APPENDIX A

Summary of Reliability and Availability Issue

Two Highly Interrelated Challenging Issues:
A) Failure Rate B) Maintainability

- A Practical Engineering System Must:
  A) Have Sufficient Reliability

    MTBF = Mean Time Between Failure

  B) Be Able to Recover From Failure in Short Time

    MTTR = Mean Time To Recover

- Two Key Questions Concerning MTBF & MTTR:
  1) What should be the goals for a practical fusion system?
  2) What values are achievable with current fusion designs?

Failure is Different From Design Lifetime

Definition

Failure is defined as the ending of the ability of a design element to meet its function before its allotted lifetime is achieved, i.e. failure before reaching the operating time for which the element is designed

Causes of Failures

- Errors in design, manufacturing, assembly and operation
- Lack of knowledge and experience
- Insufficient prior testing
- Random occurrence despite available knowledge and experience

Goals for MTBF & MTTR Can be Easily Derived

Availability = A

A (Plant) = 75%
A (BOP) = 85%
A (Reactor) = 88%

Reactor

Assume 6 major components with equal outage risk
An example of such a component is FW / Blanket
A (Blanket) = 97.8 %

A (FW / Blanket)

$$A = \frac{MTBF}{MTBF + MTTR}$$

$$\frac{MTBF}{MTTR} = 43.8$$

Note: It is the Mean Time Between Failure which is the issue.
It is NOT lifetime

Goals For MTBF & MTTR For First Wall/Blanket

MTBF = 43.8 MTTR

MTTR

- Estimated by many experts to be > 3 months
- By moving the vacuum vessel outside the blanket, we protect the vacuum vessel, but blanket removal takes longer and leaks represent failure

MTTR	**MTBF FW / B System**	**MTBF FW / B Module**
1 Month	**3.6** yr	**290** yr
3 Month	**11** yr	**877** yr

- First Wall/Blanket has typically 80 modules; each module is about 15 m^2 in surface area
- Such long MTBF requirement for such a large system is ALARMING

What MTBF Can Be Achieved?

Several Studies

- R. Bünde et al. (several articles, 1990-95)
- Abdou & Ying (1994)
- Detailed EU Blanket Evaluation (1994)

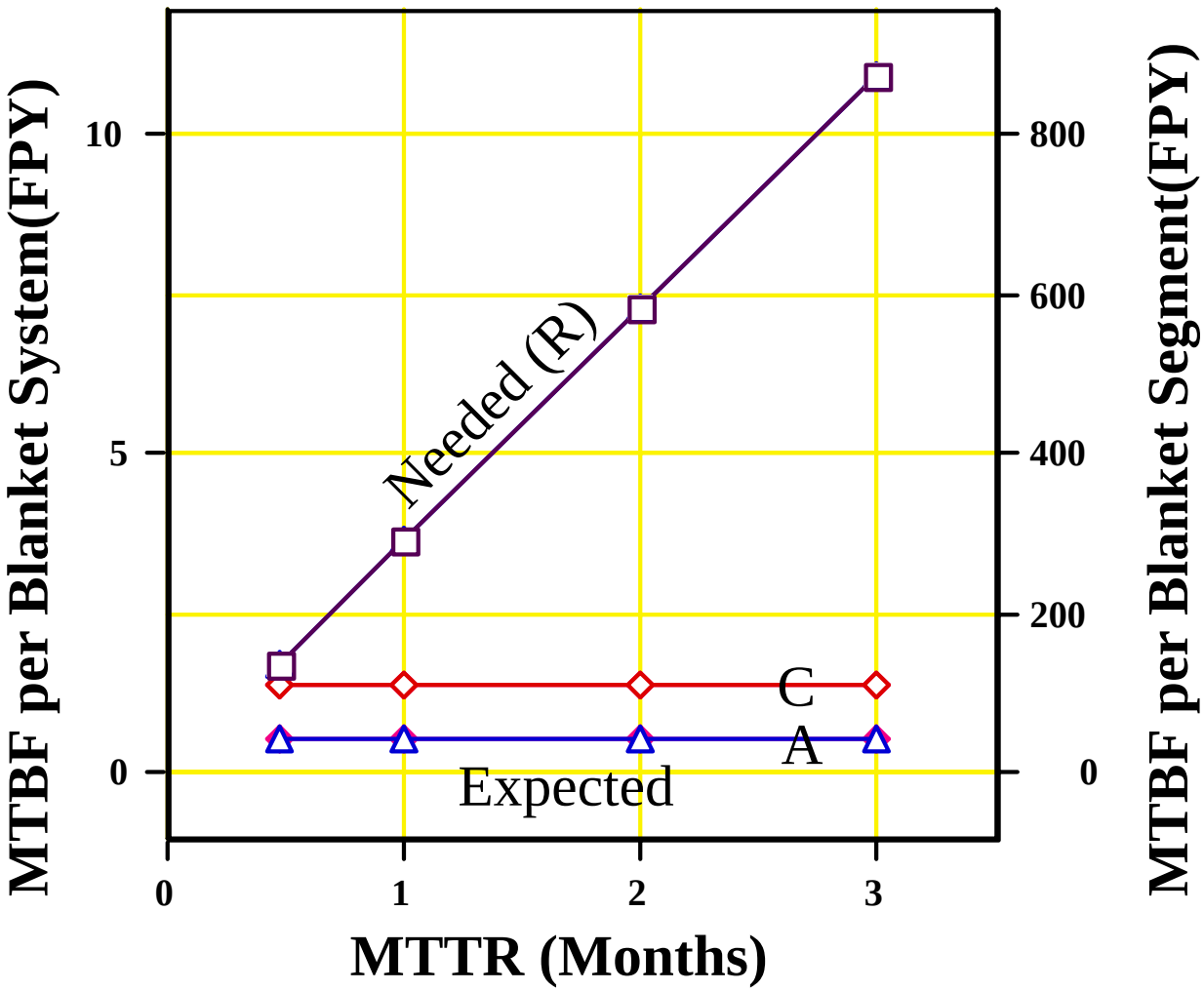
Methodology

- Compile Relevant Failure Rate from Mature Technologies (e.g. fission)
- Estimate Failure Frequency For the Best FW/Blanket Designs Available
  - ◊ Include Failures for Pipes and Welds
  - ◊ IGNORE (DO NOT Include) Fusion Specific Failure Modes

Failure Modes (FW)	**Failure Rate $hr^{-1}.m^{-1}$**	**Length**
Diffusion weld	1×10^{-9}	4.56 km
EB Weld	1×10^{-8}	2.93 km
Longitudinal weld	1×10^{-9}	19 km

Failure Modes (BLKT)	**Failure Rate $hr^{-1}.m^{-1}$**	**Length**
Longitudinal weld	1×10^{-9}	4.8 km
Butt weld	1×10^{-9}	2.58 km
Pipe bend (90°)	5×10^{-9}	1152 bends
Straight pipe	1×10^{-10}	2.9 km

R = Required
A = Expected with extensive R&D
(based on mature technology and no fusion-specific failure modes)
C = Potential improvements with aggressive R&D



The Reliability Requirements on the blanket (in current confinement concepts that have long MTTR > 1 week) are most challenging and pose critical concerns. These must be seriously addressed as an integral part of the R&D pathway to DEMO.