Minutes of the Meeting of the Fusion Energy Sciences Advisory Committee

January 13-14, 2016
Bethesda Marriott Hotel and Conference Center
North Bethesda, MD

Wednesday, January 13, 2016
8:30 a.m.

Committee Members Present
Mark Koepke (Chair) – West Virginia University
Troy Carter – University of California, Los Angeles
Robert Cauble – Lawrence Livermore National Laboratory
Arati Dasgupta – Naval Research Laboratory
John Foster – University of Michigan
Charles Greenfield – General Atomics
Richard Groebner – General Atomics
Chris Hegna – University of Wisconsin, Madison
Valerie Izzo – University of California, San Diego
Jin-Soo Kim – FAR-TECH, Inc.
Stephen Knowlton – Auburn University
Kristina Lynch – Dartmouth College
George Neilson – Princeton Plasma Physics Laboratory
Gertude Patello – Pacific Northwest National Laboratory
Juergen Rapp – Oak Ridge National Laboratory
Donald Rej – Los Alamos National Laboratory
Linda Sugiyama – Massachusetts Institute of Technology
Brian Wirth – Oak Ridge National Laboratory, University of Tennessee

Committee Members Absent
Amitava Bhattacharjee – Princeton Plasma Physics Laboratory
Ellen Zweibel – University of Wisconsin, Madison

Ex-Officio Members Present
David Meyerhofer – Los Alamos National Laboratory
Susana Reyes – Lawrence Livermore National Laboratory

Ex-Officio Member Absent
John Verboncoeur – Michigan State University

Others Present:

Designated Federal Officer Present: Dr. Ed Synakowski

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

Welcome and opening remarks – M. Koepke

- Two out of 20 regular FESAC members are absent – (Bhattacharjee, Zweibel); One of the three ex-officio members is absent (John Verboncoeur)
- Read names of attendees– roll call (list of attendees attached)
- Change in membership – June 2015 – rotation of four members – welcomed new members: Cauble, Knowlton, Lynch, and Wirth

Dr. Bernard Bigot: Current Status and Future Plans for ITER

- Dr. Bernard Bigot – was introduced – appointed March 2015 – presented current status and future plans for ITER "Moving forward at full speed"
- I was in Washington, DC in December. The ITER Project continues to move ahead at full speed.
- JIA was signed in Paris in 2006. It was ratified by all members in 2007. Had delays, and now we try to recover.
- The ITER site platform is in the Provence forest. You see the tokamak pit. Also the 270-m long poloidal field coil building—too large to be transferred from other countries. New cryostat building for equipment from India.
- We are moving along with the largest ever multi-national scientific collaboration, to demonstrate the feasibility of fusion energy.
- We are facing external scrutiny of the ITER project for escalating costs. The ITER Council is taking this seriously and making changes. One was new governance—I was approached to become the new Director General. I explained that it was not my personal plan, but I could not resign myself to see this large project in a bad situation. So I accepted, with the provision that there be an action plan and a pledge of support from the ITER Members.
- The action plan included several elements: (1) Reorganize and integrate the ITER Central Team with the 7 Domestic Agencies. (2) Finalize and stabilize the ITER critical component design. (3) Conduct a comprehensive bottoms-up review of all activities, systems, structure, and components to build ITER. (4) Develop an optimized reliable resource-loaded schedule. (5) Develop a nuclear project culture.
- ITER project costs about $1M each day. So we need a strong decision process. The DG is now in charge to make these decisions. A new Executive Project Board meets every other week and makes decisions, allocates resources from a new Reserve Fund, and empowers project teams.
- I arrived on March 5. The suppliers appreciate that we have frozen the design, so they can move ahead with fabrication. Before I came, the ITER staff members were working in silos, not working together.
- Also, no one trusted the schedule, so we had to develop a reliable schedule, resource-loaded. There are three critical items: the tokamak building (which will

take 45 months from July 2015—could not be accelerated, being a nuclear building); the vacuum vessel (deliveries from 2018 to 2022); and the assembly.

- The November meeting of the Council was pivotal. The plan is to establish the new baseline by mid-2016. Also, we will complete organizational changes (we completed hiring the senior management team = GS Lee and Tada; we are integrating operations across departments and DAs; and we created a project team for the vacuum vessel and one for buildings). The VV Project Team is led by a Korean who worked on KSTAR. The Building Project Team is led by someone from EU Fusion for Energy.
- Assembly will involve >1 million parts, >150,000 sequenced activities, and 1200 suppliers.
- Do we have the staffing and financial resources to keep ITER on the right course?
- I will not give you the date proposed for first plasma, since it is still under consideration by the ITER Council, who asked that they be allowed to approve it first.
- There is a new organization chart. Only one decision center = DG and two DDGs. Each DDG is in charge of several departments. Coordination with the DAs occurs through the IO Executive Project Board. The Project Teams report directly to the EPB.
- Progress on buildings on site. The green shaded shapes are buildings under construction (e.g., the cryogenics building; this will be the largest cryo plant in the world; to be completed in 2017). We are also starting the Control Room.
- 30 m diameter, 30 m high, 4000 tons = cryostat container. 18 toroidal field coils, from six partners. Lots of coordination is required.
- 60-m high Assembly Building. The 730-ton roof was lifted into place by computer control within 24 hours, with only one centimeter tolerance on each side.
- The six pieces of the bottom of the cryostat are being received from India.
- We are very pleased in 2015 to have the first plant components installed. The transformers for the steady-state electrical network were provided by the U.S.
- Much work is being done in the various Member countries prior to delivery.
- The remote handling of the divertor cassettes has been demonstrated in Finland.
- Two of the nine vacuum vessel sectors are being manufactured in Korea, with a tight accuracy, to a millimeter.
- Manufacturing of the central solenoid magnet is underway in the US at General Atomics.
- Delivery of components is underway. The U.S. transformers were the first to arrive. A special convoy is used from the Marseille harbor to the ITER site.
- 200 km of superconductors have been manufactured (compared to the usual world production of 15 km). Six Members set up manufacturing sites; the eight year campaign to produce the superconductors is almost finished.
- I discovered that the choice of the VVPSS for cooling down steam is very important. Hence we decided to have 45-m long, 9-m high tanks for this purpose. It was put on level five of the tokamak complex. I thought that made no sense to put it 50 m off the ground. We revisited it, and I asked the engineers to work together in an integrated manner, to optimize the function. The tank will contain

1,200 cubic meters of water, which will clean 900 g of tritium. The engineers have now proposed to remove this tank on the ceiling, and instead use some existing tanks in the basement. These will be even safer. Why did they initially decide to put it on the fifth level? I learned that contractors wanted more money to locate the tank, but the IO did not have the money. The new scheme will actually save money. This is an example of the benefit of integrated work.

- In-vessel coils have been a pending issue for several years. The best we have decided on is the option of conventional water-cooled coils. Last year we had a review committee, which advised that these coils are needed. We have to rush, because we have to decide whether to approve the design by June 2016. Currently, the IO is carrying out feasibility studies for complex 3D shaping of the in-vessel coils. Also, we have demonstrated proper welding.
- Decisions at the ITER Council meeting (IC-17) in November: (1) Approval of a two-year schedule for 2016-2017. I discovered many nonconformity reports had not been closed for over a year; we are now working to finish those. (2) IOCT-DA mutual commitment to 29 milestones. The Council will monitor progress on these milestones. (3) Reallocation of existing funds in order to meet the schedule. This includes recruiting 148 additional staff through the end of 2017. (4) Commission an independent review of the proposed schedule, budget, and staffing plan. We will use this review to validate or amend the Best Technically Achievable Schedule, and establish a new consolidated ITER baseline by the next Council meeting (June 2016).
- There has been significant progress since I arrived. There is a picture of a lightning flash over the ITER site = the "first plasma"! Conclusion: ITER is truly moving forward.

Q & A: Bigot

Q: J.S. Kim: If you find a better solution along the way that you perhaps should have done something differently, is there a way to conduct modifications or upgrades?
A: Bigot: We have a process for this, as long as it does not affect the schedule or cost. A domestic agency might be reluctant to make late changes, but now with the EPB, we first examine at the technical level (Procurement Change Report = PCR); then if beneficial, it comes to the EPB and the DG makes a decision whether to do it, who will be in charge, and whether to use the Reserve Fund. If less than $10M, I can make an immediate decision; if above, I inform the ITER Council. This is exactly what happened with the VVPSS. The EU, U.S., and others were involved, and there was no way for them to take initiative for finding an optimal solution—until now. But we cannot have schedule impact, because we are so far behind already, and the Members want to achieve First Plasma ASAP.
Q: S. Reyes: There has been impressive progress over the past months. I worked at the IO for five years. My friends there tell me about the new optimism at the IO. When I was there, I saw the lack of a nuclear culture. Few people had background from the nuclear industry. Has this changed?
A: Bigot: I myself have a deep background in nuclear. Safety is the highest priority. At ITER, I am deeply involved. I set up a Safety Management Line. Every week, I

want report about the development of a nuclear safety culture. I insisted that the NCR (non-conformity reports) be closed; 95% have now been taken care of. Twice a year, I meet directly with the nuclear regulators. The most recent meeting was January 5; the regulators expressed their observation of great progress. We need safety and quality for the hardware components.
Q: D. Rej: Congratulations on significant achievements, such as implementation of the Madia report in terms of closing NCRs, safety, and schedule. From first plasma to DT, what is the current level of specification for the resource-loaded schedule? Will the current review board look at that?
A: Bigot: My expectation is that the independent review board will do a comprehensive review. If we delay Phase 2 assembly (internal wall, diagnostics, tritium recycling, etc.) until first plasma, it will affect the schedule for DT. First Plasma is not enough for doing research; it is just checking the machine. I announced an ITER Scientist Network recently—an organization of scientists in labs and universities, who will already begin to think about DT operation on ITER and beginning with step-wise experiments. Commissioning of this large facility will take time. Quality and availability are very important to me.
Q: H. Neilson: Burning plasma achievement is extremely important for the fusion program and this community. Years ago, FESAC wrote a report saying that we need a burning plasma now. We finally decided ITER is the way to go. There is no Plan B; ITER is it. So I find your talk reassuring—industrial culture, safety, quality. Reassuring. I believe the US community will support you. About the schedule, I have some experience with simpler projects. No one is enough of a genius to lay out a reliable schedule for more than two years in advance. I wonder about that. A two-year schedule is achievable but how can a reliable schedule beyond that be produced?
A: Bigot: I agree that a large project is not easy to manage. There are only two big critical issues on the schedule at present: Building, Vacuum Vessel. Neither could be compressed. So we need to do proper risk management and monitor very carefully. Both building and VV are basic technologies—but you need to set up a proper organization. We could use three shifts. We have to demonstrate a proper organization, proper staffing, and a proper culture. At CEA, I was happy to see that the LMJ Project kept on schedule, over more than a decade. Just before I left CEA, LMJ starting taking shots. If we have the best people, we can do it. Previously, the DG had no right to speak with the suppliers. Part of my action plan was that I be allowed, with the relevant DA, to speak with the suppliers. I went to Korea and met the CEO of a supplier industry: I told him if he fails, he will be held responsible by the seven Domestic Agencies; the next day, he told his staff to be committed.
Q: G. Patello: Indeed, a very complex project. Concerning quality control, you have nuclear grade quality. How are you keeping the members and suppliers on the same page for what that means?
A: Bigot: I am lucky in that the delay of the project has allowed a learning period. Most of our quality requests are international standards (or French nuclear standards). Before I came, there was way too much back and forth between IOCT, DAs, and the suppliers. Now I insist that they all work together more effectively. No more than 2-3 back and forth discussions! We monitor that. We are succeeding. This

saves money, difficulties, and time. They have to report to me regularly. We correct things quickly. The vacuum vessel shape, for example, has to be accurate to within millimeters.
Q: G. Patello: Are your project controls using earned value project management?
A: Bigot: I started setting it up immediately when I arrived at ITER. It is absolutely central. Previously, people did not know the actual cost of each piece. Each activity now is precisely included in the schedule.
Q: J. Foster: What is the status of the gyrotrons and neutral beam injectors?
A: Bigot: NB injectors are being constructed at a new facility in Padua. Great progress. NB specifications are not yet entirely matched to specification, but things are moving forward. Yes, there was a fight between the EU and Italy about this; we said, stop the fight, because you are on the critical path; if you cannot deliver according to schedule, there will be a big problem with the nuclear safety authority, since the NB specifications and schedule are incorporated directly in connection with the VV specifications and schedule. For gyrotrons, there has been good progress to achieve specifications in the EU and Japan. These also are key components.
Q: R. Groebner: I have a question about the physics basis. A large effort on the physics basis has been invested into ITER, although there are still questions being asked, and we get requests to examine certain issues. What are the big physics questions remaining?
A: Bigot: ELM control is one. This is why I asked David Campbell to set up an ITER Scientist Network to provide a coordinated joint program, working with ITPA. I sent a letter in early January proposing this. Despite our best effort, physicists will not be using ITER for a number of years. So we have to prepare the younger scientists to be ready.

Dr. Cherry Murray, Director – Office of Science

- New Director of the Office of Science – confirmed December 2015 after nomination – introduced by M. Koepke.
- Dr. Murray remarks – She commends this community which is undergoing a culture change – fusion is becoming larger and larger and must be international, must have priorities. It is easier to sell to OMB and Congress if the scientific fusion community comes together and prioritizes. Commends Bigot for coming to talk with us. Coming together and prioritizing works very well for HEP. NP also has come together and prioritized in its good report. FES has the workshops. We need your priorities! I am glad to be here. My door is open…

Ed Synakowski: FES Program Overview and Update

- Thanks to Director General Bigot for your energy to make this visit and present a picture of the complexity—assembly, organization. Exciting talk. Thank you for taking the time to be here. Thanking Bigot – to explain complexities of ITER – and conveying the direction of ITER. He welcomed Dr. Murray, welcomed new FESAC members, and a change in ex-officio members. He acknowledged the outgoing FESAC members.

- He knew Dr. Murray at LLNL. There my boss reported to you, and it is the same now. Pat Dehmer in an acting capacity has done a wonderful job. There was collective relief when you occupied your current position.
- Where we are and who we are. Aspects of program – FES research is carried out in 53 universities, 12 businesses, and 10 national laboratories. The largest facilities are NSTX , DIII-D, and LCLS. We are striving to make NSTX-U and DIII-D attractive destinations for university scientists and students to work at these flagship facilities.
- It took a year to get the new budget structure approved at all levels of government. The largest organizing principle is burning plasma science.
- Burning Plasma Science – Focusing on domestic capabilities; major facilities and university facilities in partnership, targeting key scientific issues. Theory and computation focus on questions central to understanding the burning plasma state.
- There is a great deal of student activity in the Discovery Plasma Science part of the program.
- The pace at which NSTX-U has been commissioned and has obtained research results is very fast. NSTX-U is the world's highest-performance spherical torus.
- The highest-fidelity look at electron turbulent transport to date is has come from high-performance computing. Sometimes you just need the cycles to do such simulations in a reasonable time.
- There were delightfully convenient work hours in San Diego while operating EAST in China with a skeleton crew. It will take a large tool box to do international collaboration; such a remote control room is one such tool. And even in the absence of remote plasma control capability, the capability of streaming plasma data can be very useful for our participating scientists.
- Long time-exposure image of electron beam scan of flux surfaces in W7-X. The island structures observed in image are precisely the intended ones, so the machine is evidently meeting the high-tolerance design requirements.
- High-performance computing power is enabling material science simulations.
- FESAC undertook strategic planning activities in 2014. Our intention was to distill from that, as well as from other studies and community reports over recent years, a number of themes in a 10-year perspective. This document has been delivered to Congress. It is part of an ongoing process, which also includes the workshops held last year. Most of FESAC has probably seen the report; however, officially it belongs to Congress, so we cannot circulate it yet. But you probably know where to get it.
- The thrust of massively parallel computing for fusion allows us to benefit from a priority of the present Administration, in exascale computing. The materials science thrust aligns with DOE-wide acknowledgment of the importance of materials research.
- Congress wrote a tough charge, which challenged the FESAC 2014 Strategic Planning subcommittee. When FES analyzes additions and subtractions within budget exercises, we do not find headroom to initiate a new facility.
- It was fun to write the Strategic Plan's section about progress in fusion energy sciences.

- As important as the Strategic Plan is, its creation provided a pivot point to launch the community engagement workshops. I understand that they were hugely successful. They were ably led. (The Transients report is completed and currently with the technical editor.)
- What next? Pat Dehmer told us that the BES Research Needs Workshops began to pull the program along in directing the Office of Basic Energy Sciences. We anticipate doing more workshops. FES and SC are constantly asked to do hypothetical exercises for certain budget levels, or create new entities in the program or find new ways of doing business. I can tell you that the information from the workshops has already improved our dialogue within the Office of Science. We are much better prepared to deliver to SC a high-quality product, and make reference to these workshops.
- I have been at many ITER Council meetings and now I serve on the EPB. The nature of the dialogue at the most recent Council meeting was significantly enhanced, with time spent drilling down to details of problems and with honest challenging of positions—all done in a well-informed way. It was transformational compared to the past. We want the DG to lift the project off the PowerPoint slides to a real enterprise.
- You can imagine why we use a slide showing where the U.S. ITER in-kind hardware is being fabricated. Many states are contributing.
- Drain tanks may not be exciting, but their construction is demanding.
- Congress was generous compared to the President's request for the FY16 budget. We are now looking, with the congressional constraints, at where the upticks should go. The scientific themes described in the strategic plan and the workshop reports will be used to direct the use of these funds.
- The language with respect to ITER was all too interesting. No cash contribution—this will present problems for the new schedule. If there is a favorable outcome with the mandated report to Congress on May 2, we might find a way to pay the cash contribution. Congress is trying to force a more explicit statement about future (out-years remaining) engagement with ITER.
- The Office of Science is trying to respond positively to the COV recommendations. The COV had 15 members and was chaired by Prof. A. Bhattacharjee (PPPL and Princeton).
- Every hallway at Germantown looks the same—but with our new program managers, we have energy and vibrancy in the FES wing.
- U.S. scientists know how to frame and drive home important problems, as evidenced by the international prizes they have garnered.
- Community leadership changes at PPPL – AJ Stewart Smith – retires as PPPL VP (Feb 2016), A. Cohen, former Deputy Director for Operations, now DOE Deputy Under Secretary for Science and Energy
- Community leadership changes at General Atomics – Dave Hill – new Director of DIII-D National Fusion Program
- Community leadership changes at MIT – Dennis Whyte – new Director of the Plasma Science Fusion Center
- Community leadership changes at LANL – David Meyerhofer – new head of the Physics Division at LANL

- Changes at Physics of Plasma Journal – R. Davidson retired as editor after 25 years, and Mike Maul replaces him as the new editor
- FES personnel changes: Program Manager: Steve Eckstrand retired in December 2014. New program managers: Daniel Clark – fusion materials, Josh King – NSTX-U. Short term: Bob Bartolo – AAAS fellow, Eric Edlund - borrowed from PPPL. Summer interns: Cynthia Li – Columbia, Darius Stanton – Duke
- Recent job postings: GPS/HEDLP Program Manager, MFE Program Manager
- AWARDS:

  Recent Nuclear Fusion Journal Prizes
  2015 – R. Goldston- PPPL
  2014 – P. Snyder – GA, continues tradition of success:
  2013 – D. Whyte – MIT
  2010 - John Rice MIT
  2009 – Steve Sabbagh – Columbia
  2008 – Todd Evans - GA
  2006 – Tim Luce - GA

  Hannes Alfven Prize for European Physical Society – Nathaniel Fisch - PPPL

  E.O. Lawrence Award – Prof. Brian Wirth – University of Tennessee

  Early Career Awards
  O. Schmitz - Wisconsin
  C. Parish – ORNL
  M. Mangolini – UC Riverside
  L. Aparicio-Delgado – PPPL

  DOE Leadership changes:
  Deputy Secretary – E. Sherwood-Randal (began October 2014)
  Under Secretary for Science and Energy – F. Orr (began December 2014)
  Deputy Under Secretary for Science and Energy – A. Cohen (began Nov 2015)
  New presidential nominee – Director of the Office of Science – C. Murray

Q&A: E. Synakowski
Q: Concerning facilities: No new facility for the next ten years creates a problem. Note that ReNeW, the FESAC Facilities report, and the FESAC 2014 Strategic Planning Panel have all documented the need for a new facility. We had an opportunity to propose something, at least get it to shovel readiness. The picture for a new facility does not look accommodating now, but we always need to be prepared.
A: A narrow point and a broader point: The narrow point has to do with the constraints even with the most generous budget scenario that the FESAC 2014 Strategic Planning Panel addressed. Our judgment in SC was that a new facility would compromise our ability to move out in the high priority thrust areas. I thoroughly understand what it means to have a new facility with enhanced capabilities—I saw this recently with W7-X in Germany when I visited. In terms of

being ready, yes, but I urge that we think less about facility types and instead think about what we need to do to map onto our strategic imperatives (e.g., for PMI, for transients). Let's talk about facilities in a way that is overtly conscious of our strategic emphases. That will help us make the case on the Hill.
Q: D. Rej: Let me follow up on what is next after the workshops. I appreciate the point about their pull. Is there a timeline, a plan for taking action?
A: There are no rigorous timelines for taking action, but we will not dawdle. I will look forward to hearing your discussion today about the workshops.
Q: D. Rej: Ultimately, we need to turn a catalog into an inventory. Trades will be involved.
A: Yes, it is a complicated multivariable calculus, meaning that one factor depends on other factors. But now we are in a place where mutual roles and responsibilities are reaching a common understanding. We don't yet have a clear understanding of what additional workshops to launch; our eyes and ears are open. But, already the workshops have benefited our internal discussion in the Administration in surprising ways.
Q: C. Hegna: I was heartened by your comments about stellarators addressing transients. We were specifically told not to consider stellarators in the Transients Workshop. It fell through the cracks. How can this be remedied? The second question: Regarding movement in the community to continue the strategic planning process, like other communities (HEPAP, P5), is there thought to replicate that in the FES community?
A: Pat Dehmer made a good point that no one size fits all because communities are different. Given the makeup of our community, with facilities at given institutions, we are in a more challenging landscape compared to what HEP was, if you want to aim at a document like P5. It is due to institutional interests. Also, P5 was about projects, whereas we were asked to look at programs overall. I take to heart Pat's advice to pay attention to the workshop exercises. We should take FES workshops to a level beyond the BES-workshop model. Concerning stellarators, given the constraints of the workshop exercise, it made sense not to have them on the table. Yes, it is related to transients, but our urgent aim is to understand physics processes of transients and control of transients in tokamaks. Stellarators avoid them altogether. So, I support the choice in the strategic planning document, which is to take on the challenge of using 3D fields to control transients. Personally, I think there is a lot of fantastic physics in optimized stellarators. I share your enthusiasm for W7-X. Worthy of conversation is to consider whether the topic of stellarators is worthy of a workshop.
Q: C. Greenfield: As a leader of the Transients Workshop, I asked early on whether stellarators should be included. I was told that the Transients Workshop should specifically be for transients in tokamaks, and stellarators might be covered in a future workshop. Stellarators were not swept under the carpet. I have some concerns about additional workshops. You picked four areas in 2015, which show focus. But, if you have four every year, it indicates to the outside world that we cannot focus. Also, these workshops are very expensive. Eighty people spent a lot of time working on the Transients Workshop report instead of doing research.

A: The likely path if we do future workshops is to do a deeper dive and more targeted workshops.
Q: R. Groebner: I am heartened that the accomplishments from the workshops will bear fruit. So going forward, what will be done? If more workshops occur, let the rank and file know and understand why more workshops would be done, to get buy-in. It is interesting to hear that conducting workshops helps us take advantage of a priority in SC, but we can't talk about that, so knowing the tangible benefits would be appreciated.
A: One tangible benefit is that FES and the community are working together.
Q: M. Koepke: There is no facility during the ten years in the Strategic Planning report. What about a workshop on fusion nuclear science? Fusion Nuclear Science is an obvious theme from the FESAC 2014 report that was left out of the list of 2015 community-led workshops.
A: We backpedaled on a facility, due to the high visibility of ITER. But the high value of the science is clearly emphasized.
Q: M. Koepke: So what about an FNSP/FNSF workshop?
A: In the spirit of what Chuck said, it might be more useful now to dig deeper on the existing workshop topics.
Q: M. Koepke: I was heartened that whole device modeling was front and center in the plan. The FESAC 2014 subcommittee discussed the cost of doing this right. What about developing the culture and the assessing the priority for whole device modeling?
A: When we do assessment in the office in concert with the community (e.g. the FSP study), it is in the range of a prioritized program within congressional guidance. But there is a lot of headroom. There is talking about V&V, and there is real V&V. We are proud of our science in our field, but the class of work on V&V and UQ is much richer than what we are doing.
Q: T. Carter: Early Career awards you said are a good way to help the community. The cultural difference in our community is that the center of gravity has shifted to the national labs, whereas in HEP, the center of gravity is at universities. University leadership in Discovery is clear, but most opportunities for faculty in BP Science are in support roles (data analysis, etc.). EC awards are great, but creating an MFE faculty position in the first place is tough. Those opportunities are unclear to university deans. University programs need a boost. How can we offer university researchers and faculty opportunities for leadership?
A: We are talking with Joe Rudnick, a dean at UCLA. I had a great conversation with him. He seemed wide open to a transformed fusion enterprise. He wants to find a way to make such an enterprise work at a university. I have experienced the same thing at other universities—openness to work with us.
Q: A. Dasgupta: There were many white papers at the workshops. Is there any idea to use them for solicitations?
A: No. On the contrary, SC has cautioned us not to link solicitations directly to the workshops, because that could compromise a free-thinking workshop.
Q: A. Dasgupta: The white papers told you what people are excited about and would like to work on.
A: Yes, and that information informs our thinking.

Q: L. Sugiyama: The high cost of participating in a workshop has been mentioned. If you will use workshops to do additional planning, there is a hidden bias against younger scientists (who have less money, and who need to do more research), and smaller university groups (who are more resource constrained). Such limited participation might reduce innovation at workshops.
Q: S. Reyes: There is a fusion nuclear science study (Fusion Energy Systems Study, led by C. Kessel) already going on in the FES community. So an additional workshop is not necessarily needed. It would be nice if FES recognized this small effort as part of the FES program's strategic vision and included its reports as an element of the strategic plan moving forward. A small group of people have self-organized for this study.
A: Ed: This reminds me that the FESAC 2014 Strategic Planning report recommended a partnership with BES for linking a harness onto SNS. We had already been working on this. But the landscape of BES is that they have to develop deep confidence in their neutron sources. But we did have very collegial discussions with them about possible future partnership on SNS. But we need to be respectful of BES's own process before they are comfortable to let us in the door.
Q: M. Koepke: Would Susana Reyes send him and Sam Barish some information about the FESS study.
Q: H. Neilson: Members of the stellarator community have taken the initiative to organize a workshop: February 16-17 this year at MIT. The partnership with FES is very important, so even though the community is organizing this workshop, we hope FES will attend.
Q: J. Rapp: The workshops were to build a coherent program and a direction forward. What would be the purpose of additional workshops: details, or implementation? What would be the timeline for implementation?
A: This is an ongoing process. Even writing our own version of the strategic vision was difficult, so I am not looking forward to writing another one anytime soon. Now the workshops are serving this purpose.
Q: J. Rapp: Additional workshops might be spinoffs?
A: That is my inclination. Whether they would lead to implementation of new programs is not their objective. They identify opportunities and ways of addressing them. We don't want to link to solicitations. We want to get a better sense, also through FESAC comments later today, about where are the attractors and then orbit around them.
M. Koepke: Workshops will probably inform the 2020 Decadal Study exercise. That will help unfold the workshops into further detail.

Paul Bonoli and Lois Curfman McInnes: Report about Workshop on Integrated Simulations for Magnetic Fusion Energy Sciences

- Charge – review recent progress and identify gaps and challenges in fusion theory and computation
- Re-access opportunities and adjust or broaden them appropriately
- Approach for workshop and report
  Whitepapers
  Teleconferences

Writing workshops

- Workshop report finalized July-September 2015
- Tokamak offers unique opportunities and challenges for integrated simulations
- Whole device modeling incorporated into the work within a series of 7 panels
- Interactions involved workshop access between physics panels and math and scientific panels
- Emerging extreme scale computing resources
- Exascale computing
- DOE computing facility upgrade 2016-2018
- Sustainable collaborations – fusion, math, computer science
- Integrated simulation in fusion energy sciences has benefitted historically from ASCR partnerships
- HPC advances have enabled simulations of global MHD phenomena to be extended to higher temperatures, longer times, larger device sizes, and multiple events
- Vision for integrated extreme-scale simulations
- Integrated science applications
  1.Disruption physics – prevention, avoidance, and mitigation
  2.Disruption physics – challenges and opportunities
  3.Disruption physics – priority research directions
  4.Each panel looked at crossing cutting math / CS issues for disruption physics
  5.Boundary physics panel – pedestal scape off layer, and plasma boundary
  6. Whole device modeling: priority research directions
  7. New opportunities identified for Whole Device Modeling
  8. Computational and enabling technologies in integrated fusion simulations
- Scientific discovery is driven by exploitation of data
- Data management, analysis and assimilation: priority research directions improve support for MFE centric workflows
- Software integration and performance

Workshop conclusions

- The role of integrated simulations in magnetic fusion energy sciences has been assessed, focusing on identifying gaps and challenges.
- The role of computational and enabling technologies was considered in cross-cutting areas.
- strategies and path forward were articulated for each of these areas
- Opportunities abound for interdisciplinary FES/ASCR collaborations to fully leverage emerging extreme-scale computing resources for fundamental advances in integrated fusion simulations.
- All strategies call for strong and broad-based support for model verification and validation.
- Research will be needed on innovative workflows, data structures, and algorithms to support efficient, concurrent execution of any related moderate-concurrency simulations running for long periods of time.
- A crucial element for realization of the goals of this workshop will be stable and predictable access to high performance computing resources and workflows.

Q&A: P. Bonoli and L. Curfman McInnes
Q: J. Rapp: You say that your ambition is whole device modeling, but you said modeling ends at the surface.
A: That was only for that one graphic I was showing.
Q: J. Rapp: I meant also modeling beyond the surface (outside, e.g., fuel cycle etc.).
A: There were 2-3 white papers that suggested doing that for the Beyond Interpretative part, but not at the level of a priority thrust.
Q: D. Rej: The ASCR-FES relationship is best of class (except maybe for climate modeling) in the Office of Science. The FES Exascale Requirements workshop with ASCR is the week after next. Are people from the Integrated Modeling workshop part of that? Will Integrated Modeling workshop people make the FES Exascale Requirements workshop job easy?
A: Yes, many people from our workshop will participate. We will use the workshop report to define FES exascale needs.
A: E. Synakowski: We have a very easy working relationship with ASCR. A few weeks ago, I gave a talk to ASCAC. There were very strong resonances, very constructive interactions about how computing has transformed our research.
Q: L. Sugiyama: This is a really nice report that summarizes where we are and brings together new ideas. An unfair question is: If we could carry out everything in this report, will we be able to predict energy confinement in a tokamak?
A: The priority research directions reach very high. If achieved, we will be much, much closer to that kind of predictive capability. It is very ambitious.
Our sustained partnership with ASCR will allow us to move forward on these priority research directions.
Q: L. Sugiyama: Yes, but do we need to add new areas, new ideas, beyond what is in the report? (a rhetorical question)
A: Lois and I are happy that what the report recommends is doable. It will allow us to make advances.
Q: J.S. Kim: So many activities. Just information gathering?
A: Bonoli: Soon the SciDAC portfolios will be coming up for renewal. We hope that the Integrated Modeling workshop report will be useful guidance for both FES and ASCR.
Q: JS Kim: Strong leadership, as with ITER now, will help in coordination and planning for what the report recommends. We need short term and longer term goals - not just everyone getting small funding to keep going forever.
A: If a leader wants to figure out where to go next, many parts of the portfolio are ready for integrated modeling simulation, but others are not yet. That is one message from this report.

ANNOUNCEMENTS
If you would like to make a public comment – please contact Sam Barish

Charles Greenfield: Workshop on Plasma Transients

- Our marching orders were to focus on transients in tokamaks. No reflection on stellarators.
- The other workshops are more forward looking. Our workshop is focused on the now.
- We are disappointed that our Transients report is so long. It is due to the fact that it turned out to be a concatenation of two workshops, one on ELMs and one on disruptions.
- There were 38 presentations and 68 white papers at the community input event, and 65 attendees at the workshop.
- The report is being edited by John Greenwald (technical editor at PPPL).
- Each section has a short introductory section.
- There were 26 members on the Disruption panel, and 30 members on the ELM panel. Several persons participated on both panels.
- We need a large factor of ELM mitigation to prevent surface melting (30-50X, although some say the number is larger). And reactors beyond ITER require either complete ELM suppression or development of divertors that are impervious to natural or mitigated ELMs.
- We think that ITER has the right ELM control tools, but research is still needed on how to use them most effectively.
- We recommend a national task force on ELM control and avoidance, with a funded national initiative.
- We also recommend a national theory/simulation initiative on ELM control and avoidance. We believe that the ELM coils will work, but based on extrapolation from present experience, we need better physics understanding.
- We recommend accelerating ELM research through work on diagnostics and actuators.
- We recommend opportunities for major facility upgrades and new facilities to advance ELM control. A naturally ELM-free regime, the I-mode, occurs most accessibly at high magnetic field.
- We expect multiple ELMs, whereas one disruption can ruin your day.
- ITER is looking to the U.S. for success in mitigating disruptions, because the U.S. is quite advanced. The U.S. is a world leader in stability studies.
- We recommend a national initiative on elimination of disruptions in tokamaks.
- In the passively stable regimes, high beta seems to be the most disruption-free regime, so this might be a direction to pursue.
- We currently have disruption mitigation schemes that are fairly effective for the thermal quench. Better methods are needed for runaway electrons. It is now too late to implement alternative mitigation schemes to ITER, but not for post-ITER devices.
- The U.S. is recognized as strong, but we still need to collaborate with international partners, who have complementary capabilities (size, long pulse, materials).
- The U.S. program will make critical and unique contributions to the worldwide fusion program in the coming years

- Substantial resources are required to meet the challenge of controlling transients in time for operations of ITER and to develop design solutions for next step reactors
- The U.S. fusion program is positioned to provide these solutions by building on a strong foundation of outstanding facilities, world leading theory, and complementary fusion technology

Q&A: C. Greenfield

Q: J.S. Kim: Last APS, a scientist from DIII-D showed control of runaways on that machine, but when extrapolated to ITER, he indicated that there is a problem. It is urgent for the US to search for a runaway electron solution. The sooner the better, so as to have a chance to succeed. This morning, Dr. Bigot said there is still an opportunity to affect the design, as long as it is cost neutral. We have to be open to new solutions.

Q: R. Groebner: For both ELMs and disruptions, you recommended a coordinated national program. How would that be done?

A: We did not discuss the mechanics. I would envision it as a national team, with multiple devices at their disposal to do research. Also involve theory/simulation.

Q: H. Neilson: This issue is very important. But the resources and people you need to attack this problem already exist. The answer to your recommendations is: Go do it. Maybe just shift priorities a little bit, e.g., in DIII-D and NSTX programs and the theory/simulation program.

A: You answered your own question. The workshops were carried out to give input to FES to set priorities. We are not allowed to do that.

Q: H. Neilson: That is not what Dr. Murray said. She said that we should set priorities.

A: FES now has to decide what to do with the input from the workshops. If it is a zero sum game, more emphasis on disruptions means less on something else.

Q: H. Neilson: I think that it is our job. It would be a cop-out to say that priority setting is FES's job. We can approach the office and recommend priorities, and then they will decide. We in the community are best positioned with resources and authority to change priorities.

Q: J. Rapp: ITER operation is 15 years down the road. Is this urgent?

A: You sat next to me at the STAC meetings, so you know whatever I know. We could help fine tuning with the design, for example, with the currents in the ELM coils. That is fairly urgent.

Q: D. Rej: What is the technological readiness of Shattered Pellet Injection, whether it will scale to ITER?

A: My understanding is that it will. Again, it has only been tested on one machine. JET would like to try it. My personal view is that it is absolutely essential for another (non-JET) tokamak, with different (non-JET) parameters, to try it. One data point (JET) is not enough to be comfortable extrapolating to ITER.

Rajesh Maingi: Workshop on Plasma-Materials Interactions

- PMI community workshop summary – process and broad leadership team, priority research directions, overlap in existing domestic PMI, extend the research in certain areas, cross cutting research opportunities.
- Goal – evaluation of leading scientific challenges and options in the area of plasma materials interactions (10 year outlook)
- The ReNeW community activity was used as a starting point.
- The process was modeled after basic research needs workshops used in Basic Energy Sciences. Call for white papers – 77 submissions. Face to face workshop at PPPL – 55 talks. Community feedback webinar June 2015, final report submitted 8/21/15
- The priority research directions (PRD) are fairly separable. Then the cross-cutting research opportunities go across the PRDs. We did not prioritize.
- Note the color map of the multi-institutional team for the five subpanels. The ReNeW thrusts were used to form the subpanels.
- Linear devices have good access and parameters, but lack the toroidal plasma physics. We need both linear devices and toroidal devices to study plasma-facing components.
- There is overlap among the PRDs, so the crosscutting group came up with four crosscutting opportunities.
- We want to integrate the boundary plasma research and plasma materials R&D.
- We recommend holding a national workshop on liquid surfaces.
- We recommend initiating a community-wide working group on a Divertor Test Tokamak, to assess model extrapolation issues and evaluate the European DTT proposals.

Q&A: R. Maingi

Q: S. Knowlton: On the DTT concept, would it have reactor-relevant collisionality? If not, would it have a strong mission?
A: The Working Group would help define the mission of a DTT and its overall parameter range. If you target in a certain way, you could limit the collisionality. We are advocating not for a specific proposal, but for what we would get from it.
Q: C. Hegna: Where are we on hot walls?
A: Some parts of the report talk about this, but we did not discuss it in depth. NSTX-U has limited such capability (up to 350 degrees, well below 500-600 degrees where want to look). EAST considered the possibility of hot wall experiments, but I am not sure how far that has gone. We might have to do hot wall experiments in divertor simulators at first.
Q: J. Foster: What about the neutron flux and getting the spectrum correct?
A: Regarding the spectrum, connecting accelerator results to fusion will always require extrapolation.
Q: M. Koepke: You mentioned MAGNUM-PSI. In the FESAC 2014 panel, we distinguished multi-physics devices from single-physics devices.
A: Certain things cannot quite be done with MAGNUM-PSI, such as the ability to get high enough heat fluxes with incidence angles that are relevant. It can provide 10

MW per square meter, but not the incidence. We want a DTT with a variable tiltable target.
Q: R. Groebner: I did not see much about requirements for modeling. The existing codes probably need work to model wall interactions.
A: We talked about it, but not in depth. Also, we had discussions with the organizers of the Transients and Integrated Simulation workshops, and we knew they were looking at this.
Q: J. Rapp: The gap in the value of PB/R from today's devices to a reactor is what motivated your recommendation for a DTT working group.
A: The panel noted one option for a DTT with q_parallel extended.
D. Rej: As a follow up to Dr. Foster's question about the Spallation Neutron Source, it is correct that the neutron spectrum is quite different. Hence, if we could, we would use the Gas Dynamic Trap. Recall the Chuck Kessel nuclear science report. We need a model that can then be validated.

Fred Skiff: Workshop(s) on Plasma Science Frontiers

- FES seeks to engage the community of scientific experts working in the field of plasma science in a series of community-led workshops to identify: compelling scientific challenges at the frontiers of plasma physics, and research tools and capabilities that exist presently, and general requirements necessary to address the challenges in the next decade
- Process for this:
  1.Recruiting of subpanels
  2. Organized the submitted white papers
  3. Town hall meeting in Bethesda, MD
  4. Synthesis of input distributed across five subpanels
  5. First workshop – what is the frontier?
  6. Second workshop – what will "making progress" require?
     Panel 1: -plasma atomic physics and interface with chemistry and biology
     Panel 2: turbulence and transport
     Panel 3: interactions of plasmas and waves
     Panel 4: plasma statistical mechanics
     Panel 5: plasma self-organization

Q&A: F. Skiff

Q: M. Koepke: Will the report express a sense that all community components of Discovery Plasma Science can contribute to Plasma Science Frontiers' overarching questions, listed in the workshop call and in the Plasma 2010 report? Was this unifying approach built into the morphology of the process and the report ?
A: Skiff: To first order, everything kept its integrity. We did shift some things. Plasma Physics is not just a bunch of applications, although there are many interesting applications. The order in the final report has changed, so low temperature plasma science is not first. We put the core things first.
Q: M. Koepke: What did you learn from this? The Plasma 2010 report talked about breadth—and vulnerability—of basic plasma physics. Did you find something that you did not expect?

A: Skiff: All of us were very impressed with the quality of work being done, as presented at the town hall meetings. Plasma physics does not get the respect it deserves. There is an amazing range of physics, and amazing impact. I am concerned about the presence of plasma physics in universities. That hurts us. People are divided among physics and engineering departments. We are underrepresented in the National Academy.
Wurtele: We saw much commonality among the problems people are addressing, across the large range of general plasma science. I agree that the field is extremely healthy. People are doing interesting work and making progress. Underfunded, but there is much intellectual vitality.
Q: M. Koepke: I was hoping that part of the outcome would be a way to go forward. You mentioned that diagnostics might be a crosscutting activity. You mentioned intermediate-scale facilities. What were some ideas for intermediate facilities that rose to the top?
A: We are still debating some of the details. Some problems are best addressed with table top experiments, whereas for others you need a larger facility to study phenomena of interest. More experiments nowadays are in the intermediate space. Our goal was to describe the good physics. We are not giving advice to DOE; we are presenting opportunities.
Q: M. Koepke: Your second workshop was about platforms. What did you conclude?
A: We did not have an exhaustive list of facilities. Impossible job! Unmanageable. So our job is to outline the plasma parameters needed to move the frontier forward.
Q: D. Meyerhofer: In looking at III.6 (Transport), you missed radiation transport. That needs to be included.
A: Yes, that was an oversight. Not in my slides.
Q: D. Meyerhofer: Also, opacities of materials under extreme conditions.
A: Yes, good point. It is in the text and in white papers, but I did not highlight it in these slides.
Q: J. Foster: For low temperature plasma, some expensive diagnostics that cannot be afforded by single principal investigators are needed. Perhaps such a facility should be a user facility at a national lab.
A: Skiff: Yes, laser diagnostics are expensive for single investigator groups. Siting a well diagnosed user facility at a national lab would be one option.
Q: D. Rej: I am always overwhelmed by the wealth of science in Discovery Plasma. The non-fusion-applications FESAC report describes unbounded applications. Remember the Sarff report about priority facilities. Intermediate facilities for HEDLP were added. Did your committee think about international collaborations? I know FES has made overtures to NASA and other agencies. What about ELI? A good strategy is to lever by collaborating and cooperating just like the MFE crowd has been doing for decades. LAPD is a great example of a cooperative facility.
A: That makes sense.
Q: B. Cauble: I run one of those intermediate-scale facilities. It is completely open. I have been talking to both NNSA and FES about user access. But there is not a lot of interest. If the report will be platform non-specific, will you emphasize the availability of U.S. facilities?
A: Not in the report.

Q: B. Cauble: LAPD is rare. Without a massive movement, such places will be rare. Using international facilities (high intensity laser facilities in the EU and Asia that are being built) is being done. LCLS-II will be a user facility. But easy-access intermediate facilities are rare. Trident is almost there.
M. Koepke: The upcoming NRC Plasma Survey might get into that advocacy if the Plasma Science Frontiers workshop does not.
C. Greenfield: In the U.S. we have some large facilities focused on fusion, but could be operated for some of their time for general plasma science. The advantage is that they are very well diagnosed.
Q: B. Cauble: They are also the most expensive facilities. Dr. Synakowski talked about moving toward a user facility mode for both DIII-D and NSTX.
A: These opportunities exist. At the APS/DPP Meeting, we hear about general plasma science experiments done on MFE facilities.
A: I asked whether our report should make a list of facilities, but the desire not to do it was overwhelming, and we were advised not to. But the question of utilizing existing hardware is a good one.
Q: M. Koepke: Identifying platforms to facilitate the science was, I thought, part of your workshop's charge.
A: Not beyond discussing intermediate scale facilities and needed parameter regimes.
C. Greenfield: Neither DIII-D nor NSTX are being used to their full potential, so it might be worth noting this in the report.

PANEL DISCUSSION OF WORKSHOP REPORTS:
Q: J. Foster: Concerning transients, what is JET doing with disruptions and ELMs?
A: C. Greenfield: JET is focused on getting to DT in the near future. But they hope to stretch that timeline out. They have some capabilities at low density for ELM coils and want to add more capabilities. Also, they wish to implement a shattered pellet injection (SPI) system, which ORNL is preparing. At present, they are only using error-correction coils to deal with ELMs. They do run massive gas injection routinely for disruption protection. SPI on JET would be a critical need for the world fusion program. JET is important for transients research, but they could broaden.
Q: D. Rej: For Chuck and Rajesh. Looks like a very ambitious agenda, especially to implement on U.S. machines. Is there enough bandwidth on those facilities? Would PMI and Transients completely consume these facilities?
A: C. Greenfield: This year, we have 15 weeks. Reasons: Budgetary and also the time commitment for upgrades. Even if increased by a factor of two, we would still have a backlog at DIII-D. Yes, Transients would eat away at this, so we need balance. Anyway, we did answer the question of what research could be done—some of which is urgently needed for ITER.
Q: R. Maingi: I agree with Chuck. We are limited to some extent by the ability to analyze and validate the data, which means each facility cannot run all the time. If you make game-changing changes to the machine (e.g., convert NSTX-U to having a liquid divertor or a liquid wall), then the issue becomes one of needing to redevelop the operating scenarios.

A: C. Greenfield: DIII-D has a long term plan to eventually do divertor modifications. The plan also includes changing operating scenarios to match the changed divertors. We need to look at a bigger picture than only what is in these four workshops.
Q: J. Rapp: The PMI topic is interdisciplinary, and there is overlap with PSI and plasma processing. Could these two communities come closer together, especially for diagnostics and surface analysis? This looks like an opportunity.
A: F. Skiff: We did not receive much input (white papers) from the tokamak edge community, but I can see there are connections. Questions that people are wrestling with are not exactly identical. But it is worth looking at. We were limited by the input we received.
Q: J.S. Kim: The success of shattered pellets on DIII-D does not imply it will work on ITER. The information here is somewhat misleading. The community should be aware of this. We are delivering something to ITER, so we need to do our homework. I encourage us to evaluate what we have learned and what we still need to learn for disruption mitigation and how things really extrapolate to ITER.
A: C. Greenfield: I respectfully disagree.
Q: Brian Wirth: Keep in context the plasma density and the rate of particle flux. Rate effects have large effects on changing the dynamics. We need to document those densities and rates to understand extrapolations to the future.
Q: R. Groebner: Concerning integrated simulation, did you discuss how the community could advance whole device modeling and simulation out to the wall? This is a bigger issue than a few separate groups. To develop a larger code and to validate it, we need a group of experts.
A: P. Bonoli: One workshop conclusion is that the best way to proceed forward is for FES and ASCR to fund efforts that involve physicists, applied mathematicians, and computer scientists right from the outset. The proto-FSP projects were a step in that direction, and they were relatively successful. That is how we should proceed. Especially if exascale platforms are coming down the road, we need to develop this expertise.
Q: L. McInnes: We have to be careful not to start a project and then it ends.
A: P. Bonoli: The process of validating codes is incredibly complicated and resource intensive. People underestimate it. FES recognizes this. It must be a significant component.
Q: R. Groebner: Experimentalists should be encouraged to get involved early, so you have the data needed.
A: P. Bonoli: People in the Uncertainty Quantification community do not view our validation as very rigorous.
Q: A. Dasgupta: Where will you go from here for the Plasma Science Frontiers workshop? I was on the ReNeW panel, I read the white papers, and I listened to the presentations. There is a need for basic plasma physics and code development—but I did not see much of that in your slides today. David Meyerhofer also mentioned missing important applications.
A: F. Skiff: I did not present an exhaustive description.
Q: M. Koepke: It would be useful to add in the Discovery report some comments about the 2010 Decadal Study recommendations and the ReNeW thrusts.

A: F. Skiff: Our scope and charge were broader. We make reference to them as the starting point.
Q: M. Koepke: But, you should include comments about each one.
A: F. Skiff: I could have put together slides about that, since we started from that.
Q: M. Koepke: The NRC Decadal report had very specific recommendations on which updating the status would be worthwhile. If you could comment on them, it would be useful to reinforce them, update them, and shed light on them.
A: F. Skiff: That is essentially what we are doing.
Q: H. Neilson: All the reports today were excellent, and the workshops were fine. I was wondering what we would hear from FES as a response. We have our answer, which is that by identifying these topics for the workshops and the priorities in the strategic plan, we will not see a one-to-one correspondence with funding directions, but over time we may discern a correlation. We should not be disappointed by that. Beyond that, your reports are out there. The community has some discretion in setting priorities, especially with the facilities. FES is asking us to consider these reports and what we propose to do and allocate our resources. Are you satisfied with the response you have gotten?
Q: R. Maingi: What you said is interesting. My discussion with Richard Buttery at APS was about the community congealing around the idea of the scientific pull of the workshops. My talk with Dr. Buttery was the idea that we should not look at these workshops for the sole purpose of garnering new resources, but reorient what we are already doing. Large facilities already have resources. Dr. Buttery suggested trying to answer priority questions with only modest new resources. Put the big scientific issues out there. Ask the community to answer them. For me, a big issue is detachment physics. There is a Joint Research Target in FY 2017 that is focused on the scrape off layer. That is an opportunity to use what we found in terms of gaps, to focus what we will do, and move in that direction. We should use existing resources for the JRT to answer that question, and that will be an accomplishment for the workshop. We put something out there that the community can move toward the answers.
A: C. Greenfield: The FES reaction did not surprise me or upset me. FES said they will use this information to set priorities in coming years; that has not changed. A week before the APS/DPP meeting, we spent a day at FES and went through much detail and got a positive response. We did not expect a promise to divide up the FES budget among the topics of the four workshops! We need a more balanced program. FES chose to highlight these areas with workshops, but they do not cover the whole program. The workshops were in response to the FESAC 2014 report. They asked us to do this because it is important. For Transients, we can distinguish between what absolutely has to happen and what would be nice. The former is to ensure that ITER will work. This is the most important thing for the U.S. fusion program. Much of the world effort on transients is coming out of the U.S. The community is not stupid, so we are already doing much of this work. I am not surprised or upset by the FES response.
A: P. Bonoli: I agree. I went into this without the expectation that these would be given to Congress. John Mandrekas made it clear that these would be resource documents. Feedback from John and Randall Laviolette always made us feel like we

were useful. The U.S. simulation program is at a crossroads. Base SciDAC projects are coming to the end of their lifetime. We did proto FSPs. So now we have a chance to look at the problem again, and I think we accomplished the revisiting that was needed.
L. McInnes: The depth of interactions has excited the participants in the ASCR community. We have a rich set of opportunities.
F. Skiff: FES has the goal of stewarding plasma science. I am enthusiastic because of the FES attention to this. It may lead to an additional conference or two on the foundations of plasma physics. There has been a very positive and helpful interaction with FES. FES told us that they needed to know what Plasma Science Frontiers in the new budget framework would consist of.
H. Neilson: There is unanimous assessment of this. You might want to have FESAC comment on this positively to FES, even though we don't have a charge here.
M. Koepke: Thank you on behalf of FESAC. There was a lot of work done. This may be conveyed in some form or some fashion by FESAC to FES.

Adjourn at 5:15 p.m.

Thursday, January 14, 2016
8:30 a.m.

M. Koepke

- I would like to follow up on Hutch Neilson's suggestion to have community workshops. He explained that he thinks all were good, and he was struck by the unanimity of the workshop chairs that they were satisfied with the FES response to what the workshops had done.
- I will ask Dr. Neilson to draft a short statement and circulate it during the meeting, and we will do a quick poll.

Under Secretary Orr is running a little late – about 10 minutes. We will start today with J. Menard. (Dr. Menard then made a presentation on NSTX-U for about 10-15 minutes. Then Dr. Orr arrived.)

J. Van Dam, FES Research Division Director

- Jim Van Dam introduced the Under Secretary for Science and Energy – Dr. Franklin Orr.

Under Secretary – Dr. Franklin Orr

- Cherry Murray, Director of the Office of Science, just joined us. The confirmation process for her was more efficient. We are glad she is on board with DOE. She will be a great advocate for science programs. There is no shortage of things to work on. Pat Dehmer is also probably glad she is with the DOE team in the Office of Science. SC is widely recognized as one of the best offices in the DOE energy program. My job is to work with all of the programs to build a fully-stocked portfolio of research that goes through basic science to convert energy sources into energy services. There is no hard boundary between science and

applications. Last March, I mentioned three things: energy and climate challenge, the budget request, and the standing in the fusion energy sciences world. A lot has happened since then:

- On the energy and climate front, I went to Paris with Secretary Moniz. The fact that 190 countries have reported on nationally-determined goals to reduce greenhouse gas emissions is a great achievement. There is plenty to do – but starting with the declaration of the goals before the meeting and finishing with an agreement that provides a pathway forward is a great achievement, which was a global effort.
- I talked with FESAC last March. Then, I talked about the energy and climate challenge, the budget situation, and the FES program. Much has happened in the intervening months, so I will revisit these items.
- Not only is the climate issue urgent, but it also emphasizes that science and technology are key to addressing greenhouse gas emission. So, there was a parallel announcement at the beginning of the Paris conference that highlighted mission innovation: energy security, energy commercialization opportunities, and a special focus on developing countries. Each country will try to double its budget for clean energy R&D over the next five years (20% per year straight average or 15% compounded annually). This works out to $10B/year. This is significant, although not overwhelmingly large compared to the magnitude of the problem. There is no question that we can deploy the kind of research funding to address these goals. This investment is necessary but not sufficient. This is not about a shortage of energy resources, but about how we transform them.
- This mission innovation from the countries was matched by a private sector effort, led by Bill Gates. It involves 28 private sector capital investors in 10 countries, who are committed to clean energy investment to move it to the marketplace. These investors are willing to be patient and take some risks. These are sophisticated investors. Secretary Moniz spent a lot of time persuading other countries to join in and then help facilitate it. He has had global impact. We have to convince OMB and Congress to do this, so there is more work to be done. Over the next five years, we are talking about an additional investment of $1B/year. It will be focused on early stage R&D for breakthroughs, in addition to the work we are already doing.
- I don't want to talk about Congress. Let me talk about funding. We have experienced volatility, but this year we came out better than we might have hoped at the beginning of the budget process. SC got a 5% increase. In these days, that is a significant change. In the DOE appropriations, and also in other Federal science agency appropriations, there appears to be a renewed appreciation for the importance of science and technology. Science has been the anchor of our security and prosperity since World War II. We need all the players we can get on the field. We need to work hard to sustain our place. FES fared well in the Omnibus bill, at least in the domestic part. It got a small increase over FY15. But there are warning signs as well. The ITER Project received a clear message from Congress, which limited the budget to $115M (to cover our in-kind hardware contribution), deleted cash, and required a

recommendation from the Secretary by May 2, 2016 whether to stay in ITER and how much it will cost. We are taking this requirement and the Congressional concerns very seriously. We have been pressing the ITER Organization to work on management reforms and develop a reliable, credible cost and baseline schedule. We acknowledge the job that Dr. Bigot has done. We have seen a real change in how the project is operating; we applaud the progress; we also acknowledge that more needs to be done.

- The new schedule will be reviewed by an independent panel. The U.S. has put forward four project management experts to serve on this panel. The schedule is very tight, but we must stay on it. The panel will provide its report (or at least a draft) by April, so that its results can be incorporated in the Secretary's response in May. Also, we are planning for a ministerial meeting in Europe, with this review report in hand. We are committed to find a path forward for ITER. We believe that Director General Bigot will correct management issues from the past, and we will work with him. I met with him the evening before; he offered to do whatever we need. DOE is an important player, but not the only one. There is an interagency working group also involved with the ITER conversation (DOE, OMB, the State Department, etc…).
- Fusion holds significant promise. It has made very good progress. Our energy portfolio needs to be fully stocked overall. We are busily electrifying the planet. Electricity has high value because it is so flexible for applications. So, we need to make electricity and convey it with a reliable system. We are firmly committed to investing in fusion energy. We appreciate the role of FESAC in fulfilling this investment.
- I would like to convey a word of thanks about the workshops last year. They were very productive exercises to develop a research agenda and strengthen communications across the community. Such activities have been very useful to us in the past. We should think about the larger goal; help us make a compelling case for research going forward. I served a long stint on BESAC (a training assignment, apparently), and it was hugely educational. I appreciate the role of advisory committees to help make a case for our research programs.

Q&A: F. Orr

Q: D. Rej : Thanks for your unwavering commitment to energy and the country – and for the ITER bandwidth. I agree with Dr. Bigot with respect to reforms he has accomplished. We heard of 150,000 tasks. We have an outstanding team that will be part of the upcoming review. But what happens on May 2 if things happen to U.S. participation in ITER that are beyond our community's control? Burning plasma is not until 2030. My question is what does Congress expect? The Madia report was very consequential; there have been reforms; there is still much to be done.

A: Our job in the May 2 report is to be as thoughtful and transparent as we can be to convey the situation. In the past, we did not have a cost and schedule at earlier stages that were credible that we could manage to. The earliest days of ITER didn't have the project management and scope to deliver the project on time and within budget, to have our pieces in place and determine if the schedule is credible, that

implies a decision about the longer term. The report will hopefully let us lay it all out. I am not sure what will happen.
Q. M. Koepke: FESAC worked on a non-fusion-energy applications charge, and before that a strategic planning charge, both from Congress. Part of the motivation for these is that the price of gasoline is low. Fusioneers want to see it happen in their lifetime. But congressional justification emphasis for FES is shifting to applications and spinoffs. In your pitch, do you see yourself bringing up non-fusion applications more? Or is fusion itself enough to get the message across?
A: This is hard to answer – they are not mutually exclusive. Part of what we do is argue that to justify long term research, fundamental understanding of materials in extreme environments is key to progress in many areas. Fusion has such extreme environments. To perform the research to make fusion work will lead to many applications elsewhere. Hence, it is useful to make all the parts of that pitch, including the portfolio aspect that we need to work across a range of primary resources and timelines. Fundamental science and math advances have had applications years later. Who would have guessed at the time? We need to help our supporters and government individuals understand that the fabric of research underpins every aspect of the future. And I like the materials aspect. The world has started to catch on that nano-structures, in combination with better catalysts, could lead to designs based on fundamental understanding, which opens up a huge opportunity space in the future.
Q: H. Neilson: The issues that arise while dealing with ITER construction sometimes come across as if ITER is a big headache. The response to Congress should include the importance of ITER for fusion energy and fusion science while stressing that we have no plan B to get this science accomplished. On another level, ITER needs to be a success for the future of international collaboration in science. I hope that DOE is able to convey this.
A: We will try to make the case that ITER is not the only thing we do – the domestic fusion program is very important, and they are both part of the balance we are trying to draw.

Jon Menard: Motivation, Status, and Plans for NSTX-U

- The NSTX-U Team has 402 team members, and 290 scientists of which 70% are non-PPPL. Fifty-five Institutions, including 22 U.S. universities, are involved.
- NSTX-U represents the unique parameter regime of high normalized pressure combined with low collisionality.
- There are two new major tools for NSTX-U: (1) a new central magnet: to get higher temperature and lower collisionality at high beta, and (2) a tangential second neutral beam: to get full non-inductive current drive by doubling the heating power and tripling the current drive.
- The central magnet stack is constructed from four separately-built quadrants.
- The second beam came from the TFTR campaign, so it had to be decontaminated.
- We are now routinely making 0.8-1.0 sec plasma with 0.6 MA at 0.6 T.
- As of yesterday, we made our first sustained diverted plasmas and accessed the first H-modes with 2.5 MW NBI. Coming up is two more weeks of shot development and then our research campaign will begin.

- The five highest research priorities are electron thermal energy transport, fast particle physics, and three other topics, as follows.
- A primary motivation for NSTX-U is the favorable trend of energy confinement with reduced collisionality in STs: inversely proportional so far. Also, STs do not see degradation with beta, contrary to the ITER confinement scaling. We will find out in the next 2-3 years whether STs behave differently from tokamaks. Simulations show that electromagnetic effects may play an important role in this collisionality scaling in STs.
- Another research priority takes advantage of NSTX as an excellent testbed for alpha particle physics. Can we find TAE-quiescent, high-performance regimes in NSTX? We may be able to turn these modes off completely, at least at low field. ITER has to worry about TAE avalanches: uncontrolled alpha particle loss, resulting in damage to the reactor first wall. We have been developing a quasi-linear critical gradient model to simulate these avalanches.
- Of course, we do want to support ITER and other tokamaks and STs with studies of halo current dynamics and disruption mitigation physics, and this is a research priority. ITER-like massive gas injection valves are being installed right now to test the poloidal dependence of density assimilation.
- The NSTX program is a leader in understanding kinetic effects in MHD stability, and this will continue in the NSTX-U program.
- NSTX-U will also explore PMI issues. Tokamaks focus the heat exhaust to the divertor area, which has dedicated materials that can withstand the large heat flux. Experiments have so far found that the heat exhaust width scales inversely as the poloidal field; however, NSTX-U may break this scaling.
- NSTX-U will have 4-8 times higher peak heat fluxes than NSTX. NSTX-U will also have additional divertor coils to control the flux at the lower part of the machine.
- NSTX-U has several tools to control particles and achieve long pulse scenarios: (1) boronization, (2) a lithium evaporator, and (3) a Li granule injector for ELM pacing, which was successfully tested on EAST and DIII-D.
- The plan is to transition from an all-carbon wall to an assessment of compatibility with a high-Z wall and flowing liquid metal plasma-facing components. The major facility enhancement we are proposing is a cryo-pump. Carbon is not the wall material for future fusion reactors, but high Z also has issues, so our proposal is high Z covered with liquid lithium.
- We have carried out design studies to show that the ST is a potentially attractive FNSF or Pilot Plant (a device designed to demonstrate net energy production).
- NSTX achieved 70% transformer-less current drive. Full steady state operation is required for FNSF or a Pilot Plant. TRANSP calculations indicate that NSTX-U may achieve 100% such operation.
- With no transformer, a steady-state fusion reactor will have to generate current somehow. Ideas are coaxial helicity injection (U. of Washington), or helicity injection gun (U. of Wisconsin). Dr. Ebrahimi has simulated the current sheet reconnection (and plasmoids) associated with CHI.
- We plan to run for 18 weeks in FY16, since the FY16 budget is favorable. During the outage planned for July 2016, we will install high-*k* diagnostics and high Z tiles.

- The summary is that NSTX-U will make fundamental and world-leading contributions to toroidal fusion science.

Q&A: J. Menard
Q: R. Groebner: What would a lithium divertor look like?
A: Mike Jaworski's idea is shown on this slide. We are proposing a prefilled target with a wick to bring lithium up to the surface and see how it erodes. Evaporation may influence the pressure balance in the scrape off layer. We will look at the vapor shielding regime, with a prefilled target.
Q: R. Groebner: Will you also study where the stuff migrates to?
A: Yes, we will look at migration. It will be challenging since we will have mixed materials for a while.

Dr. David Hill: Update on the DIII-D National Fusion Program Research Directions
- Thanks for the opportunity to share with you what we are doing on DIII-D and what we plan to do in the future. The vision for the DIII-D program is based on three guiding principles: research with an energy goal, scientific excellence, and a world-class facility for the U.S.
- Key DIII-D program goals can motivate a vibrant and expanding U.S. fusion program with an energy goal.
- The most important DIII-D program goal is to ensure the success of ITER.
- Comprehensive diagnostics provide a strong foundation to advance understanding through integrated simulation.
- An integrated international team with diverse capabilities is the key strength of the program.
- The DIII-D high-level research objectives are well aligned with the restructured DOE FES program.
- The DIII-D program research objectives are well aligned with recent community workshop initiatives.
- The planned heating and current drive upgrades can advance to reactor-like conditions.
- DIII-D is discovering physics underlying ELM suppression to move beyond demonstration experiments.
- To meet the disruption challenge, DIII-D will resolve the physics for safe quenching of tokamak plasmas.
- DIII-D research will develop a multi-layered approach to achieve robust reliable operation.
- A steady-state burning plasma requires both high plasma pressure and self-driven plasma current.
- Profile flexibility will enable DIII-D to study the key physics at high bN for reactor solutions.
- Helicon implementation is progressing well and is on track for key tests as a transformational current drive source.
- Advanced divertors minimize and simplify the volume needed for reliable dissipation of plasma losses.

- Developing a power-handling solution requires comprehensive understanding of detachment physics.
- Advancing physics understanding requires improved diagnostics and a systematic variation of the configuration.
- DIII-D provides a unique capability to validate PMI in a reactor-relevant tokamak environment.
- Our planned upgrades will provide world-class capabilities and flexibility for addressing key scientific issues.

Q&A - D. Hill:
Q: B. Cauble: DIII-D has a strong user program. A point that was raised yesterday is that well-diagnosed facilities like DIII-D make excellent user facilities. Yesterday, someone mentioned that such facilities could be used for discovery plasma science in its spare time. Would you please comment on this?
A: The UFA workshop participants asked how can broader plasma physics benefit from these communities using DIII-D, and how does DIII-D engage them more? DIII-D has received the Torkil Jensen Award for topically- unconstrained ideas, so discovery plasma science research is possible on DIII-D. Performing this research on DIII-D takes run time and requires a decision process to select which experiments to perform with the run time.
Q: M. Koepke: Was DIII-D represented at the discovery plasma science workshop?
A: Yes.
Q: J. Foster: Please elaborate concerning the new helicon system.
A: The 490 MHz antenna is different from ICRH since deposition is governed by plasma conditions rather than aiming at the target. We need to figure out where the antenna will sit.
Q: J.S. Kim: Since DIII-D is at the privately-owned General Atomics site, are there more constraints than a user facility at a national lab?
A: Before GA, I worked at LLNL. Each, GA and LLNL, has strengths. GA does well in getting people on site. We provide offices for visitors. Probably the required advance notice for visitors, especially for foreign nationals, is less at GA than at a national lab. In general. DIII-D does well with getting people on site when needed, and providing offices for visitors. The advance notice is less than at national labs.

Dr. Steve Wukitch: International Collaboration on Development of Long-Pulse Heating and Current Drive Actuators and Operational Techniques Compatible with a High-Z Divertor and First Wall

- The collaboration has made substantial contributions to EAST in engineering, technical, and diagnostic areas. The physics research has been more challenging.
- The collaborative team is an integrated U.S. team which leverages collective expertise and experience to develop and collaboratively implement a high-Z divertor capable of steady-state heat flux exhaust.
- With the funding pass-back, we decided to focus most of our effort at EAST, with only a small effort at KSTAR.

- The ITER-like tungsten divertor was successfully implemented and achieved in August 2015. This was the first actively-cooled divertor structure in operation.
- The team set up the first disruption database at EAST.
- Amanda Hubbard and ASIPP colleagues identified potential I-mode discharges on EAST. Also, they are using the BOUT++ code to simulate I-modes.
- The EAST management and experimental capabilities are evolving. A major tokamak upgrade was completed in May 2014. The experimental schedule is difficult to monitor. An organization chart has finally been published. The process to propose experiments has been opaque; EAST is holding its
- first-ever Research Forum next week. A new EAST proposal management system has been recently launched, so we can track our proposals. Proposal execution has been complicated by operations; a machine operator can limit a session without prior notice. Getting permission from EAST for U.S. first-author publications has been difficult. The lack of a central repository has hindered data availability. There has been a very limited number of long-pulse discharges since the FES grant began. We thought the divertor would be high Z, but EAST has instead become heavily reliant on very-heavy lithium conditioning to get good plasma performance. A lesson learned is that EAST and mutual interest must be strongly aligned to be productive. At present, each researcher or group is working out his/her own relationship with EAST. Another complication is that international collaborators from other countries can compete directly with our task. The EU researchers seem to have a high-level worked-out agreement. Work-safety conditions at EAST are different from those in the U.S., so sending students there is tricky. Research on EAST is not yet at the frontier of opportunities. Living conditions are environmentally unhealthy, so it is hard to convince people to visit or relocate for extended periods.

Q&A: Wukitch

Q: B. Cauble: What does "bad" mean?

A: The air quality is always bad at EAST. Air quality can be so bad some days that you cannot see across the street. I grew up in Pittsburgh in the 1970s, but this is worse.

People have been put in place to increase collaborations, and leadership positions are being put into place.

Q: H. Neilson: The community appreciates your work on this. At end of the day, international collaborations are done with particular machines. We have to look at EAST collaborations with different expectations. EAST is interested in the training of their young staff and looks to collaborators to play a role with regards to education.

A: I didn't mean this to come across as really grim. Concerning training young students/staff, bringing staff gets EAST's attention and puts the U.S. in a much better position to get what the U.S. wants. The Chinese are very cordial negotiators, and we should be clear about what the U.S. wants to get out of it.

Q: L. Sugiyama: You expressed concern for communications at EAST.

A: The U.S. team on EAST has engineers and scientists who are fluent in Chinese. The challenges are getting the U.S. interests aligned with EAST. Collaborations in the EU

always want a single point of contact (e.g. JET), rather than multiple groups asking for information as in the case of EAST.

Dr. Paul Bonoli: International Collaboration on Control and Extension of ITER and Advanced Scenarios to Long Pulse in EAST and KSTAR

- This talk is given on behalf of David Humphrey (on the way to EAST now).
- This collaboration is grounded in a lot of scenario simulation and modeling. The diversity of subtasks in the structure of this project has mitigated the uncertainties in machine availability and/or performance.
- The five subtasks interact very closely.
- Challenges of machine availability have impacted the experimental collaborations. Some things are being done proactively to correct the situation. People from the neutral beam group at DIII-D visited EAST to help improve beam performance. Arnie Kellman also went there to help improve operations.
- The disruption database set up by Bob Granetz (with three two-week visits each year) was the first SQL database at EAST. They used the Gerhardt approach to develop disruption warnings.
- KSTAR could not do I-mode experiments due to the inability to handle position control.
- The University of Texas is providing the following diagnostics for EAST: charge exchange recombination spectroscopy, motional Stark effect, and electron cyclotron emission.
- KSTAR is worried that LH current drive will not work in its H modes due to the high density. They are looking at moving the wave launch to above the midplane.
- Tom Casper will lecture at EAST to train users of the CORSICA code.
- Remote collaboration is a significant part of this team's effort. The use of this remote capability has been a research activity itself.
- Among the lessons learned: our collaborative role has been beneficial to EAST and KSTAR. The effectiveness of collaborations depends strongly on planning and preparation for visits and remote experiments. Machine availability and performance have been challenges for experimental studies on both EAST and KSTAR. Development of methods and policies for multi-institution, international coordination of data ownership and publication responsibilities have been key. My solution was to initiate collaboration with a CEA scientist. Long term travel to China and Korea remains challenging; multiple two week visits (and no longer than two weeks) are optimal for most U.S. scientists. For publications, the one nut we cannot crack is to be the first author on our joint publications. Second or third author is acceptable, but not one of 30 authors, to get visibility in journals.

Q&A: Bonoli

Q: R. Groebner: There are impressive amounts of U.S. resources taken to EAST. Is there is a long term plan to take resources/benefits from EAST back to the U.S.?
A: As for my own niche, dimensionless parameters are relevant to ITER. The control algorithm material is helping us. Control is absolutely essential, so Dave Humphreys gets access. Remote collaboration is helpful, but you also have to be there in person to be really effective

M. Koepke: FESAC statement about the workshops

- There were nine votes for version 1 and three votes for version 2. Also, there were some votes for both. I suggest going with version 1. (There was no objection.) If there are no comments, we will accept version 1 and send it to Pat Dehmer. Cherry Murray will be copied on this.

Dr. Hutch Neilson: The U.S. Collaboration on W7-X

- All physics experiments look the same—all pumps and valves.
- There is a video on YouTube about the first plasma celebration. Chancellor Angela Merkel will visit W7-X soon.
- Divertor-related activity is important in the first few years.
- The U.S. is constructing several instrumented divertor plasma scrapers for risk mitigation to protect the poorly-cooled parts of the divertor plates. This is a prototype for testing. We will deliver these units later in the year.
- We are already getting Ti and Te radial profiles with the x-ray imaging crystal spectrometer.
- The following fluctuation diagnostics are in the pipeline: phase contrast imaging, gas puff imaging, and a heavy ion beam probe.
- LHD achieved its best performance with peaked density profiles. We cannot depend on a plasma pinch effect, so a pellet injector is useful.
- An important contribution from MIT is implementation of MDS-Plus (because the native W7-X system was not up to the job).
- W7-X has a "one team" philosophy, so the U.S. approach is to integrate into it.
- There are the following lessons learned on requirements: (1) Make contributions to essential capabilities, and be involved from Day One. DONE. (2) Provide sufficient research staffing to extract science from our hardware contributions. SOMETIMES DROPPED THE BALL. We need a dedicated core team to ensure key U.S. leadership roles, first-author publications, and visible representation at conferences. We have this on paper with IPP, but the human factor must be addressed. (3) Provide a strong onsite research team. CURRENTLY, AN OPEN NEED. (4) Implement an effective remote collaboration model. We are taking steps to build such a model. The BPO report for ITER collaboration has ideas that can be adapted to W7-X. We visited Fermilab to learn how they work on LHC. We are conducting a survey of W7-X collaborators and others to get input about collaboration model requirements.
- There are no limits imposed by IPP on what we can do. The door is wide open.
- The goal of the U.S. is to help the U.S. fusion program by using W7-X.

Q&A: Neilson

Q: C. Greenfield: Is W7-X an ITER-relevant model for research collaboration?
A: Yes. This is a good test model to define research collaborations.

Q: M. Koepke: I hope that part of the U.S. goal is to help W7-X scientifically advance the stellarator concept for magnetic confinement fusion.
A. No. The U.S. goal is to help the U.S. fusion program.

PUBLIC COMMENT
People may submit a public comment. Hutch Neilson asked if submitting public comments was allowed. Sam Barish cleared this up and said yes – it is allowed.

Public Comments
1. Matthew Moynihan (copy was displayed on screen). Dr. Moynihan received his PhD from the University of Rochester in 2013 for his research on NIF-scale targets.

- The written comment is based on an open letter to Representative Alan Grayson, as a comment on his "Fusion Innovation Act of 2015." Mark Koepke briefly summarized the comment:
-

In a perfect world, the Federal government should both increase and modify its support for fusion research. The government should avoid its habit of calling for yet another review panel, assessment, or study. There have been many panels over the years. They waste time and tax dollars, and they tend to come to the same conclusions. They typically call for increased funding, which is typically ignored. This delays research until a new administration calls for a new panel whose recommendations are also ignored. This cycle of inaction is very familiar to fusion researchers. Buck this trend. Take action right now. Funding should be increased right now for a variety of shovel-ready fusion projects: the EMC2 Polywell project ($30 million over 3 years), the Dynomak at the University of Washington ($35 million), the LDX at MIT ($2 million per year), the PLX machine at Los Alamos, and Wisconsin's IEC research center. Wisconsin only may not even be enough to deal with developments in fusors – a growing community of amateurs are claiming higher neutron rates of late, and Australian researchers have started developing magnetically insulated fusors. There also needs to be an increase in the SBIR program for small fusion companies to apply for. In addition, the Northwest Nuclear Consortium should be examined as a model for high school fusion programs across the country. This would fit nicely into the broader push for STEM education. One suggestion is a grant program that enables schools to build their own fusion devices (fusors) on campus. On top of this, the government needs to change the nature of its funding. The U.S. Government should fund fusion on a much more competitive basis – more like a venture capital firm rather than a blank check. This means including the real possibility of cutting funds for boondoggles and bad concepts.

- H. Neilson: Do we want to set a precedent for submitting public comment but not showing up?
- Sam Barish: I have been informed that in such a case, the chair should summarize the comment, and the Minutes should note that it is available.

2. U. Shumlak – (called in – shared screen)– University of Washington – President of the University Fusion Association. Dr. Shumlak characterized the recent UFA Forum on Fusion Energy and Plasma Science Research in the U.S. held on December 14-15, 2015. The two-day forum discussed two broad topics:

- 1. The opportunities and requirements for nurturing the growth of fusion energy and plasma science research in an academic environment, 2. The means for developing a strategic plan for fusion and plasma science.
- There were 48 attendees from 19 institutions: 13 universities, three large labs, one private company, and two Federal agencies.

3. M. Zarnstorff from the Princeton Plasma Physics Laboratory

- There will be a community stellarator research needs workshop on February 16-17, 2017 at MIT. It will include a discussion of needs, opportunities, and ways that stellarators and 3D shaping can contribute to key topics, including PRDs in four community workshop reports.

All are welcome to participate

- The contacts are D. Gates (PPPL), D. Anderson (Wisconsin), and A. Ram (MIT).

The floor was given to Jim Van Dam

- This was a great FESAC meeting. My notes will be shared with Ed Synakowski.
- Cherry Murray asked about workshops and participation. We sent her a long list of statistics. She was impressed – thanking organizers of the workshops. They were well organized, and the discussion was very functional and professional.
- The briefings and reports have been very informative.
- There is a little bit of headroom to move forward. Thanks to the organizers, the co-organizers, and the panel members. This was an extreme effort, which is highly appreciated.

Adjourn at 12:30 p.m.

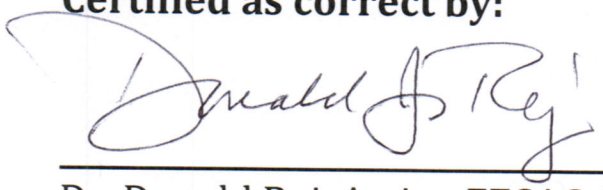
Appendix A

DOE Attendees:
Ben Brown
Marcos Huerta
Randall Laviolette
Cherry Murray
Franklin Orr

DOE/FES Attendees:
Shahida Afzal
Sam Barish
Bob Bartolo
Daniel Clark
Josh King
John Mandrekas
James Van Dam
Tom Vanek

Other Attendees:
Steve Eckstrand – RER Solutions
Dennis Whyte – MIT
Earl Marmar – MIT
Steve Dean – Fusion Power Associates
Catherine Johnson – University of Wisconsin, Madison
Lee Schroeder, Lawrence Berkeley National Laboratory
Lois McInnes – Argonne National Laboratory
Paul Bonoli – MIT
David Hill – General Atomics
Tof Carim – OSTP
Mike Zarnstorff – PPPL
Carol Austin – PPPL
Bernard Bigot – ITER
Laban Coblentz – ITER
Gerald Navratil – Columbia University
Ned Sauthoff – ORNL
Rajesh Maingi – PPPL
Jon Menard - PPPL
Saul Gonzalez – OSTP
Fred Skiff – University of Iowa
Rich Hawryluk – PPPL
Tony Taylor – General Atomics
Jonathan Wurtele – University of California, Berkeley
Steve Wukitch – MIT
Robert Ford – Department of State

Certified as correct by:



Dr. Donald Rej, Acting FESAC Chair

Aug 28, 2016

Date