

CENSSS Annual Report 2023



Norwegian Centre
for Research-based
Innovation



CENSSS

Annual report

2023

Contact

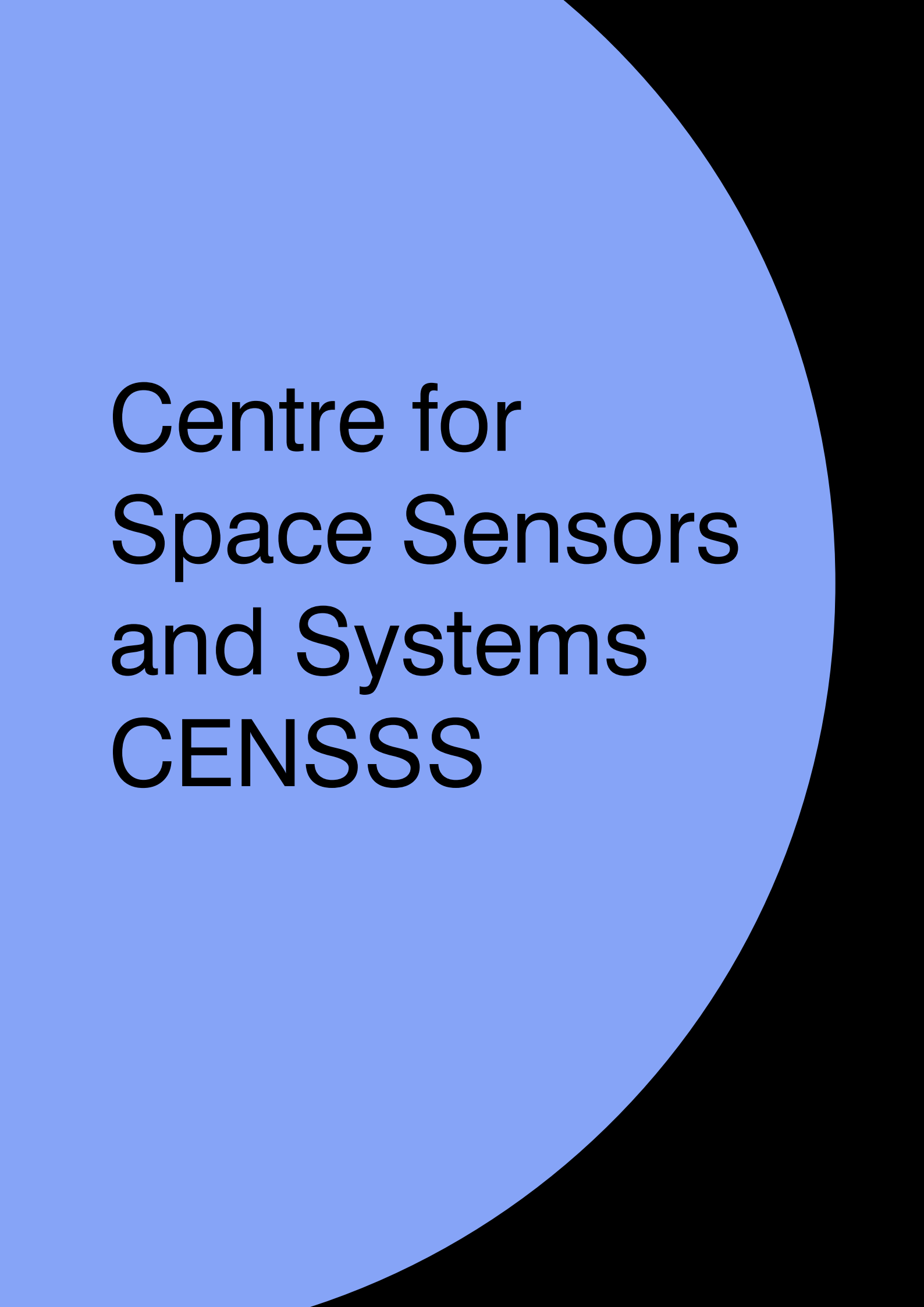
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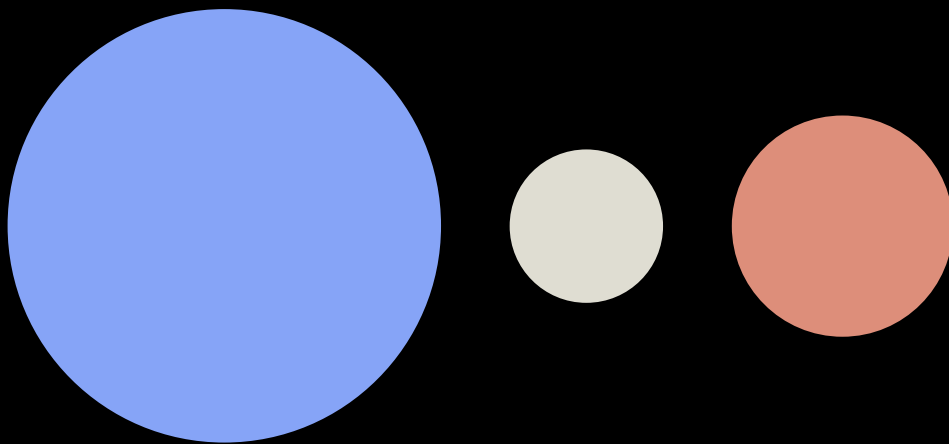
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Centre for Space Sensors and Systems CENSSS

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



Presentation of CENSSS

CENSSS is collaborating with the Norwegian industry to develop new instruments and sensor systems, integrate satellites, and facilitate the operation and exploitation of satellite data.

The centre is dedicated to advancing the frontier of knowledge in novel sensors for small Earth Observation satellites, as well as pioneering sensors for mapping and exploiting planetary resources.

CENSSS operates the RIMFAX ground-penetrating radar (GPR) instrument on NASA's Perseverance rover mission to the planet Mars. This includes commanding the instrument on the rover and analyzing the scientific data collected by RIMFAX.



Svein-Erik Hamran

Centre Director CENSSS

From the Centre Management

CENSSS is now in its fourth year and is slowly growing in the number of people and activities. We are still looking for more Postdoc candidates and hope to recruit new researchers in 2024.

The CENSSS leadership performed a Partner Canvas process to further understand how CENSSS can better support and interact with partners. This has led to a better understanding of how to increase collaboration between our partners and between the Center and our partners.

CENSSS was a co-arranger of the Norwegian Micro Satellite conference. This event has grown to be a yearly gathering almost 100 participants from academia, research institutes, and industry. The conference was regarded as a highly successful event and will continue in the future.

RIMFAX, on the NASA Mars 2020 rover Perseverance, has traversed more than 25 kilometers on Mars. The RIMFAX instrument is working perfectly and has not encountered any issues on

Mars thus far. RIMFAX is imaging structures down to more than 30 meters into the subsurface of Mars. These images are used to infer the geological history of the areas the Perseverance rover is driving through.

CENSSS is participating in international teams on proposals for new space missions. The competition is fierce, and we can only hope to be selected for one of them.

I would like to thank Adnan Latif, who served as Center Coordinator for a short period. He initiated several important internal processes, including the Partner Canvas.

In 2023, we lost one of our partners, Hans Amundsen of Vestfonna Geophysical. Hans passed away during fieldwork on the Faroe Islands in August 2023. He was a Co-Investigator on the RIMFAX team and a key contributor to the Mars 2020 Perseverance mission. He will be deeply missed.

February, 2024



Cecilie Rolstad Denby

Head of Department

From the Head of Department

CENSSS is hosted at the Department of Technology Systems (ITS), UiO, Kjeller. The cooperation between CENSSS and the department has flourished throughout 2023 and continues to be an immense source of inspiration.

During the years 2022/2023, the department, in collaboration with CENSSS, successfully established a new two-year master's program in Space Systems. The development of the study program involved extensive discussions and inputs from the scientific staff at CENSSS and ITS. We also sought feedback from renowned institutions in Norway, including NTNU, UiB, UiT, and NIFRO.

In June 2022, the university board approved the program, and in autumn 2023, we proudly welcomed our inaugural cohort of 11 master students in Space Systems. The department appointed associate professor Anja Kohfeldt as the program coordinator, and she has been performing exceptionally well in her role.

We have forged partnerships with Andøya Space Education to offer a course at Andøya. ITS has made extensive preparations in advance, and certain activities will continue to take place at ITS after the course. Additionally, we have established an agreement with the University of South-Eastern Norway, USN, to offer a course on System Engineering with a space focus at ITS. The autumn 2023 iteration of the course received positive feedback from all enrolled students.

This year, we have also welcomed adjunct professor Mariusz Eivind Santora Grøtte from FFI to join our teaching team. We are delighted to witness an increase in the number of students at Kjeller and have provided support for the activities of the student organization Portal Space by offering them a dedicated laboratory and container for rocket engine tests.

Furthermore, ITS has appointed associate professor Mathias Hudoba de Badyn, an expert in Space System Control, as the leader of work pack-age 2 in CENSSS. We are delighted

to observe the mutual inclination between ITS and CENSSS employees to collaborate closely. We envision that this collaboration will foster the establishment of long-term research activities at ITS aligned with our master's program in Space Systems.

In the year 2023 CENSSS once again advertised several positions for PhD candidates and postdoctoral researchers. We eagerly anticipate the arrival of new CENSSS employees here at ITS and look forward to sustaining our fruitful cooperation with CENSSS in the years to come!

February, 2024



Kjell Bengtsson

Leader of the Executive Board

From the Executive Board

In the past year, CENSSS has undergone notable developments, demonstrating a dynamic environment conducive to growth and advancement. Among these developments were staffing changes, which included the recruitment of a new Post-doctoral researcher and the transition of another Post-doc to a position within the industry. Moreover, leadership transitions within work packages, particularly the appointment of an associate professor with extensive experience in satellite building projects to lead the New-Space Demonstrator work package, signify our dedication to harnessing specialized expertise to drive impactful research and innovation.

Furthermore, the engagement of two summer students from the University of Oslo in constructing a test rover for the RIMFAX field test unit reflects our commitment to fostering talent and expertise. Notably, these students have since embarked on Master's degrees focused on RIMFAX data analysis and interpretation, showcasing our investment in cultivating specialized skills and knowledge. These students are likely to employ advanced technologies such as smart AI and ML to uncover new insights.

The launch of the Master's program in Space Systems by the Department of Technology Systems in the fall, with

eleven enrolled students, represents a significant milestone. This program is expected to play a pivotal role in augmenting expertise and bolstering recruitment within the Norwegian space sector, underscoring our commitment to nurturing talent and fostering academic excellence.

In the autumn, our center management undertook an industry collaboration canvas study, aimed at enhancing collaboration among partners. This initiative yielded fruitful outcomes, facilitating the identification of areas for improvement and the generation of innovative ideas to enhance collaborative efforts.



As Chairman of the Board, I reaffirm the paramount importance of international collaboration in advancing our goals. To this end, preparations have been made to welcome new international partners, with the anticipation of at least two partnerships materializing in 2024. The recent three-day workshop hosted at Kjeller by a representative from The National Centre for Space Studies (CNES) in France exemplifies the mutual benefits of collaboration, as evidenced by the integration of CNES's project management toolbox into our Master's

program in Space Systems. This collaboration not only enriches our educational offerings but also underscores the value of synergistic partnerships in driving innovation and excellence.

Additionally, our collaborative efforts with NTNU and SINTEF culminated in the successful organization of The Norwegian Microsatellite Conference in February, attracting matcealmost 100 participants and solidifying its status as an annual flagship event within the Norwegian space community. This sustained interest under-

lines the growing recognition of our contributions to the advancement of space research and technology in Norway.

In summary, the past year has been marked by significant achievements and promising developments, positioning CENSSS for continued growth, innovation, and impact in the realm of space research and exploration.

February, 2024

Partner presentations



Jotne Connect AS

Jotne Connect 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 1994, 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.

Jotne has a strong focus on Digital Twins, a subject Jotne want to inject and further explore with in the CENSSS activities. Space programs 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.

EIDEL AS

EIDEL is an engineering company established in 1966 specialized in advanced hardware and software solutions across the space, defense, and civil industries. The company boasts a rich history of engaging in scientific and environmental research, working in close partnership with academic institutions. EIDEL's expertise lies in telemetry, data acquisition, encryption, and remote control technologies in addition to space systems engineering and defense security requirements. Currently, the company employs 43 individuals and generates an annual revenue of approximately 90 million NOK (2023).

EIDEL offers services from Space Mission Design, development of space subsystems to Assembly, Integration, and Testing (AIT) of space-grade instruments and nanosatellites, utilizing its laboratory and clean room facilities. Leveraging its heritage, expertise, and the opportunities seized within the space segment, EIDEL has laid the groundwork for continued expansion in the space market. Through its involvement in CENSSS, EIDEL aims to bolster the Norwegian Space industry by contributing its vast knowledge in developing new capabilities and capacities.

EIDEL's contributions to CENSSS include its expertise in electronics for sensors, communication, instrumentation, and integration, alongside the development of new satellite platform communication interfaces. The company also aspires to become a key AIT provider within the consortium. Furthermore, EIDEL supports student initiatives, offering thesis opportunities for both Master's and PhD candidates, using these theses as a means to scout for future employees. Participation in CENSSS also opens avenues for EIDEL to forge new partnerships within the consortium, thereby enhancing its competitive edge for international proposals.

**UNIVERSITY
OF OSLO****FFI** Forsvarets
forskningsinstitutt
Norwegian Defence Research Establishment

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. As part of its commitment to advancing knowledge in space systems, the Department of Technology Systems launched the Master's program in Space Systems in the autumn of 2023, offering students a comprehensive curriculum designed to meet the evolving needs of the space industry. This program represents a significant addition to UiO's academic offerings and underscores its dedication to fostering expertise in space exploration and technology.

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



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.

Science and Technology AS

Our business is Earth Observation within the fields of Scientific Data Processing and Intelligent Software Applications.

Our vision

Better data insights for a safer life on earth

Our mission is two-fold

- S[&]T Norway provides software and processors for new satellites to the European Space Agency and the Norwegian Ecosystem for SmallSATS.
- S[&]T Norway process and analyse satellite images for monitoring the environment, applying advanced machine learning.

S[&]T Norway is a complete SW provider for space applications

A. On-ground satellite systems - instrument data simulation, processors for handling instrument data from raw data to use in applications, platforms with processing tools for algorithms and processors development, platforms for data access and handling

B. On-board satellite systems - satellite instrument processors filtering out useful data, pre-process data (image equalization, data harmonization), accommodation of machine-learned applications, compress and downlink to Earth

C. Adding value to satellite data - products and services - extracting useful information to provide digital maps with analysis tooling for monitoring state and changes in our natural environment

On-going projects with CENSSS partners

Product development on S[&]T On-board SW platform with toolkit in the following projects;

- Følgesmidler contracts with IDEAS and NEO
- ESA In-Orbit Demonstration (IOD) projects FAUBAI + REMIS + HYPERNOR + N-IOD with UiO, Vake, NEO and Eidel
- In addition we supervise CENSSS candidates and will support CENSSSAT missions.



VESTFONNA

I space

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 I space, 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
- Using Mars, Lunar and Terrestrial science questions as a guideline to develop instruments and technology for remote sensing of planetary bodies.

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 Mathias Hudoba de Badyn at UiO
- 3 **New-Space Services**
Led by Stian Løvold at Eidel
- 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 at UiO

The Centre Management



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.



Administrative Leader
Salim Øndes

Salim Øndes holds a BA in Pedagogy and an MA in Educational Leadership from the University of Oslo, supplemented by studies in International Business at the University of Almeria. With a versatile professional history spanning both higher education and diverse sectors, Salim has served in key roles such as Quality Coordinator and Administrative Coordinator for research projects. Additionally, he has experience in entrepreneurial endeavors.

At CENSSS, Salim oversees administrative and financial matters, ensuring that the Centre operates in compliance with guidelines and regulations. Salim also serves as the Secretary for the Executive Board and the General Assembly.



Science Coordinator
Tor Berger

Tor received the M.Sc. and Ph.D. degrees in applications of the wavelet transform in image processing from the University of Tromsø, in 1992 and 1996, respectively. Since 1996, he has been with Forsvarets forskningsinstitutt (FFI), working in different fields such as weapon effects, security sensors, and signal processing. Since 2007 Tor has been involved in radar signal processing related to ultra wideband systems and synthetic aperture radar.

Since 2014 Tor has been part of the development and delivery of the RIMFAX ground penetrating radar for the Mars 2020 mission, responsible for testing and verification and validation. Currently, Tor is the RIMFAX operations lead.

Tor still holds a part time position at FFI.

Work Package Leaders



Torbjørn Skauli WP1

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, Torbjørn teaches courses in basic optics and camera technology, and supervises research in drone-based remote sensing. Torbjørn is currently vice chair of a working group under the IEEE standards association developing a standard for technical aspects of hyperspectral imaging. Torbjørn 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, Torbjørn has worked on imaging for a microsatellite development, and in the past also on semiconductor technology and electronics. Torbjørn 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.



Mathias Hudoba de Badyn WP2

Mathias Hudoba de Badyn leads WP2 on the New Space Demonstrator at CENSSS. He joins as a starting associate professor at ITS UiO. Previously, from 2019-2023, he worked as a postdoc in the Automatic Control Laboratory at ETH Zürich, focusing on distributed control theory for multi-agent systems with applications in energy and aerospace. Mathias received his Ph.D. and M.Sc. degrees in the Department of Aeronautics and Astronautics and the Department of Mathematics, respectively, at the University of Washington in 2019. He contributed to the development of the attitude determination and control system (ADCS) for HuskySat-1, a 3U cubesat. Additionally, he conducted research internships at the Canadian Institute for Theoretical Astrophysics and the University of Alberta during his undergraduate studies at the University of British Columbia. His research interests encompass novel satellite reorientation control algorithms and correlations between the atmosphere and space plasmas.



Stian Løvold WP3

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. Stian 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. Stian was Head of Department at Department of Technology Systems from 2017-2021. He is currently working at EIDEL AS.



Anja Kohfeldt WP5

Anja Kohfeldt is leading WP5 - Mapping Instruments for planetary In-Situ Resource Utilization. She was a senior space project manager at Integrated Detector Electronics AS (IDEAS). Anja is an associate professor at Department of Technology Systems at University of Oslo and holds a part time associate 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.

New faces



Mathias Hudoba de Badyn

Mathias Hudoba de Badyn is joining CENSSS as a starting associate professor at ITS UiO. From 2019-2023, he was a postdoc in the Automatic Control Laboratory at ETH Zürich working on distributed control theory for multi-agent systems with applications in energy and aerospace. He received both his Ph.D. degree in the Department of Aeronautics and Astronautics, and an M.Sc. degree in the Department of Mathematics in 2019 at the University of Washington. During his studies, he worked on the attitude determination and control system (ADCS) for HuskySat-1, a 3U cubesat sent to test a novel pulsed plasma thruster and a new type of high-gain antenna. The ADCS, mission control, and simulation software from HuskySat-1 was open-sourced as part of a NASA research cubesat initiative.

Mathias did his undergraduate degree at the University of British Columbia, during which he had two summer research internships: one studying protoplanetary discs at the Canadian Institute for Theoretical Astrophysics, and one studying geomagnetic radiation belts at the University of Alberta. At CENSSS, Mathias will be leading WP2 on the New Space Demonstrator, which is a cubesat that will test novel satellite reorientation control algorithms and study the correlations between the atmosphere and space plasmas.



Ramsey Al Jebali

Ramsey Al Jebali specialises in the development of radiation detectors, covering everything from conceptual design to implementation. Before joining CENSSS, Ramsey spent six years as a Detector Scientist at the European Spallation Source (ESS), where he focused on developing and building alternative neutron detector technologies to ^3He tubes for the upcoming ESS facility in Lund, Sweden. Ramsey's academic background includes a Bachelor's degree in Nuclear Engineering in 2003, a Master's degree in Space Mission Analysis and Design in 2007, and a Doctorate in Experimental Nuclear Physics in 2013. Within CENSSS, Ramsey will primarily be engaged in the advancement of compact fast/thermal neutron detectors and high-resolution gamma-ray spectrometers, specifically tailored for space missions and In-Situ Resource Utilisation (ISRU), collaborating closely with Integrated Detector Electronics AS (IDEAS).



Luis Filipe Alves Theodoro

Luis brings a wealth of experience and expertise to the Centre for Space Sensors and Systems (CENSSS). With a PhD in Physics from Durham University and seven years' postdoctoral research experience in Computational Physics and Observational Cosmology. His research at the Instituto Superior Técnico and Los Alamos National Laboratory focused on the Cold Dark Matter Model and self-interacting dark matter, earning attention from the Particle Physics community. Additionally, his work at NASA Ames Research Center involved studying the distribution of volatiles in the Solar System and developing neutron/gamma-ray spectroscopy techniques for planetary exploration.

Since August 2023, Luis has been engaged in research at the Centre for Space Sensors and Systems, collaborating with Drs. Anja Kohfeldt and Ramsey Al Jebali on the development of a novel neutron/gamma-ray detector based on solid-state scintillators. Currently, their focus lies on designing, building, and testing the instrument, environmental radiation modeling, and quantifying the instrumental response function both numerically and experimentally.



A new type of flight software for the CENSSAT-1 satellite

By Berit Ellingsen

CENSSS will design, integrate and operate a Norwegian built New Space satellite.

This satellite, named CENSSAT-1, will perform research on space weather and the interactions between the Earth's atmosphere and magnetic field with the solar wind.

The space weather around the Earth affects all types of satellites in orbit, and can disrupt the signals for communication, navigation, Earth observation and weather forecasting.

This can have large consequences for services and infrastructure that are critically important for modern societies, such as transportation, construction, the power grid, financial transactions, computer systems, the mobile phone network, the internet, and more.

Designing CENSSAT-1

Project manager for CENSSAT-1 is Mathias Hudoba de Badyn, associate professor at the Centre for Space

Systems and Sensors (CENSSS) and Department of Technology Systems (ITS) at the University of Oslo.

- We are currently in the process of designing the satellite, its systems, payload and tasks. I'm developing the system that controls the satellite's rotation, Hudoba de Badyn says.

Turning is necessary for satellites to point in the right direction for research, navigation in space and communication with Earth.

A satellite is turned by motors that spin a wheel, which causes the satellite to turn in the opposite direction of this motion.

Challenges with the standard method

- However, the standard method for controlling a satellite's rotation simply calculates the direction the satellite should be pointing at and then turns it in that direction, without calculating the whole trajectory or future movements, says Hudoba de Badyn.



Similar to most methods used for spacecraft, the standard method for rotational control is very well tested both on Earth and in space, is very reliable and not changed much.

- But because the standard method won't take the shortest path of motion possible it's not very energy efficient, Hudoba de Badyn says.

The mathematics of the standard method of control for spacecraft will also not push the satellite into maneuvers it can't handle, which for example might send it into uncontrollable spin.

- The method I want to test calculates the least amount of motion necessary to turn the satellite, in order to use as little energy as possible. It also takes into account future actions of the satellite, says Hudoba de Badyn.

This method is called model-predictive control and is a new way of controlling the turning and direction of a satellite.

Model-Predictive Control

How to avoid going into dangerous maneuvers with model-predictive control?

- This is mathematically more difficult. But by using a different notion of stability that is more appropriate for model-predictive control, it's possible to find the trajectory that minimizes the use of energy and avoids pushing the satellite beyond its safe parameters, Hudoba de Badyn says.

The main challenge with model-predictive control for spacecraft is that it requires more computational power than the standard method.

- Because computer chips used for spacecraft must be hardened to withstand the radiation in space, these chips are not as fast as those used on Earth, says Hudoba de Badyn.

However, since CENSSAT-1 has a planned mission life of only one year, its computer chips won't need to be radiation hardened.

- This means we can use commercially available and faster chips instead, which makes the challenge of computational power a little easier, Hudoba de Badyn says.

Needs faster chips and more power

However, another issue is power consumption. Faster chips consume more power, which is always limited onboard a spacecraft that generates its electricity from solar cells and the sun.

- This is something we need to take into account when developing and building the satellite and its systems and payload, which we are currently working out the details of, says Hudoba de Badyn.

He has software ready that can be used as a full simulator tool box to write and test the algorithms that are most suitable for CENSSAT-1.

- Writing this code is something that we are looking for a postdoc or researcher to do, Hudoba de Badyn says.

Master's degree course in control

Ideally, the person working with the algorithms for rotation control of CENSSAT-1 would not only be familiar with the mathematics of control and optimization, but also with the quaternion number system.

- This is to avoid the mathematical problem of singularity for the standard three dimensions. But anyone working with control at the Master's degree level and above would either be familiar with the quaternion number system or able to learn it in a few weeks' time, says Hudoba de Badyn.

He will also be developing a new Master's degree course in control, which will start at ITS in the fall of 2024.

- This class will be an introduction to modern control and give an overview of the different techniques used for control in industry as well as scientific research. It will be designed for both students with a math background and for those who lack this, Hudoba de Badyn says.

Moving to Norway

Hudoba de Badyn did his PhD in aerospace engineering at the University of Washington in Seattle while working on a satellite named HuskySat-1.

Then he spent four years as a post-doctoral fellow working with software for control of energy systems for smart cities at the Automatic Control Laboratory at the Federal Institute of Technology (ETH) in Zurich in Switzerland.

- I'm Canadian so in moving to Norway the weather wasn't the biggest challenge. In fact, Eastern Norway has more comfortable weather than anywhere I have lived in Canada. Oslo is less humid than Toronto, less cold than Saskatoon, and less rainy than Vancouver, says Hudoba de Badyn with a smile.

Developing a dual neutron and gamma ray detector for rovers on the moon

By Berit Ellingsen

Deniz Ölçek is one of the PhD candidates at CENSSS and with their partner, the Norwegian company Integrated Detector Electronics AS (IDEAS). She is developing a dual neutron and gamma ray detector meant for rovers exploring the moon.

- So far the minerals and resources on the surface of the moon have been studied mainly from orbit, says Deniz.

These missions have shown that the moon has several resources, such as water, in the form of ice in permanently shadowed regions at the lunar poles. This could be used to support future human and robotic space exploration on the moon.

- In addition to hydrogen and oxygen, other elements such as silicon, iron and calcium can also be found on the lunar surface, and may be used as resources in future missions, Deniz says.

It is also important to understand the abundance and locations of these elements to study the lunar geology.

- Thus, the goal of the detector model that I'm working on is to identify the elements present in the lunar sub-surface, says Deniz.

Mapping the resources on the moon

One way of characterizing and mapping the minerals on the lunar surface is by using detectors that measure the neutron and gamma radiation produced when the surface is bombarded by cosmic rays.

- Two of the Apollo missions in the 1970s used gamma ray detectors for this purpose, but they were handheld and could therefore only cover a small area, Deniz says.

But a rover on the surface or a space probe in orbit could, with a gamma ray and neutron detector, cover larger areas of the moon.

- My PhD focuses on developing a combined neutron and gamma ray detector for rover missions on the moon for such in situ measurements, Deniz says.

Similar neutron and gamma ray detectors could also be used by space probes in orbit around the moon, by rovers on Mars, and even by satellites and other instruments on Earth.

- Applications on Earth for such detectors are for example mapping the composition of the soil to identify minerals and elements, for monitoring and researching the cosmic radiation that reaches Earth, and for nuclear safety in industrial processes, says Deniz.

Have presented and will be publishing results

Detecting neutron and gamma rays is usually done by two different detectors. The motivation of developing a dual neutron gamma-ray detector is to make the instrument more compact, and thus better suited for space applications.



This group is developing a combined neutron and gamma ray detector for a moon rover for NASA called Lunar-Vise.

- I have been focusing on developing such a detector and characterize it, says Deniz.

She already has a preliminary prototype using a readout system developed at IDEAS, This has been tested on a neutron radiation source in the Nuclear Physics Lab at the University of Glasgow in Scotland.

Deniz presented the results from these tests at the iWoRiD 2023 conference in Oslo this summer, earning the award for best poster. The results will also be published in a research paper that was recently accepted by the Journal of Instrumentation.

- The next step is to develop and characterize the prototype further, with neutron as well as gamma ray sources. The plan is also to do some detector modelling using a simulation toolkit that is commonly used by CERN. These simulations will help us study the detector response in a moon-like environment, Deniz says.

Research visit to Arizona

In her PhD work, Deniz will be collaborating with a research group at the School of Earth and Space Exploration at Arizona State University in the US.

- This group is developing a combined neutron and gamma ray detector for a moon rover for NASA called Lunar-Vise. I will be learning from them and then bringing this knowledge and experience with me back to Norway, Deniz says.

She will be spending six months on a research visit with the group in Arizona, and is looking forward to the experience, which starts in January 2024.

Background in physics and engineering

Deniz grew up in Turkey and has a Bachelor's degree in physics engineering. She also spent several years working in Canada and completed a Master's degree in astrophysics at the University of Montreal.

For her Master's degree she worked on modeling the magnetic field of the sun. After graduating she collaborated on developing radio telescopes for cosmological surveys in Canada and South Africa.

- In addition to doing my PhD work at CENSSS I am also a part time systems engineer at IDEAS. They are interested in the terrestrial and space applications of the type of detector I'm developing for my PhD. The hope is that this work will lead to new collaborations, new products and new customers for the company, Deniz says.

She wanted to enter into the part of the space sector that develops technology for use in space, and considered a PhD to be a good way of gaining both professional experience and a degree at the same time.

Took about a year to move to Norway

- I also wanted to be closer to my family in Turkey and therefore started to look for PhD opportunities in Europe.

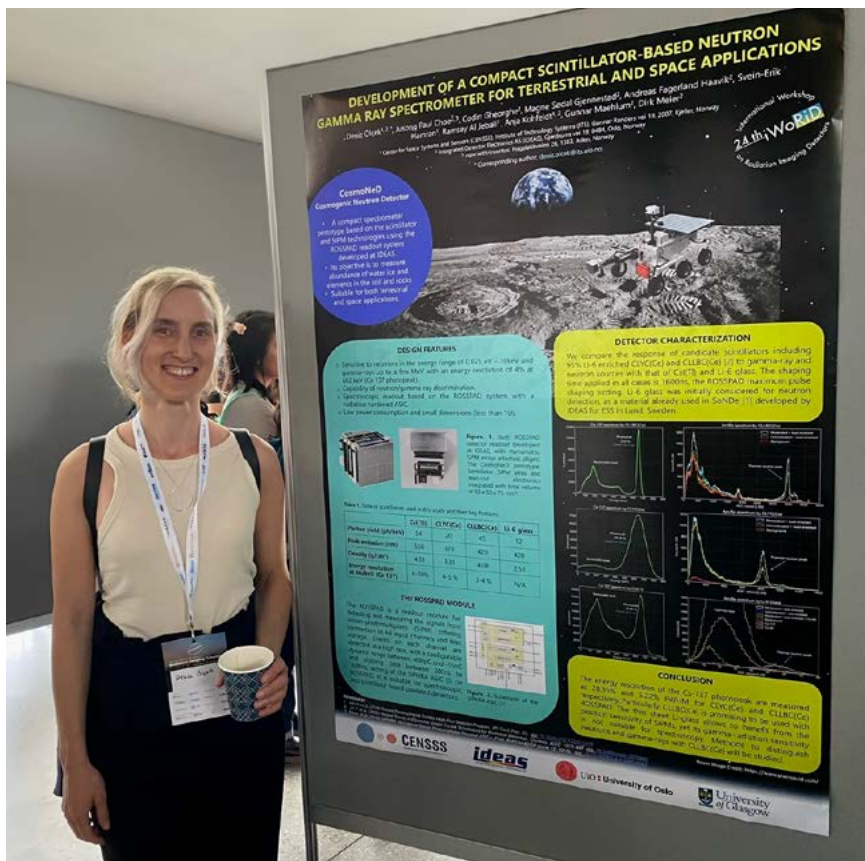
The University of Oslo and CENSSS had an appealing project that combined both my interest in engineering and in planetary research, says Deniz.

However, from she started to search for suitable PhD project, until she landed in Oslo ready to begin her work with CENSSS and IDEAS, took almost a year.

Finding the PhD project suited to my aspirations required only about six months, but the paperwork and the

process of moving to Norway, finding a place to live and get started, took several more months.

- I did need that time to get settled in. Although I'm used to harsh winters from Canada, the Norwegian work and social culture, as well as language, is different from the Canadian. I'm still learning and adapting, and appreciating the well balanced work-life culture and the amazing outdoors in Norway, Deniz concludes.



Poster presentation at the 24th iWoRiD Conference in Oslo (Best poster award).

A Master's Degree in Space Systems at the University of Oslo and CENSSS

By Berit Ellingsen

Since the fall semester of 2023, the Department of Technology Systems (ITS) at the University of Oslo has offered a Master's Degree in Space Systems.

Some of the students at this Master's degree study are doing their thesis work at the Centre for Space Sensors and Systems (CENSSS) at Kjeller.

Why a Master's Degree in Space Systems?

- A Master's Degree in Space Systems will enable you to understand how satellites, space probes and other spacecraft are developed and utilized. Often with challenging limitations based on operational environment, user needs and economic context, says Anja Kohfeldt.

She is associate professor at the Department of Technology Systems and researcher and work package leader at CENSSS. Kohfeldt is also the responsible coordinator of, and one of the academic advisors for, the new Master's Degree Programme at ITS.

The space sector, both its industrial and scientific parts, are becoming more and more commercialized and available for non-state actors. This space market, often called New Space, is both global and growing at a rapid pace.

- This means that more job opportunities in the sector are available, but also that the sector needs more people, especially graduates with relevant academic background, Kohfeldt says.

- With the opening of Andøya Spaceport in Northern Norway, which offers commercial launches for public and private actors, and with increased demands for coastal, ship and environmental monitoring, the Norwegian space sector is growing and needs more people as well, Kohfeldt says.

The Norwegian space sector may be small but is world leading in its specialized fields. It includes both public actors, private companies, and academic institutions.

The Master's Degree courses and recommended background

Before applying for the Master's Degree in Space Systems, the students have to complete a bachelor's degree in the field of the natural sciences, engineering or mathematics/informatics, with a minimum grade average comparable to a Norwegian C.

- In addition, at least one course in physics, electronics, mechanics or material science is required, says Kohfeldt.

The Master's Degree itself has four different mandatory courses. In the first semester, the students typically complete Applied Systems Development (TEK4000), Space Systems (TEK4700), and Space Sensors and Communication (TEK4710).

- While in the second semester, the students gain practical experience in a project course that we arrange in close cooperation with Andøya Space Education, Kohfeldt says.

Then the following one or two semesters are dedicated to Master's Thesis research and writing.

- Other elective courses we recommend are 4000 and 5000 level courses from the Department of Physics, such as space physics and technology, or 4000 and 5000 level courses from the Departments of Geology or Computer Science, says Kohfeldt.

For a list of recommended courses for the Master's Degree in Space Systems click here: Programme structure – Space Systems – University of Oslo (uio.no)

Hands-on knowledge by building a tiny satellite

The project course in the second semester includes a five-day trip to Andøya Space and their educational facilities. Here, the Master's Degree students will learn how to design, build and test their own tiny can-sized satellite, called a CanSat, in a similar way to satellites in real space projects.

- The CanSat will then be launched on a scientific weather balloon high into the atmosphere, and its data collected and analyzed by the students, Kohfeldt says.

The Master's Degree students also have the opportunity to meet and greet the Norwegian and international space sector at conferences and workshops held in the Oslo area, such as the Spaceport Norway conference.

Moreover, the students may join Lyra or Portal Space, organizations for space students at the University of Oslo, and build their own satellite or rocket as members of these organizations.

The fields of research at CENSSS

For the thesis work in the Master's Degree in Space Systems, several projects are available.

- For example, the students can work with the development of the CubeSat that CENSSS will build in the next few years. Or they may become involved in my research, which focuses on instruments for mapping the resources on planets, moons, and other celestial bodies used by human explorers in the future, says Kohfeldt.

Other academic advisors at CENSSS are Lars Erling Bråten – who is working with communication and radio system for small satellites, Mariusz Grøtte – an expert on satellite development and attitude control, Svein-Erik Hamran – who is leading the work with RIMFAX, the Norwegian ground penetrating radar on NASA's Mars rover Perseverance, and Torbjørn Skauli – a researcher on hyperspectral cameras and optics.

- Our Master's Degree students also have the opportunity to work closely with CENSSS' scientific and commercial partners, both in Norway and abroad, Kohfeldt says.

These include, among others, the Norwegian companies Integrated Detector Electronics AS and Jotne Connect, the Norwegian Defence Research Establishment (FFI), and the University of California in Los Angeles (UCLA).

The first students

- In the first year of the new Master's Degree we had over 50 applicants. Of the 12 students that started in the fall of 2023, five are women, says Kohfeldt.

Most of the students are from the Oslo area, but two have degrees from outside of Norway, and there is one student each from FHS, NTNU, USN and the University of Tromsø.

In the future, courses in orbital mechanics, attitude control of spacecraft and planning of space missions may be added to the degree.

- For students who wish to apply to the Master's Degree studies in Space Systems starting in the fall of 2024, the deadline is April the 15th 2024, Kohfeldt concludes.

For more information about the Master's Degree in Space Systems, see the following links:

https://www.mn.uio.no/its/studier/masteroppgaver/romsystemer_og_sensortechnologi.html

<https://www.uio.no/studier/program/romsystemer/>



Linn Yttersian, Natalia Lidia Stepien and Niraja Nakul Upadhyaya.



Niraja Nakul Upadhyaya and Brage Sørensen.

Summer students – Building a test rover for Rimfax, the Norwegian Ground Penetrating Radar on Mars

By Berit Ellingsen

This summer, two Master's students from the University of Oslo assembled a rover that will be used for testing RIMFAX on Earth.

- The rover is commercially available as a pre-built solution and can be remote controlled. But in order to simulate a rover driving on Mars, the test rover needed to be modified to drive autonomously, says Marius Anfinsen, Master's degree student at the University of Oslo.

Turning the remote controlled commercially available rover into an autonomously driving test platform for RIMFAX became the task of the two Master's degree students working at CENSSS this summer.

The students also participated in the day-to-day operations of RIMFAX and NASA's rover Perseverance on Mars. This meant sitting in at the meetings with NASA's Jet Propulsion Laboratories at Caltech in the US, together with the rest of the research teams that are working with Perseverance.

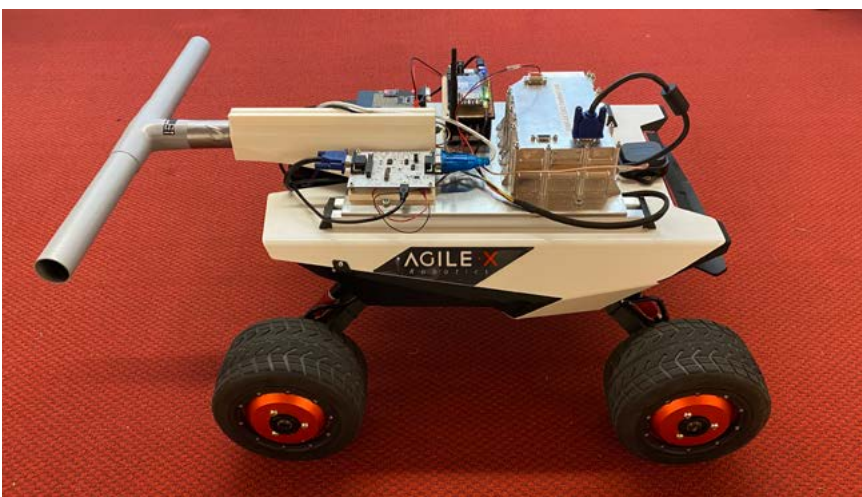
As part of the daily operations of RIMFAX on Mars, the Master's students also performed the uplink and downlink checks before and after each work day on the red planet.

[Read more about this student work here.](#)

Required practical work

The new test rover at CENSSS needed, among other things, software for autonomous driving and a web interface for easy access and control of the rover.

- In order to drive autonomously, the rover must know its own position accurately. That is provided by a GNSS receiver and a GNSS base station for correcting the data received from the GNSS satellites so that the positioning is accurate down to just a few centimeters, says Fredrik Leiros Nilsen, the second of the two Master's students working at CENSSS this summer.





Summer students Marius Anfinsen and Fredrik Leiros Nilsen.

- When working with the GNSS receiver and coding for the autonomous driving, the most challenging task turned out to be compiling the data from the GNSS receiver, the accelerometer and the gyroscope into one useable result, Nilsen says.

Here, the knowledge the students had from their course in mathematical modelling of dynamic systems, as well as coding for machine learning, turned out to be very useful.

Both students enjoyed the combination of practical and theoretical work, and hands-on problem solving that modifying the test rover required.

- Keeping the overview and correct structure in a large amount of code such as here, and working from start to finish on a relatively large project like this, were the most educational parts of the job for me, Anfinsen says.

Nilsen agrees that one of the most challenging tasks was to ensure that all the individual components worked well together on the test rover.

- This required a lot of trial and error, and some head scratching in between. But we received good help from CENSSS and the University of Oslo, and had a lot of freedom to solve the challenges in our own way, Nilsen says.

Tangible results of the work One of the most satisfying parts of the job was when the two Master's degree students could finally test drive the rover and see the tangible results of their hard work.

Thus, the test rover also needed a GNSS receiver and an antenna for the GNSS signals, and a gyroscope and accelerometer to sense its own movements. These were assembled on the rover by the Master's degree students.

- We also coded the software for autonomous driving with GNSS, created the web interface for that and mounted the antenna and a copy of the geo-radar RIMFAX on the rover. Finally, we tested everything by driving the rover on the parking lot outside the CENSSS building, and downstairs in the basement

when the weather was bad, says Anfinsen.

Assembling all of this and mounting it on the rover took some work with both screw drivers, soldering iron and laser cutter, and even 3D-printing some parts.

Theoretical knowledge needed

Both Anfinsen and Nilsen are Master's degree students in Mathematical Design and Automatic Systems at the Department of Technology Systems at the University of Oslo.

- It was really great to watch the rover handle its first U-turn, while driving autonomously as we had coded it to do, and seeing that it moved as it should, Anfindsen says.

Both students agree that although this took a lot of work, they did not need to work long into the night.

- We didn't work into the evenings, and I don't think that would have helped solve our challenges either. It was better to finish at the usual work time, and come back rested and refreshed the next day, Nilsen says.

- Although it was a lot of work, it didn't really feel like a job either, but more like a project where we solved each new challenge as it arose, and used our knowledge and creativity to get past them. That was definitely the most fun part of the job, Anfindsen says.

Talked with PhD students at CENSSS

Both Anfindsen and Nilsen have an interest in space research and exploration.

- I worked with one of the projects of Portal Space, the organization for students interested in space and space technology at the University of Oslo, says Anfindsen.

Portal Space is developing engines used for small launch rockets, built by the space interested students in their own time.

- There is so much in the field of robotics and automation that looks very exciting to work with for the Master's Thesis and beyond. The

space sector is one of the fields I'm interested in, because robotics and automation are so useful for space, Anfindsen says.

He applied for the summer job at CENSSS after having talked with one of the PhD students that are working with RIMFAX, and became interested in doing his Master's degree thesis at CENSSS.

Master's thesis work with Rimfax

- I've always had an interest in space and space exploration, and participated in one of the European Space Camps for students that are held at Andøya Space, Nilsen says.

This course has students develop, build and launch their own sounding rocket as a small space project, while at the same time introducing them to the space sector as a potential field for work. The participants are also informed about what kind of studies and work experience will help them find employment in the space business.

- When I started in the Master's degree program for cybernetics and automatic systems last fall, I saw a presentation about RIMFAX and CENSSS for Master's students. I talked with the person doing the presentation and decided to join the center for my thesis work, Nilsen says.

Useful to work together

Initially, both he and Anfindsen were supposed to write their Master's theses on geodata from RIMFAX in connection with machine learning. But after working with the test rover, that is likely to be a part of the students' thesis work instead.

- The test rover can currently drive autonomously to set coordinates, but not detect or avoid possible obstacles on the way. Thus, for the test rover to become more autonomous, we would need to add some additional sensors, such as cameras or lidars, says Nilsen.

- In order to really become a test bed for future georadars in space, the rover might also need an updated or modified georadar of a similar type as RIMFAX, or maybe even an array of such radars, says Anfindsen.

This would require more work of a similar type as the two Master's degree students have already done.

- We will most likely write individual Master's theses, but work closely together on the practical part, as we have done this summer. It was both very useful and educational to have someone to work together with on such practical tasks, and exchange ideas and solutions with, Nilsen says.

He recommends applying for a summer job at CENSSS for all Master's degree students who are interested in robotics and machine learning, and wish to see how this can be used in space exploration and space technology.

- It's a perfect combination of practical and theoretical work, very varied, interesting and fun, Nilsen concludes.

Both Master's degree students and CENSSS have decided that their thesis work will involve RIMFAX in some way, with the details to be worked out later.

RIMFAX team received multiple NASA awards



The year of 2023 was eventful for the Mars 2020 mission and the RIMFAX team. By the end of the year, the Perseverance rover had driven almost 25 km. RIMFAX collects soundings whenever Perseverance drives and we have lots of exciting data from both the Jezero crater floor and the delta. In September, RIMFAX reached the milestone of 1 million successful soundings, and in December, the Mars 2020 mission reached Sol 1 000.

NASA awarded members of the RIMFAX team several awards in 2023; Four group Achievement awards, and two individual, Mars 2020 Certificates of Appreciation. As written on the NASA webpage, the Group Achievement award criteria states that “NASA’s most prestigious honor awards are approved by the Administrator and presented to a number of carefully selected individuals and groups of individuals who have distinguished themselves by making outstanding contributions to the Agency’s mission”;

RIMFAX Principal Investigator (PI), Professor Svein-Erik Hamran says: This is a great recognition of the efforts and hard work of the RIMFAX and the Mars 2020 teams, and is an inspiration for continuing space exploration and Mars science at CENSSS.



- NASA Group Achievement Award presented to Mars 2020 Instrument Operations Development Team “For outstanding achievement in the development of the Mars 2020 Instrument Operations teams, tools and systems enabling successful initial surface operations at Jezero Crater.”
- NASA Group Achievement Award presented to the RIMFAX instrument development team “For the design, implementation, and delivery of the Radar Imager for Mars’ subsurFace eXperiment (RIMFAX), a new science capability for NASA’s Mars 2020 mission”
- NASA Group Achievement Award presented to the RIMFAX science team “For the successful operation and publication of scientific results from the Radar Imager for Mars’ subsurFace eXperiment (RIMFAX) on the Mars 2020 Perseverance Rover Mission”
- NASA Group Achievement Award presented to Pre-Landing Strategic Science Group. The pre-landing strategic science prepared the Mars 2020 mission by planning the science objectives and goals of the mission. An important part of their work was to select the landing site at Jezero crater. The group did this through a series of landing site selection workshops over several years.
- Certificate of Appreciation, presented to Tor Berger and to Sverre Brovoll “For significant contributions to the Instrument Simple Planner (SP) Technical Interface Meetings, ensuring instrument team readiness for SP1 rollout”. Simple Planner covered improvements of efficiency in the tactical planning of Mars 2020 operations. All scientific instruments participated in this effort.



Established an international standard for hyperspectral cameras and received recognition from IEEE

By Berit Ellingsen

Dr. Torbjørn Skauli at CENSSS has for several years been engaged in the work to establish an international standard for hyperspectral cameras. For this work, the Institute of Electrical and Electronics Engineers (IEEE) has awarded Skauli the IEEE SA Standards Medallion.

While the human eye can see three primary colors, hyperspectral cameras can see hundreds of wavelengths of visible, infrared and ultraviolet light.

- This means that each pixel in the camera's image contains detailed information about how the light is distributed over different wavelengths, that is to say a spectrum, says professor Torbjørn Skauli, head researcher in space sensors at CENSSS.

This spectrum is a fingerprint of any material the hyperspectral camera is looking at in each pixel, which can be interpreted by computers to reveal many of the physical and chemical properties of the material in question.

Thus, hyperspectral cameras are used for a wide variety of applications, such as precision farming to monitor crops for fertilizer use and watering, vegetation and forest cover monitoring in natural ecosystems and habitats, mineral detection for industrial use, landscape mapping for defense activities, medical imaging, and more.

Hyperspectral cameras can also be used to explore the moon and the planets, and not the least to observe Earth from space.

- For example, the Hypso-1 satellite, developed by students at NTNU, has a hyperspectral camera for oceanographic research and is monitoring algal blooms from orbit, Skauli says.

Can cost NOK 1 million or more

Hyperspectral cameras are commercially available, and at prices of NOK 1 million or more. But so far there has been no standard for specifying the capabilities of hyperspectral cameras.

- This includes information of for example how many pixels the camera actually sees, how much light it can

collect, to what extent the spectrum can be distorted by imperfections, or whether the camera takes images at all wavelengths simultaneously or sequentially, Skauli says.

One of Skauli's PhD students, Gard Selnesaunet, who has been at CENSSS since 2021, has been working with a method for characterizing hyperspectral cameras and quantifying their performance.

Selnesaunet is co-supervised by CENSSS partners IDEAS and Norsk Elektro Optikk (NEO). NEO is a world leading manufacturer of high-quality hyperspectral cameras under their HySpex brand.

- We have seen that for hyperspectral cameras that are specified by today's methods to have similar performances, there can actually be very large differences between them. For example in the integrity of spectrum measurements, which is essential for computers and machine learning to interpret and process the images from hyperspectral cameras, Skauli says.



This is significant to know, because data from hyperspectral cameras are too complex and too data intensive to be interpreted and processed manually.

CENSSS contributions to an IEEE standard

The shortcomings of specifications for hyperspectral cameras have been an issue for a long time. In 2018 people from the hyperspectral imaging community came together in a working group to start developing a standard under the auspices of the IEEE Standards association.

IEEE is the world's largest technical professional society, with more than 427 000 members in over 190 countries, spanning multiple fields of technology where hyperspectral imaging is used.

- Because I have used hyperspectral and multispectral cameras as part of my research, and published articles on how to characterize them, I was part of the IEEE standardization effort from the start, says Skauli.

Since 2020 Skauli has been vice chair of the working group, and he is currently doing the final editing of the more than 120 pages long document that will become the established standard for hyperspectral cameras.

- The working group counts more than one hundred IEEE members, and we have had more than 40 meetings, online and on conferences to agree on the methods, research results and characterizations that form the basis for the standard, Skauli says.

Among the many characteristics for hyperspectral cameras listed in the standard, a few are based on Skauli's research.

- Others are based on research at NEO, so CENSSS can be said to be well represented in the standard for hyperspectral cameras, says Skauli.

A nice appreciation from colleagues

The IEEE P4001 standard will be completed this winter, and then submitted for public review. The finalized document will be published in 2024 and is likely to be made freely available on the IEEE website thanks to company sponsors.

- But because the needs for standardization documents such as this are constantly evolving, updates and changes are likely to be included in a new version later on, Skauli says.

- However, next time it will be easier to write since we then have a basis to work from with the current document, he adds.

For his work with the standard, Skauli recently received the IEEE SA Standards Medallion. This commendation includes a diploma and a medallion from the organization.

- It's very nice to receive such an appreciation of my work from colleagues through IEEE, but of course the standard is based on input from a very large group of people from the entire hyperspectral imaging community, Skauli says.

Easier to find the best hyperspectral camera

The new standard for hyperspectral cameras will provide both researchers and manufacturers, as well as buyers and newcomers, with a common language for testing and describing the performance of hyperspectral cameras.

- This will make the commercial information leaflets for hyperspectral cameras more complex, but also more informative, without requiring much more additional work for the manufacturer, says Skauli.

That was one of the requirements for developing the IEEE standard.

- But maybe more importantly, the new standard will make it easier for buyers of hyperspectral cameras, such as satellite developers, and the users of these cameras, such as space organizations, to find the best possible hyperspectral camera for their purposes, and helping them to get the most out of the data from these cameras, says Skauli.

This will be important in all industrial sectors that utilize hyperspectral cameras, not the least the increasingly commercial international space market and the growing global space sector.

Events

Norsk mikrosatellitt-konferanse 2023

In February, CENSSS/UiO together with SINTEF and NTNU arranged “Norsk mikrosatellittkonferanse”. CENSSS/UiO, SINTEF and NTNU have established “Geminisenter Småsatellitter”. The Gemini centre is a model for strategic cooperation between research groups at NTNU, SINTEF, University of Oslo, St. Olav’s Hospital and NTNU Social Research. This was the first time the Gemini centre arranged this conference. There were 90 registered participants, a 50 % increase from 2022. The conference has a technical profile, and is relevant to everyone working with different aspects of small satellites, or students with interest in the field. “Norsk mikrosatellittkonferanse” aims to build a bridge between students, academia and Norwegian space industry.

During the day of the conference, we had the pleasure of listening to thirteen very interesting talks. The topics covered funding possibilities for small satellites, relevant standards, commercialization, maritime surveillance, sensor payloads and planned and ongoing small satellite projects.





Mars 2020 – Science team meeting

In June, The Supercam team hosted a Mars 2020 Science Team meeting in Paris, with several hundred participants from USA and Europe. CENSSS participated as part of the RIMFAX team. The four-day meeting was the first time the Mars 2020 Science Team met in Europe. During the meeting, the team

discussed mission achievements and planned for future Mars campaigns with the Perseverance rover and its scientific instruments. The Perseverance Rover had, at the time of the meeting, driven for more than two years, and was on its way up from the Jezero crater floor and into the delta.

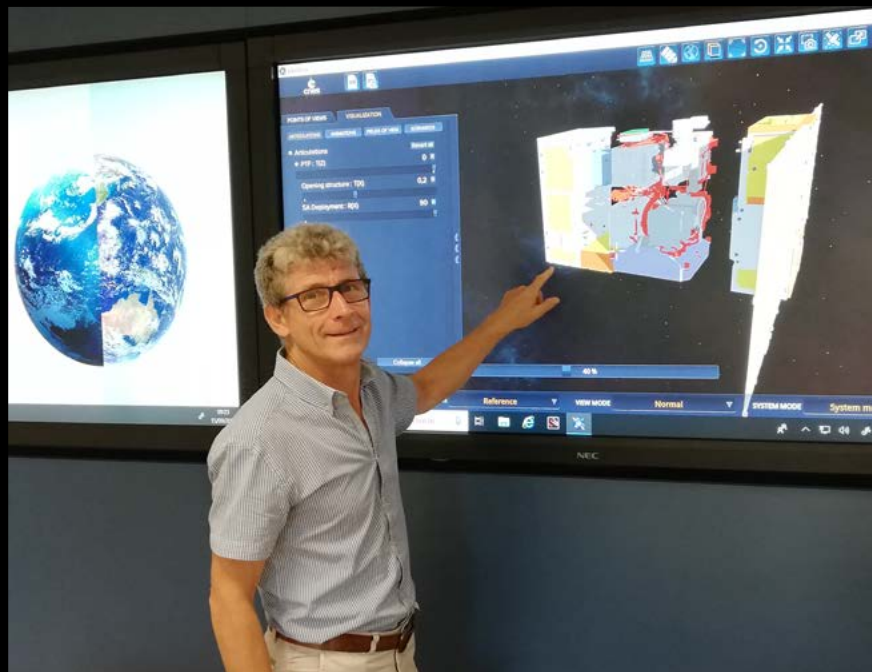


Spaceport Norway

ITS and CENSSS were presented at Spaceport Norway, October 23-25, 2023, at Vulkan Arena. At the exhibition we presented the CENSSS activities, together with some of the CENSSS partners, advertised our Space Systems master's program and networked in the Norwegian Space community.

Next year, the topic of Spaceport Norway will be Xploration and we hope that CENSSS will be present in the conference program and at stage, as well.

CNES Workshop



Jean-Luc Legal, CNES

Concurrent design is a system engineering approach where, experts in various fields, system engineers, and clients work together on the same model base to develop an integral, consistent design based on a common understanding and decision making.

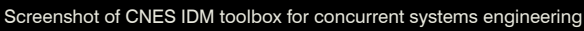
CNES developed the IDM toolbox for concurrent system engineering to structure complex projects into subsystems and elements, collect specification and design data at one place and visualize the overall system. Several plug-ins and additional programs can be used for budgeting and system simulations, allowing system analysis on Phase0/A level without using expensive and commercial simulation suits.

Between March 21st and 23rd 2023 CENSSS invited Jean-Luc Le Gal from CNES to Kjeller to introduce us to IDM and concurrent design philosophy. For 3

days, we were digitally integrating a 3U CubeSat, producing a video presenting the subsystems, creating budgets, orbit analysis, lifetime and thermal simulations.

22 people attended the workshop, including engineers from the CENSSS partners UiO, Jotne, IDEAS and NEO, and also from Kongsberg Defence & Aerospace and the Norwegian Space Agency.

The workshop was a success. The IDM made it into the curriculum of the Space Systems master's program afterwards and is now used by students at ITS. IDM will also be used in systems engineering for CENSSAT-1.



Industry Collaboration Canvas

Understanding the interaction between researchers and industrial companies is important to create an effective collaboration. The CENSSS centre management followed a methodology described by researchers at MIT¹ that describes how to structure discussions between the partners, with the goal to identify gaps in the collaboration and suggest improvements.

The CENSSS centre management met one-to-one with each partner, and the discussion covered six different subjects.

1. What are the goals that drive our partnership?
2. What are the key focus areas of the partnership, and how are they aligned with the business goals?
3. Who are the primary working partners in the partnership, and how are they chosen?
4. Are the collaboration formats matched to the focus areas and business goals?
5. Are the right key individuals, processes, and organizational structures currently in place in your organization, and available to support the partnership?
6. What Key Performance Indicators (KPIs) can be employed to evaluate the partnership?

During the series of meetings, we used a great amount of time discussing in-kind contributions. In-kind contributions need to be relevant to CENSSS, and self-funded by the partners. We identified examples of in-kind contributions partners can report:

- Project work and support to CENSSS work packages
- Other relevant work within the scope of CENSSS, e.g. contribution to the development of standards
- Supervision of Master and PhD students
- Participation on meetings and conferences
- Paid Master students, summer jobs, part time jobs, internships
- Access to scientific data
- Access to laboratory facilities

It turned out that some CENSSS partners had performed work for CENSSS that they did not report as in-kind. With this included in the reporting, the overall in-kind contributions from the partners met the budget for 2023.

The industry partners highlighted networking and visibility as advantages with CENSSS, and that collaboration with academia can contribute to increased competence. There were also some areas with potential for improvements, like the fact that we need a common project to develop the collaboration further. CENSSS is currently ramping up the small satellite project, which is such a common project. During the series of meetings, we also identified new KPIs, that we include in the annual reporting to the Norwegian Research Council.

¹ Frolund, L., Murray, F. and Riedel, M. (2018) Developing Successful Strategic Partnerships with Universities. MIT Sloan Management Review, 59 (2), 71-79.

CENSSS in the media



Scientific talks

The Upcoming P4001 Standard for Hyperspectral Imaging

Place: Orlando, Florida

Date: May 2023

Talk: SPIE Defence & Commercial Sensing Symposium

Presenters: Torbjørn Skauli, John R. Gilchrist, Christopher Durell

The Upcoming P4001 Standard for Hyperspectral Imaging

Place: Pasadena, California

Date: Juli 2023

Talk: IEEE Geoscience and Remote Sensing Symposium

Presenters: Torbjørn Skauli, John R. Gilchrist, Christopher Durell

Criterion for quantifying the amount of spatial and spectral information acquired by hyperspectral cameras

Date: 23 October 2023

Talk: Proc. SPIE 12737, Electro-Optical and Infrared Systems: Technology and Applications, 127370U

Presenters: Andrei Fridman, Torbjørn Skauli, Philippe Déliot, John R. Gilchrist, Trond Løke

<https://doi.org/10.1117/12.2689031>

The Upcoming P4001 Standard for Hyperspectral Imaging

Place: Published online

Date: Desember 2023

Talk: Photonics Spectra Hyperspectral Imaging Summit 2023

Presenters: Torbjørn Skauli, John R. Gilchrist, Christopher Durell

RIMFAX on the NASA Perseverance Mars rover

Place: Wien

Date: June 2023

Talk: EAGE

Presenters: Hamran, S-E, et. al.



Popular scientific talks

På leting etter liv på Mars

Place: Kulturhuset Lillestrøm

Date: 14. februar 2023

Presenter: Svein-Erik Hamran

Host: Lillestrøm senioruniversitet.

Foredrag om Rimfax for Realfagsprisen,

Place: Kunnskapsbyens hus, Kjeller.

Date: 9. mars 2023

Presenter: Svein-Erik Hamran

Foredrag om CENSSS for Administrasjonen ved MN fakultetet ved Universitetet i Oslo.

Date: 9. mars 2023

Presenter: Svein-Erik Hamran

Foredrag om "Kameraer som ser i mørket"

Place: Kulturhuset Lillestrøm

Date: 29. september 2023

Presenter: Torbjørn Skauli

Host: Researchers' night

ITS romdag

Date: 19.09.2023

Presenters: AK et al.

TEK4700 og TEK4710

Place: SpacePort Norway

Presenters: AK et al.

Host: UiO og ITS

Saturn Rings 2023

Luis, utvalg:

- [Slik ble Saturns ringer til - Titan. uio.no](#)
- [New Simulations Shed Light on Origins of Saturn's Rings and Icy Moons - NASA](#)
- [Video: How Saturn's Rings Formed in a Massive Moon Collision - The New York Times \(nytimes.com\)](#)



Poster Presentations

Development of a small-size scintillator-based neutron gamma ray spectrometer for terrestrial and space applications

Deniz Ölçek, Andreas F. Haavik, Anja Kohfeldt, Codin George, Dirk Meier, Gunnar Mæhlum, Jusong Paul Choe, Magne S. Gjennestad.

24th International Workshop on Radiation Imaging Detectors, iWoRiD, Oslo, Norway, 25-29 June 2023.

(Best poster award)



Conference proceedings

Atmospheric corrections using Deep Learning

Place: Oslo

Date: 15. June 2023

Conference: Copernicus user meeting

Author: Kristoffer Langstad

RIMFAX on Svalbard and Mars

Date: 15. februar 2023,

Conference: ESA Program Board on Human Mission and Exploration.

Authors: Svein-Erik Hamran

Interplanetary neutron detection

Place: ITS, UiO, Kjeller

Date: 12.09.2023,

Conference: CENSSS colloquium

Author: Luis Teodoro

Interplanetary neutron detection

Place: Institutt for Geofag, UiO, Oslo

Date: 14.09.2023

Author: Luis Teodoro

Conference: PHAB colloquium

Insitu Resource utilization – or how to find water on the moon

Author: Anja Kohfeldt

Place: Technische Universität Berlin (online event)

Date: 20.11.2023

Conference: TU Berlin

Raumfahrttechnik-Kolloquium

Space Education at UiO

Place: Norwegian Space Academy, Oslo

Date: 8.-9.11.2023

Author: Anja Kohfeldt

Conference: Space-Education 2.0 Workshop

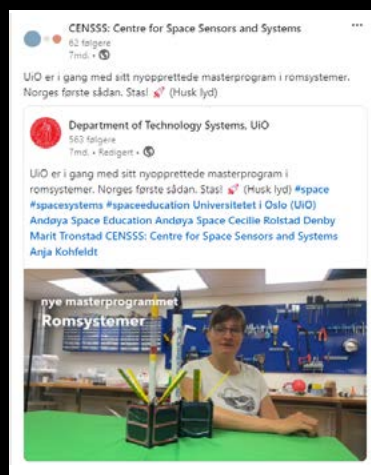


Awards

For the third year in a row, Eidsvoll Electronics (EIDEL) is recognized with the Gaselle award by the business and financial paper Dagens Næringsliv!



Social media



News articles

Gaining satellite insight through FlatSat

Publisher: Andøya Space

Date: January 26, 2023

<https://andoyaspace.no/news-articles/gaining-satellite-insight-through-flatsat-2/>

Norsk georadar til Mars

Publisher: Forskningsrådet

Date: 29. sep 2021

<https://www.forskningsradet.no/om-oss/forskningskommunikasjon/forskere-frimerker/norsk-georadar-til-mars/>

The Multi-Needle Langmuir Probe arrives at the ISS

Publisher: Eidel AS

Date: 2023

<https://eidel.no/en/articles/the-multi-needle-langmuir-probe-arrives-at-the-iss/>

Norsk sensor for romvær klar for romstasjonen

Publisher: Norwegian Space Agency

Date: 2023

<https://romsenter.no/aktuelt/norsk-sensor-for-romv%C3%A6r-klar-for-romstasjonen>

Har utviklet Mars-radar

Publisher: Altomfauske.no

Date: 30.11.2023

<https://www.altomfauske.no/post/har-utviklet-mars-radar>

Realfagsprisen 2023: Imponerte juryen

Publisher: Romeriksdebatten

Date: 02.04.2023

<https://www.rb.no/realfagsprisen-2023-imponerte-juryen/o/5-43-1990732>

- We are always looking for new talent - especially those with education in space systems

Publisher: University of Oslo

Date: 03.02.2023

<https://www.mn.uio.no/censss/english/news/-we-are-always-looking-for-new-talent---especially.html>

Publications and presentations

Imaging the point spread function of hyperspectral cameras: the full truth about coregistration error and resolution

Publisher: Proc. SPIE 12688, Imaging Spectrometry XXVI: Applications, Sensors, and Processing, 1268804 (20 October 2023)

Authors: Gard M. Selnesaunet, Marie B. Henriksen, Torbjørn Skauli

<https://doi.org/10.1117/12.2677604>

Wireless Physics - Making Amateur Radio Accessible as a Tool in Science Education Through an Upcoming New Licence

Publisher: Fysikermøtet, Bergen, August 2023

Authors: Torbjørn Skauli

Distributed Dual Quaternion Extended Kalman Filtering for Spacecraft Pose Control

Publisher: Submitted to Journal of guidance, control, and dynamics. 2023.

Authors: Mathias Hudoba de Badyn, Jonas Binz, Andrea Iannelli, Roy Smith

Design and test of a deployable broadband antenna for low frequency synthetic aperture interferometric radiometry from small satellites

Publisher: Proceedings of the International Astronautical Congress, Baku, Azerbaijan, 2-6 October 2023.

Authors: Lewis Raymond Williams

ISSN 0074-1795.

Learned atmospheric corrections for Earth Observation using deep learning

Publisher: Finnish Satellite Workshop, Espoo, Finland, 18-20 January 2023.

Authors: Kristoffer Langstad, David Völgyes

Stratigraphic Relationships of the Western Delta and Crater Floor in Jezero Crater From RIMFAX Gpr Observations

Publisher: Lunar and Planetary and Science Conference, 2023.

Author: PS Russell, DA Paige, S-E Hamran, H Amundsen, Andrew Annex, T Berger, L Carter, TM Casademont, H Dypvik, S Eide, R Kakaria, MT Mellon, D Nunes, JI Núñez, E Shoemaker, JI Simon;

Mineralogy, morphology, and emplacement history of the Maaz formation on the Jezero crater floor from orbital and rover observations

Publisher: Authorea Preprints, 2023.

Authors: Briony Heather Noelle Horgan, Arya Udry, Meïssa S Rice, Sanna Alwmark, Hans EF Amundsen, James F Bell III, Larry S Crumpler, Bradley Garczynski, Jeffrey R Johnson, Kjartan Münster Kinch, Lucia Mandon, Marco Merusi, Chase Million, Jorge I Núñez, Patrick S Russell, Justin I Simon, Michael St Clair, Kathryn Stack Morgan, Alicia Fallacaro Vaughan, Brittan Valhalla Wogsland, Andrew Michael Annex, Andreas Bechtold, Tor Berger, Olivier Beyssac, Adrian Jon Brown, Edward Cloutis, Barbara A Cohen, Sarah Fagents, Linda C Kah, Ken Farley, David Timothy Flannery, Sanjeev Gupta, Sein-Erik Hamran, Yang Liu, Gerhard Paar, Cathy Quantin-Nataf, Nicolas Randazzo, Eleni Maria Ravanis, Steven F Sholes, David Shuster, Vivian Zheng Sun, Christian Tate, Nicholas Tosca, Meenakshi Wadhwa, Roger C Wiens

Rock Properties of Shallow Martian Subsurface with the RIMFAX Ground Penetrating Radar

Publisher: EGU23, 2023

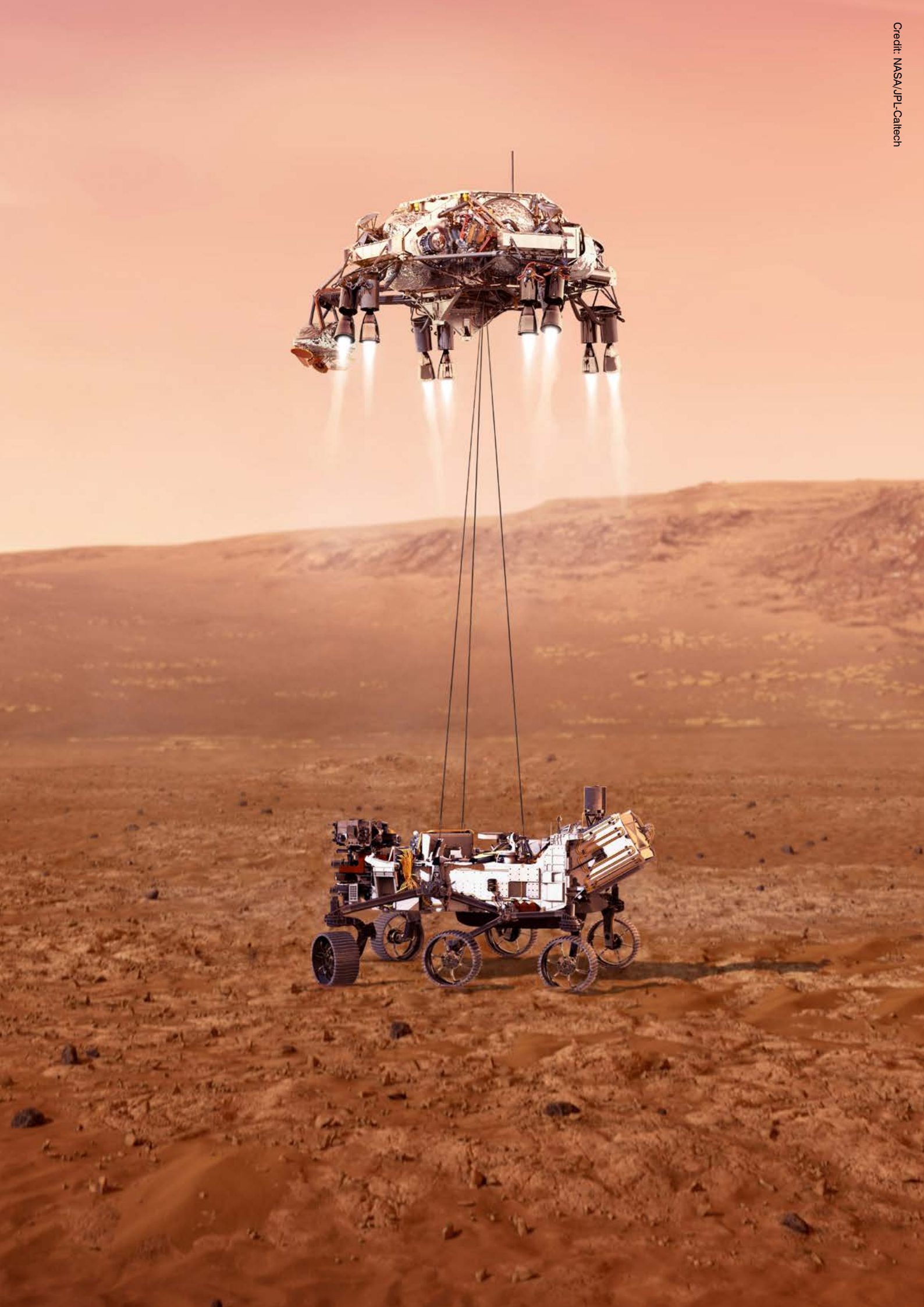
Authors: Titus M Casademont, Sigurd Eide, Emileigh Shoemaker, Tor Berger, Patrick Russell, Svein-Erik Hamran;

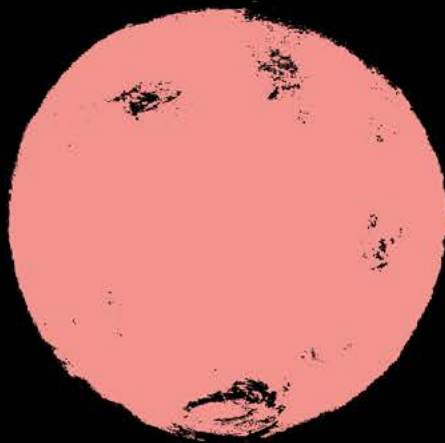
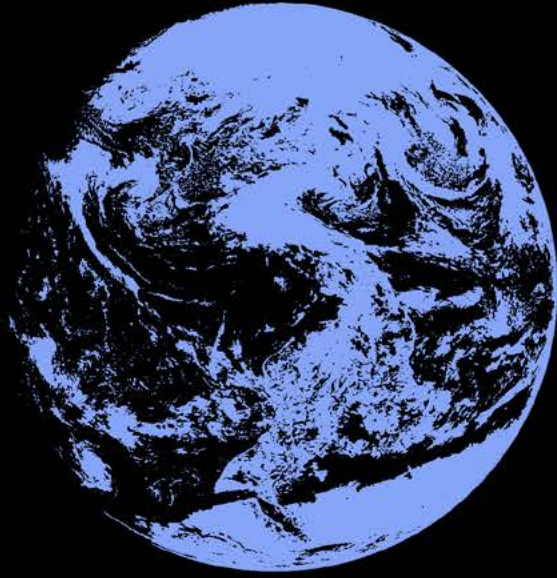
Revisiting the Subsurface Stratigraphy of the Jezero Crater Floor Using the RIMFAX GPR

Publisher: LPI Contributions, 2023.

Authors: ES Shoemaker, LM Carter, TM Casademont, P Russell, S Eide, HEF Amundsen, H Dypvik, S-E Hamran, S Brovoll, T Berger

Stratigraphy Relationships of the Delta and Crater Floor in Jezero Crater from RIMFAX GPR Observations**Publisher:** LPI Contributions, 2023.**Authors:** PS Russell, DA Paige, S-E Hamran, H Amundsen, A Annex, T Berger, TM Casademont, H Dypvik, S Eide, R Kakaria, MT Mellon, D Nunes, JI Núñez, E Shoemaker, JI Simon, L Carter**Radar Attenuation in the Shallow Martian Subsurface: RIMFAX Time-Frequency Analysis and Constant-Q Characterization Over Jezero Crater Floor****Publisher:** Geophysical Research Letters, (50) 7, 2023.**Authors:** Sigurd Eide, Titus M Casademont, Tor Berger, Henning Dypvik, Emileigh S Shoemaker, Svein-Erik Hamran**RIMFAX ground penetrating radar reveals dielectric permittivity and rock density of shallow Martian subsurface****Publisher:** Journal of Geophysical Research: Planets, (128) 5, 2023.**Authors:** TM Casademont, S Eide, ES Shoemaker, Y Liu, DC Nunes, P Russell, H Dypvik, HEF Amundsen, T Berger, S-E Hamran**Exploring the Martian Subsurface with the RIMFAX Ground Penetrating Radar on the Mars 2020 Perseverance Rover****Authors:** S Hamran, D Paige, HEF Amundsen, T Berger, S Brovoll, L Carter, TM Casademont, L Damsgård, H Dypvik, S Eide, R Ghent, J Kohler, MT Mellon, DC Nunes, D Plettemeier, P Russell, M Siegler**Publisher:** 84th EAGE Annual Conference & Exhibition, 2023.**In Situ Geologic Context Mapping Transect on the Floor of Jezero Crater From Mars 2020 Perseverance Rover Observations.****Authors:** Crumpler, L.S.; Horgan, B.H.N.; Simon, J.I.; Stack, K.M.; Alwmark, S.; Dromart, G.; Wiens, R.C.; Udry, A.; Brown, A.J.; Russell, P.; Amundson, H.E.F.; Hamran, Svein-Erik; Bell, J.; Shuster, D.; Calef, F.J.; Núñez, J.; Cohen, B.A.; Flannery, D.; Herd, C.D.K.; Hand, K.P.; Maki, J.N.; Schmidt, M.; Golombek, M.P. & Williams, N.R. (2023).**Publisher:** Journal of Geophysical Research (JGR): Planets. ISSN 2169-9097. 128(10).doi: [10.1029/2022JE007444](https://doi.org/10.1029/2022JE007444).**Samples Collected From the Floor of Jezero Crater With the Mars 2020 Perseverance Rover.****Authors:** Simon, J.I.; Hickman-Lewis, K.; Cohen, B.A.; Mayhew, L.E.; Shuster, D.L.; Debaille, V.; Hausrath, E.M.; Weiss, B.P.; Bosak, T.; Zorzano, M.-P.; Amundsen, Hans E. Foss; Beegle, L.W.; Bell, J.F.; Benison, K.C.; Berger, E.L.; Beyssac, O.; Brown, A.J.; Calef, F.; Casademont, Titus; Clark, B.; Clavé, E.; Crumpler, L.; Czaja, A.D.; Fairén, A.G.; Farley, K.A.; Flannery, D.T.; Fornaro, T.; Forni, O.; Gómez, F.; Goreva, Y.; Gorin, A.; Hand, K.P.; Hamran, Svein-Erik; Henneke, J.; Herd, C.D.K.; Horgan, B.H.N.; Johnson, J.R.; Joseph, J.; Kronyak, R.E.; Madariaga, J.M.; Maki, J.N.; Mandon, L.; McCubbin, F.M.; McLennan, S.M.; Moeller, R.C.; Newman, C.E.; Núñez, J.I.; Pascuzzo, A.C.; Pedersen, D.A.; Poggiali, G.; Pinet, P.; Quantin-Nataf, C.; Rice, M.; Rice, J.W.; Royer, C.; Schmidt, M.; Sephton, M.; Sharma, S.; Siljeström, S.; Stack, K.M.; Steele, A.; Sun, V.Z.; Udry, A.; VanBommel, S.; Wadhwa, M.; Wiens, R.C.; Williams, A.J. & Williford, K.H. (2023).**Publisher:** Journal of Geophysical Research (JGR): Planets. ISSN 2169-9097. 128(6).doi: [10.1029/2022JE007474](https://doi.org/10.1029/2022JE007474).**Ground penetrating radar observations of the contact between the western delta and the crater floor of Jezero Crater, Mars.****Authors:** David A. Paige¹, Svein-Erik Hamran, Hans E. F. Amundsen, Tor Berger, Patrick Russell, Reva Kakaria, Michael T. Mellon, Sigurd Eide, Lynn M. Carter, Titus M. Casademont, Daniel C. Nunes, Emileigh S. Shoemaker, Dirk Plettemeier, Henning Dypvik, Sanna Holm-Alwmark, Briony H. N. Horgan.**Publisher:** Accepted for publication in Science Advances, 2023**Development of a small-size scintillator-based neutron gamma ray spectrometer for terrestrial and space applications****Authors:** Deniz Ölçek, Andreas F. Haavik, Anja Kohfeldt, Codin George, Dirk Meier, Gunnar Mæhlum, Jusong Paul Choe, Magne S. Gjennestad**Publisher:** 24th International Workshop on Radiation Imaging Detectors, iWoRiD, Oslo, Norway, 25-29 June 2023.**A Recent Impact Origin of Saturn's Rings and Mid-sized Moons****Authors:** L. F. A. Teodoro, J. A. Kegerreis, P. R. Estrada, M. Čuk, V. R. Eke, J. N. Cuzzi, R. J. Massey, and T. D. Sandnes**Publisher:** ApJ 955 137, <https://doi.org/10.3847/1538-4357/acf4ed>





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