CENSSS
Annual report
2020

UiO : University of Oslo

sfi Centre for Research-based Innovation

The Research Council of Norway

CENSSS
Annual report 2020

Contents

Contact
Centre for Space Sensors and Systems
Gunnar Randers vei 19
2007 Kjeller
Norway

P.O box 70
2027 Kjeller

mn.uio.no/censss

Centre for Space Sensors and Systems

CENSSS

CENSSS will address science and technology challenges and business opportunities within New-Space satellites for Earth Observation and within Space Exploration “to the Moon and Mars”.

Presentation of CENSSS

CENSSS will in collaboration with Norwegian industry develop new instruments and sensor systems, New-Space satellites system integration, operation and exploitation of satellite data.

The centre aims to advance the knowledge frontiers in novel sensors for small Earth Observation satellites, as well as novel sensors for planetary resource mapping and exploitation.

CENSSS will operate the RIMFAX Ground Penetrating radar Instrument on the NASA Perseverance rover mission to the planet Mars. This includes commanding the instrument on the rover and analyzing the scientific data collected by RIMFAX.

Presentation of CENSSS

The Centre for Space Sensors and Systems (CENSSS) is a Centre for Research-based Innovation (SFI) supported by the Research Council of Norway (NFR). CENSSS consists of a consortium of nine indsutrial partners and three research partners. All partners have signed a Consortium Agreement for the centre, and CENSSS was operational as of November 2020. The formal kick-off was on November 17, 2020. CENSSS is in a start-up phase, where focus is on establishing the collaboration and work methodology between partners, staffing vacant positions, and plan in more detail the way ahead. During 2021, the centre will move into a nominal, operational phase.

CENSSS addresses the challenges in coordination, collaboration, and cooperation between the Norwegian space industry companies. CENSSS also addresses the challenges in collaboration between academia and the space industry, and recruitment of qualified personnel for the space industry. The consortium consists of leading space companies and research institutes. Areas covered by the consortium include:

- data acquisition, security and remote control from partners such as EIDEL
- radiation detectors and imaging systems from partners like IDEAS
- micro-robotics for lunar exploration from partners like ispace
- data exchange, sharing and archival of product data from partners like Jotne
- satellite ground station services from partners like KSAT
- electro-optical products, including hyperspectral, from partners like NEO
- earth observation (EO) data processing from partners like S&T
- detection, classification and identification of ships from EO satellites from partners like Vake
- testing of planetary instruments from partners like Vestfonna
- space research and development from research partners like UiO, UCLA and FFI.

The centre aims to create an environment where Norwegian space companies can come together and work in a common project with a system-oriented perspective, in collaboration with academia and prominent research institutes. CENSSS will stimulate the space companies to further develop their niche capacities, increasing their competitiveness and innovation potential in the international market. In addition, CENSSS will supervise PhD candidates and master students, and reach out to younger people about this exciting field with great opportunities for interesting and stimulating careers.

The centre builds upon more than 60 years of upper atmosphere space science and technology activities originating from Kjeller, Norway. This includes upper atmosphere research from Andøya, the recent development and operation of the AISSat/NorSat satellites and the Norwegian georadar RIMFAX onboard the NASA Mars 2020 Perseverance Rover.

CENSSS will address science and technology challenges and business opportunities within New-Space satellites for Earth Observation and within Space Exploration "to the Moon and Mars". The research areas underpinning these business innovation areas will be sensor and sensor systems, and New-Space satellites system integration, operation and exploitation. CENSSS shall advance the knowledge frontiers in terms of novel sensors for small Earth Observation satellites, as well as novel sensors for planetary resource mapping and exploitation. CENSSS takes an active part in NASA´s Mars 2020 rover mission.

The core activity of the Centre shall support at least 10 PhD candidates (30 PhD years) and 15 researcher-years, providing innovative research, development and engineering results as well as providing high-quality candidates for Norwegian space companies and the government sector. CENSSS shall be a national research team and a hub for collaboration and synergies between Small and Medium-sized Enterprises (SMEs), academia and prominent research organizations, stimulating competitiveness and innovation capabilities in Norway within the space sector.

Primary objective for the centre

The primary objective of the CENSSS is to contribute to Norway's innovation, competitiveness and national needs in the New-Space and Space Exploration arenas, by addressing challenges and opportunities in space sensor and system technologies.

Secondary objectives

1. Develop new knowledge and technology for sensors and on-board sensor signal processing for New-Space earth observation (EO) satellites with adequate spatial and/or spectral resolution for one or more applications of national interest, or underpinning UN´s Sustainable Development Goals (SDGs). Focus will be on optical, infrared, hyperspectral and imaging radar sensors, where significant commercial potential is foreseen. (WP1)

2. Model, design, build, integrate, launch, operate and exploit a fully Norwegian New-Space EO satellite with novel high-performance sensor(s), signal processing, communication solutions etc, for one or more of the applications addressed in the point above, to advance national capability as a basis for industry development. This will include building a digital twin of the satellite. (WP2)

3. Use data from available satellites in order to develop new exploitation models, application domains and services from New-Space EO satellites. This should include technologies for organizing, analysis and exploitation of large amounts of imagery and other big data from such satellites. (WP3)

4. Establish a RIMFAX Science Operation Centre (RSOC) that will participate in the operation and exploitation of data from the sensors on NASA´s Mars 2020 mission (WP4).

5. Develop new sensors that can contribute to finding water on the Moon and Mars, an important step on the path to commercialization of space beyond Earth. (WP5)

6. Build competence in the areas relevant for objectives1-5 by educating a number of PhD candidates, postdocs and researchers. CENSSS will supervise 10 PhD candidates, and supervise between 5 and 10 Master´s degree students annually. (WP1-5)

7. Inspire young people to seek education and career opportunities in science and technology in general, and space related topics in particular.

Anticipated results (impact) of the centre

A CENSSS has strengthened innovation capacity and increased value creation in Norwegian space based and space related businesses through a greater focus on long-term research. The utilization of space resources for terrestrial applications as well as space exploration do have long term perspectives, and thus require long term research. The collaborative research effort in CENSSS over the eight years duration, including the education of PhD candidates and researches, many of whom are expected to find job opportunities within the consortium partners, will provide strong ties between the user partners and strengthen their innovation capacity.

B CENSSS has facilitated active and long-term cooperation between innovation-oriented, R&D active companies and prominent research institutions. The R&D active user partners are primarily SMEs with niche technologies relevant for- or directly addressing space applications, while the research partners are established research groups with system competence as well as technological know-how. The PhD candidates will be tightly connected to the user partners, ensuring the good interaction between the user partners and the research partners and academia, as expressed in Secondary Objective 6 (SO6). In addition, SO2 will be instrumental in providing a tight coupling between the two partner groups, with the joint effort to model, design, fabricate, integrate, launch, operate and exploit a fully Norwegian-built New-Space EO satellite.

C CENSSS has promoted the development of an outstanding business-oriented research community that is part of strong international network and contributes to the internationalization of Norwegian space industry. The Norwegian space sector is already internationally oriented, with 80-90% export. Contracts are awarded in a competitive international market. The consortium consists of both international user partners and research partners and collaborators, ensuring an internationally oriented environment within CENSSS. Space exploration, in particular, implies large-scale international collaboration, and an international network. This is addressed in SO4 and SO5. In addition, the development of novel sensors and signal processing (SO1) will improve the competitiveness of the user partners internationally.

D CENSSS has stimulated and contributed to researcher training, knowledge and technology transfer in areas with great opportunities for future value creation. The space arena has great opportunities for future value creation, both upstream and downstream. Thus all the Secondary Objectives of CENSSS contribute to this goal. In particular, SO6 addresses the goal of researcher training, percolating all the work packages of CENSSS.

Long-term, national competence-building

The centre will contribute to long-term, national competence-building in the utilization of space through the development of cutting-edge expertise in mission-critical technologies for earth observation by small satellites and systems that can be tailored to national needs as well as supporting UNs SDGs. The centre will contribute to long-term national competence building within space exploration by coupling directly to NASA´s and JPL´s operation of the Mars 2020 rover on Mars and provide access to the Mars 2020 sensors and the operation of such an autonomous system. The centre will advance state-of-the art in sensors for mapping and exploitation of geological structures and for finding water on the Moon and Mars. These sensors have a large interest on Earth for mapping water content in soils making them unstable and prone for sliding.

The centre will enhance researcher training, first of all by funding and supporting 10 PhD candidates that will work on scientific and technological challenges in close collaboration between academia, research institutes and with the participating user group.

The space arena is a highly international arena. The CENSSS consortium has both international research partners and user partners. For the consortium in general and for the PhD students in particular, this provides unprecedented access to international cutting-edge expertise and expansion of the knowledge base. This will also be highly relevant for relevant national educational programs within robotics and autonomous systems in general.

The development of New-Space systems will be tightly coupled to the downstream needs, utilization and application of the data. CENSSS will address these requirements by establishing cross-disciplinary teams with members from both the space community and the application domains.

Partner presentations

Jotne EPM Technology AS

Jotne EPM Technology is a member of the Jotne group, specializing in system/product (PLM) information and Open Simulation Data Management, technologies required to successfully build your Digital Twin. Since 1990 the company has developed database solutions to handle product standards such as ISO 10303 STEP, PLCS, AIA/ASD S-Series, ECSS etc. These are open specifications with public availability used by aeronautics, space and defence related industries to manage information about complex systems. Jotne products are used by clients all over the world, including Airbus Defence and Space, Leonardo, BAE Systems, Lockheed martin, the European Space Agency and many other leading aeronautics, space and defence contractors. In addition, many high-end software vendors trust in Jotne solutions.

Recently Jotne sponsored a PhD student on the subject of Digital Twin, which a subject Jotne want to inject and continue to work with in the CENSSS activities. Space programmes are managed by large companies facing considerable integration challenges, both in-house and externally. Product components are often made in different countries, and when new factories are built, other companies may be responsible for maintaining the product in question. Using Standard Based Digital Twins based on open and publicly available specifications makes it easier to trace products and sensor information, and to integrate these in a well-arranged manner. This improves data exchange, sharing and archiving processes, cutting both time and cost, yet improving quality.

KONGSBERG Satellite Services, (KSAT)

KONGSBERG Satellite Services, (KSAT) is a world-leading provider of ground station- and earth observation services based on optimized ground station locations and solutions for satellites in Low Earth Orbit. We have more than 50 years history in ground station services and a 20-year track record of advanced near real-time monitoring services using multiple satellites. The KSAT Global Ground Station Network consists of more than 20 stations around the world, providing unique uplink/downlink capabilities, enabling a cost-efficient, flexible, and optimized ground segment solution tailored to the specific needs of our clients. KSAT participation in CENSSS fits well with our ambition to extend our service portfolio in new and innovative technology areas, with focus on support for the emerging SmallSat/NewSpace industry. This includes efficient mission control and command services, optical space-to-ground communication, deep space communication and “Lunar” network, and generally to support a national R&D based effort to build, launch, and operate an innovative NewSpace EO satellite.

Norsk Elektro Optikk AS

Norsk Elektro Optikk A/S (NEO) was established in 1985 as a privately-owned research-oriented company within the field of electro-optics. The founders had their scientific and technical background from the Norwegian Defence Research Establishment, at that time the leading research organization in electro optics in Norway.

The company has since its start grown to be the largest independent research and development organisation in electro optics in Norway and has in addition established itself as a manufacturer of advanced electro optical products for an international market.

The hyperspectral imaging activities at NEO started in 1995 with the HISS (Hyperspectral Imager for Small Satellites) project for ESA. The R&D activities in hyperspectral imaging have been internally funded through commercialization of the technology together with participation in several EU projects, as well as projects funded by the Ministry of Defense, the Norwegian Research Council, etc. Today, HySpex is established as an industry-leading brand for both airborne and ground-based hyperspectral imaging. HySpex sensors are renowned for their stability, flexibility and superior data quality

The company has invested in laboratory and test equipment relevant for the activities for developing high-end hyperspectral cameras. The laboratories are equipped with instrumentation necessary for manufacturing, calibrating, testing, repairing, diagnosing and servicing hyperspectral cameras. Additionally, NEO has a climate chamber, electronics development laboratories and a mechanical workshop.

NEO is certified to the ISO 9001:2015 International quality standards.

NEO’s motivations for participating in the CENSSS:
- Product development, in order to remain at the forefront in the field of hyperspectral imaging.
- Market expansion following the “New-Space” development approach.

NEO acknowledges CENSSS as an important resource that can be employed both for improving existing designs as well as developing new technology. The teaming of people having competence from academia and different industries will ensure this goal, which is especially demanding when it comes to the specific requirements related to space qualification etc.

Eidsvoll Electronics AS (EIDEL)

Eidsvoll Electronics AS (EIDEL) is an engineering company founded in 1966 and have delivered R&D and system design of advanced hardware and software-based solutions for space, defence and civil industries. EIDEL also has a long history of participating in scientific and environmental research in close collaboration with academia.

The company’s core technologies are within telemetry, data acquisition, encryption and remote control. Today EIDEL has 25 employees and an annual revenue of about 40 M NOK. EIDEL has developed several solutions for the space industry including sensors for Space Situational Awareness (SSA), telemetry decoders, payload integration systems and secure communication. EIDEL provides services within Assembly, Integration and Test (AIT) of space grade instruments and nano satellites within our labs and clean room facilities.

Through our heritage, competence and opportunities taken in the space segment, EIDEL has established a platform for further growth in the space market. Through our participation in CENSSS we will contribute with our knowledge in development of new capabilities and capacities to help strengthening the Norwegian Space industry.

Examples of our added value to CENSSS are contribution with our knowledge in sensors, communication, instrumentation and integration. Building new sensor capabilities and new satellite platform communication interfaces. EIDEL also has an ambition to be an AIT provider in the consortium. In addition, EIDEL will be supporting students' tasks and new proposals for thesis for both Master and PhD students, using the thesis to evaluate future employees. Finally, by participation we will have an arean for developing new partnerships within the consortium to strengthen our competitiveness on international proposals.

Partner presentations

The University of Oslo (UiO)

The University of Oslo (UiO) is Norway´s oldest and highest internationally ranked research-intensive university. The Faculty of Mathematics and Natural Sciences (MN) is a steward of a long-standing tradition of knowledge built on collegial values and free, independent research. The Faculty conducts research and education at a high international level and has extensive collaboration with external partners, both nationally and internationally.

The Department of technology systems (ITS) at MN was established in 2017 when UiO took over the activities of the University Graduate Centre at Kjeller (UNIK). UNIK was a foundation for collaboration between the research institutes at Kjeller and UiO and NTNU on education at the Master´s and PhD level..

Forsvarets forskningsinstitutt (FFI)

FFI is owned by the Norwegian Ministry of defence and is the prime institution responsible for defence related research and development in Norway.

Its principal mission is to carry out applications-oriented research to meet the requirements of the Armed Forces and the defence sector in general.

The Institute provides counsel on possibilities and challenges connected to the procurement and use of military equipment and develops new solutions when necessary. FFI develops small satellite pathfinders spanning from the mission concepts through systems and payload developments to pilot demonstrations on orbit. The missions are mainly for national government purposes. Thus, we are interested in details of payload development from design through MAIT to tests in space, including operations concepts and data exploitation. Work packages 1-3 are of larger interest to us than the others, although some synergies with satellite missions could be extracted from them too.

Our missions to date have depended on platform and integration in other countries (Canada, Denmark, Lithuania). We hope to see CENSSS contributing to enable Norwegian industry to assemble small satellite systems and prepare them for launch in Norway, essentially gaining more systems competence. Our experience and knowledge are available to contribute towards that end.

We also see CENSSS as an important tool for recruiting young scientists and engineers to the Norwegian space ecosystem of companies, research institutes and academia.

Integrated Detector Electronics AS (IDEAS)

Integrated Detector Electronics AS (IDEAS) develops application specific integrated circuits (ASICs) and systems for radiation detection and imaging applications. The company was founded in 1992 with a strong background in applied physics, radiation detector instrumentation and electrical engineering. The company headquarter is located in Oslo. IDEAS' products are used in industrial applications, nuclear and space science.

With more than 20 years of space heritage, our products help to miniaturize complex instruments, reduce power consumption and enable certain instrument types to be used on satellites. In addition to ASICs, we develop instrument systems for terrestrial and space applications.

With CENSSS we want to create business related to space activities based on scientific knowledge and engineering methods. We intend to use the company's existing know-how on terrestrial applications and adapt it to the space environment or applications. We will also seek to exploit the technologies and know-how developed in CENSSS for applications on earth.

With IDEAS sensing technology we will contribute to develop methods for In Situ Resource Utilization as well as infrared imaging and spectroscopy for earth observation. We are proud of being a partner in CENSSS which brings together top academic researchers and businesses in the field of space sensors. This is a great opportunity for IDEAS to contribute to innovation and value creation in Norway in this field.

Vake AS

About Vake:
With the flick of a switch, any ship can opt-out of legacy tracking systems to perform illegal activities. To highlight this activity Vake deliver actionable maritime insights to authorities and decision-makers. Vakes ML models are trained on ship activity from millions of global satellite data points, providing holistic insight across data sources. The company's core technologies are image processing, data fusion, big data processing, cloud and Machine Learning. The commercial goal is to support our customers in making the ocean more transparent and safe.

In CENSSS:
Our research goal is to extract unprecedented insight from satellite data, made possible through combining automatic multi-source analysis and domain expertise. We want to share our knowledge on big data insights with the centre, and explore the boundaries of real-time delivery through on-board inference.

Through synergies and partnerships with centre participants, we will develop the next generation of smart satellite systems. We will continue to aid Master and PhD students, and strengthen the capabilities of the Norwegian space ecosystem.

Projects in the pipeline:
- ESA IODs (with S&T and NEO)
- User testing (with BarentsWatch)
- ESA Environmental Crimes
- Copernicus Incubation

Partner presentations

Science and Technology AS

Our business is Earth Observation within the fields of Scientific Data Processing and Intelligent Software Applications, with focus on efficient use of the Copernicus Satellite data for providing sustainable EO Services.

CENSSS participation

- Sensors and EO Services
- Networking, generating partnerships
- Projects in the pipe-line;
- ESA IODs for on-board processing for SmallSAT (with UiO, NEO, VAKE)
- R&D for S&T EO Services – application to Forskningsrådet (with UiO, NEO ++)
- Defining and supporting PhD activities in line with S&T needs

UCLA

University of California Los Angeles (UCLA) – Earth, Planetary and Space Sciences One major collaborating research partner is the Department of Earth, Planetary and Space Sciences at University of California in Los Angeles (UCLA). UCLA's Department of Earth, Planetary, and Space Sciences is a preeminent academic center for studies of the Earth and Planets. It includes over thirty full-time faculty, sixty graduate students from around the world, and forty researchers engaged in a wide range of research extending from the center of the Earth to planetary systems surrounding other stars. The department maintains strong involvement in domestic and international space missions, including providing instruments and scientific leadership for DAWN, Artemis, Lunar Reconnaissance Orbiter, Insight, and Europa Clipper.

The proposed involvement in the Center for Innovation is consistent with the overall mission of the University of California as a center of higher learning to provide long-term societal benefits through the discovery of new knowledge, and the transmission of advanced knowledge through the training of students. The key contact point will be Professor David Paige who has a long record of accomplishment of developing planetary missions. These developments have been in collaboration with both industry and government-run facilities like Jet Propulsion Lab in Pasadena. UCLA is located close to the major New-Space companies leading the technological development. We foresee an exchange of both Post Doc's and PhD's between CENSSS and both UCLA and JPL.

Ispace

A world where the Earth and Moon are one ecosystem.

Life on Earth in the future will not be sustainable without satellite-based space infrastructure. Communications, agriculture, transportation, finance, environmental sustainability, as well as a variety of industries will all depend on this extraterrestrial infrastructure. Furthermore, its importance will continue to rise as technology continues to evolve with innovations such as IoT and self-driving vehicles.

How should we develop space infrastructure to make it sustainable and efficient? The key is how we use space resources.

At ispace, we've turned our attention to the Moon. By taking advantage of lunar water resources, we can develop the space infrastructure needed to enrich our daily lives on earth—as well as expand our living sphere into space. Also, by making the Earth and Moon one system, a new economy with space infrastructure at its core will support human life, making sustainability a reality. This result is our ultimate goal, and our search for water on the Moon is the first step to achieving that goal.

However, we face many challenges. While technology is important, it alone can't overcome every difficulty. Finance, law, policy, science, education, and environmental conservation all comprise a social system that must integrate into the planning process. Our vision has attracted the attention of many potential stakeholders around the world who we need to succeed at creating this new ecosystem..

Vestfonna Geophysical AS

Vestfonna Geophysical AS is a company owned and run by Hans E.F Amundsen.

The interest of Vestfonna Geophysical in CENSSS is centered around two main activities:

- Operating of the RIMFAX GPR on the Mars 2020 Mission
- Unsing Mars, Lunar and Terrestrial science questions as a guideline to develop instruments and technology for remote sensing of planetary bodies.

The Interim Executive Board

Credit: IDEAS

Gunnar Mæhlum (leader)

Gunnar Mæhlum is the CEO at IDEAS. He holds a Ph.D. in Physics from the University of Oslo and has a broad background from positions at CERN, the University of Karlsruhe and the University of Perugia. He joined IDEAS ASA in 1997 where he worked in technical, scientific and managerial positions. Prior to his current role, he has been Vice President of Research at Gamma Medica Inc. and General Manager of Gamma Medica-Ideas (Norway) AS. He is also on the executive board of the Norwegian Industrial Forum for Space activities, NIFRO.

Credit: Jotne

Kjell Bengtsson

Mr. Kjell Bengtsson, is a Vice President at Jotne, has a Mechanical Engineering background and a diploma in Marketing. He started out at Volvo Car and General Electric doing CAD/DB applications and later management positions. Kjell has been exposed to ISO 10303 (STEP) and other related standards for the last 25 years and is actively involved in neutral database and Digital Twin implementation projects in the most complex Aeronautics, Space and Defense sector projects. Kjell is a Member of the Board of PDES, Inc and supports other industry organizations like AIA/ASD, NIAG (NATO), FSI and more.

Credit: UiO

Stian Løvold

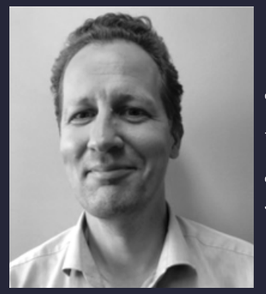
Stian Løvold has a Engineering degree in Technical Physics from NTH (now the Norwegian Institute of Science and Technology (NTNU) in Trondheim, and a PhD in physics from the University of Oslo (UiO). He worked for more than 30 years as a scientist at the Norwegian Defense Research Establishment (FFI), including 10 years as research director, with responsibilities for various project in lasers, optics and semiconductor technologies and system applications. Dr. Løvold was director of the University Graduate Centre at Kjeller (UNIK) for six years until the research and education activities at UNIK were acquired by UiO in 2017, and where he is currently Head of Department of Technology Systems (ITS).

Dr. Løvold has several assignments from international research collaboration including vice chair and chairman (2006-2011) of the Sensors- and Technology Panel (SET Panel) of the Nato Science and Technology Organization. He was strongly involved in the CENSSS proposal and is currently leader of WP6 Project Administration. Dr. Løvold is a member of the Norwegian Academy of Technical Sciences.

Credit: EIDEL

Jan-Erik Nordal

Jan-Erik Nordal is the CTO of EIDEL-Eidsvoll Electronics AS. Nordal has worked at EIDEL in 26 years, and has for the last 11 years been the Chief Technical Officer in the company.



Credit: Norwegian Space Agency

Øystein Helleren

Øystein Helleren is an R&D-coordinator at the Norwegian Space Agency. Øystein started at the Norwegian Space Agency in 2020, where he, among other things, is the national contact person for space under the Horizon Europe program. Previously Øystein worked 14 years at FFI, focusing on small satellites, experiments at the international space station and RIMFAX.

Observers are

Herman Farbrot,
Marit Larsen and
Svein-Erik Hamran
Secretary is Marit Larsen

Presentation of the projects

The research is divided in five research fields:

1 New-Space Sensors
Led by Torbjørn Skauli at UiO

2 New-Space Demonstrator
Led by Lars Erling Bråten at FFI

3 New-Space Services
Led by Evelyn Honorè-Livermore at UiO

4 RIMFAX Science Operation Center
Led by Svein-Erik Hamran at UiO

5 Mapping Instruments for planetary In-Situ Resource Utilization
Led by Anja Kohfeldt from IDEAS

Project 1:

New-Space Sensors

Led by Torbjørn Skauli at UiO

Aims

Sensors and sensor systems are central to the business areas of a National New-Space capability. The partners in CENSSS are already deeply involved with developing sensors for New-Space applications. The sensors are at different readiness level spanning from ideas to flight instruments.

CENSSS will increase the maturity level for the ideas and develop next generation instrumentation toward flight hardware. This includes both electro optical and other remote sensing sensors. In order for the sensor systems to be effective in space, they must be able to withstand harsh conditions in terms of temperature differences, vibration and exposure to cosmic radiation. For New-Space applications, CENSSS will focus on developing novel optical sensors as well as other sensors and sensor systems. Improvement will be sought in properties such as spatial and spectral resolution, spectral coverage (multi/hyper spectral sensors), beam- steering and antennas, miniaturization, power reduction, signal and data processing, efficiency, versatility, functionality and cost.

CENSSS will design, construct and launch, if possible, a high-performance hyperspectral imager for New-Space, drawing on experience from NEOs development of high-end commercial imagers for airborne use.

Another objective is to advance the state of the art of characterization of multi- and hyperspectral imagers to reach a new level of spectral integrity.

CENSSS aims to continue the development of both passive and active RF-sensors. The development of wireless connectivity for practically all electronic devices have made the performance increase and cost reduce for RF-electronics components. The speed of signal processing and digitizing have moved the digital electronics closer to the analog antenna. This gives the opportunity to make new and flexible RF-sensors that can be re-programmed in flight.

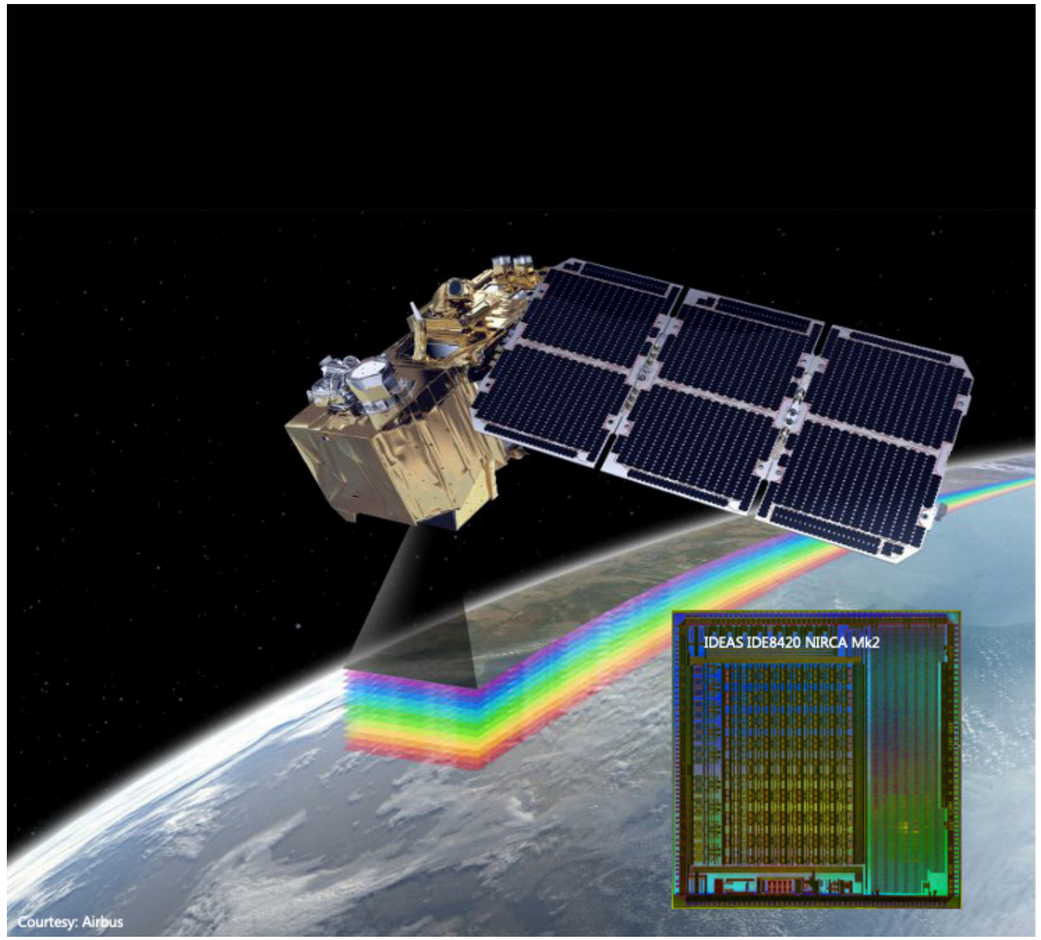
CENSSS aims to use the experience from the already made flight instruments to develop new passive and active radar sensors for surveillance and Earth observation. Synthetic Aperture Radars from space can produce images of the earth with less than one-meter resolution and using Interferometric SAR processing measure changes in surface topography of less than one centimeter. Several space agencies like ESA, NASA, JAXA and Canada have developed large Earth Observation Satellites that carries SAR imaging systems.

Goals

This work package aims to develop a synthetic aperture radar sensor and a hyperspectral sensor suitable for integration on a New-Space satellite.

CENSSS will increase the maturity level for the ideas and develop next generation instrumentation toward flight hardware.

IDEAS IDE8420 NIRCA mk II, radiation tolerant control and acquisition integrated circuit (IC) for large area hybrid imaging focal plane arrays (FPA), suitable for hyperspectral Earth-observation cameras (NIRCA-MkII-with-Sentinel2). Credit: Illustration of Sentinel-2 courtesy of Airbus.



Project 2:

New-Space Demonstrator

Led by Lars Erling Bråten at FFI

The CENSSS partners involved in WP 2 are: UiO, FFI, KSAT, IDEAS, EIDEL, NEO, Jotne, Vake and S&T. The partners have designed and developed payloads and are now operating several small satellites orbiting the Earth. CENSSS will, based on the most promising payload developed in WP 1 model, design, integrate, launch, operate and exploit a Norwegian built New-Space satellite.

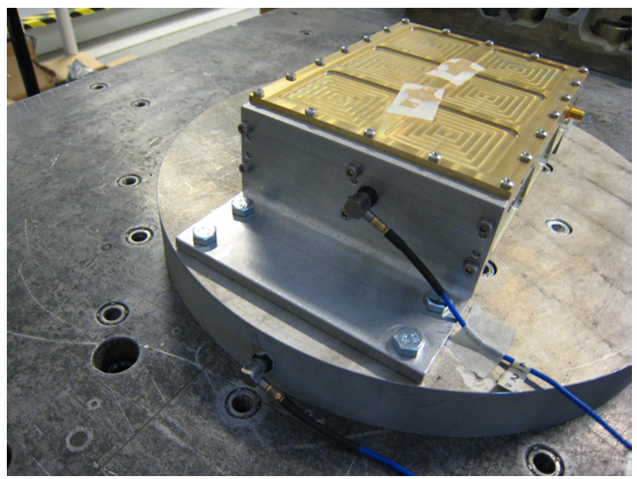
Partners in CENSSS are already working on busses for onboard integration of sensors in CubeSats. CENSSS will continue this development to make complete solutions including the design and integration of complete small satellites, including subsystems for power, attitude determination and control, positioning and orbit maintenance, up/down-link, data processing and handling, communication, thermal control, mechanical structure etc, as well as the ground segment for tracking, telemetry and control, data processing, analysis and distribution.

The development will go through bread boarding in the lab, prototype manufacturing, environmental and functional testing and eventually flight ready hardware ready for launch. Innovative methods, such as digital-twins, will be utilized in the design, testing and validation of the spacecraft.

During 2020 most of the activities have been centered around planning and organization, as well as preparing for PhD and Postdoc positions.

The development will go through bread boarding in the lab, prototype manufacturing, environmental and functional testing and eventually flight ready hardware ready for launch.

AISSat-1. Credit: FFI, Kongsberg Seatex and Norwegian Space Agency



Payload vibration testing for AISSat-1 at FFI Credit: FFI, Kongsberg Seatex and Norwegian Space Agency

Project 3:

New-Space Services

Led by Evelyn Honorè-Livermore at UiO

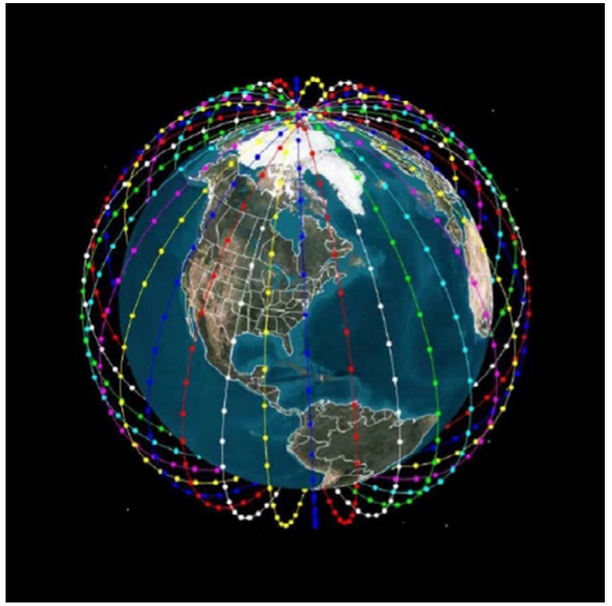
One of the main objectives for this project is to use data from available satellites and from new satellites to develop new exploitation models, applications and services.

There are many possibilities for developing on-ground services from existing satellite data, such as from the Copernicus program. Or, to develop on-board processing capabilities to work together with the new sensor and satellite development for small satellites to deliver new capabilities. The UN Office for Outer Space Affairs reported that space-based services from navigation- and earth observation satellites are beneficial to 40% of UN´s Sustainable Development Goals, which are important motivational factors for new research areas. Norway has strong national needs for maritime surveillance, forest monitoring and other types of land coverage monitoring, and has proven that even small satellites may service these needs through the AISSat- and NORSat-series. At CENSSS, we will build on this knowledge and expand our knowledge through research and development with close cooperation with our partners.

CENSSS will develop new exploitation models, application domains and services from New-Space Earth Observation satellites. For this, CENSSS will also investigate and explore data fom available satellites. New-Space technologies makes it possible to develop, manufacture and launch satellites in larger numbers and at lower costs. The large number of satellites will give a much shorter re-visit time for imaging a certain location on the Earth. It is expected that this new capability will generate a number of new products and make new applications possible.

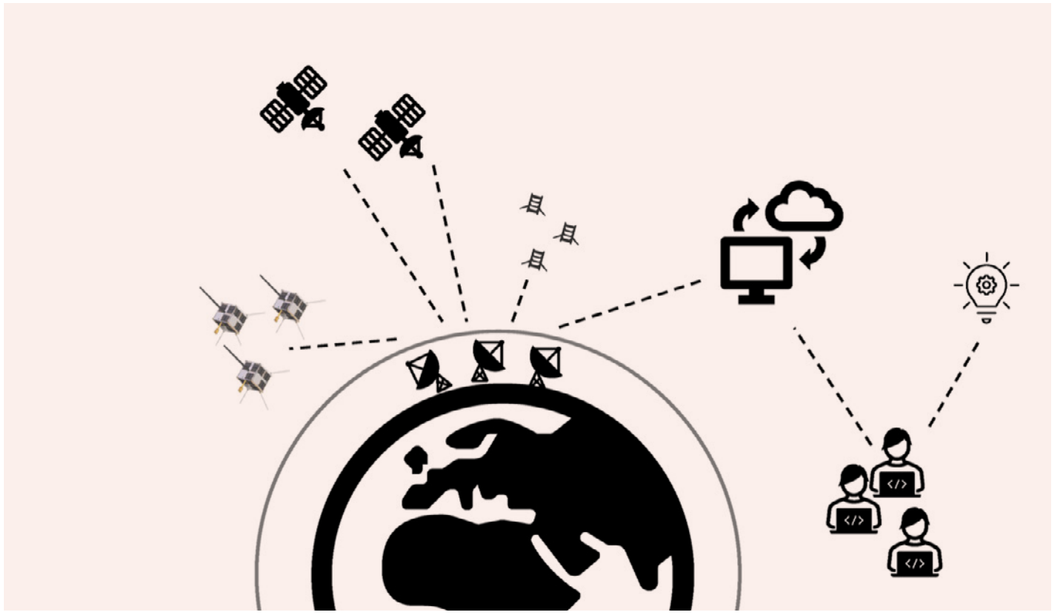
Swarms of new satellites with electro optical imaging sensors and radar imaging sensors can collect a large volume of data and thereby generate high data rates that eventually will need to be sent down to Earth. There is a large momentum in Artificial Intelligence and Deep Learning that can be used to reduce the amount of data needed to be downlinked. Additionally, the use of Edge Computing, where intelligent processing and data reduction done onboard, can also reduce the need for a high data rate link.

In 2020, the project focused on establishing lines of communication between the partners and exploring new avenues for research and innovation within New-Space services.



> CENSSS will develop new exploitation models, application domains and services from New-Space Earth Observation satellites.

Figure 1 Satellite constellation. Illustration from www.esa.int



Project 4:

RIMFAX Science Operation Center (RSOC)

Led by Svein-Erik Hamran at UiO

Aims

CENSSS will through this work package explore new modes for operating geophysical instruments on planetary rovers and use them to mapping resources on the Moon and on Mars. The tools developed will be transferred to operating New-Space small satellites orbiting Earth.

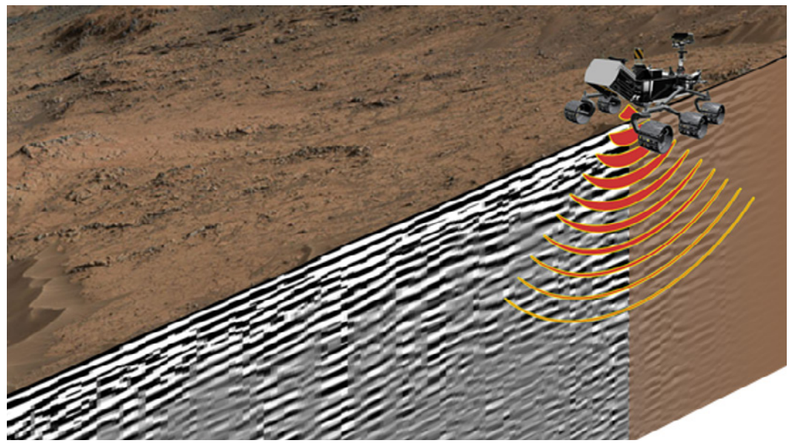
Establishing whether life ever existed, or is still active on other planetary bodies today, is one of the outstanding scientific questions of our time. Life as we know it requires water, and search for life on Mars is centered on the question when and how much liquid water existed on the planet. Revealing the geological and environmental history in relation to water is a key issue in this regard. RIMFAX will be the first GPR to land on Mars and be operated from the surface. RIMFAX will allow the rover science team to quickly assess the extent and depths of possible buried layers and their stratigraphic relationship to nearby outcrops. RIMFAX will provide a unique view of the stratigraphic section and cross-cutting relations, and thus a window into the geological and environmental history of Mars at depth.

CENSSS will establish a RIMFAX Science Operation Centre at ITS and operate the RIMFAX instrument on Mars. The participation in NASAs Mars2020 mission will give CENSSS hands on experience on how to operate spacecraft remotely. The RIMFAX team has developed web-based software tools to operate the instrument. The tools will generate the sequences to operate RIMFAX on the rover on Mars and analyze the data coming back to Earth.

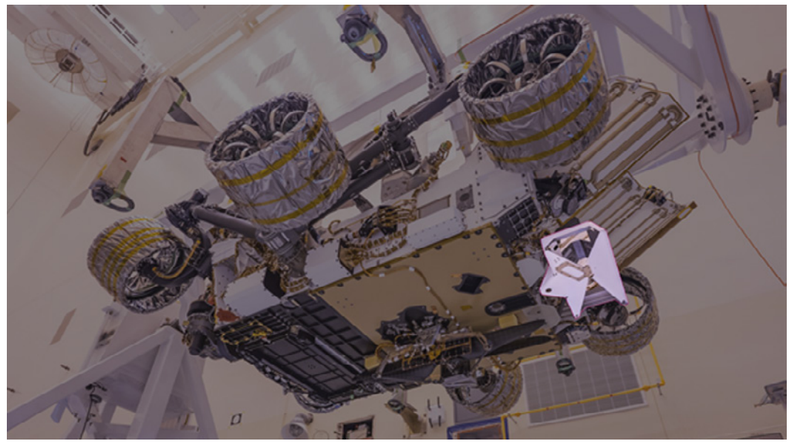
Goals

Scientific output from operating RIMFAX on Mars and the operational know how from developing remote operating tools and using them on the Mars 2020 rover.

> Life as we know it requires water, and search for life on Mars is centered on the question when and how much liquid water existed on the planet.



Artistic illustration of the Mars 2020 Perseverance rover traversing the surface of Mars, including RIMFAX transmission of radar waves into the subsurface and visualization of subsurface geomorphology and layering in collected data. (From Hamran et. al, 2020)



Location of RIMFAX antenna (white highlight), looking up at underside of suspended rover. (From Hamran et. al, 2020)

Project 5:

In Situ Resource Utilization (ISRU)

Led by Anja Kohfeldt from IDEAS

Aims

NASA and ESA have started to plan the next step in space exploration to bring humans back to the Moon and later to the planet Mars. Astronauts on the International Space Station receive today regular supplies from Earth with food, air, water, rocket fuel and spare parts. This constant resupply is driving the costs and the sustainability for humans to live in space or in the future on extraterrestrial bodies. To overcome this shortage, there is a drive to develop technologies to identify and harvest local resources and generate products with available local materials. This is called in-situ resource utilization (ISRU). Some of the most promising commodities to exploit locally are oxygen, water, and carbon dioxide.

CENSSS will develop next generation planetary water mapping instrument. The instrument will be a combination of some or all of the following techniques: Neutron detector, electromagnetic induction spectrometer (MIS), ground penetrating radar (GPR), optical spectrometer, and a gamma-ray spectrometer.

Combining a neutron detector, GPR and a MIS will give both the amount of water, composition and the stratigraphy of the shallow subsurface. The gamma-ray and optical spectrometer enable further analysis of (sub-) surface compositions.

Goals

The outcome of this work package is a next generation planetary water-mapping instrument that is ready to be space qualified and flown on a rover mission to the Moon or Mars.

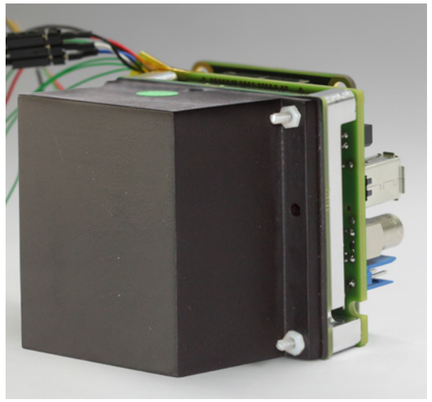
For that, existing sensor technology, such as gamma-ray spectrometers and neutron detectors, that were developed by IDEAS for science projects on Earth shall be evaluated, adapted for the application in extraterrestrial environments, characterized and tested according to the expected environments on space rover missions.

An electromagnetic induction instrument shall be developed and tested and combined with the neutron detector and the RIMFAX instrument, a GPR developed by FFI, see WP4.

A combination of sensors to identify and characterize subsurface water shall be integrated into an instrument package that allow for rover integration. The rover with instrument will be field tested in relevant terrain.

Involved partners in WP5 are

- IDEAS with competency in radiation and optical instrument development,
- UiO providing RIMFAX and MIS,
- ispace being experts on lunar rovers,
- and UCLA for scientific support in the field of ISRU.



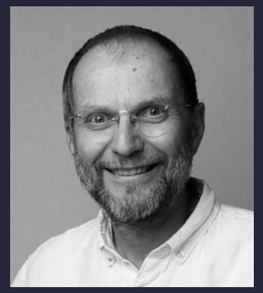
IDEAS ROSSPAD, terrestrial Neutron detector module. Credit: IDEAS

> NASA and ESA have started to plan the next step in space exploration to bring humans back to the Moon and later to the planet Mars.

IDEAS SRE3021, terrestrial Gamma and x-ray spectrometer.

Gettyimages

The Centre Management



Credit: UiO

CENSSS Centre Director
Svein-Erik Hamran

Svein-Erik Hamran has an MSc in Technical Physics from NTNU (former NTH), Trondheim and a PhD in Physics from UiT, Tromsø. He worked for 10 years as a Research Associate at the Environmental Surveillance Programme under the Norwegian Technical Research Council - NTNF. He spent more than 20 years as a Chief Scientist at FFI where he worked on radar remote sensing techniques. He was for 10 years an Adjunct Professor in Near Surface Geophysics at the Department of Geosciences, UiO, and 6 years as an Adjunct Professor in RF-systems at the Department of Informatics. In 2017, he started as an Adjunct Professor at the Department of Technology Systems, UiO and from 2019 as a full-time professor in radar remote sensing. He is the Principal Investigator of the Radar Imager for Mars' Subsurface Experiment – RIMFAX on the NASA Perseverance Mars 2020 Rover Mission. He is Co-Principal Investigator of the WISOM GPR on the ESA ExoMars Rover Mission. He is an elected member of the Norwegian Technical Academy of Sciences.

Credit: UiO

Administrative Leader
Marit Larsen

Marit Larsen has an MA in Political Science from Norwegian University of Science and Technology (NTNU) in 2010, and a Designated Degree of MA in Political Studies from the University of Aberdeen (2007). Marit has worked with higher education administration since 2010, and specifically with research administration since 2013, for The University College of Southern Trøndelag (now NTNU) and the University of Oslo.

At CENSSS she works with administrative and financial matters and works to ensure that the Centre is run in accordance with guidelines and regulations. Marit is also the Secretary for the Executive Board and the General Assembly.

Work Package Leaders

Credit: UiO

Torbjørn Skauli

Professor Torbjørn Skauli is the head of CENSSS work package 1. His research interests are in optics and imaging, particularly hyperspectral imaging and remote sensing. At ITS, Skauli teaches courses in basic optics and camera technology, and supervises research in drone-based remote sensing. Skauli is currently vice chair of a working group under the IEEE standards association developing a standard for technical aspects of hyperspectral imaging. Skauli joined ITS at the end of 2019. Earlier, Skauli worked at FFI, the Norwegian Defence Research Establishment, also at Kjeller, where he retains a part-time appointment. At FFI, Skauli has worked on imaging for a microsatellite development, and in the past also on semiconductor technology and electronics. Skauli engages in science outreach to children and youth, in volunteer networks promoting technology-related activities such as programming and amateur radio through schools and leisure activities.

Credit: UiO

Lars Erling Bråten

Lars Erling Bråten is leading WP 2 New-Space Demonstrator in the CENSSS project. He is a researcher at the Norwegian Defence Research Establishment (FFI). He is also a part time professor in radio communications at the Department of Technology Systems, UiO, teaching a course on satellite communications. At FFI he works on small satellite missions, specializing in radio communication systems. He is currently leading the ARCSAT missions, aiming at demonstrating tactical UHF satellite communications via a CubeSat in Arctic areas. His current research interests include utilization of micro satellites for communications and improvement of system performance at various frequency ranges.

Credit: UiO

Evelyn Honoré-Livermore

Evelyn Honoré-Livermore has an MSc in Electronics Engineering from the Norwegian University of Science and Technology (NTNU) (2012). She has worked as a project manager for the Division of Space and Surveillance at Kongsberg Gruppen, in various electro-optical space projects for ESA. She also holds a Master of Business Administration from Yonsei University in Seoul, South-Korea. Since 2017 she has been enrolled as a PhD Candidate at NTNU in systems engineering and project management. She is also the project manager for their 6U CubeSat HYPSO, which is planned for launch in 2021. At CENSSS, Evelyn is employed as a researcher, and is the work package manager for WP3 - New-Space Services.

Credit: UiO

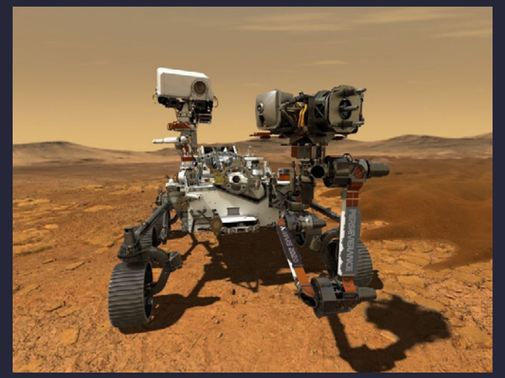
Anja Kohfeldt

Anja Kohfeldt is leading WP5 - Mapping Instruments for planetary In-Situ Resource Utilization. She is the senior space project manager at Integrated Detector Electronics AS (IDEAS) and holds a part time associated professor position at the Department of Physics at University Oslo, teaching Sensor and Measurement Technology. Her background is in micro- and opto-electronics and she has been working with space payload and satellite bus development her entire professional career. Anja is interested in optical and radiation sensing payload development for several space platforms, like satellites, sounding rockets and now recently also rovers. Currently she is involved in the development of a charged particle radiation monitor, NORM – Norwegian Radiation Monitor, suitable for high-elliptical orbit satellites.

Events and outreach

Outreach

Space exploration is a very inspiring topic for children and youth, and well suited to kindle an interest in science and technology. Therefore, CENSSS will draw on its activities in earth orbit and elsewhere in the solar system in outreach to pre-university youth. A link has been established with the "science talents" school at the Norwegian Museum of Technology, where gifted children are given alternate science-themed schooling for a week each semester. A visit to CENSSS in early 2021 has been planned for a class of these exceptional pupils.



Events

Digital kick-off and formal opening of CENSSS. Tuesday 17th of November 2020.

The event marked the start of CENSSS with presentations from Head of Department of Technology Systems Stian Løvold, Dean Faculty of Mathematics and Natural Sciences at UiO Morten Dæhlen, the Norwegian Research Council represented by Herman Farbrot, Centre Director Svein-Erik Hamran (UiO), Chairman of the Executive Board Gunnar Mæhlum (IDEAS) and the Norwegian Space Agency represented by Øystein Helleren.

News story (In Norwegian):

Center for Space Sensors and Systems (CENSSS) formelt åpnet - Institutt for teknologisystemer (uio.no)

CENSSS

Centre for Space Sensors and Systems