"FUSION NUCLEAR TECHNOLOGY DEVELOPMENT"

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SCHOOL OF ENGINEERING & APPLIED SCIENCE
UCLA

BRIEFING TO
DR. ALVIN TRIVELPIECE
DIRECTOR, OFFICE OF ENERGY RESEARCH, DOE
FEBRUARY 10, 1984
UCLA

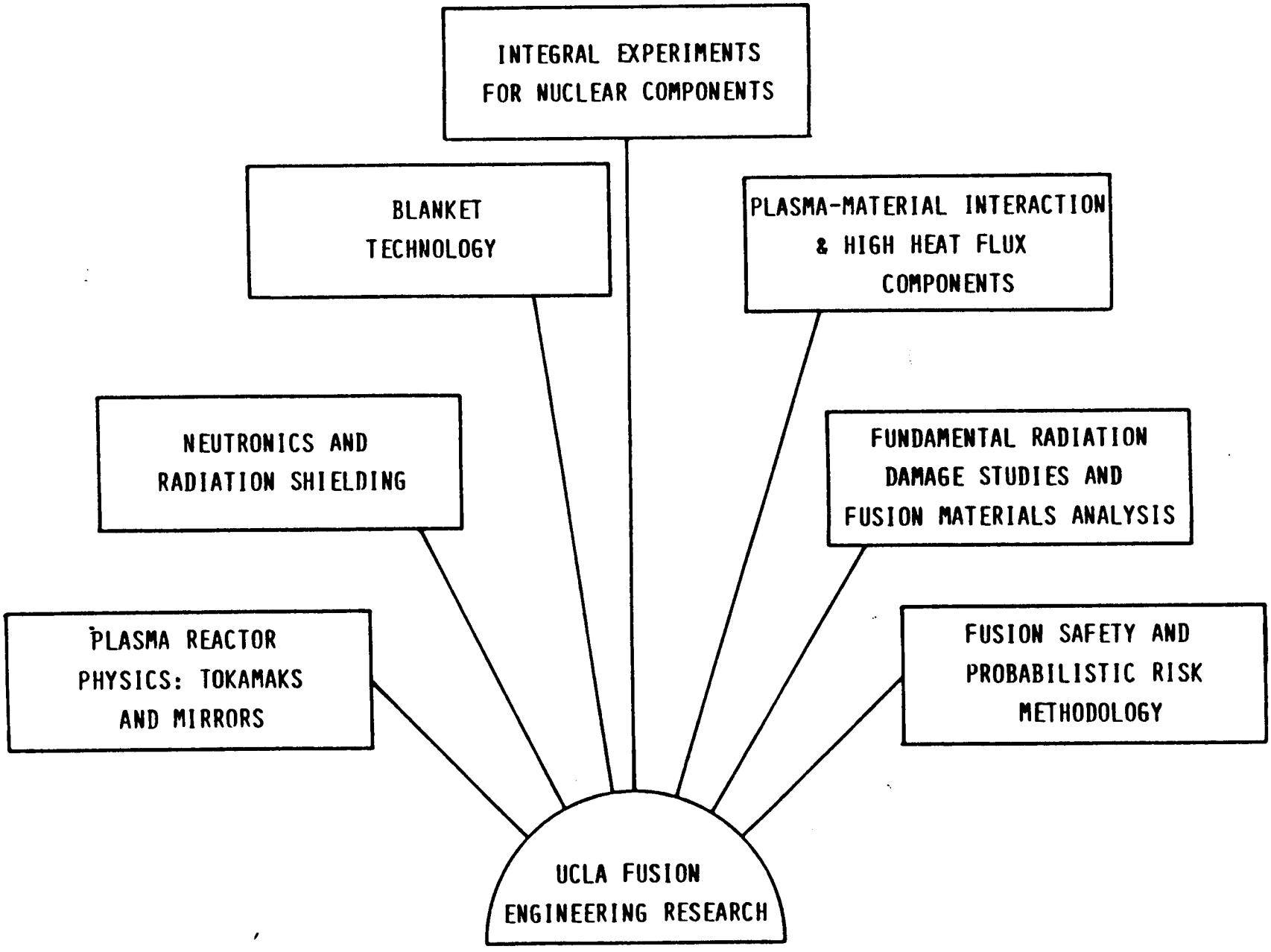
TOPICS

1. UCLA Activities in Fusion Engineering

2. FINESSE, "Fusion Nuclear Technology Development Study"

3. Thoughts on Fusion Engineering Needs

REACTOR SYSTEM AND DESIGN STUDIES



FUSION ENGINEERING AND SYSTEM STUDIES AT UCLA

FACULTY (FULL COMMITMENT TO FUSION)

PROF. MOHAMED A. ABDOU
(FUSION NUCLEAR ENGINEERING, SYSTEM STUDIES)

PROF. ROBERT W. CONN
(PLASMA PHYSICS AND ENGINEERING, SYSTEM STUDIES)

PROF. NASR M. GHONIEM
(MATERIALS, RADIATION EFFECTS)

OTHER FACULTY

PROF. GEORGE E. APOSTOLAKIS
(FUSION SAFETY)

PROF. VIJAY K. DHIR
(THERMOMECHANICAL)

PROF. WILLIAM E. KASTENBERG
(FUSION SAFETY)

STAFF

A NUMBER OF DEDICATED RESEARCH STAFF WITH BROAD CAPABILITIES IN ENGINEERING RESEARCH, DESIGN AND SYSTEM STUDIES

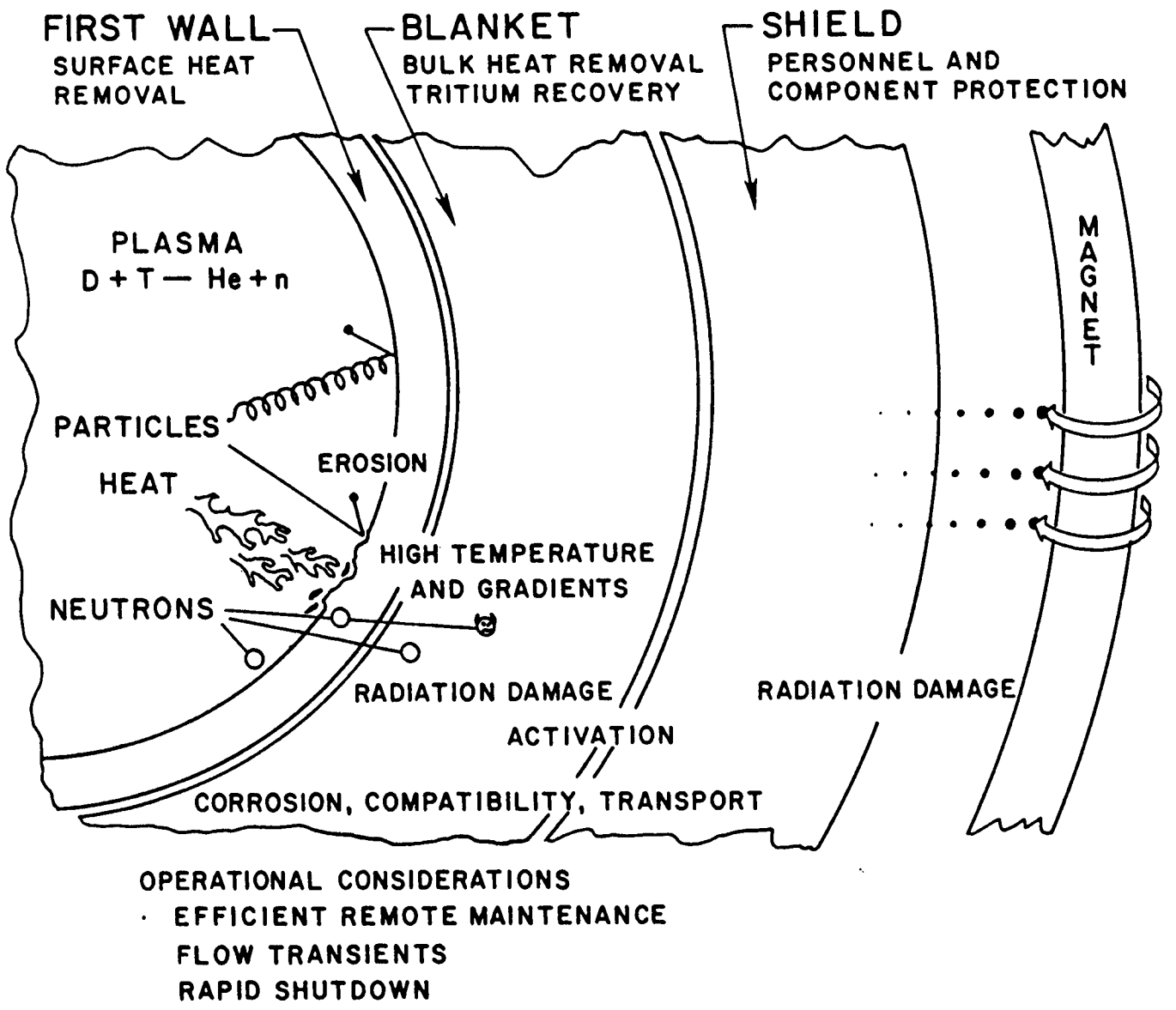
GRADUATE STUDENTS

A NUMBER OF EXCELLENT STUDENTS HAVE BEEN ATTRACTED TO FUSION; RESEARCH TOPICS OF KEY IMPORTANCE TO FUSION

FUSION NUCLEAR TECHNOLOGY DEVELOPMENT STUDY

(FINESSE)

- TWO-YEAR STUDY (STARTED NOVEMBER 1983)
- LEVEL OF FUNDING: $550,000 PER YEAR
- STUDY IS LED BY UCLA:
  MOHAMED A. ABDOU, PROJECT MANAGER
- MAJOR PARTICIPATION BY KEY U.S. ORGANIZATIONS
- SIGNIFICANT INTERNATIONAL PARTICIPATION


FIRST WALL
SURFACE HEAT REMOVAL
BLANKET
BULK HEAT REMOVAL
TRITIUM RECOVERY
SHIELD
PERSONNEL AND COMPONENT PROTECTION
PLASMA
D + T — He + n
MAGNET
PARTICLES
EROSION
HEAT
HIGH TEMPERATURE AND GRADIENTS
NEUTRONS
RADIATION DAMAGE
RADIATION DAMAGE
ACTIVATION
CORROSION, COMPATIBILITY, TRANSPORT
OPERATIONAL CONSIDERATIONS
· EFFICIENT REMOTE MAINTENANCE
FLOW TRANSIENTS
RAPID SHUTDOWN

FUSION REACTOR ELEMENTS

- PLASMA
- ENGINEERING COMPONENTS:
  - MAGNETS
  - PLASMA HEATING
  - NUCLEAR COMPONENTS

NUCLEAR COMPONENTS

- HANDLING OF PLASMA PARTICLES AND ENERGY CONVERSION:
  - PLASMA-INTERACTIVE COMPONENTS (FIRST WALL, LIMITER, DIVERTOR, ETC.)
  - BLANKET
  - SHIELD
  - TRITIUM SYSTEM

FUSION NUCLEAR COMPONENTS

IMPORTANCE OF R&D NEEDS

- THE DEVELOPMENT OF FUSION NUCLEAR COMPONENTS REQUIRES RESOLVING DIFFICULT AND CRITICAL ISSUES

- THESE ISSUES RELATE TO:
  - FEASIBILITY
  - ATTRACTIVENESS OF FUSION REACTORS

- RESOLVING THESE ISSUES:
  - APPEARS TO BE RELATIVELY COSTLY (REQUIRES NEUTRONS IN TEST ENVIRONMENT)
  - REQUIRES LONG LEAD TIME

- THE U.S. (AND OTHER INTERNATIONAL PROGRAMS) MUST SEEK SUCCESSFUL AND TIMELY RESOLUTION OF THE FUSION NUCLEAR ISSUES

BACKGROUND ON STRATEGY FOR FUSION DEVELOPMENT

OLD STRATEGY

- ONE ENGINEERING TEST REACTOR FOR PHYSICS AND TECHNOLOGY
  EXAMPLE: FED, INTOR
- PROBLEMS: DEVICES ARE TOO COSTLY, RISKY

TRENDS IN PRESENT STRATEGY

TFCX	FOR PHYSICS TESTING
?	FOR NUCLEAR TECHNOLOGY TESTING

FINESSE PROGRAM SCOPE

- IS A NEW FUSION DEVICE DEDICATED TO NUCLEAR TESTING NEEDED?
- WHAT IS THE BEST DEVICE?

FINESSE OBJECTIVES

General

Investigate the technical and programmatic issues involved in the development of fusion nuclear components

Specific

1. Develop the foundations for the technical discipline of fusion engineering testing:
   - Understanding of the problems/issues of testing
   - Quantify test requirements
   - Investigate the issues of engineering scaling and develop, on technical bases, engineering scaling relationships
2. Evaluate the need for a fusion device dedicated to nuclear testing
3. Explore options for such a device and make recommendations:
   - Emphasize innovative ideas that result in a device with:
     - Lower cost
     - Better capabilities to satisfy nuclear testing requirements

FINESSE PARTICIPANTS

Major Organizations

- University of California, Los Angeles
- Argonne National Laboratory
- EG&G Idaho, Inc.
- Hanford Engineering Development Laboratory
- TRW, Inc.
- McDonnell Douglas Astronautics Company

Major Support Organizations

- Lawrence Livermore National Laboratory
- Princeton Plasma Physics Laboratory

Future Support Expected

- Los Alamos National Laboratory (TSTA Group)
- EG&G Idaho, Inc. (Safety Group)
- Sandia National Laboratory (PMI, HHF Programs)
- High Risk Approach Advocates?

INTERNATIONAL PARTICIPATION IN FINESSE

MOTIVATION

- ALL WORLD FUSION PROGRAMS FACE THE SAME ISSUES:
  - FINESSE IS A GOOD MECHANISM FOR EXAMINING THESE ISSUES
- POSSIBLE OUTCOME OF THE STUDY IS A RECOMMENDATION FOR A FUSION DEVICE DEDICATED TO NUCLEAR TESTING:
  - SUCH A DEVICE IS A GOOD CANDIDATE FOR INTERNATIONAL COOPERATION

MECHANISM

- SEMI-INFORMAL
- EACH MAJOR INTERNATIONAL FUSION PROGRAM SENDS A TECHNICAL EXPERT TO RESIDE AT UCLA FOR DURATION OF PROJECT AND PARTICIPATE DIRECTLY IN THE TECHNICAL EFFORT

STATUS

- CANADA - EXPERT FROM CFFTP AT UCLA NOW
- WEST GERMANY - EXPERT FROM KFK STARTS AT UCLA ON MARCH 1, 1984
- JAPAN (JAPANESE UNIVERSITIES) - TWO EXPERTS AT UCLA NOW
- JAPAN (JAERI) - TWO EXPERTS START AT UCLA ON MARCH 20, 1984
- COMMUNICATIONS UNDERWAY WITH OTHER COUNTRIES (ITALY, FRANCE, THE NETHERLANDS)

FUSION NUCLEAR ENGINEERING TESTING DEVICE

DESCRIPTION OF THE BROBLEM (BACKGROUND)

- THE COST OF A FUSION TESTING DEVICE SUBSTANTIALLY INCREASES WITH THE MAJOR DEVICE PARAMETERS (E.G., WALL LOADING, FLUENCE, SURFACE AREA)
- IDEAL INTEGRATED TESTING OF A COMPONENT REQUIRES DUPLICATION OF THE ENVIRONMENTAL CONDITIONS WITHIN THE TEST MODULE (E.G., POWER DENSITY)
- FOR EXAMPLE, FISSION REACTOR TESTING DID NOT HAVE TO SCALE THE POWER DENSITY (DEVICE POWER IS NOT COUPLED TO POWER DENSITY)
- REALISTIC COST CONSTRAINTS DICTATE THAT FUSION TESTING MUST BE PERFORMED UNDER SCALED ENVIRONMENTAL CONDITIONS
- "LOOK-ALIKE" TEST MODULES ARE ALMOST USELESS UNDER SCALED CONDITIONS
- SERIOUS EFFORT IS REQUIRED TO DEVELOP METHODS FOR ENGINEERING SCALING AND TO PROVIDE GUIDANCE TO THE DESIGN OF A FUSION ENGINEERING TESTING DEVICE
- COST/BENEFIT/RISK ANALYSIS IS A USEFUL "FRAMEWORK"

PRINCIPAL TECHNICAL TASKS

I. Identification of Issues and Required Nuclear Tests

II. Quantifying Test Requirements

III. Evaluation of Experience from Other Technologies

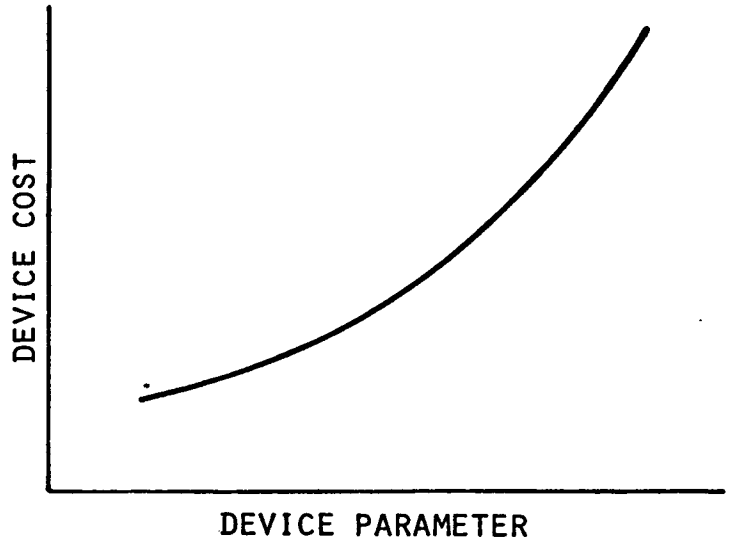
- A. Fission
- B. Aerospace

IV. Survey and Evaluation of Neutron-Producing Test Facilities

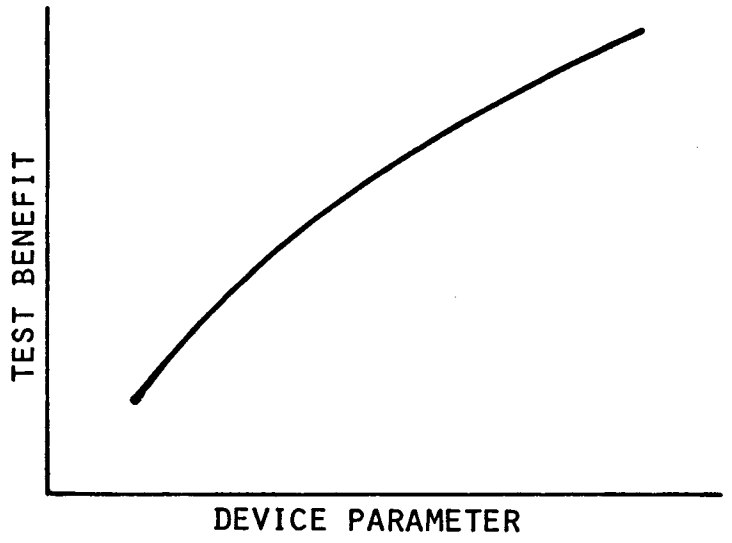
- A. Non-Fusion Devices
- B. Fusion Devices

V. Comparative Evaluation of Non-Fusion and Fusion Devices

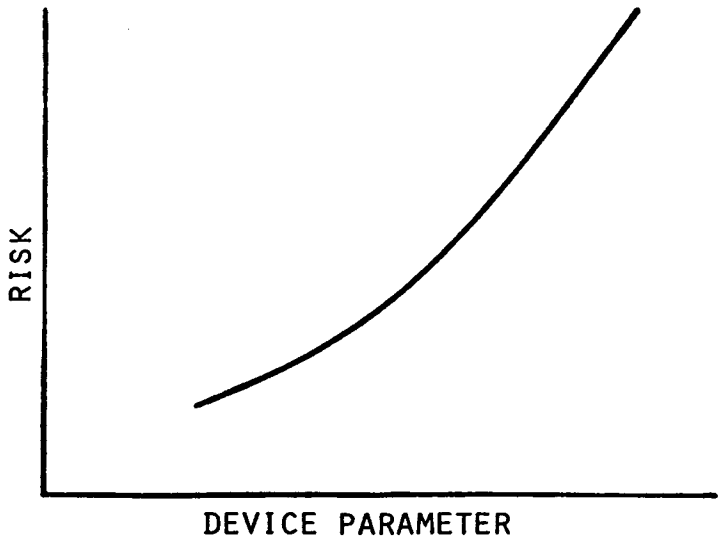
VI. Recommendations on Fusion Nuclear Technology Development



COST



BENEFIT



RISK

WHY SHOULD RESEARCH BE CARRIED OUT NOW ON BLANKET, MATERIALS AND NUCLEAR ISSUES?

- THE DEVELOPMENT OF A VIABLE FIRST WALL AND BLANKET CONCEPT REPRESENTS A MAJOR, UNRESOLVED FEASIBILITY ISSUE FOR FUSION

- THE SELECTION OF A FIRST WALL AND BLANKET CONCEPT CAN SIGNIFICANTLY IMPACT PLASMA ENGINEERING ISSUES AND VICE VERSA. EXAMPLES INCLUDE:
  - IMPURITY CONTROL OPTIONS
  - ACCESS AND MAINTENANCE

- OPERATION OF ANY FUSION DEVICE THAT BURNS TRITIUM FOR A SIGNIFICANT PERIOD OF TIME WILL REQUIRE CONSTRUCTION OF A TRITIUM-PRODUCING BLANKET

- THE PERCEPTION OF FUSION'S SAFETY AND ENVIRONMENTAL FEATURES IS LARGELY DETERMINED BY NUCLEAR/MATERIALS TECHNOLOGY CONSIDERATIONS

- FUSION ECONOMICS WILL GREATLY DEPEND ON THE PERFORMANCE OF THE NUCLEAR SYSTEMS

- THE TIME SCALE FOR THE DEVELOPMENT OF ADVANCED ALLOYS IS LONG

- LESSONS LEARNED FROM OTHER TECHNOLOGY DEVELOPMENT STRONGLY SUGGEST WORKING ON LONG LEAD TIME ITEMS EARLY

WHAT WE NEED TO DO

- MAINTAIN A BALANCE BETWEEN PHYSICS AND ENGINEERING R&D PROGRAMS

- MAINTAIN A STRONG AND STABLE R&D PROGRAM AIMED AT RESOLVING THE CRITICAL FEASIBILITY ISSUES OF FUSION

- KNOWLEDGE OF THE LIMITS ON BOTH PHYSICS AND ENGINEERING IS NECESSARY:
  - TO IDENTIFY A BETTER "END PRODUCT"
  - TO QUANTITATIVELY JUDGE THE POTENTIAL OF FUSION