

National Institutes of Natural Sciences
National Institute for Fusion Science

NIFS Peer Review Reports in FY2023

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National Institute for Fusion Science
Advisory Committee External Peer Review Committee

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Summary

of the External Review Report in FY2023

The FY2023 NIFS External Peer Review Committee (hereafter referred to as “the committee”) held its meetings and hearings from Oct.27, 2023 to Feb.7, 2024 and communicated intensively via E-mail to evaluate “Unit System (US)” and “Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section (IAGCS)”. Since these innovative organizations were just launched at the beginning of this fiscal year, the charge to the committee is to review the important issues in this initial phase including strategy, readiness, and action agenda along with the perspectives defined by the Advisory Committee. It is also an important aspect to check how their activities contemplate "Recommendations on for the Future of NIFS" and "Recommendations for the Future Collaborative Research of NIFS" compiled by the appointed Working Group and endorsed by the Advisory Committee in FY 2021 and FY 2022, respectively.

Two sub-committees were organized. One sub-committee was charged in US, and another sub-committee was charged in IAGCS. They have compiled their reports for each subject, and then the committee worked out the review report from their reports.

1. Unit System (US)

The committee is pleased to note that the Unit System (US) was meticulously constructed after two years of intensive discussions with the broad scientific community, including fusion science experts inside and outside the National Institute for Fusion Science (NIFS) as well as researchers in related disciplines. The 10 units have been established by integrating 46 originally proposed research themes with approximately 250 external members together with approximately 120 members from NIFS. It is notable that many researchers are participating from new fields other than conventional fusion science, such as space and astronomical physics, mathematical physics, computational science, laser science, atomic physics, accelerator physics, and material science which foster interdisciplinary research. The committee notes that the US is a unique innovative scheme to organize a fusion science institute and covers a wide range of research themes which show great promise for future development.

While it is not yet the time to assess each unit's scientific achievements and its impact on world-leading research, the committee notes that the successful outcomes from NIFS, in particular, its academic research

platforms like LHD, plasma simulator, and engineering facilities, are effectively used for collaborative and interdisciplinary approaches under the US.

The committee notes that the Unit Evaluation Committee has successfully accommodated the diversity of proposals to the 10 Units and elaborated their academic plans through intensive communications with proponents. It should be noted at the same time that the relationships between researchers inside and outside NIFS and various managerial processes are complex and it is easy to imagine that they would run about in confusion to some extent for a while. By nature, the Units are expected to develop autonomously along with their own initiative and ownership. The committee expects Unit Evaluation Committee to play an important role to resolve any confusions and conflicts when they arise during the implementation process through the support and assessment of the Units.

The committee notes that collaboration among Units has seen evident success with 33 proposed projects, including 10 from young researchers. While 10 of these projects have secured funds at this moment, the committee is concerned about their progress due to lack of a fund. Therefore, the committee recommends that NIFS considers providing dedicated research funds to support, in particular, young researchers to facilitate their challenge of interdisciplinary projects.

The committee notes favorable substantial commitment of young researchers to the construction of the US and building future research. And around 50% of Unit leaders are appointed from young researchers with relevant promotion. The committee finds that it is challenging for young researchers to balance primary research work and stretching out to interdisciplinary research while they are expected to propose interdisciplinary projects. Therefore, the committee recommends that the senior NIFS management pays attention to potential managerial issues in Units for appropriate action.

The committee commends that seminars at various levels are organized in order to promote interdisciplinary research and their efforts. The committee recommends that the Units continue these seminars and establish a linkage mechanism between them.

Even before NIFS organized the US, it has a strong history of engagement in international activities. The committee finds that there has been a significant increase in personnel exchanges and that the remote collaboration system has been effective in enhancement of internationalization since the inception of the US in 2023. While it's premature to judge the ideal environment for the US for internationalization, the committee expects its diverse scientific scope to attract international collaboration. To promote internationalization further, the committee recommends NIFS to expand the number of foreign members within the Units. The committee also recommends NIFS to pay attention to that sustainment of international efforts for organization of international conferences and editing works for journals should be carefully considered for the continued success of internationalization.

The committee notes NIFS together with the Advisory Committee and the Unit Evaluation Committee should have a lot of further discussions on how to effectively utilize and deploy the US. The committee points out that sincere self-assessment of activities in Units is critical. The content of the discussions, including any

concerns, needs to be fully shared among the parties involved. The committee reminds that monitoring of activities in the Units by the standing Unit Evaluation Committee and external review of each Unit in a timely manner are indispensable.

2. Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section (IAGCS)

NIFS has established the Fusion Science Interdisciplinary Coordination Center, fostering interdisciplinary fusion science across scientific fields, fusion development research, and social implementation. The committee notes that the Industry-Academia-Government Cooperation Section (IAGCS) plays a central role in implementing a well-formulated strategy, involving protocol development, creating opportunities, and adopting research seeds. The committee recommends that the collaborative framework involving the National Institutes of Natural Sciences (NINS) signifies an essential structure for industry-academia-government collaboration, promotion of transparency and continuous improvement.

The committee finds that NIFS has seen a notable rise in external funds due to improved staff awareness and a focused approach on fusion research, supported by inter-organizational activities involving IAGCS, URA(University Research Administrator), and other entities. Collaborative research has increased to 30 projects annually. NIFS effectively utilizes 30 platforms for industry-academia-government collaborations and contributes to practical research applications. Exhibitions and meetings organized by IAGCS foster private sector interactions and advance industry-academia-government collaboration. The committee notes that IAGCS has also demonstrated stability in ongoing research and intellectual property preservation, with consistent patent registrations since 2019.

The committee finds that NIFS employs conflict-of-interest measures, requiring staff to record time and location with card keys. The committee recommends that the Fusion Energy Industry-Academia Collaboration Laboratory and the Fusion Energy Cooperative Research Group strengthen collaboration, although clearer role delineation is needed. The committee also notes that NIFS effectively manages conflicts through NINS and the Conflict of Interest Committee at NIFS and supports collaborative research with industry including startups.

Recommendations include evaluating successful examples of the other institutes for interdisciplinary development, targeting the management and investment sectors for social implementation, and enhancing communication within IAGCS and NIFS researchers. Establishment of an educational system for NIFS researchers and clear decision-making strategies within the cross-organizational structure are deemed crucial. The committee points out that operating rules for IAGCS, along with a comprehensive document outlining its background, purpose, and goals, are essential for staff awareness.

To adapt research seeds effectively, the committee suggests the establishment of a review committee to discuss priorities for collaborative research and oversee Full-Time Equivalents (FTEs) management. Given

the recent launch of IAGCS, a periodic review and refinement of its strategy in response to evolving environmental changes are recommended.

Recommendations also include identifying NIFS researchers for strategic support, improving communication between IAGCS and URA, and increasing dedicated staff in anticipation of rising facility utilization and collaborative research. Developing a strategy for social implementation of patents through collaboration with URA, and streamlining the patent application process are also recommended.

Finally, recommendations for IAGCS include emphasizing access management and proper management of research notes to prevent intellectual property contamination. The committee encourages continuing discussions with the Conflict-of-Interest Committee to eliminate impediments to sound development with industry.

3. Additional Suggestions from the External Peer Review Committee

The committee, in constructive spirits, suggests that the following issues should be considered for review in the future.

- 1) Assessment of scientific achievements and future prospects in each unit.
- 2) Assessment of availability and effectiveness of research platforms.
- 3) The low level of competitive funding has always been a problem in the past years. Although there is no silver bullet, each member in NIFS should learn from each other and come up with ways for external funding with taking opportunity of the on-going revolution for interdisciplinary development of fusion science. Strategic approaches are requisite depending on the dimension and the framework of fundings. Institutional efforts to secure the budget for large-scale platforms shared with communities are also indispensable.

Main Body

of the External Review Report in FY2023

1. Unit System (US)

Perspective 1

Is US building up a broader interdisciplinary collaborative research system and research organization to address unresolved issues in fusion science?

Findings/Evaluation

- The construction of the US has been completed after a meticulous two-year process. Original 46 proposals were selected to form 10 Units. The selection process was comprehensive, involving input from hundreds of researchers, numerous meetings, and drawing on the knowledge and perspectives of researchers both within and outside of the National Institute for Fusion Science (NIFS). It's worth noting that while there were around 120 participants from within NIFS, there were approximately 250 participants from outside NIFS.
- Notably, the participation of researchers from fields different from conventional fusion research, such as space and astronomy, mathematical physics, computational science, laser science, atomic physics, and accelerator physics, was essential to promote interdisciplinary research. This system can be evaluated as something unprecedented, not undertaken by any other major research institution worldwide. The research items currently listed cover a wide range of scales and research methods, from fundamental physical phenomena to elemental technologies, from astronomical objects to nuclear fusion. These items show great promise for future development.

Recommendations

- In order to address unresolved issues in fusion science, the committee notes that it is necessary to leverage the strengths of each Unit and promote 10 research themes in collaboration with new members. To this end, the Science Council of Japan's advisory opinion "Plasma Science" should be referred.
- System administrators should be aware that Unit coverage will need to be reviewed and adjusted in the coming years. In addition, the operation requires the cooperation of researchers within NIFS and researchers from outside organizations, and the committee notes that this will need to be considered as a future evaluation standard.
- Additionally, since this is a new system, personnel exchanges may not be possible in order to respond to unexpected difficult situations that may occur during operation, requests and requests due to special power relationships within and outside of NIFS, and rapidly emerging needs. Flexible management is required. The committee recommends that NIFS should do them.
- The low level of competitive funding has always been a general problem in the past years. With regard to the US, this improvement will be necessary not only to increase research funding, but also to foster an interdisciplinary perspective and gain support from a wider academic community than fusion science. Although there is no silver bullet, each member in the Units should learn from each other and come up with ways for external funding in line with the interdisciplinary development of the Units.
- In 10 years, present young scientists and students should be able to independently clarify their Unit

research plans and construct a concrete roadmap based on the level of achievement of their Unit research themes.

- NIFS together with the Advisory Committee and the Unit Evaluation Committee need to have a lot of further discussions on how to effectively utilize and deploy the US. Also sincere self-assessment of activities in Units is critical. The content of the discussions, including any concerns, needs to be fully shared among the parties involved. The committee reminds that monitoring of activities in the Units by the standing Unit Evaluation Committee and external review of each Unit in a timely manner are indispensable.

Perspective 2

Is US promoting world-leading research through the rational and multilateral use of the research accomplishments and academic research platform which NIFS has established?

Findings/Evaluation

- Without sufficient details, it is challenging to assess whether each Unit is driving world-leading research. However, considering the successful results from NIFS, the academic research platforms - LHD, Plasma simulator, and engineering equipment - have been utilized for joint research and interdisciplinary projects under the US, commencing this year. This should be evaluated. The committee does not provide detailed comments on individual facilities and equipment, but the general evaluation is summarized below.
- LHD: The LHD can stably generate ultra-high-temperature plasma and is equipped with various diagnostic equipment and manipulators. It is expected to conduct international joint research as an interdisciplinary research platform, not only for nuclear fusion but also for understanding the principles of various complex phenomena common to space and astronomical plasmas. The plan is to promote experimental research combined with theoretical and simulation research and to expand the use of data to a vast community of researchers, including those in other fields. It has received high praise for these efforts.
- Plasma simulator: The plasma simulator is not limited to internal research or within the fusion/plasma community; it operates as a collaborative research system open to related fields. The number of joint research projects and users remains at a high level, contributing significantly to research in nuclear fusion, plasma, and related fields. As a new initiative, a demonstration experiment will link plasma simulators and LHD experimental data to improve the efficiency of high-speed, large-scale data analysis and machine learning, with high expectations for its success.
- Engineering facilities: Compared to LHD and the plasma simulator, the deployment of experimental physics facilities and engineering platforms is less clear. Concerns exist regarding the utilization rate of engineering facilities due to budget cuts. In response, the 4th mid-term plan aims to "widely develop energy science research and contribute to the realization of a hydrogen energy society and a decarbonized society." NIFS has established an experimental environment for plasma and fusion energy research in line with external demands, and it may necessitate a system for launching new research collaborations among industry, academia, and government.

Recommendations

- The use of these platforms to conduct research in different Units should be accounted for, as well as the need for improvements to existing platforms and the need for new platforms of moderate size.

- It is recommended that each Unit should provide a written document detailing rationale, organization, personnel within and outside of NIFS, and research strategy including funding sources and yearly plans. It is highly desirable for each Unit to identify a list of “low hanging fruits” that can demonstrate the value of the US in its beginning years, that are otherwise difficult to accomplish.
- To promote world-leading research in a rapidly evolving environment, it is recommended that midpoint inspections be conducted during each Unit's 10-year lifespan, ideally at around the 5-year mark the results should be communicated to his NIFS leadership. They may reward top-performing companies with additional support and restructure or terminate early companies that are underperforming.
- To promote research effectiveness, it is recommended that objective and rational evaluation criteria be developed and published for the US that include researchers both within and outside of NIFS. Depending on the specific situation, the criteria may need to be different for each Unit.
- In addition to NIFS resources and expertise, the use of external resources and platforms should be encouraged to foster world-leading research in each Unit.
- Research facilities are very important for Unit to advance research towards its goals. To this end, each Unit should (i) utilize facilities other than those at NIFS, such as JT-60SA and university facilities, and (ii) improve existing facilities at NIFS. At present, it seems that these activities are expected to be carried out by individual Units, but it would be better to establish an organization consisting of Unit leaders and stakeholders to formulate strategies, and discuss it there.

Perspective 3

Is the Unit Evaluation Committee's assessment and advice on the Units' activities functioning effectively for the Units' activities?

Findings/Evaluation

- It is commendable that the 46 proposal were eventually consolidated into 10 Units after receiving proposals and evaluations from the Unit Evaluation Committee. The Unit Evaluation Committee has successfully accommodated the diversity of proposals and elaborated their academic plans through intensive communications with proponents.
- It should be noted at the same time that the relationships between researchers inside and outside NIFS and various managerial processes are complex and it is easy to imagine that the they would run about in confusion to some extent for a while.

Recommendations

- By nature, the Units are expected to develop autonomously along with their own initiative and ownership. The Unit Evaluation Committee is expected to play an important role to resolve any confusions and conflicts when they arise during the implementation process through the support and assessment of the Units.
- The new US is quite different in scientific emphasis and philosophy than many, or most, of the large fusion labs. Most other labs are aiming for research using large facilities that provide new physics or engineering regimes for study. The US approach offers potential for new discoveries not necessarily accessible to other labs. This potential payoff also carries risks. It will be important to perform rigorous self-assessment or external review of results with sufficient frequency to allow

for modification and optimization of the research plans as the research proceeds.

- Because the US is itself an experiment, data should be taken fairly continuously and readjustments made as needed.
- It could be useful to continue such evaluation committee meeting for the US, to re-assess how efficiently the US works and to figure out if any adjustment of the organization needs to be addressed. As this would be the challenging point once the US was constructed.
- It is recommended to publish an organization structure of the US, including Unit Evaluation Committee and other important elements, with functions and reporting chains clearly defined.

Perspective 4

Is US effectively promoting collaboration and cooperation among Units in order to enhance the level of research?

Findings/Evaluation

- As for collaboration and cooperation among Units, 33 projects have already been proposed, which can be evaluated as excellent. Additionally, the fact that 10 projects have been proposed by young researchers is highly commendable, as it demonstrates that the institute's policies are well-received, even by young researchers. However, it's worth noting that only 10 of these proposed projects have received funding and are currently being implemented. This raises concerns about the smooth progression of all projects.
- Since the promotion of interdisciplinary research is grounded in fostering exchanges among researchers from diverse fields, the recent initiative to organize seminars at various levels to facilitate interdisciplinary research collaboration is commendable. Notably, the Research Division seminars, held frequently with dozens of participants each time, incorporate interdisciplinary research themes. It is highly recommended that these seminars continue in the future. Moreover, it is important not only to conduct each seminar independently but also to establish a mechanism for organic linkage between them.
- Young researchers are expected to propose interdisciplinary collaborative projects. However, for young researchers, it is often challenging to simultaneously apply for both their primary research projects and interdisciplinary collaborative research. Therefore, it is essential for the institute to provide dedicated research funds that enable young researchers, in particular, to initiate their interdisciplinary research endeavors.

Recommendations

- It will be critical to rigorously self-assess the success of the cross-unit collaboration or cooperation and, if needed, adjust the Units or the Unit collaboration early enough to optimize results in five or ten years.
- Before applying for competitive funds, the applicants are recommended to ask for a critical review within NIFS.
- It may be necessary to somehow assess the outcome of the launched projects, to see how effectively promote the collaboration among Units.
- Since the success of fusion energy requires collaboration and cooperation of all Units (possibly beyond), it is recommended to build and maintain robust inter-unit interaction to form a network

of strong ties.

- In addition to promote collaborations among Units, it is necessary to make specific research topics and plans of each Unit more visible to distinguish the inter-unit collaborations and the research overlaps.

Perspective 5

Is the operation of US suited to young researcher's activity and success?

Finding

- Presented data from NIFS reveals a strong focus and active involvement of young researchers in both the construction of the US and future research initiatives. Impressively, approximately 60% of the proposed research topics stem from young researchers, reflecting a high degree of inclusiveness in the process. This inclusivity is further demonstrated by the fact that around 50% of Unit leaders are young researchers.
- It's worth noting that the majority of early career researchers, including some newly hired employees, are actively proposing and leading new Units. This marks a positive trend. However, there are concerns about whether these young leaders will be able to take the lead in research initiatives within their Units while working under the supervision of senior experts responsible for administrative and budget management.

Recommendations

- It will be important for the NIFS leadership team to convince university and national lab fusion researchers, and the relevant funding agencies, of the exciting opportunities offered by the US. Of course, such outreach has likely been carried out. It should be continued aggressively, particularly as research results are obtained.
- Young people go into fusion science for differing reasons. Reasons include energy development to save the planet, interest in technological advance, and more fundamental questions in nonlinear science and mathematics. Creating a nurturing environment for young people in this last group, which are often quite talented, is important for the future of fusion science.
- For these young researchers, it is strongly recommended to create methods to assess their performance and how to provide further room for their promotion. It may be important for the sustainable development.
- Since early-career researchers need to develop a path of success with a sense of belonging rather fast at the beginning years when joining NIFS, it is recommended to assign a mentor who can advise and advocate for the case of early-career researchers.
- Some Unit leaders are young. Since the Units are administrative organizations of the institute, business of Unit leaders include administrative management as well as research management. It is needed to make a system to support young Unit leaders so that they can concentrate research management without taking much time on administrative management.
- The "Support for the start of a developmental research program" should be continued upon a follow-up of the effectiveness.
- The publication of summaries of newly published papers on the Web should be carried out surely.

Perspective 6

Is the operation of US suited to promote internationalization?

Findings/Evaluation

- Even before NIFS organized the US, it had a rich history of engaging in various international activities, with many NIFS members actively participating in program committees for international conferences, serving as editors for international journals, and being involved in fusion and plasma-related international organizations. Additionally, several international collaborative research projects spanning atomic and molecular physics to material science were ongoing. These endeavors laid the groundwork for future internationalization efforts within the US and were highly commended in the previous year's evaluation.
- Notably, since the inception of the US in 2023, there has been a remarkable increase in personnel exchanges. In the early half of 2023 alone, the number of exchanges has doubled compared to the total number in 2022. Furthermore, the effective use of the Remote collaboration system, which received high praise in the previous evaluation, is expected to further enhance NIFS's internationalization efforts under the new US.
- Given the current situation, it may be premature to determine whether the US provides an ideal environment for internationalization. However, the diverse scientific scope covered by the Units is expected to attract significant international interest in collaboration. Moreover, the Unit System's advantages lie in its ability to propose international collaboration themes based on extensive discussions within the Units, rather than relying solely on individual efforts. As a result, several international and interdisciplinary proposals are already in the planning stages, representing a promising development.
- On the other hand, there are a few areas for improvement to further promote internationalization through the Unit System. Firstly, while there are currently 15 foreign members within the Unit representing 9% of all Unit members, there is room for expansion in this regard. Secondly, sustaining internationalization efforts, such as participation in conference organization and journal editing, may become challenging without continued evaluation and support from the NIFS organizational system. These aspects should be carefully considered for the ongoing success of internationalization efforts.

Recommendations

- Given the inclusion of interdisciplinary and fundamental science in the US, it seems natural to promote collaborations with academic institutions, e.g., theoretical physics, computational, and mathematics departments in the United States and Europe. Several of the Units already have large potential for such collaborations.
- It is encouraged to keep open the US for international researchers, by inviting abroad experts joint the research Unit and also the evaluation committee. As a non-conventional system, NIFS would be required to advertise the US to attract more researchers home and abroad.
- In response to the changes of the circumstances, NIFS should search the best way to maximize the international academic activities as the core institute of Japanese University. Given the inclusion of interdisciplinary and fundamental science in the US, it seems natural to promote collaborations with academic institutions, e.g., theoretical physics, computational, and mathematics departments in the United States and Europe. Although it looks that several of the Units should have easy potential for such collaborations, the NIFS leadership team should work hard to explain the

research opportunities to fusion and plasma labs internationally, as the approach of the NIFS Unit System is non-standard or non-conventional. This will take a concentrated international outreach effort to advertise the system to attract more researchers home and abroad.

- It is recommended that NIFS should open various experimental platforms abroad for Japanese researchers in the field through the international collaborations. Each Unit in NIFS should be the core to integrate research requests, along its specialized themes, from members of universities including NIFS staffs and foreign distinguished collaborators, and should make efforts to obtain the budgets to support the domestic and international collaborations. For this purpose, each Unit should include tight collaboration with foreign active researchers using the manner of cross-appointment and some other tight manners. The important role of Fusion Science Interdisciplinary Coordination Center should be emphasized in creating the channels and winning the supporting budgets.
- It is highly desirable for each Unit to make good progress in early years on “low hanging fruits” goals that can demonstrate to the international community the value of the US and are otherwise difficult to accomplish.
- It is recommended to take advantage of the existing international relationships that NIFS has already (MOU between institutions, countries, IAEA committees, etc) to promote internationalization of the US. For example, a mirroring Unit can be proposed in the collaborating institution and jointly apply for collaboration funding.
- It is also expected to enhance the existing international research collaborations, such as US-Japan and Japan-Korea research collaborations, to promote internationalization of the Unit activities further.
- NIFS should try to get a position in Research Center for Science Systems in JSPS from NIFS.

2. Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section (IAGCS)

Perspective 1

Is the Section's strategy taking advantage of and promoting NIFS's basic policy of "Interdisciplinary development of Fusion Science" from the perspective of industrial applications?

Finding/Evaluations

- NIFS has organized the Fusion Science Interdisciplinary Coordination Center with three sections, including the Industry-Academia-Government Cooperation Section (IAGCS). The coordination among these sections and Units aims to broaden the interdisciplinary nature of fusion science and contribute to various scientific fields, fusion development research, and social implementation.
- Four essential issues have been identified to promote NIFS's policy of "Interdisciplinary development of Fusion Science" from the perspective of industrial applications. The present strategy, involving protocol development, creating opportunities, and adopting research seeds, is well-formulated.
- IAGCS is praised for its central role in implementing the strategy and building a cooperative system

with different organizations. The cross-organizational approach is expected to facilitate effective collaboration among experts from different fields.

- The collaborative framework, with the National Institutes of Natural Sciences (NINS) as the contracting entity for joint research agreements and patent applications, signifies an essential and appropriate structure for industry-academia-government collaboration. Cooperation between NINS and NIFS promotes transparency, effective information sharing, and continuous improvement.
- From abovementioned findings, IAGCS' strategy is evaluated as excellent to commendable.

Recommendations

- The effectiveness of industrial collaboration in achieving interdisciplinary development goals is not self-evident. Evaluation based on successful examples is suggested to predict the feasibility of interdisciplinary development.
- Initiatives connecting research outcomes with industrial applications should consider the management and investment sectors as targets to accelerate societal implementation.
- To promote NIFS's basic policy effectively, IAGCS needs to stimulate communication between IAGCS staff and all NIFS researchers, and routinely search for seeds for industrial applications.
- To ensure the implementation of strategies, IAGCS needs to establish an educational system for better understanding and adherence to the content.
- Effective collaboration within a cross-organizational structure is crucial for fostering collaborative activities among industry, academia, and government. Decision-making strategies should be clearly defined, with IAGCS playing a leading role based on the NIFS policy for interdisciplinary development.
- The operating rules of the Fusion Science Interdisciplinary Coordination Center govern IAGCS functions. A comprehensive document outlining the background, purpose, mission, strategies, and goals of IAGCS is essential for a deeper understanding of its activities and staff awareness of industry-academia-government collaboration.
- In the adaptation of research seeds, it is recommended to establish a review committee to discuss priorities for collaborative research contributing to fusion technology development. The committee could also oversee the management of Full-Time Equivalents (FTEs) for staff members.
- The current strategy of IAGCS need to be reviewed and refined in response to future changes in the surrounding environment since IAGCS is recently launched. It is expected that the strategy will lead to the development of an industrial network for fusion science in the future.

Perspective 2

Is IAGCS putting survey, support, and obtaining external funding for industry-academia-government collaboration in place?

Finding/Evaluations

- The increase in the number and amount of external funds is attributed to improved staff awareness, a strengthened focus on fusion research, and enhancements in protocols with IAGCS, contributing to the overall sustainable development of NIFS. Collaborative research has gradually increased,

reaching 30 projects per year, with four new collaborative technology developments established.

- NIFS possesses 30 publicly available platforms effectively utilized for industry-academia-government collaboration activities. The active utilization of platforms contributes to practical applications of research outcomes.
- NIFS organizes exhibitions and meetings to facilitate interactions with the private sector, promoting collaboration and contributing to the advancement of industry-academia-government collaboration.
- Activities to assess needs and support the acquisition of external funding for industry-academia-government collaborations are carried out in the inter-organizational structure of IAGCS, URA, the Department of Administration, the Research Enhancement Strategy Office of NIFS, and NINS. This structure provides integrated support to promote collaborative activities.
- From abovementioned findings, it is evaluated as excellent to commendable overall. It is noted that the rapid increase in the amount of external funds is highly evaluated (outstanding).

Recommendations

- There is a need to identify NIFS researchers conducting industry-academia collaboration and establish a strategic support system for them.
- Facilitating communication between IAGCS and URA is essential for effectively acquiring external funding for collaborative industry-academia-government activities. Adequate manpower should be allocated for sincere networking efforts to assess technology needs developed at NIFS.
- It is desirable to secure additional special resources for URA and outreach efforts.
- NIFS platforms, featuring state-of-the-art instrumentation and research opportunities in otherwise unavailable experimental conditions (use of neutrons, ultrahigh voltage, etc.), are attractive to industry.
- With an expected increase in facility utilization and collaborative research in the future, it is recommended that the number of dedicated staff should be increased.

Perspective 3

Is IAGCS promoting the development of fusion technology for social implementation?

Finding/Evaluations

- The organization, IAGCS, demonstrates stability in ongoing research and intellectual property preservation, evident from consistent patent registrations since 2019. The initiative to utilize unused biomass activated carbon for sustainable development goals (SDGs) is positively acknowledged. However, a future challenge is identified as the almost non-existent number of license agreements for registered patents.
- IAGCS collaborates with the Committee for Intellectual Property, the Department of Administration, and NINS to manage intellectual property for patent licensing. While commendable progress is noted in establishing a mechanism for social implementation of fusion technology, the current small number of patent applications necessitates future collaboration with private companies.

- The limited budget prompts strategic patent application discussions, but the difficulty in licensing to industry despite the importance of patents for generating industry interest is acknowledged. From abovementioned findings, it is evaluated as commendable overall. But it is noted that no licensing is critical and IAGCS should take appropriate actions.

Recommendations

- There is a need to increase license agreements for patents by enhancing collaboration with the private sector and promoting commercial utilization based on industrial needs.
- IAGCS should lead efforts with URA to secure intellectual property funding within NIFS, reduce costs through joint applications with research companies, and reexamine its intellectual property from multiple angles.
- IAGCS needs to collaborate with URA to identify researchers conducting industry-academia collaboration, establish a support system, engage in proactive dialogue with companies, and uncover research needs.
- IAGCS needs to develop a strategy, in line with NIFS policy for interdisciplinary fusion science, to promote the social implementation of patents and assist inventors in streamlining the patent application process to reduce the burden of the process.
- IAGCS is encouraged to continue its activities.

Perspective 4

Is IAGCS putting sound development collaboration and cooperation with industry including start-ups in place?

Finding/Evaluations

- NIFS implements measures for conflict-of-interest management, requiring staff to record time and location using a card key. The introduction of category D for detailed records of activities with the private sector is praised for avoiding resource confusion.
- The Fusion Energy Industry-Academia Collaboration Laboratory and Fusion Energy Cooperative Research Group strengthen the organizational structure for effective collaboration, although there is a need for clearer delineation of roles and hierarchy. The establishment of these divisions supports collaborative research with industries, including fusion startups, contributing to the advancement of fusion energy innovation in Japan.
- For effective collaboration and cooperation with industry, mutual understanding of objectives and clear separation of mission, place, time, information, and budget are crucial. NIFS manages conflicts of interest through NINS and the Conflict of Interest Committee at NIFS. The Fusion Energy Cooperative Research Group collaborates with various entities to create new social values, contributing to sound development and cooperation with industry, including startups. Overall, there is an expectation for continued positive developments in these areas.
- From abovementioned findings, it is evaluated as excellent to commendable.

Recommendations

- IAGCS should emphasize access management of individuals and proper management of research

notes to prevent intellectual property contamination.

- Education and guidelines are needed for effective research note management practices, ensuring detailed and accurate information, and implementing appropriate storage and access controls.
- Managing conflict of interest is challenging but crucial for collaboration and cooperation between NIFS researchers and industry, including start-ups. New card key entry systems can manage the separation of place, time, and budget for collaborative activities, but mission and information separation depend on researcher trust. Awareness of the commercial value of the NIFS name is crucial when collaborating with industry, especially start-ups.
- Reassigning collaborating NIFS researchers to the Fusion Energy Cooperative Research Group can simplify conflict of interest management.
- It is recommended to establish strict rules for the separation of mission, place, time, information, and budget in collaborative activities with industry, preventing deactivation of collaborations.
- IAGCS should continue discussions with the Conflict-of-Interest Committee to eliminate any impediments to sound development with industry, addressing conflicts in advance.

General Recommendations

- Effective cooperation within the inter-organizational structure, with the IAGCS playing a leading role, is necessary to develop the protocols of a system for industry-academia-government collaborative activities.
- A strong collaboration with the URA in NIFS is a prerequisite for the IAGCS to create more opportunities for such activities and to adapt the research seed in NIFS to the needs of industry.

Annex

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List of FY2023 NIFS External Peer Review Committee members

[External Peer Review Committee members]

	Ishida Shinichi	Managing Director, Fusion Energy Directorate, National Institutes for Quantum Science and Technology (QST)
●	Ueda Yoshio	Professor, Graduate School of Engineering, Osaka University
	Ozawa Tohru	Professor, Faculty of Science and Engineering, School of Advanced Science and Engineering, Waseda University
	Kaneko Toshiro	Professor, Graduate School of Engineering, Tohoku University
	Fujisawa Akihide	Professor, Research Institute for Applied Mechanics, Kyushu University
	Fujita Takaaki	Professor, Graduate School of Engineering, Nagoya University
	Matsuoka Ayako	Professor, Graduate School of Science, Kyoto University
	Morii Takashi	Professor, Institute of Advanced Energy, Kyoto University
◎	Yamada Hiroshi	Professor, Graduate School of Frontier Sciences, The University of Tokyo
○	Yoneda Hitoki	Professor, Institute for Laser Science, University of Electro-Communications
●	Watanabe Tomohiko	Professor, Graduate School of Science, Nagoya University
	Stewart Prager	Professor, Astrophysical Sciences, Princeton University, USA
	Philip J Morrison	Professor, Department of Physics, The University of Texas at Austin, USA
	Yuntao Song	Director-General, Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, China

[Specialist Committee members]

	Yokomine Takehiko	Professor, Graduate School of Engineering, Kyoto University
	Uzawa Yoshinori	Professor, Industry Liaison Office, National Astronomical Observatory of Japan (NAOJ), National Institutes of Natural Sciences (NINS)
	Hayashi Takumi	Deputy Director General, Rokkasho Fusion Institute, National Institutes for Quantum Science and Technology (QST)
	Hantao Ji	Professor, Astrophysical Sciences, Princeton University, USA

◎: Chairperson, ○: Vice Chairperson, ●: Expert Subcommittee's Chairperson

List of FY2023 NIFS External Peer Review Committee members Expert Subcommittee on Unit System

[External Peer Review Committee members]

Ozawa Tohru	Professor, Faculty of Science and Engineering, School of Advanced Science and Engineering, Waseda University
Matsuoka Ayako	Professor, Graduate School of Science, Kyoto University
● Yoneda Hitoki	Professor, Institute for Laser Science, University of Electro-Communications
Stewart Prager	Professor, Astrophysical Sciences, Princeton University, USA
Philip J Morrison	Professor, Department of Physics, The University of Texas at Austin, USA
Yuntao Song	Director-General, Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, China

[Specialist Committee members]

Yokomine Takehiko	Professor, Graduate School of Engineering, Kyoto University
Hantao Ji	Professor, Astrophysical Sciences, Princeton University, USA

[Observers]

Fujisawa Akihide	Professor, Research Institute for Applied Mechanics, Kyushu University
Fujita Takaaki	Professor, Graduate School of Engineering, Nagoya University
Watanabe Tomohiko	Professor, Graduate School of Science, Nagoya University

●: Expert Subcommittee's Chairperson

List of FY2023 NIFS External Peer Review Committee members
Expert Subcommittee on Fusion Science Interdisciplinary Coordination Center
Industry-Academia-Government Coordination Section

[External Peer Review Committee members]

Ishida Shinichi	Managing Director, Fusion Energy Directorate, National Institutes for Quantum Science and Technology (QST)
● Ueda Yoshio	Professor, Graduate School of Engineering, Osaka University
Kaneko Toshiro	Professor, Graduate School of Engineering, Tohoku University
Morii Takashi	Professor, Institute of Advanced Energy, Kyoto University

[Specialist Committee members]

Uzawa Yoshinori	Professor, Industry Liaison Office, National Astronomical Observatory of Japan (NAOJ), National Institutes of Natural Sciences (NINS)
Hayashi Takumi	Deputy Director General, Rokkasho Fusion Institute, National Institutes for Quantum Science and Technology (QST)

●: Expert Subcommittee's Chairperson

Annex 2: Backgrounds

The National Institute for Fusion Science (below as NIFS) was established in 1989 as an inter-university research institute to advance fusion research in universities in Japan.

Since 2004, NIFS has been a research institute under the Inter-University Research Institute Corporation National Institutes of Natural Sciences. Upon becoming an inter-university research corporation, a system for mid-term goals and mid-term planning spanning six years was introduced, and a system of annual evaluations regarding the progress, too, was introduced. This annual evaluation focuses primarily upon administrative management. In addition, at NIFS it has been determined that receiving external evaluations of research results is important. Under the NIFS Advisory Committee, each year an External Peer Review Committee is organized, and the members evaluate the research. The topics of evaluation and its perspectives are determined by the Advisory Committee. The evaluation is undertaken by the members of the External Peer Review Committee, which is composed of experts who are external members of the Advisory Committee and external experts who are appropriate for evaluating the topics. The External Evaluation Committee submits its evaluation results to the Advisory Committee. Then, NIFS, together with making the results public by uploading that information to the NIFS homepage, utilizes this information to improve research activities in the following years.

The topics for evaluation for the External Peer Review Committee are discussed and decided upon by the Advisory Committee, and those topics for evaluation differ each year. Most recently, in 2021 the “LHD Project”, the “Numerical Simulation Reactor Research Project”, and the “Fusion Engineering Research Project” ,and in 2022 “Human Resource Development” ,”International Collaboration”, and the “Department of Engineering and Technical Services” were topics evaluated by external reviewers. This year, 2023 “ Unit System” and “Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section” were selected and reviewed by the external examiners.

As external members of the External Peer Review Committee this year there are eleven external members from the Advisory Committee and three members from abroad. Further, four (including a member from abroad) experts are invited from outside NIFS. Thus is the External Peer Review Committee composed, and thereby the evaluation was undertaken.

The first meeting of the External Peer Review Committee including the Experts’ Subcommittee was convened on October 27, 2023. The Committee discussed the process for moving forward with this fiscal year’s external peer review. The second meeting of Experts’ Subcommittee on the “Unit System” was held on November 6, 2023. The second meeting of Experts’ Subcommittee on the “Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section” was held on November 22, 2023. NIFS provided a detailed explanation that utilized documents from the material of viewgraphs and reports based on the perspectives. A question-and-answer session also was arranged. Extra-meetings primarily for international members were

organized for “Unit System” on November 10, 2023, and December 11, 2023, with participation of major members in Japan. Subsequently, the second meeting of the External Peer Review Committee and the third meeting of the Experts’ Subcommittee was held on February 7, 2024. The Committee discussed the coordination of the evaluation work and confirmed the configuration of the external peer review report based on the drafts from two sub-committees. Then, the committee elaborated the report through communications by electronic mail. Upon confirmation and examination by the External Peer Review Committee and the Experts’ Subcommittee, the external review report was finalized on February 27, 2024.

In the external evaluation regarding “Unit System”, and the “Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section” which were implemented this fiscal year, the perspectives for the evaluation were determined as follows.

Evaluation items in FY2023 External Peer Review

The external peer review of “Unit System (US)” and “Fusion Science Interdisciplinary Research Center, Industry-Academia-Government Coordination Section (IAGCS)” will be conducted in FY2023 with the evaluation perspectives set as follows. Each evaluation perspective is essentially based on the evaluation of the appropriateness and achievement of research and other activities conducted by the National Institute for Fusion Science (NIFS) as an Inter-University Research Institute, as well as the future direction and strategy in referring to the “Recommendations on for the Future of NIFS” and the “Recommendations for the Future Collaborative Research of NIFS” compiled by the appointed working group and endorsed by the advisory committee in FY 2021 and FY 2022, respectively.

In addition, the following points presented as “recommendations” in the previous peer review report of “Human Resource Development,” “International Cooperation,” and “Department of Engineering and Technical Services” in FY2022 are also taken into consideration in this evaluation.

Recommendations from the FY2022 external evaluation

- (1) The new organization of UNITS starts from 2023 in NIFS aiming at interdisciplinary development of fusion science. A new platform succeeding to LHD, i.e., a post-LHD project should be planned as early as possible through intensive discussion in domestic and international communities, where the UNIT system should play an essential key role.
- (2) NIFS is driving the paradigm shift to extend the horizon of fusion science. The new research organization employing the units starts in FY2023. These units are formed involving researchers outside NIFS through thorough discussions in the community and challenge unresolved critical scientific subjects related to realization of fusion energy as well as energy circulation in nature through interdisciplinary approach. The progress on this reform and the activity of the units should

be reviewed at the right time.

Perspectives on “US”

- (1) Is US building up a broader interdisciplinary collaborative research system and research organization to address unresolved issues in fusion science?
- (2) Is US promoting world-leading research through the rational and multilateral use of the research accomplishments and academic research platform which NIFS has established?
- (3) Is the Unit Evaluation Committee's assessment and advice on the Units' activities functioning effectively for the Units' activities?
- (4) Is US effectively promoting collaboration and cooperation among Units in order to enhance the level of research?
- (5) Is the operation of US suited to young researcher's activity and success?
- (6) Is the operation of US suited to promote internationalization?

Perspectives on “IAGCS”

- (1) Is the Section's strategy taking advantage of and promoting NIFS's basic policy of “Interdisciplinary development of Fusion Science” from the perspective of industrial applications?
- (2) Is IAGCS putting survey, support, and obtaining external funding for industry-academia-government collaboration in place?
- (3) Is IAGCS promoting the development of fusion technology for social implementation?
- (4) Is IAGCS putting sound development collaboration and cooperation with industry including start-ups in place?



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