TECHNICAL PLANNING ACTIVITY FOR FUSION TECHNOLOGY

MOHAMED ABDOU

TPA STEERING COMMITTEE MEETING,
ARGONNE NATIONAL LABORATORY
JUNE 4-5, 1985

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.

MFPP SUMMARY (CONT'D)

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."

- MUST TAKE INTO ACCOUNT:

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

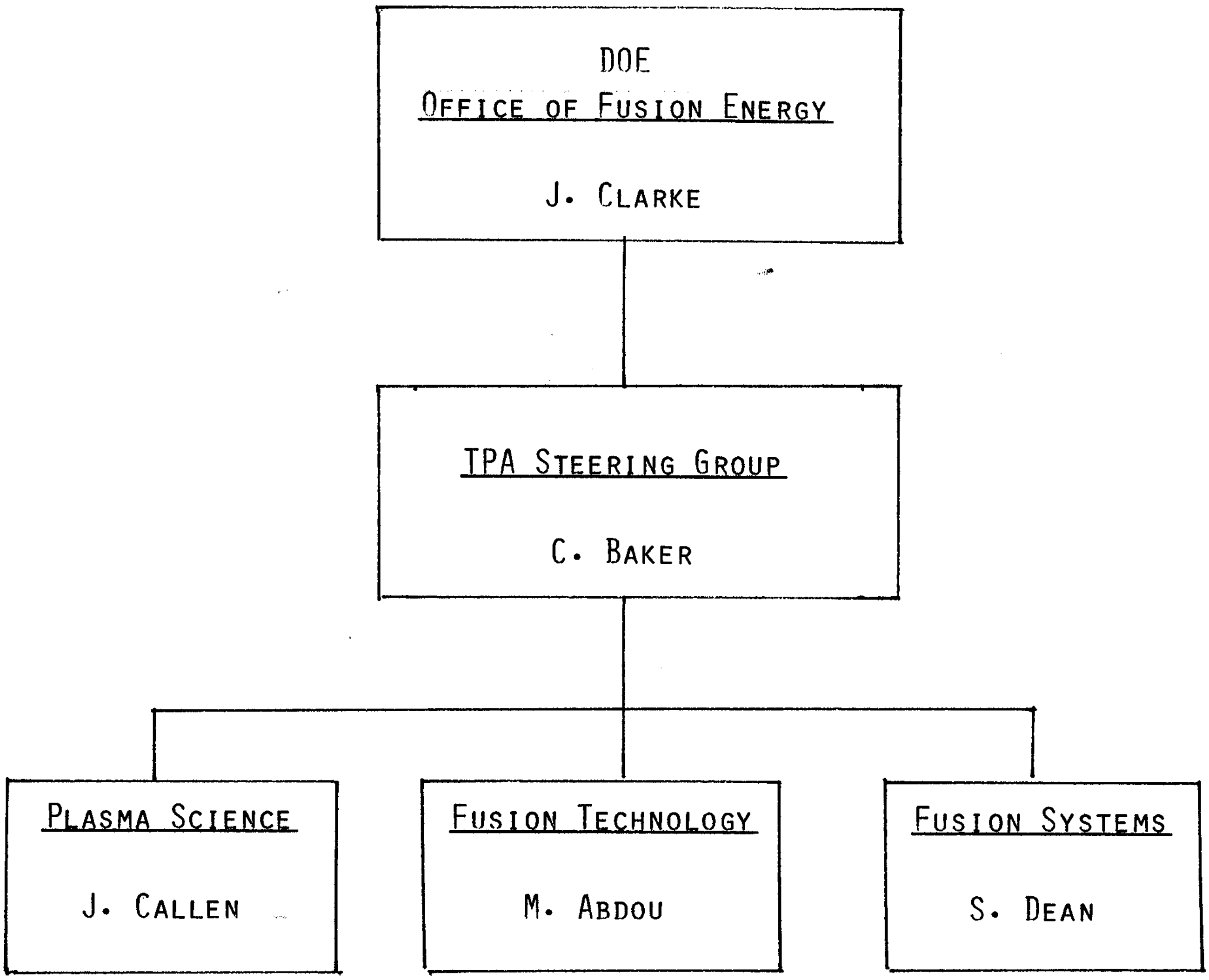
- SCHEDULE

  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


DOE
Office of Fusion Energy
J. Clarke
TPA Steering Group
C. Baker
Plasma Science
J. Callen
Fusion Technology
M. Abdou
Fusion Systems
S. Dean

TECHNOLOGY STEERING COMMITTEE (TSC)

MOHAMED A. ABDOU, CHAIRMAN

LEE A. BERRY (ORNL)

WILL GAUSTER (SANDIA)

CARL D. HENNING (LLNL)

MICHAEL KORENKO (W/HEDL)

JAMES A. MANISCALCO* (TRW)

JOHN SCHMIDT (PPPL)

DALE L. SMITH (ANL)

HERBERT WOODSON (U. OF TEXAS)

TECHNICAL DISCIPLINES IN FUSION TECHNOLOGY

NUCLEAR PHYSICS

NEUTRON TRANSPORT

THERMODYNAMICS

FLUID MECHANICS

CHEMISTRY

ELECTROMAGNETICS

STRUCTURAL MECHANICS

METALLURGY

RADIATION DAMAGE

NUCLEAR, MECHANICAL, CHEMICAL ENGINEERING

FUSION TECHNOLOGY COMPONENTS

- FIRST WALL/BLANKET/SHIELD
  (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

TECHNOLOGY STEERING COMMITTEE

- TECHNOLOGY COMPONENTS
  - MAGNET
  - HEATING/FUELING
  - FW/BLANKET
  - PIC
  - TRITIUM/VACUUM
- SPECIAL (MATRIX) TASKS
  - MATERIAL BASIC PROPERTIES
  - MATERIAL IRRADIATION
  - SAFETY & ENVIRONMENT
  - NON-ELECTRICAL APPLICATIONS
  - REMOTE MAINTENANCE

- EACH TECHNOLOGY COMPONENT HAS A TECHNICAL WORKING GROUP CONSISTING OF:
  - TSC MEMBER
  - LEADER (NOT FROM TSC)
  - SEVERAL EXPERTS FROM THE COMMUNITY
- EXISTING STUDIES, PROGRAMS, TASK GROUPS PROVIDE INPUT TO WORKING GROUPS

COMPONENT (OR TASK)	SC MEMBER	LEADER	MEMBERS
MAGNETS	HENNING	MONTGOMERY	
HEATING/FUELING	BERRY		
FW/BLANKET/SHIELD	ABDOU	GIERSZEWSKI	
TRITIUM PROCESSING/VACUUM		BARTLIT	
PLASMA INTERACTIVE COMPONENTS	GAUSTER/SCHMIDT		
MATERIAL BASIC PROPERTIES	SMITH		
MATERIAL IRRADIATION	KORENKO/SMITH		
SAFETY & ENVIRONMENT		CROCKER	
NON-ELECTRICAL APPLICATIONS	MANISCALCO	BERWALD	
REMOTE MAINTENANCE			

EXAMPLES OF TECHNICAL

WORKING GROUPS

MAGNETS

SC MEMBER: C. HENNING

GROUP LEADER: B. MONTGOMERY

MEMBERS

HEATING/FUELING

SC MEMBER: L. BERRY

GROUP LEADER:

MEMBERS

D. SWAIN
D. BAKER
J. RAWLS
H. HAZELTON
J. HOSEA
S. FRIJIE

FIRST WALL/BLANKET/SHIELD

SC MEMBER: M. ABDOU

TECHNICAL GROUP LEADER: P. GIERSZEWSKI

MEMBERS

- D. K. SZE
- R. MATTAS
- C. JOHNSON
- M. TILLACK
- J. GROVER
- D. BERWALD
- C. GARNER
- T. CARPENTER
- W. WIFFEN (OR R. CLIFF)
- J. DAVIS
- K. SCHULTZ
- M. HOFFMAN

BASIC MATERIAL PROPERTIES

- PURPOSE: PROVIDE ACROSS THE BOARD ASSESSMENT OF NEEDS AND PRIORITIES FOR BASIC MATERIAL PROPERTIES (PHYSICAL, CHEMICAL, MECHANICAL AND NUCLEAR PROPERTIES)

- NOTE THAT IRRADIATION IS INCLUDED IN A SPECIAL TASK GROUP AND UNDER COMPONENTS.

  UNDER BASIC PROPERTIES ADDRESS IRRADIATION ONLY FOR:
  - SINGLE MATERIAL TESTS
  - IRRADIATION IN EXISTING FACILITIES

SC MEMBER: D. SMITH

GROUP LEADER:

MEMBERS

MATERIAL IRRADIATION

- THIS TASK GROUP WILL ADDRESS "SPECIFIC DIFFICULT QUESTIONS" ON MATERIAL IRRADIATON IN FUSION ENVIRONMENT

- MOTIVATION FOR TASK:

  BEYOND EXISTING IRRADIATION FACILITIES (I.E., FISSION REACTORS, ION SIMULATION), A NEW FACILITY TO PROVIDE FUSION ENVIRONMENT (E.G., FMIT-LIKE, FERF-LIKE) MAY NOT BE BUILT IN THE MFPP TIME FRAME (NOW TO THE YEAR 2000). THE IMPACT OF SUCH A POSSIBILITY NEEDS TO BE CAREFULLY ADDRESSED.

- SCOPE
  - EVALUATE THE LEVEL OF CONFIDENCE IN PREDICTING MATERIAL BEHAVIOR UNDER IRRADIATON ATTAINABLE IN THE YEAR 2000 USING ONLY EXISTING FACILITIES
  - ASSESS THE IMPACT OF THE LACK OF FUSION TESTING ENVIRONMENT ON SELECTION OF MATERIAL CANDIDATES TO BE INCLUDED IN TPA STRATEGY.

    E.G., CAN WE STILL INCLUDE AN ADVANCED STRUCTURAL ALLOY IN R&D PLAN FOR SELECTION OF A BLANKET IN THE NEXT 15 YEARS? LOW ACTIVATION STRATEGY? ANY IMPACT ON BREEDER MATERIAL CHOICES?
  - EVALUATE THE IMPROVEMENT IN CONFIDENCE LEVEL IN THE YEAR 2000 IF TESTING IN THE FUSION ENVIRONMENT WAS POSSIBLE BEFORE THEN TO A TESTING FLUENCE OF 3 $MW \cdot Y/M^2$

- PROVIDE INPUT TO BLANKET GROUP IN THEIR SUBTASK OF EVALUATING AND COMPARING OPTIONS FOR FUSION TESTING (ACCELERATOR-DRIVEN OR PLASMA-DRIVEN)

TRITIUM PROCESSING/VACUUM

SC MEMBER: ? (ANDERSON?) (ABDOU?)

GROUP LEADER: J. BARTLIT OR J. ANDERSON

MEMBERS

D. K. SZE
J. REIMANN
K. WILSON
(OTHERS FROM LANL?)

PLASMA INTERACTIVE COMPONENTS

SC MEMBER(S): W. GAUSTER, J. SCHMIDT

TECHNICAL GROUP LEADER: ?

MEMBERS

K. WILSON
R. MCGRATH
J. WHITELY
R. WATSON
J. BROOKS
R. MATTAS
B. LIPSCHULTZ
P. GIERSZEWSKI
S. COHEN
D. GOEBELS
F. CLINARD
J. DOWNING

SAFETY & ENVIRONMENT

- **SCOPE**

  - EXAMINE OPTIONS AND DEFINE GUIDELINES FOR MFPP STRATEGY TO IMPROVE SAFETY & ENVIRONMENTAL ATTRACTIVENESS OF FUSION BY THE YEAR 2000

  - INTERACT WITH "TECHNOLOGY COMPONENT GROUPS" AND SUGGEST MODIFICATIONS, GUIDELINES, AND SPECIFIC EXPERIMENTS/ FACILITIES NOT COVERED BY GROUPS

- SC MEMBER: ? (CROCKER?)

  GROUP LEADER: J. CROCKER

MEMBERS

M. KAZIMI
S. PIET
J. BARTLIT
J. HOLDREN
M. TILLACK

NON-ELECTRICAL APPLICATIONS

- ASSESS IMPACT OF NON-ELECTRICAL APPLICATIONS DEFINED BY THE TPA SYSTEMS GROUP ON THE R&D DEFINED IN THE TECHNOLOGY GROUP

SC MEMBER: J. MANISCALCO

GROUP LEADER: D. BERWALD

MEMBERS

R. MOIR

REMOTE MAINTENANCE

- ARE THERE ASPECTS OF REMOTE MAINTENANCE THAT NEED TO BE ADDRESSED BY A R&D PROGRAM SEPARATE FROM THOSE FOR TECHNOLOGY COMPONENTS AND PROJECT DEVICES (E.G., IGNITION DEVICE PROJECT)?

SC MEMBER: ? (HENNING?)

GROUP LEADER: ? (L. MASSON?)

"STRUCTURED" 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

DECISION PROBLEMS

In order to simplify the problem, a number of distinct decision problems will be considered separately. These are:

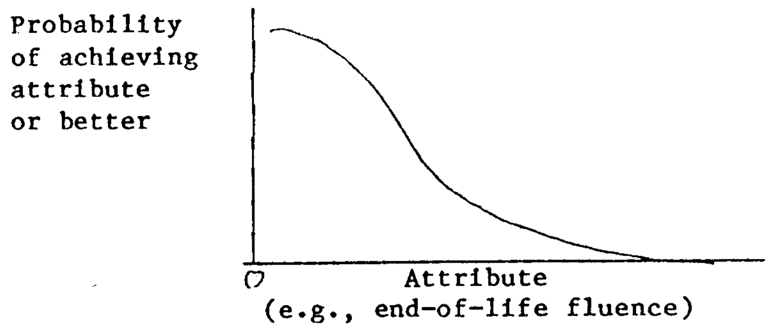
A) Determine optimum blanket development test plan assuming modest funding levels (15 year test plan, no major facilities over 100 M$ such as FMIT or FERF). Include plans that develop a primary LM blanket, multiple LM blankets, primary SB blanket, multiple SB blankets, and combined SB/LM blankets. Test plans should have comparable funding levels (to be determined). Alternative test plans within the above categories may be considered to better illustrate the "optimal" plans. Test plans will be determined by each technical group.

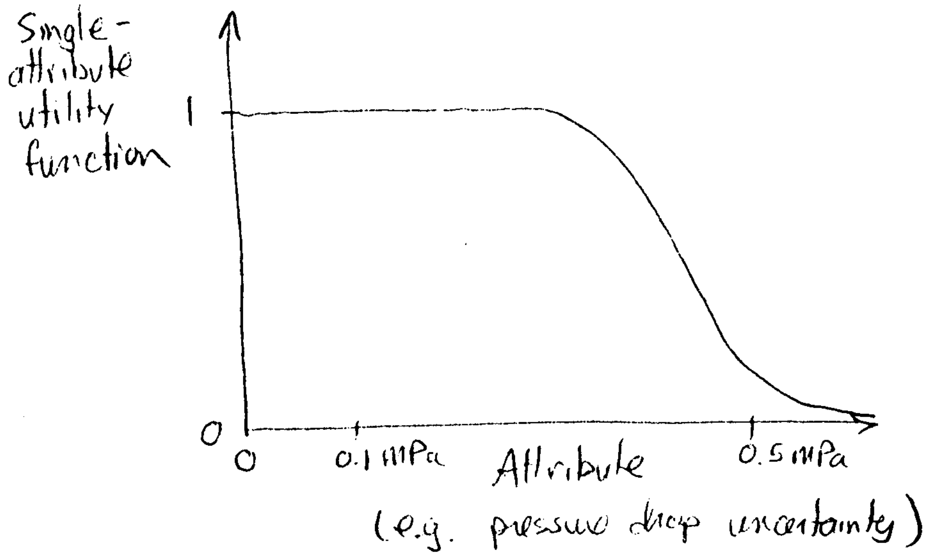
B) Comparison of utility of blanket test plans with FMIT-class facility versus those with FERF-class facility (or with both?), for LM, SB and SB/LM test plans.

C) Comparison of two overall fusion test plans: fusion technology test plan with FERF or FMIT (whichever is more useful from (B) plus physics test plan with BCX device, and fusion technology test plan without FERF or FMIT plus physics test plan without BCX.

Initial efforts are focussed on Decision Problem A.

Figure 2: Representative input to decision analysis evaluation from technical group for a particular test plan.





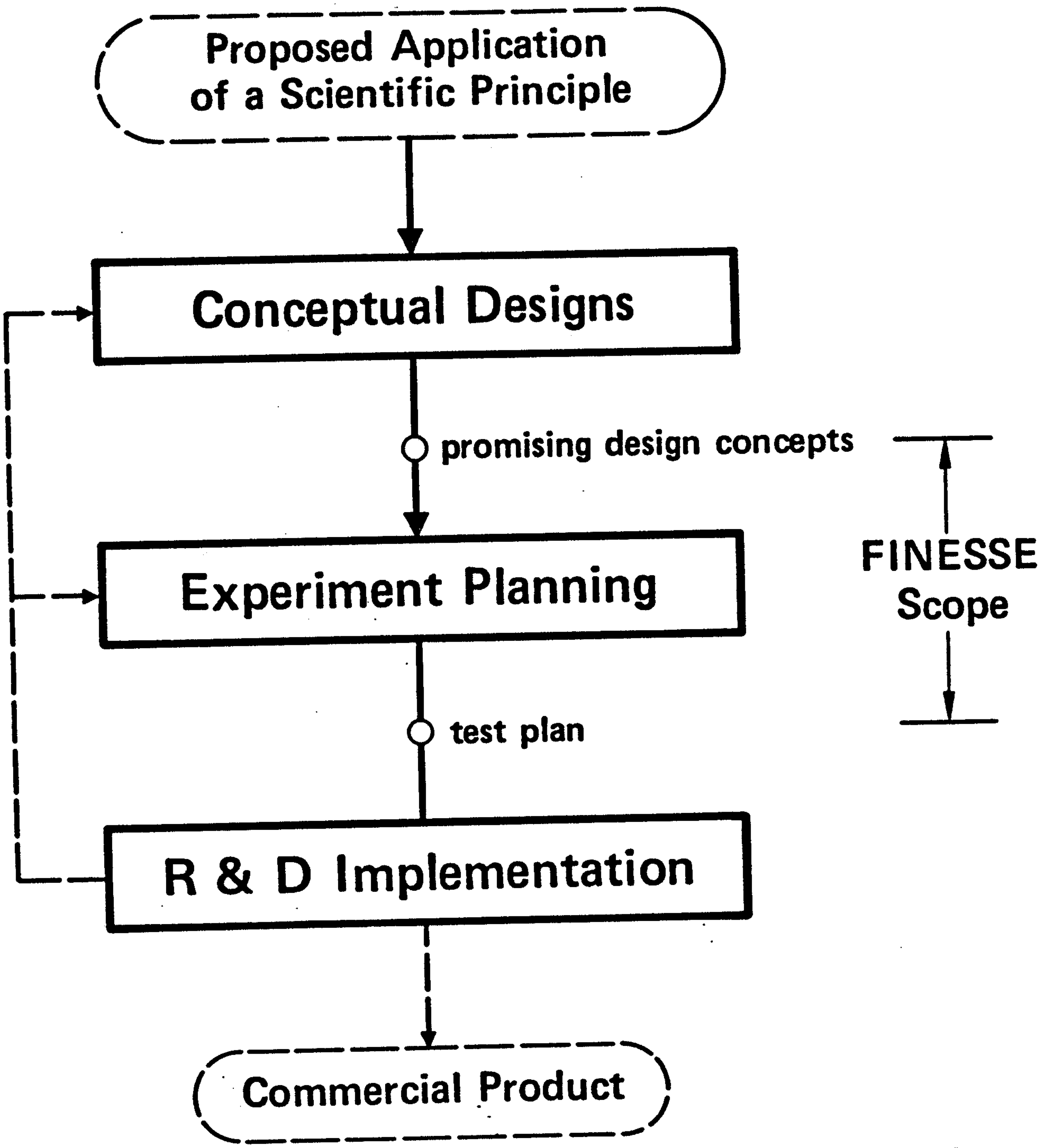
APPENDIX

FINESSE Process

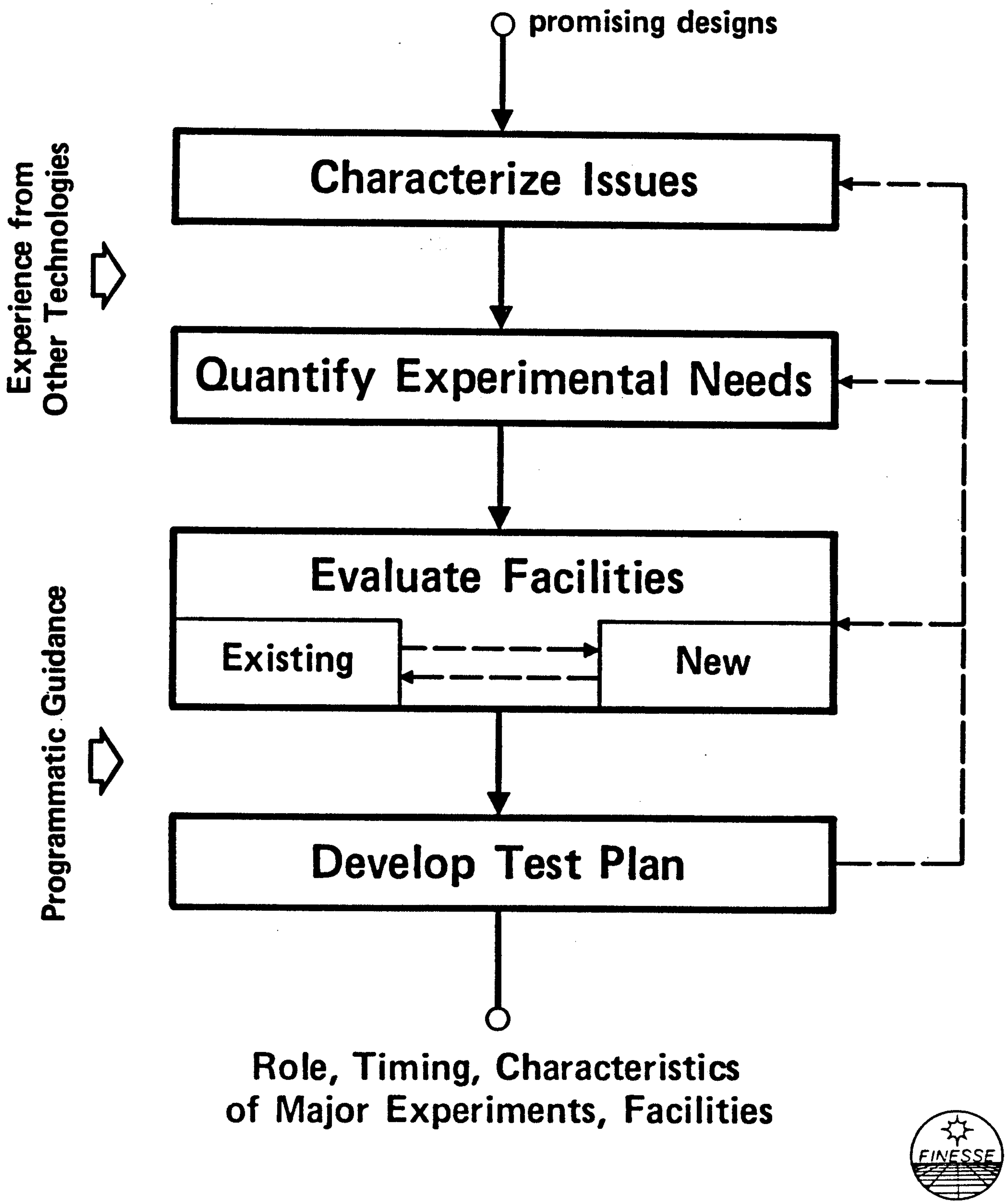
In the course of carrying out FINESSE, a Process for Experiment Technical Planning has evolved. This process has proved useful in technical planning of Fusion Nuclear Technology. The process has important features relevant to TPA. Highlights of the process follow. Details are provided in the FINESSE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

EXPERIMENT PLANNING

Is a Key Element of Technology Development



FINESSE PROCESS For Experiment Planning



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

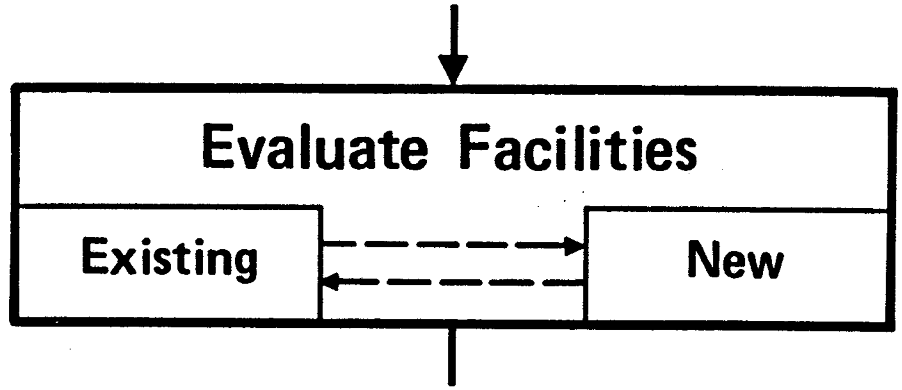
△ Quantified Understanding of Important Issues, Interactions, Parameters . . .

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

POTENTIAL IMPACT

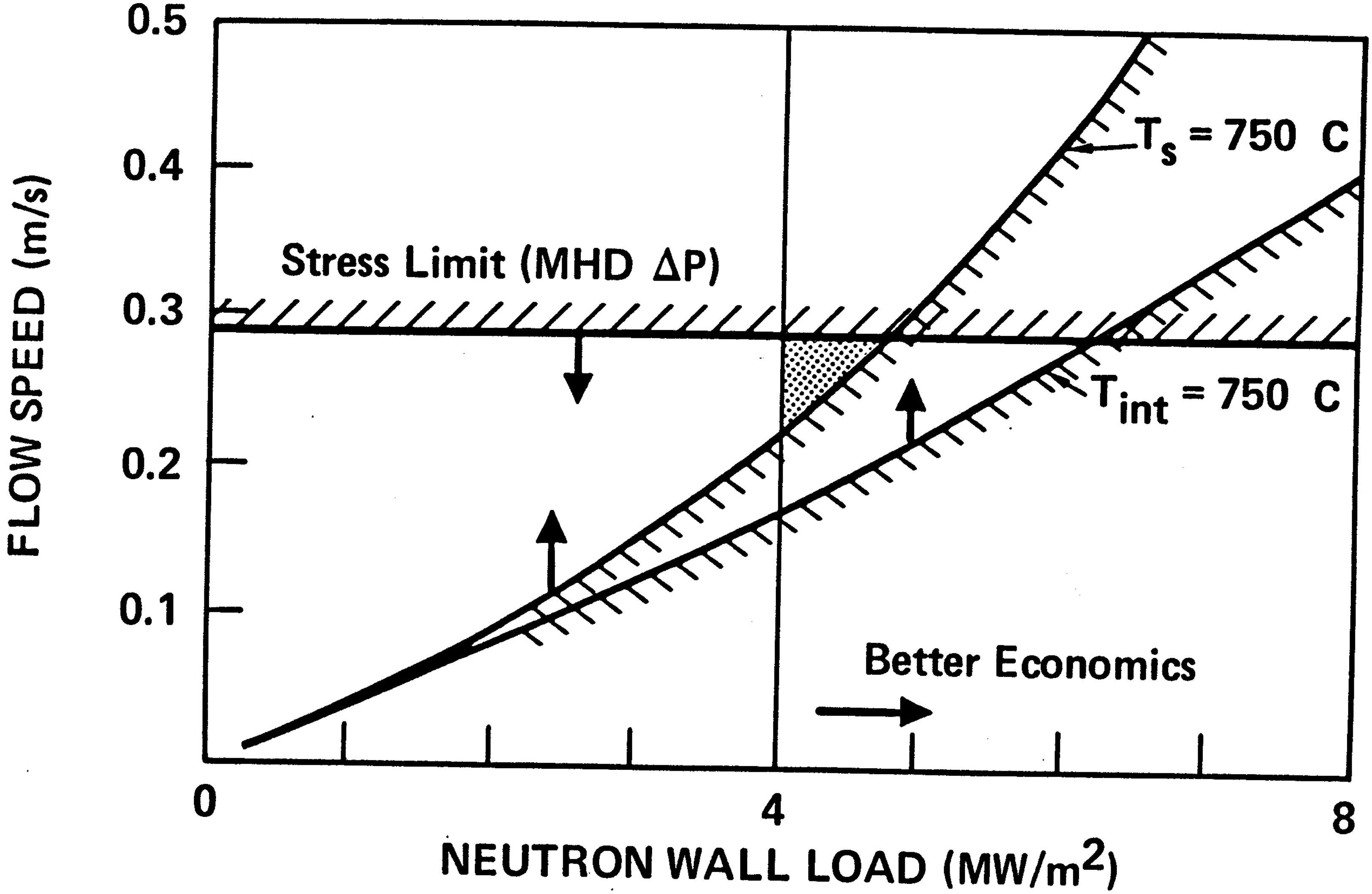
Feasibility Issues

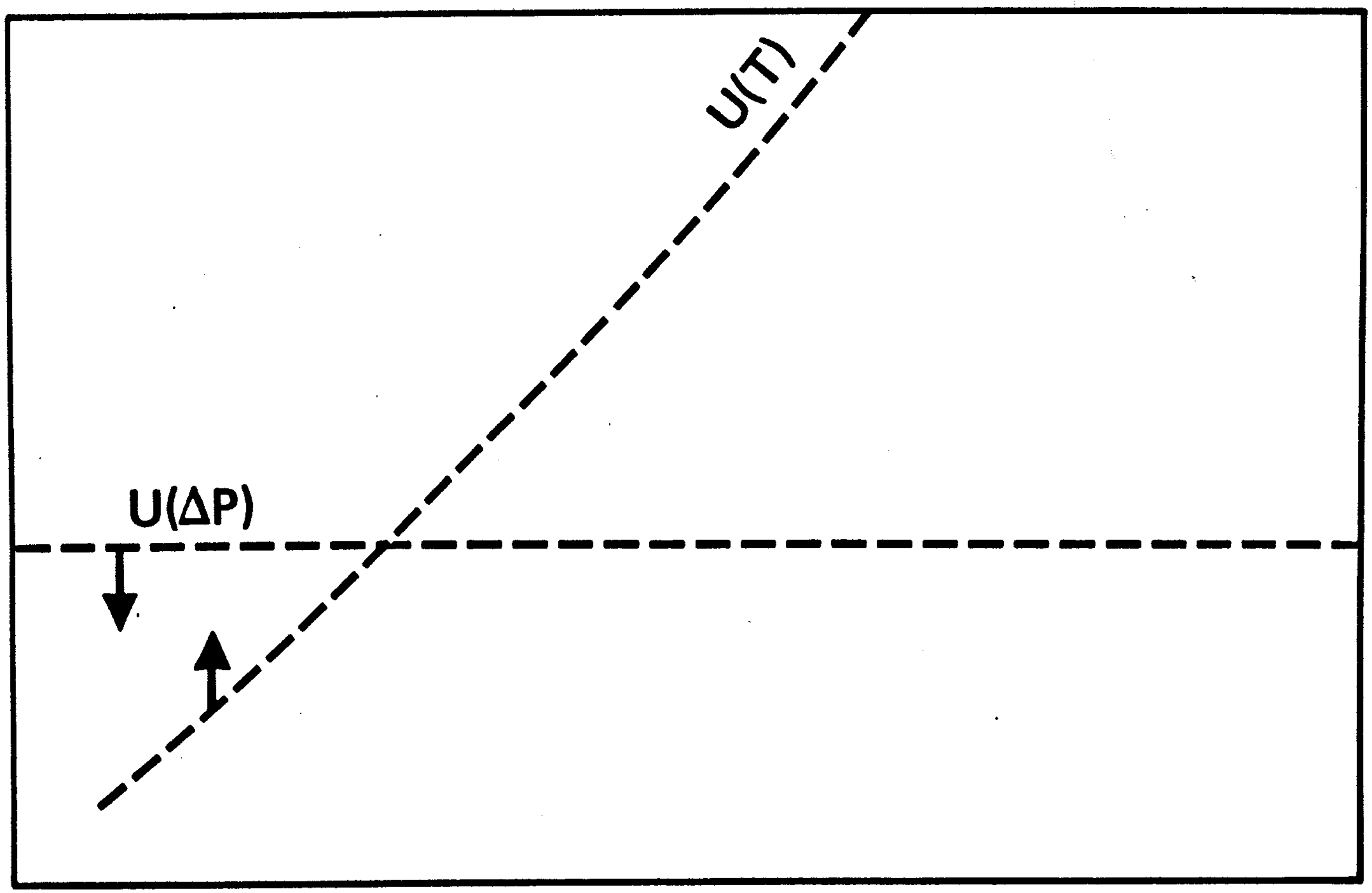
- May Close the Design Window
- May Result in Unacceptable Safety Risk
- May Result in Unacceptable Reliability, Availability or Lifetime

Attractiveness Issues

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

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

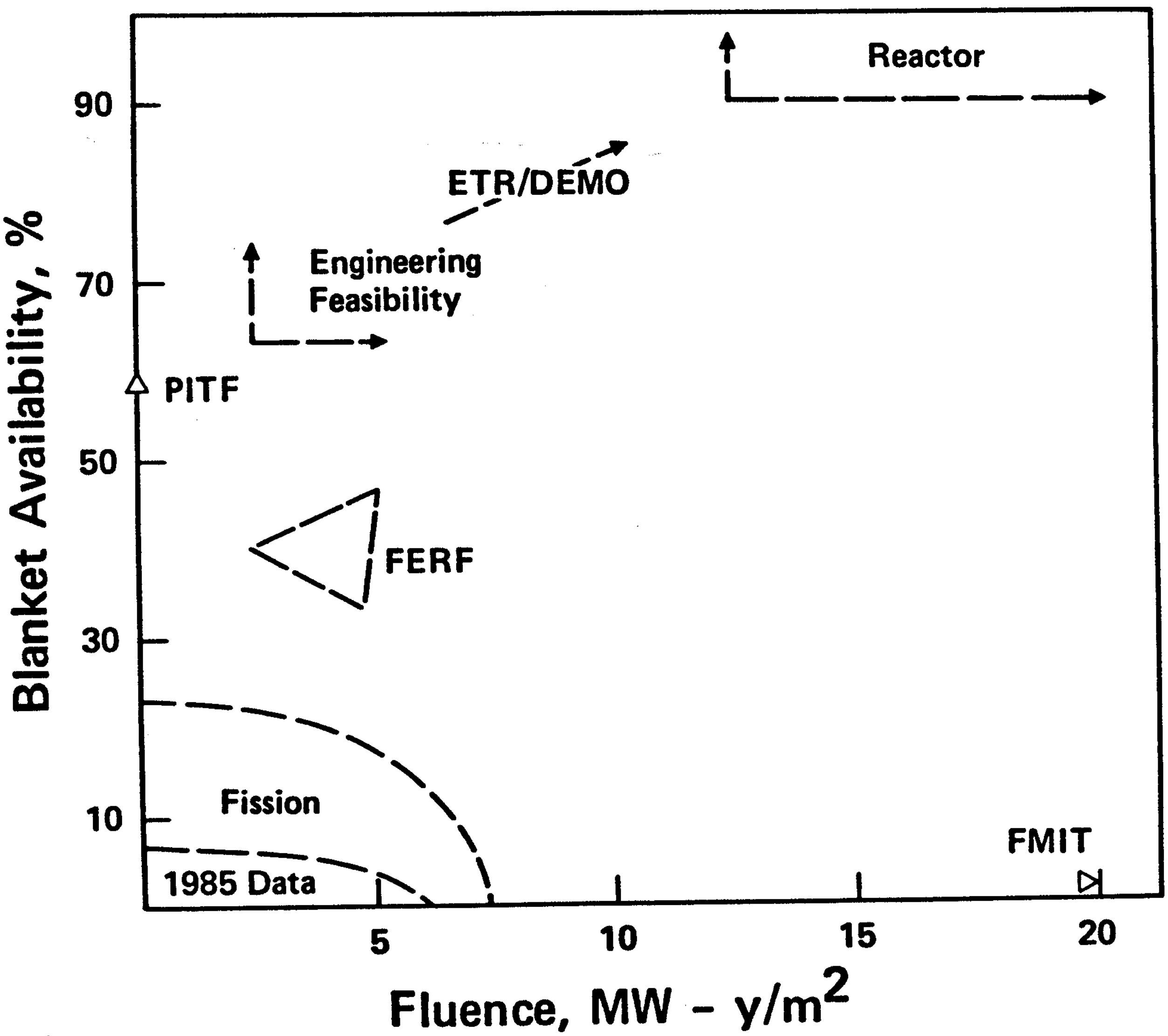




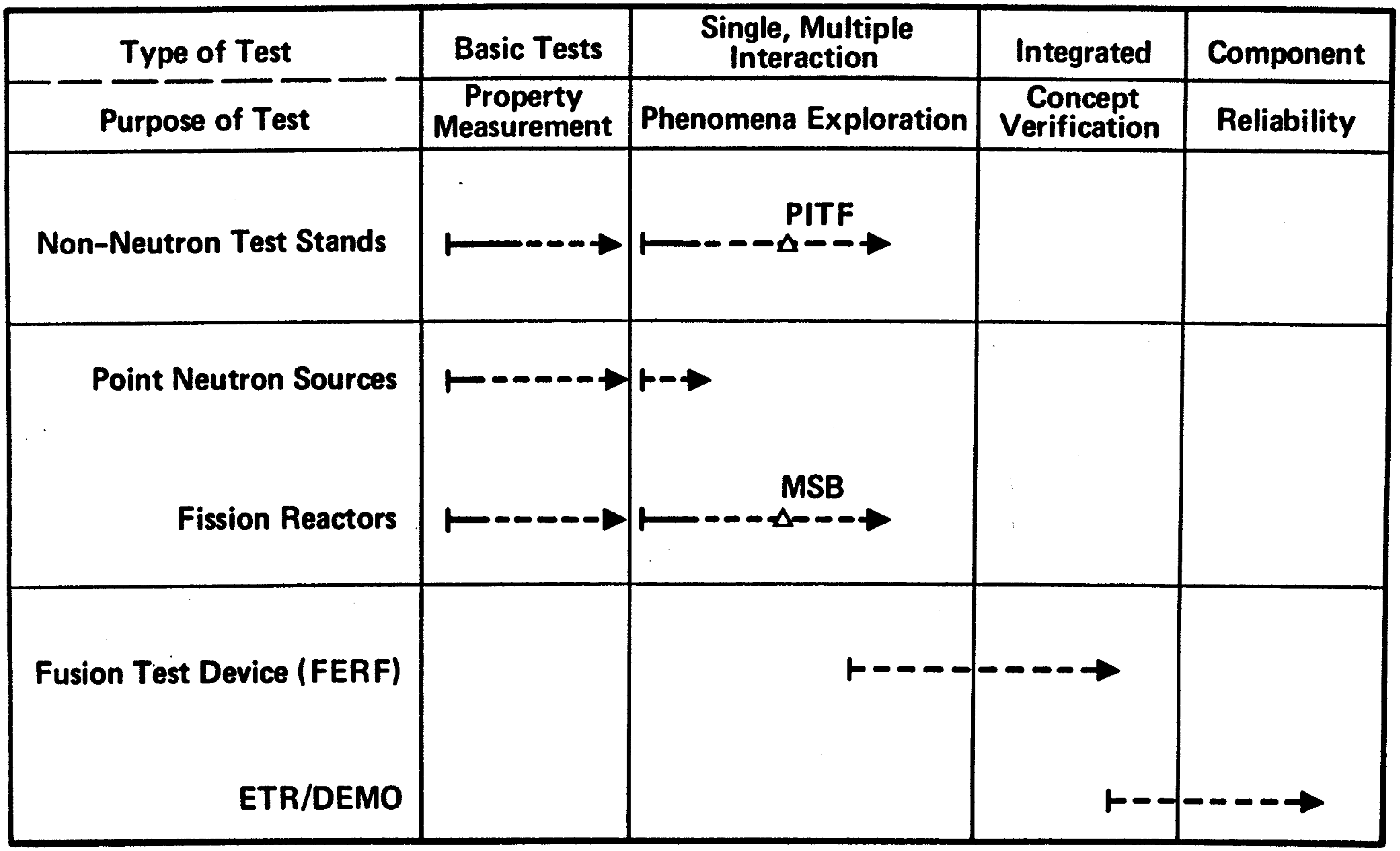
U(T): Any of:
T_s = 650 C
T_{int} = 550 C
h_m = 0.7h

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

TECHNICAL PLANNING ACTIVITY
TECHNOLOGY STEERING COMMITTEE

Prof. Mohamed A. Abdou
6288 Boelter Hall
School of Engineering & Appl. Science
University of California, Los Angeles
Los Angeles, CA 90024
(213) 206-0501

Dr. Lee A. Berry
Associate Director for D&T
Magnetic Fusion Energy Division
Oak Ridge National Laboratory
Oak Ridge, TN 37830
(615) 574-0998
FTS 624-0998

Dr. Wil Gauster
Division 6248
Sandia National Laboratories
P. O. Box 5800
Albuquerque, NM 87185
(505) 846-1648
FTS 846-1648

Dr. Carl D. Henning
MFE Mechanical Engineering Dept.
Lawrence Livermore National Laboratory
P. O. Box 5511
Livermore, CA 94550
(415) 422-0235
FTS 532-0235

Mr. Michael Korenko
3790 Bldg., Room 102, 300 Area
Westinghouse Hanford Company
Hanford Engineering Development Lab.
P. O. Box 1970
Richland, WA 99352
(509) 376-3177
FTS 444-3177

Dr. James A. Maniscalco
Energy Development Group
TRW, Inc.
One Space Park, R1/2128
Redondo Beach, CA 90278
(213) 536-1816

Dr. John A. Schmidt
Plasma Physics Laboratory
Princeton University
P. O. Box 451
Princeton, NJ 08544
(609) 683-2538
FTS 340-2538

Dr. Dale L. Smith
Fusion Power Program, Bldg. 205
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439
(312) 972-5180
FTS 972-5180

Prof. Herbert Woodson
Center for Fusion Engineering
Engineering Science Building 143
The University of Texas at Austin
Austin, TX 78712
(512) 471-4262