FUSION TECHNOLOGY
TECHNICAL PLANNING ACTIVITY

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BRIEFING TO JOINT HHFMCD/PMI
TASK GROUPS MEETING
WASHINGTON, D.C.
MAY 21, 1985

OUTLINE

- Summary of Key MFPP Points
- TPA Technology Approach
- Experience from the FINESSE Process and Other Activities
- HHFMCD/PMI Task Groups

Note

- TPA is still in the stage of structure formulation
- Ideas presented here are tentative

MFPP SUMMARY

GOAL

"ESTABLISH THE SCIENTIFIC AND TECHNOLOGICAL BASE REQUIRED FOR FUSION ENERGY"

(THE SCIENTIFIC AND TECHNOLOGICAL BASE SHOULD BE SUFFICIENT TO ASSESS THE TECHNICAL, ECONOMIC AND ENVIRONMENTAL POTENTIAL OF FUSION AS AN ENERGY SOURCE).

STRATEGIC OBJECTIVES

1. SCIENTIFIC OBJECTIVE: IS TO BE ABLE TO PREDICT, CONTROL AND OPTIMIZE THE BEHAVIOR OF PLASMA CONFINED IN FUSION RELEVANT MAGNETIC CONFIGURATIONS.

2. TECHNOLOGY OBJECTIVE: IS TO SHOW THAT IT IS POSSIBLE TO CREATE THE UNIQUE FUSION COMPONENTS AND SUBSYSTEMS UNDER CONDITIONS RELEVANT TO FUSION ENERGY SOURCES.

3. TECHNOLOGY TRANSFER OBJECTIVE: IS TO PROVIDE A RANGE OF OPTIONS FOR PRIVATE SECTOR INVESTMENT AND COMMERICAL DEVELOPMENT OF FUSION.

STRATEGY

- ESSENCE: "MAINTAIN A BROAD DOMESTIC RESEARCH AND DEVELOPMENT PROGRAM WITH EMPHASIS ON ESTABLISHING THE BASIC ELEMENTS (COMPONENTS OR SUBSYSTEMS) OF THE SCIENCE AND ENGINEERING TECHNOLOGY REQUIRED FOR FUSION."

MFPP SUMMARY (CONT'D)

- MUST TAKE INTO ACCOUNT:

  KEY TECHNICAL ISSUES
  - MAGNETIC CONFINEMENT SYSTEMS
  - PROPERTIES OF BURNING PLASMAS
  - MATERIALS OF FUSION SYSTEMS
  - NUCLEAR TECHNOLOGY OF FUSION SYSTEMS

  SCHEDULE

  SOLVE FUSION'S TECHNICAL PROBLEMS WITHIN A TIME FRAME KEYED TO RESOLUTION OF PROBLEMS IN OTHER AREAS OF ENERGY DEVELOPMENT

  RESOURCES
  - TECHNICAL PERSONNEL
    - UNIVERSITIES, CREATIVE RESEARCH WITHIN OVERALL PROGRAM
  - BUDGETS
    - SUPPORT DOMESTIC PROGRAM FOR EFFECTIVE INTERNATIONAL COOPERATION
    - SUPPORT APPROPRIATE EXPERIMENTS, FACILITIES
  - INTERNATIONAL COOPERATION

- NEXT 5 YEARS:

  - INTENSIVE EFFORT TO IDENTIFY COST-EFECTIVE COMPONENT AND SYSTEM TEST FACILITIES FOR RESOLVING THE KEY TECHNICAL ISSUES
  - IF MORE INTEGRATED AND EXPENSIVE FACILITIES ARE NEEDED.......DEGREE OF INTERNATIONAL COOPERATION

FUSION TECHNOLOGY COMPONENTS

- FIRST WALL/BLANKET
  (INCLUDING HEAT TRANSPORT SYSTEM)
- PLASMA INTERACTIVE COMPONENTS (PIC)
  (FIRST WALL, LIMITERS/DIVERTORS, DIRECT CONVERTORS, ETC.)
- TRITIUM PROCESSING/VACUUM SYSTEM
- MAGNETS
  (INCLUDING ASSOCIATED POWER SUPPLIES)
- PLASMA HEATING/FUELING SYSTEMS
- INSTRUMENTATION AND CONTROL SYSTEMS
- REMOTE MAINTENANCE

KEY ELEMENTS OF APPROACH FOR TPA TECHNOLOGY

- OBJECTIVES
  - OVERALL OBJECTIVE FROM MFPP
  - DEVELOP MEASURABLE (SUB)OBJECTIVES FOR EACH TECHNOLOGY COMPONENT
- ATTRIBUTES
  - DEVELOP ATTRIBUTES (EVALUATION SCALES) TO MEASURE PROGRESS TOWARD GOALS (FACILITATES COMPARISON OF RELATIVE WORTH OF ISSUES, FACILITIES, ALTERNATIVE PATHWAYS, ETC.)
- CHARACTERIZE ISSUES
  - QUANTIFIED UNDERSTANDING OF KEY ISSUES (POTENTIAL IMPACT, CONDITIONS UDNER WHICH ISSUE BECOMES DOMINANT OR UNIMPORTANT, ETC.)
- QUANTIFY EXPERIMENTAL NEEDS
  - IDENTIFY DESIRED EXPERIMENTS AND KEY EXPERIMENTAL CONDITIONS TO RESOLVE KEY ISSUES
- EVALUATE FACILITIES

  EXISTING
    - EVALUATE CAPABILITIES AND LIMITATIONS
    - IDENTIFY EXPERIMENTS
    - ESTIMATE COSTS, TIME

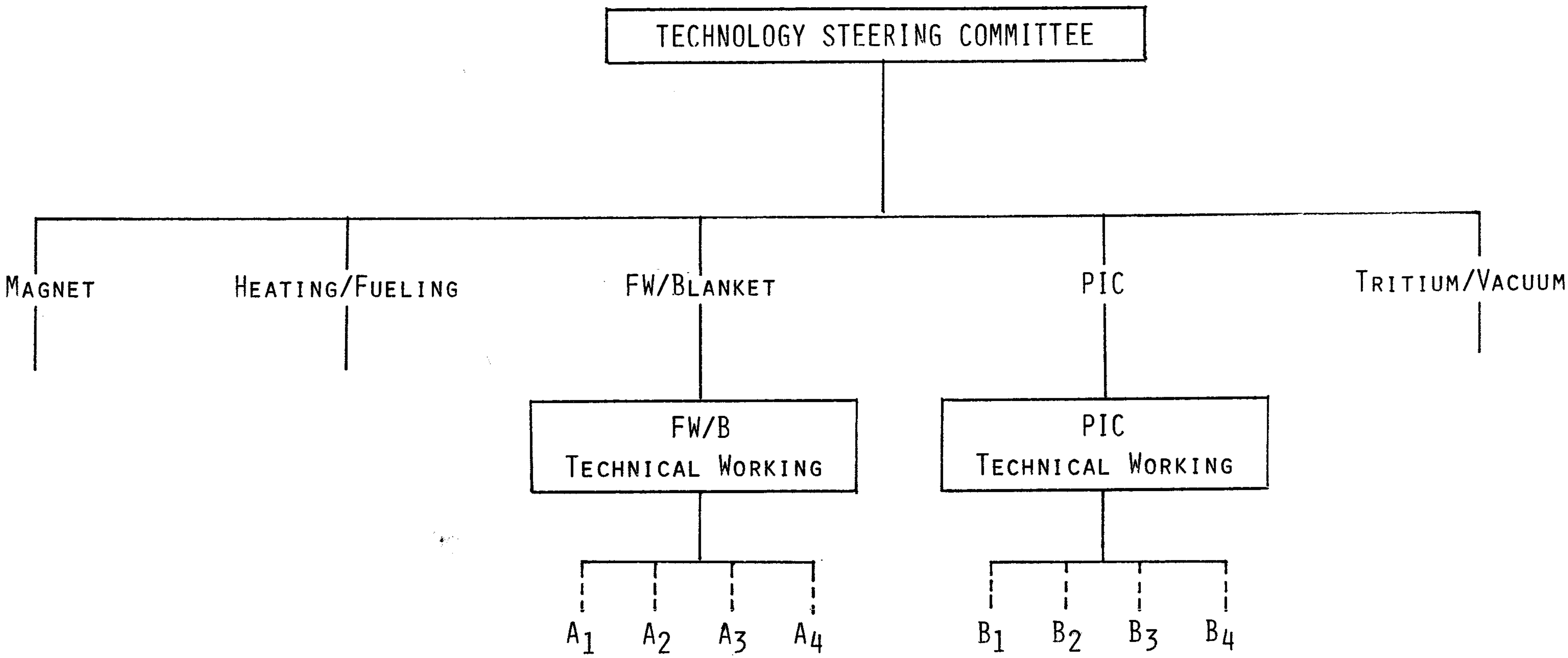
  NEW
    - EXPLORE TESTING IDEAS
    - DEFINE MAJOR NEW FACILITIES
    - ESTIMATE COSTS, TIME

KEY ELEMENTS OF APPROACH FOR TPA TECHNOLOGY (CONT'D)

- DEVELOP TEST PLAN ALTERNATIVES
  - DEFINE ALTERNATIVE R&D PATHWAYS AND LOGIC (DESIGN OPTIONS TO BE INCLUDED, ISSUES TO BE ADDRESSED, EXPERIMENTS TO BE PERFORMED, FACILITIES TO BE USED, SEQUENTIAL OR PARALLEL TIMING, ETC.)
  - ELIMINATE CLEARLY UNACCEPTABLE ALTERNATIVE PATHWAYS
  - PREDICT CONSEQUENCES OF REMAINING ALTERNATIVE PATHWAYS (RESULTS FROM PATHWAY ELEMENTS MAY BE POSITIVE OR NEGATIVE, DEGREE OF PROGRESS TOWARD OBJECTIVES, ETC.)
  - DETERMINE PREFERENCE OF COMMUNITY/OFE TO CONSEQUENCES

- EVALUATE AND COMPARE ALTERNATIVES

- ITERATE



- TENTATIVE STRUCTURE FOR TPA FUSION TECHNOLOGY
- STEERING COMMITTEE (ABOUT SIX MEMBERS)
- TECHNICAL WORKING GROUP FOR EACH COMPONENT
- (A_1, A_2,...), (B_1, B_2,...) REPRESENTS INPUT FROM EXISTING STUDIES, PROJECTS, TASK GROUPS, ETC.

SUGGESTED ROLE OF HHFMCD/PMI TASK GROUPS IN TPA

- TPA INTENDS TO MAXIMIZE INPUT FROM AND INTERACTION WITH EXISTING STUDIES, PROGRAMS, PROJECTS, TASK GROUPS, ETC.

- TWO MEMBERS OF HHFMCD/PMI TASK GROUPS ARE MEMBERS OF THE TPA STEERING COMMITTEE

- OTHER MEMBERS WILL BE SELECTED FOR THE PIC TECHNICAL WORKING GROUP

- PMI/HHFMCD TASK GROUPS REPRESENT AN IDEAL RESOURCE TO:

  - PERFORM IMPORTANT TPA TASKS ON PIC

  - DEVELOP/CRITIQUE/REVIEW/MODIFY PROMISING ALTERNATIVE PATHWAYS FOR PIC

PLASMA INTERACTIVE COMPONENT ISSUES/FACILITIES MATRIX

Issues	Non-neutron tests: Benchtop tests	Non-neutron tests: T glove box tests	Non-neutron tests: High plasma flux	Non-neutron tests: Tritium plasma facility	Non-neutron tests: Transient EM facility	High heat flux facilities: Beam source (spot)	High heat flux facilities: Radiative source (modest A)	High heat flux facilities: Multiple beam source (modest A)	High heat flux facilities: Plasma source (large A)	Neutron sources: Fission specimen tests	Neutron sources: Point source specimen tests	Fusion devices: Plasma confnmnt exp.	Fusion devices: Existing DT exp.	Fusion devices: Ignition device	Fusion devices: FERF
1. Surface Physics															
a. Erosion/redeposition	L	-	M	-	-	-	-	L	M	L	L	L	L	H	H
b. Surface conditioning	L	L	M	L	-	-	-	L	M	L	L	M	M	H	H
c. Tritium permeation/retention	L	L	L	M	-	-	-	L	L	L	L	L	M	H	H
d. Fluence effects	-	-	-	-	-	-	-	-	-	L	L	-	-	H	H
2. Disruption effects															
a. Eddy current forces/response	L	-	-	-	M	-	-	-	-	-	-	M	M	H	H
b. Melt layer formation/behavior	L	-	-	-	M	-	-	L	L	-	-	-	L	H	H
3. Composite structure behavior															
a. Heat transfer across structure	L	-	L	-	-	-	M	M	M	-	-	M	M	H	H
b. Thermal stresses and fatigue	L	-	-	-	-	L	M	M	M	-	-	M	M	H	H
c. Radiation effects	-	-	-	-	-	-	-	-	L	-	-	M	M	H	H
d. Bond or attachment integrity	L	-	-	-	L	-	L	L	M	L	L	L	L	M	H
4. Insulating materials															
a. Thermal stresses and fatigue	L	-	-	-	-	L	M	M	M	L	L	L	L	H	H
b. Radiation effects	-	-	-	-	-	-	-	-	-	M	M	-	-	H	H
5. Active cooling of large areas															
a. CHF and channel erosion	-	-	-	-	-	L	H	H	H	-	-	L	L	H	H
b. Multiple channel flow behavior	L	-	-	-	L(1)	-	M	M	H	-	-	L	L	H	H
6. Replacement and maintenance	L	L	L	-	-	-	-	-	-	-	-	L	M	H	H

-: No particular value.
L: Useful.
M: Significant, but not definitive.
H: Probably definitive.

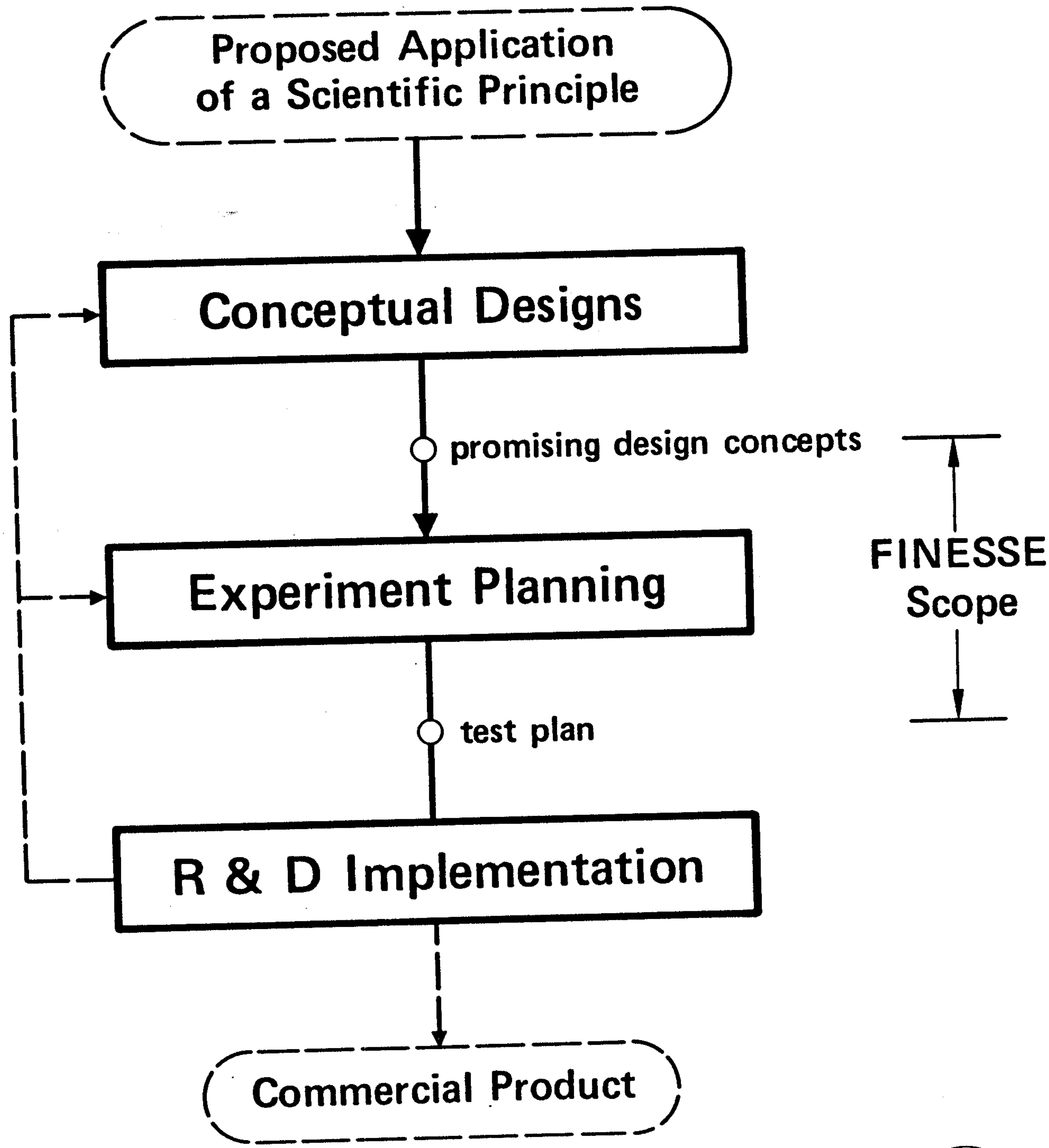
(1) For liquid metal cooled HHFC.

APPENDIX

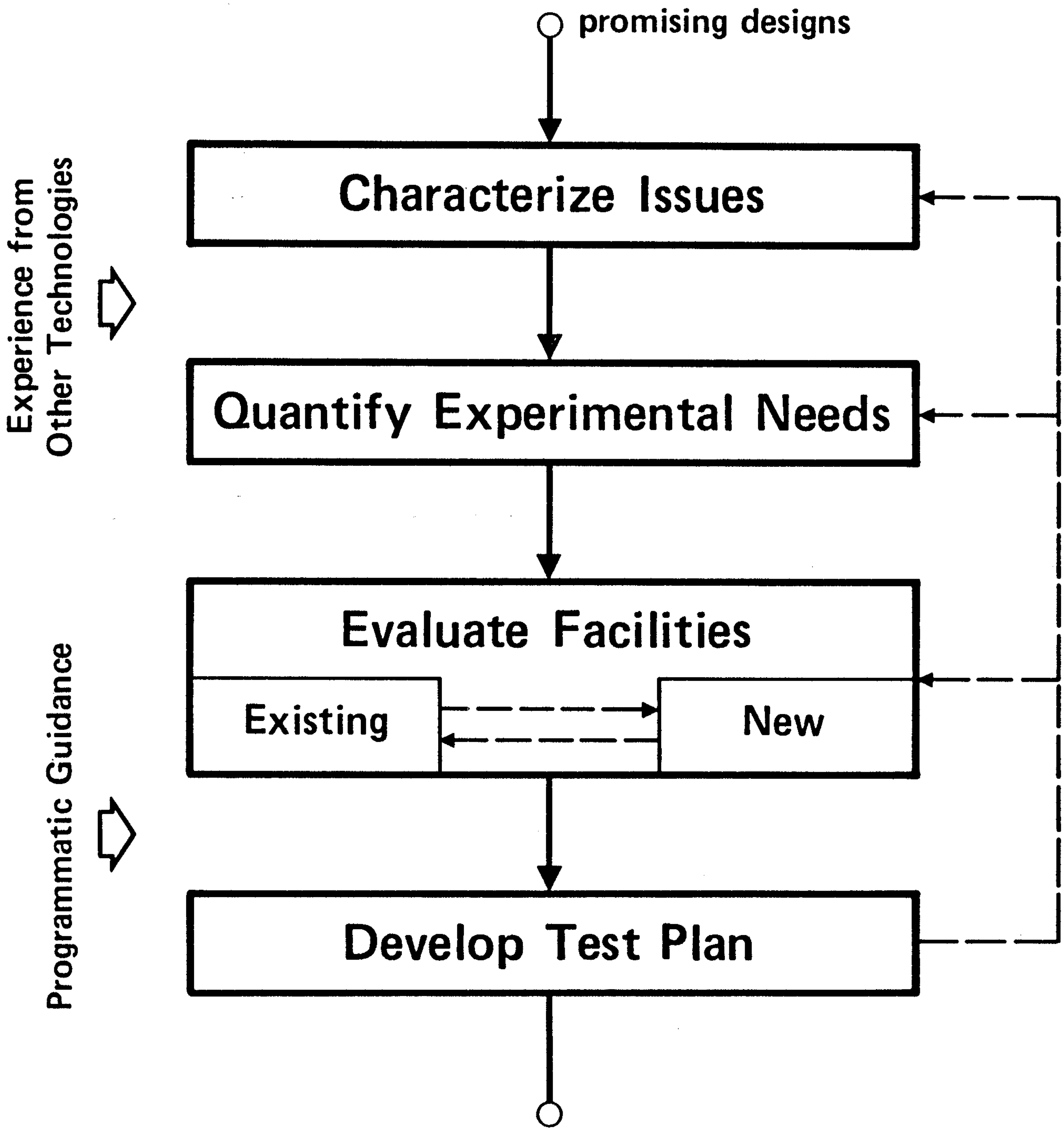
FINESSE Process

In the course of carrying out FINESSE, a Process for Experiment Technical Planning has evolved. This process has proved useful in technical planning of Fusion Nuclear Technology. The process has important features relevant to TPA. Highlights of the process follow. Details are provided in the FINESSE reports.

EXPERIMENT PLANNING
Is a Key Element of Technology Development



FINESSE PROCESS For Experiment Planning



Role, Timing, Characteristics
of Major Experiments, Facilities

FINESSE

Characterize Issues

- Assess Accuracy and Completeness of Existing Data and Models
- Analyze Scientific/Engineering Phenomena to Determine (Anticipate) Behavior, Interactions and Governing Parameters in Fusion Reactor Environment
- Evaluate Effect of Uncertainties on Design Performance
- Compare Tolerable and Estimated Uncertainties

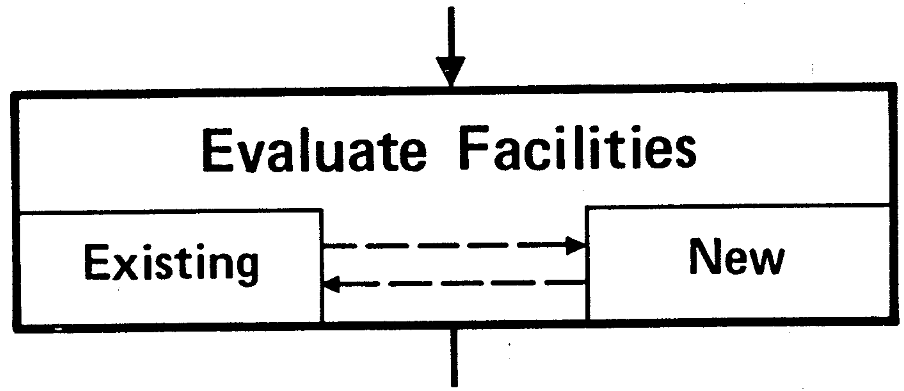
△ Quantified Understanding of Important Issues, Interactions, Parameters . . .

FINESSE

Quantify Experimental Needs

- Survey Needed Experiments
- Explore Engineering Scaling Options
  (Engineering Scaling is a Process to Develop Meaningful Tests at Experimental Conditions and Parameters Less Than Those in a Reactor)
- Evaluate Effects of Scaling on Usefulness of Experiments in Resolving Issues
- Develop Technical Test Criteria for Preserving Design-Relevant Behavior
- Identify Desired Experiments and Key Experimental Conditions

FINESSE



- Survey (Availability)
- Evaluate Capabalities and Limitations
- Define Meaningful Experiments (Experiment Conceptual Design a Tool)
- Estimate Costs

- Explore Innovative Testing Ideas
- Assess Feasibility of Obtaining Desired Information (e.g. I & C Limitations)
- Develop Preliminary
  - Conceptual Designs of Facilities
  - Cost Estimates
- Trade offs in Sequential and Parallel Experiments and Facilities
- Define Major Facilities

Develop Test Plan

- Define Test Program Scenarios Based on
  - Promising Design Concepts
  - Importance of Issues
  - Desired Experiments
  - Possible Test Facilities
- Compare Risk, Usefulness and Cost of Test Program Scenarios

FINESSE

POTENTIAL IMPACT

Feasibility Issues

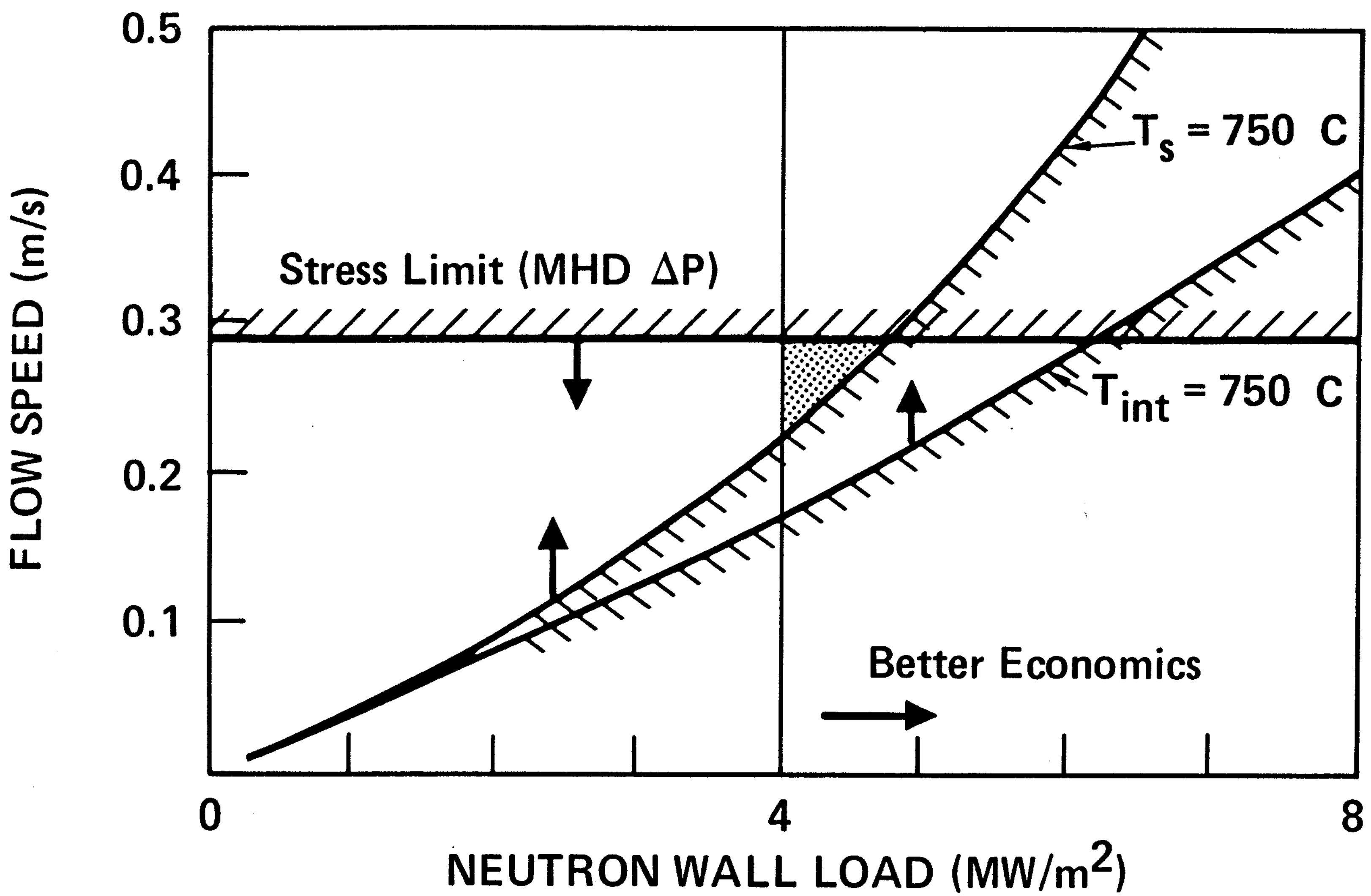
- May Close the Design Window
- May Result in Unacceptable Safety Risk
- May Result in Unacceptable Reliability, Availability or Lifetime

Attractiveness Issues

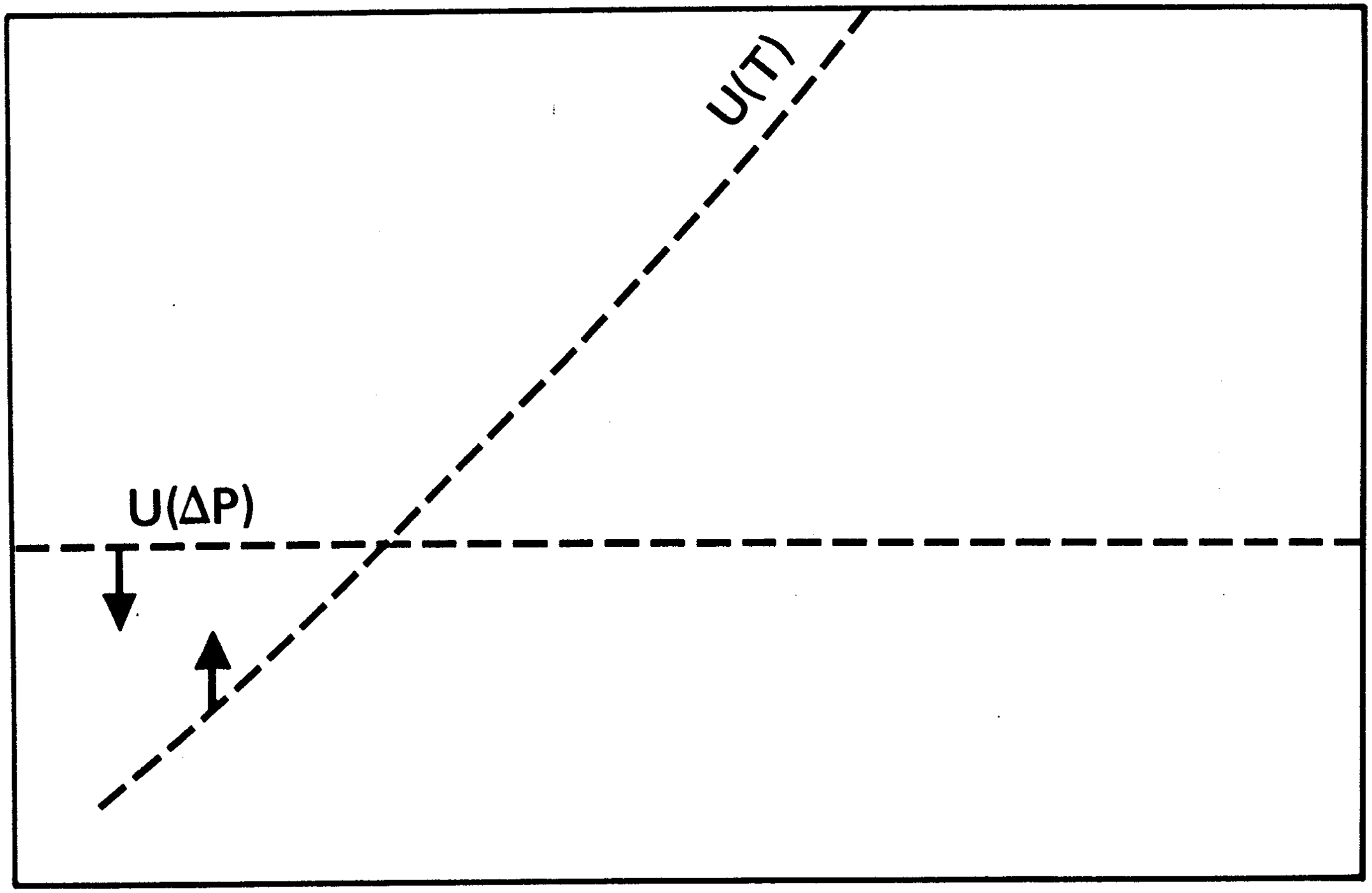
- Reduced System Performance
- Reduced Component Lifetime
- Increased System Cost
- Less Desirable Safety or Environmental Impact

FINESSE

Design Window Is Narrow For Best Liquid Metal Blanket (Li/V)



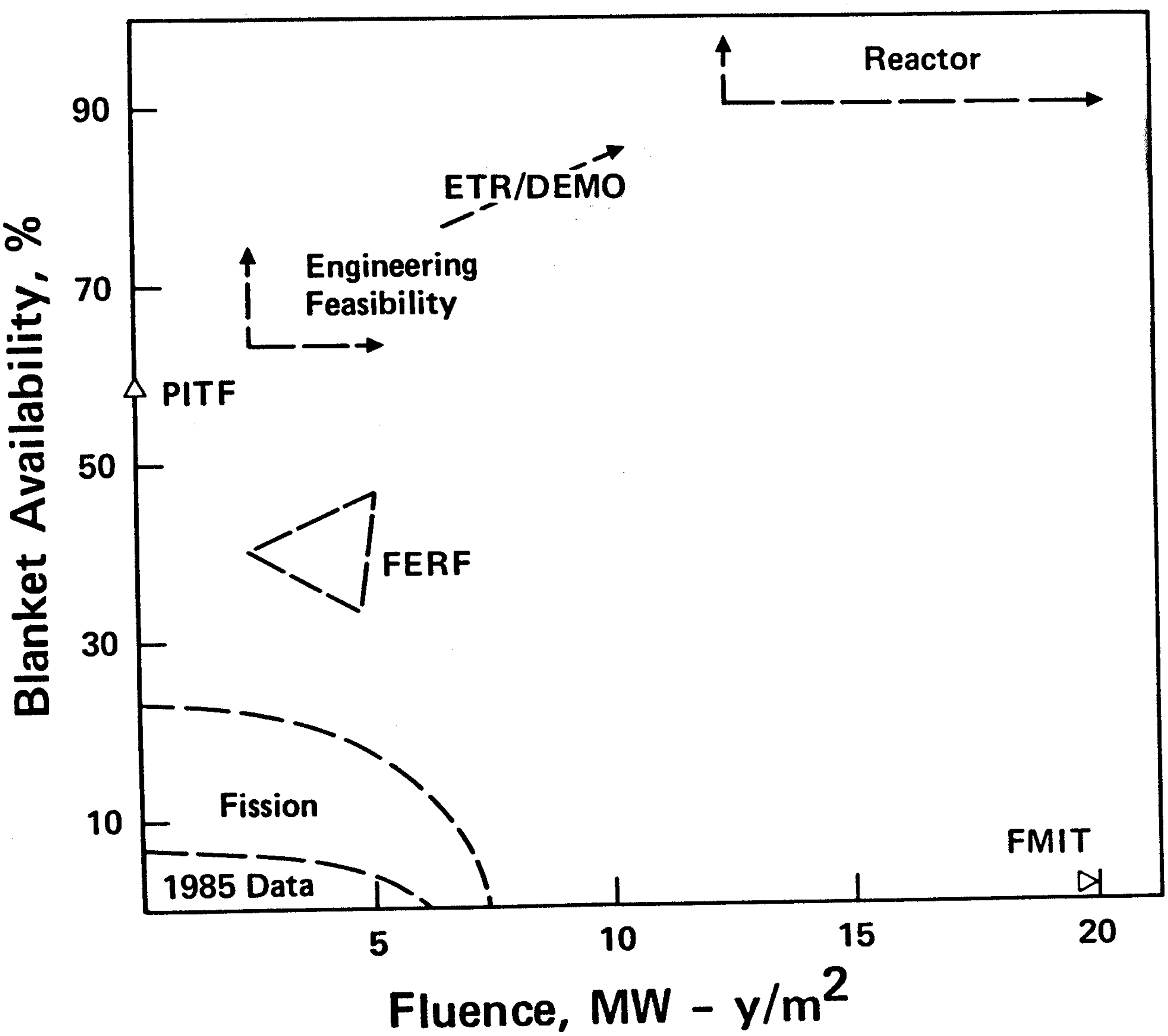
FINESSE



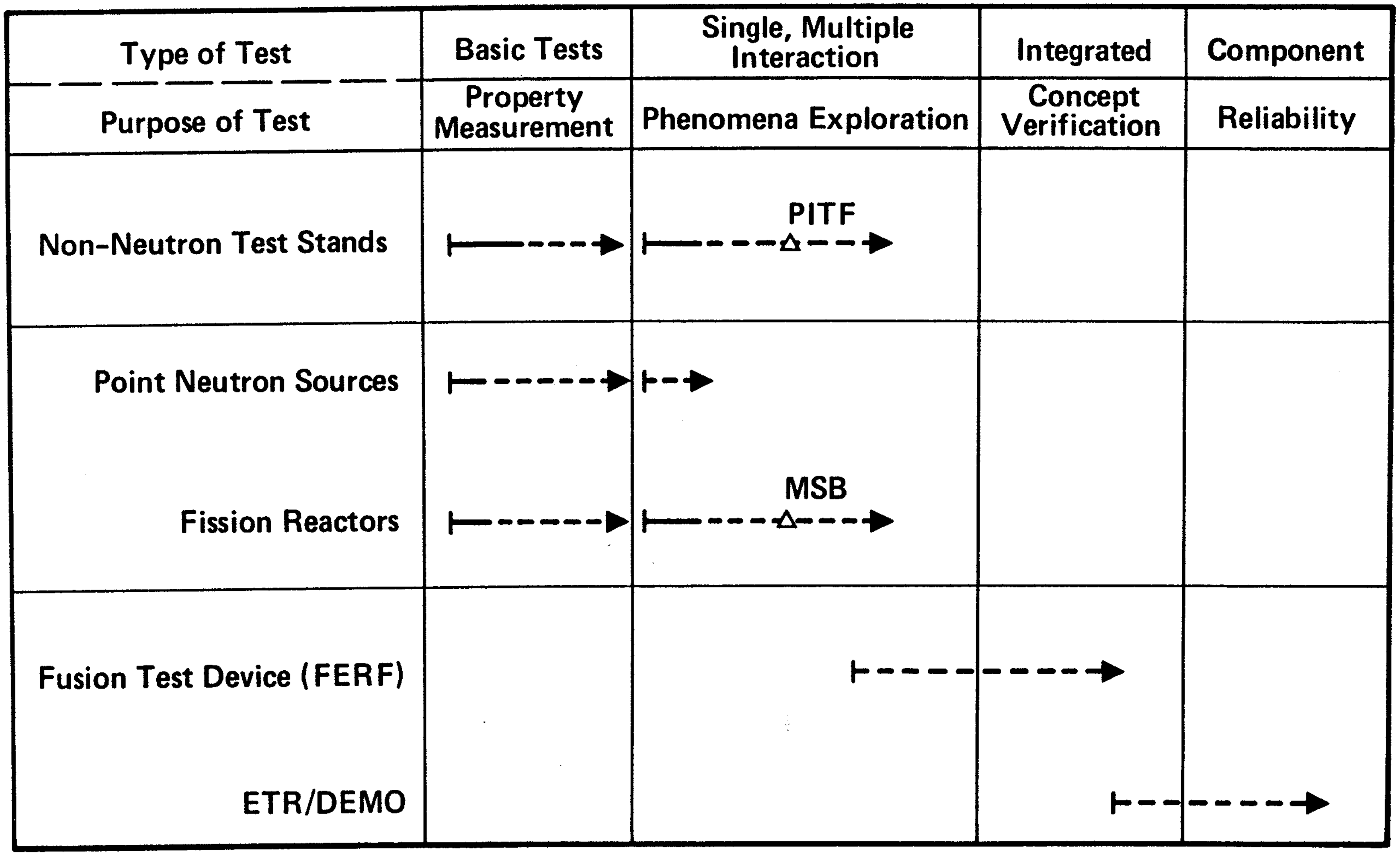
U(T): Any of:
$T_s = 650\ C$
$T_{int} = 550\ C$
$h_m = 0.7h$

Uncertainties in MHD, Corrosion, Heat Transfer,
Radiation Effects Represent Major Issues

Obtaining Availability and Fluence Data For Blanket Is Most Difficult



Role of Facilities For Fusion Nuclear Technology



FINESSE