

Minutes of Fusion Energy Sciences Advisory Committee

September 22nd – 23rd, 2014
Gaithersburg Marriott Washingtonian Center
9751 Washingtonian Boulevard
Gaithersburg, MD 20878

FESAC Members Present:

Professor Amitava Bhattacharjee – Princeton Plasma Physics Laboratory and Princeton University
Professor Troy Carter – University of California, Los Angeles
Dr. Bruce Cohen – Lawrence Livermore National Laboratory
Dr. Arati Dasgupta – Naval Research Laboratory
Professor John E. Foster – University of Michigan, Ann Arbor
Dr. Charles M. Greenfield – General Atomics
Dr. Richard J. Groebner – General Atomics
Professor Chris Hegna – University of Wisconsin, Madison
Dr. Valerie Izzo – University of California, San Diego
Professor Christopher J. Keane – Washington State University
Dr. Jin-Soo Kim – FAR-TECH, Inc.
Professor Mark Koepke (chair) – West Virginia University
Dr. George H. Neilson – Princeton Plasma Physics Laboratory
Dr. Gertrude Patello – Pacific Northwest National Laboratory
Dr. Juergen Rapp – Oak Ridge National Laboratory
Dr. Don Rej – Los Alamos National Laboratory
Professor Robert Rosner – University of Chicago
Dr. Linda E. Sugiyama – Massachusetts Institute of Technology
Professor Steven Zinkle (vice chair) – University of Tennessee, Knoxville
Professor. Ellen G. Zweibel – University of Wisconsin, Madison

FESAC Members Absent:

(none)

Ex-Officio Members Present:

Professor Fred Skiff – University of Iowa
Dr. Susana Reyes – Lawrence Livermore National Laboratory

Ex-Officio Member Absent:

Professor John Steadman – University of South Alabama

Others Present:

Designated Federal Officer Present: Dr. Ed Synakowski

Names of guests who were present at the meeting are listed in Appendix A at the end of these Minutes.

Note: virtually all of the speakers and FESAC members thanked the sub panel members who prepared the Strategic Planning (SP) Panel report for their hard work.

Monday, September 22nd, 2014

1. Call to Order

The meeting was opened at 8:30 a.m. on Monday, September 22nd by Dr. Mark Koepke, the FESAC chair, who discussed the meeting agenda for approximately seven minutes with no slides. He mentioned that on Tuesday there would be three discussions unrelated to the main topic of this meeting, including a presentation on multi-disciplinary team science from the Office of Biological and Environmental Research; the ITER project status; and the 2014 Committee of Visitors. He said that most of the meeting would be dedicated to a discussion and consideration of the FESAC strategic planning panel report by the FESAC members, and comments by members of the public.

2. DOE/SC Perspectives by Dr. Patricia Dehmer

Dr. Patricia Dehmer indicated that she didn't want to use much time since the subcommittee report is the main topic today. She stated that DOE has begun to engage the Administration seriously about the FY16 budget—this timing is business as usual. She also observed that the Office of Science Presidential Appointment nominees are languishing, although a new Deputy Secretary of Energy was confirmed last week.

She then spoke for approximately 30 minutes on the topic of a summary of surveys of workforce development needs in the Office of Science.

The motivation for this study is that in the Fall 2013 “pass back” for the FY14 Presidential Budget Request, OMB directed cuts to STEM education and workforce training programs in more than 10 federal agencies including DOE. Some affected DoE STEM programs had already made plans to phase out (one of which was the National Undergraduate Fellowship program of FES for which \$500K was added for FY14 for the Workforce Development for Teachers and Sciences (WDTs), completely accommodating that program). In response, the Office of Science issued an SC-wide charge to identify STEM disciplines in which significantly greater emphasis in workforce training at the graduate student or postdoc levels is needed to address gaps in current and future Office of Science mission needs. In this charge, each of SC's six Federal advisory committees, seven SEC associate directors, and 10 SC laboratory directors were asked for their assessment of STEM-related issues in academia and DOE laboratories, and for recommendations for programs at the graduate student or postdoc levels that could address discipline specific workforce development needs.

The Office of Science received responses from everyone who was polled. Interdisciplinary sciences were emphasized in many responses. Several crosscutting areas were identified, including computational sciences, accelerator and detector R&D, instrumentation, and nuclear chemistry/radio chemistry. The Computational Sciences Graduate Fellowship was the single highest-cited program—it was also cited as a model for training in other disciplines. Dr. Dehmer said that DOE is trying to use this program as a wedge for retaining other programs. The report concluded that a number of STEM training programs were identified as appropriate for Materials Sciences and Engineering (MSE) and that a number of STEM training programs involve the DOE labs.

One major comment from responders to the surveys is that "the demand for graduates and postdocs in computational sciences and engineering far exceeds the supply from academic institutions." With specific regard to FESAC workforce development needs, the survey covered three broad areas: magnetic fusion energy sciences and engineering, high energy density laboratory plasma/inertial fusion energy sciences, and discovery plasma science (DPS). Key points were, unlike DPS, the

diagnostics and emerging disciplines in fusion engineering sciences, including fusion materials science, are poorly represented in curricula even though those disciplines are in high demand. Emerging disciplines and fusion energy sciences represent the largest potential gaps in workforce development. Summer school seminars and internships, in collaborations with national labs, and increased support for developing and delivering needed curriculum topics, would help address workforce development needs.

Dr. Dehmer indicated that, of all the responses from advisory committees, the survey results provided by FESAC were one of the most thorough studies—it polled groups and conducted surveys. This resulted in thoughtful and far-reaching advice. She is using this report as a foundation. The results of all groups will be seen in several days. DOE will engage in serious discussions with OMB and OSTP to devise programs that are appropriate for mission-driven agencies and for agencies with assets (for example, the asset of having national labs), as well as agencies whose workforce needs will not be addressed by the National Science Foundation or other programs. FESAC did a very thorough job; it was very impressive.

3. DOE/FES Perspectives by Dr. Ed Synakowski

Dr. Ed Synakowski delivered a nominally 60 minute talk on the topic of DOE/FES perspectives.

He first welcomed the new FESAC members and noted that the nature of the SP Panel effort [to prepare the report] has been extraordinary. He noted that FESAC provides help to the fusion community and its governance and provides cogent advice to SC. He observed that how we, the fusion community, project ourselves to our stakeholders on Capitol Hill is vital.

Dr. Synakowski then conveyed his personal view that the fusion program must evolve despite the administration's challenging budget outlook. In addition, ITER has immense challenges, but it is the vehicle for our next step.

DOE is nearly complete in a high-level reorganization of the structure of the fusion program elements. The subprogram elements will be categorized into two major areas:

- Burning plasma science, which includes
 1. Foundations: understand the fundamentals of plasma transport, macro-stability, wave-particle interactions, and plasma-wall interactions. Advanced tokamak, spherical tokamak, theory and simulation, heating and fueling systems, and magnet technology. The experimental effort will focus on domestic facilities.
 2. Long pulse: establish the basis for indefinitely maintaining the burning plasma state and developing materials that can function in this environment. Long pulse superconducting tokamak, long pulse stellarator, materials science and fusion nuclear science. The experimental effort will build on domestic capabilities and will involve international partnership.
 3. High-power: the challenge in the high-power thrust is to establish the scientific basis for robust control of self-heated and burning plasmas. Test the fundamentals and long

pulse science at reactor scale. The experimental effort is focused around the ITER research program.

- DPS: includes general plasma science, high-energy-density laboratory plasma, exploratory magnetized plasma research, and measurement innovation.

Dr. Synakowski has been presenting the FES program along these axes in recent public talks with the Administration and Capitol Hill in terms of this new structure. The budget narrative also is organized around this program structure, albeit with the same information. FES presented the FES program to the Panel using these subprogram elements.

GAO report: Dr. Synakowski then discussed the recent Government Accountability Office review of the ITER cost and schedule. The final report was issued in June 2014 and made four recommendations that were accepted by the Office of Science.

1. Revise and update the project cost estimate.
2. Present at the next ITER Council meeting a proposal that describes the actions DOE believes need to be taken to define a reliable project schedule and improve the ITER Organization project management.
3. Use that schedule to propose a funding plan for the U.S. ITER project, approve the performance, develop a baseline for the finalized cost and schedule estimates, and communicate this information to Congress.
4. Set a specific date for completing a strategic plan for the U.S. fusion program that addresses DOE's priorities for the overall U.S. fusion program in light of U.S. ITER project costs. Involve FESAC in development of the plan.

ITER management developments: in response to the 2013 management assessment report containing 11 recommendations, the ITER Council has set up three working groups: succession planning, management performance, and improved ITER Organization/domestic agency interactions. A selection board has been formed to initiate the succession process for the ITER Director General. The goal is to have a selected candidate approved by the ITER Council at its November 2014 meeting.

Dr. Bob Iotti, described by Dr. Synakowski as “a real force of nature,” is the new Council chair and has invoked management changes. With help from FES (Dr. John Glowienka), he is trying to change the ITER Council from a diplomatic approach to a board-of-directors approach. Dr. Iotti is trying to get decisions made on the spot. The ITER Director General selection committee met for the first time in Paris on July 15, 2014 with Dr. Iotti present as an observer. In about a week, a short list of candidates for the ITER directorship will be interviewed in Paris.

Budget and other developments: the Senate and Congress have passed a short-term continuing resolution for fiscal year 2015 to fund programs through December 11th, 2014. FES is working on funding allocations based on this continuing resolution.

IAEA conference in Russia this October: only DOE grantees and others who are not Federal employees or national laboratory employees were permitted to attend this meeting from the U.S..

FES office developments: there are two new position openings, including a physical scientist/physicist and a program analyst. FES hosted three summer interns at HQ this year, and encourages applications for next year.

Status of recent solicitations: Dr. Synakowski described the status of eight recent solicitations totaling \$(8 -10) million.

Early Career awards: Dr. Synakowski briefly discussed seven recent Early Career awards for fusion energy sciences.

FESAC membership: Dr. Synakowski thanked this year's outgoing FESAC members and welcomed new undetermined FESAC members as of June 2nd, 2015.

Strategic Planning Panel: Dr. Synakowski thanked the community for its earnest participation in the open sessions that Dr. Koepke structured. He noted that the Panel had a very compressed schedule, set by a Congressional deadline, and by the need for FES to write a plan and enter it into concurrence in time. Hence, FESAC needed community input on this time scale. He thanked the community for getting this intense work done.

Dr. Synakowski's final comment was that, to impress stakeholders of the U.S. fusion program, it is important that we demonstrate a collective ability to project an image that our enterprise knows where it needs to go, that we can make difficult choices, that we can look beyond what is comfortable, and can do what is best for the collective good of the enterprise. Dr. Synakowski said that this FESAC meeting would be followed by a future teleconference meeting to vote on the SP Panel report. He asked that if the Panel could act sooner, and vote at this meeting, that would be appreciated.

QUESTIONS

- Dr. Cohen: With the Continuing Resolution, can you comment on when money will go out to universities and labs? There is latency. We cannot find ourselves in a stop-work situation.
- Mr. Gene Nardella: We have an allotment, and we need to figure out who is most in need. Labs will generally get about 1/12th.
- Mr. Cohen: Given that the Senate and House marks were rather far apart, do you have any idea where it will settle?
- Dr. Synakowski: Nothing that I can responsibly talk about here.

4. Discussion and Consideration of FESAC Strategic Planning Panel Report by Dr. Mark Koepke

Dr. Koepke discussed the FESAC SP Panel report for approximately 90 minutes. Because Dr. Koepke was chair of the panel which wrote the report, he delegated chairmanship of the meeting to Dr. Chris Keane. Dr. Koepke explained that he would first present the report itself; then there would be lots of discussion amongst the FESAC members.

Dr. Koepke introduced all of the panel members who wrote the SP Panel report. He then discussed the process for strategic planning, which was followed by the panel vision, primary recommendations, and initiatives. The charge was to assess priorities for four specific budget scenarios over the next 10 years, 2015 through 2024, with a vision for 2025 and beyond.

A question from Dr. Keane, for Dr. Sam Barish: has the report has been posted? Answer: Yes.

Dr. Koepke said that his presentation would be followed by comments from the public which would be followed by each FESAC member being able to comment on the report.

Dr. Koepke then described how the FESAC panel organized their discussions based on FES's newly structured program: foundations, long pulse, DPS, and high-power. He discussed the objectives and schedule of the Panel. Schedule: FES is required to formulate a strategic plan as specified by the fiscal year 2014 Omnibus Appropriations Act by mid-January 2015. In response, the DOE SC asked FESAC for the following recommendations:

- Prioritize between the FES subprogram elements;
- Include views on new facilities, new research initiatives, and facility closures;
- Establish a scientific basis for advancing fusion nuclear science;
- Assess the potential for strengthened partnerships or new partnerships with other Federal agencies and international research programs.

Dr. Koepke emphasized that the SP Panel had the responsibility to deliver a serious, careful, and precise response to the DOE charge. The process followed by the Panel was designed to gather information openly and to deliberate in an unencumbered, unbiased, and independent manner to minimize conflict of interest issues.

Dr. Koepke then described the process by which the panel communicated with the larger fusion community. This included a website where Panel documents including white papers were stored for general viewing. The process involved two public meetings at which dozens of ideas were presented, including one meeting on June 3rd – 5th covering: burning plasma science: long pulse, DPS, and universities. A second meeting was held on July 8th – 10th, covering burning plasma science: foundations, international experiments, theory and modeling, and plasma-materials interactions.

Dr. Koepke introduced the members of the SP Panel and their institutional affiliations. He pointed out that the Panel members unanimously approved and signed the draft report, which he viewed as a very important achievement.

The SP Panel worked in four sub panels: burning plasma/foundations, burning plasma/long pulse, DPS, and partnerships with other federal and international programs. The Panel considered 18 science and technology thrusts from the 2009 MFE ReNeW report, prior reports and studies, along with community input in 2014 through presentations, question-and-answer sessions, and white papers. The four highest priority initiatives chosen by the Panel were categorized into upper and lower tiers.

Dr. Koepke then discussed the structure of the FESAC SP panel report. As a preface, he observed that fusion promises a nearly limitless, high density energy source that does not produce greenhouse

gases. Man's quest for controlled fusion energy is a grand scientific challenge that has been going on for approximately six decades. He said that we are now poised to enter a new era, the magnetic fusion energy era, characterized by burning plasmas, steady-state operation, advanced materials, and safe regeneration of fusion fuel.

In parallel with ITER construction, international fusion programs are building other large-scale new facilities with capabilities that complement those in the United States. These new facilities provide two opportunities for US fusion science.

1. To initiate and then grow a new subprogram in fusion nuclear science including the design of the facility to conduct research in an area not currently being addressed internationally.
2. For the U.S. to selectively participate in collaborations on these international facilities to access new parameter regimes in preparation for the design of the new facility.

The Panel's vision for 2025 is that the US will continue as a world leader in fusion. The Panel's view is that over the next 10 years, the U.S. program will transition into having a fusion nuclear sciences subprogram comparable in effort to its fusion plasma sciences subprogram. The vision enables successful operation of ITER with significant, leading participation by the United States. It provides a scientific basis for a U.S. fusion nuclear science facility (FNSF) and creates a U.S. next-generation ITER-FNSF workforce to lead scientific discoveries and technology innovation.

Mark then discussed the schedule for the SP Panel activities, covering the date range of April 8th through September 23rd.

Discussion

- Dr. Robert Rosner asked Dr. Koepke whether he will talk later about how the primary recommendations map into the two tiers.
- Dr. Koepke responded affirmatively: Tier 1 is higher priority. Within each tier, the items have equal priority.
- Dr. Amitava Bhattacharjee asked: What are the criteria the SP Panel used to distinguish Tier 1 from Tier 2.
- Dr. Koepke explained that the criteria are in the appendix to the report and that he would go over it.
- Dr. Richard Groebner asked Dr. Koepke whether he means working on the science for a future FNSF, rather than the design per se.
- Dr. Koepke responded that the goal is the development of a potential facility with the fusion nuclear science subprogram supporting plenty of science as a precursor to a design. Meanwhile, DPS gives you lots of curiosity driven science for your buck, and stewarding plasma science in the federally supported research enterprise is important.

- Dr. Bhattacharjee asked: What is the basis for the reductions, particularly the DPS reductions?
- Dr. Koepke responded: Collaborative partnerships provide a vehicle to do more with less, if DPS funding has to go down, for example in the lower budget scenarios.
- Dr. Keane asked: How did you come up with Vision 2025?
- Dr. Koepke explained that, as a Panel, the first thing they did was construct a vision, because they felt this was so important. Then they could stick to it the whole way and make sure everything was true to it.
- Dr. Groebner asked whether the SP Panel costed out the different elements to see if they fit in the scenarios.
- Dr. Koepke replied that the Panel did so, to a detailed degree. He noted that the Panel report doesn't give numbers, but he did confirm that the Panel did that. He explained that the Panel had numbers from the 2012 MFE Priorities report and from the public input, and that the Panel double-checked them with FES.
- Dr. Rosner noted that he was struck by the difference between recommendations and the tiered initiatives. So he asked, which comes first: recommendations or tiered initiatives?
- Dr. Koepke replied that the recommendations are the gaps and opportunities to address, and the initiatives are designed to reflect, the new efforts that can fit into the budget. The initiatives are designed to speak to the higher priority ReNeW Thrusts, some of them grouped.
- Dr. Cohen observed that the Panel did calculations supporting the budgets, but the charge wanted priorities as a function of various scenarios. He said the Panel report says to go slower if there is less money, but it is not specific. He asked whether or not DOE gave the Panel instructions for how specific to be. And he asked Dr. Koepke whether or not the Panel is specific enough.
- Dr. Koepke replied that, yes, we were specific enough for the Panel knowledge-gathering process and for responding to the Office of Science charge. He explained that the Panel felt, in order to gauge what could be accomplished, where new initiatives would fit into the existing FES program, and what resources could support the initiatives, the Panel had to examine the small details of the FES program to understand how the FES program budget breakdown works while assessing the initiatives provided by the public. FES was not expecting the recommendations and budget scenarios to be prescriptive. There was a verbal endorsement by FESAC that the Panel succeeded in satisfying FES's needs with the level at which the Panel provided budget details.
- Dr. Keane asked whether the Panel had enough budget data. Do we know enough about the budget to see that?
- Dr. Koepke said he would expand on that topic later.
- Dr. John Foster noted that the report talks about leveraging existing facilities, but also constructs new facilities. He asked: which facilities?

- Dr. Koepke replied that the Panel saw white papers about adding an element to the Spallation Neutron Source, which would be very cost effective. He noted that the work on scoping this out has already been done.
- Dr. Synakowski said that regarding SNS, we are receiving guidance from the fusion side, but we have to be thoughtful about the partnering office.
- Dr. Koepke asked Dr. Don Rej, the relevant group leader, to answer the question.
- Dr. Rej said that there have been discussions between FES and BES for possible parasitic use of SNS, with perhaps an HFIR-like capsule around the main target station. These discussions are in nascent form. The report makes a recommendation about the mutual benefit. He noted that there has to be clear benefit to BES as well. They've already had initial discussions. He said the leverage for this is quite significant and this will inform the FES decision about whether to join the Broader Approach IFMIF. He explained that funding scenarios were done in great detail, using river-flow charts, etc.
- Dr. Juergen Rapp asked whether or not Vision 2025 will mean that we will be at CD-1 level.
- Dr. Koepke replied that CD-1 could be an objective consistent with the Panel report.
- Dr. George Neilson observed that it seems strange that this phrase "scientifically justified" is applied only to international partnerships.
- Dr. Koepke replied that the subcommittee did not want to give the impression that we will do international partnerships for the sake of being international; some may not fit FES needs. In his opinion, international partnerships need to have a strategic purpose.
- Dr. Neilson: But a linear divertor simulator?
- Dr. Koepke explained that the SP Panel was thinking totally about how international partnerships would be perceived strategically; the Panel wanted high fidelity.
- Dr. Foster asked whether or not the timeline linked to the ITER timeline.
- Dr. Koepke replied affirmatively: The Panel had excellent input about the ITER timeline.
- Dr. Foster asked whether this is a solid timeline?
- Dr. Koepke explained that the Panel took into account the uncertainty about the ITER timeline. It had excellent input from ITER. For the FNSF facility, there is a certain presumed-optimal timeline.
- Dr. Susana Reyes commented that we [the SP Panel] had community input about how to align domestic activity with the ITER timeline; priorities and initiatives were made consistent.
- Dr. Ellen Zweibel noted that the DPS primary recommendation relies heavily on other agencies. She asked what input from other agencies did the Panel have regarding what they want to do.

- Dr. Koepke replied that the Panel had information from NSF, it had white papers from lab directors, and that Dr. Rej did outreach on that.
- Dr. Rej said that we received white papers, and that the partnership with NSF has been very strong. We had a presentation from Denise Caldwell (NSF). He commented that another partnership is in HEDLP with NNSA, coming from labs and universities.
- Don Correll noted that the chapter on DPS (page 27 in the report) points out that in looking for opportunities to expand frontiers, intermediate-scale facilities cost on the order of \$10M (Omega is quite a bit more expensive). Exploring opportunities will therefore require partnerships, since there is not enough money in any of these budget scenarios to go it alone. But, he stated that this should not be done at the detriment of single-PI facilities. He stated that we do not have a commitment from any one agency, but partnerships with NSF and NNSA exist. Also, there exist in-house partnerships that FES has within SC, such as in SciDAC.
- Dr. Groebner observed that this is also a question about DPS; the report talks mostly about facilities for DPS. He asked whether or not the theory/simulation component is important for DPS.
- Dr. Koepke replied that he thought about DPS theory-simulation. He said that Dr. Groebner made a good comment, that in talking about cost sharing, we are talking about major and intermediate-scale facilities. They provide great user access for research. DPS does involve theory-simulation.
- Dr. Groebner asked whether or not people relying on theory grants will be covered.
- Dr. Koepke replied that collaborating on facilities provides benefits to the DPS community that single-PI facilities do not have. So the Panel mostly focused on the experimental side and that they are already doing this in the HEDLP community. He noted that to do it in MFE would be a high -expansion. Those communities already have a well-coupled theory-simulation program.
- Dr. Valerie Izzo noted that Dr. Koepke said that the two Tier 2 items have the same priority level, but in the different budget scenarios this appears not to be the case.
- Dr. Koepke asked Dr. Zinkle will help him out on this question.
- Dr. Zinkle commented that if you look at the budget wedges, the predictive initiative would cost less than the full Fusion Nuclear Science initiative and is the first one to slow down in low-budget scenarios. So if we look at how budget scenarios are laid out, the Panel did rank initiatives within a given tier. In doing that, we used the argument of cost, not opportunity.
- Dr. Koepke said that the difference was the amount of money for each Tier 2 initiative. Even if we slow down the FNSF initiative, we still get as much percentage increase in effort for it as for predictive, as opposed to the much bigger percentage of increased FNS effort in the higher-budget scenarios.
- Dr. Zinkle noted that it depends on where the break points were for the budget scenarios that we were given to analyze; it might have come out differently for different scenarios.

- Dr. Bhattacharjee observed that the Panel was briefed by FES. It had information that is not in the report. He stated that that information should be made available to the community. He said that FESAC members were not aware of the detailed calculations that were used.
- Dr. Koepke said that the SP Panel checked that what it did is consistent with FES numbers.
- Dr. Bhattacharjee noted that the Panel made informed choices, based on FES information to the Panel. He noted it would be helpful to have that information.
- Dr. Koepke replied that it resembles a COV process, where you have questions and FES responds. We got the information we needed, in response to our questions. He said that while much of what FES does nowadays is Foundations, some resources may need to be shifted to Long Pulse. He noted that there are five Foundations recommendations, including a recommendation to focus research efforts on studies crucial to deciding the viability of a Spherical Torus for an FNSF. These recommendations are not the status quo.
- Dr. Rosner asked whether the idea is to push for community consensus.
- Dr. Koepke replied that we understand whole device modeling insufficiently, and a community-based workshop could be a way of assessing consensus to reach sufficient understanding, but prescribing this workshop goes beyond deciding that a significant whole-device-modeling effort is a top strategic priority.
- Dr. Groebner asked: Then why not use the words Fusion Simulation Program in the 4th recommendation?
- Dr. Koepke replied that there were some sensational white papers that struck the SP Panel as creative and important and sensible ways to go; we were impressed with those presentations and white papers.
- Dr. Groebner asked whether or not they could form the basis for peer review.
- Dr. Koepke replied that core-to-wall interaction is what the Panel emphasized. Foundations had additional secondary recommendations for Vision 2025.
- Dr. Neilson noted that the first two bullets (Supporting Recommendations for Long Pulse) are very specific. The third bullet is about a research subprogram (nuclear and non-nuclear facilities). He asked what do you have in mind that is more specific?
- Dr. Zinkle replied that there were several white papers that proposed some specific facilities for that bullet. Also the prior FESAC materials subcommittee had some specific suggestions. He observed that we would not be able to build all of the proposed facilities, but we do want to restart some fundamental research activities (such as extracting tritium from lead coolant). He stated that we need those activities -- there are things that can be done even without a \$10M facility. There is low-hanging fruit for modest investments. The Panel report did not list them because a number of million-dollar-class facilities would be envisioned.
- Dr. Neilson commented that there is a white paper that talks about an advanced linear divertor. The report says it would cost \$29M to construct (to be done in ten years) and then \$3.5M/year to operate. But there are already linear divertor simulators elsewhere in the world. He asked whether

or not our international colleagues say that this is a world-leading facility and what will make the proposed facility world-leading?

- Dr. Zinkle replied that this facility will have multi-effects capabilities superior to those of any existing linear device, and it could also handle neutron-irradiated materials in the fusion environment. Its capabilities would be superior to those of Magnum PSI.
- Dr. Zinkle noted that the Panel forgot to cut and paste the definition of DPS (see page 27 of the report) into the presentation. This recommendation talks about diagnostics cutting across all of DPS, even though it actually cuts across all of FES.
- Dr. Cohen asked that, in the absence of budget specificity, what fraction of program resources should DPS occupy in the four scenarios? He noted that there is something missing in the guidance the report gives to DOE.
- Dr. Koepke replied that our plan is that DPS will not have big budget changes.
- Dr. Cohen asked whether that language could be put in the report.
- Dr. Koepke replied that that language is not in the report, but on the other hand the Panel did not put that kind of language in the report for anything else either. The Panel prioritized the changes, initiatives, and recommendations and then made sure that the budget scenarios were consistent with the recommendations.
- Dr. Rosner noted that budget numbers did appear implicitly in the report. The report talked about the possibility of drawing down DPS. On Page 27 it mentions numbers. He expressed amazement that the Panel considered DPS as a source for funding.
- Dr. Koepke explained that there is a recommendation in the DPS chapter to treat these elements in an integrated way and to have peer review of all of them. In that process, there may be some moving of money among the DPS sub-elements. Between DPS and other subprograms, it was felt that the transformation to a fusion long-pulse science program is a big headline, and that DPS would not take away from that transformation. The Foundations budget element would donate to that transformation. The Panel felt that the collaborative element and the intermediate-scale-facility element, and using 10% of major MFE facilities for DPS science is a much bigger perturbation. On that scale, DPS stays about the same—except for one of the lower budget scenarios. Then, the large facilities take a hit, and DPS might also.
- Dr. Foster observed that DPS is already small, and this is the only game in town for small facilities. He asked whether some of the DPS elements in the 2010 NRC Decadal Report are embedded in Foundations or Long Pulse.
- Dr. Koepke replied that DPS is doing great in terms of students and invited papers. There is much to be gained through collaborations. Some of the best DPS work is being done in collaboration with other Federal agencies. DPS could expand on what it is already taking advantage of. Foundations will give up a lot of money (even a machine) to do more Long Pulse. He said that the Panel thought it better to talk about the way to do business, rather than get into numbers.
- Dr. Synakowski commented that FES received questions from the Panel about budgeting. FES was clear to caution the Panel not to be too specific, not to try to do program management, since

one can easily get into unintended consequences. FES encouraged boundaries on this. The draft report level of specificity is consistent with the guidance that FES provided. But, he expressed confusion with what is written regarding DPS funding being impacted but not significantly; given the priorities expressed in the budget, even with the cessation of C-Mod, you have to put a little squeeze on DPS (page 31, bottom). He noted that the report takes advantage of collaborative opportunities and that nothing comes for free. FES wants to maintain excellence in DPS, but at the lowest scenario we might have to rethink how that business is done. That is what FES articulated to the Panel, and it seems to be reflected here.

- Dr. Correll said it is not fair to say that only DPS is “discovery” science; some good discovery-type science is being done in foundations and long pulse. It crosses budget categories.
- Dr. Knowlton acknowledged that as being true: the Diagnostics element crosscuts almost all budget lines. It is hard to fit in one cage. He commented that a second aspect is that more generally, one sees that major MFE facilities will be increasingly considered user facilities. The panel did not consider how this would occur, but the Panel opinion is that discovery-type plasma science can be done on major facilities as appropriate.
- Dr. Foster commented that under the worst-case budget scenario it seems counterproductive to take the DPS budget down to take up the slack.
- Dr. Koepke replied that the Panel projects that if DPS has to contribute, it can do so in a way so as to still be able to access scientific frontiers.
- Dr. Zweibel noted that DPS is very diverse, and it is not really obvious how you judge which subfields are more important than others. She questioned where university programs will be after these ten years.
- Dr. Koepke replied: everywhere; these initiatives should lead to plasma being in more departments at universities. He said the research will be on more devices, with higher capabilities, and universities will have access to and participate in governance.
- Dr. Correll commented that the chart should show more vitality in the program. He noted that 10-15% of runtime on major facilities is devoted to fundamental DPS. With regard to the Partnering chapter, he said this has a very rich group of recommendations, and that the SNS collaboration is shovel ready. The partnership status of Federal program collaborations really means the FTEs that are involved. “High” means that it meets all four criteria.
- Dr. Bhattacharjee said that concerning ASCR, we have had partnerships on SciDAC. He asked: What are the specific plans to rebuild the connection with ASCR for a predictive simulation initiative? When would this happen? Will there be partner solicitations?
- Dr. Koepke replied that that is not a clarification question, so he deferred that issue to the Q&A session.
- Dr. Rosner expressed astonishment that the report did not mention the Nuclear Regulatory Commission.

- Dr. Rej replied that Appendix G on partnerships explicitly brings out NRC. The Nuclear Energy AD was a former commissioner. He said that to get into fusion nuclear science, it is not too soon to start consulting the experts.
- Dr. Reyes: The Panel had access to NRC reports, past interactions with fusion, and perspectives.
- Dr. Rosner said that the NRC is viewed as the gold standard internationally.
- Dr. Gertrude Patello explained that paragraph came out of the internal section, so it does not cover the NRC.
- Dr. Koepke accepted responsibility for improper cutting and pasting.
- Dr. Rosner noted there was a Secretarial initiative to support basic science, about \$50M. He asked whether that initiative could make its way into this report.
- Dr. Koepke replied that might be included in the significant HEDLP discovery science sentence in the table.
- Dr. Zweibel expressed surprise to see NASA collaboration considered to be weak or minimal. She noted that NASA already funds so much space plasma physics and even some plasma experiments, plus fellowships and grants.
- Dr. Koepke explained that the table refers not to future partnership potential, but to current partnership status. DOE has no partnership at present with NASA. This is not due to disinterest on the part of FES, but due to NASA's view of its mission.
- Dr. Rej stated that there are huge opportunities with NASA. Our principal investigators go between both worlds. But is there a federal-to-federal relationship (like the Memorandum of Understanding with NSF and HEDLP). Dr. Rej's answer: No. He observed that there have been FES overtures, but what is needed is a coordinated approach, as written in the National Research Council Plasma 2010 report. In his estimation that might not need to be a formal agreement, but rather well-coordinated activities.
- Dr. Koepke said the level of interaction with NASA at present is a monthly luncheon.
- Dr. Correll suggested that FESAC recall how Dr. Keane at NNSA started the joint program with FES.
- Dr. Patello said to remember that the table is a summary; there is much more detail in the appendices.
- Dr. Keane noted that there is a tone in the report that these collaborations are meant to bail out DPS. He asked whether or not there is a possibility for increased funding by other agencies.
- Dr. Koepke replied that the impressive demonstration of such collaborations resulting in high-profile science results (and workforce development) led the Panel to conclude that this was only a barely tapped resource, especially in HEDLP.

- Dr. Groebner reminded the committee that NASA has put a gyrotron on DIII-D, which they are sharing with DIII-D, so maybe there is some hope for collaborations with NASA.
- Dr. Charles Greenfield questioned whether ‘partnership’ means scientists collaborating on machines, or something else? Is it unidirectional where US scientists collaborate? For example, he noted that currently the JT-60 team is collaborating on a US facility (DIII-D), but not vice versa.
- Dr. Koepke replied that there are different models in place at different facilities.
- Dr. Rej said this refers to collaborations on facilities. Agreements between agencies and between governments should be bilateral. Status refers to the FTEs that are involved (based on information from FES and people in the field).
- Dr. Jin-Soo Kim asked, in the future, who would initiate such collaborations?
- Dr. Koepke asked to defer that issue to the panel discussion. He went on to say that the public presentations made to the Panel were impressive and really helpful to the Panel. He said that these presentations helped the authors write their white papers. The Panel appreciated the input also from international scientists.
- Dr. Koepke commented that Dr. Don Correll gets the credit for constructing this table.
- Dr. Correll said that everything flows down from the vision statement at the top. The table summarizes the report.

Dr. Chris Keane: About Procedure

- Dr. Keane explained the FES congressional plan: The target date for internal completion is November 1, 2014. The FESAC role is to review the draft report of the subcommittee and transmit a letter to DOE about action on the report.

Discussion session

Comments on the Vision Statement

- Dr. Keane said that he did not see the phrase “steward of basic plasma science” in the Vision 2025 statement. DPS is an admixture of basic science and more applied work.
- Dr. Koepke replied that we hold dear the phrase “steward of basic plasma science” from the 2010 Decadal Report. Stewarding is a way to do the vision, but it is not the vision itself.
- Dr. Correll added that that is exactly what the Panel did. The Panel wanted an actionable set of activities for the Vision. He commented that everyone in the room understands the importance of stewardship for plasma science.
- Dr. Keane observed that this report will go to Congress, so it has to be clear.
- Dr. Koepke commented that the word stewardship is used in the report.
- Dr. Correll added that on page 27, the word ‘stewardship’ is used at least five times.

- Dr. Zweibel: If you are looking for a verb to describe DPS, how about “pursue”?
- Dr. Bhattacharjee said that this report will go to Congress, which occasionally surprises us with what they will do. His view is that this should be an aspirational document and he commented that sometimes our vision is so circumscribed by boundaries imposed from above that we lose our aspirations. In his view, the present budget numbers are not great. He also believes that the report needs a ringing endorsement of what this community is all about. He recommended that the report give Congress excuses for doing more. He noted that basic plasma science is part of our aspiration and that Dr. Dehmer’s report at the FESAC meeting in April talked about university participants in the program. He believes the Vision Statement should be more far-reaching.
- Dr. Koepke would characterize this document as incorporating much aspiration. In his view, the report responds not only carefully to the charge, but it also indicates the derivative for what could be done with more money. The report’s preface and forward look are quite aspirational. If FESAC wants to enhance the aspirations, that would be in the direction that the Panel was working. The Panel wanted its report to be aspirational, but also realistic and credible.
- Dr. Neilson expressed his opinion that the vision statement is OK. His view is that word-smithing aside, these three things are the right things; this is what the fusion program should aspire to ten years from now. He has quibbles about the alignment of the recommendations with the vision. For example, the third bullet talks about workforce, but if this is a pillar of the vision statement, it deserves more discussion in the report (there is little).
- Dr. Koepke commented that the whole Office of Science is concerned about workforce development. He encouraged FESAC to compare the recent FESAC report on this subject. The present report talks mostly about workforce in Chapter 4 on DPS.
- Dr. Correll encouraged FESAC to examine page 27 in the definition of DPS (also see page 32). He can’t provide FESAC with a specific word count, but says the word “workforce” is used in the report.
- Dr. Linda Sugiyama commented that nowhere in the report did she see the phrase “self-heated state,” which is mentioned in the Vision statement.
- Dr. Koepke replied that “Self-heated state” is ITER research.
- Dr. Sugiyama disagreed, saying that she does not consider ITER a self-heated state as ITER will achieve only $Q=10$.
- Dr. Greenfield commented that we [the fusion program] want to make fusion a real energy source, but we seem to be stagnating and not moving toward that goal. He is excited by this vision [in the report]. He is also happy with the statement about a transition to an energy program. He commented that the first two bullets are good. However, he agrees with Dr. Neilson in being not quite sure about the third bullet.
- Dr. Rapp reported that he likes the vision very much. He would add “technological basis” in the second bullet.
- Dr. Koepke replied that technology is mentioned in the report many times.

- Dr. Groebner also reported that he feels pretty good about this Vision Statement. But he expressed frustration that we [the fusion program] are not moving ahead. He also believes that we need more materials research. He commented that it is exciting to talk about a big new facility that is world class -- but money is a problem and the scenarios only allow some steps in this direction. He observed that we need a good workforce, but do we need to say this in the Vision Statement?
- Dr. Synakowski commented that he understands the urgency about workforce. But in articulating the FES vision, he would find it difficult to use workforce as a rationale. Instead, the real reason is the science. His view is that workforce is not what the program is for; we need to pay attention to workforce in order to pursue the mission, but workforce is not the reason why fusion exists.
- Dr. Fred Skiff stated that there is a good statement for Vision, but then there is the issue of mission-driven versus academic. He stated that DPS is in both.
- Dr. Neilson proposed a modest suggestion to improve bullet 3: Turn around the sentence so that scientific discovery and innovation are not subordinate. He also proposed to eliminate the catchy phrase “Generation ITER-FNSF”.
- Dr. Chris Hegna observed that in an earlier version of the report, there was a section about the role of universities. He asked whether university-based research got dropped. He believes it needs to be reflected.
- Dr. Rej replied that he was also thinking of inverting the third bullet. But he thinks it is OK to retain the catchy name to reflect the role of universities. He also commented that the Vision Statement should not be very different. He suggested that FESAC compare the Vision Statement in the G-7 white paper that was submitted to the subcommittee. He stated that a Fusion Nuclear Science program means more than just plasma physics.
- Dr. Troy Carter noted that workforce is not the primary reason for the existence of universities; they also have to sell their programs on the basis of science.
- Dr. Keane asked the FESAC members to send their comments on the Vision Statement to him (chris.keane@wsu.edu). He will incorporate them in the summary tomorrow. He stated that he will also ask Dr. Koepke to take a crack at it.

5. Discussion of Initiatives and Priorities

- Dr. Keane raised the issue: We have to be ready to give an answer to our favorite congressional staffer if he were to ask us: What do you think of this report?
- Dr. Neilson replied that he was looking for initiatives that are exciting, that will change the trajectory of our funding fortunes, which have been declining for too long. He observed that the fusion program has not built any new facilities for a long time. He noted that Scenario 4 is the most pessimistic, but it is where the program is now for FY15. So what remains (Tier 1) in the pessimistic scenario looks like more of the same. The fusion program has been working on disruptions and plasma-material interactions for a long time. But he cautioned that these are not initiatives that will cause our colleagues in the broader science community and in Congress and overseas to say that our program will turn around.

- Dr. Koepke replied that the idea was, that with upgrades and with devices really set up to use diagnostics and that have flexibility, to look at transients in order to weigh in regarding disruption-mitigation solutions for tokamaks. With regard to PMI, the approach taken by the Panel is to look at it with existing facilities in order to validate whole-device modeling. He said that neither of these Tier 1 initiatives is status quo.
- Dr. Knowlton said that to get an initiative, the Panel determined priorities and the needs of the program. That is how three of these Tier items became initiatives. He thinks DIII-D and NSTX staffs are highly capable of solving the transient problem. He commented that the fusion program already looked at transients and PMI, so maybe they should not be characterized as initiatives. He stated that more correctly, these are issues that absolutely need to be resolved in ten years' time.
- Dr. Izzo noted that scenarios in the report all have NSTX and DIII-D operating for five years, but the rationale seems to be the selection of the best geometry for FNSF. She asked whether that should be the same reason for the lowest budget scenario,
- Dr. Koepke replied that NSTX was upgraded to make this decision point whereas MAST is not as capable of doing this.
- Dr. Bhattacharjee recommended a process to promote predictive capability to Tier 1.
- Dr. Koepke asked in reply, which issue would you move down in priority?
- Bhattacharjee replied that he would move none of them down. He commented that the predictive initiative is very cost effective. If it were demoted to Tier 2, we might lose an opportunity. He stated that this has been a no-brainer for fusion for a long time. His view of the problem [with predictive capability] is that we started with an overly grandiose proposal for it; now we are more realistic. He stated that as a community, we are building this capability. He noted that the disruption workshops show that the data are incomplete and that we need predictive capability for this initiative.
- Dr. Koepke concurred that he cannot argue with Dr. Bhattacharjee on the rationale. But he does take issue with making it [predictive capability] Tier 1. In his opinion, the transient initiative is urgent while the predictive initiative is not quite as urgent. He would be dissatisfied with having three Tier 1 items because the charge asked for a ranking.
- Dr. Hegna noted that not all Tier 1 items are purely experimental; in fact, they require a theory-modeling effort. Also, he said that item 3 (predictive) includes experiments; it is not purely theory.
- Dr. Bhattacharjee replied that he recognizes that, but what is missing is doing whole device simulation modeling. He questioned, what stops you from putting one more in Tier 1?
- Dr. Koepke replied that it makes the descriptor of the Tier useless.
- Dr. Sugiyama stated that the transient events initiative is almost entirely related to ITER; the words "Successful tokamak burning" should be added.

- Dr. Koepke asked: is doing so consistent with us not dealing with ITER in the charge? High Power was removed from the charge. He noted that the Panel was instructed to assume that ITER would happen.
- Dr. Sugiyama indicated that what she meant is that this item is exclusively pointed at ITER. So the report should say that.
- Dr. Koepke replied that the report talks about their deleterious effects on burning plasma, but they do also put limitations on existing machines.
- Dr. Sugiyama responded: but it is only for tokamaks, whereas the other bullets are platform independent. So she questioned, why not put this in the title of the initiative?
- Dr. Neilson raised a point of order: we should hear comments from FESAC. He said that we don't need responses from the Panel for every comment.
- Dr. Greenfield provided comments on both Tier 1 initiatives. In his view, the first one should not be tokamak-specific. He noted that it is called damage control in the report, but in reality it is also operation control. He said that some issues are tokamak specific, but operating point control is not specific to tokamaks. He suggested changing its name from damage control to plasma control. This is not ITER specific, since it is common to existing tokamaks.

For the second initiative, he noted that the report says this is a prerequisite for ITER success. He commented that some things might be prerequisites, but the fact is that few changes will be made to ITER before it runs, so this is more to do with how to run ITER. It will become more important for FNSF—which again is not tokamak-specific.

- Dr. Cohen said that he suspects that theory, simulation, and modeling are integral, part-and-parcel of the first two initiatives, but this is not obvious. He requested that, in the longer description of the initiatives on page 9 of the report, a phrase be added that explicitly states these two initiatives involve teamwork among theory, simulation, and experiment. He recommended that the report be clear where ASCR can help us with our Tier 1 items. He disagrees with Dr. Bhattacharjee: theory capability is present in all four initiatives, whereas Integrated Modeling is something special.
- Dr. Synakowski commented on how FES might use this, for its plan and for briefings in response to Dr. Neilson. He embraces what Dr. Greenfield said about how it is framed. But in terms of what our stakeholders need to advance the fusion cause, he has talked about urgent problems in the burning plasma realm, and this class of things comes up. He said that people can understand these things and that to be able to tell the story, that we should identify major classes of issues involving both experiments and theory and that that combination represents an exciting scientific story. He noted that the predictive initiative plays well in the Administration and that in his view we must capture the wave in massively parallel computing. He mentioned that we can talk about both Tier 2 initiatives readily. His view is that the FNSF initiative and heading toward CD-1 are both very substantial initiatives. He admonished the committee that word-smithing is not the best use of FESAC's time. He concluded by saying that all four initiatives are things that will play well with the audiences that he deals with.
- Dr. Rosner commented that the audience for this report is Congress and the American Physical Society and that words do matter. He is worried about the wording. He noted that at a general APS Meeting (not the APS-DPP Meeting), this would look like an engineering program, which

might later do some science. He suggested adding a line at the bottom about theory, simulation, and experiment.

- Dr. Groebner stated that these are good initiatives: the Tier 1 items are showstoppers, while the Tier 2 items are ‘needed’.
- Dr. Neilson stated that the arguments about the importance of these items are not new; we have been putting them in reports for twenty years. He wants to produce a report that will change the vector of the fusion program. He observed that every few years, we lose another piece of ourselves. He said that what he heard at this meeting is that Tier 1 items are not just more of the same—but he doesn’t see that in the report. He concluded by saying the report talks at length about the problems--that is not compelling.

Discussion of Budget Scenarios

- Dr. Keane says that concerning Chapter 6, he has two thoughts. First, presenting impacts without a detailed basis worries him. Second, if we give this report to congressional staffers, that is what they will say.
- Dr. Bhattacharjee said that he, too, is concerned by that. In his view, the report should be an aspirational document and it should make clear what will be lost. He said that if we don’t aspire highly, we will lose; we should push for a more ambitious plan.
- Dr. Cohen noted that with all four budgets, there is immediate cessation of C-Mod, but the report does not say why. There is no scientific justification. He is not satisfied with a blanket statement to terminate C-Mod. Second, he observed that the charge is the charge; it gave us four budget scenarios. The Rosner panel pushed back on the charge given to it and he mentioned that he was on that subcommittee. He stated that we need this present report to be perceived by stakeholders as responsive and responsible, so as not to be dismissed.
- Dr. Neilson suggested trying something. He noted that what is in the report starts with Modest Growth (Scenario 1) as the reference, and then displays greater and greater levels of pain in going to the other scenarios. But he believes we are now on a [funding] path to Scenario 4 (FY2015 Presidential Request with cost of living increases).
- Dr. Synakowski replied that that is an assumption you are making.
- Dr. Neilson replied that, yes, that is an assumption. He observed that Scenario 4 is the FY15 budget request. He said that Dr. Dehmer told us that SC is focusing on cost-of-living growth only. He questioned, what is the most compelling thing that will keep the situation from getting worse? He observed that Scenario 1 is \$900M more than Scenario 4 over ten years, so it would help if we portray some tough decision making and a compelling program for Scenario 4.
- Dr. Keane said that FESAC would have to decide whether to ask the Panel to revise its report.
- Dr. Koepke commented that the Panel assumed that no existing machines would be still operating in 20 years. If you don’t get rid of any existing machines between now and then, you won’t be able to do anything strategic for then (20 years from now). So the Panel decided to keep people first, weigh existing facilities with new investments and research directions, and sequence the

priorities according to optimally addressing them within the budget constraint, starting with the highest scenario first.

- Dr. Synakowski reminded FESAC that the number one thing FES urged the panel to do is to prioritize. FES will do our best to make the priorities happen. The timing and how much money is FES's job. Priorities are what matter.
- Dr. Keane asked the FESAC members to please send their comments to him.

6. PUBLIC COMMENTS

1. Tony Taylor – General Atomics

There was extensive community input: 83 presentations and 95 white papers. This input provided excellent advice. Almost everyone in the community will find something in the report to be unhappy about. Clearly the Panel took the community input seriously and clearly they made tough decisions. He heartily supports the elements of the Vision Statement, especially the first two are exciting. He stated that is an appropriate plan to move the program forward in this vision. He found it noteworthy that the entire Panel supports this plan, and he encouraged his colleagues in the community and on FESAC to do likewise.

2. Dave Hill – Lawrence Livermore National Laboratory

The Panel did a wonderful job getting community input. The first high-level item should be fusion energy in general, not specifically transient events. That is only one aspect, and it's happening anyway. He raised the question about adding a bullet regarding sustained fusion power. Fusion as an energy source is captivating to the general public. He observed that the challenge is that we have not realized this vision for the past 50 years. The issue is how to stimulate funding without making expansive promises. He asked that the report be made more concrete about deliverables.

He noted that there are examples of partnering with other agencies that are already working. HEDLP is one, although the funding ramped down before the program got its feet on the ground. He encouraged language that supports other such partnerships.

3. Dr. Steve Dean – Fusion Power Associates

Dr. Dean stated that "I feel like John the Baptist: He didn't know the way, but he came to prepare the way". He said that the Panel put in much effort, but there are some weaknesses in the report. From his perspective, the Vision Statement is not exciting. It is not a 20-year vision statement. No batting averages are recorded for leadership. He stated that the plan would be strengthened if it had an introduction section that describes the world situation (Korea, China, Europe).

With respect to ITER, Dr. Dean noted that, conservatively, it will cost US \$(4-6)B. It needs \$(300-500)M/year, but currently only gets \$150M. Will it be built in ten years without a commitment from the US government? He said that we should take our rosy glasses off and look at the cost of ITER. No electric utility company will want a \$(40-60)B device. How can we get to a concept or configuration that is more affordable and more likely to impact the US market? He encouraged the Panel to look at the white paper from Professor Dennis Whyte. High temperature superconductors are an idea that might lead to a concept at a fraction of the cost of ITER. He stated the need to foster these kinds of ideas and observed that nothing in this plan encourages power plant studies to search for

something better. The report gives the impression that solving physics problems will make ITER work.

Also, he questioned what differentiates the budget categories. Nothing in the report allows one to pick among the scenarios. The report uses phrases like “acceptable probability” and “partially met”. It is important to get on the higher path.

Finally, he noted that under a Continuing Resolution, we have lost the top three funding profiles. There is no sign that anyone will give the fusion program more money. He said that the fusion program needs compelling arguments, but they are not in the Vision Statement. He sees lots of trees, but who will see the forest? He said that the fusion program needs to get to a power plant earlier than 40 years.

4. Dr. Earl Marmor – Massachusetts Institute of Technology

Dr. Marmor agrees with some of the priorities in the Tiers. In particular, he stated that the top two are very important and are potential showstoppers for the development of fusion. It is right to look at them. He noted that for PMI, the report urges a community assessment about how to address the PMI key issues, and that resonates with him. But, he believes that making irreversible decisions before that panel of experts meets would be a serious and fundamental mistake.

He observed that late in the report (p. 28) the Panel noted that the ITER level of power fluence has been studied in C-Mod. Instead, he believes the report could say that we need to study this issue in C-Mod. It is the only facility in the world that can do this now. Hence there is a strong dissonance between the identification of PMI being a high-tier issue with the recommendation to immediately cease operation of Alcator C-Mod.

Also, Dr. Marmor observed there is no discussion in the report of follow on, such as ADX or high-temperature superconductors. He believes this represents a huge hole in the program, to which Dr. Dean alluded. It misses the high-field approach to an FNSF and a pilot plant. The reactor designs in the US for a burning plasma plant (BPX etc.) were all high field. They got to the plasma parameters needed, in a tractable-size machine. He stated that the physics is basically in hand; there are issues with disruptions, ELMs, and steady state that we need to work on, but the basic physics is in hand and only needs modest investments. He believes that needs to be in the report.

Finally, he reminded the Panel that Dr. Neilson referred to the fact that this is not a very inspiring plan. He observed that ten years from now, with this plan, we would have only one tokamak facility and a linear plasma simulator (the only new device), and we would be designing FNSF—nothing else. This is not inspiring. He believes that we can do better, and we should do better. That resonates with Dr. Cohen that there is no backup for the statement that the Alcator C-Mod program should be terminated; it gives no opportunity for rebuttal.

5. Professor Miklos Porkolab – Massachusetts Institute of Technology

First, Dr. Miklos Porkolab questioned how the immediate cessation of C-Mod operation in FY15 can be consistent with students completing their theses and with C-Mod having a three year phase out plan approved by DOE to be completed in FY16. He quoted from Dr. Synakowski’s letter: that funding for C-Mod in FY16 to be level with FY15. It is unclear to Dr. Porkolab where the Panel came up with the recommendation to shut down C-Mod.

Dr. Porkolab observed that there are still 10 PhD students in their fourth and fifth years, who need data to finish, and MIT cannot send them elsewhere. He has sent a third-year student to DIII-D. He noted that C-Mod has just completed 12 weeks of operation in FY14 and that the program has ten papers at the IAEA Conference next month and a comparable number of invited talks at the APS-DPP Meeting, so C-Mod is very productive.

Dr. Porkolab said that the House markup for FY15 has 12 weeks of operation for C-Mod. With an initial continuing resolution in FY15, there is a chance that we might stay on a CR throughout FY15.

He observed that Alcator C-Mod is the only US machine with metal tiles which is the material that ITER has chosen for its operation and that major EU machines have converted to tungsten. But, he noted that there are issues with tungsten such as impurity injection and pedestal height. Also, he noted that C-Mod is investigating a new antenna geometry to mitigate impurities and that it has a plan to put on a second such antenna. He stated that Alcator C-Mod is the only machine in the US to explore lower hybrid current drive, which is new driver technology relevant to FNSF, and that we lose exploring this technology if we shut down Alcator C-Mod. In the PMI area, he observed that C-Mod has high heat fluxes and can study interaction with metallic walls. Some FNSF designs have high field (similar to C-Mod).

In conclusion, Dr. Porkolab said that the report should say what we lose when we shut down a machine: C-Mod, then either DIII-D or NSTX.

7. Dr. Mark Haynes

Dr. Mark Haynes said that Congress asked for a plan, and this report is the basis for that plan. This report therefore, must be part of the compelling case for Congress to fund the program. He asked: what makes a compelling strategic plan? His answer to that question is: [1] A vision—but maybe the one in this report is not very compelling. [2] Hard choices—these it has, especially one for C-Mod. He said that the report should elucidate the possibilities that were left on the cutting room floor and that FESAC should incorporate this information to make it more compelling.

8. Stewart Prager – Princeton Plasma Physics Laboratory

There is a lot of great stuff in the report: support for ITER, FNSF, challenges. He has a positive response to it. He then listed four impressions as if he were an outsider to the field:

- World leadership of the US: This is a challenge in a budget-constrained environment. The report does not answer how these initiatives are world-leading. It should give a concise answer to this.
- The report seems not to emphasize innovation: We need ideas. Strength of our ideas accompanied by experiments leads to innovation. The report seems to be at a low energy level. It should raise the energy level in the room. I sat through all the community presentations to the Panel; I found them exciting and inspiring. Somehow this is not coming through.
- Preparing for ITER and FNSF is not enough for the Vision Statement: This is weak. Re-express this.

- DPS: Within this box are many critical things. However, the report just talks about generic plasma science. It needs good examples.

8. Dr. Mike Zarnstorff -- Princeton Plasma Physics Laboratory

Dr. Zarnstorff recommended that the Panel emphasize science in the Vision Statement; tell the story in that language and from that perspective. He observed that the Vision Statement is focused on the facilities that will carry out the mission. With the initiatives, he stated that the initiatives are scientific, but they could be made more so. Dr. Zarnstorff said that the challenge with fusion is to integrate solutions for all issues, which is very difficult. He believes that the fusion program currently focuses on individual aspects and short-term phenomena but that we need to transition to long sustained performance. Finally, he said that collaboration with international devices is not justified with these initiatives; this needs to be brought into the report.

7. FESAC Member Comments

- Dr. Skiff said that given the charge and the financial limitations, the Panel has tried to align them. He echoed the comment that we should not lose vision.
- Dr. Cohen thanked the spouses of the Panel members for putting up with this process. He said that the cessation of C-Mod operation needs a justification statement. He believes that a fourth actionable bullet is needed about DPS and that differentiation is needed. Of the four top priorities in the two tiers, he said that three that are not integrated modeling and that we need to include an explicit statement that theory and modeling are important elements of them.
- Dr. Rosner subscribed to Dr. Cohen's two comments. He said the Panel did a very good job of responding to the charge. But he did miss a greater sense that this is really science; there is too much application. He observed that there is so much science in this field, and it's a shame not to highlight it. The other thing that he worries about is the wording that describes the FY2015 Presidential Request with COL (Budget Scenario 4). Congressional staffers would see this scenario as being acceptable, since scientists outside the US will do what we don't.
- Dr. Izzo stated that the description of the different budget levels does not draw out the differences.
- Dr. Kim asked: Why don't we say that the worst scenario is unsustainable? She said that it will give no future to young scientists, and that the report should emphasize that point. As for the Vision Statement, she said it is hard to come up with good things to promise. She observed that currently, we are trying to make big progress in engineering. But she believes that the report should make it clear that we are doing research in innovative things as well.
- Dr. Bhattacharjee said that DPS is a very important area and that should be in the Vision Statement, right up front. He observed that the report is supportive of DPS, but not the Vision Statement. He said that we should not stray from the charge that was given, but that cessation of C-Mod operation will be a huge cost for our program. He noted that we might be considering elimination of another large group later on. Finally, he said that the strategic plan should try to keep the enormous talent at MIT in the program.
- Dr. Koepke asked: Is it science or workforce that you want to emphasize in #3?

- Dr. Bhattacharjee responded: Science, with workforce as a consequence.
- Dr. Neilson thanked the Panel for the amount of work and the quality. He said that there is much in this report to like and that we will not turn this report on its head in the next week or two. He then made two recommendations:
 1. Improve the description of the four initiatives to make it clear what will be done and to explain why it is important. Do this in the Executive Summary and Chapter 1. Bring in material from the white papers. Say what will be done, why it is compelling, why it is not just more of the same.
 2. Make Scenario 4 be the reference case. What might convince stakeholders to fund us is that we need to clarify the sacrifices in this case--what can be done, not just C-Mod cessation, and put the nail in coffin for transient and PMI issues. Then make compelling arguments to go up to higher budgets. He prefers to see new investment in new facilities (fusion nuclear science and technology).
- Dr. Sugiyama said that overall, it is a good report in spite of her earlier comments, which she stills stand by. She said that it is dangerous to emphasize technology more than science. She observed that the importance of analytical theory is mentioned in the report, but there are no recommendations that mention it. She asked that the report not just shove analytic theory under predictive modeling or DPS.
- Dr. Groebner thanked the Panel for giving FESAC a 50-page report rather than a 200-page report. He noted that we have to move the community to address materials problems more clearly, and the report does this. He stated that the Panel did a good job of responding to the charge. He noted that the Vision Statement is meant for different audiences: colleagues, non-fusion scientists, Congress. He recommended that the report should include a statement of rationale about the closure of C-Mod: it has huge scientific expertise that we need to keep somehow (and his colleagues there are his friends). He observed that if we want new things, we have to eliminate others.
- Dr. Foster said that this is a nice report but that it should clarify why we must cease Alcator C-Mod. He recommended that basic plasma science be integrated into the Vision Statement. With the reference in the Vision Statement to ITER, he believes that it might be better to say something about confidence. He stated that the definition of the impacts for various scenarios on DPS should be improved. Also, he asked, what are the budget impacts on international collaborations for the various scenarios?
- Dr. Patello said that the white papers contain exciting ideas and the Panel could not incorporate all of them. She observed that the product has some important things that can be implemented.
- Dr. Dasgupta said that the Panel did its best to incorporate quality science in the report.
- Dr. Hegna noted that he was one of the only fusion scientists on the Panel, and that it was very lonely. He stated that it was a miserable charge, which put stress on the Panel, and that the membership of the Panel was disappointing. He expressed his sorrow that we did not articulate a more exciting vision.

- Dr. Rej observed that he used to be an insider, but now is a rehabilitator. He said that strategies are really hard; they don't simply consist of inventories. He said FESAC's editing recommendations can make this a better report.
- Dr. Steven Zinkle stated that the Panel believes that this is the community's report. He said that the Panel tried to strike for a community-balanced report. He observed that the charge left the Panel with a very restrictive budget window, as there is less than 10-15% difference among the scenarios. There is very little wriggle room between Scenarios 1 and 4. He stated that it was hard to come up with exciting initiatives when the budgets in the charge are half the European level. The Panel made tough decisions about the highest priorities. He concluded by saying that, yes, the Panel left other investments with lower priority on the cutting room floor; tough decisions were made.
- Dr. Reyes said that the initiatives are aligned with the Vision Statement.
- Dr. Carter said the Panel process was frustrating; Dr. Hegna's comments resonate with him.
- Dr. Zweibel focused on one thing: the heterogeneous category called DPS, which comprises many threads. She observed that many exciting discoveries are achieved here cheaply, but it only appears in the Vision Statement through the mention of workforce. It is not in Tier 1 or Tier 2. In Budget Scenarios 2 and 3, it will have to be squeezed; it is not mentioned at all in Budget Scenario 4. This leaves the impression that this area will be orphaned.
- Dr. Rapp said the report could be polished to show the world-leading aspects and that preparing for a major facility (FNSF) could be emphasized. He endorses the report.
- Dr. Greenfield said that he arrived late last night, so was happy to see how thin the report is [note: the Panel's report was given to the FESAC members upon arrival on Sunday prior to the Monday morning meeting]. He noted that he has served on recent FESAC panels, so he understands the hard work the Panel did. He is happy with the Vision Statement, which is focused on developing fusion as an energy source. He recommended that some work be put in the third part of the Vision Statement: emphasize science more, with workforce development as a consequence. He noted that science and technology are not in competition, but are hand in hand—this needs word-smithing. He also recommended that the report reword the transients initiative to reflect control of plasma behavior, rather than damage because PMI is not a prerequisite for ITER success. He said that anything we learn about materials will impact not just ITER, but also FNSF. He recommended that predictive models permeate the fusion program. Finally, he said that we need to do a better job motivating higher budgets.
- Dr. Koepke said that the Panel actually composed the ingredients of a strategic plan, so congratulations to the panel. He observed that if the Panel members had all been comfortable, the Panel, by trying to satisfy everybody, would have not reached its potential for strategic success. He said that the Panel actually discussed the very things on which FESAC members have just now commented. He admitted that the product did take a long time and that, yes, there is much enabling technology. In his perspective, the Panel's report is a transformation of a fusion science program into a long-pulse program that embraces a whole dimension of the fusion community that needs to be ready in twenty years. He stated that while DPS is great, we have things to accomplish scientifically for fusion energy, and those require transforming the program to be better balanced between Foundations and Long Pulse. He recommends that we celebrate that the

international program has picked up the work that the US used to lead. We should use our agile flexible short-pulse facilities to make overseas facilities great.

Dr. Koepke then addressed the question of why to terminate the Alcator C-Mod program. He observed that the US has had no new major facility in twenty years and that NSTX was just upgraded. He stated that DIII-D can answer specific initiatives. He observed C-Mod has great people and great capabilities, but it has to be the first facility to cease operation—otherwise we cannot pay for upgrades to DIII-D that are needed to get answers in the next 5 years. What is in the report is a consensus of the Panel—which included experts from DPS, high performance computing, materials, ITER, fusion plasma physics, fusion technology, and fusion nuclear science. He is a big fan of general plasma science. But he stated that we have to be stewards of everything—in particular, stewards of a new vision. He observed that we started low temperature plasma research in 2009 and that we need to do the same thing in partnering with other Federal agencies. This report contains the prioritized opportunities that are worth new investment. The lowest budget scenario is nothing to be ashamed of: it provides for significant attention to be given to transients, boundary, and some attention to validated modeling.

- Dr. Keane said that the initiatives could be described better; he stated that the priorities defined by the Panel are generally correct, but could be more exciting. He would prefer that the report have more science in tone. He also questioned the lack of rationale for the Panel’s recommendation to terminate the Alcator C-Mod program and he is concerned about the DPS impacts. He stated that over the course of the FESAC discussions, he has heard “endorse with caveats” repeatedly. In response, he will draft a possible transmittal letter for the Panel report, and that tomorrow FESAC will decide the path forward: either endorse with caveats, or meet again in a few weeks.
- Dr. Koepke stated that tomorrow the Panel group leaders could comment on the C-Mod cessation rationale and other such questions.
- Dr. Keane said that some word-smithing action can be done after this meeting.

General Discussion

- Dr. Synakowski noted that we cannot have a follow-up meeting as soon as October 1. Also, FES needs to get moving on its strategic plan. For this purpose, at this point FES understands sufficiently the general thrusts of the FESAC Panel report, although FES can modify its plan if FESAC changes anything in the Panel report.
- Dr. Rosner observed that there are two levels issues: word-smithing and substantial. The latter are what might cause people not to vote for the report. Work on those.
- Dr. Bhattacharjee said that there is no way he can digest this report, written over five months, overnight. He agrees with much of the good work that has been done, but said that some changes could make the difference between a good report and an outstanding report. He would welcome more information on budget matters. He expects to vote in favor of this report, but it could be improved.
- Dr. Neilson agreed with Dr. Bhattacharjee’s comments.

- Dr. Keane asked whether or not the Panel considered a ramp down for C-Mod, rather than a crowbar.
- Dr. Koepke replied that the Panel did consider a ramp-down scenario, but that it needed the money to fuel the transformation.
- Dr. Knowlton concurred that the Panel initiatives needed the money.
- Dr. Koepke said that Dr. Zinkle will explain why we need the money (for long pulse).
- Dr. Zinkle said that there was a panel-wide consensus for migration of funding from Foundations to Long Pulse activities. The latter consists of stellarators and long-pulse tokamaks (domestic and international), plasma-material interactions (ReNeW thrusts 9-12), fusion materials, blanket science, and fusion power conceptual design. These are the five elements in Long Pulse. The Panel evaluated the milestone to be at CD-1 for FNSF in 2025. He observed that the fusion program is light years away from that, so we need a substantial investment. Based on community input, the Panel assigned subpanel leaders to come up with a budget profile to meet this Vision 2025 objective. He said that the Long Pulse subpanel iterated with the Foundations subpanel and went over the budgets line by line. That led to clarity on what needs to be decreased in Foundations.
- Dr. Koepke said that the Panel chose not to include what we would lose without a certain facility, because that would sound like whining. He observed that everybody in the Office of Science is limited in funding, as is also DOD etc. So the Panel chose to talk about what we would gain, not what we would lose.
- Dr. Rosner: The question is the history of FES. When FES was moved into SC, the justification was that it is not tech ready. But are you saying the FES program is now like the Office of Nuclear Energy?
- Dr. Synakowski responded that the FES program is appropriately situated in SC; that is the Administration view. The fusion program establishes the scientific basis (including the technology) for fusion, but getting into FNSF is another beast. He said that in ten years, we can make the case to be ready to take on the FNSF mission.
- Dr. Koepke mentioned that the FES technology subprogram's real name at FES is enabling technology which includes science and engineering.
- Dr. Zinkle said that for the ten-year period that the subcommittee was asked to look at, it is enabling science for the next step. The Long Pulse publications during the next ten years will be closer to PRLs [Physical Review Letters] than to papers in nuclear engineering journals.
- Dr. Koepke said that diagnostics in a nuclear environment is an important and needed research area.
- Dr. Keane noted that FESAC will need another teleconference to resolve the issues raised at this meeting.
- Dr. Synakowski reminded FESAC that the Federal Register requirements mean that it can be no earlier than October 10 and that FES is already seeking an exception for that date.

- Dr. Keane recommended that FESAC prepare to meet on October 10 via public phone call. He asked that the FESAC members send him their comments by 11 pm tonight. He asked that the FESAC members let him know if they want their comments to be unattributed.
- Dr. Bhattacharjee said it is important for him to have the budget numbers.
- Dr. Koepke said that the Panel feels it has delivered its report and thinks its job is done.
- Dr. Keane said that we might wordsmith the report or write a transmittal letter that urges Dr. Synakowski to address certain things in the FES plan.
- Dr. Cohen responded by saying no, we have to deal with the FESAC document; the FES plan is separate.
- Dr. Barish noted that FESAC is responsible for sending a report to SC-1. It will be considered by FES in developing its strategic plan.
- Dr. Koepke requested that if FESAC asks the Panel to do anything, it will comply, but please be very specific. Without further instructions, the Panel feels that it has fulfilled its duty.
- Dr. Keane agreed.
- Dr. Barish reminded the FESAC members to attend the ethics briefing tomorrow at 8:30 a.m. to receive guidance about how to handle the draft report between now and October 10. For example, groups of 11 FESAC members, or more, are not allowed to discuss this report.

Note: the FESAC recording secretary was not present at the ethics briefing.

Tuesday, September 23rd, 2014

8. Multidisciplinary Team Science from the Office of Biological and Environmental Research (Dr. Sharlene Weatherwax)

This presentation follows a new tradition at recent FESAC meetings that the meeting includes presentations outside the narrow scope of the charge to the FESAC committee (in this case, to receive, discuss, and possibly vote on the SP Panel report).

The major thrust of this talk was how Office of Biological and Environmental Research (BER) has changed the way it manages multidisciplinary team science over the past several years. Dr. Weatherwax noted that other agencies can drill down farther, but BER tries to integrate it all. BER research spans microns to kilometers to the entire Earth, and seconds to years to centuries. BER research and facilities are managed within and across two divisions: Biological Systems Science and Climate & Environmental Sciences. BER also manages three Bioenergy Research Centers (LBNL, Wisconsin & Michigan State, ORNL): single focus, multi-disciplinary, team-based transformational science. Each center has authority and responsibility to reallocate resources and personnel to meet their milestones.

QUESTIONS

- Dr. Rosner: How does the program collaborate with other agencies?
- Dr. Weatherwax said that BER does a lot of such collaboration. It has a three-agency modeling effort with NSF, NNSA, and BER.
- Dr. Rej admired how BER has refreshed and refocused itself on multidisciplinary topics. He asked, what does it take to make those cultural changes in the community and how did you deal with the appropriators?
- Dr. Weatherwax responded that some things we were directed to do, so we need to be prepared. She said that they asked themselves the questions: Where are the gaps? What are other agencies doing? So, they held lots of workshops and town hall meetings and had lots of communication with all the major stakeholders.
- Dr. Cohen raised two issues. First, ReadyTalk is going away (as sponsored by SC), so we will have to come up with our own solutions and figure out compatibility. Second, SC rolled out a new policy on making data available, but he is a bit skeptical about investing taxpayers' dollars in something that did not need fixing. He asked who will pay for the servers. He asked that someone please watch these two issues.
- Dr. Weatherwax responded by saying that she was shocked by the loss of ReadyTalk, but we will make a transition. She observed that there are many other tools [i.e. Internet-based applications

for remote meetings] out there. As for data management, she observed that this issue has been in the works for some time. BER started doing it a long time ago.

- Dr. Neilson said that FES has some experience with multi-lab projects to do science and build things. He was struck by the close interaction between the BER program managers and the researchers in the field. Some resist it, and some welcome it. He asked how large is your office.
- Dr. Weatherwax said that she has a budget of \$600M and a staff of 30. Her program managers are happy to get preprints of papers coming out.
- Dr. Foster asked how long the Bioenergy Centers have been around.
- Dr. Weatherwax responded that they were set up after a workshop. Initially they had a five-year lifetime. They were doing well, so we renewed them for another five years. This summer they had another workshop on what the challenges are. They have not yet decided what to do at this point.

9. US ITER Project Progress: Mr. Brad Nelson

A second Tuesday presentation was provided by Brad Nelson on the progress being made by the US ITER project. This talk was shortened from its originally scheduled 45 minutes because the ethics briefing that started at 8:30 a.m. ran longer than scheduled.

The main point of the talk was to convey to FESAC that the United States in particular and ITER in general are actually making progress fabricating components for ITER construction, many of them large, expensive, and high-tech. The talk consisted mostly of photographs of the fabrication facilities and the components themselves. For scale, he observed that the size of the tokamak itself is about the same as that of the Jefferson Memorial. The neutral beam is almost the same size.

The United States is responsible for delivering the water-based cooling system to ITER. He discussed a technical issue with this system, that being that as the water is irradiated with neutrons, the isotope nitrogen-16 is generated, which is highly radioactive and cooks the surrounding pipes.

QUESTIONS

- Dr. Foster asked: Will ITER recycle the water or scrub it?
- Mr. Nelson responded: Recycle the water.
- Dr. Foster asked whether ITER will capture the hydrogen from each shot or exhaust it.
- Mr. Nelson replied: It is captured in the cryopumps and then regenerated.

10. Committee of Visitors' Presentation (Dr. Amitava Bhattacharjee)

This 30-minute presentation, originally scheduled for 10:45 a.m., was cancelled due to the time overrun of the ethics briefing. It will be made available on the FESAC web site.

Dr. Bhattacharjee, the COV chair, told the FESAC members that if they have any issues with the COV membership or the issues, please let him know.

Dr. Keane reassumes chair.

11. Further Discussion of Strategic Planning Panel Report

- Dr. Keane said that Mrs. Shahida Afzal [DOE administrative assistant] is passing out an integrated summary of FESAC members' comments sent to him by email. The comments are anonymous. He asked that FESAC members send him any further comments by this Friday. He said that FESAC will vote on the revised report at the next meeting, on October 10th. FESAC members may have individual discussions with Panel members (Dr. Koepke will provide points of contact: Drs. Zinkle, Wootton, Knowlton, Rej, and Correll). FESAC members need to work on an individual basis until we meet as a Federal Advisory Committee. Information will be given to Dr. Barish, who will distribute it to the whole committee. He said that for the remainder of today, we will discuss the budget. Based on yesterday's discussion, this is what we need to focus on in order to understand the impacts and where they come from.
- Dr. Greenfield asked that FES check if he can cast an absentee ballot since he will be in France at the ITER STAC meeting.

Budget discussion

- Dr. Koepke showed the Zinkle presentation. He said the Panel used the white paper by Ray Fonck presented at the June open meeting of the Panel.
- Dr. Rej observed that if you really want to go to the fusion nuclear science mission, then certain strategic deliverables are needed. The money for it comes from either Foundations or DPS.
- Dr. Koepke noted that examples of possible major program additions in the second five-year term are the following: capability in fusion nuclear science, a stellarator, major upgrades to an existing facility, and a PMI facility (toroidal or linear).
- Dr. Bhattacharjee asked: How were you thinking of using a stellarator?
- Dr. Koepke replied that he would address that after discussing the budget.
- Dr. Koepke said the Panel was looking twenty years out to figure out what needed to be done by ten years out. The Panel looked at the Meade roadmap, the Tony Taylor white paper, and the long pulse-related ReNeW thrusts. The Panel also looked at the contribution of major facilities to PMI science and technology issues, and to materials degradation science and tech issues.
- A money slide was then displayed, providing a visual flow of materials research and facilities needed to accomplish that research in preparation for a FNSF (early DEMO).
- Dr. Neilson noted that this slide or a version of it was presented at one of the meetings. He asked where the estimates came from.
- Dr. Koepke: Dr. Rej will answer.
- Dr. Neilson reminded FESAC that he was a co-author on this white paper. It was intended to be a low-cost approach, not to get you all the way to readiness for FNSF or CD-1.

- Dr. Koepke replied that the Panel interpreted it that way.
- Dr. Rej said that one can construct a significant, yet realistic, work plan. The Panel got down to the \$1M level of resolution. He noted that the Panel learned that Fossil Energy has a research program in oxide steels, which could be leveraged.
- Dr. Bhattacharjee asked about a Conceptual Design Review.
- Dr. Rej responded by saying that is a diamond on the Meade plot. He said this is our assessment of what research is needed to make a decision on configuration, materials, etc.
- Dr. Keane questioned whether or not \$17.5M gets you to CD-1 in 2024.
- Dr. Rej replied that we do not promise CD-1, only to have enough information to make a design and confidently go forward with a project. CD-1 involves engineering decisions.
- Dr. Keane asked whether Dr. Rej is looking for about \$110M over 10 years.
- Dr. Rej replied affirmatively. He observed that shutting down a facility is tough, but we need the team associated with a shut-down facility to continue in the program. He said this is why the Panel report has a strong recommendation to increase international collaborations. Also, in the Panel report, freed-up operations money would go toward materials science research. That [termination of Alcator C-Mod program] is how the Panel found the funding for these new initiatives. He observed that the [C-Mod] researchers continue to do research, albeit on other facilities, domestic and international. The funding that is freed up will go toward long pulse research. He noted that otherwise there is no way to move the science toward preparing for a billion-dollar-class FNSF facility. That causes risk for DPS, but these were the only options the Panel could find.
- Dr. Koepke said that the Panel also used the time axis to find out how to make things happen. It needed to put a time stamp at certain decision points.
- Dr. Neilson said he appreciated this explanation. He stated that he doodled with some similar things, to familiarize himself with the budget numbers. He thinks the Panel followed a reasonable process. The Panel is doing budgeting, not bottoms-up estimating, like executives at a company doing strategic planning. The Panel did the right thing by not promising CD-1 since these estimates are in their infancy. Since the Panel report talks about moving money from Foundations to Long Pulse, he was hoping to see a pie chart for 2015 and 2025 to show what is being recommended as a shift in priorities.
- Dr. Koepke said that the Panel decided that that would be overly prescriptive, so it preferred to say it in words.
- Dr. Keane asked about the impact statements. For Scenario 4, he asked whether the Panel has the totals for the budget categories. He noted that the entire community must understand these impacts.

- Dr. Koepke replied that the Panel was charged to do a prioritization assessment, not impacts. If FESAC wants the Panel to do that, it can. The Panel focused on ranking priorities and fitting things into budgets. You [Dr. Keane] are talking about what is not there.
- Dr. Keane stated that we need to comment on impacts.
- Dr. Koepke asked the FESAC members whether or not they are asking the Panel to put the grayed-out material in the report. He wanted to know if this is an action item. He stated that he thinks that would be too much detail.
- Dr. Synakowski commented that whatever you recommend (tiers, what's in and out), if FES accepts these recommendations, it will need detailed budgeting—and this is what FES is paid to do. In the transmittal letter, FESAC might recommend a rigorous budgeting exercise to accompany acceptance of these recommendations.
- Dr. Bhattacharjee observed that the Panel started with Scenario 1, which is fairly favorable from a funding perspective. By the time the Panel got to Scenario 4, which is actually where FES starts from, it sounded like scenario 1 lite. It didn't sound too bad. So he is concerned that staffers will give us that scenario. He stated that the damage to the program is not reflected in the report. He noted that we should give Congress plenty of ammunition to do something good for us.
- Dr. Synakowski cautioned that we must be careful how you capture that. If the community comes across as unable to do something exciting for a quarter of a billion dollars, that is unhelpful.
- Dr. Koepke stated that the Panel started off with a non-status-quo vision. The Panel actually started with lowest scenario. Later, the Panel decided to use the highest scenario as the reference. There was a deliberate attempt to make each scenario be impactful, and there was an explicit intent to avoid complaining about the lowest scenario.
- Dr. Keane asked whether the Panel has a table that shows how the money changes among the three budget categories for the four scenarios.
- Dr. Koepke replied that we do, but the numbers have uncertainty. Putting numbers on this is flawed. But he observed that maybe we could do something without numbers.
- Dr. Keane said that this sort of table will be the first thing requested to show relative change with each scenario.
- Dr. Neilson agreed: the charge asked us to do numbers, because the scenarios were given in numbers.
- Dr. Koepke disagreed: the charge gave smooth curves, and the Panel was asked to rank priorities.
- Dr. Synakowski said the transmittal letter might comment on the FESAC non-role for detailed budgeting.
- Dr. Keane agreed: he said we should make it clear that this report is not a detailed budget. Nevertheless, to understand the recommendations, FESAC needs to look under the hood.

- Dr. Rapp said this was a very good exercise to show that the program needs to shift even under the most restrictive budget.
- Dr. Koepke reminded FESAC that the Panel was not asked to create a strategic plan, but to prioritize.
- Dr. Keane said he is not sure we should put it in the report, but that FESAC needs the budget numbers to make a strong decision.
- Dr. Cohen said that regarding pages 42-43 of the report (chapter 6), he is adamant that in describing the differences in the program under the different scenarios, the Panel chose to report its conclusions at an extremely high level. He agrees that these are estimates, but he believes it needs more words to specify what the programs would be at different budget levels. The Panel report is not detailed enough for him. He requested that the Panel report include more words, even though it should stop short of the numbers. He requested more exposition of the priorities.
- Dr. Koepke asked that FESAC take DPS as an example. He asked whether FESAC wants a table with scenarios on one axis, and Foundations, Long Pulse, and DPS on the other axis and would this be only for FESAC information? The Panel had a contentious discussion of whether to take funds from run weeks or from DPS for a given budget scenario.
- Dr. Rapp suggested that perhaps add an appendix to explain the methodology, or do a case study as an example.
- Dr. Greenfield noted that it would be useful for FESAC to see the numbers, but he is thinking of a Senate staffer reading the report. What would he like them to get out of it? He observed Dr. Rosner's report from last year said the fusion program could not live with the lowest scenario; consequently, that was disregarded by the staffers. He said that we should be clear in the report about the incremental value of Scenario 1 over 4.
- Dr. Keane said that one way to do this is with a table of what you get, and another table of what you don't get. FES gave us a one-pager that bins the current FES budget in the new structure.
- Dr. Bhattacharjee asked whether FESAC could have access to the documents used by the Panel.
- Dr. Koepke replied that the Panel would provide FESAC with any documents it requested. But the Panel did not want to put documents used by the Panel in the report. He stated that the Panel does want Dr. Keane to give the Panel explicit instructions.
- Dr. Barish stated that he would review the comments. The Panel will try to integrate them to make a good report into a great report.
- Dr. Barish reminded the committee that eleven members make a quorum for FESAC.
- Dr. Kim asked about whether or not proxy votes would be allowed in the October 10th vote.

Meeting adjourned at 12:07 p.m.

Appendix A

ROLL CALL

Committee/Voting Members Present:

Professor Mark Koepke, **Chair**
West Virginia University

Dr. Steven Zinkle, **Vice Chair**
University of Tennessee, Knoxville

Professor Amitava Bhattacharjee
Princeton Plasma Physics Laboratory and Princeton University

Dr. Bruce Cohen
Lawrence Livermore National Laboratory

Dr. Arati Dasgupta
Naval Research Laboratory

Professor John E. Foster
University of Michigan, Ann Arbor

Dr. Charles M. Greenfield
General Atomics

Dr. Richard J. Groebner
General Atomics

Professor Chris Hegna
University of Wisconsin, Madison

Dr. Valerie Izzo
University of California, San Diego

Dr. Chris Keane
Washington State University

Dr. Jin-Soo Kim
FAR-TECH, Inc.

Dr. George H. Neilson
Princeton Plasma Physics Laboratory

Dr. Gertrude Patello
Pacific Northwest National Laboratory

Dr. Juergen Rapp
Oak Ridge National Laboratory

Appendix A - continued

Dr. Don Rej
Los Alamos National Laboratory

Dr. Robert Rosner
University of Chicago

Dr. Linda E. Sugiyama
Massachusetts Institute of Technology

Professor Ellen G. Zweibel
University of Wisconsin, Madison

Liaisons/Ex-Officios Present:

Professor Fred Skiff
American Physical Society
Division of Plasma Physics
Professor of Physics
University of Iowa

Dr. Susana Reyes
American Nuclear Society
Fusion Energy Division
Lawrence Livermore National Laboratory

Liaisons/Ex-Officios Absent:

Dr. John W. Steadman
Institute of Electrical and Electronics Engineers
Dean of Engineering
University of South Alabama

DOE Attendees:

Dr. Dehmer, SC
Dr. Brown, SC
Dr. Laviolette, SC
Mr. Lehman, SC/Contractor
Ms. Satsangi, DOE/FE

DOE/FES Attendees:

Dr. Synakowski
Mrs. Afzal
Dr. Barish
Dr. Bolton
Dr. Finnegan
Dr. Glowienka
Dr. Mandrekas
Mr. May
Mr. Nardella
Dr. Pappano
Dr. Podder

Appendix A - continued

Mr. Stevens
Dr. Van Dam
Mr. Vanek