The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

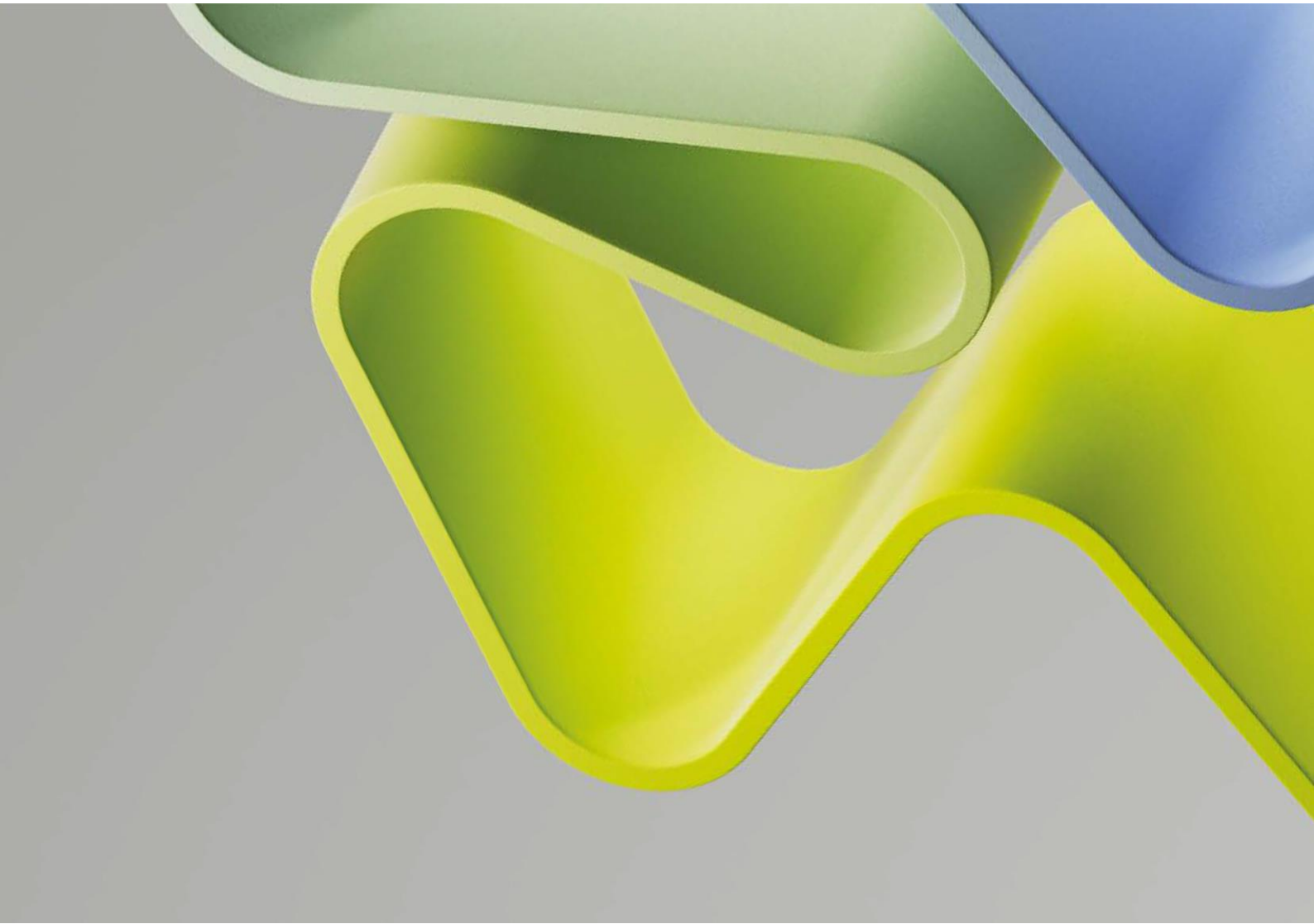
Evaluation Report for Administrative Unit

Administrative Unit: **Department of Marine Technology (IMT)**

Institution: **Norwegian University of Science and Technology (NTNU)**

Evaluation Committee Higher Education Institutions 3

December 2024



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The members of this Evaluation Committee have evaluated the following administrative units at the higher education institutions/research institutes within Mathematics, ICT and Technology 2023-2024 and has submitted a report for each administrative units:

- Department of Industrial Technology, UiT The Arctic University of Norway
- Department of Electric Energy (IEL), Norwegian University of Science and Technology (NTNU)
- Department of Marine Technology (IMT), Norwegian University of Science and Technology (NTNU)
- Department of Mechanical and Industrial Engineering (MTP), Norwegian University of Science and Technology (NTNU)
- Faculty of Engineering and Natural Sciences (FIN) / Faculty of Technology, Environmental and Social Sciences (FTMS), from 1.1.2026, Western Norway University of Applied Sciences (HVL)
- Department of Mechanical, Electronic and Chemical Engineering, Oslo Metropolitan University (OsloMet)
- Faculty of Computer Science, Engineering and Economics (IIØ), Østfold University College (ØUC)
- Department of Electrical Engineering (IET), UiT The Arctic University of Norway
- Department of Technology and Safety (ITS), UiT The Arctic University of Norway
- Department of Electrical Engineering (IT) and Cybernetics (EIK), University of South-Eastern Norway (USN)
- USN School of Business, University of South-Eastern Norway (USN)
- Department of Microsystems (IMS), University of South-Eastern Norway (USN)

The conclusions and recommendations in this report are based on information from the administrative units (self-assessment), digital meetings with representatives from the administrative units, bibliometric analysis and personnel statistics from the Nordic Institute for Studies of Innovation, Research, and Education (NIFU) and Statistics Norway (SSB), and selected data from the National survey for academic staff in Norwegian higher education and the National student survey (NOKUT). The digital interviews took place in the autumn 2024. The members of the Evaluation Committee are in collective agreement with the assessments, conclusions and recommendations presented in this report. None of the committee members has declared any conflict of interest.

The Evaluation Committee has consisted of the following members:

Professor Lina Sarro,
Delft University of Technology (Chair)

Professor Stefania Bruschi,
University of Padova

Professor Khaled Ahmed,
University of Strathclyde

Professor Andreas Müller,
Johannes Kepler University Linz

Professor Maria Teresa Correia de Barros,
University of Lisbon

Professor Kostas J. Spyrou,
National Technical University of Athens

Description of the Administrative Unit

The administrative unit

IMT's strategic knowledge fields are marine structural engineering, marine hydrodynamics, marine energy systems, marine engineering, marine cybernetics, and marine systems design. Within these fields, it has a long list of prioritised applicant areas: Green shipping; Renewable ocean energy; Aquaculture and fisheries technology; Offshore oil and gas; Autonomous inspection, mapping, and intervention; Marine minerals; Arctic marine technology and operations; Floating bridges and other large, floating structures; and Ocean observation.

IMT is a substantial department, with a permanent academic staff of 26 professors and 9 lecturers/associate professors, as well as 69 PhD fellows, 19 postdocs and researchers and 16 adjunct professors or associate professors. About 10% of the permanent academics are women; among the contract academics, the proportion is about twice this.

The research groups of the administrative unit

IMT was originally formed by reorganising a faculty with four small departments – Marine Structures, Marine Hydrodynamics, Marine Machinery, and Marine Systems Design – into first two and later into the following three research groups:

- Marine Structures (MS)
- Marine Systems Design (MSD)
- Marine Energy Systems and Autonomics (MESA),

It will shortly be rehoused into the Norwegian Ocean Technology Centre in Trondheim together with SINTEF Ocean.

The unit's work and strategies

IMT describes its overall objective as to contribute to environmentally and economically sustainable ocean industries in Norway and globally. Its main strategic goals for research and innovation are to do research of high international quality, to own the domain knowledge of marine technology and relevant application areas, to be an attractive partner for companies within its domain, and to contribute to research-based innovation – striving to have research results exploited and to create impact. The Unit regards its strategy as a deepening of the University's overall strategy in the areas of oceans, seas and coasts.

The unit's work in its sector

The unit's sectoral objectives are to provide high quality research and education. This is done close to application, with strong links to industry and 34 reported disclosures to the university TTO during the evaluation period. It has a dedicated innovation manager.

The future of the unit

The self-assessment says little about this, except to refer to the unit's future location in the Norwegian Ocean Technology Centre.

Overall Assessment

The NTNU Marine Technology (IMT) Administrative Unit is a department under NTNU's Faculty of Engineering, serving a key priority area of the Norwegian economy focussed on the sustainable exploitation of marine resources. It is one of the leading departments in Europe and worldwide, offering education and research in ocean engineering and marine technology.

In the Unit, three groups are active with focus on Marine Structures (MS), Marine Systems Design (MSD), and Marine Energy Systems and Autonomics (MESA). However, MS and in particular MESA cover a diverse range of research topics; they resemble sections of a department more than groups in their own right, and they may not be considered as exactly cohesive research groups.

The MS group has a solid foundation and a very prominent position in the international marine structures and hydrodynamics communities, combining fundamental and applied research. It will be a challenge to maintain, however, such a balanced approach in the coming years as key people have retired from the group. MESA is the largest group in the Unit, with a clear orientation towards emerging marine technologies such as sustainable marine vehicles and autonomy. It is very successful in some research areas, as for example in control, risk assessment and others, yet it could benefit from more systematic synergies with the other two groups in involving more first-principles modelling of marine structures. The MSD group covers design and operation. These are topics of continuous interest for the marine technology field, but with an R&D orientation. The visibility of its research impact could be further enhanced.

The Unit is the definitive top destination for study and research in marine technology in Norway. Its esteem is reflected by having co-hosted, over the last twenty years, two Norwegian Centres of Excellence – one for ships and ocean structures and, more recently, one devoted to autonomous marine operations and systems. It also participates in several other innovation-orientated initiatives in Norway. Commitment to instilling innovation culture is proven by the appointment of an innovation manager. The Unit works closely with SINTEF Ocean, an R&D organisation which serves as an excellent interface with the marine industry.

The Unit provides students and researchers with access to a comprehensive range of experimental facilities, which is rare for a university department. The Norwegian Ocean Technology Centre (NOTC), where the Unit participates and which is nearing completion, is expected further to strengthen the Unit's capacity for influential research as well as the Norway's leading role in ocean technology.

Research funding is at a level sufficient for pursuing ambitious research goals. The publication output is, overall, very good in terms of quality and impact.

To enhance efficiency and adapt to new technological and organisational challenges, the Unit has undergone restructuring in two stages, thus demonstrating a commitment to continuous improvement. In its efforts to re-orientate, the Unit should not, however, risk losing its core values, which are grounded in the pursuit of excellence in research, based on an environment nurturing original thinking and learning.

The Unit has in place a programme for attracting international talent based on research fellowship schemes. New faculty members receive support in order to kick-start their academic career and women receive start-up support. However, attracting high-calibre academic staff educated elsewhere seems to be an acknowledged weakness and an area of concern.

Gender balance in the Unit is poor, especially amongst the academic staff. To some extent, this is caused by a lack of sufficient number of female candidates for academic posts in marine technology. Yet, initiatives to improve on this need to be thought out.

To summarise, the Unit is successfully achieving its research goals and is well-positioned for future success, while conforming to institutional and national strategies.

The Terms of Reference for the administrative unit is attached to the report.

Recommendations

1. To maintain capacity for influential research internationally, the Unit should devise a plan for attracting Faculty educated elsewhere that would develop strategically selected scientific and technological areas of interest where the Unit does not have strong in-house expertise. A competitive starting package, family relocation assistance, funding for lab equipment, support for building research team etc, would strengthen the prospect of attracting high-calibre candidates. Additionally, the Unit might consider sending selected members abroad to expand their knowledge and networks in areas where it currently lacks sufficient expertise.
2. Synergies within the Unit need to become more solid. The MESA group's research is likely to benefit by working more closely with the two other groups of the Unit, in order to involve, in higher detail, a marine structure model in the analysis. The MSD group could consider looking into design optimisation issues involving the structure, motions as well as operational factors.
3. First principles safety engineering would complement the risk management studies conducted in MESA, while exploiting the available in-house expertise. Moreover, a wider scope (not only for autonomous vessels) would impart greater impact.
4. Research projects in the Unit are currently mostly applied research, although projects with strong basic research elements are also noted. As the Unit rapidly shifts towards addressing emerging global challenges, it should take steps to preserve the capacity for fundamental research inherited from its past and promote research excellence more actively through specific initiatives. These could include establishing internal awards for excellence; prioritising research achievements as a key criterion in new appointments and promotions; and offering targeted guidance—especially for early-career faculty—on securing funding for foundational research.
5. With access to a comprehensive range of lab facilities, especially after the forthcoming opening of the New Ocean Technology Centre in the next year, the Unit appears to be well positioned to lead a new Norwegian Centre of Excellence, building on the legacy of the previous two centres that it hosted. This Centre should be the driver of research excellence in the Unit.
6. Measures are necessary for ensuring that the academic staff's focus on research and securing funding does not interfere with their attention to teaching and engagement with students.
7. In an era of heightened competition for funding, it is essential to diversify sources by systematically seeking support from the EU and other international entities. PhD grants funded directly from industry would also be beneficial.
8. The Unit's societal contribution regarding its impact on the works of shipping organisations is not very visible, especially in relation to the development of new rules and regulations. It is recommended this to be added to the Unit's priorities.
9. Gender balance in the Unit should be improved. Whilst the availability of research-qualified women in marine technology is low, the Unit should work more actively towards achieving a better balance.

1. Strategy, Resources, and Organisation of Research

NTNU IMT is committed to advancing research that promotes environmentally and economically sustainable ocean industries, aiming to lead both in Norway and on the global stage. It embraces a philosophy of building and sustaining a strong academic knowledge base, which empowers it to competently address current and emerging applications related to the ocean environment.

The Unit has sufficient resources to conduct research with international impact and presents excellent prospect for gaining access to state-of-the-art research infrastructure in the near future. It is successful in attracting the funding that is necessary for pursuing ambitious research goals. Also, it maintains a strong portfolio of industrial and academic collaboration, which help to strengthen the relevance and societal impact of the research. However, increased collaboration with international partners would further enhance the Unit's potential for research with a global impact on a broader range of topics. Also, industrial funding for PhDs could be targeted that would help to orientate research towards challenging technical problems that the ocean industry is currently facing. The academic staff are highly qualified, with sufficient expertise to cover target areas effectively.

The organisation of research corresponds to a top-level academic unit, drawing on the extensive experience gained from previously hosting two Norwegian Centres of Excellence.

1.1 Research Strategy

The strategy for achieving the set goals is aligned with the national strategy of Norway for Blue Oceans and Green Future, as well as with the NTNU's broader research strategy for world lead in the Ocean and Arctic areas. The Unit further develops its strategic plan at the departmental level, which is then refined by the individual strategies of its research groups.

The core knowledge fields are marine structural engineering, marine hydrodynamics, marine energy systems, marine cybernetics, and marine systems design. With this expertise, it is well equipped for advancing the state-of-art in technological fields that have traditionally attracted attention in the Unit, such as, maritime engineering, offshore petroleum and energy, fisheries, and aquaculture. The expertise is also suitable for research in emerging areas, particularly offshore renewable energy and autonomous marine vessels. IMT is facing however the challenge to build upon its established world-class research strengths in order to tackle effectively the new strategic focus fields.

The Unit has access to a full range of experimental facilities for ocean engineering education and research. It works in close collaboration with the R&D organisation SINTEF Ocean, a strategic partnership that enhances also communication and collaboration channels with the marine industry. Such a relation is quite remarkable for an academic department on a world scale, providing also opportunities for career in R&D for highly trained PhD graduates of the Unit. A new Norwegian Ocean Technology Centre is currently built for IMT, with the Unit being fully involved in the planning. The new Centre will be equipped with state-of-art facilities and will likely enable the Unit to expand its research activities and enhance its leading role in Ocean Technology. The Unit is successfully achieving its research goals and is well-positioned for future success, while effectively aligning with both institutional and national strategies. However, in an environment of changing research priorities, there is a threat of losing key competences and depth, a matter that needs to be addressed by the Unit's leadership. The Unit's three research groups seem to correspond to an academic Department's Divisions. The degree of synergy achieved among the members of the groups and also across the groups is unclear.

The Unit respects academic freedom in defining its research directions, with academic staff taking the lead in initiating research and related initiatives. The Unit's research strategy is discussed in special meetings of the permanently employed staff, ensuring that, members of the Unit are fully aware of and contribute to the plan, and accept the Unit's research strategy. The research strategy effectively exploits the legacy of two Centres of excellence that have been hosted in the Unit over the years (the only ones for the field of Technology in Norway) and also of three other research-based innovation Centres where the Unit was a participant. These endowed the Unit's members with very significant expertise. By relying on such a legacy, the research strategy implemented in the Unit successfully cultivates an environment conducive to high-quality research.

Whilst the academic staff's research competences are well known to the experts, the self-assessment document does not fully identify the unique features and contributions associated with the research conducted across the Unit.

In trying to respond to higher level strategies and to funding opportunities, the research groups should pay attention to maintaining the Unit's strength in fundamental studies. They could also consider paying more attention to safety engineering in the marine technology field, which seems to be lacking as a strategic research focus area. This could strengthen the Unit's potential to contribute to the work of organisations such as the International Maritime Organisation.

Recommendations

- Devise a plan for attracting new Faculty members with complementary expertise to the available in-house, for strategically selected scientific and technological areas of the marine technology field.
- At a time of technological shift, take active measures to ensure key competences and depth are not lost.
- Continue pursuing research excellence. Utilise the capabilities of the new Norwegian Ocean Technology Centre to establish a new Centre of Excellence. Use it for developing active collaboration and engagement with established and promising researchers from around the globe.
- Consider enhancing competence on safety engineering topics in marine technology.

1.2 Organisation of Research

The IMT has an efficient research management structure, with the Head of Department (HD) ensuring that activities are effectively performed within the NTNU framework. He is supported, for research matters, by the IMT Deputy Research Leader who is member of the Faculty's research committee and acts also as the local PhD coordinator. A PhD Administrator helps with practical issues of the PhD students. Research groups have their own leaders. The appointment of an innovation Manager is a NTNU novelty that can be highly beneficial for systematically identifying innovation potential within the research projects and PhD studies conducted in the Unit. There is also a Digitalisation Engineer for internal data management, internal software maintenance etc, and a Communication Manager, for the dissemination of research results.

The organisation reflects a cohesive, very well-thought-out research strategy, aligning very well to NTNU's organisation and research culture. The Unit contributes to the formulation of NTNU's strategic goals by participating in the university's future technology studies.

The academic expertise in the Unit is broad and interdisciplinary. This is particularly advantageous for conducting research in ocean engineering/marine technology—fields that are inherently broad and diverse. Some collaborative research involving the Unit's staff members is evident in the publication output. However, it remains unclear whether the interdisciplinary approach, exploiting the internal expertise, is a deliberate choice or occurs incidentally. This can be particularly important in a period of refocus towards new emerging fields where the optimal utilisation of academic resources is vital. It is therefore recommended that the Unit systematically develop synergies to exploit internal expertise better.

The three research groups are all of good international standing and are successful in attracting research funding with very good output. The Marine Structures group has enjoyed an outstanding reputation over the past several years with a tradition of high-level fundamental and applied research. The Marine Systems Design group has a strong cooperation record with key Norwegian partners and has been successful in transferring research findings into industrial applications. The Marine Energy Systems and Automatics group is the biggest group in the Unit, combining two thematic areas that are quite diverse while being very modern. Their submission to the current assessment as a single group seems to reflect the organisational structure of the Department rather than the underlying research group structure.

During the interview, the academic staff said that that the administrative support for managing research in the Unit is efficient and service orientated.

The synergy between education and research is good. The Unit implements a policy of learning through research. Masters and PhD students benefit greatly from the fact that their mentors are actively engaged in research.

Recommendations

- Ensure that the current, very well thought out, research management structure truly works in practice.
- Adopt a more systematic approach to developing synergies and motivating collaboration through an interdisciplinary framework.
- The MESA group's research could benefit from working more closely with the two other groups of the Unit, for example in order to involve more first-principles-based marine structure models. The MSD group could consider looking into design optimisation issues involving the structure, the motions as well as operational factors.
- As a research-led Unit, it is essential to ensure that academic staff maintain a balance, allowing its focus on research to complement rather than interfere with its commitment to teaching and student engagement.

1.3 Research Funding

The department steadily manages a large number of projects (98 in the period 2018 to 2022). Some 64% of these are funded by RCN, 9% by the EU and 9% by the industry.

The total R&D funding (except the basic funding from the Ministry) for the above period was 76,114,000 NOK. For a faculty of 35, 16 adjunct professors and 88 PhD students and postdocs it can be considered, overall, as satisfactory, although it is understood that the funding is not equally allocated to all academic staff members. The research output seems large compared with the amount of funding received, implying an efficient organisation and excellent utilisation of resources.

Since a large portion of the research is applied, many opportunities for increasing and diversifying research funding should be available. As was said during the interview, in the last two years the Unit has succeeded in significantly increasing the funding received from the EU. However, the Unit should ensure that this is not incidental and these funding sources, especially in the EU, are approached regularly. The Academic staff (especially the younger members) need to receive training to be effective at this. With the state-of-the-art research laboratories soon to be available at the new Norwegian Ocean Technology Centre, the Unit will become a highly attractive partner. This presents an opportunity to pursue additional funding sources, particularly from the EU. The Unit recently secured an Advanced Grant from the ERC. This is a significant achievement, rare in the field of marine technology. Securing industry funding directly to support PhD positions would also be beneficial for enhancing the relevance and direction of the research. However, this should not come at the expense of the attention given to fundamental research within the Unit.

The unit has a good network of academic and industrial collaborators, which facilitates the formation of strong research teams and successful proposals for funding. However, it is not very clear what internal mechanisms the department has in place for supporting the academic staff (especially the younger members) in obtaining research funding. Such mechanisms should include access to information (such as Calls), support in proposal writing, assistance in finding suitable partners, and more. It is recommended this matter to receive the Unit's attention.

Recommendations

- Offer training programs for new academic staff to enhance their skills in securing research funding and building professional networks.
- Continue strengthening the focus on attracting EU funding. The new Ocean Technology Centre’s state-of-art facilities will enhance the Unit’s appeal to European research consortia.
- Aim to enhance funding from industry directed to grants for PhD and postdoctoral research.

1.4 Research Infrastructures

The Unit has access to a wide range of laboratory facilities for conducting research. Together with SINTEF Ocean, they host several hydro-laboratories, including an ocean basin, ship towing tank, wave flume, cavitation laboratory as well as laboratories for machinery, marine cybernetics, and marine structures. These are managed by the joint Marine Technology Centre (MTC).

The new Norwegian Ocean Technology Centre (NOTC) currently being built for NTNU and SINTEF Ocean represents a 10 billion NOK national investment. It is planned to be available in 2025. In collaboration with the NTNU IHB department, the Unit also participates in developing the OceanLab and its later extension the Fjordlab. These will be integrated into NOTC. Whilst the Committee was not informed about the type and the specifications of the new laboratories, the scale of the investment strongly suggests that they will significantly enhance the Unit's potential for advanced research, further strengthening its leading position in research and education.

The Unit is an active user of National High Performance Computing resources, mainly for hydrodynamic and oceanographic simulations.

Recommendations

- Ensure a good balance of skills within the Unit for effective utilisation of the research facilities.
- Motivate the academic staff actively to utilise and engage with the facilities.

1.5 National and international collaboration

The Unit has developed effective collaborations with academic and industrial partners, exploiting the researchers' extensive network of contacts. Sabbatical leaves are sometimes used to establish new international collaborations and strengthen existing ones. The Unit's general policy is to be selective and seek to collaborate with the best. Individual researcher-to-researcher collaborations are highly valued, reflecting the collaborative nature and spirit of these partnerships.

The main national partners are SINTEF (mainly SINTEF-Ocean), local industry active in ocean technology, and universities located in the Arctic (the University of Tromsø, the University Centre at Svalbard). Active collaboration with industrial leaders, such as, Kongsberg Maritime, Equinor, Aker Solutions, TecnhipFMC, Subsea7 and others, has been established, mostly in the context of international multi-partner collaborative projects. Several collaborations with international academic and research institutions have been developed over the years with partners such as, the Hamburg University of Technology, Shanghai Jiao Tong, University of Michigan, Italy's National Research Council (CNR), University of Porto and others.

The collaboration profile has served the research interests of the Unit well. Nonetheless, the establishment of new partnerships should be encouraged, in the EU and elsewhere. These will help attract funding and enhance the value of the research by expanding the researchers' knowledge base, increasing the relevance of their work, and encouraging them to explore new directions and research topics.

Recommendations

- Preserve domestic strategic alliances and especially the one with SINTEF-Ocean.
- Extend collaborative efforts with EU and other international partners.

1.6 Research staff

With a faculty consisting of 35 professors of all ranks plus 16 adjunct professors and 139 total scientific staff, the Unit is one of the largest marine technology academic departments in the world. The research staff is generally of a high academic standard, and includes some outstanding scientists recognised worldwide for their contribution to ocean technology. These have developed an excellent research environment producing high-calibre PhD graduates and postdocs.

The ratio of professors to temporary researchers is satisfactory (about 1/2.5) enabling good interaction and supervision. It is not clear how many PhDs and postdocs can simultaneously be supervised by a single professor, nor what the PhD graduation rate and time are. A large portion of the faculty members are over 50, so the department is actively hiring new qualified scientific staff.

While it is tempting to recruit from the pool of highly competent scientists who are PhD graduates of the Unit, it is important also to look internationally to broaden the scope of the research and expertise. The Unit seems to be addressing this challenge, to some extent. The Unit always sets up search committees for new appointments. A Fellowship program

has been set up for recruiting promising international researchers some of whom later join the faculty. The Unit could consider sending members abroad, for a period of time, for strategically selected areas, in order to increase competence.

New faculty members receive support to kick-start their academic career in the Unit. They are offered a starting grant, a PhD position and mentoring. Sabbatical leaves are encouraged as they are seen as a strategic necessity for international networking.

Promising master's students are offered an integrated PhD track to start their PhD study before graduating their master's.

A gender balance criterion is applied in recruitment but the availability of female candidates for marine technology posts is relatively low. The gender balance is better among PhDs and postdocs while the faculty is still male dominated. The Unit should enhance efforts to improve gender balance.

Recommendations

- While the Unit has the critical mass of expertise and manpower required for competitive marine technology research, it is essential to ensure a consistent research effort across the Research Groups, with all academic staff actively participating in research activities.
- Assistance and benefits provided to newly hired academic staff need to be competitive from an international perspective.
- Gender balance, especially among academic staff, needs to be substantially improved. The Unit should create clear pathways to support the academic development and career progression of female graduates.

1.7 Open Science

The Unit follows NTNU's policy for Open Science. The main goal of this policy is to enable access to research results, data and methods, applying the rule, "be as open as possible but also as closed as necessary".

Staff is encouraged to publish with "open access" in high rank scientific journals. It is understood that this is often financially supported by project funds, but it remains unclear whether NTNU has agreements with publishers that allow its members to publish open access when such external funding is unavailable.

The Unit is committed to establishing open access to research data, applying the FAIR principles for data storage and archiving. Hence it is establishing a system for storing data from its laboratory research. The Unit is also working towards establishing an open-source software development culture. While recognising current efforts, prioritising the FAIR principles is essential, and the Unit should explore ways to accelerate progress through strategic collaborations.

Recommendations

- Offer training programs to academic and research staff to promote wide adoption of the FAIR principles.
- Ensure that the system for storing laboratory research data that is currently under development is practical and user friendly. Forge strategic collaborations to facilitate and accelerate this system's development while ensuring compatibility with international trends.

2. Research Production, Quality and Integrity

NTNU-IMT is an internationally leading place of academic study and research for ocean engineering/marine technology. The output of its research groups varies; but in general, research performance is of a high standard. It is active in a range of research fields, some of which are traditional for ocean engineering and others are newly emerging. The expertise of the academic staff extends over the following scientific and technological topics:

- Marine Structural Engineering, with focus on structural reliability of various types of structures, hydroelastic and hydroplastic responses; marine operations (wave observation and prediction, structural monitoring methods); and new materials.
- Marine Hydrodynamics, with focus on wave-induced loads and motions of structures, ship resistance and propulsion; multi-body hydrodynamic interaction; bio-hydrodynamics; sloshing; wave kinematics and breaking waves.
- Marine Energy Systems, with focus on internal combustion engines, emission reduction by new fuels, new power/energy concepts for propulsion, condition monitoring and powertrain analysis, system analysis and optimisation, design and control of hybrid-electric systems.
- Marine Cybernetics, with focus on applications of automatic control to ocean engineering, autonomous marine systems and operations, risk monitoring and management for autonomous systems, marine robotics, digitalisation, fault detection and error handling, use of AI in marine control systems.
- Marine System Design with focus on design theory, optimisation/simulation/data analysis, multi-objective analysis of complex marine systems, systems performance in terms of risk, environmental impact, and economy.

Applications of the research conducted in these fields are orientated to green shipping, renewable ocean energy, aquaculture and fisheries technology, offshore oil and gas, arctic operations, floating structures, ocean observation and intervention.

The above constitutes a strong portfolio of research with a clear focus on national and international industrial and societal priorities. Perhaps one area that could have appeared more strongly is scientific approaches to engineering safety, which is intrinsic to most of the research topics and combines well with the unit’s risk assessment research.

The Unit has been a key actor in Norway’s development of its oil and gas industry with the pioneering research studies of its earlier professors (currently emeriti) of Marine Hydrodynamics and Marine Structures who had a status of world leaders for their scientific fields.

Publication and citation analysis data indicate that, for 2021, NTNU contributed about half the Norwegian publications in the field of marine technology. Moreover, over the years the Norwegian output in marine technology appears stable with respect to the total scientific publication volume of Norway. Norwegian publications in marine technology are cited slightly higher than the global average.

The number of NTNU publications for 2021 was 184. Considering these to be mostly produced by Unit’s staff and their collaborators, for a faculty of about 35 this corroborates an excellent publication record also in terms of volume. About one third of these papers were in the journal Ocean Engineering and the rest in other well-established ocean/marine technology journals.

The Unit actively applies the university's general policy for research integrity and the associated guidelines and procedures.

2.1 Research quality and integrity

The reports of the expert panels for the three research groups submitted to the evaluation are summarised below:

Research group Marine Systems Design (MSD) overall assessment

The group specialises in the design and operation of marine systems, by applying design methodologies, system analysis and management methods. It covers sufficiently the main marine design research areas, namely shipping, offshore oil & gas, fisheries, aquaculture and ocean energy production. The group consist of 8 faculty members (three full professors, one associate professor, two assistant professors and two adjunct professors), 2 postdocs and 15 PhD students, which is considered rather small, given the group's broad scope. Its contribution is mainly in digitalising the ship design process, optimising fleet structure for sustainability and competitiveness, improving aquaculture operation and technologies. Strong interdisciplinary cooperation with key Norwegian players is noted. The Group has also developed academic collaborations with foreign institutions. Several research projects of the group deal with the transfer of research findings into industrial applications and the development of methods that support decision-makers in industry in the planning and introduction of new technologies into industrial operation or commercial utilisation. In an international context, the group is relatively successful, based on the number of research projects and publications in scientific journals. The research group should enhance its international and European cooperations and seek more funding from international sources including the EU.

Research group Marine Structures (MS) overall assessment

The group specialises in marine structural mechanics and hydrodynamics, in some cases combining these for dealing with fluid-structure interaction (FSI) problems. It has a tradition in fundamental research as well as in applied high-level work for serving Norwegian marine industry needs, but is relatively understaffed in terms of faculty, which comprises 10 members and, in addition, four emeriti, six adjunct professors, four postdocs and 38 PhD students. The group has a prominent position in the international marine structures and hydrodynamics research community. International collaboration and mobility are at very good level. However, as the research group goes through a transition to younger faculty, it is a challenge to maintain its high research standards. In particular, the group's ambition to strengthen its fundamental research capabilities while contributing to society through national and European projects (including industrial) is excellent but it will be difficult to achieve. It receives about 50% of its funding from RCN and 30% via basic state funding, but international funding is comparatively low. It mainly uses the SINTEF Ocean and national High Performance Computing facilities experimental research, but also has an in-house lab for testing structures and materials and a small towing tank, mostly for student projects. It has also access to a research vessel. The group's structure is functional, and the produced publications are of excellent quality. The practice of cooperating with industry via adjunct professors is good and should be continued, and possibly extending via industry PhDs. The research group is well connected to Norwegian industry with several adjunct professors active in the group, it can thus be expected that the research performed have societal benefits for Norway.

Research group Marine Energy Systems and Automatics (MESA) overall assessment

This group specialises in marine energy conversion, machinery, robotics, cybernetics, autonomy and risk assessment. Its current research focuses mainly on: risk assessment for autonomous navigation; sustainable maritime transport, with a focus on electrification; exploitation of offshore wind; underwater operation using robotics; and fisheries. All these relate to newly developed directions of research which however represent niche areas of marine research internationally. The research group's size is above average, with 15 Faculty members, 2 postdocs and 45 PhD students. However, as the topics addressed within the group are quite diverse, it is a challenge to maintain the coherence of the group in the longer run. The group should strengthen its ties with the two other IMT research groups in order to enhance its modelling capabilities. The level of funding attracted by the group is good, with 40% coming from RCN. The research quality is very high, and the group should consider also publishing also in highly esteemed journals outside the marine/maritime sector. The assessment panel also recommend looking more into the optimisation-based design of energy systems. The group maintains a very good network of collaborations at national and, to some extent, international level, with a good mix of academic and industrial partners. The group's research reaches society through teaching, collaborations with the industry and through official relationships with the public institutions.

3. Diversity and equality

The Unit is subject to the NTNU policies (especially the university's HR policy) for protection against any form of discrimination and harassment. These are appropriate, though it is not explicitly stated in the self-assessment whether staff and students receive formal induction to these policies. Regular informal meetings are used for communicating NTNU's values and policies in a welcoming environment. In general, the Unit is successful in maintaining a work environment characterised by friendliness, respect and inclusivity, regardless of ethnicity or gender.

The university's plan for gender equality and diversity is implemented via specialised funding schemes. A start-up program is available for women and other underrepresented groups.

In recruitment it is ensured that equal opportunities are provided for all applicants. However, despite the AU's efforts, there is still a gender imbalance, and more active efforts should be made to recruit qualified women into the faculty.

4. Relevance to institutional and sectoral purposes

The research conducted at the Unit is highly relevant to both institutional and sectoral objectives. In the last few years, the research has clearly been reorientated towards satisfying sustainable development goals. It is high quality and internationally recognised, addressing topics relevant to both current and future challenges in the marine technology industry. The research groups tackle a diverse array of topics and, while upholding academic freedom.

The Unit provides university education in marine technology, promoting a learning environment that prioritises quality over efficiency. The philosophy is to focus first on the basics and build upon these towards the Sector's application areas. As a result, graduates are quite adaptable to technological changes. In general, the graduates enjoy an excellent reputation in the market. One 5-year integrated MSc program and two MScs (one in Norwegian and the other in English) are run by the Unit for the Marine Technology discipline.

Also, it participates in the joint Nordic Master in Maritime Engineering and in the Erasmus Mundus Joint Master in Marine and Maritime Intelligent Robotics. Several MSc Theses are the result of cooperation with industry or research partners.

Education is linked to ongoing research in the Unit. This provides numerous benefits for the students, such as, enhanced understanding of concepts and methods through practical application; opportunities for connecting with faculty and industry professionals; learning through example about current trends; and others.

In terms of PhD education, the Unit participates in the university's PhD in Engineering program. Currently, about 100 students study towards the doctoral degree. They are all supported financially and most of them participate in collaborative research projects run by academic staff.

The Unit has a very clear orientation towards serving Norwegian ocean industry's needs thereby contributing to value creation. As the Ocean industry is a major contributor to the Norwegian economy, the Unit's impact to technological innovation for society's welfare is great and indisputable. The focus on innovation is evidenced by the good track-record of nine spinoffs and the appointment of an innovation manager who helps to instil a culture of innovation in the Unit.

5. Relevance to society

Ocean technologies are of vital importance to Norway and IMF is the main academic hub of the country for high-level education and research in these technologies. Among the sectors served by the Unit are: shipping, including arctic operations; offshore and renewable energy; offshore marine operations; marine mining; aquaculture, fisheries and fish-farming; coastal infrastructure; maritime tourism; and ocean science and management. New focus areas are also served, including marine decarbonisation and electrification; smart marine structures; offshore wind installations; floating solar structures; and others. Among the UN SDGs the Unit pursues a number of relevant goals, mainly Zero hunger; Affordable and clean energy; Industry, innovation and infrastructure; Climate action; and Life below water.

Despite the Unit's international standing, it was not clear whether there were cases where research has yielded notable impacts to shipping organisations, in particular with regard to the generation of new regulations, rules, guidelines and others. This would constitute an important societal contribution of the Unit. On the other hand, members of the Unit contribute to international engineering organisations like the ISO.

5.1 Impact cases

4 impact cases were submitted by IMT that are briefly discussed below. It is believed that, given the strength in research of the faculty, more case could have been presented. Unfortunately, no additional impact cases were found at IMT's website (https://www.ntnu.edu/web/imt/impact-cases). The three out of the four presented impact cases are associated with a high number of publications.

Comments on impact case 1:

Fostering Entrepreneurship and Shaping the Future Business landscape of Autonomous Ships

This impact case is relevant to the IMT strategic goals and has been accomplished together with the NTNU Centre for Autonomous Marine Operations and Systems (AMOS) in the

period 2014-2023. As noted, 8 spinoffs have been realised out of the AMOS research centre, indicating the strong relevance of the research to societal needs. Key contributions relating to the current impact case are, a methodology to automate and formalise the simulation-based testing of autonomous ships and a framework for online risk modelling of autonomous ships. Two professors and 1 adjunct professor have led the effort. A number of research projects have contributed to this impact case, some funded in part by RCN (such as a Ferry and SFI Autoship). Regulatory impact has also been realised on the basis of a project led by DnV, relying on the NTNU concept of automatic simulation-based testing for autonomous ships. However, the presentation of the impact case could usefully have addressed more clearly the research achievements instead of discussing the challenges at length.

Comments on impact case 2:

Realising Digital Twin Technologies for Offshore Slender Structures

A new time-domain model has been developed, accounting for all load types (wave and vortex induced), for marine risers and power cables connecting floaters to seabed infrastructures. The level of detail in the modelling and the tendency to rely on first principles rather than empirical coefficients makes the approach suitable for realising an effective digital twin technology for slender offshore structures. The research is relevant and of high academic and practical value. It is led by 3 professors and 1 professor emeritus. The impact case outlines nicely the research contributions which can be important for the offshore industry. A number of major industrial partners, in cooperation with SINTEF Ocean, have supported the development of this digital twin technology featuring an integrated 3D nonlinear time-domain motions and finite element tool.

Comments on impact case 3: (NTNU and SINTEF)

Research-Based Innovations towards Improved Energy Efficiency and Reduced Harmful Emissions from the Maritime Sector (SFI Smart Maritime)

This impact case is jointly submitted by NTNU (IMT) and SINTEF Ocean under the name SFI Smart Maritime. A very extensive network of Norwegian industrial partners supported this effort which has been realised over the period 2014 to 2023. More than 30 funded projects make up the SFI impact case. The research is led by 5 NTNU professors and it is focused on the development of hydrodynamic (hull and propeller) and power system simulation tools for ship performance evaluation. The research supports regulatory efforts at IPCC, IMO and ISO and it has also some immediate technological impact to onboard installations for reduced emissions of greenhouse gases. A large number of PhDs have been completed in association with this research. Several R&D innovations accrued from SFI, benefiting industrial partners and the society. However, the impact case could have addressed more clearly the new findings and methodologies developed which could lead to improved energy efficiency onboard.

Comments on impact case 4:

Implementation of Research-Based Marine Technology Education for Improved Interaction between Aquaculture Industry and Academia: “Bridgehead Aquaculture 2050”

This research impact case outlines the regional multi-partner Bridgehead Aquaculture 2050 platform that was established for bringing together aquaculture stakeholders and academia, in order to raise the engineering competence and innovation capability in aquaculture. These efforts mainly took place over the period since the platform’s establishment and funding by

RCN in 2018, although there were also earlier activities involved. An aquaculture engineering bachelor's programme, a pilot package of the Master of Technology called "Minor in Aquaculture", an annual conference and a series of specialised meetings at various places are considered products of this initiative. An increasing number of NTNU students have undertaken projects on aquaculture topics, exploiting the facilities of the Bridgehead Aquaculture 2050 platform. While the platform can be regarded internationally as a cooperation model for regional aquaculture development, it is not clear whether and how Faculty members are involved in relevant research, nor is the standard of this research clear. Moreover, specific research contributions are not included in the impact case.

Methods and limitations

Methods

The evaluation is based on documentary evidence and online interviews with the representatives of Administrative Unit.

The documentary inputs to the evaluation were:

- Evaluation Protocol that guided the process
- Terms of Reference
- Administrative Unit's self-assessment report
- Administrative Unit's impact cases
- Administrative Unit's research groups evaluation reports
- Bibliometric data
- Personnel and funding data
- Data from Norwegian student and teacher surveys (only for HEI's)

After the documentary review, the Committee held a meeting and discussed an initial assessment against the assessment criteria and defined questions for the interview with the Administrative Unit. The Committee shared the interview questions with the Administrative Unit at least two weeks before the interview.

Following the documentary review, the Committee interviewed the Administrative Unit in an hour-long virtual meeting to fact-check the Committee's understanding and refine perceptions. The Administrative Unit presented answers to the Committee's questions and addressed other follow-up questions.

After the online interview, the Committee attended the final meeting to review the initial assessment in light of the interview and make any final adjustments.

A one-page summary of the Administrative Unit was developed based on the information from the self-assessment, the research group's evaluation reports, and the interview. The Administrative Unit had the opportunity to fact-check this summary. The Administrative Unit approved the summary with very minor adjustments.

Limitations

The Committee judged that the Administrative Unit self-assessment report was insufficient to assess all evaluation criteria fully. However, the interview with the Administrative Unit filled gaps in the Committee's understanding, and the information was sufficient to complete the evaluation.

List of administrative unit's research groups

Institution	Administrative Unit	Research Groups
NTNU	Department of Marine Technology	Marine Systems Design
		Marine Structures
		Marine Energy Systems and Automatics

Terms of Reference (ToR) for the administrative unit

The board of the Faculty of Engineering, Norwegian University of Science and Technology (NTNU), mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess the *Department of Marine Technology* (IMT) based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality, and diversity of research conducted by IMT as well as its relevance to institutional and sectoral purposes and to society at large. You should do so by judging the unit's performance based on the following five assessment criteria (a. to e.). Be sure to take current international trends and developments in science and society into account in your analysis.

a) Strategy, resources and organisation

b) Research production, quality and integrity

c) Diversity and equality

d) Relevance to institutional and sectoral purposes

e) Relevance to society

For a description of these criteria, see Chapter 2 of the mathematics, ICT and technology evaluation protocol. Please provide a written assessment for each of the five criteria. Please also provide recommendations for improvement. We ask you to pay special attention to the following 5 aspects in your assessment:

1. As a department under NTNU's Faculty of Engineering, IMT follows common strategic goals and priorities from both a faculty level and centrally at NTNU, as well as on a departmental level. Relevant strategic documentation from NTNU has been listed under "Documentation". Note that the Faculty of Engineering's Research Strategy for 2018-2022 is still valid.
2. IMT is responsible for 3 research groups, i.e., Marine Structures (MS), Marine Systems Design (MSD), and Marine Energy Systems and Autonomics (MESA), all within the domains of mathematics, ICT, and technology.
3. IMT was formed by the reorganization of a faculty with four small departments named Marine Structures, Marine Hydrodynamics, Marine Machinery, and Marine Systems Design. These were merged into one department under the Faculty of Engineering Science and Technology in 2001, and the four original groups were reorganized into two research groups: *Marine Structures* (consisting of the earlier Marine Structures and Marine Hydrodynamics departments, and about the same time added the discipline of Marine Cybernetics) and *Marine Systems* (consisting of the earlier Marine Machinery and Marine Systems Design departments). In 2022, the scientific staff within the original two research groups were reorganized into the following three groups:
    a. MS (or MK in Norwegian): Scientific profile within marine structures and marine hydrodynamics.
    b. MSD: Scientific profile within marine systems design and project engineering.
    c. MESA: Scientific profile within marine cybernetics and robotics, autonomous marine systems, marine machinery, and marine electrification and decarbonization.

Since the reorganization is recent, but in total consists of the same staff as earlier, the groups should be evaluated with respect to the activities, track record, and impact of the scientific members of each group.

4. IMT has been temporarily located at the NTNU campus Moholt in Trondheim since 2022 while the Norwegian Ocean Technology Centre is being built at Tyholt (expected relocation in 2025).
5. IMT has co-hosted the Centre of Excellence on Autonomous Marine Systems and Operations (NTNU AMOS), with centre leader in the marine cybernetics subgroup.

In addition, we would like your report to provide a qualitative assessment of IMT as a whole in relation to its strategic targets. The committee assesses the strategy that the administrative unit intends to pursue in the years ahead and the extent to which it will be capable of meeting its targets for research and society during this period based on available resources and competence. The committee is also invited to make recommendations concerning these two subjects.

Documentation

The necessary documentation will be made available by the mathematics, ICT and technology secretariat at Technopolis Group.

The documents will include the following:

- A report on research personnel and publications within mathematics, ICT, and technology commissioned by RCN.
- A self-assessment based on a template provided by the mathematics, ICT, and technology secretariat.
- Strategic plans of relevance from NTNU and its Faculty of Engineering, (hyperlinks to NTNU-sites included): o NTNUs main strategy 2018-2025 (e)
    - NTNUs development agreement with the ministry 2023-2025 (n)
    - NTNUs wider contribution to innovation, (n)
    - NTNUs international development plan 2023-2025 (e)
    - NTNUs development plan for open science 2023-2025 (e)
    - NTNUs development plan for gender equality and diversity 2023-2025 (e)
    - Faculty of engineering main strategy 2018-2025 (n)
    - Faculty of engineering research strategy 2018-2022 (e)
- Strategic plan (n) and Annual action plan 2023 (n) for IMT (enclosed)

Interviews with representatives from the evaluated units

Interviews with the IMT will be organised by the evaluation secretariat. Such interviews can be organised as a site visit, in another specified location in Norway, or as a video conference.

Statement on impartiality and confidence

The assessment should be carried out in accordance with the *Regulations on Impartiality and Confidence in the Research Council of Norway*. A statement on the impartiality of the committee members has been recorded by the RCN as a part of the appointment process. The impartiality and confidence of committee and panel members should be confirmed when evaluation data from IMT are made available to the committee and the panels, and before any assessments are made based on these data. The RCN should be notified if questions concerning impartiality and confidence are raised by committee members during the evaluation process.

Assessment report

We ask you to report your findings in an assessment report drawn up in accordance with a format specified by the mathematics, ICT, and technology secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to the IMT and RCN. The IMT should be allowed to check the report for factual inaccuracies; if such inaccuracies are found, they should be reported to the mathematics, ICT, and technology secretariat within the deadline given by the secretariat. After the committee has made the amendments judged necessary, a corrected version of the assessment report should be sent to the Faculty of Engineering, NTNU, and the RCN no later than two weeks after all feedback on inaccuracies have been received from IMT.

Appendices

1. Description of the evaluation of EVALMIT
2. Invitation letter to the administrative unit including address list
3. Evaluation protocol
4. Template of self-assessment for administrative unit (short-version)

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