INITIAL THOUGHTS ON TECHNICAL PLANNING FOR FUSION NUCLEAR TECHNOLOGY

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NOTE:

THE PURPOSE OF THE MATERIAL PRESENTED HERE IS ONLY TO STIMULATE DISCUSSIONS. NO ATTEMPT ON "WORD ENGINEERING" OR SELECTING A RECOMMENDED APPROACH HAS BEEN MADE.

STATUS OF EXISTING EFFORTS (FINESSE) ON TECHNICAL PLANNING FOR FUSION NUCLEAR TECHNOLOGY

ISSUES

- IDENITIFIED, CHARACTERIZED AND DOCUMENTED
  (~ 125 ISSUES)
- ISSUES RANKED INTO CLASSES
  (CRITICAL, VERY IMPORTANT, ETC.)
  - CAN NOT ASSIGN ABSOLUTE PRIORITY WITHIN A CLASS

EXPERIMENT & MODEL REQUIREMENTS

- EXPERIMENTS: QUANTIFIED AND DOCUMENTED REQUIREMENTS
  (TYPES OF EXPERIMENTS, ENVIRONMENTAL CONDITIONS NEEDED IN THE EXPERIMENTS)
- ANALYTICAL MODELS/THEORY: NO EFFORT YET TO IDENTIFY NEEDS

FACILITIES

- EXISTING:
  - EVALUATED CAPABILITIES AND LIMITATIONS (DOCUMENTED)
  - PRESENT EFFORT: IDENTIFYING SPECIFIC EXPERIMENTS
    (FISSION REACTORS AND NON-NEUTRON TEST STANDS)
- NEW:
  - BEING EVALUATED
  - NON-NEUTRON TEST STANDS ARE A LARGE PART
  - NEUTRON SOURCE NEEDED IS VOLUMETRIC
    (PLASMA-DRIVEN?)

STATUS (CONT'D)

TEST PLAN

- PURPOSE IS TO DEFINE ROLE, TIMING, CHARACTERISTICS AND COSTS OF MAJOR EXPERIMENTS

- EFFORT IS IN ITS INITIAL STAGES

  INITIAL EFFORT HELPED IDENTIFY:

  - AREAS WHERE MORE TECHNICAL WORK NEEDED
  - QUESTIONS THAT REQUIRE PROGRAMMATIC GUIDANCE

SUMMARY

- WE UNDERSTAND THE ISSUES

- WE KNOW WHAT WE NEED TO DO (EXPERIMENTS, FACILITIES, MODELS) TO RESOLVE THEM

- BUT, THERE ARE SOME DIFFICULT QUESTIONS WHOSE ANSWERS ARE NECESSARY FOR DEVELOPING A TECHNICAL PLAN.

MAJOR (PROGRAMMATIC) QUESTIONS

(AREAS OF DIFFICULTY IN DEVELOPING TECHNICAL PLAN)

1) SHOULD WE CONNECT GOALS WITH TIME?

YES, BECAUSE

- IT HELPS DEFINE A POSITIVE IMAGE FOR FUSION AND FACILITATE COMMUNICATION WITH ADMINISTRATION/CONGRESS
- IT PROVIDES AN INTERNAL DRIVER WITHIN THE PROGRAM AND MAKES IT EASIER TO MEASURE PROGRESS

NO, BECAUSE

- NEEDS ACCURATE KNOWLEDGE OF BUDGET
- IMPLIES ABILITY TO PREDICT THE NATURE OF FUTURE TECHNICAL RESULTS (AT LEAST NO MAJOR POSITIVE OR NEGATIVE RESULTS) AND THE TIME IT TAKES TO RESOLVE ISSUES

SUGGESTED RESOLUTION?

- CONNECT "FLEXIBLE" GOALS WITH TIME
- GOALS SHOULD BE STATED CAREFULLY TO ENSURE FLEXIBILITY (E.G., TO REFER TO BROAD PROGRESS RATHER THAN A WELL-DEFINED SINGLE ACHIEVEMENT)

MAJOR (PROGRAMMATIC) QUESTIONS (CONT'D)

2) WHAT SHOULD WE ASSUME ABOUT BUDGET (FUNDING LEVEL TO YEAR 2000)?

A) SHOULD WE ASSUME A BUDGET AND PLAN -- THEN DETERMINE WHAT WE CAN DO WITH IT?

OR B) SHOULD WE DEFINE WHAT WE NEED TECHNICALLY AND ESTIMATE COSTS?

OBSERVATION

- NEITHER APPROACH IS SATISFACTORY
  - A) APPROACH MAY RESULT IN TOO LITTLE TECHNICAL WORK TO ACHIEVE SIGNIFICANT PROGRESS (OR AT LEAST VERY HIGH RISK PROGRAM)
  - B) APPROACH MAY RESULT IN CONSERVATIVE PLAN THAT CAN NOT BE AFFORDED

SUGGESTED RESOLUTION

CARRY OUT BOTH APPROACHES AND ITERATE UNTIL A MEANINGFUL PLAN WITH ACCEPTABLE RISK AND AFFORDABLE COST IS FOUND

OPTIONS FOR STATING THE (SUB) GOAL FOR FNC

(FNT = FUSION NUCLEAR COMPONENTS)

OPTION 1

GENERATE SUFFICIENT DATA FOR FNC TO PERMIT QUANTITATIVE ASSESSMENT OF THE POTENTIAL ECONOMIC AND ENVIRONMENTAL MERITS OF FUSION

OPTION 2

PERFORM INTEGRATED EXPERIMENTS FOR FNC IN FUSION-RELEVANT ENVIRONMENT

OPTION 3

OPERATE (RELIABLY) FNC IN A REACTOR-RELEVANT FUSION ENVIRONMENT

OPTION 4

ESTABLISH ENGINEERING FEASIBLITY OF FNC

EXAMPLE OF A DETAILED GOAL DEFINITION

ESTABLISH ENGINEERING FEASIBILITY

- ESTABLISH CONFIDENCE IN THE ABILITY TO REACH (EXTRAPOLATE TO) ATTRACTIVE REACTOR CONDITIONS
- OPERATE SUBSYSTEMS (OR INTEGRATED TEST MODULES) SUCCESSFULLY (OR RELIABLY) IN A REACTOR RELEVANT FUSION ENVIRONMENT
- ESTABLISH (QUANTITATIVELY) THE PRESENCE OF A DESIGN WINDOW FOR ATTRACTIVE REACTOR CONDITIONS
- EXPLORE PHENOMENA AND DEVELOP EXPERIMENTALLY-VERIFIED MODELS TO PREDICT PERFORMANCE

KEY PARAMETER	REACTOR-RELEVANT ENVIROMENT	REACTOR CONDITIONS
NEUTRON WALL LOADING, MW/M^2	?	5
SURFACE HEAT FLUX	DEPENDS	DEPENDS
FLUENCE, $MW.Y/M^2$	?-4	15-20
NUCLEAR SYSTEM MTBF, DAYS	1600	16000
NUCLEAR SYSTEM AVAILABILITY	30%	90%
TRITIUM SELF SUFFICIENCY	LOCAL	GLOBAL

FIGURE-OF-MERIT TO MEASURE PROGRESS TOWARD GOALS

- DEGREE OF TESTING
  - BASIC PROPERTY MEASUREMENT
  - SINGLE EFFECT TESTS
  - MULTIPLE EFFECT TESTS
  - INTEGRATED TESTS
  - COMPONENT TESTS
  - SYSTEM TESTS

- NUMBER OF ISSUES RESOLVED, NUMBER REMAINING

- DESIGN WINDOW
  - DEGREE OF UNCERTAINTY RELATIVE TO BOUNDARY (MEASURE OF ISSUE RESOLUTION, QUALILTY OF DATA)
  - WIDTH OF DESIGN WINDOW (MEASURE OF IMPROVEMENT)

OBSERVATIONS

- WILL PROBABLY NEED A COMPOSITE
- FIGURE OF MERIT SHOULD NOT BE SPECIFIC TO A DESIGN CONCEPT

ORGANIZATION OF DISCIPLINES

Materials and Nuclear Technology

- Difficult to separate into two completely separate activities for obvious reasons. Complete separation may result in serious flaws in technical plans
- More logical:
  - Materials as a subelement of nuclear technology

or

  - Nuclear technology as a subelement of materials (difficult to implement for many reasons)

Suggested Resolution

- Keep as two separate elements and
  - provide a working definition for each
  - ensure interaction among the two activities
    - two members common to both groups
    - a mechanism to resolve differences in philosophy, goals, etc. (e.g., end-of-life irradiation tests versus early life phenomena experiments)

Basic Materials

- Concerned with basic properties of materials
- Experiments for single material, geometry-independent tests

Nuclear Technology

- Concerned with R&D for nuclear components
- All experiments and models except those for basic material properties

EXISTING ACTIVITIES, TASK GROUPS, ETC. RELEVANT TO FUSION NUCLEAR TECHNOLOGY AND MATERIALS

- FINESSE
  - TECHNICAL PARTICIPANTS (~ 20)
  - EXECUTIVE COMMITTEE (12)
  - ADVISORY COMMITTEE (10)

- DESIGN/SYSTEM STUDIES

- PLASMA INTERACTIVE COMPONENTS TASK GROUPS
  - HHFMCD (HIGH HEAT FLUX MATERIALS AND COMPONENT DEVELOPMENT)
  - PMI (PLASMA MATERIALS INTERACTION)

- MATERIALS TASK GROUPS
  - ADIP (ALLOY DEVELOPMENT FOR IRRADIATION PERFORMANCE)
  - DAFS (DAMAGE ANALYSIS AND FUNDAMENTAL STUDIES)
  - SPM (SPECIAL PURPOSE MATERIALS)

SUGGESTIONS ON ORGANIZATION OF TPA FOR FNT

BASIC ORGANIZATIONAL APPROACH

1) USE EXISTING FINESSE ORGANIZATION

   - RESOURCES TO DO THE TECHNICAL WORK
   - RESOURCES TO PROVIDE INITIAL AUDIT OF WORK AND RECOMMENDATIONS (ADVISORY AND EXECUTIVE COMMITTEES, INTERNATIONAL PARTICIPANTS AND CONNECTIONS TO THE SUMMIT PROCESS)

2) SELECT A TPA SUBGROUP FOR FNT

   - RESPONSIBLE FOR WRITING THE TECHNICAL PLAN FOR FNT
   - INTERACTS WITH FINESSE TEST PLAN GROUP TO SPECIFY GROUNDRULES, ETC.

QUESTION

HOW MUCH TIME ARE WE PERMITTED TO ASK THE TPA SUBGROUP MEMBERS TO SPEND ON TPA?

ORGANIZATION OF TPA FOR FNT (CONT'D)

ORGANIZATION OF TECHNICAL TOPICS

A. ORGANIZATION BY COMPONENT

1. PLANKET/FIRST WALL
   - A. LIQUID METAL BLANKETS
   - B. SOLID BREEDER BLANKETS
   - C. OTHERS

2. PLASMA-INTERACTIVE COMPONENTS (FIRST WALL, LIMITER, DIVERTOR, DIRECT CONVERTERS, ETC.) ENGINEERING ASPECTS

3. TRITIUM AND VACUUM SYSTEMS

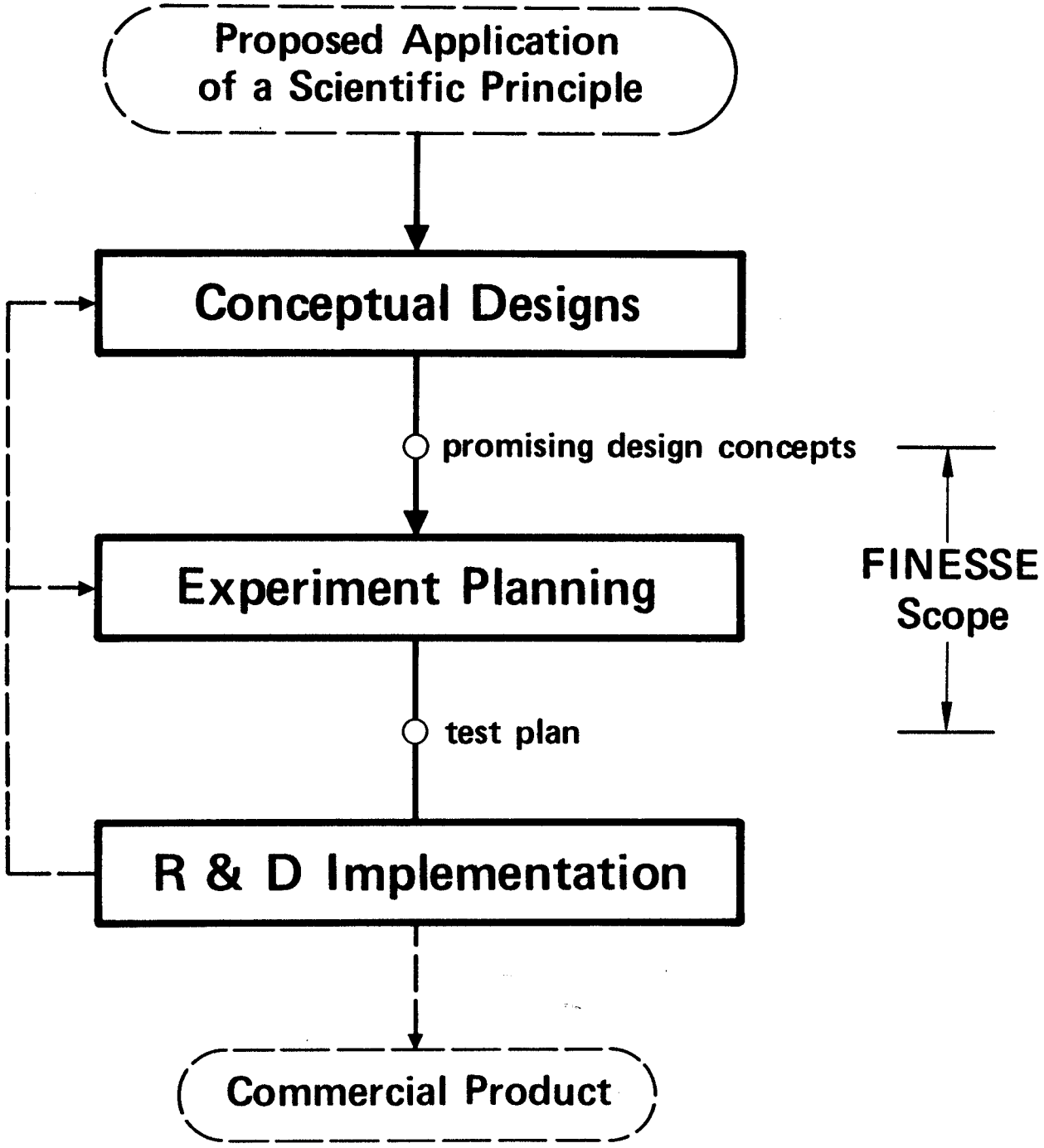
4. OTHERS

B. ORGANIZATION BY FACILITIES

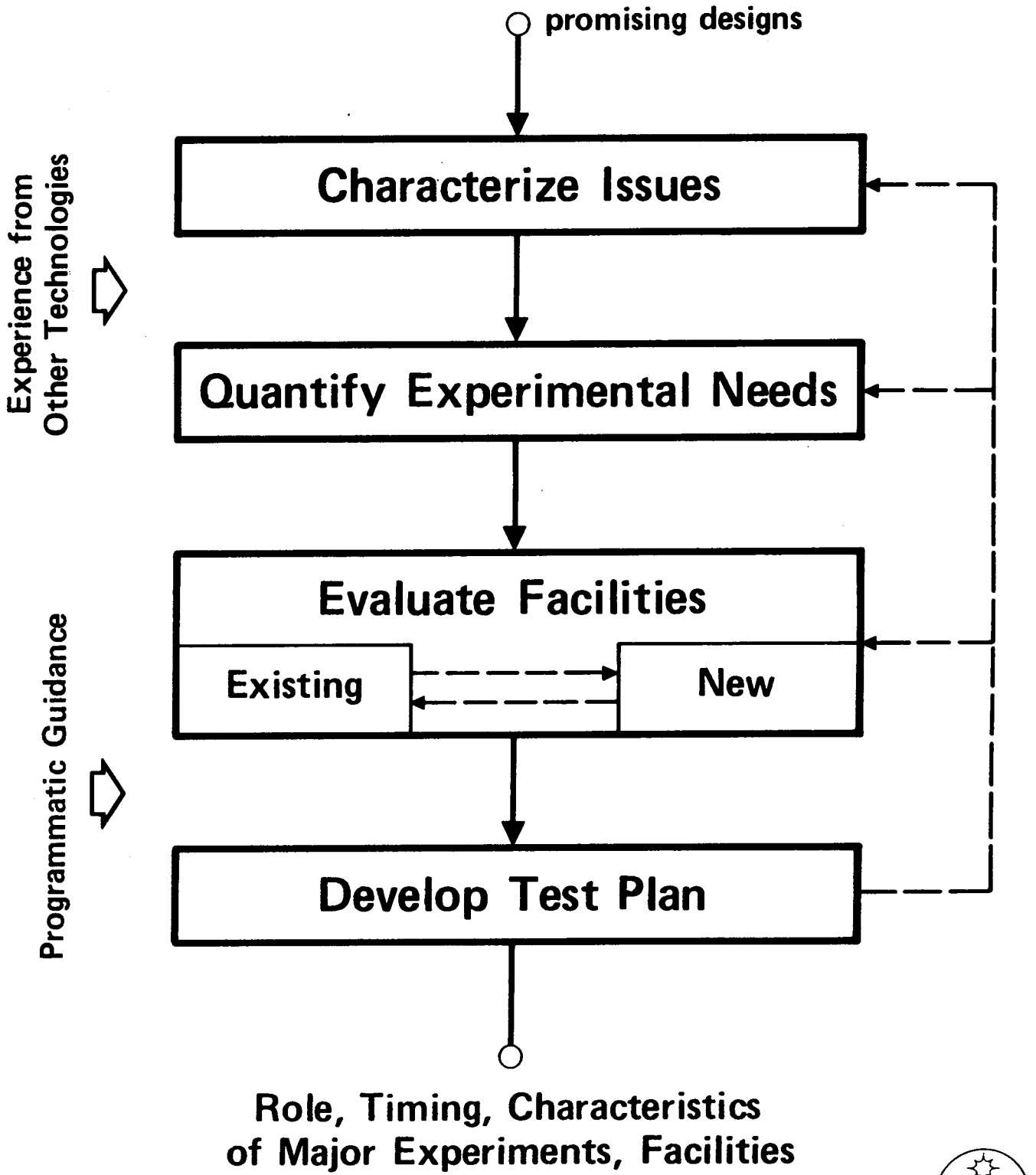
1. ONLY TO THE EXTENT NOT COVERED IN A (OR REQUIRE A CROSS COMPONENT EXAMINATION) - E.G., TESTING IN FUSION ENVIRONMENT ISSUES

C. OVERALL TEST PLAN

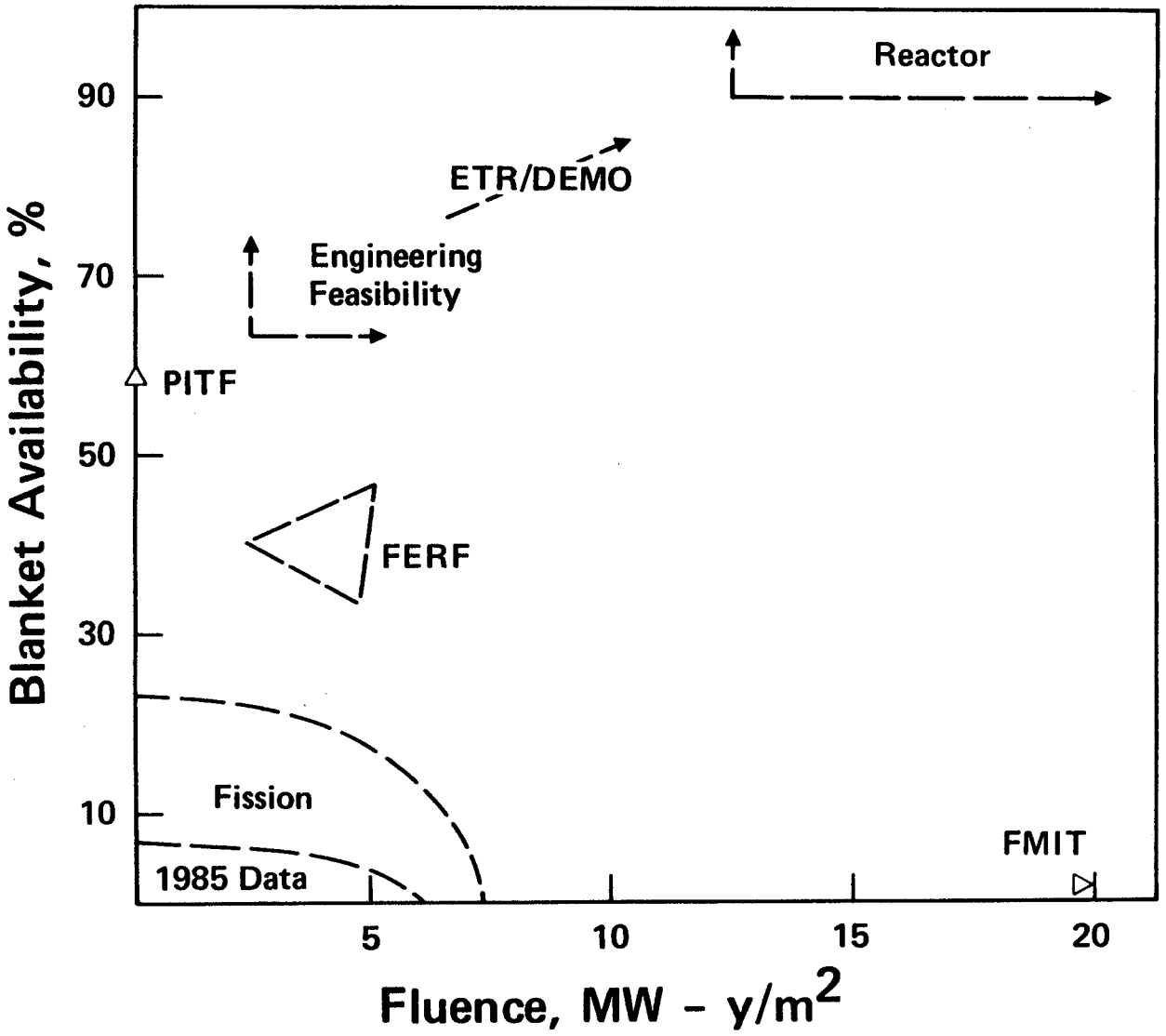
EXPERIMENT PLANNING
Is a Key Element of Technology Development



FINESSE PROCESS For Experiment Planning



Obtaining Availability and Fluence Data For Blanket Is Most Difficult



FINESSE