2018 Committee of Visitors (COV)

Report to the Fusion Energy Sciences Advisory Committee (FESAC)

Program Reviewed: Fusion Energy Sciences
Fiscal Years Reviewed: FY2014–FY2017
Dates of COV: August 7–9, 2018
COV Chair: Gertrude Patello (PNNL)
Date of Approval by FESAC:

December 2018

Acknowledgments

The committee members would like to thank the Office of Fusion Energy Sciences (FES) staff for hosting them during the Committee of Visitors (COV) review August 7–9, 2018, and for their open and honest discussions of their programs. The Committee was able to develop a great deal of understanding on the workings of the office and the constraints and challenges that FES faces in the effective execution of its duties. The Committee would like to thank Dr. Nirmol Podder, Marty Carlin, Vera Bibbs, Sandy Newton, and Yvette Walker for overseeing the logistics of the review. Finally, the Committee would like to thank Dr. Don Rej, Fusion Energy Sciences Advisory Committee Chair, for his guidance and advice during the review.

Contents

1.0 Introduction

This report documents the findings, comments, and recommendations from a Committee of Visitors (COV) established by the Fusion Energy Sciences Advisory Committee (FESAC) to evaluate the management process of the Office of Fusion Energy Sciences (FES). The Committee convened for 3 days (August 7–9, 2018) at the Department of Energy (DOE) FES Offices in Germantown, Maryland, to conduct the review.

1.1 Charge to the Committee of Visitors

The charge to the FESAC to establish the COV was provided by letter from Dr. J. Stephen Binkley, Deputy Director for Science Programs in the DOE, Office of Science on January 16, 2018 (see Appendix A). The period covered by the review is the four fiscal years (FY2014–2017) since the previous COV review in 2014. The COV was charged with evaluation of:

- The efficiency and quality of the processes used by FES to solicit, review, recommend, monitor, and document awards and declinations for universities, national laboratories, and industry.
- The breadth, depth, and quality of the resulting program portfolio, and providing an evaluation of the program's national and international standing.
- FES's management of its portfolio of line item construction and Major Items of Equipment (MIE) projects, including the U.S. Contributions to the ITER project.

The COV was also requested to comment on FES's progress toward addressing action items from the previous COV review.

1.2 COV Members

The Chair of the 2018 COV, Dr. Gertrude Patello, was selected by Dr. Don Rej, FESAC Chair, in consultation with the FES management. The members of the COV were selected by the COV Chair in consultation with Dr. Rej and FES management. The members have broad expertise relevant to the FES programs. They are from national laboratories, universities, industry, and federal agencies and represent a balanced distribution of researchers who do and do not receive FES funding. The COV members and their affiliations are listed in Appendix B.

1.3 COV Process

After the COV members were selected and their willingness to serve on the Committee was confirmed, the dates for the onsite portion of the review were established for August 7–9, 2018, by polling the members on availability. The committee members were assigned by the Chair into one of six groups.

- Group 1: Magnetic Fusion Energy (MFE) Experiments Domestic
- Group 2: MFE Experiments International and Diagnostics

- Group 3: Theory and Simulation
- Group 4: Enabling Research and Development (E-R&D), Fusion Nuclear Science (FNS), and Materials Research (MR)
- Group 5: General Plasma Science (GPS), Exploratory Magnetized Plasma (EMP), High Energy Density Laboratory Plasmas (HEDLP), and Early Career Research Program (ECRP)
- Group 6: Facility and Project Management

Members were assigned a group associated, as much as possible, with their expertise. However, to avoid conflicts of interest, members with FES contracts were assigned to a group unrelated to their funding.

Prior to the onsite review, a conference call with the Committee and FES was held in mid-July to discuss the COV charge, member group assignments, the onsite review agenda, travel logistics, and the schedule for completing the COV report after the review. Additionally, prior to the review, FES established a COV Review workspace in the Portfolio Analysis and Management System (PAMS) for sharing materials with the COV. Reference materials were posted to the site for the COV to review prior to the onsite visit. During the visit, additional materials such as presentations were posted, and select proposals were made available to the Committee.

The first morning of the onsite visit consisted of an executive session followed by plenary presentations from the acting FES Associate Director and division directors. Presentations were also made on the FES budget structure, the ECRPs, and FES Outreach Activities. The remainder of the day consisted of group breakout sessions with respective program managers providing program presentations. The day concluded with an executive session. The second day of the review was conducted in group breakout sessions with the groups reviewing material provided in PAMS and holding discussions with program managers. Each group of committee members worked on drafting findings, comments, and recommendations to provide to the Chair by the end of the day for consolidation. On the morning of the final day of the review, the Committee convened to review a consolidated draft of the group reports and discuss findings that overarch the FES program. The Committee drafted a preliminary summary of their findings and presented it to FES on the afternoon of the onsite visit's third day. The COV onsite visit agenda is provided in Appendix C.

At the conclusion of the onsite review, each group was tasked to prepare a group report and submit it to the Chair for preparation of a draft COV report. The draft report was discussed and revised by the COV members, provided to FES for fact checking, and revised as needed to produce the final report. The final report was then provided to the FESAC for review in advance of the December FESAC meeting.

With regard to the COV process, the Committee found the schedule of the COV to be challenging and would have appreciated additional time to work as a committee on common themes that emerged among the groups. Additionally, Groups 4 and 5 covered multiple programs, making it difficult to review the individual programs in depth. The Committee suggests that the next COV Chair consider either extending the review duration from 3 days to 3.5 or 4 days, or adding committee members to some groups.

1.4 Layout of the Report

The findings, comments, and recommendations of our COV are summarized in Section 2.0. Within Section 2.1, we discuss elements that overarch the FES program (not all findings and comments of each group). These are organized (and ordered) with the charge element that they most closely address. The recommendations of all groups, on each of their topical areas, are presented collectively in Section 2.2. We also provide some brief comments on our impressions of FES performance with respect to the 2014 COV recommendations within Section 2.3. The entirety of individual group reports that provide the context for the group recommendations are presented in Appendices D through I.

2.0 Summary

Our Committee made a conscious effort to produce a succinct report and set of actionable recommendations. We also strove to identify common themes that emerged among multiple Groups. These were coalesced as appropriate into a set of programmatic encompassing Overarching Findings, Comments, and Recommendations. The balance of our critiques was narrower, more aligned with specific programs, and collated within the set of recommendations on each topical program. The result is a total of nine recommendations.

2.1 Overarching Findings, Comments, and Recommendations

2.1.1 Efficiency and Quality of the FES Processes

Charge Element 1: *The efficiency and quality of the processes used by FES to solicit, review, recommend, monitor, and document awards and declinations for universities, national laboratories, and industry.*

The Committee's evaluation of this charge element is that FES is doing a very good job in soliciting, fairly reviewing, and selecting proposals for award. The Committee found that FES could strengthen its processes for documentation of selections/declinations and monitoring of awards. Additional details are provided in the sections below.

2.1.1.1 Review Documentation

The Committee commends FES for exemplary documentation of funding decision rationale for DIII-D collaborations within the MFE Domestic program. However, among other FES programs, the documentation of selection and declination rationale within PAMS varies greatly. While these entries are not provided to the principal investigator (PI), when comments are terse or less-than-clear, they make COV evaluations difficult and decisions less transparent. A uniform standard would be helpful and could be modeled after the DIII-D MFE Domestic program example. Recommendation-1, below, addresses this topic.

Onsite or virtual panels were used by some programs for proposal or program reviews. The Committee recognizes the value of such reviews but found that feedback of reviewers during the discussion phase of a panel review was often lost since few panels documented the comments of their members in writing. Recommendation-1 also addresses this topic.

> **Recommendation-1:** We recommend that FES establish a uniform standard for documenting selection/declination decision rationale within PAMS or other suitable repository. If a panel review informed the decision, it should be summarized in the repository by the program manager (PM).

2.1.1.2 Monitoring

We commend FES for successfully implementing PAMS for cataloguing university and industry annual progress reports, as was recommended in the 2014 COV report. The recording of progress and accomplishments (e.g., through PAMS):

- allows efficient communication of results to program managers, and communication of program successes within and outside the agency;
- enables COV evaluation and review processes (transparency); and
- provides a mechanism for PMs to assess productivity (and likely future success) of an awardee.

However, the Committee found that progress reporting (across all programs) within FES does not follow a uniform/consistent set of guidance and content, or occur within a single application/format.

- Awards to universities and industry are, in general, subject to a uniform annual progress reporting layout and content within PAMS (since at least FY2015).
- Scientific Discovery through Advanced Computing (SciDAC) reports do not generally follow a uniform guidance. Important information, such as the dissemination of results in papers/talks and recognition of the work by the broader community, is not consistently recorded.
- National laboratory reports are not readily available on PAMS, and they do not follow a uniform method of reporting.
- National laboratories provide reports to FES management on at least an annual basis. These contain overall progress and accomplishments as related to the Laboratory's missions. These reports are reviewed by FES management and relevant PMs.

Recommendation-2 addresses this concern.

> **Recommendation-2:** We recommend implementing systematic documentation having uniform fields/content/format for the recording of achievements, progress, products, and recognition, whether in PAMS or other suitable repository, for universities, industry, and national laboratories.

2.1.1.3 Staffing

The Committee found that a common theme that emerged during the COV review was understaffing of the FES office. Single FES individuals are tasked with multiple significant jobs and/or working in an 'Acting' capacity.

- The position of U.S. ITER PM has been vacant for nearly three years; the Facilities, Operations, and Projects (FOP) Division Director has been serving as 'Acting' program manager.
- The Theory and Simulation program manager is also serving as the 'Acting' Research Division Director.

The Committee believes that understaffing may be impacting the quality of the documentation of the FES review processes and the ability to monitor programs effectively.

The Committee commends FES for hiring two highly capable PMs into the Research Division office of FES. However, additional new hires are needed to more reasonably distribute the FES work load with priority on filling the U.S. ITER PM position (Recommendation-3). This position is singled out because the challenges associated with providing oversight to uniquely complicated large projects (NSTX-U Recovery and U.S. ITER) warrants dedicated and focused attention.

> **Recommendation-3:** We recommend that FES place a high priority on filling the vacant U.S. ITER PM position in the Facilities, Operations, and Projects Division.

2.1.1.4 Institutional Priorities

FES acknowledged during the review that when conducting budget planning meetings there was a disconnect between the FES's need to assess priorities and the inability of academic institutions to internally identify such priorities when there are multiple autonomous projects awarded to different PIs and academic programs. The Committee feels that FES can reasonably request priorities for institutions as a whole when their research is managed under a single structure. When this is not the case, FES should instead align priorities on the basis of different scientific priorities within FES.

2.1.2 Effect of Award Process on Portfolio

Charge Element 2*: The breadth, depth, and quality of the resulting program portfolio, and provide an evaluation of the program's national and international standing.*

2.1.2.1 Breadth and Depth of the Program

The Committee found significant breadth and depth in the FES program; however, it did vary by program. The committee found that the breadth was impacted by budget contraction of the domestic fusion program.

The FES budget was restructured in an effort to better align the management of funded projects and grants with scientific considerations. The budget restructuring outcome was the achievement of a better match to major scientific themes in FES-funded research, but also resulted in projects previously grouped within a single category and under one PM onto multiple categories and PMs. The transition in management appears to have been handled well. The positive outcomes from the budget and management restructuring effort instituted by FES to better align research projects and grants with scientific objectives should be communicated to the research community and FESAC. Also, the FES should periodically evaluate the effectiveness of the restructuring and management adjustments as projects mature and as researchers rotate through the funding portfolio.

2.1.2.2 Quality of Program

The Committee recognizes that FES is doing a good job of investing in and maintaining recognized excellence within their program considering the constraints of their budgets. There is demonstrated national and international leadership as evidenced by top-tier journal publications, invited talks, and national and international awards. FES could strengthen their measurement of productivity through a more consistent approach to collecting this information as discussed in Section 2.1.1.2, 'Monitoring', above. Specifics on each program can be found in the appendices.

2.1.2.3 Validation

FES considers validation to be very important for Burning Plasma Science. The committee notes that multiple elements are necessary to carry out validation yet are not reflected in conventional and recent FES solicitations that target specific issues (such as Theory, Diagnostics, or Computation), machine configurations (such as Tokamak or Stellarator), or facility (such as DIII-D or the National Spherical Torus Experiment Upgrade [NSTX-U]). Furthermore, the Committee found no evidence of funding mechanisms to enable such deep coordinated validation between theory, simulation, experiment, and diagnostics. The Committee found that in the area of validation, FES has an opportunity to enhance the quality and strength of its programs.

> **Recommendation-4:** We recommend that FES find an effective mechanism to fund multi-faceted collaborations that target validation and involve theory, simulation, advanced-diagnostics, and experiment.

2.1.3 Management of Line Item Construction and Major Items of Equipment Projects

Charge Element 3*: FES's management of its portfolio of line item construction and Major Items of Equipment projects, including the U.S. Contributions to ITER project.*

The Committee found that FES has effectively managed the execution of the U.S. ITER project with minimal staff, particularly in light of the DOE uncertainty in their future participation in the international ITER project. The Secretary of Energy delivered a report to Congress in May 2016 to recommend the U.S. remain a partner in the international ITER project through FY2018. In

FY2016, the U.S. ITER project was separated into two subprojects, known as SP1 and SP2, with SP1 completion expected in 2025 and SP2 completion in 2035. In FY2017, the Deputy Secretary approved Critical Decision-1R and SP1 Critical Decision-2/3. To date, 2 of 13 work breakdown structure elements (Toroidal Field Conductor and Steady State Electrical Network) are completed. The engagement by FES includes weekly management conference calls of the Integrated Project Team discussing a variety of topics, including those related to the ITER Organization.

With regard to management of the NSTX-U project, which received its Critical Decision 4 approval in September 2015, FES appropriately managed the project through completion. In 2016, numerous technical failures occurred, resulting in a cessation of operations and the initiation of a recovery effort. The Committee focused mainly on the management of the recovery effort during the review. We found that FES is appropriately requiring that the NSTX-U recovery efforts be treated like a formal project. The path forward to a return to research operation of NSTX-U is a unique situation that has required heavy involvement from personnel in both FES Divisions. It is critical that this effort is highly coordinated and executed with a shared vision that represents the FES program. In light of this, the following recommendation was put forth.

> **Recommendation-5:** Because the NSTX-U Recovery Plan will be based on an "operations project" treated like a DOE Order 413.3B project, it is critical that the FES program office formally define and document the internal roles and responsibilities for both the Research and FOP Division PMs to support the return to operations of the NSTX-U research facility.

2.2 Recommendations on Each Topical Program

This section provides the recommendations made by the groups on each of the programs reviewed. Detailed reports can be found in Appendices D–I. They contain the findings and comments for each group and provide context for these recommendations

2.2.1 Group 1 – MFE Experiments Domestic

Recommendation: None

2.2.2 Group 2 – MFE Experiments International and Diagnostics

Recommendation-6: Regarding the innovative solicitation "Measurement Innovations for Magnetic Fusion Systems," FES should assess the effectiveness and/or success rate of the 13 awarded high-risk, high-reward Category-1 proposals after two years and, if the result is deemed successful, FES should consider this model approach for future solicitations.

2.2.3 Group 3 – Theory and Simulation

Recommendation: None

2.2.4 Group 4 – Enabling Research and Development, Fusion Nuclear Science, and Materials Research

Recommendation-7: Design and release effective competitive solicitations/ Funding Opportunity Announcements (FOAs) (in areas of E-R&D, FNS, and MR), targeting narrow scientific or technical challenges, that enable ideas to be openly vetted by the fusion community. The currently funded national laboratory and non-laboratory projects should (when appropriate) submit and compete within these solicitations. Use of parallel (non-laboratory and national laboratory) solicitations is suggested.

Recommendation-8: Utilize panels to assess the scientific and technical quality and progress R&D activities associated with awards to national laboratories. We suggest that these are held at a minimum of once every three years (which also agrees with the most common duration of awards).

Recommendation-9: Assemble documents that capture and rapidly convey connections between FES technical priorities, projects funded through the E-R&D, FNS, and MR programs, and major project or user facilities to ensure that information needed by the COV to assess the breadth, depth, and quality of these programs is readily available. We suggest including: funds granted by FES to E-R&D, FNS, and MR projects; use (if any) by those projects of user-facilities or major-project facilities; and the key capabilities and the funding channel for (general) operations of user-facilities and major-projects that are considered elements of the E-R&D, FNS, and MR portfolio.

2.2.5 Group 5 – General Plasma Science, Exploratory Magnetized Plasmas, High Energy Density Laboratory Plasmas, and Early Career Research Program

Recommendation: None

2.2.6 Group 6 – Facility and Project Management

Recommendation: See Recommendation-5 within Section 2.1.3.

2.3 FES Response to 2014 COV Recommendations

Comment within Charge*: The panel should also comment on FES's progress in addressing action items from the previous COV review.*

The Committee found that FES progress in the responses to recommendations of the previous COV were generally good. A few of the recommendations responses are highlighted below. Comments on the response to specific program recommendations can be found in Appendices D though I.

2.3.1 Community Input

The need for FES to utilize community input was a common recommendation in the 2014 COV report. The Committee feels that FES's employment of the community input was much improved during this COV period in comparison to the last COV period. Input was solicited through community workshops and the implementation of budget planning meetings.

The Committee strongly encourages FES to continue to seek community input.

2.3.2 Panel Reviews

The Committee commends the FES for adopting the recommendation of the prior COV for enhanced use of panel reviews. For example, in the Theory and Simulation program, panel reviews are generally used for the SciDAC proposals where several similar proposals need to be evaluated. The Committee understands the difficulty and expense in organizing such panels, particularly when overseas experts are invited to attend such reviews. The Committee would like to reiterate the 2014 COV recommendation on adopting wider use of virtual or video panel reviews. While these types of reviews may not be as effective as onsite panel discussions, they may present fiscal and logistical advantages that will enable the further adoption of panel reviews by the FES.

2.3.3 Use of Portfolio Analysis and Management System

The Committee commends the FES for acting on the recommendations of the prior COV for the development of an integrated document management system for proposal submissions, reviews, recommendations, and progress reports. The result is the adoption of PAMS for this purpose. The colocation of proposal and award information made the Committee's task of reviewing the FES program much easier. From the information in PAMs and other information presented, we conclude that FES is doing a very good job in soliciting, reviewing, and selecting proposals for awards.

Appendix A: COV Charge Letter

Department of Energy
Office of Science
Washington, DC 20585

January 16, 2018

Dr. Donald Rej
Chair, Fusion Energy Sciences Advisory Committee
Program Director
Office of Science Programs at LANL
Los Alamos National Laboratory, MS-A121
Los Alamos, New Mexico 87545

Dear Dr. Rej:

I am writing to request that the Fusion Energy Sciences Advisory Committee (FESAC) establish a Committee of Visitors (COV) to review the management processes of the Department of Energy Office of Science Fusion Energy Sciences (FES) program. The panel should consider and provide evaluation of:

- The efficiency and quality of the processes used by FES to solicit, review, recommend, monitor, and document awards and declinations for universities, national laboratories, and industry.

- The breadth, depth, and quality of the resulting program portfolio, and providing an evaluation of the program's national and international standing.

- FES's management of its portfolio of line item construction and Major Items of Equipment projects, including the U.S. Contributions to ITER project.

The last COV activity evaluated the FES program through Fiscal Year (FY) 2013. Accordingly, in this assessment the COV should review the entire FES program for activities during FY 2014, FY 2015, FY 2016, and FY 2017. The panel should also comment on FES's progress in addressing action items from the previous COV review. The COV panel should be composed of recognized scientists and research program managers with broad expertise relevant to the fusion program. Panel members should be familiar with FES research programs; however, a significant fraction of the COV members should not be involved in research that is being funded by FES. Each panel member will be requested to sign a Conflict of Interest statement and a Confidentiality statement.

The results of this assessment should be documented in a report that clearly articulates findings, comments, and recommendations. FESAC should submit a report on the COV activity by October 1, 2018. COV reviews conducted in this manner have proven highly valuable to the Office of Science in maintaining a high standard of excellence in program execution. I look forward to the panel's report and appreciate FESAC's willingness to take on this important activity.

Sincerely,

J. Stephen Binkley
Deputy Director for Science Programs
Office of Science

Appendix B: Members of the COV and Assigned Groups

Name	Institution
Chair and Co-Chair	
Gertrude Patello	Pacific Northwest National Laboratory
Fred Skiff	University of Iowa
Group 1 – Magnetic Fusion Energy Experiments Domestic	
Paul Terry	University of Wisconsin-Madison
Mitchell Walker	Georgia Institute of Technology
Group 2 – Magnetic Fusion Energy Experiments International & Diagnostics	
Robert Cauble	Lawrence Livermore National Laboratory
Jerry Navratil	Columbia University
Group 3 – Theory and Simulation	
Richard Groebner	General Atomics
Raffi Nazikian	Princeton Plasma Physics Laboratory
Fred Skiff	University of Iowa
Group 4 – Enabling Research and Development, Fusion Nuclear Science, and Materials Research	
Diane Demers	Xantho Technologies, LLC
David Donovan	University of Tennessee
Group 5 – GPS, EMP, HEDLP, and Early Career Research Program	
Vassilis Angelopoulos	University of California, Los Angeles
Gertrude Patello	Pacific Northwest National Laboratory
Group 6 – Facility and Project Management	
David Arakawa	Retired ORNL Site Office
Diane Hatton	Brookhaven National Laboratory
Allison Lung	Jefferson Laboratory

Appendix C: COV Agenda

Agenda
FES Committee of Visitors (COV)
August 7–9, 2018
U.S. Department of Energy Headquarters
19901 Germantown Rd, Germantown, MD 20874-1290

Tuesday, August 7

Time	Item	Room
8:00–8:45 AM	**Arrive for Badging/Laptop Property Passes**	**North Lobby**
9:00–9:30 AM	Executive Session (**Gertrude Patello**)	E-401
9:30–10:15 AM	Welcome remarks and overview by the FES management (**Jim Van Dam)** and logistics (**Nirmol Podder**)	E-401
10:15–10:45 AM	Overview Research Division **(John Mandrekas)**	E-401
10:45–11:00 AM	Break	
11:00–11:30 AM	Overview Facilities, Operations & Projects Division **(Joe May)**	E-401
11:30–12:00 PM	FES Budget (**Gene Nardella**)	E-401
12:00–12:15 PM	Early Career Research Program (**Nirmol Podder**)	E-401
12:15–12:30 PM	FES Outreach Activities **(Matt Lanctot)**	E-401
12:30–1:30 PM	Lunch at the DOE cafeteria	DOE cafeteria
1:30–4:30 PM	Subgroup Parallel Breakout Sessions *MFE experiments domestic (**Foster, King, Barish, & Lanctot**)* *MFE experiments international & diagnostics (**Lanctot**, **Barish, & Foster**)* *Theory and Simulation (**Mandrekas**)* Enabling R&D, Fusion Nuclear Science, and Materials Research *(**Nardella, Clark, & Sullivan**)* *GPS, HEDLP, EMP, & Early Career Research Program (**Podder, Akli, & Bolton**)* *Facility & Project Management **(May)***	Various (see COV assignments sheet)
4:30–6:00 PM	Executive Session – *Initial Impressions, Questions for FES, Assess Schedule for next day*	E-401
6:00 PM	Adjourn for the day	

Wednesday, August 8

Time	Item	Room
8:30–11:30 AM	The COV continues its deliberations in breakout sessions	Various
12:00–1:00 PM	Lunch at the DOE cafeteria	DOE cafeteria
1:00–3:00 PM	The COV continues its deliberations either in breakout sessions or in executive session; FES POCs and the FES PSS are available to answer questions, and provide requested information	Various
3:00–5:30	Executive Session – *Committee drafts Findings, Comments & Recommendations; Assess schedule for next day*	E-401
5:30 PM	Adjourn for the day	

Thursday, August 9

Time	Item	Room
8:30–9:30 AM	Q&A with FES staff	E-401
9:30–12:00 PM	COV executive session to consolidate input and develop first draft of findings and recommendations	E-401
12:00–1:00 PM	Lunch at the DOE cafeteria	DOE cafeteria
1:00–3:00 PM	COV executive session to consolidate input and develop first draft of findings and recommendations	E-401
3:00–5:00 PM	Debriefing session: COV presents initial findings and recommendations to the FES management and staff	E-401
5:00 PM	COV meeting adjourned	

Appendix D: Group 1 – Magnetic Fusion Energy Experiments Domestic

D.1 Efficiency and Quality of the FES Processes

D.1.1 Findings and Comments

The Office of Fusion Energy Sciences transitioned the process whereby proposals for DIII-D collaboration grants are submitted from open solicitations to targeted FOAs. Supplemental grants have been used to help renewal grants synchronize with the FOAs. Once DIII-D collaboration grants are fully managed through FOAs, the process will more closely conform to that of NSTX, which was held as exemplary in the 2014 COV report, and will help ensure improved community access to opportunities for DIII-D collaborations. The 2015 FOA for DIII-D collaborations received 18 proposals for new collaborations and 6 proposals for renewal. Three new collaboration grants and three renewal grants were funded. The nonrenewal of three grants and the addition of three new grants represent an appropriate broadening of community involvement in DIII-D collaborations.

There was considerable variation in internal documentation and rationale for decisions to fund or decline across the open solicitations for domestic experiments and the FOAs for DIII-D collaborations; research, diagnostics for NSTX-U; and Research on Innovative Approaches to Fusion Energy. With the DIII-D collaborations FOA, the weighting of review inputs; the consideration of scientific merits, programmatic merits, and budgetary constraints; and the rationale for the decision to fund or decline were well documented, making the handling of funding decisions in this area a model of transparency.

FES has critical staffing shortages with only two personnel added to offset a loss of five persons. The two new hires are involved in management of projects within the area of domestic experiments. They are highly qualified and therefore constitute an excellent addition to the staff.

As a result of NSTX-U hardware failures and the inability to run the device, FES management requested PIs on NSTX research and diagnostic grants to submit revised research plans. Where necessary, management worked with PIs to ensure that plans were adequate and realistic. Subsequent annual progress reports reflected these revisions. FES's steps in managing grants affected by the NSTX-U outage were appropriate and effective. The procedure followed by FES for requesting modifications to research plans for NSTX research and diagnostic grants should be documented, along with lessons learned from the perspective of program management.

D.1.2 Recommendations

None.

D.2 Effect of Award Process on Portfolio

D.2.1 Findings and Comments

The Office is doing a good job of investing in and maintaining areas of recognized excellence and has fostered opportunities for collaboration with Wendelstein (W)-7X, taking advantage of a compelling experiment to which the U.S. made no contributions for construction. At the same time, both domestic stellarator projects have been supported by FES renewal of their grants. FES support for both collaborative work on W-7X and domestic stellarators recognizes the value of contributing to research on W-7X, and at the same time addresses the reality that the domestic stellarator programs are both unique and valuable within the international program.

D.2.2 Recommendations

None.

D.3 Response to 2014 COV Recommendations

As detailed above, FES has taken effective steps to pattern the solicitation and management of collaborative research on DIII-D after the well-regarded processes in place for NSTX. This, and the balance of awards and declinations between renewals and new proposals, has helped broaden community participation in DIII-D research. Comments regarding lack of transparency in award decisions have been effectively addressed by procedures adopted in the management of solicitation and awards within the DIII-D collaboration. The reinstituting of budget planning meetings with community input is an important response to one element of the 2014 COV call for better community involvement in FES planning. However, it does not eliminate the need for an effective community-wide strategic planning process.

Appendix E: Group 2 – Magnetic Fusion Energy Experiments International and Diagnostics

E.1 Efficiency and Quality of the FES Processes

E.1.1 Findings and Comments

Both research areas in this subgroup have seen significant growth over the 4-year COV review period. Funding for MFE International experiments has grown from $9.9M in FY2014 to $15M in FY2017, and Measurement Innovation has gone from $3.5M in FY2014 to $10.1M in FY2017 (an increase which reflects compliance with DOE full-forward-funding requirements and does not signify a proportionate increase in the level of effort). This growth in program activity was carried out by FES through three targeted FOAs, all of which were examined by the COV:

- FY2014 "Collaborative Research in Magnetic Fusion Energy Sciences on Long-Pulse International Stellarators"
- FY2016 "Collaborative Research in Magnetic Fusion Energy Sciences on International Long-Pulse Superconducting Tokamaks"
- FY2016 "Measurement Innovations for Magnetic Fusion Systems"

The primary basis for the increased activity was the set of recommendations in the 2012 FESAC Report on International Collaboration[1]. Those recommendations were implemented in expanding the FES program activity to take advantage of unique capabilities on long-pulse superconducting international tokamak and stellarator facilities. This was done both in the scientific areas of opportunity identified in the 2012 FESAC Report and the recommended modes of collaboration. This included forming multi-institutional teams of laboratory, university, and industry participants and investment in remote collaboration tools.

The FY2014 Stellarator FOA supported the creation of four new efforts on W7-X (Germany), three led by universities and one by a small business that added to the ongoing W7-X collaboration led by Princeton Plasma Physics Laboratory (PPPL), Oak Ridge National Laboratory (ORNL), and Los Alamos National Laboratory that began in FY2011. The FY2016 Superconducting Tokamak FOA supported the formation of four multi-institutional teams, one led by a national laboratory on the Chinese Experimental Advanced Superconducting Tokamak (EAST), one led by industry on EAST & the Korean Superconducting Tokamak Advanced Research (KSTAR), and one led by a university on KSTAR. In addition, a small, industry-led scoping effort was funded aimed at JT-60SA.

The FY2016 Measurement Innovation FOA offered applicants a choice of two categories of proposal application: Category 1 solicited high-risk/high-reward proposals with a 1- to 2-year

[1] FESAC. 2012. Opportunities for and Modes of International Collaboration in Fusion Energy Sciences Research during the ITER Era. (https://science.energy.gov/~/media/fes/pdf/workshop-reports/20120309/Intl_Collab_Final_SCSC-PRINT.pdf)

time frame funded at the $50K to $200K per award level and Category 2 (Complex Development) that required substantial development effort over one or two funding cycles spanning three years with funding levels typically $600K to $1.2M per award cycle. The FOA resulted in 17 Category 1 applications and 22 Category 2 applications. Of these, 13 new projects were funded in Category 1 (2 laboratory and 11 non-laboratory) and 12 projects (7 renewal, 4 new, and 1 close-out) were funded in Category 2 (4 laboratory and 8 non-laboratory).

Our overall impression of this effort is that the programs created in this area address the critical needs identified by the community through 2012 FESAC report on International Collaborations and 2015 Community Workshops, have been soundly selected, and have been structured to achieve the recommended breadth of institutional participation. Examination of the funding decisions made on all proposals submitted to the three FOAs reviewed by this subgroup showed a very strong correlation with the consensus score by peer reviewers. In the few cases where a relatively higher ranked proposal was declined, programmatic and/or technical reasons were provided to justify the decision. Records showed adequate and, in general, consistent reviews, and that awardees provided progress reports as needed. It was easier to track for non-laboratory awards.

The two-category Measurements Innovation FOA was inventive. It is too early to examine the portfolio within the scope of this COV, but the intent of seeding a number of high-risk but low-funding-level proposals appears to have a good chance at success. Success might be measured by one or more of the seed ideas being carried forward to more extensive development. Attention should be paid to the structure of this FOA; it could become a model for some future FOAs.

We found that documentation of information regarding declinations varied depending on the PM entering the decisions. Documented feedback to declined PIs consists of an email directing the PI to redacted reviews. The reason(s) for the declination are not given although they could be in PI-PM communications that are not generally denoted. The reason(s) for declination are inserted by the PM into PAMS, which the PI does not see. Those reasons can be fully explicit or cursory, depending on the PM. The short and sometimes less-than-clear comments, although likely reflecting careful considerations by the PM, make COV evaluations more difficult and may cause continuity issues when PMs change. However, the COV recognizes that this situation could be improved by increased staffing.

In reviewing the 2016 International Tokamak FOAs, we found that reviewer information was lost in panel reviews unless panel members took the trouble to document their comments in writing or the PM took the time to capture the relevant information. Often the documented declination description for proposals was cursory. Alternatives would be to employ a scribe or ask a member to keep extensive and detailed notes although neither alternative seems viable without an increase in staff.

We believe that not only communication and documentation would be improved by a less-busy staff, but also monitoring of awards could be enhanced if the FES PMs were able to perform more site visits and attend additional meetings of relevance to their portfolios.

E.1.2 Recommendations

We would like to reinforce Recommendation-2 on consistency in reporting. This is not a separate recommendation.

E.2 Effect of Award Process on Portfolio

E.2.1 Findings and Comments

It is possible to judge the standing of the portfolio produced by one of the three FOAs described above—the FY2014 "Collaborative Research in Magnetic Fusion Energy Sciences on Long-Pulse International Stellarators"—since the FOA came out early in the COV evaluation period. The primary aim of the FOA was to insert U.S. participation and exploit U.S. hardware in two non-U.S. stellarator projects, W7-X in Germany and the Large Helical Device in Japan with an emphasis on core-edge solutions and limits/transients. There was already a U.S. presence at these devices in diagnostics. The call was successful in producing U.S. collaborations, especially with W7-X. The W7-X collaborations succeeded in making U.S. participants embedded experimental team members. W7-X has proven to be a productive device, and the U.S. participation has been substantive.

Awards for the FY2016 FOA "Collaborative Research in Magnetic Fusion Energy Sciences on International Long-Pulse Superconducting Tokamaks" were made late in the COV evaluation period, making a deep assessment difficult, or at least premature. As in the 2014 FOA, the primary purpose was to insert U.S. participants in international tokamak projects with specific emphases (long-period operations, boundary and scrape-off physics, and wall interactions), studies, and solutions that are relevant to ITER. The resulting portfolio created research teams directed at Asian tokamaks EAST, KSTAR, and JT-60SA. The funded teams are all very good and have relevant expertise; also there is a good collaborative precedent for EAST and KSTAR so that the three awardees are likely to be successful. A later evaluation—presumably the next COV—should be made of the JT-60SA effort. It remains to be seen whether U.S. participants will be leading some aspects of the science and engineering on these devices.

As noted in the previous section, FES, and possibly the next COV, should evaluate the productivity of the two-category FY2016 FOA "Measurement Innovations for Magnetic Fusion Systems" as it is too early to evaluate the resulting portfolio other than to note that awards under the high-risk, high-payoff, low-dollar-figure Category 1 are appropriately broad-based. This funding approach can likely be deemed successful if more than one of the Category 1 proposals grows into the development stage. It is too early to assess the effectiveness of the Category 2 awards.

E.2.2 Recommendation

Recommendation-6: Regarding the innovative solicitation "Measurement Innovations for Magnetic Fusion Systems," FES should assess the effectiveness and/or success rate of the 13 awarded high-risk, high-reward Category-1 proposals after two years and, if the result is deemed successful, FES should consider this model approach for future solicitations.

E.3 Response to 2014 COV Recommendations

The 2014 COV report made three recommendations in this area: two under International Collaborations and one under Diagnostics. As evidenced by our findings in this report, all were addressed by FES.

The 2014 COV report recommended a "move toward a specific FOA for international projects." The 2014 FOA "Collaborative Research in Magnetic Fusion Energy Sciences on Long-Pulse International Stellarators" was aimed specifically at collaborations on W7-X and the Large Helical Device. A second aspect of this recommendation was consideration of a "more discerning peer review process." We found that the peer review process was fair and effective.

The second International recommendation noted that experimental facilities should be given the chance to provide significant input on proposals affecting those facilities. Overall, we found the peer review process for the 2014 Stellarator and 2016 "Collaborative Research in Magnetic Fusion Energy Sciences on International Long-Pulse Superconducting Tokamaks" FOAs to be inclusive and effective.

With regard to diagnostics, the 2014 Report recommended that FES "explore alternate ways to ensure outstanding and innovative proposals do not have to wait four years to re-compete." The two-tiered 2016 FOA "Measurement Innovations for Magnetic Fusion Systems" is apparently a direct result of this recommendation. As noted in the previous subsection, we found the novel proposal structure to have excellent potential and that success of the resulting portfolio should be assessed as a model for future FES FOAs.

Appendix F: Group 3 – Theory and Simulation

F.1 Efficiency and Quality of the FES Processes

F.1.1 Findings and Comments

The Committee would like to express great appreciation for the time and effort the FES PMs invested in accommodating our requests for additional information and assistance. With the strong support of the PM and the FES staff, we were able to develop a great deal of understanding on the workings of FES and the constraints and challenges that FES faces in the effective execution of its duties.

In the Theory and Simulation program, panel reviews are generally used for SciDAC proposals when several similar proposals needed to be evaluated. Since panel reviews improve the uniformity of the peer review process for competing proposals, it is desirable that their use be expanded to other types of reviews. However, the group understands the difficulty and expense in organizing such panels, particularly when overseas experts are most appropriate to attend such reviews.

Thus, the Committee suggests that the FES consider adopting video panel reviews. While these may not be as effective as in-person panel discussions, they may present advantages in terms of logistics that will enable further adoption of panel reviews by the FES.

The PAMS database possesses the primary advantage of collecting all relevant information associated with a proposal in one location, including the FOA relevant to the submission. The colocation of this information and the uniform requirements for submissions made our task of reviewing Theory and Simulation proposals much easier. From the information in PAMs and other information presented, we conclude that FES is doing a very good job in soliciting, fairly reviewing, and selecting proposals for awards.

However, the Committee was surprised to find a great deal of non-uniformity in the progress reports for the SciDAC projects. The group believes that the lack of uniformity, combined with the constrained staffing situation in the FES, could lead to difficulties in evaluating the productivity of the projects due to a lack of information. Important information such as the products of the research is sometimes not documented. Important information on the quality of the collaborations (SciDACs are encouraged to be collaborative and multi-institutional) is sometimes not provided. Some reports appear to be a collection of individual institutional updates making it difficult to assess whether some SciDACs are responsive to an important requirement.

The Committee finds that the national laboratory exemption from submitting SciDAC progress reports to PAMS is a possible hindrance for the efficient monitoring and quality assessment of the SciDACs. The Committee recognizes that the national laboratories are extensively reviewed, and they can be even more regularly and strenuously reviewed than universities and private companies. Nonetheless, the group sees the possibility of ineffectiveness for the FES in monitoring progress and products due to non-uniform reporting.

The Committee recognizes that regular travel to conferences and site visits by FES PMs is essential for the effective monitoring of the Theory and Simulation portfolio. International travel is particularly important for gauging the relative strength and weakness of the U.S. program against international efforts. The Committee is encouraged to see that the FES staff can now begin to travel again, and we urge the Office of Science to continue to provide adequate travel support for the FES staff.

The Committee recognizes that the FES has extensive interactions with PIs beyond the documents submitted to PAMS and that generally these interactions are effective in enabling the office to provide effective oversight. Other portfolio assessment methods include remote conferences, site visits or reverse site visits, mid-term progress reviews (primarily for SciDAC centers), meetings with PIs (SciDAC), annual Laboratory Appraisal processes for national laboratories, and interactions with PIs at national conferences.

The Committee appreciates the difficulties that the FES experiences in funding new projects quickly because of budgetary uncertainties that push decisions later in the year and the time it takes for contract review and approval once a funding decision is made. While some issues are beyond the scope of the COV, the Committee believes that inadequate staffing at the FES contributes to the duration of the review process. Identifying reviewers, following up with them, and evaluating their input takes serious effort and attention. With a shortage of staff, either the duration or the quality of the review process will be affected.

Therefore, we urge the Office of Science to adequately staff the FES program in order to shorten the duration of the review process while maintaining quality. We have not made this a recommendation as it falls outside of the COV guidelines.

F.1.2 Recommendations

We would like to reinforce Recommendation-2 on consistency in reporting in the context of SciDAC projects. This is not a separate recommendation.

F.2 Effect of Award Process on Portfolio

F.2.1 Findings and Comments

The Committee commends the FES for their outstanding stewardship of the Theory and Simulation program. We can claim with considerable pride that the Theory and Simulation program is a great jewel in the crown of the U.S. fusion program, and considerable credit must go to FES for their able management. The portfolio is of very high quality, has great breadth and depth, and is producing excellent science.

However, it was noted several times that the world is catching up and perhaps surpassing the U.S. in terms of support for theory and computation. It is therefore of great importance that we assess the quality and depth of the Theory and Simulation program in the context of a more competitive international climate. While the U.S. cannot expect to lead in all areas of Theory and

Simulation, it should expect the recipients of U.S. funding to be world leaders. We should also plan to have concentrations of leadership in certain areas where it is essential for the U.S. to lead.

The U.S. fusion program is a great beneficiary of the international race for computational supremacy, through the strategic partnership between FES and Advanced Scientific Computing Research (ASCR). Of the $24M for SciDAC funding in FY2017, 1/4 comes from ASCR. The success of this partnership is a great credit to the FES program managers.

A concern voiced in the Committee is whether the push toward multiscale integrated simulation and exascale computing was being done in a way that strengthens areas of traditional U.S. leadership in model validation and basic theory. The FES noted that most of the International Atomic Energy Agency theory overviews are given by U.S. scientists, and that the U.S. has received seven European Alfven prizes. A short survey by the group finds that the great majority of those talks and prizes go to analytic theorists. The group also recognizes that often the most impactful research papers are those that present detailed model comparisons with experimental data at a level that is worthy of the title “model validation.”

The group agrees that U.S. leadership in exascale computing, quantum computing, and machine learning is of vital importance. The group members also agree that U.S. leadership in fusion simulation through the SciDACs will be strengthened by an increased emphasis on interaction with analytic theory and experiment. With the incorporation of these approaches, the goal needs to remain—improved understanding.

F.2.2 Recommendations

We would like to reinforce Recommendation-4 with respect to SciDAC projects as it would strengthen the collaborative aspect of these projects to have close interaction between traditional theorists and experimental programs. We believe that such interactions will accelerate U.S. leadership in Theory and Simulation while simultaneously strengthening traditional areas of U.S. leadership. This is not a separate recommendation.

F.3 Response to 2014 COV Recommendations

The Committee commends the FES for adopting the recommendation of the prior COV to adopt enhanced use of panel reviews. These have generally been used for evaluation of SciDAC proposals where several similar proposals need to be evaluated. Panel reviews improve the uniformity of the peer review process.

The Committee commends the FES for acting on the recommendations of the prior COV for the development of an integrated document management system for proposal submissions, reviews, recommendations, and progress reports. The resulting PAMS system made our reviewing task much easier. Moreover, this is major advance in improving the ability of FES personnel to develop and monitor their research portfolios.

Appendix G: Group 4 – Enabling Research and Development, Fusion Nuclear Science, and Materials Research

G.1 Efficiency and Quality of the FES Processes

G.1.1 Findings and Comments

The E-R&D, FNS, and MR programs fund fundamental science in support of fusion energy. They are focused on enabling a burning plasma environment. The DOE-FES website states "The Enabling Research and Development (R&D) element develops the technology to enhance the capabilities for existing and next-generation fusion research facilities, enabling these facilities to achieve higher levels of performance and flexibility needed to explore new science regimes." and "The Materials and Fusion Nuclear Science element supports the development, characterization, and modeling of structural, plasma-facing, and blanket materials for use in future fusion devices."

The E-R&D, FNS, and MR programs received average yearly funding (over a 4-year period, inclusive of universities, industry, and national laboratories) of $2.165M, $11.373M, and $12.682M, respectively. These programs fall under two of the four FES program elements. E-R&D is within Burning Plasma Science: Foundations, and FNS and MR are within Burning Plasma Science: Long Pulse. Expenditures for E-R&D, FNS, and MR combined are ~8% of the total FES annual research budget.

Two PMs and a technology team leader within FES are assigned to overseeing projects within E-R&D, FNS, and MR. During the 2014–2017 period, several retirements and hires occurred, causing PM staffing discontinuity. The Committee would like to thank the PMs for the information and assistance they provided to enable our work and facilitate comprehension of their portfolio of programs.

The processes used by FES to receive and vet proposals associated with the E-R&D, FNS, and MR topical areas differ from those used in most other areas. During the 2014–2017 period that this COV was charged to review, FES did not release any FOAs to solicit proposals targeting E-R&D, FNS, and MR. Proposals from universities and industries were submitted to FES via the *General/Open Solicitation*, whereas those from national laboratories were submitted directly to the PMs via *Field-Work Proposals* (FWPs). Since none of the associated proposals were in response to competitive FOAs, the proposed projects did not compete, and thus were not ranked, against other proposed projects. FES has made strides to utilize peer review to ensure programmatic breadth and quality, and long-term health. However, without targeted and competed solicitations/FOAs, these factors can suffer.

The FES process used to vet proposed projects differs according to type of institution. Proposals from universities and industries were subjected to a minimum of three peer reviews, whereas FWPs from national laboratories were not peer reviewed. The absence of blind reviews by experts outside of DOE is typical for FWPs, yet the modest degree of vetting is a striking contrast to the peer-review and merit-evaluation processes that university and industry projects undergo.

The Committee acknowledges that FES put forth an openly competed FOA in 2011 targeting the areas of Plasma-facing Materials, Structural Materials, and Blankets. The FOA received more than 90 proposals, as documented in the 2014 COV report. This put a large strain on FES and the fusion community (from which reviewers were drawn) that was disproportionate to the limited funds available for award.

FES conducted merit reviews of E-R&D-, FNS-, and MR-funded projects in the form of panels, in response to the 2010 COV recommendation and subsequent discussion in the 2014 COV report. We appreciate DOE's address of these recommendations. The panel reviews (conducted in 2018) assessed the scientific and technical quality and progress of projects funded during the 2014–2017 period. Panels having a minimum of three (non-FES) members were convened in-person at FES on topical areas of MR, Plasma Material Interactions, and FNS. Within each topical area, a single panel conducted reviews inclusive of awards to universities, industry, and national laboratories.

The PMs informed the Committee that the means by which they monitor projects is dependent on the type of institution performing the project. Universities and industry submit annual progress reports that detail research progress, accomplishments, products, and problems/challenges via PAMS, which follows the format that is detailed in the federal-wide standard Research Performance Progress Report.[2] Projects at laboratories do not use PAMS; the PMs monitor national laboratory awards by laboratory visits, PI visits to FES, and monthly or bimonthly discussion between the PI and the PM.

A notable difference in the monitoring of the university and industry, versus national laboratories, is documentation, particularly the consistency of content, regularity, and format. Without consistent documentation by the PMs of projects at national laboratories (for example, the progress and renewals of FWPs in a database such as PAMS), assessment of national laboratory awards by a COV is challenging.

The Committee notes that the degree of community scrutiny and FES oversight of university and industry projects is high: proposals are peer reviewed (through blind reviews by external experts), and those receiving awards submit annual progress reports within PAMS. The degree of community scrutiny and FES oversight of national laboratory projects is less stringent. FWPs are not peer reviewed, and those receiving awards do not submit annual progress reports within PAMS. The use of panel reviews and merit evaluation can offset some shortcomings of the national laboratory review and monitoring processes. Panel reviews of national laboratory awards can achieve goals similar to a program advisory committee; provide feedback to awardees on progress, quality, and direction; and provide technical insight and evaluation to the PMs.

During late FY2015, Dr. Ferguson of ORNL was named as (the new) Director of the Virtual Laboratory for Technology (VLT). This action by FES was in response to the 2014 COV recommendation to "Revise VLT structure to separate program management from project leadership, and move leadership of the program to outside of FES." Notable activities of the VLT include video-conferences every two months with presentations by DOE program

[2] https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=10:4.0.1.3.13

management and topical updates among areas; input into community planning activities; and ad-hoc meetings. The periodic and regular convening of university, industry and national laboratory PIs, together at various meetings, is facilitated by the VLT and is valuable for community building and sharing information. The meetings need not (always) be in person; the use of videoconferencing can be an economical and effective solution.

G.1.2 Recommendations

Recommendation-7: Design and release effective targeted and competitive solicitations/FOAs (in areas of E-R&D, FNS, and MR) for narrow scientific or technical challenges that enable ideas to be openly vetted by the fusion community. The currently funded national laboratory and non-laboratory projects should (when appropriate) submit and compete within these solicitations. Use of parallel (non-laboratory and national laboratory) solicitations is suggested.

Recommendation-8: Utilize panels to assess the scientific and technical quality and progress of R&D activities associated with awards to national laboratories. We suggest that these are held at a minimum of once every three years (which also agrees with the most common duration of awards).

G.2 Effect of Award Process on Portfolio

G.2.1 Findings and Comments

The E-R&D, FNS, and MR program portfolio is topically broad. There are two FES PMs, each overseeing a particular dimension of the program's portfolio. Its awards are spread largely among universities and national laboratories, with just one award made within industry. Some projects are conducted at the home institution of the PI, whereas others require the capabilities of user facilities. It was not possible to identify the depth of the work that is directly funded by the E-R&D, FNS, and MR programs using the information provided to the COV. This was largely because collated scope-of-work, budget, and budget-justification documents were not readily available for many projects, particularly those at national laboratories, which makes identifying and assessing the depth of award-funded work elements intractable.

The rank of two national laboratory projects, according to an average of the 2018 peer-review panel scores, was considerably lower than other projects in the FNS program. This would logically factor into FES programmatic decisions, principally in relation to quality. Unfortunately, the Committee was not told how or if such peer-review feedback will be utilized.

The U.S. does not have the resources to be a world leader in every technology critical to the FES mission. The Committee was provided with a list of E-R&D, FNS, and MR associated U.S. facilities and major projects, and programs within universities and industry but the information lacked context. To improve clarity regarding the purpose, performance, and world-standing of projects funded through E-R&D, FNS, and MR, it would be informative for FES to identify and document topics that are being tackled by programs in the U.S. and by international programs (and scientists outside of the U.S.), and where world leaders of key capabilities exist among them, to avoid duplication of effort during a period of constrained budgets.

Multiple U.S. world-leading core capabilities are associated with the E-R&D, FNS, and MR program portfolio. Some of these (High Flux Isotope Reactor [HFIR] at ORNL, Tritium Plasma Experiment [TPE] at Idaho National Laboratory [INL], PISCES at UC San Diego) attract international collaborators and domestic users of the facility. Many of the projects within the E-R&D, FNS, and MR portfolio are leveraging these U.S. capabilities. The facilities promote U.S. leadership as evidenced by the array of published works and invited talks by the PIs and their research teams. FES should continue to cultivate international collaborations that leverage U.S. world-leading capabilities to increase their visibility within the international arena, by supporting participation in international conferences, workshops, and technical visits

The PMs informed the COV that FES has upgraded capabilities at existing facilities (INL-TPE, ORNL-HFIR), incorporated facilities into their portfolio (Lawrence Berkeley National Laboratory-Berkeley Center for Magnet Technology), developed plans for future upgrades (ORNL-Shattered Pellet Injection), and proposed a new facility (ORNL-Material Plasma Exposure Experiment). These have the potential to elevate the U.S. position in the associated technologies and provide opportunity for international collaborations.

G.2.2 Recommendations

Recommendation-9: Assemble documents that capture and rapidly convey connections between FES technical priorities, projects funded through the E-R&D, FNS, and MR programs, and major project or user facilities to ensure that information needed by the COV to assess the breadth, depth, and quality of these programs is readily available. We suggest including: funds granted by FES to E-R&D, FNS, and MR projects; use (if any) by those projects of user-facilities or major-project facilities; and the key capabilities and the funding channel for (general) operations of user-facilities and major-projects that are considered elements of the E-R&D, FNS, and MR portfolio.

G.3 Response to 2014 COV Recommendations

The previous COV recommended that future plans be well-formulated and communicated before canceling programs. This recommendation could not be assessed as no programs were canceled during the review period in the E-R&D, FNS, and MR programs. Similarly, the recommendation to initiate a scientific review for any proposed new facilities could not be assessed as no new facilities were proposed during the COV review period. The Material Plasma Exposure Experiment should be considered by the next COV committee.

As mentioned in the section above, FES conducted merit reviews of E-R&D, FNS, and MR-funded projects in the form of panels, in response to the 2010 COV recommendation and subsequent discussion in the 2014 COV report.

In response to the 2014 COV recommendation to “Revise VLT structure to separate program management from project leadership, and move leadership of the program to outside of FES,” FES named Dr. Philip Ferguson of ORNL as the new Director of the VLT in late FY2015.

With regard to the recommendation to initiate a scientific review of closed-out materials research and, where appropriate, consider impact of cancellations on future activities, FES responded that decisions to close programs were final but pointed to community workshops as a source of input for future activities.

Appendix H: Group 5 – General Plasma Science, Exploratory Magnetized Plasma, High Energy Density Laboratory Plasmas, and Early Career Research Program

H.1 General Plasma Science and Exploratory Magnetized Plasma

The EMP program was merged with the GPS program during the reporting period. The two together will be referred to as GPS in the ensuing discussion. When EMP-type research is called out, it will still be implied that it is a part of the GPS program. The funding of the GPS program in the reporting period (total over 4 years) was $70M, including $40M for EMP. The GPS program is composed of (1) National Science Foundation (NSF)/DOE Partnership in Basic Plasma Science and Engineering, (2) the DOE National Laboratory General Plasma Science Program and the Max Planck-Princeton Center for Plasma Physics (MPPC), (3) Plasma Science Centers, and (4) Plasma Science User Facilities.

The NSF/DOE partnership supports individual investigator research of fundamental plasma science and engineering issues awarded through an annual joint NSF/DOE solicitation for non-laboratories. It also supports the Basic Plasma Science Facility (BaPSF) at University of California, Los Angeles, and the anti-hydrogen trapping for the international ALPHA collaboration at CERN. The NSF/DOE Partnership in Basic Plasma Science and Engineering has been reviewed by an NSF COV and is not subject to the current FES COV review.

Through periodic release of FOAs, approximately once per 3 years, the DOE National Laboratory Program on GPS supports individual and collaborative research that addresses specific applied plasma, laboratory, space, and astrophysical plasma issues. For example, work on magnetic reconnection, solar flares, flows in magnetic nozzles, plasma sheath, and surface interactions are funded under this program. During the reporting period, one such solicitation (LAB 16-1592) was made, focused on areas of (1) Turbulence, Transport, and Self-Organization in Magnetized Plasmas; (2) Interactions of Plasmas and Waves; and (3) Low-Temperature Plasma Kinetics and will be discussed further in this report. MPPC is focused on plasma astrophysics and fusion-related topics, such as magnetic reconnection, turbulence, energetic particles, magnetorotational instability, and stellarator physics, and is jointly funded by the GPS and Theory and Simulation programs.

During the review period, two GPS Plasma Science Centers were at least partially supported. At the beginning of the review period, there were two centers: the Center for Predictive Control of Plasma Kinetics led by the University of Michigan (also known as the Low-Temperature Plasma Science Center at UMich) and the Center for Momentum Transport and Flow Organization led by the University of California, San Diego. The former was continued under a special continuation proposal through FY2017–FY2018. Funding for the latter was terminated in 2016.

During the FY2014–FY2017 period, a new intermediate-scale Frontier Plasma Science Facilities call (DE-FOA-0001713) was issued in January 2017, and selection was made for a new user facility that operated during the review period: the Wisconsin Plasma Physics Laboratory (WiPPL), funded for August 2017–August 2022. The WiPPL user facility includes the basic plasma science efforts of the Big Red Plasma Ball and Madison Symmetric Torus (MST)

experiments. Originally, the MST experiment at the University of Wisconsin-Madison, the only reversed field pinch (RFP) configuration device in the U.S., was focused on (1) increasing fundamental understanding of the physics of the RFP magnetic configuration, (2) expanding validated predictive capability of toroidal magnetic confinement, and (3) advancing discovery science and its links to plasma astrophysics. The MST effort was supported under the Experimental Plasma Research or EMP program during the review period (FY2014–FY2017). However, in FY2018, the MST effort was downsized, and its basic plasma part was combined with Big Red Plasma Ball under the new WiPPL user facility, an intermediate-scale, integrated, collaborative plasma science user facility that will expand the frontiers of basic plasma science and astrophysics. Additionally, one more user facility was selected for the period August 2018–August 2021, but falls outside this COV review period: the Auburn Magnetized Dusty Plasma Experiment (MDPX).

H.1.1 Efficiency and Quality of the FES Processes

H.1.1.1 Findings and Comments

For the purposes of this COV review only one solicitation, the DOE Laboratory Program on GPS call (LAB 16-1592), issued in 2016 (awards made in 2017), is being commented on. This solicitation was driven as a response to the previous COV (2014) recommendations, and was focused on areas recommended by the 2015 FES strategic plan priorities (A Ten-Year Perspective), and the 2015 community workshops leading to the 2016 report on Frontiers of Plasma Science. Of the 27 proposals in the GPS and EMP categories, 9 were selected. A total of $2.3M/yr. was awarded. Reviews consisted of adequate number of external (3) and panel (2) reviewers, and the selection was made based on ratings (primarily), programmatic, and budgetary reasons (in decreasing order). The panel was able to gauge for consistency of written responses compared to scoring, and avoid over-emphasis on numerical scores, as well as scrutinize outliers further. For proposals that were closely rated, the panel considered also reviewer expertise, possible reviewer biases, programmatic priorities and program balance, impact of a termination on a renewal proposal (e.g., on graduate students), overall FES program portfolio, and synergies with other programs. For significant variations between reviewers, the PM also considered additional formal or informal input. Reviewing through PAMS allowed: (1) program to efficiently communicate results to reviewers and proposer; (2) reviewing panelists to modify review after deliberations when insight on a proposal improved, and (3) recordkeeping and award monitoring for FES managers.

The COV also was appraised on the results of the annual calls from the NSF/DOE partnership on basic plasma science. The size of that program, ~ $8M/yr., was significantly larger than the aforementioned LAB call. While the process was reviewed by an NSF COV, a few points merit discussion here. First, there is excellent communication with NSF (including participation in each other's agencies review panels) to avoid overlap, and join forces where appropriate. Second, the continuity of this program and the high (yearly) cadence of its reviews allows FES the flexibility to solicit proposals so as to absorb funds quickly, even when such funding is not known far enough in advance to plan a separate FOA.

Not all awardees record their products, making the COV evaluation of past productivity difficult. It would be good to expand the PAMS capability to store and communicate information of the awardees results, in a simple, user-friendly, standardized format. For example, publications and highlights should be stored in a uniform format so they can be queried in the future. This would help reviewing future proposals when past performance is a criterion for selection, promote visibility of the review process and program monitoring for future COVs, and generate program success metrics for communication within and outside DOE.

H.1.1.2 Recommendations

We would like to reinforce Recommendation-2 on consistency in reporting. This is not a separate recommendation.

H.1.2 Effect of Award Process on Portfolio

H.1.2.1 Findings and Comments

For the purposes of evaluating the GPS and EMP programs, the COV considered the overall science conducted by the program, not just the science resulting from the specific (LAB) funding opportunity during the reviewing period. The GPS and EMP programs constitute a diverse and agile element of the FES. They are driven by the prioritizations of the community and agency reports, and allocate funding in a way that balances small-, medium-, and large-scale laboratory resources; coordinates with NSF; and is synergistic to other programs in FES such as Tokamak research. The portfolio of basic plasma and other plasmas (e.g., low-temperature, dusty, non-neutral, and antimatter plasmas) complements MFE and HEDLP research. The funding of a range of intermediate-scale facilities (BaPSF, MDPX, ALPHA, WiPPL, and Magnetic Reconnection Experiment) at universities and national labs across the country ensures breadth. As another example of breadth, GPS funds research on magnetic reconnection/energy transformation (a high priority for the science community) both at Magnetic Reconnection Experiment at PPPL and at the Terrestrial Reconnection Experiment at Wisconsin to provide complementary perspectives and system sizes.

Outstanding science has been produced as evidenced by high-impact publications (10 *Nature*, many Nature Publishing Group papers, 1 *Science*, many *Physical Review Letters*, and invited talks). The GPS/EMP-funded scientists received high accolades as evidenced by numerous awards (1 Maxwell Prize, 1 Alfven Prize, 2 Stix Awards, 7 American Physical Society and Institute of Electrical and Electronics Engineers Fellowships, Early Career Awards, etc.). Numerous invited talks at international conferences validate the strength of the program.

The GPS program was agile enough to benefit from an uptick in 2017 funding, to establish for the first time in nearly two decades, two new intermediate-scale facilities (WiPPL and MDPX). Both the MST (the only RPF configuration device in the U.S.) and the establishment of the MDPX (a dusty multi-sourced plasma device with higher B_{max}, and larger size than any other facility in the world) constitute important national assets providing U.S. leadership.

H.1.2.2 Recommendations

None.

H.1.3 Response to 2014 COV Recommendations

With regard to GPS, the 2014 COV stated that there have been no new solicitations since 2012 and a new solicitation seems very advisable. During the 2018 COV reporting period, one such solicitation (LAB 16-1592) was issued with 9 awards (each 3 years in duration) out of 27 proposals received. The selection covered both GPS and EMP program areas (2 selected proposals were in the EMP category).

The 2014 COV also commented that it is important for FES to issue a new solicitation for Plasma Science Centers with allowance for Centers of both smaller size and intermediate size. During the COV reporting period, a new center solicitation for Frontier Plasma Science Centers was issued in January 2017 and selections were made for three centers mentioned above.

With regard to monitoring, the 2014 COV found that management tools and processes used for monitoring active GPS awards were adequate and effective. Regular site visits by DOE PMs was encouraged, but the 2014 COV recognized that such visits may be problematic due to limited travel funds. Visits by PIs and other key program staff to DOE Germantown for reviews were encouraged as a substitute for site visits, but these were judged to be less informative for DOE PMs. The 2018 COV observed that annual progress reports for universities, DOE laboratories and user facilities, plus mid-term progress reviews for user facilities, remain a requirement for funding continuation, ensuring good visibility. Direct interactions at conferences, site (or reverse site) visits, and videoconferencing, when appropriate, are practical monitoring tools. Program managers are actively engaged in the community to assess impacts of awards on the overall program.

H.2 High Energy Density Laboratory Plasmas

The HEDLP Program comprises the study of ionized matter at extremely high density, temperature, and pressure, including both matter on the order of megabar pressures, and warm dense plasmas at somewhat reduced pressures. It also includes high energy density (HED) hydrodynamics, non-linear optics of plasmas, relativistic HED plasmas and intense beam physics, radiation-dominated dynamics and material properties, and magnetized HED plasmas. It was established following the recommendation in the 2007 Report of the Interagency Task Force on High Energy Density Physics: “The Office of Science and the National Nuclear Security Administration (NNSA) within DOE will establish a joint program in high energy density laboratory plasmas (HEDLP) responsible for stewarding fundamental HEDLP science within the Department of Energy.” The scientific thrusts covered by HEDLP are outlined in the 2009 Research Needs Workshop report.

In the FY2014–FY2017 review period, the program supported 50 grants to 29 universities and 4 small businesses of ~$560K/award ($28M total), out of an approximately $18M/year budget authority. The remainder of the funding was used for laboratory funding (research and operations), Matter in Extreme Conditions facilities operations, and Early Career Awards.

There was high management personnel turnover at FES during the reporting period (program management changed twice). This was handled efficiently, by planning an overlap of one year between outgoing and incoming managers to allow for hand-off and time for the incoming manager to build up experience.

During the reporting period there has been a significant disconnect between the congressional requests for HEDLP, averaging ~$6.7M/yr. (the funding projections used for initial program planning) and the actual budget authority, averaging ~$18M/yr. The FES HEDLP PM had to be agile and resourceful in order to ensure funding absorbability in line with the recommendations of the community and prior COV reports. In particular, at the beginning of the reporting period (FY2014), the program contended with a severely contracted budget relative to prior years (congressional request for FY2014 dropped from ~$17M in FY2013 to $6.7M for FY2014). This made planning difficult and risked project and personnel continuity at laboratories and the community at large. The PM refocused the program to research on the Matter in Extreme Conditions (MEC) instrument (plus associated laboratory support), and on the Linac Coherent Light Source (LCLS) at the Stanford Linear Accelerator Center (SLAC). This was deemed by the community to be the highest research priority and leveraged considerable facility funding from other Office of Science, Basic Energy Sciences, and NNSA investments, specifically Basic Energy Sciences investments. The 2014 COV commented that this planned downsizing was done thoughtfully and with adequate (open and candid) communication to the research community.

H.2.1 Efficiency and Quality of the FES Processes

H.2.1.1 Findings and Comments

In 2014, the HEDLP program issued an FOA (DE-FOA-0001153) informed by the HED community workshops, the 2014 COV recommendations, and the 2014 FESAC report. The HEDLP program was very effective in leveraging NNSA support and selecting and funding competitive high-quality HED proposals in 2015. There was a high success rate (31%, or 24 proposals, 50-50 split with NNSA, selected from a total of 94 proposals). The reviews were high-quality. They were conducted by peer reviews and panels, which were arranged by sub-area. The panels provided expert discussions, clarifications, and vetting, enabling informed decisions. The monitoring of these awards, as well as the laboratory awards is effective and occurs via a combination of methods: All awards (both to universities/industry and to laboratories) are required to submit annual reports and products in order to get renewed, plus a final report. In addition, laboratory site visits are conducted (when possible in conjunction with various meetings), reverse site visits were encouraged, and teleconferences were used as needed. The Committee noted that some awards have products, but some do not. This inconsistency makes program review, transparency, and recordkeeping difficult.

H.2.1.2 Recommendations

We would like to reinforce Recommendation-2 on consistency in reporting. This is not a separate recommendation.

H.2.2 Effect of Award Process on Portfolio

H.2.2.1 Findings and Comments

The core program (MEC and HED science and SLAC experiments) is very high-quality, and very productive (9 *Nature*, 1 *Science*, and 7 *Physical Review Letters* publications), even with MEC receiving only 8% of SLAC time during the reporting period. The additional funds from congressional appropriations beyond budget authorization were used in accordance with 2014 FESAC recommendations, 2014 COV recommendations, and 2015 FES "ten-year perspective" documents. The funds were used to broaden program, including new user areas (National Ignition Facility [NIF] experiments, enabling the new Jupiter Laser Facility [JLF] facility and associated research), and new awards through DOE open, NSF/DOE, and FES/NNSA calls. The HEDLP program complements the GPS and MFE programs within FES, the NNSA programs within DOE, and other basic plasma physics and geophysics programs at NSF and Planetary and Astrophysics programs at the National Aeronautics and Space Administration. It provides unique science at SLAC (LCLS) and NIF as well as unique facilities (JLF). Europe and Asia (China, Japan) are trying to catch up on LCLS. These publications, as well as numerous awards and invited talks worldwide, demonstrate clear U.S. leadership in this area. Additionally, the HEDLP program is able to attract young talent in an exciting new field of critical importance to DOE and the Department of Defense.

H.2.2.2 Recommendations

None.

H.2.3 Response to 2014 COV Recommendations

The 2014 COV recommended that HEDLP organize a community workshop on how best to couple theory and simulation support for shot time on MEC. In response, the FES in general, and HEDLP in particular, has been active in sponsoring town hall meetings and community workshops to identify the research needs of the plasma science community, including researchers in the area of HEDLP and users of mid-scale facilities. These venues provided opportunities for researchers to express their needs and opinions on which facilities are best suited for research at the frontiers of plasma science and how to best exploit their capabilities.

The 2014 COV also recommended that HEDLP solicit community input on how to best use the portfolio of HEDLP user facilities, should additional funds become available, giving special attention to the status of mid-scale facilities and needed investment. This recommendation also resonated with the 2014 FESAC report's recommendation for FES to "avail itself of leveraging opportunities at both SC and NNSA high-energy-density-physics user facilities, within the context of the NNSA-SC Joint Program in HEDLP." The COV also recommended that the HEDLP consider targeted solicitations, as funding becomes available, to revitalize parts of the HEDLP Program that have suffered during recent budget cutbacks.

In response to this recommendation, HEDLP created the prioritized budget of: (1) MEC-enabled science, (2) Early Career Awards, (3) support for its joint program with NNSA, (4) funding for

its User Support Program, and (5) partnerships with NSF, High Energy Physics, Air Force Office of Scientific Research, etc. In FY2014, HEDLP was able to fund MEC science at LCLS plus laboratory facilities related to MEC. When budget authorization in excess of the base-level budget request arrived, the HEDLP program absorbed it in this prioritized way through existing funding opportunities (such as through NSF/DOE partnership yearly calls or national laboratory funding) especially when solicitations could not be released in the time available before the end of the fiscal year. The additional laboratory funding for HED science was awarded to mid-scale facilities such as JLF at Lawrence Livermore National Laboratory or by leveraging larger-scale experiments at NIF. However, in FY2015 and FY2017 funding arrived early enough in the fiscal year where FOA planning for joint funding with NNSA was possible. This occurred under two FOAs: DE-FOA-0001153 (July 3, 2014, due date October 1, 2014) with awards made using FY2015 dollars and DE-FOA-0001664 (issued: 09/30/2016; Amendment 000007 amended end date to: May 25, 2018) with awards made in FY2017–FY2018. These resulted in 3-year awards (average award duration) totaling $21M and $3.9M, respectively, from FES HEDLP with an equivalent number/amount/duration of awards made by NNSA. Because the latter solicitation proposal period was extended well after FY2017, it was not reviewed by the 2018 COV, leaving the 2015 FOA as the only proposal opportunity that was reviewed by the 2018 COV.

H.3 Early Career Research Program

H.3.1 Efficiency and Quality of the FES Processes

H.3.1.1 Findings and Comments

FES participated in the ECRP solicitation each of the years covered by this COV review. The table below shows the number of proposals received and awarded in each fiscal year. A subset of the award documents were provided to the COV for review. An adequate number of qualified external peers (3–5) reviewed the proposals and used the review criteria in the solicitation for the context of their review. The individual reviewer's comments and scores were captured in PAMS. Following the technical review, a panel of five PMs representing MFE Experimental Research, Theory and Simulation, HEDLP, GPS, FNS, MR, and E-R&D programs met to make award

Fiscal Year	# of Proposals Received	# of Proposals Awarded	Funds Awarded	Programs
2014	30	3	$1.75M	HEDLP, MFE Experimental, Theory and Simulation
2015	23	4	$2.5M	GPS, MFE Experimental (2), Materials
2016	32	6	$4.0M	HEDLP (3), GPS, MFE Experimental, Materials
2017	29	6	$4.0M	HEDLP (3), GPS, Materials, Theory and Simulation

selections. Selections were first made based on reviewer scores. The population of high-scoring proposals (usually ~4.5 and higher out of 6.0) were then reviewed by PMs for program relevance. High-scoring proposals were rejected if not aligned with the program. From the program-relevant proposals, program balance was considered. FES took into consideration their existing portfolio of (previously awarded) ECRP grants and the number of existing awards in each program. Final decisions on awards were made by the five PMs who then recommended the awards to the FES Director. The number of awards in each program is shown in the table below. The larger programs are able to fund more ECRP awards because they have more funds available and can direct more to ECRP grants. However, when highly ranked, highly aligned proposals from the smaller programs were identified, they were funded out of management reserve.

One thing noted during the review was that PM declination justifications were not entered into PAMS. The justifications were provided to the COV on a table. The COV discussed the selection process with PMs to gain understanding of selection decisions as the justifications were very generic. The reason given for not placing declination justifications in PAMS was that this allowed SC to use a 'bulk declination' function on PAMS to process all early career declinations at one time. Without the justification entry into PAMS, the program support staff could combine all declinations into one package and proceed with processing this declination package. This way of handling the awards is very different than for solicitations in the other FES programs.

The efficiency and timeliness of the process was good. Since the ECRP is part of the Office of Science portfolio, FES staff had strict internal deadlines that enabled them to complete their reviews and selections in a manner that supported the SC ECRP process schedule.

H.3.1.2 Recommendations

We would like to reinforce Recommendation-1 on consistency in documenting selections/declinations of awards. This is not a separate recommendation.

H.3.2 Effect of Award Process on Portfolio

H.3.2.1 Findings and Comments

The process for reviewing and selecting ECRP awards has resulted in a well-balanced portfolio across the programs in FES. During the review period of the COV, there were 45 active ECRP awards. This number includes awards that started before FY2014 but were still within their 5-year period of performance. MFE Experimental and HEDLP are the largest programs in FES, and as such had the most ECRP projects with 13 each. Theory and Simulation had 7 ECRP projects, and GPS and Fusion Nuclear Science each had 6 ECRP projects. The ECRP awards were also fairly evenly split between awards to university faculty (25) and national laboratory staff (20).

The quality of the research and the national and international standing of the ECRP awardees have been outstanding as judged by the productivity and recognition received by the awardees. For the university faculty awardees, of 14 awardees that became eligible for tenure, 12 achieved tenured positions. Twenty-one of the awardees were highlighted during the review for their

publication in high-impact journals. Awardees have also achieved 15 national awards/ recognitions and 1 international award. Publication statistics for all the awardees were not provided, and it was explained that the only way to prepare these numbers was to search Web of Science for each researcher. A suggestion is to improve the tracking of this important productivity measure.

H.3.2.2 Recommendations

None.

H.3.3 Response to 2014 COV Recommendations

The ECRP was not reviewed during the 2014 COV; therefore, there were no FES recommendation responses.

Appendix I: Group 6 – Facility and Project Management

I.1 NSTX-U and NSTX-U Recovery Effort

I.1.1 Findings and Comments

NSTX-U was a MIE Project at the PPPL with a start date (Critical Decision 0) in 2009, and with a total project cost of $94.3M. The NSTX-U Project was completed and received Critical Decision 4 Approval in September 2015. This was followed by a transition to operations of the NSTX-U facility. Ten weeks of operation were carried out in FY2016.

During FY2016, numerous technical failures led to the acknowledgment in August 2016 that the facility was not capable of operating for a research program. The approach to recovery during 2016 was a series of repairs during the operations period. As the scope of the technical problems became clearer, FES considered capturing the recovery as a follow-on MIE Project. However, to be compliant under the rules of DOE Project Management Order 413.3B, this would likely have required an effective 'stop work' for approximately two years while awaiting Congressional approval of a new project start.

During FY2017, extensive and independent Design Verification and Validation Reviews (DVVRs) and Extent-of-Condition (EOC) Reviews were held to understand better the issues and extent of the NSTX-U failures. A total of 12 DVVRs and 2 EOC Reviews were completed with the participation of 47 external reviewers.

FES appropriately required PPPL to develop a corrective action plan (CAP) in FY2016/FY2017. In hindsight, FES likely should have ensured that PPPL was following through with corrective actions as issues arose and failures were identified. Loss of staff in the FES FOP Division made it difficult to devote sufficient attention to issues at PPPL and may have compromised the ability to effectively monitor and follow through on CAP responses. This challenge may have been exacerbated by a lack of continuity in the PPPL Site Office Manager position. It should be noted that the PPPL Site Office Manager position was not permanently filled during most of the period 2014–2017.

FES used a number of mechanisms to monitor the NSTX Recovery efforts, such as FES Notable Outcomes in the appraisal process for PPPL related to NSTX-U. Three examples of those Performance Evaluation and Measurement Plan (PEMP) Notables are shown below:

- FY2016 – Goal 4.0 (Leadership and Stewardship of the Laboratory), Objective 4.2 – "Organize/reorganize engineering services and personnel to optimize engineering services to laboratory customers."
- FY2017 – Goal 2.0 (Effective Design, Fabrication, Construction, and Operation of Research Facilities), Objective 2.1 – "Complete an extensive extent-of-condition review of NSTX-U to identify all design, construction, and operational issues. Prepare CAP to include cost, schedule, scope and technical specifications of actions. Provide an interim progress report by March 31, 2017, and complete the CAP review and send the final report to DOE by September 30, 2017."

- FY2017 – Goal 4.0 (Leadership and Stewardship of the Laboratory), Objective 4.2 – "Conduct a review of policies and procedures for design, construction, installation, commissioning and operations of NSTX-U and other construction activities and projects. Develop corrective actions to ensure the highest quality project management across the lab."

FES has been involved in the path forward for the recovery of NSTX-U with feedback to PPPL on the PEMP goals and objectives relevant to NSTX-U during this COV period that was appropriate given the difficulties being experienced by PPPL and NSTX-U. Their feedback was honest and direct, including assigning grades as low as "C+" in FY2016.

The recovery efforts associated with NSTX-U are not considered a formal DOE Order 413.3B project. However, as of late 2017, FES, working with the Office of Science and the Office of Project Assessment is requiring PPPL to manage this return to operations like a formal project. FES should consider conducting a review of its own project management relative to the NSTX-U failures to determine what lessons learned should be applied to the planning and execution of the recovery and return to operations.

The path forward to research operation of NSTX-U is a unique situation that has required heavy involvement from personnel in both FES Divisions (Research and FOP). It is critical that this effort is highly coordinated and executed with a shared vision that represents the FES Program.

I.1.2 Recommendations

From Section 2.1.3. This is not a new recommendation.

Recommendation-5: Because the NSTX-U Recovery Plan will be based on an "operations project" treated like a DOE Order 413.3B project, it is critical that the FES program office formally define and document the internal roles and responsibilities for both the Research and FOP Division PMs to support the return to operations of the NSTX-U research facility.

I.2 U.S. ITER

I.2.1 Findings and Comments

The DOE Deputy Secretary issued a December 2012 memorandum that removed the U.S. ITER project's designation as a DOE Order 413.3B capital asset project. The U.S. ITER project is not delivering any capital asset in the U.S., and all of the equipment constructed/fabricated is going to France. The Secretary of Energy delivered a report to Congress in May 2016 to recommend the U.S. remain a partner in the international ITER project through FY2018.

In FY2016, the U.S. ITER project was separated into two subprojects, known as SP1 and SP2, with SP1 completion expected in 2027 and SP2 completion in 2035. In FY2017, the Deputy Secretary approved Critical Decision-1R and SP1 CD-2/3.

The U.S. ITER project contributes 9.09% of ITER funding during construction and 13% during operations to the ITER Organization. The ITER Organization is considered the design authority.

To date, 2 of 13 work breakdown structure elements (Toroidal Field Conductor and Steady State Electrical Network) are completed. Overall, the U.S. ITER SP-1 subproject is 53% complete versus 57% scheduled.

The position of U.S. ITER PM within FES has been vacant for more than three years since the previous manager retired in April 2015. The Division Director for the FES FOP Division serves in an acting capacity.

FES engagement with the U.S. ITER project office is effective with weekly management conference calls of the Integrated Project Team discussing a variety of topics, including those related to the ITER Organization. The FOP Division staff is stretched and spends a significant amount of time supporting ITER "what if" analyses and calls for information. FES has effectively managed the execution of the U.S. ITER project with minimal staff in light of the DOE uncertainty in the future participation of the international ITER project.

Prolonged understaffing in the FES FOP Division may have created challenges in providing the focused and extensive oversight of two uniquely complicated large projects: NSTX-U and U.S. ITER.

I.2.2 Recommendations

See Recommendation-3 in Section 2.1.1.3 on placing a high priority on filling the U.S. ITER PM position.

I.3 Response to 2014 COV Recommendations

I.3.1 Findings and Comments

The FES FOP Division received a total of three recommendations from the 2014 COV panel related to: (1) separating management of U.S. ITER project contributions from ITER program issues, (2) developing an FES Program Management Plan, and (3) utilizing FES strategic plan and community workshops to a develop project portfolio. FES provided a response dated December 2015 as well as a current status for all of these Recommendations.

The FES responses to the three recommendations from the 2014 COV are appropriate and satisfactory.

Appendix J: Acronyms, Abbreviations and Definitions

ASCR	Advanced Scientific Computing Research
BaPSF	Basic Plasma Science Facility
CAP	Corrective Action Plan
COV	Committee of Visitors
DOE	Department of Energy
EAST	Experimental Advanced Superconducting Tokamak
ECRP	Early Career Research Program
EMP	Exploratory Magnetized Plasma
EOC	extent-of-condition
E-R&D	Enabling Research and Development
FES	Office of Fusion Energy Sciences
FESAC	Fusion Energy Sciences Advisory Committee
FNS	Fusion Nuclear Science
FOA	funding opportunity announcements
FOP	Facilities, Operations, and Projects
FWP	Field-Work Proposal
GPS	General Plasma Science
HED	high energy density
HEDLP	High Energy Density Laboratory Plasmas
HFIR	High Flux Isotope Reactor
INL	Idaho National Laboratory
JLF	Jupiter Laser Facility
KSTAR	Korean Superconducting Tokamak Advanced Research
LCLS	Linac Coherent Light Source
MDPX	Magnetized Dusty Plasma Experiment
MEC	Matter in Extreme Conditions
MFE	Magnetic Fusion Energy
MIE	Major Items of Equipment
MPPC	Max Planck-Princeton Center
MR	Materials Research
MST	Madison Symmetric Torus
NIF	National Ignition Facility
NNSA	National Nuclear Security Administration
NSF	National Science Foundation
NSTX-U	National Spherical Torus Experiment Upgrade

ORNL	Oak Ridge National Laboratory
PAMS	Portfolio Analysis and Management System
PEMP	Performance Evaluation and Measurement Plan
PI	principal investigator
PM	program manager
PPPL	Princeton Plasma Physics Laboratory
R&D	research and development
RFP	reversed field pinch
SciDAC	Scientific Discovery through Advanced Computing
SLAC	Stanford Linear Accelerator Center
TPE	Tritium Plasma Experiment
VLT	Virtual Laboratory for Technology
WiPPL	Wisconsin Plasma Physics Laboratory

awardee: recipient; the organization or individual awarded a grant or cooperative agreement by DOE that is responsible and accountable for the use of the funds provided and for the performance of the grant-supported project or activity.

contract: An award instrument used to acquire from a non-federal party, by purchase, lease, or barter, property or services for the direct benefit or use of the Federal government. The same term may be used to describe a vendor relationship between a recipient and another party under a grant (to acquire routine goods and services); however, the recipient may use subaward to describe the contract under a grant relationship.

cooperative agreement: A type of financial assistance used when there will be substantial Federal scientific or programmatic involvement. Substantial involvement means that, after award, scientific or program staff will assist, guide, coordinate, or participate in project activities.

Funding Opportunity Announcement (FOA): A publicly available document by which a Federal Agency makes known its intentions to award discretionary grants or cooperative agreements, usually as a result of competition for funds. Funding opportunity announcements can be found at Grants.gov/FIND and at https://science.energy.gov/grants/foas/. An FOA may also be known as a solicitation.

grant: A financial assistance mechanism providing money, property, or both to an eligible entity to carry out an approved project or activity. A grant is used whenever DOE anticipates no substantial programmatic involvement with the recipient during performance of the financially assisted activities.

merit (or peer) review: The process that involves the consistent application of standards and procedures that produce fair, equitable, and objective examinations of applications based on an evaluation of scientific or technical merit or other relevant aspects of the application. The review is performed by experts (reviewers) in the field of endeavor for which support is requested. Merit review is intended to provide guidance to the DOE individuals responsible for making award decisions.

program manager (PM): The DOE official responsible for the programmatic, scientific, and/or technical aspects of a grant or project.

progress report: Periodic, frequently annual, report submitted by the awardee and used by DOE to assess progress and to determine whether to provide funding for the budget period subsequent to that covered by the report.

solicitation: See Funding Opportunity Announcement.

validation: Validation is the process of determining the degree to which a model, including numerical algorithms, is an accurate representation of the real world from the perspective of intended uses of the model. This is an exercise in physics in which models are tested against experimental observation.