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Emphasizing
Nuclear Engineering
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October 8, 2009

Professor Stewart Prager, Director
Princeton Plasma Physics Laboratory
P.O. Box 451
Princeton, NJ 08543

Dear Professor Prager,

Please find enclosed the report from the recent meeting of the Program Advisory Committee for the Fusion Simulation Program (FSP) Definition Activity.

We thank the FSP Definition Activity group and Princeton Plasma Physics Laboratory for preparing and hosting the first meeting of the Program Advisory Committee (PAC) for the definition phase of the FSP. We appreciate the work of the Definition Activity members in these early stages of its formation.

For future meetings, it would be preferable that drafts of the presentation material and any helpful references were made available to the committee members beforehand, to both better prepare for the on-site discussions and to inform members who may not be able to make a particular meeting. If possible, posting these materials on a PAC-accessible web site for download would provide access to these materials without the need for emailing large documents.

We hope these comments are helpful to the participants in the Program Definition Activity, and the PAC looks forward to future discussions with this group as the FSP Definition Activity develops in the near future. We are, of course, available for any questions you or the team may have concerning this report.

Sincerely,

Raymond J. Fonck

Raymond J. Fonck
Steenbock Professor of Physical Science

cc: W. Tang, PPPL
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Program Advisory Committee Report
Program Definition Activity
for the Fusion Simulation Program

First Meeting; September 17-18, 2009 at PPPL

This report summarizes the results of discussions undertaken at the first meeting of the FSP Program Advisory Committee. Members attending: A. Boozer, R. Fonck, C. Sovinec, B. Gross, G. Hammett, E. Marmar, M. Norman, and T. Taylor

A. General Comments

The PAC notes that the team has made progress in a short period of time in several activities covered by this present FSP Program Definition activity. This was apparently made possible by the division of activities into separate science driver, integration, validation, and modules groups. The PAC recognizes that the new Project Definition team performed considerable work to address the issues covered by the initial charges to the PAC, and congratulates the team members for quickly bringing some coherence to the activities of the various sub-groups.

However, an evaluation of progress in defining the proposed FSP activities in general, and addressing the charges to the PAC in particular, is hampered by the apparent lack of clear statements of mission and scope for the proposed FSP as a whole. The presented statement describes general technical goals for the software produced by the FSP but does not present an overriding mission that clearly defines the role of the FSP in the fusion program. In addition, groups in the present organization presented different views of the overall FSP mission and of the mission for their subgroup. It would be helpful for the individual groups to have their own clear mission statements, but the separate missions must be consistent with an overarching mission and with each other.

There is thus an immediate need for the senior management of this activity to develop and clearly define the mission, vision, scope of activities, and specific goals projected for inclusion in the proposed FSP. This vision must be shared and supported by the FSP leadership and membership and by the funding agencies, and it will need to be compelling to the broader research community. These statements will then provide the foundation for the needed strategic plan and management plan for the proposed FSP.

For planning to evolve, the FSP groups, OFES, and the fusion community will need an understanding of how the FSP program is expected to interact and coordinate with the rest of the FES program. A broad range of theoretical, computational, and experimental tools are needed for progress in the magnetic fusion program. At the present stage of development, the relationship between proposed FSP activities and existing activities in the fusion community (e.g., the general theory and SCIDAC programs) is unclear. We encourage FSP leadership to engage in discussions with OFES and the community to better clarify the scope of their activities and how they would interface with non-FSP elements of the broader program. The definitions of the mission, vision, goals, and

specific strategies of the FSP will need to be sufficiently developed to elucidate these relationships and the added value that the FSP will bring to the U.S. Fusion Energy Sciences research enterprise.

Finally, the PAC agrees with the advice from an earlier review that, in deciding scientific challenges to address and the computational tools to be employed and/or developed, the FSP should be structured to "lead with the science," with primary consideration for advancing predictive understanding in fusion science. In this process, the FSP will need to clarify its definition of "predictive understanding" for any given activity.

Charge 1 - Science drivers and associated gaps analysis:
Do the science drivers and associated gaps analysis presented provide a compelling case for needing integrated modeling to achieve key fusion advances?

Addressing particular charges is intimately connected to the proposed overall mission and scope of the proposed FSP activities, and is thus conditional since sufficient definition of the proposed FSP is not yet developed.

There is general agreement on the need for integrated modeling for the proposed set of initial Science Drivers. For at least some of these Science Drivers, however, it was not clear that a compelling case was made for developing a new organizational activity in the fusion research program to achieve the given goal. For example, there are programs in plasma turbulence and transport, plasma edge pedestal, etc. that already are attempting to facilitate coordination between experiment, theory, and computation, albeit at varying levels of resources. However these move forward, they will require advances in fundamental theory, computational capabilities, and novel experiments. The value to be added by incorporating these activities as specific areas of focus for the proposed FSP will need further elucidation.

The selection criteria chosen to guide the selection of initial Science Drivers for the FSP are reasonable and inclusive of a wide range of potential topics. The PAC agrees that science needs should be the primary driver, but the relative weights given to other factors in the selection process need clarification. In particular, one key objective of the FSP was stated to be: "Accelerate predictive understanding and control of magnetic fusion experiments through integrated modeling of multi-scale physics by exploiting the computational power of emerging peta/exascale computers." The role of this objective in the selection process was not clear, although it was noted that the selected potential drivers would all eventually benefit from those new computational capabilities.

The Science Drivers chosen in this Project Definition Phase represent reasonable provisional drivers for FSP initiation; these are expected to evolve through the Project Definition stage to an initial set of science drivers for the first FSP activities. The PAC strongly supports the emphasis the group placed on developing a prioritized listing of these Drivers. It also supports the team's intent and plans to provide transparency in this process to help generate support from the broader research community.

Generally, a transparent scoring process used to assign relative weights to the selection criteria is needed to clarify the resulting ranking of Drivers. Indication of how the chosen Science Drivers scored against the selection criteria would be useful, as would a listing of potential drivers that did not make the cut. The latter would help avoid the impression that FSP is planned to be all things to all people.

Finally, each of the Science Drivers presented was discussed in the context of improving the understanding of the fusion plasma state. It would be useful to also include an evaluation of how addressing a given Science Driver may help develop active control capabilities, motivate or improve designs of future experiments, and/or describe other contributions to the practical implementation of fusion energy systems.

Charge 2 - The plan for the project definition phase:
Do the FSP team's plans for project definition provide an appropriate roadmap for accomplishing these tasks, properly prioritized, on a relatively tight time schedule?

- *FSP Strategic Plan Development:*

The conceptual approach to developing a 15-year strategic plan is not yet evident. In developing such a plan, the team needs to consider how such a project might be divided into phases, and what would determine the cadence of these phases. In large software development projects, it is natural to phase development according to capability thresholds. What would these be for FSP?

The PAC supports the vision of a "staged-evolutionary" software delivery model, including an early delivery of practical software capability. Exactly what will be delivered in the first several releases must be defined early in the planning process to develop a coherent longer-range plan. Additionally, the PAC recommends an overview of this process, with explicit reference to the how each element of the WBS (Work Breakdown Structure) would contribute to the objectives of the project. Various pieces were presented in the individual talks, but a synthesis is needed.

As an element of the strategic planning activity, an output of the Project Definition Activity should include a statement of anticipated long-term deliverables. In addition, metrics of success in moving towards resolution of issues defined for each of the chosen science drivers need to be developed and integrated into the strategic plan.

- *Program Management:*

The management structure for the FSP Project Definition Activity is appropriate for developing the plan for a suite of validated codes aimed at predictive understanding of magnetic fusion plasmas and integrated simulation capability. The definition of work scope of the four major efforts appears to be suitably advanced, but the overall balance and integration of those efforts into a unified work plan remain to be developed.

The PAC supports adapting DOE project management guidelines for the FSP project/program activities. The procedures in developing the project plan according to these guidelines are fairly well articulated, but the efforts in developing the early stages (mission, vision, goals, strategic plan) are behind schedule and require immediate attention.

It will be challenging to develop a clearly defined project plan with appropriately well-defined schedules and deliverables while allowing for a "living" plan that includes active research programs. Apart from the draft work breakdown structure, most of the management plan (which does consider the 10-15 year timeframe) appears to be generic for software development. However, the FSP seems to be at least as much a project in integrating (and developing) plasma understanding as in integrating software, and it is not clear that all of it can be managed in software terms. As discussed by the FSP Project Definition team, there is a need for longer-term fundamental and algorithmic research on certain components that multiple small teams may approach best, and this may also be more effective with a different type of management. The FSP project definition team needs to address how these two approaches can be reconciled.

The PAC is concerned about the plan for where the components for the FSP will be developed. It is assumed this will be elucidated in a resource-loaded Project Execution Plan (PEP) as part of the overall project plan. The PAC looks forward to a detailed discussion on this topic at a future meeting.

The FSP Project Definition PAC supports the inclusion of Frameworks, Validation, and Advanced Physics Modules in the Program Definition Activity. The component evaluation planning process (the forest diagram) seems well thought out. The team should document and publish (on its wiki) the results of the evaluation process in order to improve transparency as to how the conclusions were reached. It is less clear what the physics component group will do during the actual project. The Project Definition Activity needs to define the functions of the Physics Components group in the FSP. Validation will be a very important part of the program. A clearer timeline is needed, indicating what will be accomplished during the planning stage. It is also important to know whether the FSP intends to provide analysts and any new infrastructure (software if not hardware) for doing validation exercises or whether it will primarily provide advice on these activities.

Charge 3 - Community engagement:
Do the plans presented provide an effective approach for needed community outreach?

The PAC agrees that community participation from the start of the project definition will be absolutely necessary for success of the project. The plans for community outreach, as outlined so far, are obviously only in the very first stages, and are making steps in the right direction. However, some important parts of the existing SciDAC and related fusion computational projects have not yet been engaged, and their involvement is needed to provide important components of the integrated FSP. Ways need to be found

to tap this important expertise. In a similar vein, the FSP Project Definition team should examine the experience gained by ASCII activities (viz., management, validation, etc.).

In terms of engaging the broader fusion community, the FSP Project Definition Activity has outlined a number of useful steps. Using recent community reports (e.g., RENEW and "Grand Challenges") certainly makes sense, although details are lacking at this point. Specific outreach through videoconferences, briefings and site visits, and presentations at relevant conferences, are encouraged. However, rather than to "vet" a proposed plan, these interactions should be thought of as fully interactive and "two way", since the plan itself is at such an early stage. This is in some respects beneficial, since it means that there is a lot of room for community input. Use of web sites is helpful, and it will be important to "get the word out" as widely as possible. The team should make use of existing mailing lists, possibly engaging the USBPO, UFA, APS-DPP, and other relevant community groups,. Identifying specific liaisons at institutions across the country (labs, universities, companies) might also be a useful approach, particularly for some of the institutions that have relatively small plasma groups and no current direct FSP participants.

The PAC appreciates that the Program Definition activity has plans to appropriately engage segments of the experimental and computational fusion science communities. Community engagement in the FSP should include analytic theorists as well. Analytic theorists can help guide ongoing improvement of the underlying FSP models, define verification and validation test problems, and guide the division of complex problems into simpler ones that can be more easily investigated.

Finally, the PAC recommends that the FSP team consider adding a workforce development component to the FSP plan. Manpower development could include a postdoc/graduate education component and involvement of universities. There are ample opportunities for graduate students to work on aspects of the FSP integrated code and FSP standalone codes. For example, these could include validation efforts, improved algorithms for various components, improved physics in various components, and theoretical foundations of some components. Many of the present SciDAC projects have essential university involvement, and tapping the expertise in the universities will be important.

Coordination with the international community will be more challenging, and specific steps have not yet been identified. When considering international outreach, this should not be limited only to addressing the needs of ITER. The PAC requests a future discussion on efforts in coordination and possible collaborations with similar activities of the international partners, including ITER.