Report on Evaluation Criteria

Mohamed Sawan
Fusion Technology Institute
The University of Wisconsin

APEX Project Meeting
8-11 November 1999
UCLA

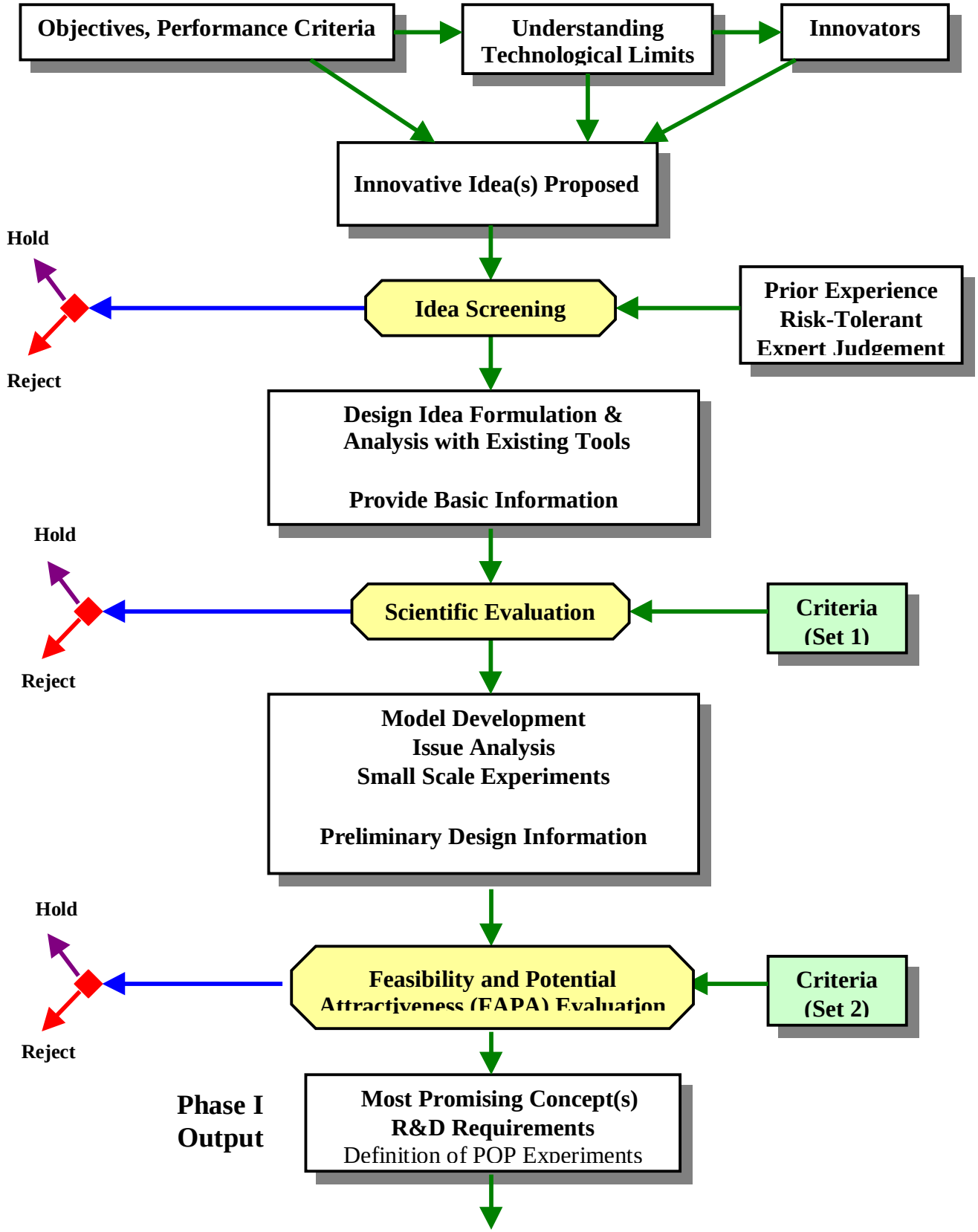
Background

- At the beginning of the project a flow diagram showing the steps of the APEX process included two major evaluations:
  - ***Scientific evaluation***
    Determine if a concept can proceed into a more detailed level of analysis beyond the initial exploration phase
  - ***Feasibility and Potential Attractiveness evaluation***
    Determine the promising concepts to move to proof-of-principle

- An evaluation criteria group was formed to develop the scientific evaluation criteria

Group Leader:
Mohamed Sawan
Group Members:
Mohamed Abdou, Charlie Baker, Siegfried Malang, Rich Mattas, Kathy McCarthy, Dale Meade,
Brad Nelson, Dave Petti, Mohamed Sawan,
Dai-Kai Sze, Mark Tillack, Mike Ulrickson, Mahmoud Youssef, Steve Zinkle

Initial Flow Diagram for the APEX Process



Evaluation Criteria Group Activities in FY99

- We compiled a list of the minimum information required for each concept to facilitate the evaluation. This list was made available to the team early at the start of FY99 activities

- The evaluation criteria were developed by the group. They went through several iterations within the evaluation group

- The evolving list of criteria were presented to the team in the APEX meetings and by E-mail for discussion and comments

- The scientific evaluation criteria were divided into four major categories:
  - Does the concept meet the minimum functional requirements?
  - Does the concept have potential for improved attractiveness?
  - What are the design margins and uncertainties associated with the concept?
  - What are the major critical issues and R&D needs?

- Members of the group generated detailed explanation for the criteria within each of the four categories with some quantitative requirements if possible

Information Required for Scientific Evaluation

These are the minimum information required for each concept to be considered in the scientific evaluation and should be included in the interim report

A) Sketches of the geometry of the in-vessel components

B) Outline of FW/blanket/shield radial build including approximate dimensions

C) Candidate materials for PFC, structure, breeder, and coolant

D) Estimated values of the following parameters, based on a peak neutron wall loading of 10 MW/m^2, a peak surface heat flux of 2 MW/m^2, and a peaking factor of 1.4 for both:

a) Coolant parameters (temperature, pressure) at inlet/outlet of:
   - plasma facing surface (liquid FW)
   - FW cooling channel (solid FW)
   - breeding zone

b) Maximum/minimum temperatures of
   - breeder material
   - structural material

c) Maximum primary and total (primary+secondary) stress in the structural material

d) Tritium breeding ratio (Overall TBR estimated from local 1-D calculations with heterogeniety)

e) Maximum power density in structure, breeder and coolant material

f) Energy multiplication in in-vessel components

g) Maximum structure damage

h) Structure activity, decay heat, and radwaste classification

E) For a typical unit size module, which could be one of the following elements:
(Include the sketch of coolant routing)
- a chunk with a FW surface of $1m^2$
- a cut out of a blanket segment with a poloidal height of 1m
- a sector cut of a segment with full height and a toroidal width of 1m
- a complete outboard segment
- a full sector

estimates for the following parameters have to be provided, assuming the heat loads given under D):

a) total surface heat load
b) total heat load (surface heat load + volumetric heat generation)
c) coolant mass flow rate (either total or for the different zones, depending on the concept)
d) coolant velocities in FW and breeding zone
e) coolant inlet and outlet manifold sizes
f) coolant inlet and outlet piping location and sizes
g) coolant pumping power
h) a brief indication of structural support needed
i) identification of external primary or secondary coolant pumping system

Summary of Evaluation Criteria

(1) Minimum Functional Requirements

These are the absolute minimum requirements for a concept to be proposed for use in a fusion power plant. The concept must satisfy the following requirements:

- Adequate tritium breeding
- Suitable tritium extraction
- Sufficient vacuum pumping
- Efficient power extraction

(2) Potential for Improved Attractiveness

The potential of the concept for improved attractiveness is measured by addressing several performance attributes. These are listed below. A detailed list of criteria was generated for each of these issues and is given in Interim report.

- High Power Density and Heat Flux Handling
- High Power Conversion Efficiency
- High availability and reliability
- Attractive Safety and Environmental Attributes
- Low cost

(3) Design Margins and Uncertainties

This assesses how far are the calculated parameters from the operational design limits. The uncertainties in estimating the parameters used in the evaluation will be evaluated and compared to the design margins.

(4) Critical Issues and R&D Needs

This involves identifying the key issues for this design concept. The R&D required to resolve these issues will then be described. The facilities needed to perform these R&D activities will be defined.

Observations

- Originally, we thought we will have many concepts or ideas proposed in which case ranking and/or elimination will be necessary. However, we ended up with a few concepts

- In addition, we do not have enough details to allow for meaningful quantitative evaluation of the concepts using the evaluation criteria developed

- The evaluation criteria provide guidance to the concept developers regarding improving the attractiveness of the concept by comparing design variations or material choices within the concept (e.g., compare performance of different breeders in liquid wall concepts)

- The criteria developed represent a good list of performance characteristics that we need eventually to achieve for the concept to make a difference in improving the attractiveness of the fusion system

- Actually, these criteria can be fully applied only if we have the concept used in a full system study

- We need to change the scope of the evaluation criteria to help the designers implementing changes that improve the attractiveness of the concepts

Suggested Scope Change

- Change name of the group to "CONCEPT PERFORMANCE MONITORING" to clearly reflect what will be done

- The group will continuously monitor the development in the concept by reviewing presentations made in project meetings and any written documentation given by concept developers

- Members of the group will then provide a report emphasizing recommendations regarding areas that need more attention to improve the attractiveness of the concept

- We need to look at all aspects of concept performance and make sure that concept developers do not improve one aspect of performance at the expense of others which might hurt rather than help the overall attractiveness of the concept

- This is a valuable service to the concept development process

- This is not a casual effort. It needs commitment and funding

- Tasks assigned to this group could be as follows:
  - Review the progress of the concepts as presented in meetings and conference calls
  - Provide a report on the performance of the concept and its potential for enhanced attractiveness
  - Make recommendations regarding areas that need more attention and suggest possible change of emphasis in the tasks performed for each concept

Questions for Discussion

- Do we need a separate group for evaluation/monitoring?
  (steering committee, concept developers,..?)

- Do we need to revise the present evaluation criteria to allow their application at this stage of concept development?
  (In absence of full system design it is difficult, if not impossible, to apply most of the present criteria)

- Do we need to apply the evaluation criteria to reduce number of concepts?
  (Do we have too many concepts to develop with the available resources?)