Development goals and measures (UMV) 2020-23

DTU Space

ASIM mounted on the International Space Station. Credit. NASA

April 13, 2019

Table of contents

1. Executive summary

Long term goals

DTU Space will develop and create lasting value to the benefit of society through the natural and technical sciences within the broad area of space. The institute should be characterized by a vivid interaction between the natural and technical sciences and engineering in order to foster and advance space activities at the highest international level. The goal of DTU Space is to be a *preferred international partner*, participating in, and profiting from, international projects and missions through innovative collaborations with the private and public sector. The interaction and experiences gained from being *involved in the full life cycle of space activities* shall strengthen the institute's global position by realizing satellite missions and by exploiting their applications. DTU Space aims for a *strong educational profile* by recruiting bright students, educating them to the highest international level, and thereby enabling graduates to pursue attractive careers and meet the demands of employers.

Goals 2020–2023

DTU Space will focus on the three research fields: space science, geoscience and space technology. The main new research developments will focus on exploiting data from operational instruments (space, airborne, ground), engagement in new space missions/projects, and applications of space data. The ambition is to attract and implement several major research efforts, e.g. ERC/Villum/Danish National Research Foundation centers of excellence, and to have major engagement in space missions.

DTU Space will seek to expand collaborations across DTU via, e.g. Security DTU, Arctic DTU, and drone activities. Establishing Security DTU in the long term will be pursued through the launch of a national center for defence and security technology.

Special efforts will be made to attract international students to the ESPE MSc program by discussing closer collaboration with universities abroad and by constantly improving recruitment.

Scientific advice will focus on business development within the Polar regions, autonomous systems and smart cities, e.g. through the testbed TAPAS in Århus.

The institute will be a driving force in facilitating a significant increase in the number of space-related start-ups through establishing a European Space Agency Business Incubator Center in Denmark with DTU as the lead.

Strategic leadership will be a center of attention for DTU Space and in particular the succession of the current division heads. DTU Space believes that a stimulating work environment is the key to attract and retain top class employees and to host diversity. Hence, initiatives on carreer development, intro-program, and establishment of a Strategic Forum will be developed further.

The fascination of space will be used to strengthen DTU's profile and recruit bright students by, e.g. developing the rummet.dk web site, hosting high-profile events for media and the public, and by actively taking part in the public debate.

2. Education and teaching

2.1 Education and teaching (BEng, BSc and MSc programmes)

The institute's research fields are the basis for the production of candidates that fulfill the societal needs within a number of fields. The need for instrumentation, data processing and interpretation is large and increasing both for Earth observation missions and for space exploration missions. The Copernicus and Gallileo programs by the EU and ESA for satellite monitoring and navigation, respectively, have created and will create an extra need for such candidates from government institutions and companies within fields such as environmental and climate monitoring, topographic and thematic mapping, land cover and agricultural mapping, navigation, water resource and ground water assessment, climate impact assessment, and marine security monitoring. The Earth observation techniques will be able to contribute to a number of the UN sustainable development goals.

BEng, BSc and MSc programs. DTU Space contributes significantly to the BSc and MSc programs in Earth and Space Physics and Engineering (ESPE) (Geofysik og Rumteknologi) including the two directors of studies. Furthermore, DTU Space contributes to the Electrical Engineering (EE) BEng, BSc and MSc programs, to the Environmental Engineering MSc program, and to the BEng programs in Arctic Technology (AT), and Civil Engineering (CE).

Earth and Space Physics and Engineering. The ESPE programs will in the coming years undergo consolidation of courses and continued development with special focus on creating a portfolio of student projects. The directors will continue the visits to international universities to be inspired and to form networks. The study lines of the MSc program will be adjusted in order to even better fulfill the requirements from the employers. The DTU decision that the BSc students should be bilingual will be implemented by ensuring that some of the ESPE BSc courses are taught in English. The input from the study program assessment in the spring 2019 will be implemented in the ESPE programs in the coming years.

Other study programs. DTU Space is responsible for the study line Space Technology in the EE MSc program, a major part of the electronics courses in the EE BEng program, and the specialization on Geoinformatics in the CE BEng program. DTU Space contributes to the Arctic Semester, which will be part of the Cold Climate Enginering (CCE) Nordic master program, with focus on remote sensing, geoinformatics, geodesy and climate changes in the Arctic. DTU Space will continue to develop these contributions, and hence contribute to the fulfillment of vision of ARTEK and Nalakkersuisut/Greenland government.

Pedagogic development and didactic organization of study programs and teaching. The Study Committee (SC) will streamline the processing of evaluations by introducing a preprocessing of the results for setting up priorities for which courses are evaluated. In addition to this processing, the SC performs a detailed evaluation of the course content and curriculum with an approximate 5 years cycle. Together with the reference group and the DTU Learning Lab, the directors will evaluate the ESPE programs' diversity in the didactic organization and progression of the programs. Many courses at DTU Space involve assignments, project-based learning and learning though active experimentation. Especially, the project-based learning is key to many teaching activities, and the focus will be to use tools like e.g. peer review, video presentations for status reports, and Google Drive, both in order to improve the learning process for the students, but also to make more efficient use of the teachers' time due to the increasing number of students. The SC will use a group of teachers interested in e-learning as a reference group for implementing e-learning tools. A teacher's seminar on e-learning will be used to identify the courses where e-learning is relevant, and e-learning techniques will be implemented in all those courses during the UMV period. All new courses have to consider the use of e-learning tools.

Development of teacher's pedagogical skills. The teachers responsible for a course must have pedagogic skills corresponding to the UDTU course, or they must be enrolled in that course. The UDTU course will be offered to all newly employed researchers and assistant professors. Meetings will be arranged for the teachers to ensure a common understanding of pedagogic content and quality and act as a forum for exchange of good practices. Appointment of a new pedagogic coordinator will increase the focus on the development of teacher's pedagogical skills.

Student completion rates, readiness for the labor market, and student projects. The directors of studies for the ESPE programs will continue monitoring the student completion rates and launch appropriate activities to ensure a swift completion of their studies. It will be considered if a homework café arrangement with TA's could improve completion rates. DTU Space arranges each year a project day where students can discuss student projects with supervisors, companies, and public authorities, to streamline starting e.g. the master thesis project. DTU Space will seek to incorporate UN's sustainable development goals in courses and projects to enhance the contribution to DTU's Green Challenge initiative.

Recruitment and internationalization. DTU Space contributes significantly to DTU's recruitment activities, e.g. "Åbent Hus", MSc information day, SRPs, visits by high schools, participation in DTU Explore, and web pages. The directors of studies are taking the gender balance issue into account in the different recruitment activities by, e.g. using female students as role models, having a balance between the genders at "Åbent Hus", in the testimonials from students, and in the recruitment material. The directors for the ESPE programs seek to increase the exchange of students with international universities by customized study plans and establishing networks. Special efforts will be made to attract international students to the ESPE MSc program by constantly improving the web pages, e.g. with testimonials from international students. The directors will start discussions with TUM about a closer collaboration and a possible dual degree program.

Study environment. An attractive, inspiring, and creative study environment for the students is a must. DTU Space has already allocated some workspace for student projects. When the ESPE programs are fully established more than 250 students are expected simultaneously. Hence, there is a need for generally improved student facilities and more workspace for projects.

Laboratory and research based teaching. The institute is operating a number of unique research facilities originating from the high activity level in design, implementation, launch, and operations of space flight instrumentation. At the widest possible level, these facilities are used in the education program, both in regular classes and in projects, to offer cutting edge education and foster innovative thinking. DTU Space will exploit these unique facilities in the promotion of both the educational programs but also of the natural sciences and technology in general.

2.2 PhD programme

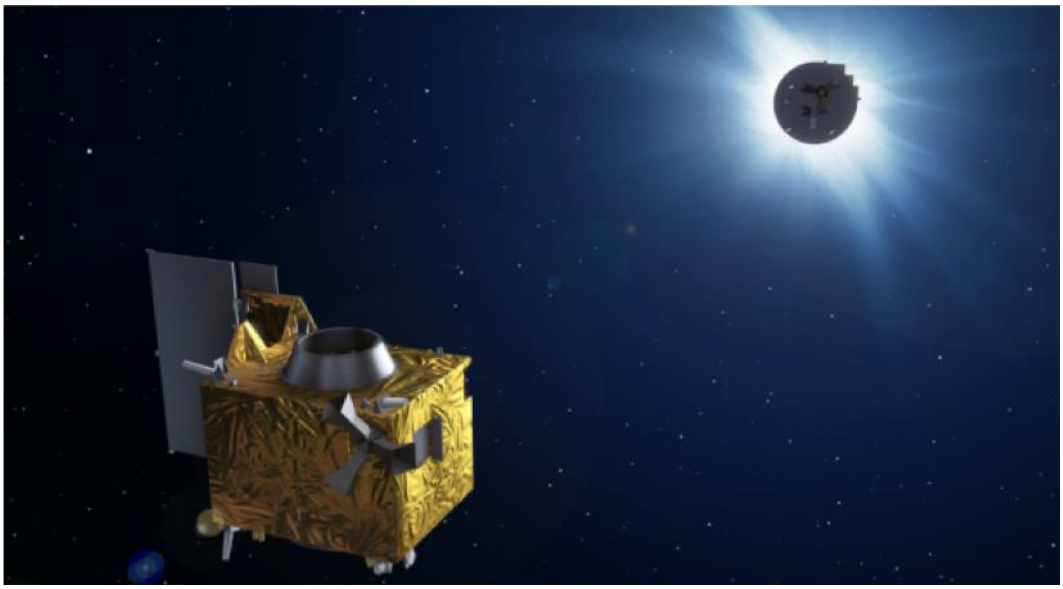
The goal of the institute's PhD program is to graduate excellent candidates, who will increase the knowledge base and, hence, set their mark on the development of society. The candidates should thus be able to excel either in the public sector or in private companies and DTU Space will increase the PhD population to ~30 PhD. The PhD students meet monthly for an informal lunch, quarterly for formalized information and networking meetings, and annually for a PhD day, where the PhD students present their projects with ample time for informal discussions and feedback.

Innovation is stimulated by encouraging PhD students to (i) stay 6 months abroad, (ii) focusing on establishing PhD projects with industry, and (iii) by involving PhD students in international space projects. The institute's large instrumentation and space mission portfolio enables students to work at the highest level of relevance to maximize innovation and collaboration with industry. Thereby PhD graduates are in a strong position for a successful on-wards career.

The institute will set up ~3 new PhD courses, which will be supplemented by (joint) courses from other institutes or universities, e.g. the EuroTech alliance universities, to offer a healthy mix of specialized and broad PhD courses. DTU Space will actively ensure education and skills development for new supervisors, e.g. by participating in the DTU supervisor courses. As a rule, PhD students are TAs and supervise student projects and this must be included in the study plan.

2.3 Lifelong Learning

DTU Space collaborates with the Royal Danish Defense College in order to facilitate possible involvement in the new educational program for officers. Furthermore, activities on continued education for officers and other military personnel will be discussed with the Danish Defense, as well as the establishment of the Security DTU may discover new needs in companies. DTU Space explores the possibilities of contributing to continuing education of high school teachers in collaboration with teacher organisations. DTU Space will collaborate with the new centre DTU Learn for Life in developing new courses on e.g., applications of Earth observation data from the EU Copernicus system.



Rendering of ESA's PROBA3 two-spacecraft mission to study the solar corona. DTU Space provides star trackers.

3. Research

Research is the "engine" of the DTU Space activities, enabling high quality, and offering new challenges for, education, innovation, and scientific advice. The top goals for research at DTU Space are that (1) DTU Space is world leading in a handful of space research areas, (2) the research base is broad enough to support education, public sector consultancy and innovation, and (3) DTU Space research combines engineering, technology and science.

DTU Space research activities will focus on three broad areas (with considerable overlap) defining the institute: Space instrumentation and technology systems, Earth Science, and Space Science. In order to have a prominent international profile DTU Space must be a world leader in at least a handful of areas, so-called "lighthouses", demonstrating the excellence of the institute. Research "lighthouses" are areas where DTU Space already has a unique position, i.e. amongst the few world leaders in the field of focus, or DTU Space has the potential to reach that level within a few years. The lighthouses are space driven and combine technology and natural science, and ideally they have strong ties to education, innovation and research-based consultancy and they encompass the full lifecycle of space activities. Lighthouses are further characterized by a size making them self-sustaining. The institute's current 6 research lighthouses are listed in the table below. An organic growth within all main areas is foreseen, but continued adaptation will be effectuated when necessary and new lighthouses are expected to emerge.

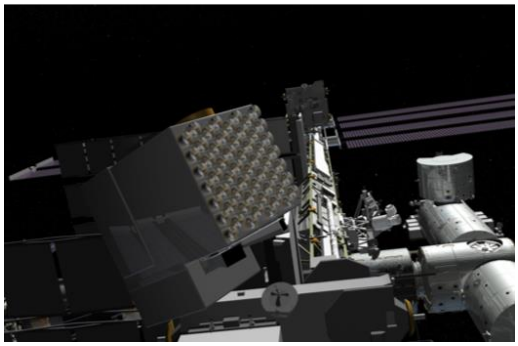
Funding strategy. The key external sources of funding will be ESA, EU, NASA, space companies, international space agencies and national research councils and foundations. The funding support at the institute will be reviewed and developed and optimized in collaboration with DTU's funding office. The instruments will be, e.g. early identifying the most promising projects, set up the best proposal teams and provide internal feedback on draft applications. After a proposal round, the results will be evaluated in order to implement actions, which could increase the success rate. In particular, EU Horizon Europe actions will be a natural target for the institute's funding efforts over the coming years, e.g. the COPERNICUS program, and it is an objective to attract major ERC grants or centers of excellence.

Research lighthouse	Activities 2020-2023
Changes of the cryosphere	Development of improved methods for measuring changes in the cryosphere by new ESA and NASA satellites, supplemented by airborne instrumentation and campaigns including drones. Particular focus on monitoring of changes, for Greenland and Antarctica, as well as Arctic sea ice. In situ research includes the use and development of the GNSS station network in Greenland (GNET) for monitoring mass loss of the Greenland ice sheet.
Sea level and gravity	Development of methods of measurement, processing and interpretation of Earth observation data for sea level and gravity mapping to develop new space-based services for, e.g. assessing climate changes. Gravity field data from satellites are used together with airborne and in-situ data for modeling the Earth's gravity field to fine details, both for use in geodesy (geoid determination) and geophysics (Earth structure).
Geomagnetism – exploring Earth's interior and its environment	Scientific exploitation of data from the 3-satellite constellation mission Swarm. Extending the ESA-funded *Swarm DISC* consortium, which is responsible for the data processing, scientific exploitation, as well as of the communication and public outreach of the Swarm misison. Further develop and improve our world leading geomagnetic reference models, with greater integration of source physics and quality check of data and distribution to customers.
Scientific instrumentation for high energy astrophysics satellite missions	Preparation of focusing optics in hard X-rays for several planned missions and optics for the ESA mission ATHENA in collaborations with institutions in both Europe and USA. Develop X-ray detectors with unprecedented position and energy resolution in the hard X-ray/Gamma-ray range.
High performance autonomous space instrumentation systems	Space exploration instrumentation: Exploration missions with NASA and ESA. Further development and implementation of large-scale aperture systems. Sub-arcsecond technologies: Enabling the next generation satellite platforms by improving the benefit to cost ratio by an order of magnitude. Data fusion methods: Substantially improve autonomy and robustness of operations by correctly fused data from multiple sensor systems.
Radar- and radiometer systems and measurements of the Earth's surface	Microwave radiometer systems, radar systems, and methods of processing and interpreting data from such systems from airplanes and satellites for several applications. Airborne radar and radiometer systems web be developed for ESA for research in new measurement concepts and for validation. Development of advanced radio frequency interference detection and mitigation methods for satellite missions. Methods for processing and interpretation of data from airborne sensors and satellites.

Besides the research lighthouses, there will also be focus on the following key research areas:

Large-scale Structure of the Universe based on science with major telescopes, e.g. ALMA, James Webb Space Telescope, and Euclid through the DAWN center of excellence.

Research on compact objects in order to understand the detailed physics of neutron stars, based on INTEGRAL, SWIFT, NuSTAR, and NICER. Further strengthen research in transients by studying super- and hypernovae explosions as well as by participating in BlackGem, a world wide set of telescopes to do quick follow-up on gravitational wave detections.



NASA's NICER instrument on the ISS with DTU Space star trackers and science CoI-ship

Research in exoplanets through detection and characterization of small exoplanets (sizes between Earth and Neptune). The focus is on: 1) determining the bulk composition of small exoplanets via precise mass measurements and 2) measuring the composition of their atmospheres. This will allow us to infer the diversity of the small planets, discover what types of planetary environments are common in our solar neighborhood and ultimately pave the way for the first detections of life outside our solar system in the atmospheres of these planets.

Through collaboration with Albert Einstein Institute and the Danish company AXCON, DTU Space will further develop the mission enabling phase-meter for the future gravitational wave mission LISA, and will continue effort to determine the physics behind apparently correlation between (some) gravitational wave emitting objects and the electromagnetic radiation observed from those.

DTU Space contributes to several planetary science missions with enabling technology, instruments, and scientific research, e.g. NASAs Juno, Mars 2020 and 2022 missions and the new series of NASA MIDEX missions.

Investigations of the underlying physical-chemical mechanism behind cosmic rays' influence on climate via cloud formation.

The Atmosphere-Space Interactions Monitor experiment was mounted on the ISS in April 2018 and will be exploited extensively to reveal high-energy processes associated with thunderstorms.

Development of applications of satellite-based navigation from new technologies and systems, such as the upcoming European Galileo and its associated services. Perform cutting edge research in high-precision drone navigation and remote sensing aiming at using drone-swarms in fixed constellations and use of drones in polar environments.

Security DTU is a cross-disciplinary center driving strategic cooperation between DTU and the authorities responsible for national safety and security, including the Danish Defense and Police. The long-term establishement of the center will be pursued as the DTU contribution to a national center for defence technology. It is the vision to have the national centre funded by the government budget starting in 2020 and an important purpose is to support the Danish defense industry with applications for and repatriation from the new EU Defense Foundation. For the near future, the focus will be on establishing a cyberhub funded by the Industrial Foundation Denmark and possibly extend it to an EU cyber centre.

Interdisciplinary collaborations with other DTU institutes. DTU Space will collaborate with several DTU institutes and centers, especially for polar and marine related activities (e.g., DTU Byg/Arctic DTU and DTU Aqua/new Polar section), but also on new sensor development (e.g. DTU Compute for inertial navigation system processing, e.g. for drones and aircraft) and development of new methods for data processing with DTU Compute. DTU Space will collaborate with DTU Environment on development of new sensor systems for drones to complement the satellite based Earth observation of Copernicus. DTU Space will collaborate with DTU Physics in various areas, in particular in X-ray optics simulation, where we make use of software developed at DTU Physics to calculate performance of the optics and to compare with our own simulations. DTU Space will collaborate with DTU Management on Smart Cities and urban mobility. The institute continues collaborations with the CERE center and with the Danish Hydrocarbon Research and Technology Centre. DTU Space DroneCenter will drive more inter-institute projects, and support the DTU Collaborative Autonomous Systems initiative.

Additive machine process technology is now proven for space flight use, and expected to add value to a range of high value technologies and products. DTU Space will support the effort of DTU MEK in the creation of a center of excellence in this field, which may service several DTU institutes as well as high tech industries. The activity will be centered around a high-end additive processing facility, but will also address in-situ resource utilization applications.

4. Scientific advice

DTU Space's goal is to be an internationally leading provider of services to public sector authorities in the fields of space science, geoscience and associated technical sciences. DTU Space will develop our scientific advice for ministries, agencies and other public sector bodies on a national and international level.

DTU Space has a central role in advising the Agency for Data Supply and Efficiency (SDFE) on geodesy and mapping. DTU Space engages in a 4 year running agreement with SDFE, as a part of the general agreement between the Danish Ministry of Energy, Utilities and Climate and DTU. DTU Space will expand this cooperation by developing new advisory services and testbeds, such as TAPAS and GNET, for high precision real time positioning and autonomous vehicles developments.

Denmark's membership of ESA and EU is strongly supported by the institute by increased exploitation of the research, innovation and instrumentation opportunities within ESAs' programs and EU space initiatives. DTU Space will further seek to expand its well-founded cooperation with NASA especially regarding instrumentation and Polar programs.

DTU Space is a key adviser to the Ministry of Foreign Affairs on law of the sea regarding maritime delimitation and sovereignty issues, such as the Continental Shelf Project where the Kingdom of Denmark is seeking expanded sovereignty rights beyond the 200 nautical miles' zone in areas around of the Faroe Islands and around Greenland. Furthermore, DTU Space will develop the advising on space infrastructure topics, including connectivity in the Arctic Council work programs.

DTU Space is a key adviser to the Danish Defense on scalable satellite and UAV infrastructures, especially in the Arctic region, supporting the Danish Defense in operationalizing their new Arctic strategy. It is the ambition of DTU Space to leverage the existing cooperation and strong relationships with Danish Defense units to develop other areas where DTU Space may provide primary and beneficial consultancy services in close cooperation with Security DTU. DTU Space will continue the cooperation with the US defense on delivery of satellite instrumentation, mapping of the global gravity field, altimetry and running a core GPS station at Thule Airbase.

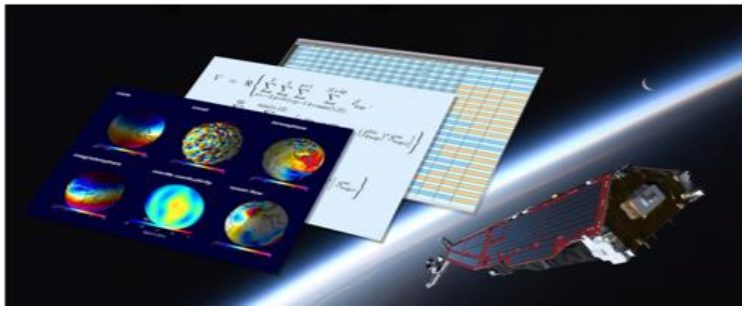
The scientific advice of DTU Space will also cover civil safety and space safety, including space weather, sea ice, radiation and space debris. The potential is considerable for scientific advice within civil readiness, covering issues as securing navigational and communication infra-structures. DTU Space seeks to meet these increasing society demands by international cooperation and cooperation with relevant Danish authorities, such as the National Operative Command (NOST), Danish Meteorological Institute (DMI) and the Danish Defense.

DTU Space will continue the cooperation with different foreign authorities and public organizations via projects on establishment and maintenance of national geodetic reference systems to develop and enhance the use of satellite position and navigations systems. DTU Space will also expand its strategic cooperation with the National Geospatial-Intelligence Agency in USA on these issues with special focus on Asian and African countries, and on Antarctica.

5. Innovation

The overarching ambition for entrepreneurship and innovation activities at DTU Space is to be a driving force for economic value creation within industries where space-related technology, research and know-how can be utilized.

Denmark's National Space Strategy sets out the direction for the Danish space sector in the years to come. The main aim of the strategy is to help businesses harvest the commercial potential of the sector. Supporting the implementation of the Danish space strategy through collaboration with industry, government and other external stakeholders along with other DTU institutes will be a main tenet in the innovation strategy of the institute. There are more than 199 Danish companies with space-



ESA's Swarm mission. DTU Space is responsible for instruments and data exploitation.

related activities. The department already has a large number of industrial collaborations, but will continue to develop the network among space-related Danish companies.

A main focus in the coming years will be the establishment and operation of a DTU-led national European Space Agency Business Incubator Center (ESA BIC). A number of Danish universities, investors and existing incubation environments will be partners in the ESA BIC which will accelerate the incubation of competitive space-related high-tech start-ups in Denmark. The plan is to incubate 40 new high-tech space startups over five years beginning in 2020. Using the ESA BIC as the platform, a number of long-term strategic partnerships will also be established with existing companies.

In close collaboration with DTU Compute and DTU Photonics, DTU Space will continue to be a driving force in the DTU-led national Open Entrepreneurship project which has been funded by the Danish Industry Foundation. The project matches experienced entrepreneurs with researchers to form competitive teams which can turn world-class research into world-class start-ups. It is the aim of the Open Entrepreneurship project to triple the number of research-based start-ups from the participating DTU departments, including DTU Space.

DTU Space will focus on developing the existing collaboration within student innovation and entrepreneurship with DTU Skylab focusing on cultivating the potential for entrepreneurship on the basis of space-related technologies. In collaboration with DTU Entrepreneurship and as part of the contribution to the existing program in Earth and Space Physics and Engineering DTU Space will also develop curricular activities to support the creation of new DTU student space startups for the ESA Business Incubation Center. These activities will be developed to complement the new DTU Master programme on Technology Entrepreneurship starting in 2020.

6. Partnerships

DTU Space has a well-developed and dynamic, global network of partners. Partnerships are established with leading national and international parties who can contribute to realizing the institute's strategic goal as a preferred international partner. In total, the institute has +100 partners globally, and focus will be on agencies and companies in new emerging/expanding space nations, e.g. Japan, China, India, Brasil.

European Space Agency (ESA) is conducting most European scientific space missions, as well as Earth observation missions, and is as such DTU Space’s "home market". DTU Space will collaborate with ESA at all levels from mission design and science studies over core technology and support instrumentation to mission operations and science products.

National Aeronautic and Space Administration (NASA). The largest space organization in the world, NASA, is a key partner and DTU Space will work with most NASA centers.

US universities. The leadership in space research is shared between several universities in USA and the most important are Caltech, Ohio State University, MIT, U. of Texas and Stanford University. DTU Space will collaborate with these universities leading a research field of interest to DTU Space.

Airbus ADS is Europe's largest system integrator with companies in most European countries. DTU Space will intensity collaborations with ADS entities in Germany, France, UK, Spain and Portugal, on technology development and mission designs.

National Geospatial-Intellligence Agency (USA) is DTU Space's largest foreign public authority partner, primarily regarding gravity surveys and gravity field modelling.

GeoForschungsZentrum, Potsdam (GFZ). DTU Space will cooperate with GFZ on e.g. the Swarm and CHAMP satellite missions, via the Swarm DISC consortium.

ETH Zurich. DTU Space will have an intensive collaboration with ETH Zurich as part of the Swarm DISC consortium, focusing on the use of geomagnetic data for exploring Earth's interior.

Technical University of Munich will be a key European partner in gravity field modeling using the GRACE and GOCE satellite missions for determination of ocean currents.

Agency for Data Supply and Efficiency is in charge of the majority of DTU Space's contracted consultancy with the Danish authorities and constitutes the major partner in geoscience.

Danish Meteorological Institute (DMI). DTU Space will continue the long-term collaboration with DMI on, e.g. development of methods for sea ice and glacier monitoring.

The Geological Survey of Denmark and Greenland (GEUS) will be a key partner in the ESA Greenland Climate Change Initiative and the national monitoring of the Greenland ice sheet (PROMICE), as well as the continental shelf project (UNCLOS).

Terma A/S (DK). DTU Space will continue the long-standing and evolving strategic collaboration with Terma, the largest space and defence company in Denmark.

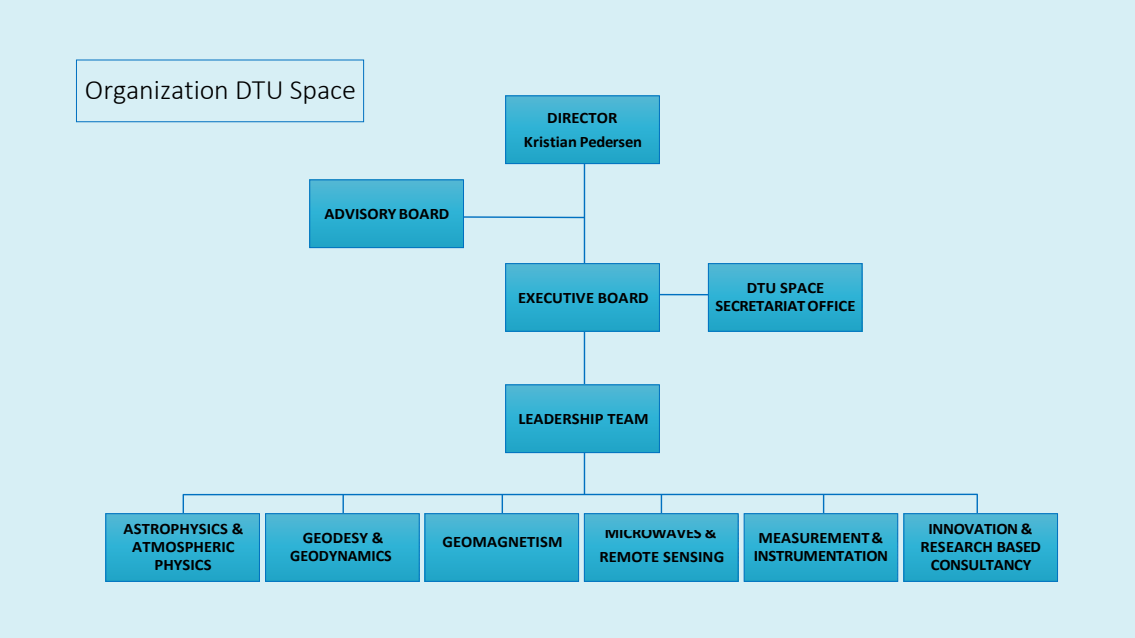
University of Copenhagen (KU). DTU Space will collaborate with KU on research and education within geoscience, climate change, planetary sciences and astrophysics.

7. Human resources

7.1 Organisation

DTU Space has a flat organization, which is dynamically adapted to changing challenges and opportunities. Currently there are 5 academically focused divisions plus the division of Innovation and Research-based Consultancy. DTU Space is lead by institute director Kristian Pedersen, who in addition to the overall responsibility of the institute, is directly responsible for research, PhDs, HR, and communication. The Executive Board consists of Kristian Pedersen, Niels Andersen, who is in charge of innovation and research-based consultancy, and Henning Skriver, who is in charge of education and the institute finances. The institute's operations are carried out by the Management Office (referring to the institute director).

Matters of interest to DTU Space are discussed in the institute's Leadership Team, chaired by the institute director, and consisting of the heads of the six divisions. Permanent as well as ad hoc strategic committees are established in order to discuss activities and strategy within their respective topics and provide advice to the Leadership Team. The committees have typically one representative from each division and take up issues on their own initiative or deal with specific tasks commissioned by the Leadership Team.



7.2 Leader and leadership development

Strategic leadership is a focal point of DTU Space. The division heads actively participate in leading the institute through the Leadership Team, as well as leading their own division. Managers continuously develop their leadership and management skills, typically via DTU's management training program. An important goal is to identify and train the next generation of leaders, and consequently, the role and responsibilities of deputy division heads will be discussed and clarified There will also be focus on succession of division heads. A key outset for the annual performance appraisal interview (LUS) is each manager's performance with regard to the development objectives of the institute's Action Plan. In the LUS it is thus discussed how the individual manager can be supported in order to achieve these objectives and where there might be an unrealized potential.

Top class research is often conceived and carried out by strongly driven individuals. DTU Space embraces this by making room for "stars", as well as by actively nurturing and recruiting upcoming "stars".

DTU Space focuses on job satisfaction and the 2018 institute seminar resulted in a number of focus areas for further improving DTU Space as an attractive work place. Interesting points are identified and action plans for addressing these will be laid out and followed up at institute level, as well as at division level. Hence, focus for the next few years will be on career development, stress countermeasures, and on decreasing the administrative burden.

7.3 Employee development

DTU Space strives to obtain a transparent, simple and effective management where the individual's duties and responsibilities are clear to the individual employee, the colleagues, and

the manager. There is a high degree of delegation and employees are supported to be self-managing, for example through coaching and the annual performance appraisal interview (MUS) discussion. DTU Space has developed a career guide for VIP staff in order to outline typical career paths and focus on continueous interaction between employee and manger on career development. In order to accommodate more career flexibility DTU Space will look into how incentives for sabbaticals and shared employment can be set up, and how the administrative barriers can be lowered. Furthermore, a Strategic Forum is being established with about ~30 employees in order to include key staff, who are not part of the Leadership Team, in the discussions of strategic importance to the institute.

7.4 Attracting and recruiting

DTU Space believes that in order to attract and retain top class employees and achieve some diversity we should foster and develop an attractive work environment with skilled and helpful colleagues, where employee diversity and mutual respect are catalysts for creativity and team effectiveness. Employees should be active in the development of a stimulating work environment, conducive to their best performance, and in accordance with the institute's values and goals. In accordance with this, the most important values of DTU Space are:

(1) *That "rocket science feeling":* The drive to do the best, push the boundaries of knowledge.

(2) *Credibility*: When collaborating with colleagues and when dealing with external partners, it is of prime importance to be credible and capable, to build confidence and lasting relations.

(3) *Recognition*: Employees should be recognized for their achievements, be it individually, as a team or division, or as an entire institute.

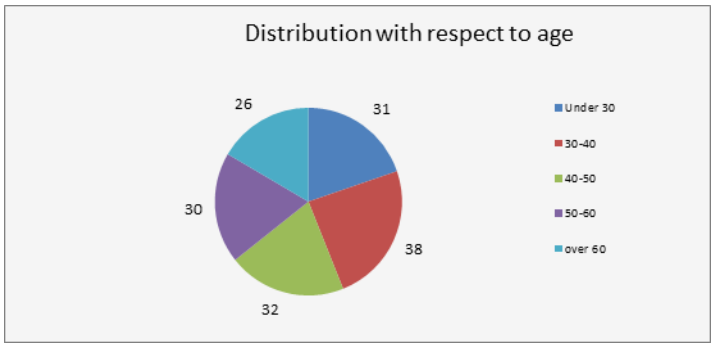
The institute continuously assesses the need to recruit new, excellent staff. This is achieved by nurturing internal talent as well as by attracting the best international candidates. The following research fields will be in focus for recruitment the next four years: Space instrumentation, science analysis of data from instruments, applications of data from instruments.

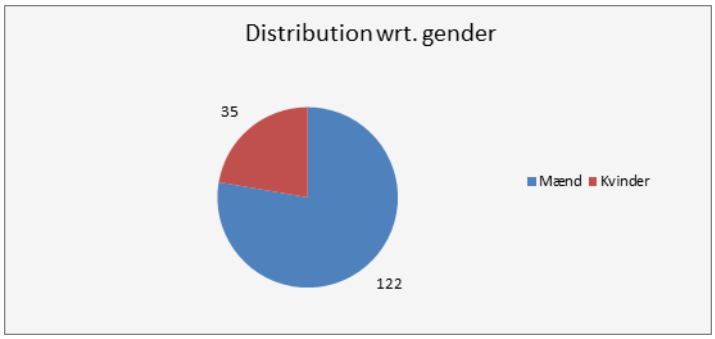
Experiences from the intro-program for new employees as well as exit interviews will be systematically used to improve the work environment and recruiting process. DTU Space's communications efforts are focused on sharpening the profile and visibility of the institute in order to highlight the institute as a leading international space institution, and thus an attractive workplace for all types of employees.

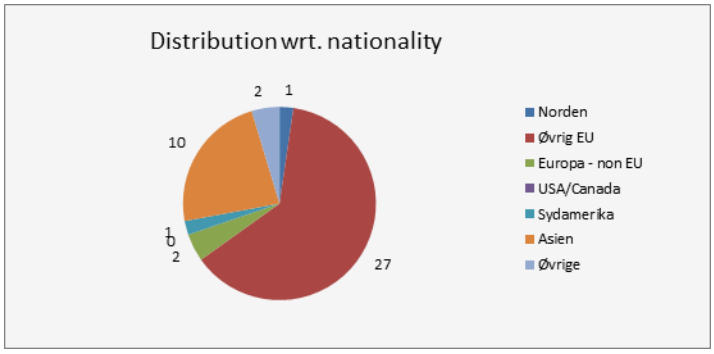
7.5 HR key figures

The general trend is an increasing number of staff at the institute. Several professorships will be filled in order to consolidate and develop strategic areas of the institute. The accompanying figures show the distribution of employees according to gender, nationality and seniority. The gender distribution reflects fairly well that of the recruiting pool, and the fraction of international employees is at a reasonable level. Also the age distribution is quite even so there seems to be no strong imbalances in the employee population at DTU Space. However, overall trends are being monitored in order to make sure that any negative trends are spotted early on so that proper

actions can be taken. There will be particular focus on succession of division heads during the next years, a process which has already started.







8. Material resources

8.1 IT and GDPR

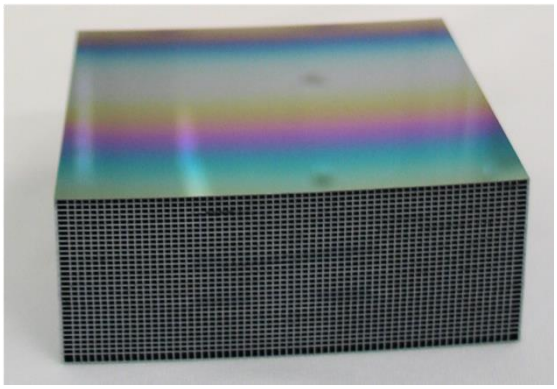
DTU Space continues to work with the IT security group based in AIT to ensure that the ISO system is correctly implemented. This will be completely rolled out and maintained in the UMV period. DTU Space continues to operate and maintain a high performance mini computer cluster

to allow the institute to comply with the requirements to do the scientific processing of data from the Swarm and ASIM missions. The two data centers will store invaluable scientific data, where the focus regarding IT security will be to ensure the data's integrity and availability. DTU Space continues to operate an institute wide Unix server environment which, in close connection with our mini HPC, provides a homogeneous computing environment used for both research and teaching. DTU Space also plans to upgrade and update the current data- and disk servers and parts of the printer park.

The aspects of GDPR at DTU Space is covered by the transverse listings issued by the central administration at DTU. The institute will continue to increase the awareness of GDPR and will issue specific listings to ensure the correct treatment of personal data in any case where the general listings do not comply.

8.2 Laboratory equipment/scientific infrastructure

Instruments and s/w operating in space and from aircraft are the strongest non-human assets of the institute. Through its engagement in technological research satellites, DTU Space also has privileged access to guaranteed observation time (science data) as well as mission management (house keeping) data. This access provides in-situ "space laboratories" where the institute's researchers can conduct investigations and verification of new ideas, concepts or measurement principles. This significant investment forms a crucial basis for the institute's cutting-edge technology research. The number of satellite missions where DTU Space is obliged to process and interpret data has increased substantially recently, and will increase further in the coming years. The data from these missions is a substantial asset, and consequently safeguarded in the "flight control facility". To accommodate the increased number of control panels, DTU Space plan to enlarge this facility in the next two years time frame.



Silicon pore optics element prototype for ESA's Athena X-ray mission.

DTU Space has a significant expertise and know-how in airborne/suborbital flight operations. Key elements include an expensive suite of own-developed or own-implemented sensors (radars, lidars, imagers, GPS, inertial navigation systems, gravity meters, power systems, etc.) and know-how for cold-region operations. The expertice and know-how are used in, e.g. the development of drone systems. Many of the survey grade instruments (GNSS, inertial navigation systems, gravimeters for land and marine use) are getting older and will gradually be replaced.

Qua Denmark's membership of international organizations, DTU Space employees furthermore have access to major international observatories on Earth and in space, accelerators and other research facilities. Continued access to these facilities is absolutely essential to perform state-of-the-art research and technology development and construction.

To meet the market demand, the capability and capacity of two labs will be substantially enhanced in the following years: The (1) Long baseline robotic rail system, and (2) Ultra-stable optical attitude methodology lab. DTU Space will also upgrade its airborne remote sensing instrument

suite (P-band radar, inertial navigation and gravity sensors), primarily for satellite validation and augmentation campaigns.

DTU operates permanent GNSS and geomagnetic stations/laboratories in Greenland and in Denmark, as part of the global network for establishing international standards. Moreover, they form the basis for scientific advice for the authorities of Greenland and the Agency for Data Supply og Efficiency as well as specific deliveries to industry. DTU Space also operates tide gauges to support early warning services, e.g. for tsunamis. DTU Space furthermore sublet specially built non-magnetic pavilions in Brorfelde by Holbæk for geomagnetic observations and calibration of magnetic instruments. The magnetometer station network in Denmark and Greenland will be extended with new stations and existing stations will be upgraded with new hardware for improved temporal sampling.

DTU Space delivered the flight instruments for the NASA2020 rover to Mars in 2019. In preparation for the flight and science support, a test facility must be designed, which can be used to support this mission for the next decade.

8.3 Premises

The rapidly growing field of research and developments related to drones and UAV systems require additional laboratory space for developing the systems, assembling payloads and drones, and storage. Currently, DTU Space supports projects across DTU by providing drones and flights. These activities will expand significantly posing further requirements on the available laboratory space. In addition, separate student facilities are needed to accomodate the growing number of student projects using drones.

DTU Space's involvement in "new space", and the growing number of collaborative projects with industry and government institutions, has resulted in, that the present lab facilities are now being used at full capacity. Further growth and/or further support to our partners, and/or new activities/technologies, will require more laboratory space. The facilities in demand must as a minimum be ISO class 7, be clean from scilicone and be ESD protected. A rational size of 200 m^2 will solve the issue for another 2-4 years at the present growth rate.

With the still increasing number of students in the ESPE program, a focus area over the next years is to improve the facilities to host this student population, i.e. project work space and student meeting rooms. The institute has already allocated rooms for project work, but more rooms needs to be identified in the vicinity of the labs. Also, student meeting and work facilities must be secured for ESPE students e.g. in neighbouring buildings. The lecture rooms and laboratories need to be upgraded with up-to-date e-learning technologies.

Building 348 needs general maintenance due to many years' usage; in particular, selected north-side rooms need glass doors.

9. Communication

DTU Space activities are conducted with the support of, and in close interaction with, society, i.e. industry, authorities and other institutions, and thus the communication efforts support and promote these activities. The institute's communication strategy focuses on strategic communication by identifying key target groups and stakeholders, and by prioritizing objectives, activities and channels for communication efforts. The communication will be based on availability, reliability, professionalism, functionality, and independence and the goal is to be amongst DTU's top-3 institutes regarding media appearances.

DTU Space will focus on recruitment of students from home and abroad to the ESPE education's BSc and MSc program by contributing to DTUs communications efforts, e.g. "DTU Avisen", "Dynamo", dtu.dk, "DTU Open House", "Forskningens Døgn", and "Kulturnatten". The institute will also continue to receive school visits and to give lecturers at colleges as well as promote the institute's activities through the media via, e.g. interviews, articles and popular talks in various fora. The institute will continue the successful use of master students to help develop SRPs.

DTU Space will participate in the public debate by actively setting the agenda as well as with rapid response to requests. The long term effort on engaging with decision makers, through e.g. visits and VIP events, will continue together with DTU's central staff.

Alumni activities are gearing up due to the increasing number of ESPE graduates. Consequently, DTU Space will draw on DTU's other alumni networks with respect to the wider dissemination activities and with a focus on collaboration across DTU. Furthermore, staff, students, and graduates will be used as ambassadors for DTU and the institute when they participate in meetings, conferences and visits abroad.

10. Process and employee involvement

DTU Space's strategy and objectives (including this report) are outlined in close cooperation between the institute director, the institute Executive Board and the institute Leadership Team. Discussions about strategy and objectives are anchored in the divisions of the institute, both through the division heads and through the strategic committees. Strategy and objectives are addressed at the divisions' regular meetings so that all employees have the opportunity to express views and suggestions to be taken up by the strategic committees and by the Leadership Team.

In addition to the formal lines of communication the division heads and the institute director practices an "open door policy", meaning that all employees are encouraged to come by for discussions and expression of opinions.

The study committee, including both representatives for teachers and students, as well as the directors of studies for the B.Sc. and M.Sc. programs of Earth and Space Physics and Engineering and the secretary of studies, has either contributed directly to education and teaching topics or they have had the possibility to comment on the content. The institute's contribution to the other educational programs mentioned in Chapter 2 is coordinated through a continued dialog with the relevant directors of studies.

Appendix C: Strategic transition and infrastructure

If the department has a need for strategic transition and/or research infrastructure and has tried without success to finance this in other ways, describe the proposal in the table below. The proposal will then be included in discussions by the Management Board of strategic proposals presented in the departments' UMV reports.

Where several requirements exist, present them in priority order.

Description	Total budget *preparation, establishment and operation*	Co-financing from the department	Period of time over which the strategic transition will take place	Argument

Appendix D: Discussion points for UMV meeting

1. Budget and staff projects include a new DG center of excellence, ExoOrigins, presumably starting medio 2020. If funded, DTU Space needs office space for an additional 20 people. How can this be realized?
2. The planned activities on satellite instrumentation requires an additional 200 m^2 lab space. How can this be realized?