Planning Panel Status Report

Presented by Martin Greenwald

FESAC Meeting

Rockville, 7/16/2007

Panel

- Martin Greenwald – Chair
- Richard Callis
- Bill Dorland
- David Gates
- Jeff Harris
- Rulon Linford
- Mike Mauel
- Kathryn McCarthy
- Dale Meade
- Farrokh Najmabadi
- Bill Nevins
- John Sarff
- Mike Ulrickson
- Mike Zarnstorff
- Steve Zinkle

Outline

- Review of Charge
- Process
- Results so far
- Next steps

From Charge by Under Secretary Orbach

"To assist planning for the ITER era, it is critical that FESAC identify the issues arising in a path to DEMO, with ITER as a central part of that effort"

1. "Identify and prioritize the broad scientific and technical questions to be answered prior to a DEMO."
2. "Assess available means (inventory), including all existing and planned facilities around the world, as well as theory and modeling, to address these questions."
3. "Identify research gaps and how they may be addressed through new facility concepts, theory and modeling."

Scope of Charge

- We're not creating a new development plan or roadmap for fusion energy – in so far as we need this, we will use the 35 year plan
- We're not treating entire fusion sciences program, for example
  - ITER baseline considered "done"
  - Highest priority is making ITER a success (just pencil it in above anything we come up with)
  - Not considering IFE
  - Only thinking about alternates to tokamak with "short term" potential for impacting the development path
  - All above are left out of prioritization by construction – nothing is implied about their importance relative to what we are considering

Discussion of Charge

- What do we need to learn and what do we need to do, aside from ITER and other existing elements of the international program, to develop the knowledge base, and to be prepared for DEMO?
- We are using DEMO and the development plan to set a rough scope, timeline and path
- We are using the priorities panel (and recent NRC report) to help define issues
- Our focus is/will be on informing near-term decisions for next major steps in the program

How Do We Define DEMO For The Purposes Of This Charge ?

- DEMO mission = prototype, electricity producing fusion reactor demonstrating high availability, reliability and all relevant technologies
  - Last step before commercialization
  - Industry will set the bar quite high
- We cannot predict DEMO instantiation
  - How advanced in operating mode (or concept)?
  - How aggressive in use of new materials?
  - How aggressive in terms of technologies employed?
  - What is the funding source – public, private, hybrid?
- Since we don't know, we take a broad view of the technical issues in order to ensure that the program is prepared

How We See The Panel's Job

- **Identify issues** that must be addressed to create knowledge base for DEMO
  - How do we define a "basis" set of "broad" questions and issues?
- **Prioritize** these issues
  - What are the criteria we should be using?
- **Inventory available means** – in current and planned programs
  - What will these programs actually do?
- **Identify critical paths and gaps**
  - Where do we need to head? How far? How fast?
- **Identify opportunities** – missions to fill the gaps
  - How to synthesize from all of the above?

Resources – Existing Reports and Studies

- FESAC Priorities Panel (2005)
- FESAC Review of Major Facilities (2005)
- FESAC Fusion Development Plan (2003)
- NRC Plasma 2010: Assessment and Outlook for Plasma Science (2007)
- NRC Burning Plasma (2003)
- EU Fast-track Fusion Development Plan (2005)
- Japan; National Policy of Future Nuclear Fusion Research and Development (2005)
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Resources - Concurrent activities

- BPO/EPAct committee (Summer)
- ARIES Industrial Advisory Committee meeting (June)
- ITER Test Blanket Module workshop (May)
- Fusion Simulation Project workshop (May)
- ARIES project meeting (April)

All have participation by panel members

Resources – Community Input

- Website
  - http://www.psfc.mit.edu/~g/spp.html
- Online discussion board (72 registered users currently)
  - http://www.psfc.mit.edu/phpbb3
- Communicating through BPO, VLT, UFA, FPA mailing lists (for the future: can we do something more coherent here?)
- White papers (27 submitted so far)
- Presentations and discussion of white papers
  - June 25 at General Atomics (13 presenters)
  - August 7 at PPPL (open invitation…)

Process

- The panel has had 2 face to face meetings so far, 1 to go
- Numerous conference calls
- Innumerable email
- Where are we?
  - We've defined the set of themes, issues
  - Reviewed existing and planned programs/facilities
  - Adopted a formal process for prioritization
  - Adopted a process for gap analysis
- Our aim is to have a first draft by 9/1 and a final draft to FESAC by 10/1

Broad Set of Themes and Issues Identified

- Issues grouped into 3 Themes
  - Themes similar, but not identical to priorities panel
- We’ve tried to define a “basis” set which will be complete **AND** useful for prioritization and gap analysis
  - Recognize that this is not a unique decomposition
  - There are strong couplings and a high degree of integration between issues
- We’ve tried to be very careful and precise about what each issue means
- Subtopics for each issue have been enumerated and defined as well (you won’t see these today)

Themes: In Preparation for DEMO

A. Predictable, high-performance steady-state burning plasmas

- *The state of knowledge must be sufficient for the construction, with high confidence, of a device which allows the creation of sustained plasmas which meet simultaneously, all the conditions required for practical production of fusion energy.*

B. The plasma material interface

- *The state of knowledge must be sufficient to design and build, with high confidence, robust material components which interface to the hot plasma in the presence of high neutron fluences.*

C. Harnessing fusion power

- *The state of knowledge must be sufficient to design and build, with high confidence, robust and reliable systems which can convert fusion products to useful forms of energy in a reactor environment, including a self-sufficient supply of tritium fuel.*

A. Predictable high-performance steady-state plasmas

1. Measurement
   - *Development of hardware, procedures and algorithms for making measurements of all necessary plasma parameters with sufficient coverage and accuracy needed for the scientific mission, especially plasma control*
2. Integration of steady-state, high-performance burning plasmas
   - *Creation, on a routine basis of core, edge and SOL plasmas in steady-state with the combined performance characteristics required*
3. Development of validated predictive models of plasmas
   - *Development of physical and computational models which have been thoroughly tested against experiments and are capable of predicting all important plasma behavior in the regimes and geometry relevant for practical fusion energy.*

A. Predictable high-performance steady-state plasmas(2)

4. Control
   – *Development of schemes for maintaining a high-performance, burning plasmas at a desired, multivariate operating point with a specified accuracy for long periods (months?) without disruption or other major excursions.*
5. Avoiding off-normal events
   – *Demonstration that events which can cause catastrophic failure of internal components would be essentially non-existent for DEMO*
6. Heating, current drive, rotation drive, fueling
   – *Development of auxiliary systems which can provide power, particles, current and rotation at the appropriate locations in the plasma at the appropriate intensity.*
7. Magnets
   – *Provision of economic, robust, reliable, maintainable superconducting magnets that provide the fields for plasma confinement and control.*

B. The Plasma Material Interface

8. Plasma wall interactions
   - *Understanding and control of all processes which couple the high-performance plasma to its immediate surroundings*
9. Plasma Facing Components
   - *Development of replaceable components which can survive the enormous heat, plasma and neutron fluxes without degrading the performance of the plasma or compromising the fuel cycle.*
10. Antennas, diagnostics and other internal components
    - *Development of RF antennas and launchers, control coils, final optics and any other diagnostic equipment which can survive and function within the plasma vessel and are subject to a combination of plasma and neutron loading*

C. Harnessing Fusion Power

11. Fuel cycle
    - *Development of components for managing the flow of tritium throughout the entire plant, including breeding and recovery.*
12. Power extraction
    - *Provision of components for extraction of fusion power at temperatures sufficiently high for efficient production of electricity or hydrogen.*
13. Materials for breeding and structural components
    - *Development of basic materials for construction of breeding blanket and structural components in high neutron fluence area*
14. Safety
    - *Implementation and integration of all systems in a manner which realizes the safety and environmental benefit inherent in fusion*

Prioritization Process Adopted

- Challenge: "*all the children are above average*"
  - All of the issues we have listed are important and must be resolved before we are ready for DEMO
  - Context for priorities – a resource limited environment
  - Which means we may have to accept additional risk or delays toward the ultimate goal
- Defined: a set of criteria with clear definitions
- Created: a scoring system with as precise definitions as we could manage
  - Allow for differentiation between issues (all of which are important)
  - Get as consistent result from panel as possible

Criteria For Prioritization

- Importance:
  - How central is the issue to the fusion mission and extrapolation required to DEMO?
- Urgency:
  - What is the impact on development plan schedule? When must significant work on this issue begin? Includes considerations of risk, dependencies and decision points.
- Uncertainty:
  - How much technical uncertainty does the issue present? To what extent are the programs in place likely to resolve the issue?
- Generality:
  - Are solutions to issue generic with respect to possible instantiations of DEMO?
- Opportunity for U.S. leadership:
  - How strong is the **opportunity** for US leadership on this issue? Includes areas where we currently have strength or leadership **and/or** where the international program leaves an opening.

Assess available means

- This is mostly straightforward – substantial documentation exists already.
- Inventory existing and planned programs - We are in the process.
  - In many cases it is not possible to be precise about what the programs will actually accomplish – we've tried to go to original sources where they are available
  - The ITER program beyond the basic burning plasma mission is still not completely clear
- We've also looked at international fusion development plans to help us understand where other parties are headed

Approach to Gap Analysis

- We are starting at sub-issue level
  - Otherwise we have nothing but large gaps
- We are defining metrics for each and assessing the degree of extrapolation required
  - Quantitative if possible
  - Capture knowledge base requirement
- Extrapolation is defined
  - Start where current and planned programs end
  - End with DEMO
  - As a reality check, we are also looking at gaps from where we are now
- Gaps inherit prioritization from the issues

Next Steps

- Continue gathering community input
- Complete prioritization process
- Complete gap analysis
- At that point we can identify gaps in high-priority areas
- Use these to define critical missions and opportunities
- Draft report