Component Test Facilities will be needed

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I. Destructive testing of components.

Destructive testing of components before their deployment in a new system is the standard practice in many industries, including the auto, aerospace, and nuclear industries:

Automobiles are crash tested with dummies to establish their safety qualities. This is done despite the fact that modern computer codes do a good job of predicting what will happen when an automobile is crashed into a concrete wall. In addition, vehicles of all kinds are put through a series of stringent tests, including, on occasion, finding out what children can do to dismember in-vehicle components.

Aircraft and their components are put through rigorous tests before they are licensed for passengers. For example, Boeing engineers proved the composite technology barrel design of the 787, "Dreamliner," by taking the barrel to limit load—a test condition that simulates the most extreme conditions expected to be experienced in the life of the airplane. They then took the barrel to 150% of limit load.—a condition called "ultimate load" that is required for certification.

Fission fuel rods were taken to criticality in the Phebus reactor at Cadarach, and then the cooling water was removed. The melt-down behavior was compared to code predictions, showing that the codes needed improvement.

The point of giving these examples is to show that no less will be expected of the fusion program before it is allowed to build a Demonstration power plant. While ITER and NIF successes will be hugely important to establishing the viability of MFE and IFE, respectively, and an IFMIF (if built) will be important to validate materials for the walls, but they will not will satisfy the total of what will be required. We will need one or more Fusion Component Test Facilities, in both MFE and IFE, including large volume 14 MeV neutron systems.

II. Needs assessments.

The FINESSE study (Abdou et al, 1994) provides an analysis of the kind of nuclear testing required for in-vessel components such as the first wall, blankets, divertor, antennas (read final focusing in IFE), diagnostics and controls, remote maintenance.

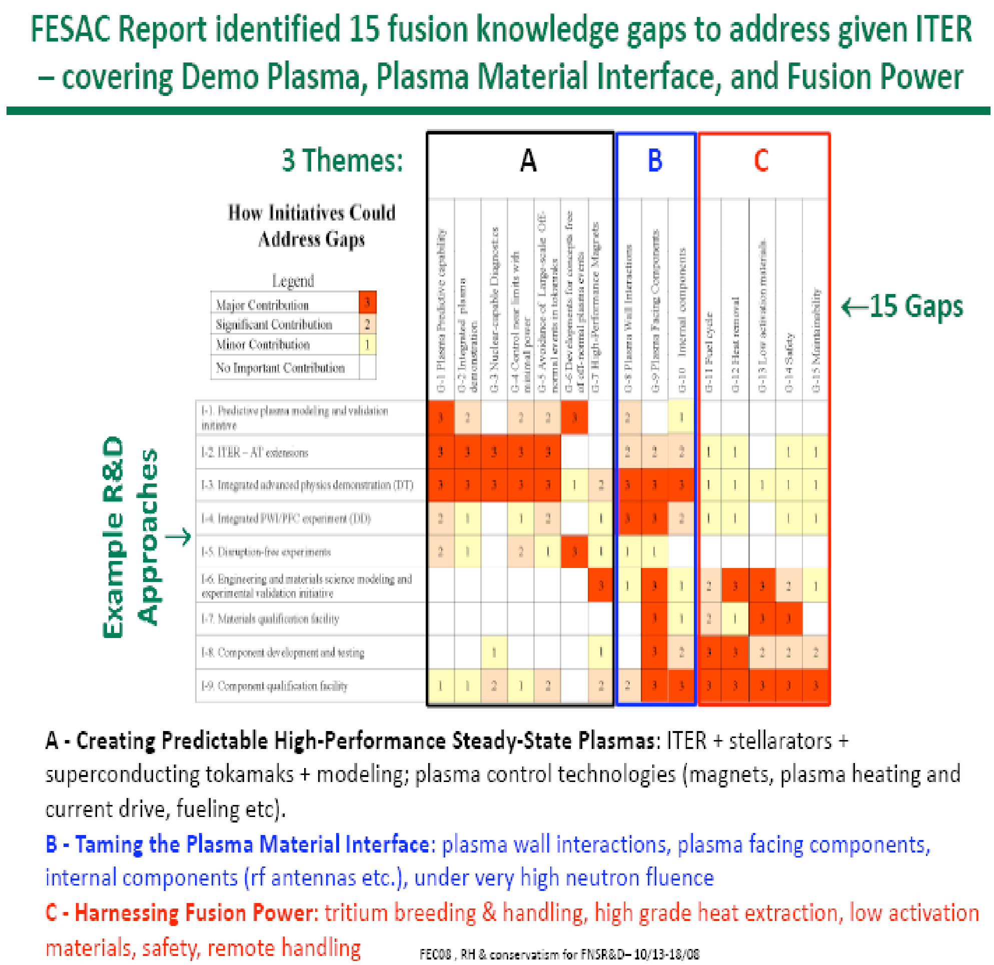
Even the Europeans are now considering this need, "R&D Needs and Required Facilities for the Development of an Energy Source," October 2008.

Some testing requirements identified in FINESSE are:

- Neutron wall loading of 1-2 MW/m^2.
- Plasma mode: steady state (>80% duty cycle) or a few timed a second for IFE.
- Minimum continuous operating time 1-2 weeks.
- Neutron fluence at test module

	$MW.y/m^2$
Stage 1: Initial fusion "Break-In"	0.3
Stage 2: Concept performance verification	1-3
Stage 3: Component engineering development and reliability growth	4-6
Total neutron fluence for Test Device	> 6

The gaps in our present program are discussed in a recent FESAC report, see figure. An approach to refining the understanding of what will be needed, based upon a system used by Boeing, is being studied by the ARIES group.



	G-1 Plasma Predictive capability	G-2 Integrated plasma demonstration	G-3 Nuclear-capable Diagnostics	G-4 Control near limits with minimal power	G-5 Avoidance of Large-scale Off-normal events in tokamaks	G-6 Developments for concepts free of off-normal plasma events	G-7 High-Performance Magnets	G-8 Plasma Wall Interactions	G-9 Plasma Facing Components	G-10 Internal components	G-11 Fuel cycle	G-12 Heat removal	G-13 Low activation materials	G-14 Safety	G-15 Maintainability
I-1. Predictive plasma modeling and validation initiative	3	2		2	2	3		2		1					
I-2. ITER – AT extensions	3	3	3	3	3			2	2	2	1	1		1	1
I-3. Integrated advanced physics demonstration (DT)	3	3	3	3	3	1	2	3	3	3	1	1	1	1	1
I-4. Integrated PWI/PFC experiment (DD)	2	1		1	2		1	3	3	2	1	1		1	1
I-5. Disruption-free experiments	2	1		2	1	3	1	1	1						
I-6. Engineering and materials science modeling and experimental validation initiative							3	1	3	1	2	3	3	2	1
I-7. Materials qualification facility									3	1	2	1	3	3	
I-8. Component development and testing			1				1		3	2	3	3	2	2	2
I-9. Component qualification facility	1	1	2	1	2		2	2	3	3	3	3	3	3	3

III. CTF Options.

In the MFE area, two D-T burning approaches are being considered:

- A tokamak, where the options range from a spherical torus to the conventional tokamak with R/a in the range 1.5 – 3.
- The gas dynamic trap offers is another possible option, although with a smaller irradiated Volume.

In the IFE area, a direct drive laser system is being studied in the HAPL program.
It is likely that any of these approaches would benefit both MFE and IFE.

IV. Program needs.

Work is needed to refine the understanding of the gaps and when results are required to fill them.

Work is needed, including experimental tests of key issues affecting the viability of each CTF, to optimize their designs.