Natural Sciences (MN). It also outlines ITS's own directions, ambitions, and goals.

The strategy is based on the current state of ITS as of the end of 2020, and the unique nature of being a department at UiO located in Kjeller.

The ITS - Strategy 2021 - 2025 is built upon UiO's and MN's strategies towards 2030. It is also based on the vision formulated by UiO during the transfer of operations from UNIK to UiO in January 2017:

UiO aims to develop a strong technology environment for research, education, and innovation in close collaboration with the research and technology communities in Kjeller, while being tightly integrated with complementary activities at Blindern.

3.1 History: Research and Education at Kjeller

The Kjeller environment has a long and proud tradition in technology, research, and development. Kjeller Airport was established in 1912 and is among the world's oldest operational airports. Kjeller Flyfabrikk produced over 100 aircraft between 1921 and 1939. The Norwegian Defence Research Establishment (FFI) was established in 1946 and eventually moved most of its main activities to Kjeller. The Institute for Atomic Energy (IFA, now IFE), the Telecommunications Research Institute (TF), and NORSAR were later established based on FFI's activities.

Today, the Kjeller environment is one of Norway's largest research and development communities with over 3,000 employees, including nearly 1,500 researchers and engineers. Characteristic of the Kjeller entities are large and applied research projects that address complex and demanding national and global challenges, as well as close connections with the Norwegian industry, which translates research results into industrial products and services. In addition to FFI, IFE, and NORSAR, the Kjeller environment includes the Norwegian Institute for Air Research (NILU), Justervesenet, Akershus Energipark, Kjeller Innovation, OsloMet, new and established knowledge-based companies, collectively comprising approximately 70 entities in the Kjeller Research Park, which is a member of The International Association of Science Parks.

The Kjeller University Center Foundation (UNIK) was established in 1987 as a research and education collaboration between FFI, IFE, TF, and UiO. The rationale was to better utilize the collective knowledge resources of the Kjeller environment and strengthen higher education, research, and knowledge-based production and services in Norway (UNIK's "societal mission"). The Norwegian Parliament established scientific positions at the Faculty of Mathematics and Natural Sciences at UiO with a workplace at Kjeller and allocated funds for investments and operations at UNIK.

The operations at UNIK were transferred to UiO and organized as a separate Department of Technology Systems at the MN faculty from January 1, 2017. A diverse committee prepared a disciplinary strategy for the new department, which was reviewed and approved by the MN faculty board in the autumn of 2016.

3.2 ITS - Status 2020

As of December 2020, the Department of Technology Systems has nine full-time scientific employees, around 40 employees in adjunct positions (mostly 20% positions, amounting to approximately six full-time positions), and around 25 PhD candidates. The department is currently organized into two sections; the Energy Systems section (ENSYS) and the Autonomous Systems and Sensor Technologies section (AUTOSENS). In 2020, the department was granted a Centre for Research-based Innovation (SFI); the Centre for Space Sensors and Systems (CENSSS). ITS also has an unmanned section for Information and Societal Security.

ITS's scientific staff has expertise in the fields of radar, electro-optical and electromagnetic sensors, cybernetics, communication, ICT security, data science, complex systems, materials science, energy conversion and storage, and modeling of energy systems. Close cooperation with the Kjeller environment and the industry, including researchers from these entities employed in adjunct positions at ITS, contributes to a strong academic environment at ITS beyond these mentioned disciplines. The department is involved in several national and international research projects.

The department teaches a total of around 40 courses at the master's and PhD levels and two bachelor's courses. From the fall of 2019, ITS established its own master's program in Renewable Energy Systems, which had 20 study places in the fall of 2020. ITS has its own study direction in Cybernetics and Autonomous Systems, with 26 study places, in the Robotics and Intelligent Systems master's program at the Department of Informatics (IFI), and the department collaborates on a master's program in Information Security at IFI.

3.3 UiO and MN overarching strategies towards 2030

As a department at the Faculty of Mathematics and Natural Sciences at UiO, ITS is subject to the strategic plans of MN and UiO. In UiO: Strategy 2030; "Knowledge-responsibility-engagement, for a sustainable world", (https://www.uio.no/om/strategi/strategi-2030/), it is stated that UiO should

- Promote independent, groundbreaking, and long-term research

- Educate students with the knowledge, ability, and willingness to create a better world

- Strengthen dialogue with the outside world and work to ensure that knowledge is put into action

- Be an innovative organization and an attractive workplace and study place UiO defines itself as a research-intensive comprehensive university, with the ambition of being among the leading research-intensive universities in Europe. In MN's strategy towards 2030; "Knowledge development for a changing world, Natural science and technology towards 2030", (https://www.mn.uio.no/om/strategi/), it is stated that the faculty manages a long tradition of knowledge built on collegial values and free, independent research. The foundation of the faculty's activities is fundamental, long-term research within mathematics, natural sciences, and technology. The faculty's ambition is to be among Europe's leading environments for research, education, and innovation by range among the top research-intensive universities in Europe. The faculty will contribute to the use of new and existing knowledge. The faculty assumes a particular responsibility for promoting interdisciplinary research and education. The faculty has extensive research collaborations with research institutes, companies, and public sector entities and will facilitate an expanded research collaboration with companies and public sector entities, including increasing the availability of socially relevant research projects. The faculty highlights sustainability, convergence, and education as central guidelines for university activities. The faculty recognizes a significant responsibility for linking basic research and higher education to the major global challenges expressed by the UN's Sustainable Development Goals and the need for sustainable social development. The faculty states that honesty, ethical reflection, mutual respect, constructive interaction, and humane attitudes should permeate the faculty's activities. This concept of education involves a commendable combination of general knowledge, insight, respect, and behavior.