Minutes of the Meeting of the Fusion Energy Sciences Advisory Committee

October 10th, 2014
Teleconference, 1 – 4 PM.

Committee Members Present:
Mark Koepke (Chair) — West Virginia University
Amitava Bhattacharjee — Princeton Plasma Physics Laboratory, Princeton University
Troy Carter — University of California, Los Angeles
Arati Dasgupta — Naval Research Laboratory
John E. Foster — University of Michigan, Ann Arbor
Richard J. Groebner — General Atomics
Chris Hegna — University of Wisconsin, Madison
Valerie Izzo — University of California, San Diego
Christopher J. Keane — Washington State University
George H. Neilson — Princeton Plasma Physics Laboratory
Gertrude Patello — Pacific Northwest National Laboratory
Don Rej — Los Alamos National Laboratory
Robert Rosner — University of Chicago
Steven J. Zinkle — University of Tennessee, Knoxville
Ellen G. Zweibel — University of Wisconsin, Madison

Committee Members Absent:
Bruce Cohen — Lawrence Livermore National Laboratory
Charles M. Greenfield — General Atomics
Jin-Soo Kim — FAR-TECH, Inc.
Juergen Rapp — Oak Ridge National Laboratory
Linda E. Sugiyama — Massachusetts Institute of Technology

Ex-Officio Members Present:
Susana Reyes — Lawrence Livermore National Laboratory

DOE Personnel Present:
Edmund Synakowski – FES, Associate Director
James Van Dam – FES, Research Division Director
Samuel Barish – FES, FESAC Manager
Gene Nardella – FES, Chief of Staff
John Mandrekas – FES

Others Present:
Ted Biewer (ORNL), Don Correll (LLNL), Steve Dean (FPA), Phil Ferguson (ORNL), Ray Fonck (U. Wisconsin), Cary Forest (U. Wisconsin), David Greene (ORNL), Martin Greenwald (MIT), Mark Haynes, Rich Hawryluk (PPPL), Don Hillis (ORNL), Chris Holland (UCSD), Amanda Hubbard (MIT), Mike Jaworski (PPPL), Hantao Ji (PPPL),

Zhihong Lin (UC Irvine), Jeremy Lowery (ORNL), Dale Meade (FIRE), Wayne Meier (LLNL), Joe Minervini (MIT), Miklos Porkolab (MIT), Stewart Prager (PPPL), John Sarff (U. Wisconsin), Charles Skinner (PPPL), S. Smolentsev (UCLA), Carl Sovinec (U. Wisconsin), Don Spong (ORNL), Greg Wallace (MIT), Alice Ying (UCLA), Mike Zarnstorff (PPPL, acting as FESAC secretary)

1. Opening Remarks

The telephone meeting was called to order by the FESAC Chair, Dr. Mark Koepke, at 1pm on October 10, 2014. He said that the meeting will last three hours and will focus on consideration for approval of the Strategic Planning panel report, including discussion of the report, details leading up to this teleconference, and a vote for adoption. Dr. Koepke said that during the consideration of the Strategic Planning panel report, Dr. Chris Keane would chair of the meeting. This will be followed by a public comment session and a discussion of any new business. He thanked FES or setting up the teleconference.

2. Consideration for Approval of the Strategic Plan Panel Report

Dr. Keane, as acting chair, asked Dr. Sam Barish to take attendance of the FESAC members. Dr. Barish also asked for the names of other attendees to the teleconference. Chris then thanked the participants for attending the call and thanked the panel for their hard work in preparing the initial draft and the latest version. He asked the FESAC members if they had received the latest version from the panel the previous day, which they all had. He then asked Dr. Barish for the list of members that can vote on the report.

Dr. Barish said there are 20 FESAC members and three ex-officio members. Of the 20, nine were recused due to advice from the DOE General Counsel due to conflicts of interest related to their employer. They are the employees of PPPL, GA, MIT, and ORNL. In addition, Dr. Jin-Soo Kim's husband is employed by GA and Dr. Valerie Izzo has a contract with GA. Both of them have been recused. The remaining ten members on the teleconference are able to vote on the report. They are: Dr. Troy Carter, Dr. Arati Dasgupta, Dr. John Foster, Dr. Chris Hegna, Dr. Chris Keane, Dr. Mark Koepke, Dr. Gertrude Patello, Dr. Don Rej, Dr. Bob Rosner, and Dr. Ellen Zweibel.

Dr. Keane asked whether all the voting members could be on the call through the time of the vote. Drs. Rosner and Foster indicated that they must leave to teach courses at 2pm and 2:30pm, respectively. Dr. Barish said that in order to vote, a member must have participated in a substantial part of the discussion, and be present at the time of the vote. Proxies are not allowed.

Dr. Keane said that Dr. Barish had emailed a factual statement of the conflict of interest resolution that would be attached to the report after it is updated to include

the last two recusals. He then commented on the FESAC activities since the September FESAC meeting, noting that a lot of community and FESAC input had been received including a variety of letters from the community. He said he was struck by a top-level disconnect on strategy, particularly between science vs energy, and in the context of the Office of Science. He noted this makes it more difficult for this panel to do its work. He asked Dr. Koepke to make opening comments.

Dr. Koepke said that the FESAC actions since the end of the September FESAC meeting were:

- Gathering notes from the FESAC SP Panel after the FESAC meeting,
- by ~9/26, he received corrections from the Panel
- by 9/26 he had received input from FESAC
- on 10/2, he sent a revised report to editor J. Dawson
- on10/5, he gave the document to M. Branigan for production formatting
- on 10/8, the latest draft version was provided to Dr. Barish for distribution to FESAC

Throughout this process, he monitored the updating of the report to ensure that the meaning was not changed. He noted that most of the changes clarified the report, and other changes corrected typographical errors.

Dr. Keane added that the changes included modifying the vision statement to emphasize science, parts of chapter 6 on impacts, clarifying the four budget scenarios and their impacts, and tweaking some technical details in the chapters. Dr. Koepke said that he confirmed the changes were consistent with Chapters 1 and 6, and confirmed that the descriptions were consistent. The time-line description was also adjusted to be correct.

Dr. Keane then asked which members wanted to make comments on the report. It was noted that only non-recused and ex-officio members can participate in the discussion. Drs. Rosner, Hegna, Zweibel, Carter, and Foster asked to comment.

Dr. Rosner congratulated the panel for a report that makes decisions, including difficult decisions. But, he is troubled by two issues:

1) Is this a science program in the Office of Science or is this primarily an application program? This is a question of balance. Compared to a similar program, NE (Nuclear Energy), this is really still a science program, and appropriately located within the Office of Science. He is troubled that science is not up front in the report. This will make the discussion much more difficult, both with Congress and with our colleagues (in other sciences). He also urged that the report be compared with the (HEPAP) P5 report.
2) Dr. Rosner said that he is also troubled by report's support for specific proposals which have not yet been peer reviewed. He would like the report to call for a study of these ideas, not provide an explicit decision.

Dr. Hegna noted that he was a member of the report panel, that he wanted to explain why he decided not to endorse the revised report, and why he would vote against FESAC approval. He said that this should not be a surprise to other panel members. He is troubled by use of the Fusion Nuclear Science Facility (FNSF) as the main element driving and defining the program. FNSF is not well defined (mission, scope), and its role in the program is still an open question that needs community discussion. He is supportive of fusion nuclear science, but he is troubled by using it and FNSF as a metric for the whole program, particularly to drive a change of the program emphasis. Dr. Hegna does not support a transition from plasma science to a technology program. Subsequent to the FESAC meeting, he attempted to modify the report to provide a broader description of the science and reduce the emphasis on just facilities. However, this drew ire from other panel members, and his comments were rejected. As a consequence, he will vote No.

Dr. Zweibel said that she would only comment on aspects not already mentioned. She stated that there is now some new rhetoric in the report on discovery plasma science (DPS) and the universities. But the only scenario that adequately funds these and supports them is the Modest Growth scenario, the most optimistic. The report's reliance on agency partnerships is unproven. The existing NSF/DOE partnership is working, but is not at a scale to resolve this problem. There is an issue of balance in the report.

Dr. Carter stated that, like Dr. Hegna, he is one of three panel members that removed their names from the report. He is concerned by the reliance on workforce development as the motivation for DPS in the report. This marginalizes the value of DPS, is the worst way to advocate for the program, and will have an effect opposite to that desired. The justification is the need for innovation and knowledge. He does not want the justification for the field to be the production of students. This is not the right way to justify a DOE program, for members in the universities. The report needs to make a case for the science, recognize the great science that is being done, and the need to do more. He also urged that peer review be included in all the initiatives.

Dr. Foster said that his thoughts and comments resonate with those of Drs. Zweibel and Carter. DPS is put in too weak a position by the report. The arguments for it should go beyond just workforce development. The primary recommendation for DPS to strengthen peer reviewed collaborations is an empty statement. The source of funding should be stated to be DOE.

Dr. Koepke responded to the comments.

- Regarding Dr. Rosner's comments, he said that yes, the Panel made decisions. Each decision did not always start off as unanimous, but the Panel found a balance. There is a lot of science in all the recommendations. The Panel considered metrics, as used by the Office of Science. The FNSF was a representative goal for a leading fusion program. The linear divertor simulator was selected because it was in a community white paper, was

significantly cheaper than other options, and could fit in some budget scenarios. It was labeled unambiguously in the report and its cost was assessed so its inclusion would be consistent with specific budget levels.

- Regarding Dr. Hegna's comments: Dr. Hegna gave a good description of his decisions. There was a range of members on each side of the science vs facilities argument, but they found a common ground. Dr. Hegna's suggestions were incorporated fully, but the ones that would emphasize the science more did not survive into the final version.
- Regarding Dr. Zweibel's comments: That only the highest budget scenario had DPS unpenalized reflected the realities of fitting the highest priority investments into the budget scenarios. Dr. Koepke said that he felt that the realities of DPS would actually protect it. The partnerships with other Federal agencies were thought to offer cost-effective opportunities that expanded DPS.
- Regarding Dr. Carter's comments: There were panel members on both sides of the workforce-development argument. The panel worked to find common ground, but this ground shifted with the FESAC edits.
- Regarding Dr. Foster's comments: there was lots of discussion on DPS, but the report needed to focus on a transition to start the FNS program. The Panel identified a new option for DPS to obtain run-time on facilities. The FESAC-requested changes were in the right spirit, but the changes could not receive unanimous agreement by the Panel. Dr. Koepke hopes for continued community input on implementation and Congressional and Administration protection of DPS.

Dr. Rosner said that the paragraph at the end of page 20 and at the top of page 21 does not have any discussion on peer review, nor on page 22 in the recommendation. He urged that the process should include peer review (similar to other parts of the report). Dr. Koepke agreed and said that this could be added to make intention for peer review to be more apparent throughout the report.

Dr. Keane said that regarding FNSF, the view is that if you are doing a fusion nuclear science program, FNSP, you need and would like to have an FNSF.

Dr. Koepke said that the Panel's emphasis was on a FNS program, building on elements in the Drs. Martin Greenwald- and Steven Zinkle-chaired FESAC reports, and community-submitted white papers. He said that the actionable goal is for the U.S. to have a major facility, through which the U.S. could have world leadership. The main thrust of the report is to launch a FNS program. The report identified FNSF as an actionable goal, but otherwise steered away from specifics, since there are many aspects not adequately known.

Dr. Rosner continued the discussion of assessments, saying that the most relevant part is on page 47, but that this treats assessment of existing facilities. Dr. Koepke

replied that it was certainly in the panel's thoughts to include assessment and peer review in all recommended actions.

Dr. Keane said that we will need to add a sentence or words to address this. He added that he thought the panel worked very hard and that he wanted to salute the panel for making hard decisions.

Dr. Koepke said that he hopes the report will inspire lots of community activities on how to implement these initiatives. He hopes the community activities will fill in the areas that the Panel did not specify in actionable detail in the report.

Dr. Rej said that strategies are about trade-offs. The choices made were driven by realistic budgets and U.S. strengths. The U.S. program has remaining strengths, but the status-quo has led to atrophy. The status quo also limits where we can go. We want to engage the long-pulse issues and an FNS program. We need to do R&D to figure out what is needed. From the community white papers and previous reports, a lot of good science can be done in these areas. FNSF is a capstone, but it is beyond the time scale of the charge. The revised report handles the workforce issues better, putting science first. Regarding the linear PMI simulator, the issue is what can be afforded that addresses requirements. Certainly this needs to be reviewed and competed. But it should start with the scientific requirements of what is needed in this area.

Dr. Hegna said his concern was in rating program elements according to their relevance to a CD-1 decision for a facility. He also said there was a question of launching a fusion energy program which permeated the discussions.

Dr. Dasgupta said that she agreed with earlier comments that science should be the driver. Regarding the DPS budget going down in most scenarios, she agreed with the concerns that science is not in the forefront in the report. It also does not identify the role of universities in science. However, the modified version of the report is better than the earlier version presented at the meeting.

Dr. Keane asked for more discussion. Hearing none, he asked for a motion to approve the report, subject to minor revisions regarding peer review to be handled via email. Dr. Zweibel moved to vote on accepting the report, and Dr. Rej seconded the motion.

Dr. Barish called for the votes of eligible FESAC members.

- Yes: Drs. Dasgupta, Foster, Keane, Koepke, Patello, Rej
- No: Drs. Carter, Hegna, Zweibel
- no response: Dr. Rosner (who had to leave to teach a class)
- absent: Dr. Bruce Cohen

With a quorum of the eligible voting members, the motion to approve the report passed by a vote of 6 to 3.

Dr. Barish said that the report is being edited, including inserting graphics to make it more readable by a broad audience (similar to the P5 report). He asked the committee to allow these modifications and designate Drs. Keane or Koepke to oversee them. Dr. Koepke said that this was already discussed with the panel. Sandbox Studio is doing the editing, and it is set to proceed.

Dr. Keane asked whether the committee members had seen the draft conflict of interest (COI) statement, emailed by Dr. Barish, for inclusion in the report. Comments were made that it is not in final form, in that it does not mention all the recused members and reasons. Sam Barish agreed and said that it would be updated, and then the modified version must be approved by the DOE General Counsel.

Dr. Hutch Neilson said that the statement does not accurately represent his situation. He does not have a direct financial interest. The statement should be modified to state that he is employed by an organization that has a financial interest. Sam Barish said that they can request this change with the General Counsel.

Dr. Zweibel expressed concern that only half the FESAC members were able to vote on such an important report. Dr. Edmund Synakowski, FES Associate Director, said that he shares the frustration. However, DOE is part of the Federal government, and there are specific laws covering conflict of interest. This is a fundamental difference relative to activities of the National Academies. The nature of the charge and Congress's request, regarding specific budgets, drove the panel to consider specific facilities and make facility and institution specific recommendations, which is a trip-wire for conflict of interest. The General Counsel's fundamental interest in providing guidance is to protect the integrity of the process and the Department's interest. We are all learning and frustrated.

Dr. Keane asked Dr. Barish to modify the conflict of interest statement to include all the recused members and reasons, and note that the statement about financial interest comes from the General Counsel. The modified statement will be approved via email.

Dr. Keane said that the next task is to write the transmittal letter for the report. This generated some discussion on whether it should include top level strategy and discussion of facilities. Dr. Keane said that FESAC had approved the report and will not rewrite it in the letter, but the letter should note issues. He proposed to circulate drafts of the transmittal letter via email for comments and approval.

Dr. Patello agreed with this process and said it seems reasonable. She noted that the charge was not to form a strategic plan. The committee should use the same wording as in the charge. Dr. Keane agreed.

Dr. Carter noted the P5 sub-committee of HEPAP is a standing panel for strategic planning, and that community input and discussion are needed in strategic planning and road-mapping.

Dr. Keane agreed, and noted that the report will now go to FES and Congress, for use in crafting the FES strategic plan.

Dr. Synakowski said that with this approved draft report in hand, it will be considered in developing the plan to be submitted to Congress by the end of January. He will be talking at the UFA meeting about this strategic plan. Since this will be before the plan goes to the Administration, it will be his personal views. In formulating the plan, FES will attempt to address issues from the Administration viewpoint, including identifying the science and its execution. The plan will go through concurrence in the Administration sometime in November, and then go to Congress.

Dr. Neilson asked about Dr. Synakowski's reaction to the discussion and the call for broader community involvement. Dr. Synakowski said that this is the first of many steps, and is in everyone's interest to get broader input, but he is not sure of the process. He said he is interested in a continuing committee, like P5, but has not thought it through.

Dr. Amitava Bhattacharjee asked that the cover letter: (1) indicate that the process was weakened by the silencing of many voices; and (2) note or include the various letters from the community, which he found to be of great value.

Dr. Barish said that the transmittal letter should only be from voting FESAC members. After additional discussion, Dr. Barish said that it would be appropriate to include the community letters in the public comment part of this meeting.

Dr. Bhattacharjee dissented, asking for flexibility so that the community voices could be heard and kept. Dr. Keane said that the goal is to capture the input, and he would look into how to incorporate this.

Dr. Hegna noted that there were No-votes, against approval, and asked whether the transmittal letter can include representation of the dissenting opinions. Dr. Barish said that this could be done in the transmittal letter. Dr. Koepke agreed that the letter is an appropriate place to note dissenting opinions, and that this is better than a minority report.

Dr. Keane and Dr. Barish summarized the steps to finalize the report, including corrections and final comments, sending the revised conflict of interest statement to General Counsel, inclusion of graphics, and approval. Dr. Keane will send the draft transmittal letter to the non-recused members for iteration and approval.

Dr. Keane closed this portion of the meeting.

3. Public Comment

Dr. Barish requested public comments.

Dr. Greenwald said that there was lots of interest in the report, but particularly on the conflict of interest topic. He noted the irregularity of having ORNL members recused from voting on FESAC, but being on the panel drafting the report. He asked how this fit with General Counsel's perspectives.

Dr. Barish said that there was no way to know in advance about conflicts that could emerge in the report, except with the major facilities (C-mod, DIII-D, NSTX-U). After seeing the report, it was realized that four institutions hosted facilities identified in the recommendations: PPPL, GA, MIT, and ORNL (for SNS). On advice from General Counsel, FESAC members from those institutions had to be recused from discussions or voting on the report.

Dr. Carl Sovinec summarized the public letter sent to FESAC and the panel with 50 signatures, including its major points:

- The underlying strategic vision is flawed. It unnecessarily limits the fusion science research program to a few initiatives.
- It is presented too much as a facility development program.
- No scientific cases are made for the choices made. It appears to be management decisions made to fit into tight budgets.
- There was a lack of competition or peer review for the facility decisions advocated.
- The stewardship of plasma science as an underlying program is seriously undermined.

They recommend:

- The report should be recast to emphasize science and provide scientific justification for its recommendations.
- It is premature to select new facilities for the high priority initiatives. The report should identify missions and scientific goals for the initiatives, and encourage an open solicitation and peer review.
- Plasma science should not be a donor program in any scenario.

He added that the context of the letter and concerns are not a matter of pitting plasma science and materials science against each other. We are still in a state where we cannot create and control a burning plasma. It is premature to move onto technology development.

Dr. Miklos Porkolab noted that a letter critiquing the report had been sent to FESAC from MIT. He asked to include it as public comment for the meeting (Appendix A). Dr. Koepke and Dr. Barish agreed to this.

Dr. Dale Meade said that he had also submitted a document to FESAC, labeled as a public comment and including recommendations. He noted an important aspect: the strategic planning process should not stop. He cited the EU process as a model, which resulted in increased support for the fusion program. He requested that his submission be included in the record of public comment for the meeting, to which this was agreed (Appendix B).

Dr. Ray Fonck asked that the entire letter that Dr. Sovinec spoke about be accepted into the public comment, to which this was agreed (Appendix C).

Dr. Steve Dean made four comments:

1. FESAC has 23 members (including three non-voting ex-officio). After the recusals (and absences) the report was only endorsed by six. This seems to be a weak situation.
2. The recusals were due to connections to major facilities. But anyone supported by the overall program has a conflict of interest, because the recommended shifts in funding are broader than the facilities. This is much broader than just those recused.
3. The consideration of C-mod was given short-shrift. The discussion in the report says that the closing of C-mod was necessary to fund the linear divertor and other new activities, but this was done without peer review, or evaluation of what C-mod might contribute.
4. This draft has been improved, but he reiterates his comments on the previous draft. In particular, the program needs to consider the implications of the very large ITER costs, including their implications for the prospects of fusion energy power plants.

4. Other Business

Dr. Koepke asked the committee for any other business. He also remarked that FNS is important science in its own right, and the current version of the report does not identify specific facilities. It does identify the linear device as being affordable. The spallation neutron source could be outside the US.

Dr. Neilson asked about the plan and status of the Committee of Visitors (COV) panel.

Dr. Bhattacharjee (chair of the COV) replied that the committee is fully constituted. They will hold a couple of telephone meetings before meeting in Germantown on December 2nd – 4th. He noted that, due to schedule conflicts, they had to delay the meeting and may have difficulty completing their report by January. They may need to request an extension of ~two months.

Dr. Richard Groebner asked whether recused FESAC members can now make their opinions on the Strategic Planning Report known to other members, now that the vote is completed. Dr. Barish said they can participate in discussions after the

remaining issues in the report are settled. The recused members should not contribute to finalizing the report or transmittal letter.

Dr. Koepke asked whether FES is planning to give FESAC any new charges in the coming months. Dr. Barish said that none are planned at this time. Dr. Koepke said that Dr. Synakowski will give the FES overview at the UFA meeting at the APS/DPP meeting in New Orleans, and that Dr. Koepke will give an overview of the SP report. He thanked all the attendees on the teleconference and closed the meeting.

Appendix A

Plasma Science and Fusion Center
Massachusetts Institute of Technology
77 Massachusetts Avenue, NW16, Cambridge, MA 02139-4307

October 7, 2014

Dr. Christopher J. Keane
Vice President for Research
Office of Research
Washington State University
PO Box 646525
Pullman, Washington 99164-6525

Attention: Dr. Christopher Keane: Acting FESAC Chair for Strategic Planning Panel Report Discussion; Fusion Energy Sciences Advisory Committee and 2014 Strategic Planning Panel

Critique of FESAC Strategic Planning Sub-Panel Draft Report
We are writing to express our deep concern with the recent draft FESAC sub-panel report on strategic planning. While we can agree with many of the identified priority areas, in our view the present draft fails to offer a strategic plan, contains inconsistent recommendations and fails to take account of the extensive input of the fusion community.

In the following sections, we present specific criticisms regarding 1) the alignment of the plan with its stated goals, 2) the recommended approach to the plasma-material interface challenge and 3) its lack of innovative initiatives to improve fusion concepts.

1. **Alignment of Strategy and Goals:** The draft report adopts a 10 year goal - to be ready for a start on an FNSF in 10 years - but does not provide a roadmap for getting there; nor does it assess whether that goal is achievable. As a result, the program elements favored by the report do not constitute a coherent plan that would lead us to the goal, within the constraints of the given budget scenarios. Instead the report suggests a set of budget choices uninformed by a consistent broader strategy. This is a major flaw. Choices on where to put resources need to be consistent with a realistic roadmap. In our view, this flaw led in fact, to incorrect choices and priorities. A useful plan to achieve the proposed goal would place high priority on the near-term R&D required to start the FNSF design by the end of this 10 year period, but the report recommends initiatives whose results will not be essential for decades (for example long-term neutron fluence effects on structural materials). A roadmap is also essential in order to assess the resources needed to achieve the goal. The recent FESAC priorities panel report [1] judged that budget levels significantly higher than the guidance would be required. Thus the path endorsed by this report would almost certainly not achieve its aspiration while failing to take advantage of opportunities that are in reach. Consequently it is strategically imbalanced.

2. **Addressing the PMI Challenge:** With respect to the plasma materials interaction challenge, which the panel endorsed as critical, the report ignores the numerous white paper submissions and testimony by the community which emphasize research on integrated toroidal confinement experiments that can best simulate the divertor and boundary plasma conditions needed [2]. Instead it recommends development of linear-plasma material test stand(s) which would not be unique in the world and would not be capable of addressing this issue in a decisive way. The real challenge is to develop a configuration and operational scenario, compatible with realistic engineering constraints and a high performance plasma core. The correct metrics for relevance in such experiments are ITER-level power flux density and plasma pressure along with reactor-like divertor geometry and materials. It recommends that the US program "undertake a technical assessment with community experts to ascertain which existing facility (or facilities) could most

effectively address the key boundary physics issues". In making this recommendation the panel acknowledges the fact that it is not technically qualified to make a judgment in this area. We strongly support carrying out this assessment of facility effectiveness -- by an expert peer group. The assessment should be open to all proposals and carried out without prejudice. Inconsistently with this review recommendation, and without justification, the draft report goes on to recommend the linear plasma device initiative, which would be a "single-effect" experiment and would not address the main challenge of integrated physics. In making these and other recommendations concerning facilities, the report offers programmatic choices in this area that are technically unjustified and potentially damaging to the US research portfolio; it therefore does not provide appropriate guidance towards a solution to this critical challenge.

3. **Improving Fusion Concepts:** The report does not support, in a serious way, innovations that could improve fusion concepts and make them more attractive as a power source. For example, by ignoring research into high-field fusion magnets that would exploit emerging high-temperature superconductor technology, the report misses perhaps the best opportunity for major cost savings in next-step fusion facilities and reactors. The current path, using conventional superconducting magnets, as in ITER, leads to large unit size, high costs and very long development times. The recent emergence of high temperature superconductors as a forward-looking magnet option offers the possibility of game changing technology for future high-magnetic-field fusion reactor concepts. The option for higher fields can only be available for next step designs (including an FNSF) if R&D not advocated by the report is pursued. Its omission would effectively eliminate perhaps the best option we have for reducing the cost of the next step and a future reactor [3]. By shortchanging research on RF current drive and stellarators, the draft report sidelines the U.S. in the vital area of plasma steady state sustainment. For the tokamak to be useful for component testing or as a practical steady-state energy source, advanced operation with reactor-relevant current drive will be required. Exciting new ideas have emerged for efficient, reactor-compatible RF current drive systems, as outlined in the white papers [4]. However, domestic contributions in current drive, under the report's recommendations, would focus on technologies (such as neutral beam current drive) that are unlikely to be reactor-relevant or reactor-compatible, and are thus essentially irrelevant [5]. The draft report also fails to advocate any significant experiments in the U.S. on stellarators. The stellarator, while not as advanced in performance as the tokamak, is a plausible alternate with advantages for producing a steady-state fusion plasma and for avoiding the transient events that are identified as a high priority [6].

We are conscious of how difficult the task was with which the panel was charged. However, its draft report proposes research and facility priorities without technical justification or a broader strategic focus and does not support innovations in areas required to make fusion energy feasible and attractive. If followed, the draft report would effectively cede leadership in most important areas to other countries while ending up with a fusion reactor concept that is economically unattractive in U.S. terms. We therefore urge FESAC to reject this report and to engage more strongly with the community to formulate an exciting and effective plan for the nation's fusion energy research.

References

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"Priorities: Integrated Multi-Scale Divertor Simulation Project" Krstic
http://www.burningplasma.org/resources/ref/fspp/whitepapers/FESAC-SPpaperInitiatives-Krstic.pdf
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"A Strategy for Resolving the Problems of Plasma-Material Interaction for FNSF" Goldston
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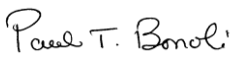
This statement reflects the personal views of the undersigned, not MIT as an institution.



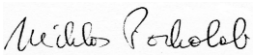
Paul Bonoli

Joseph Minervini

Peter Catto

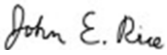
Ronald Parker

Jeffrey Freidberg



Miklos Porkolab

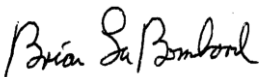
Martin Greenwald



John Rice

Ian Hutchinson

Richard Temkin



Brian LaBombard

Anne White

Earl Marmar

Dennis Whyte

cc. FESAC Members
FESAC Strategic Panel
S. Barish, DOE FES
E. Synakowski, DOE FES

Appendix B

Public Comment on Draft FESAC-SP Report
October 9, 2014
Dale Meade
Princeton, NJ

The FESAC Panel has done a remarkable job making significant progress on addressing the Charge despite constraints imposed by DOE that made this a nearly impossible task. The Panel's recognition of the program's critical needs including a significant paradigm shift toward fusion energy is an important change in direction. However, it is clear that more interaction between the Panel/FESAC and the fusion community, similar to that in other Office of Science programs (Nuclear Physics, 2011-2012) and High Energy Physics, 2012-2014), is needed to develop a strategic plan that is both technically sound at the detailed level and has the support of the fusion community.

General Aspects of a Strategic Plan

The Panel's report is not a strategic plan- it is constrained to being a limited response to a narrowly focused charge from the Office of Science. The report is a plan for prioritization of resources under four constrained budget scenarios for the domestic program. This report is missing many of the essential elements needed for a U. S. Magnetic Fusion Strategic Plan. Where is the analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT)? The draft panel report says nothing about the overall strategic issues of the overall fusion program; especially those associated with ITER, the biggest driver for the U. S. fusion program.

Recommendation – Change the title of the FESAC Report transmitted to DOE to reflect its content e.g., Priorities Assessment of the U. S. Domestic Fusion Program for Congressional Budget Scenarios.

It is my understanding that this FESAC Panel Report will be sent to the Fusion Energy Sciences Office where it will be used as input to develop a Strategic Plan for the U. S. Fusion Energy Program. It will be essential for the Fusion Energy Sciences Office to interact with the U. S. Fusion Community during the development of the Strategic Plan for the U. S. Fusion Energy Program.

Recommendation: The development of the Strategic Plan for fusion might occur in two stages. The first stage high level plan in the very near term to satisfy the Congressional request in the 2014 Omnibus Bill, followed by a second stage with a more detailed technical plan, at the same level of detail as the EU Fusion Road Map, developed interactively with the fusion community.

General Comments on 10 Year Program

Increasing the emphasis on resolving science issues directly related to fusion energy is a welcome change in direction for the U. S. fusion program, and is consistent with the

direction of the international fusion community. It is important to set out a plan to accomplish the stated goals with specific easily understood milestones and decision points that can be used to guide the program, and provide a basis for Congress to track our progress. In addition, the goals, milestones, and decision points need to be described in more exciting terms and a sense of urgency that will make this a more compelling plan.

Recommendation – Add a section in the beginning of the report that conveys the importance of fusion as an energy source to combat the challenges of the future, and that also conveys the tremendous progress that was made during the decades when fusion research was more strongly supported, and describes the challenging scientific/technical issues that need to be attacked with a sense of urgency. The addition of several figures would help communicate the technical challenges and excitement. (Review the Nuclear Physics and High Energy Physics reports for examples)

Resources needed for the stated 10 Year Vision are inadequate

The goals set out for the next decade provide a basis for rejuvenating the U. S. fusion program. For the past 20 years the U. S. fusion program has been living off the investments that were made in the late 1970s and early 1980s. This enabled the U. S. to have a leadership position through the mid-1990s. However, the US fusion program has not recovered from the disastrous budget cuts of FY 1996, and has steadily lost its position among the leaders in international fusion research. This loss of position is clear when one considers the new confinement and fusion technology facilities that have been built and are under construction in Europe and Asia, while the US doesn't even have the resources to effectively operate its aging facilities.

Even if one of the three major facilities is terminated and all remaining resources are focused immediately on only FNSF/ITER tasks, the remaining facilities will not have the resources to make the required modernization upgrades, and operate at full availability. The recommendations for a large-scale migration of U. S. experimental research to foreign facilities is an admission that U. S. facilities are not world leading at the present time.

Under the most optimistic budget scenario, the U. S. fusion base program (non-ITER construction) will have ~$3.5B available over the next decade. Detailed budget breakouts are not available in the Panel Report to support the Panel recommendations. As a result, I expect that the resources needed to accomplish the goals described in the Panel Report far exceed the budgets foreseen in any of the budget scenarios. For comparison, the EU Commission (Horizon 2020 extended to 2025) plus the budget of the National Associations would have ~ $7B available for Non-ITER construction activities from 2015 to 2025. It is unrealistic to expect the U. S. to remain among the leaders in Magnetic fusion energy under these conditions.

Finding: The Panel Report does not provide a description and quantification of the resources needed to carryout the stated program, or those needed for the U. S. program to be world leading. The EU developed a Technical Road Map for what needed

to be done, including the required budgets, and this is now serving as a basis for budget discussions with the government funding agencies.

Recommendation: Add a section to the report that describes in quantitative terms the present U. S. facility capability and compares that with the front line research facilities that exist and those under construction in Europe and Asia.
Add a section to the Panel Report that compares the present funding and projections for the total European Program (EU Commission plus National Associations) funding with the budget cases analyzed by the FESAC Panel. The EU Road Map for Fusion provides the data for EU Commission funding and facilities. For China and Japan, a comparison of funding is problematic, but a comparison of the existing facilities and those under construction is sufficient to reach a similar conclusion.

Analysis of Initiatives

There are some serious technical inconsistencies between the highest priority initiatives and the recommended research program to address those initiatives.

The four highest priority Initiatives identified by the 2014 FESAC Strategy Panel, categorized in two tiers, are:

Tier 1:
- Control of deleterious transient events (Transients)
- Taming the plasma-material interface (Interface)

Tier 2:
- Experimentally Validated Integrated Predictive Capabilities (Predictive)
- Fusion nuclear science (FNS)

Implementation of a Program to Address Tier 1 Initiatives

It is well known that the plasma facing component material has a very strong impact on plasma performance (confinement, MHD, disruptions, etc), and over the period 1976 to 2010 nearly all of the plasma confinement experiments gravitated to using carbon plasma facing components (PFC). Unfortunately, there is a strong consensus among the materials scientists and fusion facility designers that carbon PFCs are not relevant for use in the fusion power environment. The previous Nuclear Science Pathway Assessment (2011) also concluded that carbon PFCs were irrelevant to an FNSF and that high-Z high-temperature PFCs would have to be developed for an FNSF and DEMO. The leading candidate for PFC material for an FNSF and fusion DEMO is a tungsten based metal operating at temperatures over 500°C according to the FESAC Fusion Materials and Technology Panel Report 2012.

The previous trend toward carbon PFCs has now reversed in the international fusion community as they move forward with a fusion energy emphasis. ITER has decided to go with an all metal (W/Be) PFC system from the beginning of operation due to tritium retention and safety requirements. The EU has now transitioned its major confinement

facilities (JET, ASDEX, Tore Supra/WEST) to all metal PFCs. EAST is partway through a transition to W PFCs with the upper divertor W and the lower divertor carbon. Eventually, EAST and WEST will have all W PFC systems operating at relevant (~500°C) temperatures. However, the major U. S. plasma confinement facilities propose to continue using room temperature carbon PFCs on DIII-D and NSTX-U for at least the next five years, while only C-Mod has all high-Z PFCs and a proposal to convert to a high temperature W divertor on hold by DOE since 2012.

The experience on ASDEX and JET-ILW has demonstrated that the plasma behavior is different and more challenging with plasma performance degraded relative to experiments with carbon-based PFCs. The JET ILW experiments also demonstrated that changing the PFC material from carbon to tungsten also changes the behavior of transients – disruptions and ELMs. The **integration of a high performance plasma core with a relevant plasma wall interface** has been and will continue to be one of the most vexing challenges for fusion confinement experiments, and the near term U. S. Program should be focused on addressing this critical issue.

Finding: the PFC material has a significant effect on both Tier 1 Initiatives – Transients and Plasma Materials Interface through the close coupling of confinement physics and the plasma material interface. In addition, the implications for the very long pulse lengths in a FNSF are critical.

If the US BP Foundations and BP Long Pulse sub programs are going to **focus on supporting ITER and FNSF,** then the operating regimes of the operating experiments need to access conditions relevant to ITER and FNSF. The Panel recommendation to immediately cease operation of C-Mod with a relevant PFC system under all budget scenarios, and continue operating DIII-D and NSTX-U for the next five years or more with an irrelevant PFC material is difficult to justify technically. I don't believe that a **virtual integration** of plasma confinement results from carbon based PFC tokamaks plus PMI results from a high power linear device with metal PFCs that are input to a Fusion Plasma simulation code will provide the data to achieve the 2025 Vision goals.

Recommendation: The Strategy Panel and FESAC should reconsider their logic and resulting recommendations regarding the appropriate materials/facilities for pursuing the Tier 1 Initiatives - Control of deleterious transient events, and Taming the plasma-material interface. A detailed technical analysis should be done to compare the requirements needed to address the issues with the capabilities of the facilities along with a timeline for accomplishing this task. High priority should be given to near term operation under fusion relevant PMI conditions.

Divertors for Controlling the Plasma Material Interaction (PMI)

The classic poloidal divertor (1972-1982) is a concept for effectively removing the plasma exhaust heat while providing a low temperature plasma interaction at the divertor target material and allowing for a higher temperature plasma at the confined plasma edge.

Initial experiments on tokamaks, using coils internal to the TF coils and vacuum vessel, confirmed the basic features of scrape-off dynamics and power flow. Linear divertor simulators demonstrated (1980) detaching the plasma from the divertor target as proposed in the early (1970) reactor divertor concepts. However, this configuration with internal coils fell out of favor in the early 1980s, since the internal poloidal coils were considered to be irrelevant for a fusion environment due the difficulties of providing neutron shielding and cooling. In addition, the use of valuable space inside the TF coil bore was thought to reduce the reactor economics to unacceptable levels.

In the early 1980s, the discovery of the H-Mode demonstrated that a poloidal field X-point near the plasma surface was sufficient to provide an edge transport barrier, but did not provide divertor action. In the 1970s, this "X point" configuration would have been called a "magnetic limiter", but the terminology evolved to labeling this a "divertor" even if it did not provide the classic divertor action. Over 40 years the divertor concept has now come full circle with extended divertor channels produced by PF coils trapped within the TF, and even vacuum vessel, but now described as an "advanced divertor." One new variation has been introduced – a higher order multiple null produced by an even more complex set of coils trapped within the TF coil/Vacuum vessel. When the engineering requirements for neutron shielding, cooling and mechanical structure required for an FNSF or DEMO are imposed, the practical application of this concept becomes even more intractable than the classic divertor of the 1970s.

Finding: It is appropriate to take another in depth look at finding a divertor configuration that would be feasible for implementation in the fusion environment.

Recommendation: The evaluation of experimental concepts/configurations/facilities for tests related to addressing Tier 1 initiatives must include an analysis of the direct relevance/feasibility for operation in the fusion environment of FNSF or DEMO. Note: If the fusion program is transitioning toward fusion energy, fusion compatibility should now be a general requirement for all aspects of the confinement configuration. The exploitation of liquid metal PFCs would be an example of a task that would benefit from a fusion power environment compatibility analysis. Another example, is whether the RWM coils similar to those being designed for ITER are compatible with a fusion power environment. In my view, the present design concept may not even be compatible with high availability ITER operation. This last example illustrates the important of having a single integrated Fusion Strategic Plan, and not one Strategic Plan for the domestic program and another for the ITER construction activities. Design concepts with better maintainability and improved availability, or perhaps an entirely different strategy should be developed for avoiding transients.

Possible Alternate Approaches:

The Nuclear Physics Priorities Panel 2011-2012 faced a similar challenge of what to do with three facilities (RHIC, CEBAF Upgrade and FRIB Construction) under similar budget scenarios. The report (p.91-94) describes in detail the scientific impact of closing each of the three facilities. The panel report (p. 95-96) described two options: one stopped RHIC

operation and the second stopped FRIB construction. They quantified the impact of each option, and after much debate NSAC indicated a slight preference for the first option.

Recommendation: Structure the FESAC Panel description of the impact of restricted budgets on facilities along the lines of the NSAC report and NSAC Transmittal letter to Office of Science as suggested by Congressional language and the FESAC Charge.

The FESAC panel report should have considered at least two facility options for proceeding.

Here is a possible option for discussion:

1. Assess what C-Mod could do in 3 years if dedicated to addressing only PMI issues. If compelling, continue C-Mod as a dedicated PMI facility for 3 years.

2. Assess immediately, upgrading either DIII-D or NSTX-U to relevant PFCs (ready to operate in 3 yrs)
   a) if DIII-D is chosen to upgrade to W PFCs ASAP, then it's operation would be extended beyond 5 years to exploit the capability. NSTX-U would focus the next five years entirely on establishing the capability for non-inductive start-up and sustainment, which is essential for an ST FNSF.
   b) this would be the reverse of a).
   c) panel should assess the technical aspects a) versus b)

The likely conclusion is that the restrictive budget cases (with resources < 1/2 that of the EU) will have a severe negative impact on the US fusion research effort to be a world leader no matter which option is chosen, and the US will be relegated to being a follower in the world fusion effort. **The FESAC report should say this clearly as the NSAC report did.**

The FESAC Panel Process

The FESAC panel process for a charge as important as responding to a Congressional directive on prioritization of fusion program priorities for the next decade should have had more interaction between the fusion community, the FESAC Panel and FESAC. The NSAC and HEPAP panels had much more interaction between the scientific community, the panel and the parent Advisory Committee.

The restriction that prohibited scientists from three of the four institutions with the largest fusion programs eliminated critical technical expertise and experience from the FESAC Strategy Panel. For example, expertise and experience with construction, operation and research on large fusion facilities was absent, yet the panel made key recommendations in this area.

The limited public interaction with the Panel took the form of a community wide solicitation for White Papers that resulted in nearly 100 10-minute presentations to the Panel that frequently seemed like a blizzard of mini proposals. **In the draft Panel report, there are recommendations for two specific proposals that appear to bypass the traditional independent peer review process. This should be clarified in the final report.**

Appendix C

October 8, 2014

Dr. Christopher Keane
Acting FESAC Chair for Strategic Planning Panel Report Discussion
Prof. Mark Koepke
Chair, Strategic Planning Sub-Panel

Dear Dr. Keane and Prof. Koepke:

We are writing to the FESAC panel to comment on the draft report "Strategic Planning: Priorities Assessment and Budget Scenarios", and request that FESAC address several deficiencies in this report before transferring it to DOE/FES. We are taking this approach to comment on this report because, given the late release of the report to the public, there was no time to offer constructive comments at the recent FESAC meeting.

Generally, we welcome a new strategic vision to include research on relevant fusion nuclear science issues within the FES program, such as materials under intense neutron fluxes and the interactions of hot confined plasmas with adjacent solid material structures. An increase in emphasis in these areas will necessarily require changes in allocations of scarce research funding, and that in turn requires difficult choices among program elements. Indeed, such changes to the program have been advocated by some U.S. fusion researchers, and suggestions for an evolution of the program while maintaining critical strengths in the U.S. program have been offered. None of the signees to this letter advocates maintenance of the status quo in the fusion research portfolio, and all welcome dialog and planning to advance the program in new directions. However, we are deeply concerned that the elements of the strategic plan as described in this report have major flaws and unsubstantiated foundations. Furthermore, arbitrary or abrupt changes can lead to a degradation of the program if not justified or managed well. In that context, we note the draft report has several glaring deficiencies that could undermine the support of the research community for the proposed strategic directions as a whole. The points of most concern to us that need to be addressed by FESAC are given herein.

• The underlying strategic vision that guides this report is flawed
This report unnecessarily narrows the fusion science research program to a few initiatives. The proposed programmatic emphasis is focused on preparing for the operation of two future facilities that will be producing significant fusion-relevant plasmas more than 10 years from now. The third part of the proposed program vision consists of an extremely narrow call for workforce development aimed at these future facilities as "Generation ITER-FNSF". None of this defines the program as a science-issue-oriented research enterprise that has pressing scientific issues and opportunities.

A troubling feature of the strategic plan is the wholesale orientation of the research program on preparing for an undefined Fusion Nuclear Science Facility in the near future. While some members of the fusion community believe FNSF is a logical next step facility, there is not yet technical or scientific consensus on what the design or even mission for such a facility is. The need and/or importance for such a major step can only be judged in the context of an overall strategic roadmap to fusion energy, which has not been discussed in this or other recent FESAC planning processes. Indeed, many of our international partners do not include an FNSF-like step in their fusion energy development plans, nor do their plans depend on the U.S. pursuing that

step. The cost for such a facility makes it unlikely that the U.S. would pursue FNSF on its own, so international collaboration would be essential and is simply assumed to exist. An extended planning and study exercise is needed in the U.S. technical community to define and motivate any such major step, and no such discussion has taken place as yet. We clearly will not be able to advocate for this step, if needed, unless there is wide technical consensus and enthusiasm for it, both here and abroad.

A major element of the proposed strategy is the development of fusion energy technologies, accompanied by a significant reduction in fusion and plasma science research under any realistic budgets. While an increased emphasis on fusion technology development can be expected along any path to fusion energy at some point, there is no demonstration in this report that progress in fusion and plasma science is sufficiently mature in the context of fusion program objectives to warrant this reduction. New fusion energy technologies include topics such as test blanket module development, tritium fuel cycle tests, etc. Such energy technologies are required to realize fusion power production. However, fusion research is currently located in the DOE Office of Science, and historically such energy technology development has been associated with a commitment to a fusion energy development program. To our knowledge, no such change in policy has been made by the government, and hence it is hard to believe a redirection with an emphasis on fusion energy development will result in maintaining, much less increasing, support for fusion research in the U.S. Here again, the strategic plan appears to make an assumption that is poorly justified. Even the most optimistic funding scenario considered by the subpanel appears to fall well short of what is required to pursue a viable fusion energy development program.

Finally, there are repeated claims to "leadership" in specific areas of fusion research and development, with no accompanying discussion of the content or value of such leadership. The two major initiatives called out as Tier 1, the transient events and PMI studies, are topics of extensive experimental and theoretical investigations by fusion research groups around the world. It is hard to claim leadership in these areas without an in-depth discussion of the particular physics issues that can be resolved exclusively by the U.S. community. Such analyses are not presented in the draft report. It is incumbent on FESAC to more specifically define how such leadership is measured and achieved if it is to be a defining focus of the program.

• The program is presented too much as a facility-oriented development plan

A wide range of white papers and presentations were submitted to this panel by the research community on relatively short notice. These offered challenging and scientifically interesting topics and initiatives to guide and motivate evolution of the research portfolio in fusion sciences, but there is very little reflection of that scientific vitality of the program in this report. The proposed plan starts with an assertion that the fusion program should condense to support participation in ITER and preparation for a large new DT facility in the U.S. The repeated references to those two facilities as the focus of the U.S. fusion program, without justification or broader references to the wide range of compelling scientific issues and challenges inherent in the fusion quest, reinforces the old bias from outside communities that this program is simply an empirical machine-building enterprise. This does a disservice to the fusion science research community, which has worked assiduously over the past decades to be more relevant to the mission of the DOE Office of Science and follow the best scientific practices of the research communities supported by the Office of Science.

• There are no scientific cases made for the choices made in this report
Almost all programmatic choices are presented as simple management decisions to fit the desired new initiatives into a tight budget envelope. In contrast, clear compelling scientific reasons for such decisions are missing. The critical issues to be addressed need to be enunciated, and the reasons for the particular choices must be clearly justified. Simply stating that the program should support ITER and move to a large new FNSF facility does not, in itself, make programmatic choices obvious. There are many assertions of discussions by the subpanel on reaching the conclusions described, but no layout of the scientific reasons to support those conclusions. As such, the conclusions carry little weight but that of declared management direction.

• There is a lack of competition and rigorous peer review for the few major new facilities or programs advocated in the strategic plan
Over the past few decades, FES has done an admirable job in developing a culture of and processes for intellectual competition and peer review to identify research initiatives worthy of funding in times of scarce resources. This conforms to the practices of the Office of Science as a premier sponsor of physical science research, and assures Congress and the Administration that judgments of funding merit are as unbiased and free of conflicts of interest as much as possible. This approach has both improved the science focus of the fusion energy sciences program, and helped improve the standing of fusion and plasma sciences with other STEM communities. Indeed, FESAC itself just received a briefing from the Associate Director for Biological and Environmental Research, which again confirmed the benefits of following these practices.

This Draft Report repeatedly emphasizes the need for community discussion and peer review for some areas of the program. However, in the case of the three recommended major initiatives (the linear high heat flux facility, the spallation-source-based neutron irradiation facility, and the FNSF itself) the report simply declares these initiatives should be pursued in specific facilities, implying no need for competition of ideas and peer review. This contrasts with all past practices that led to significant new facilities in the fusion program. Decisions based on ad hoc 10-minute presentations to this FESAC subpanel should not substitute for in-depth competition and review of proposed new facilities.

To garner support for these new initiatives and identify the best options for fulfilling the goals of such initiatives, FESAC should instead identify the scientific issues and missions for such initiatives and FES should then follow with an open competition for proposals to address the identified issues. Such an approach will result in a sounder decision on these initiatives and significantly reduce any appearance of conflicts of interest in the choice of what initiatives are ultimately funded.

• The stewardship of plasma physics as a respected component of the U.S. physical science research portfolio is seriously undermined
Following repeated FESAC reviews and several National Academies reviews, FES has been encouraged to lead the stewardship of plasma physics in the Federal complex. In the past, FES has attempted to do so, even in the face of limited resources. However, the proposed strategic plan is explicit in its weak support of basic plasma science. It identifies the already modest

Discovery Plasma Science program as a donor for funds to support other initiatives, under any of the more likely funding scenarios. The principal recommendation for DPS defers support for new directions in plasma science to unspecified collaborations with other agencies, with no evidence that growth in such partnerships are in fact welcome or fundable. This recommendation is therefore unsubstantiated, and portrays a willingness to leave plasma science without strong stewardship.

A much better approach would be for FESAC to make a clarion call for eliminating the chronic lack of modest funding of plasma physics in the Federal portfolio by recognizing plasma physics as a fundamental physical science in its own right. The discussion offered in the present report can only encourage suggestions of moving plasma science stewardship in the U.S. to more welcoming sponsors, to the detriment of the fusion community and FES.

• RECOMMENDATIONS:

- FESAC should undertake or require a rewriting of this report to more clearly make the scientific case for recommendations made in the report, and should orient the presentation of these topics to enunciate the deeper scientific issues being addressed.

- The overall 10-year plan needs to be framed as challenging and exciting scientific investigations to resolve specific issues and test relevant theories related to advancing fusion and plasma sciences. It should reflect the wide range of issues that need to be addressed for fusion energy.

- It is premature to select specific facilities for the highest priority initiatives identified by the subpanel. This report should be modified to identify the mission and scientific goals of any new initiatives, and encourage open solicitation and peer-reviewed competition to invite innovative and exciting solutions for those initiatives.

- Plasma science should not be a donor program under any budget scenario. A robust case for funding increases to support plasma science as a physical science in its own right, without depleting fusion science sources, needs to be made.

Thank you for your attention, and we look forward to seeing this report evolve into a plan the research community can enthusiastically support.

The following signatories do so as individuals, not representing their home institutions:

Prof. David Anderson
University of Wisconsin-Madison

Dr. Simon Anderson
University of Wisconsin-Madison

Prof. Paul Bellan
Caltech

Prof. Riccardo Betti
University of Rochester

Prof. Stanislav Boldyrev
University of Wisconsin-Madison

Res. Prof. Boris Breizman
University of Texas at Austin

Dr. Dylan Brennan
Princeton University

Prof. Michael Brown
Swarthmore College

Prof. Andrew Cole
Columbia University

Prof. Darren Craig
Wheaton College

Prof. Ronald Davidson
Princeton University

Res. Prof. Daniel Den Hartog
University of Wisconsin-Madison

Prof. William Dorland
University of Maryland

Prof. Jan Egedal
University of Wisconsin-Madison

Prof. David Ennis
Auburn University

Prof. Nathaniel Fisch
Princeton University

Prof. Raymond Fonck
University of Wisconsin-Madison

Prof. Cary Forest
University of Wisconsin-Madison

Dr. Martin Greenwald
Massachusetts Institute of Technology

Prof. James Hanson
Auburn University

Prof. Richard Hazeltine
University of Texas at Austin

Prof. Thomas Jarboe
University of Washington

Prof. Hantao Ji
Princeton University

Prof. Sergei Krasheninnikov
University of California, San Diego

Prof. Arnold Kritz
LeHigh University

Dr. Konstantin Likin
University of Wisconsin-Madison

Dr. Earl Marmar
Massachusetts Institute of Technology

Prof. Michael Mauel
Columbia University

Prof. David Maurer
Auburn University

Prof. David Meyerhofer
University of Rochester

Prof. Gerald Navratil
Columbia University

Res. Prof. Brian Nelson
University of Washington

Dr. Mark Nornberg
University of Wisconsin-Madison

Prof. Scott Parker
University of Colorado

Dr. Tariq Rafiq
LeHigh University

Prof. John Sarff
University of Wisconsin-Madison

Prof. Oliver Schmitz
University of Wisconsin-Madison

Prof. Uri Shumlak
University of Washington

Prof. Carl Sovinec
University of Wisconsin-Madison

Dr. Dan Stutman
Johns Hopkins University

Dr. Joseph Talmadge
University of Wisconsin-Madison

Prof. Paul Terry
University of Wisconsin-Madison

Prof. Edward Thomas
Auburn University

Dr. Kevin Tritz
Johns Hopkins University

Prof. George Tynan
University of California, San Diego

Prof. Andrew Ware
University of Montana

Res. Prof. François Waelbroeck
University of Texas at Austin

Prof. Anne White
Massachusetts Institute of Technology

Prof. Dennis Whyte
Massachusetts Institute of Technology

Prof. Setthivoine You
University of Washington