TPA TECHNOLOGY STATUS

PRESENTATION TO OFE

MOHAMED ABDOU

30 JANUARY 1986
TPA TECHNOLOGY STATUS SUMMARY

• Completed Steps 1 and 2
  - Characterize Issues
  - Specify Objectives

• Interim Report was issued in December

• Phases II and III will focus on Steps 3-5
  - Major Experiments and Facilities
  - Present Emphasis: Technical Logic Network
TPA TECHNOLOGY METHODOLOGY STEPS

1. Characterize Issues

2. Specify Objectives

3. QUANTIFY EXPERIMENTS, MODEL NEEDS

4. EVALUATE FACILITIES
   Existing
   New

5. DEVELOP PATHWAYS
   COMPARE PATHWAYS

TEST PLAN
DEFINITION OF ISSUE?

- Difficult to develop precise meaning

- Often used to convey different meanings:
  
  Problem
  
  Uncertainty with negative consequence

  Element
  
  Technical area, topic

- Seldom used to mean positive
ISSUE CHARACTERIZATION ITEMS
IN TECHNOLOGY REPORT

1. Description

2. Potential Impact on Design
   - Feasibility
   - Attractiveness

3. Design Specificity
   How Generic/Specific Relative to
   - Class of Designs
   - Technology Component
   - Confinement Concepts

4. Overall Level of Concern
   Overall Importance to Fusion
   Composite: Based on 2, 3 and other factors
POTENTIAL IMPACT ON DESIGN

Feasibility Issues

- May Close the Design Window
- May Result in Unacceptable Safety Risk
- May Result in Unacceptable Reliability, Availability or Lifetime

Attractiveness Issues

- Reduced System Performance
- Reduced Component Lifetime
- Increased System Cost
- Less Desirable Safety or Environmental Impact
EXAMPLES OF ISSUES
PRIMARY ISSUES FOR MATERIALS

• **Radiation Effects on Materials Properties**
  - Mechanical
  - Thermophysical
  - Thermochemical
  - Others

• **Baseline (Unirradiated) Properties**
  - Necessary for Scoping Prior to Irradiation

• **Fabrication/Joining**
# PRIMARY ISSUES FOR BLANKET

<table>
<thead>
<tr>
<th><strong>Liquid Metal</strong></th>
<th><strong>Solid Breeder</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- MHD Effects</td>
<td>- Tritium Recovery, Inventory</td>
</tr>
<tr>
<td>- Compatibility</td>
<td>- Thermomechanical Interactions</td>
</tr>
<tr>
<td>- Irradiation Effects Structure</td>
<td>- Irradiation Effects Structure/Breeder/M</td>
</tr>
</tbody>
</table>

- Fuel Self Sufficiency
- Tritium Extraction, Control
- Failure Modes and Effects
PRIMARY ISSUES FOR PLASMA INTERACTIVE COMPONENTS (PIC)

- PARTICLE EXHAUST, RECYCLING
- EROSION/REDEPOSITION
- ENERGY REMOVAL/RECOVERY
- THERMOMECHANICAL LOADING AND RESPONSE
- RADIATION EFFECTS
- TRITIUM PERMEATION AND INVENTORY
- FABRICATION
PRINCIPAL ISSUES FOR HEATING AND CURRENT DRIVE

- **Negative Ion Beam System Attractiveness**

- **Negative Ion Beam Component Performance**
  - Ion Source
  - Accelerator
  - Neutralizer

- **Identification of an Attractive Ion Wave Heating Mode**

- **Development of ICRH Components**
  - Launchers
  - Feedthroughs
  - Matching Systems
  - Power Sources

- **Understanding of LHH Power Deposition**

- **LHH Components**
  - Launcher
  - Source

- **ECH Tubes**

- **Identification of Efficient Current Drive Technique**
PRIMARY ISSUES FOR MAGNETS

• Copper Coils
  - Strength of copper
  - Demountable or sliding joints

• Pulsed Coils
  - OH coil development
  - High field coils
  - Energy storage

• Superconducting Coils
  - Radiation hardening of conductors, insulators and structures
  - Superconducting current density
  - Structural materials strength and toughness
EXAMPLES OF OBJECTIVES
OBJECTIVE

- Identifies what must be achieved and a direction for achievement

ATTRIBUTE

- A specific or quantifiable parameter to indicate the degree to which its associated objective is met

- Variety of Measurement Scales

  Natural, Proxy, or Constructed
FUSION NUCLEAR TECHNOLOGY

OBJECTIVE

SHOW THAT IT WILL BE POSSIBLE TO DEVELOP ATTRACTIVE NUCLEAR TECHNOLOGY SUBSYSTEMS UNDER CONDITIONS RELEVANT TO FUSION ENERGY SOURCES.

PROVIDE A PREDICTIVE CAPABILITY WHICH CAN BE USED TO ASSESS THE PERFORMANCE OF FUSION NUCLEAR SUBSYSTEMS.
BLANKET OBJECTIVE
DEVELOP ATTRACTIVE BLANKET TECHNOLOGY
FOR ENERGY AND FUEL PRODUCTION AND RECOVERY

ATTRACTIONNESS
(Subobjective)

PREDICTIVE CAPABILITY
AND UNDERSTANDING
(Subobjective)

ECONOMICS/PERFORMANCE
(Sub-subobjective)
Attribute: CS-E

SAFETY/ENVIRONMENT
(Sub-subobjective)
Attribute: CS-S

ATTRIBUTE: CS-P
<table>
<thead>
<tr>
<th><strong>Economics/Performance</strong></th>
<th><strong>Safety/Environment</strong></th>
<th><strong>Prediction/Understanding</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron Wall Load</td>
<td>Chemical Reactivity</td>
<td>MHD</td>
</tr>
<tr>
<td>Surface Heat Flux</td>
<td>Response to Loss-of-Coolant</td>
<td>Fluid Velocity Profile</td>
</tr>
<tr>
<td>Tritium Breeding</td>
<td>Vulnerable Tritium Inventory</td>
<td>Pressure Drop</td>
</tr>
<tr>
<td>Thermal Efficiency</td>
<td>Long-term Activation</td>
<td>Heat Transfer</td>
</tr>
<tr>
<td>Energy Multiplication</td>
<td>Afterheat</td>
<td>Corrosion</td>
</tr>
<tr>
<td>Blanket Thickness</td>
<td>Routine Radioactivity Release</td>
<td>Tritium Inventory</td>
</tr>
<tr>
<td>Reliability</td>
<td>Others</td>
<td>- Solubility</td>
</tr>
<tr>
<td>Lifetime</td>
<td></td>
<td>- Transport</td>
</tr>
<tr>
<td>Sector MTBF/MTTR</td>
<td></td>
<td>- ETC</td>
</tr>
<tr>
<td>Blanket/Transport Loop Cost</td>
<td></td>
<td>Materials Interactions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Breeder/Structure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Coolant/Structure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Purge/Breeder</td>
</tr>
</tbody>
</table>
Plasma Technology Objective
Establish the scientific and technological base required for plasma technology.

Magnet Objective
Improve magnets for fusion experiments and establish a database for the confining magnetic fields technology under conditions applicable to fusion reactors.

Heating and Current Drive Objective
Establish scientific and technological database for reliable operation of subsystems for heating plasmas to high temperatures and creating desired particle distributions and efficient confinement.

Fueling Objective
Establish scientific and technological database for reliable operation of fueling large, high temperature plasmas.

Remote Maintenance Objective
Develop design inputs, equipment and procedures to support machine availability goals.

Plasma Interactive Components Objective*
Establish the scientific and technological database for reliable operation of subsystems that provide for plasma particle and energy removal, input power transmission, and impurity control.

*Also shown under Nuclear Technology in Fig. 4.4–1.
EXAMPLES OF PLANNED EFFORT ON EXPERIMENTS, FACILITIES AND TEST PLAN
<table>
<thead>
<tr>
<th><strong>Item</strong></th>
<th><strong>Capital Cost</strong>&lt;sup&gt;a&lt;/sup&gt; (M$)</th>
<th><strong>Operating Cost</strong>&lt;sup&gt;b&lt;/sup&gt; (M$/yr)</th>
<th><strong>Duration</strong> (years)</th>
<th><strong>Total Cost</strong> (M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced liquid metal flow facility (LMF1)</td>
<td>7-10</td>
<td>0.5</td>
<td>4-6</td>
<td>10-15</td>
</tr>
<tr>
<td>Integral Parameter Experiment (LMF2)</td>
<td>7-10</td>
<td>0.5</td>
<td>4-6</td>
<td>10-15</td>
</tr>
<tr>
<td>MHD mass transfer facility (MHDM)</td>
<td>8-12</td>
<td>1.0</td>
<td>6-8</td>
<td>15-20</td>
</tr>
<tr>
<td>Thermal convection loops (~4)</td>
<td>2-4</td>
<td>0.8</td>
<td>4-6</td>
<td>5-9</td>
</tr>
<tr>
<td>Forced convection loops (~4)</td>
<td>4-6</td>
<td>0.8</td>
<td>4-6</td>
<td>7-11</td>
</tr>
<tr>
<td>Tritium extraction test (2)</td>
<td>2-3</td>
<td>0.4</td>
<td>3-4</td>
<td>3-5</td>
</tr>
<tr>
<td>Tritium transport loop test</td>
<td>6-8</td>
<td>0.6</td>
<td>5-7</td>
<td>9-12</td>
</tr>
<tr>
<td>Thermomechanical Integrated Test Facility (TMIF)</td>
<td>20-25</td>
<td>2.0-3.0</td>
<td>8-10</td>
<td>35-60</td>
</tr>
<tr>
<td>Analysis and model development</td>
<td>--</td>
<td>2.0-4.0</td>
<td>15</td>
<td>30-60</td>
</tr>
</tbody>
</table>

<sup>a</sup>In 1985 constant dollars

<sup>b</sup>Does not include analysis of data