FESAC REPORT ON PRIORITIES AND BALANCE

To be presented at the
Fusion Power Associates 20-Year Anniversary Meeting and Symposium
525 New Jersey Avenue, NW
Washington, DC 20001
to be published in the Journal of Fusion Energy

October 19-21, 1999

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Managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-96OR22464

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Presentation at the FPA Symposium, Washington, DC, October 21, 1999

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In 1996, the FEAC[1] recommended a restructured fusion program, reflecting congressional guidance, budget realities, and the perception that there was no domestic energy shortage. The mission for this fusion energy sciences program placed greater emphasis on plasma science and technology and less emphasis on the rapid development of fusion energy. Nevertheless, recent reviews of the U.S. fusion program by PCAST[2], SEAB[3], and FESAC[4] have had the common themes that the U.S. should pursue fusion energy aggressively, and that it is premature to narrow among the energy options offered by magnetic (MFE) and inertial (IFE) fusion energy.

In October 1998, the Director of the Office of Science requested that FESAC review the Office of Fusion Energy Sciences (OFES) programs and recommend directions for the near-, mid-, and long-term and, in particular, comment on the balance between MFE and IFE. As requested, the FESAC commented also on the balance within the MFE and IFE programs and the priorities for three Proof of Principle (PoP) experiments. As emphasized in the FESAC report on Priorities and Balance, "The MFE and IFE programs should be consistent with their respective time frames, set in part by:

• MFE opportunities to participate in major international experiments;
• IFE opportunities to leverage the Defense Programs (DP) funded Inertial Confinement program."

The report identified the achievement of a more integrated national program in MFE and IFE as a major programmatic and policy goal in the years ahead. In terms of a balance between the two programs, the FESAC recommended that at a $300M budget (total from the Office of Science and energy-related DP work), the split should be $250M in MFE and $50M in IFE; at a total budget of $260M, a split of $230M in MFE and $30M in IFE; and at $222M a split of $207 in MFE and $15M in IFE. At the $222M budget level, both MFE and IFE are sub-critical for meeting program objectives.

The FESAC stated that, "Establishing an optimal balance between IFE and MFE in a more integrated national program in fusion energy sciences should be based on the following guiding principles:

(1) The MFE and IFE programs should be consistent with their respective time frames, set in part by

- MFE opportunities to participate in major international experiments;
- IFE opportunities to leverage the DP funded ICF program.

(2) Specific elements of science and technology critical for evaluating the ultimate energy potential of IFE and MFE, such as interaction of the plasma with chamber walls, should be brought to comparable levels of maturity.

(3) The dramatic advances in the predictive power of modern theory and simulation make these tools essential elements of a cost-effective program.

(4) A common peer review process for MFE, IFE, and cross-cutting activities should be implemented wherever possible.

(5) Cross-cutting science and technology, with application to both MFE and IFE, deserves special encouragement.

Attracting and maintaining a talent pool of creative young scientists in the combined program, for example through research with broad scientific or technological implications, is crucial to fusion progress."

The FESAC emphasized that, "The MFE research plan is motivated by three considerations: the continued development of fundamental scientific understanding and innovative technologies, the advancement of innovative magnetic concepts, and the time frame of the international fusion effort. In the next five-year time frame, the international fusion community will be making construction decisions for major next-step experiments. The MFE plan assures that the U.S. remains actively engaged with the international community and is able to participate in a meaningful way with the worldwide development of magnetic fusion energy. Also, on approximately a five-year time scale, our understanding of some of the new magnetic fusion concepts can be sufficiently advanced to warrant consideration for study at the larger scales which most closely resemble fusion conditions. At the $260M budget level, it would be possible to augment the principal MFE thrust areas."

"With regard to overall balance and priorities within the MFE program, the Panel believes that at present the program is reasonably well-balanced given the available resources and the ongoing restructuring of the program since 1996**.** The Panel recommends funding increases to accomplish the following:

(1) "Strengthen theory and computation as very cost effective means to advance fusion and plasma science, taking advantage of advances in computation science and technology. Strengthen activities in general plasma science and encourage research on near-term applications of plasma science and technology."

(2) "Pursue an aggressive portfolio of confinement concepts through increased effort in the Proof of Principle area, and through strengthening of the Concept Exploration program."

(3) "Focus the moderate-pulse advanced tokamak program, including U.S. collaboration on leading international facilities, and to a lesser degree the spherical torus program, towards a five-year assessment point; and prepare for participation in a burning plasma experiment."

(4) “Revitalize the technology program to provide for continued innovation in this area because of its overall importance to the success of fusion science and fusion energy and applications. Utilize systems studies to identify attractive fusion energy concepts and affordable development paths.”

“Approximately two-thirds of additional resources (relative to the Administration's request for FY 2000) should be divided about equally between recommendations (2) and (3) above. However, it is high priority to increase support for (1) and (4), with a somewhat greater emphasis on (4), especially under small budget increases.”

The near term goal of the IFE program is to provide the data base for a decision on an Integrated Research Experiment (IRE) and the associated program. In parallel, the National Ignition Facility (NIF) is expected to undertake the single shot target tests to provide the physics base and optimized target designs for energy production. Since the Defense Program addresses critical target issues in single-shot experiments, the OFES program focuses on high-pulse rate, efficient and affordable drivers and associated fusion chamber and target technology.

The ultimate goal of the NIF is to achieve gain in the range of ten, where gain is defined as the ratio of the thermonuclear yield to the laser energy delivered to the target. Indirect-drive targets have been the most thoroughly explored for testing on the NIF. However, the NIF target chamber is being constructed with additional beam ports so that direct-drive targets may also be tested.

“The IRE objective for the heavy ion beam driver approach is a completely integrated ion accelerator from injector to beam focus in the target chamber center. The size and characteristics of the accelerator will be chosen so that the performance and cost of a driver, for the fusion engineering development stage Engineering Test Facility (ETF), can be accurately projected.”

“For lasers, the IRE plan is to develop and optimize one complete laser beam line that would be prototypical of the ETF driver. Presently, both diode-pumped solid-state and KrF lasers are being developed.”

In the $300M budget, both ion beam and laser approaches would be pursued in a timely fashion, while at the $260M level there would be a delay in the development of the laser path and a reduction in opportunities for concept exploration. At still lower budget levels, the report recommends mounting an adequate, albeit delayed, program to develop the ion beam option, while reducing funding for the laser option.

In regard to the three PoP experiments, the conclusions of a FESAC sub-panel were as follows:

(1) “The RFP is ready for PoP designation but a more focused sequential approach should be implemented. The modified budget levels generated in response to the original review are viewed as appropriate. Specifically, this calls for a budget increment of $2M in FY 2000 and $3.5M in FY 2001.”
(2) “The CS is not ready at this time for PoP designation because of one important technical concern about the NCSX. The sub-panel believes that this concern will likely be addressed

in the near future. The sub-panel also believes that in the long run the NCSX promises a high probability of success and that a FESAC sub-panel participate in the Conceptual Design Review (CDR) of the NCSX project to complete the evaluation of readiness to proceed as an approved PoP program. The sub-panel further recommends that the design effort and supporting theory and modeling on NCSX be adequately funded to permit expeditious completion of an optimized design and a successful CDR. This is expected to entail an increment of $1M in 2000 and $1.5M in FY 2001."

(3) "The MTF is not ready at this time for PoP designation. There are a number of important technical issues that must be resolved. The sub-panel recommends a three-year continuation of the MTF concept exploration program at approximately the present level of effort to produce and translate the required target plasma for the experiment."

The FESAC deliberations benefited from various fusion community discussions, including the Fusion Summer Study at Snowmass [5].

The numerous opportunities for exciting research and development in the fusion energy sciences area – MFE, IFE, Fusion Technologies, Plasma Science, and Near-Term Applications – are reviewed in the FESAC report, Opportunities in the Fusion Energy Sciences Program[6].

References

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