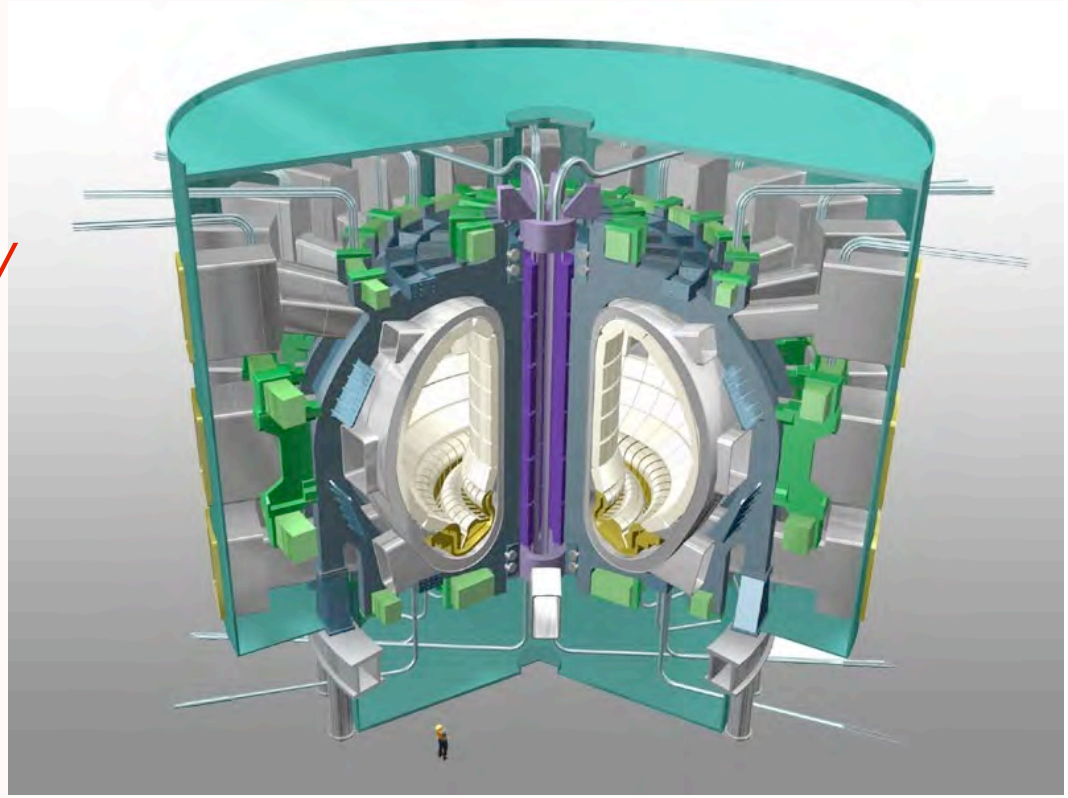
ITER Project Status

An experiment both in science and technology and in international collaborations/ project management



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FESAC
February 19, 2008
Gaithersburg, MD

Outline

- Working to deliver to the Council in June 2008 an updated baseline design, including schedule and cost
  - Scope: technical issues and missing items
  - Cost: assessing impacts of changes
  - Schedule: integration and optimization

- Configuring an effective international project of ITER scale
  - Project management and team dynamics
  - Export controls and information management
  - Responsibilities for regulatory matters
  - Transfers of ownership, responsibility and liability for in-kind contributions
  - Forming a research plan and team

Scope: technical risks and missing items

- The “Design Review” was concluded in September 2007
- Significant technical issues remain
  - The Science and Technology Advisory Committee (STAC) reviewed the outputs of the Design Review and the design itself and reported issues
  - The Council directed that the June 2008 updated baseline design should address the STAC issues
- The ITER Organization (IO) and the Domestic Agencies (DAs) are working to resolve issues and clarify the scopes (April deliverable)
- In addition, the IO and DAs are reviewing procurement package scopes for completeness

The U.S. is executing a plan addressing these STAC issues

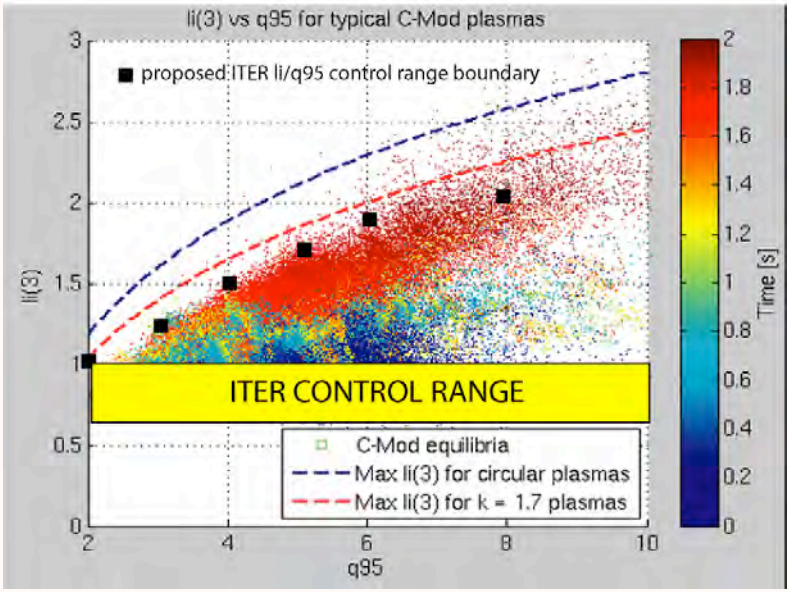
- The US participation is very strong:
  - Participants: US 23%, EU 19%, CN 13%, JA 5%, ...

- The response of institutions in the U.S. has been very positive, with extensive participation from the USIPO and
  - Princeton Plasma Physics Laboratory (PPPL)
  - General Atomics (GA)
  - Lawrence Livermore National Laboratory (LLNL)
  - Columbia University
  - Oak Ridge National Laboratory (ORNL) [not counting USIPO]
  - Sandia National Laboratory (SNL)
  - Massachusetts Institute of Technology (MIT)
  - Others….

STAC Issues: Topical Groups and U.S. Involvement

*** Vertical Stability, plasma shape control, and flux swing	Humphreys, Kessel
*** Edge Localized Mode (ELM) control	Hawryluk
*** Vacuum Vessel/Blanket Loading Conditions	Nelson
Heating and Current Drive Strategy (H&CD), Diagnostics, and Research Plan	Synakowski
Capacity of 17 MA Discharge	Wesley
Blanket Manifold/Remote Handling	Hechler
Magnet Cold Coil Test	Miller
Test Blanket Modules (TBM) Strategy	Glowienka
First Wall Material	Hechler
Remote Handling	N/A
Hot Cell Design	N/A

STAC Issues: Vertical Stability, plasma shape control, and flux swing

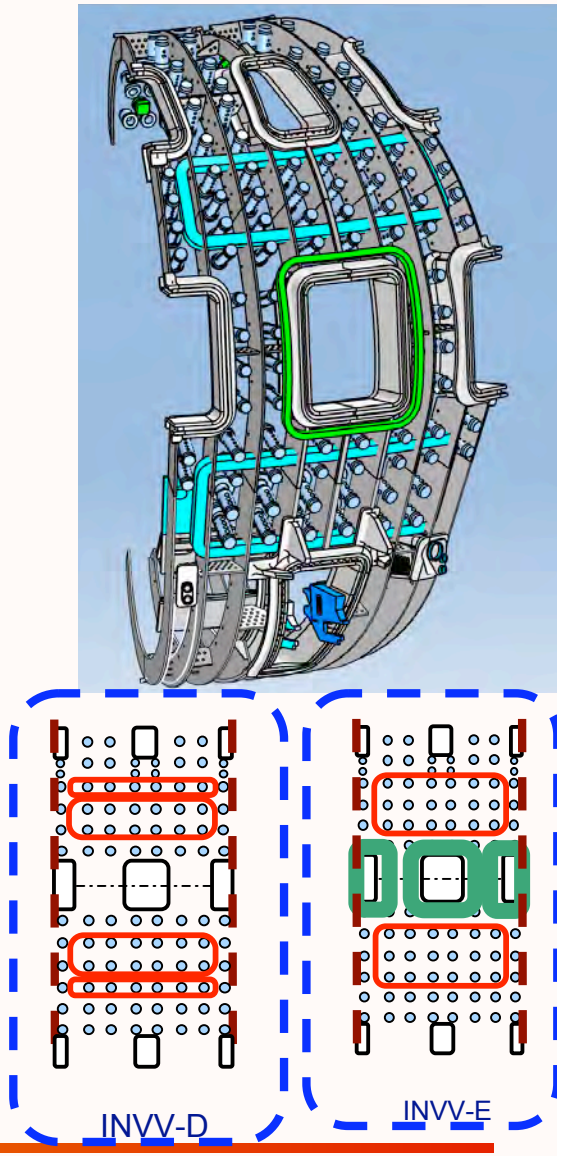


- US participants: Humphreys, Kessel, Casper, Ku, Meier, Hutchinson, Neumeyer, Miller, Strauss
- present system is judged to be marginal (during ramps, ...) with coil saturation, ... for vertical displacements >2-4 cm or with higher noise
- approaches for increased controllable vertical displacements include
  - increased coil voltage/current, involvement of CS in vertical control,
  - intra-blanket/vessel connections and coils, ...
  - reduced elongation, with re-design of the vacuum vessel
- possible impacts on design of PF coils (current and voltage), CS (voltage), blankets (interconnections and loads), vacuum vessel (copper cladding, loads), power supplies, and controls

STAC Issues: Edge Localized Mode (ELM) control

Led by R. Hawryluk (PPPL) who also serves on the STAC-2 issue coordinating committee

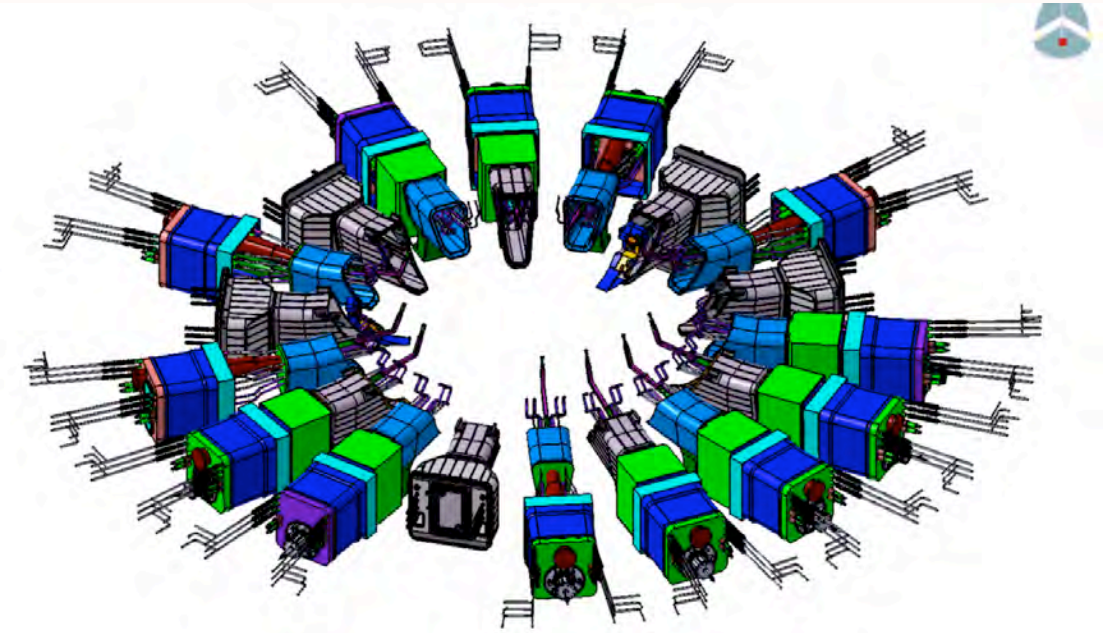
- unmitigated ELMs would seriously limit first wall and divertor life
- Approaches (intense R&D motivated)
  - ELM-free operating modes (not yet sufficiently assured)
  - ELM control by coils (in[tra]-vessel and/or port plugs) associated pro's and con's
  - pellets to trigger frequent smaller ELMs
- Significant concerns about reliability, inspectability, maintainability/replacement,...., and safety/licensing implications
- Tentative cost and schedule impact: estimated at ~$70M and 12 months



STAC Issues: Vacuum Vessel/Blanket Loading Conditions

- plasma disruption loads may increase by a factor of 1.4 or more due to revised interpretation of data from Joint European Torus (JET) and possible toroidal connection of blanket modules

- Responses range from modest additional supports to an increase from 9 supports to 18 supports, with impacts on the vacuum vessel

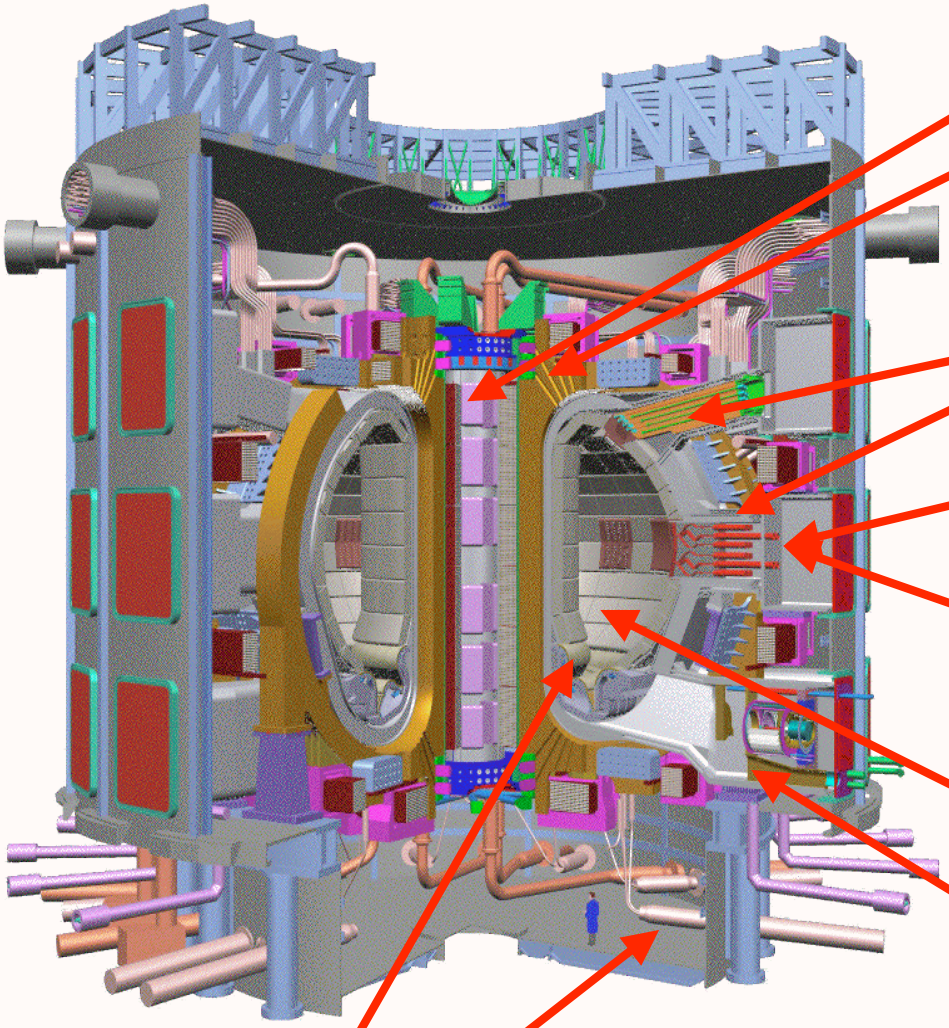


Cost: assessing impacts of changes

- The US is working with the ITER Organization on assessing the estimated costs of changes
  - Approved design changes
  - Likely design changes
  - Missing items
  - Spares

- Parties are estimating the cost evolutions for their in-kind scopes, as defined in the 2001 Final Design Report (the basis of the ITER Agreement)

U.S. 2006 ITER In-kind Hardware Contributions



7 central solenoid windings

8% of toroidal field conductor

15% of port-based diagnostics

100% ion cyclotron transmission lines

100% electron cyclotron transmission lines

20% blanket/shield & port limiters

Possible deletion

roughing pumps, standard components

pellet injector

75% cooling for divertor, vacuum vessel, …

steady-state power supplies

tokamak exhaust processing system

Schedule: integration and optimization

- Goal: high-level reliable schedule by Spring 2008
- Planning and Scheduling workshops started in October 2007, extending into March 2008
- Foci
  - Special attention to formal "first plasma" date
  - Consideration for “readiness for research”
- Design Review outcomes are included
- STAC issues and related actions/additions are not yet incorporated
- Near-term attention to Procurement Arrangements

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Project management and team dynamics

- Building an integrated multi-party/multi-cultural team (IO and DAs)
- Implementing effective decision-making processes
- Managing change
- Devising an integrated configuration of project management tools and procedures
- Positioning for and performing systems engineering/integration

Export controls and information management

- Recognizing the benefits of joint work and international collaboration
- Achieving the proper balance between openness and limits on information-sharing
  (at the boundary between the “research exemption” and “reduced to practice”)
- Implementing related information-access boundaries and systems

Responsibilities for regulatory matters

- Determining the requirements for obtaining a license for operations
- Assigning the roles of operator, designer, and manufacturer
- Specifying the proper codes and standards
- Integrating the activities of the IO, the DAs, and contractors with regulatory bodies regarding safety-related subsystems

Transfers of ownership, responsibility and liability for in-kind contributions

- Optimizing assignments of roles for design, fabrication, in-process tests/inspections, factory acceptance tests, shipment, on-site tests, assembly, installation, commissioning, ….
- Implementing related requirements, test plans, and test facilities
- Configuring systems of warranties, self-insurance, etc.

Forming a research plan

- US participants: M. Bell (PPPL), M. Wade (GA), E. Synakowski (LLNL)
- Target: end of February 2008
- Seek to identify schedule of research priorities and associated configurations
  - Start-up configuration
  - Upgrades
- May need more top-down planning based on plasma scenarios...
- Need to achieve balance between foci: initial configuration and upgrades

Forming a research team

- ITER is beginning to address the formation, evolution and engagement of the ITER research team

- ITER will expand the opportunities for research on key physics and engineering/technology questions
  - Burning plasma topics are already under study on existing facilities and in theory/simulation
  - The US fusion community should view ITER as an opportunity for extending its existing burning plasma/toroidal physics program to larger scale and self-heated regimes

- The ITPA is transitioning to ITER integration as well as a forum for coordination of research and joint experiments

ITPA High Priority Research Topics 2007 - 2008

- *** Pedestal & Edge Physics
- *** Sol & Divertor
- *** MHD
- Diagnostics
- Steady State Operation
- Transport Physics
- Confinement Database and Modelling

Pedestal & Edge Physics

- Improve predictive capability of pedestal structure
  - Cross machine comparisons to isolate physics setting pedestal width; …toroidal field ripple, rotation, beta, power, shape, aspect ratio and neutral density
  - Utilize profile database for integrated modeling of pedestal structure and transport comparison to experiment
  - Establish pedestal profile database for hybrid and advanced regimes
  - Assess impact of ELM control techniques on pedestal structure
- Improve predictive and design capability for small ELM and quiescent Hmode regimes and ELM control techniques
  - Define minimum pellet size and penetration for pellet ELM triggering
  - Define magnetic field structure and magnitude required for ELM control, accounting for plasma response and field penetration
  - Assess compatibility of ergodic field and pellet ELM control
  - Assess impact of ELM control on auxiliary systems; pumping, etc.
  - Develop physics of ELM dependence on toroidal ripple and rotation
  - Assess applicability of low collisionality small ELM regimes
  - Test nonlinear MHD and turbulence models of ELM evolution

Sol & Divertor

- Improve understanding of Tritium retention and development of efficient T removal methods.
  - Comparison of post-campaign and shot-integrated studies of retention w/respect to ion fluence (new)
  - Lab & tokamak experiments and modelling of deep D retention in high- and low-Z materials (new)
- Understand the effect of ELMs/disruptions on divertor and first wall structures
  - Exploration of the effect on the SOL and power loadings of ELM mitigation (new)
  - Scaling of disruption mitigation to ITER (new)
- Improve measurements & understanding of plasma transport to targets and walls to better predict heat loads and effects on the core
  - Code-code comparisons including impurities - specifically carbon (new)
  - ITER neutral density benchmarking of model physics to current experiments (underway)
- Understand how conditioning & operational techniques can be scaled (or not) to future devices
  - Implications of a metal wall (no coating) for startup, fuel retention, density control and core impurity levels (underway but 1st step done)

MHD

- Continue development of the disruption DB to include pre-disruptive energy loss and halo current data.
- Develop ITER applicable disruption mitigation techniques and understand influence of MHD on impurity penetration under massive gas injection. Validate 2 and 3-D codes, in particular MHD and radiation models, on gas injection. Develop reliable disruption prediction methods.
- Study NTMs in Hybrid Scenarios, the effect of plasma rotation, validate ECCD control models against data (including modulation) and specify diagnostics for NTM detection.
- For RWMs understand mode damping particularly at low rotation. Continue benchmark tests of theory models for RWM feedback and experimentally study feedback control at low rotation. Study coil systems for RWM control in ITER and specify diagnostics.
- Quantify effects of non-resonant error fields, specify multi-mode error correction requirements and error field thresholds at high β.
- Understand intermediate-n AEs and Energetic Particle Modes; redistribution of fast particles from AEs; and perform theory-data comparisons on damping and stability.

Bottom Lines

- The international ITER Project is:
  - Preparing an updated baseline scope, cost and schedule
  - Working to establish institutional and project infrastructures

- Despite the severe budget cut, the USIPO is:
  - Addressing the technical design issues, through strong community engagement on the STAC issues and through project design
  - Strongly engaged in the joint planning and scheduling activity
  - Supporting US secondees
  - Working to establish an effective international project
  - Prepared to perform additional R&D, design, and prudent procurement as the budget permits

- ITER is an essential component of the integrated US program of studies in burning plasmas