Safety at ITER

John Poole

June 2011

Historical Development of ITER

- An international project was set up after the 1985 super-power summit in Geneva (Gorbachev, Mitterand, Reagan and Thatcher).
- Initial signatories were Soviet Union, USA, European Union and Japan.
  - Joined by China and Korea in 2003
  - and then India in 2005.
- 28 June 2005, agreement to site ITER at Cadarache.

The ITER Agreement

- The ITER Agreement was officially signed at the Elysée Palace in Paris on 21 November 2006 by Ministers from the seven ITER Members

- This agreement established a legal international entity to be responsible for construction, operation, and decommissioning of ITER

ITER Framework

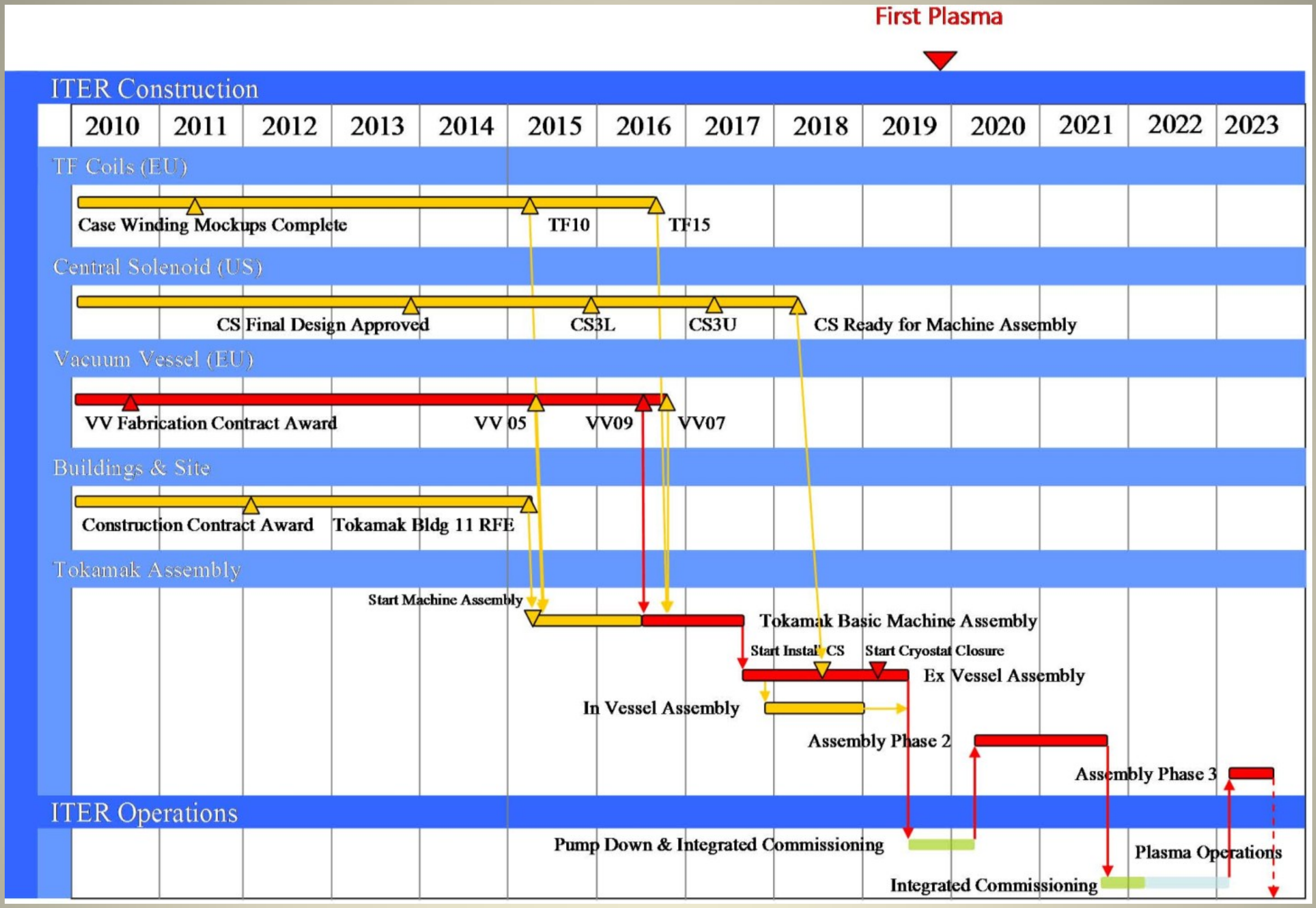
- ITER, which means "the way" in Latin, will require unparalleled levels of international scientific collaboration.
- Key plant components, will be provided to the ITER Organization through in-kind contributions from the seven Members.
- Each Member has set up a domestic agency, employing staff to manage procurement for its in-kind contributions.

ITER's Mission

- To demonstrate the feasibility of producing commercial energy from fusion.
- Q ≥ 10 represents the scientific goal of the ITER project: to deliver ten times the power it consumes.
  - aiming for 500MW during a pulse of 300-500s
- Test blanket modules will be used for the development of tritium breeding.

- … and if it all works, after ITER will come DEMO

Schedule



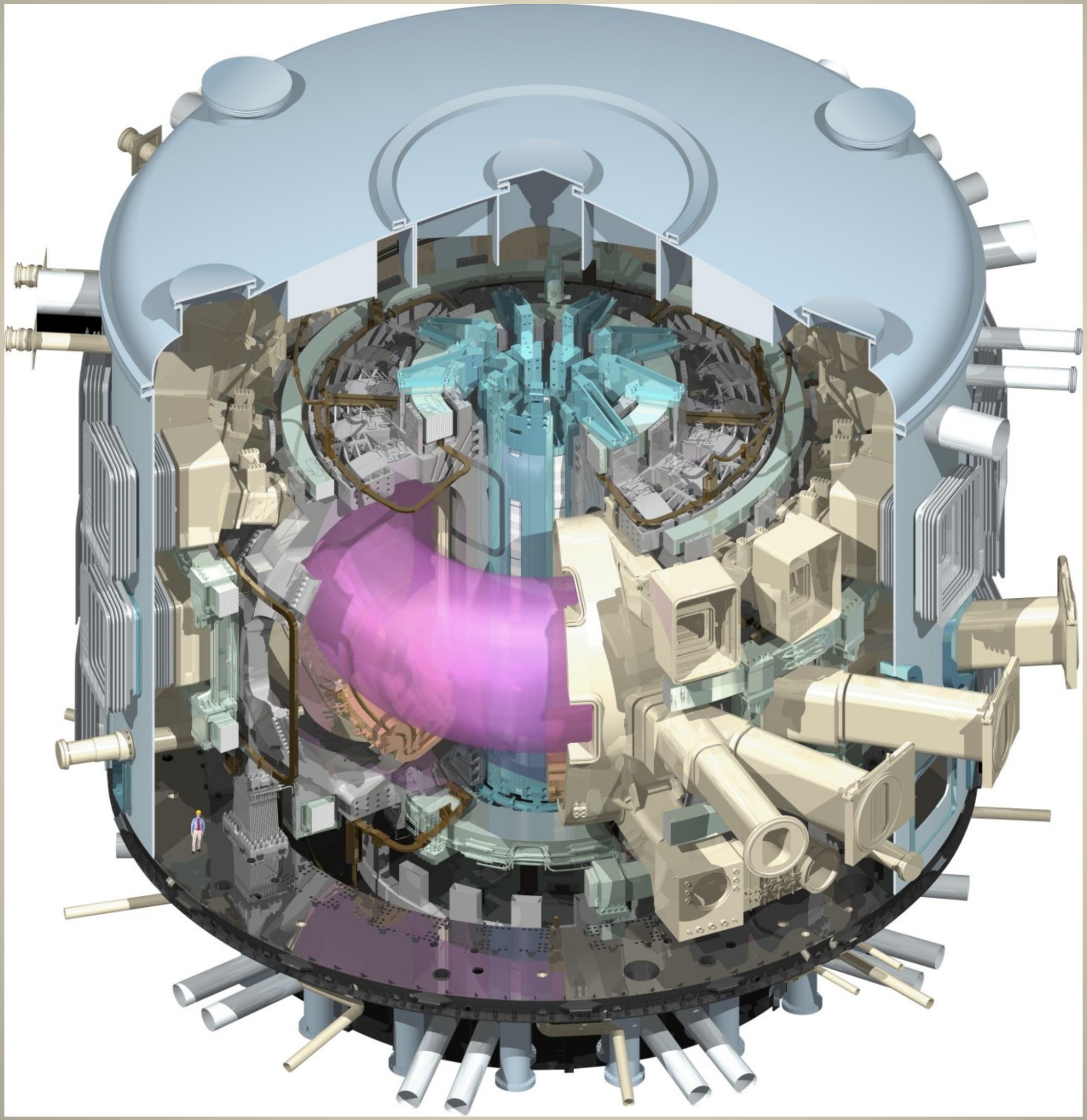
November 2007 – November 2019	Construction
April 2019 – October 2037	Operation
November 2037 – September 2042	Deactivation
October 2042	Decommissioning

Phases of Development

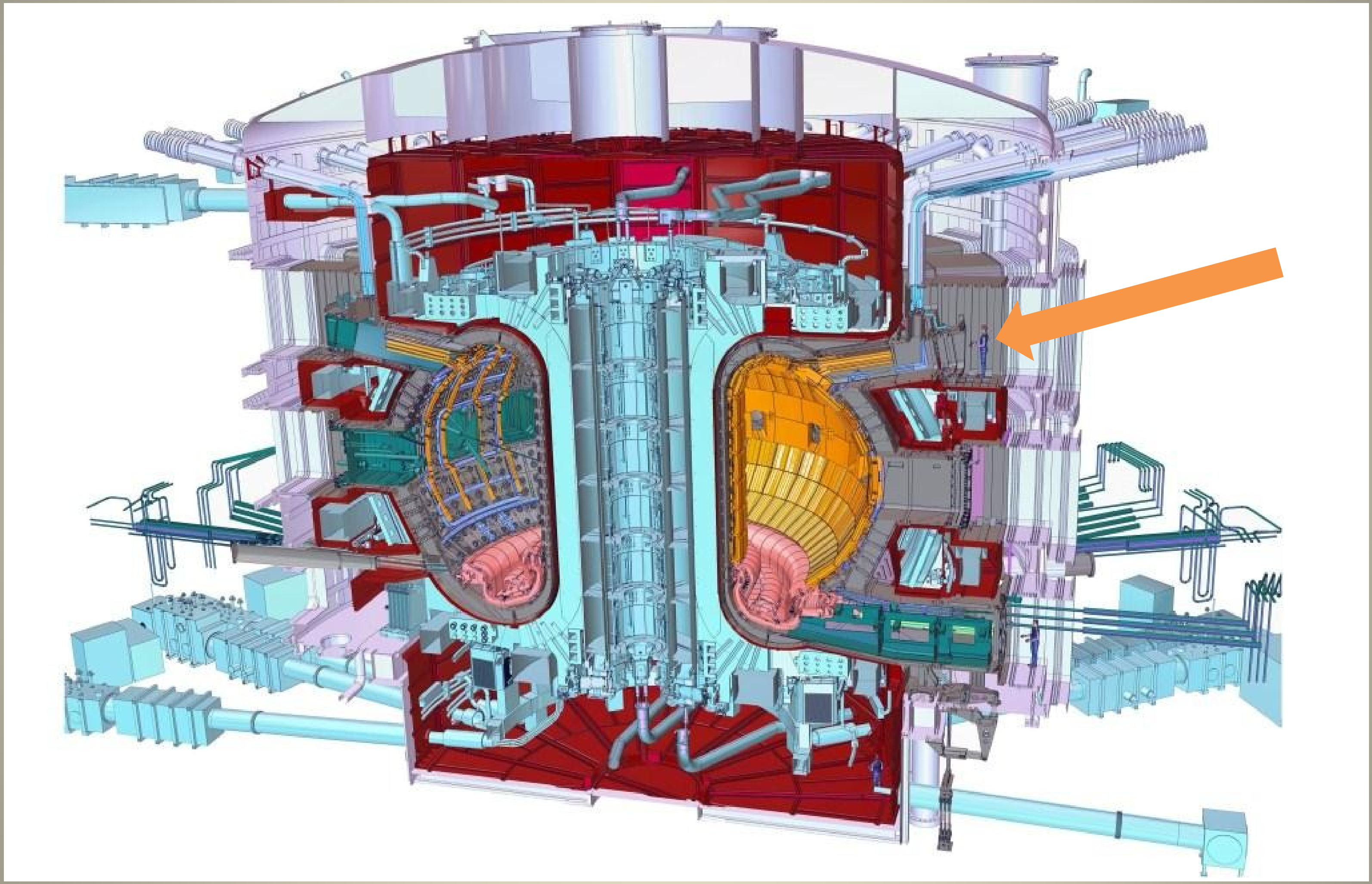
Phased Operation

- Hydrogen plasmas from 2019 followed by a 10 year programme working through helium, deuterium and ultimately deuterium-tritium (D-T) plasmas.
- The initial phases (H, He and D) are non-nuclear and will not generate anything significant in terms of radioactivity.

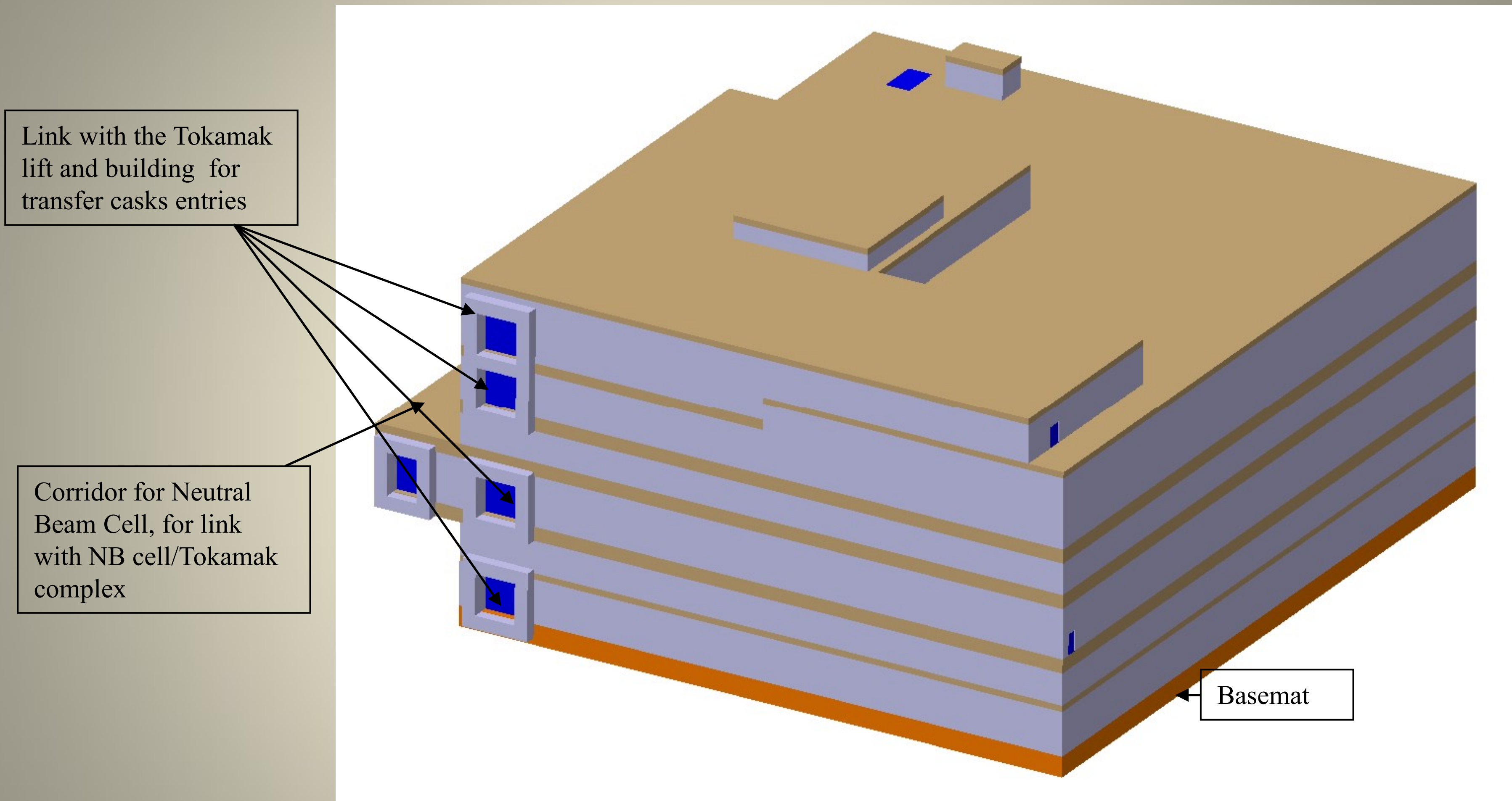
The Tokamak



Cutaway View



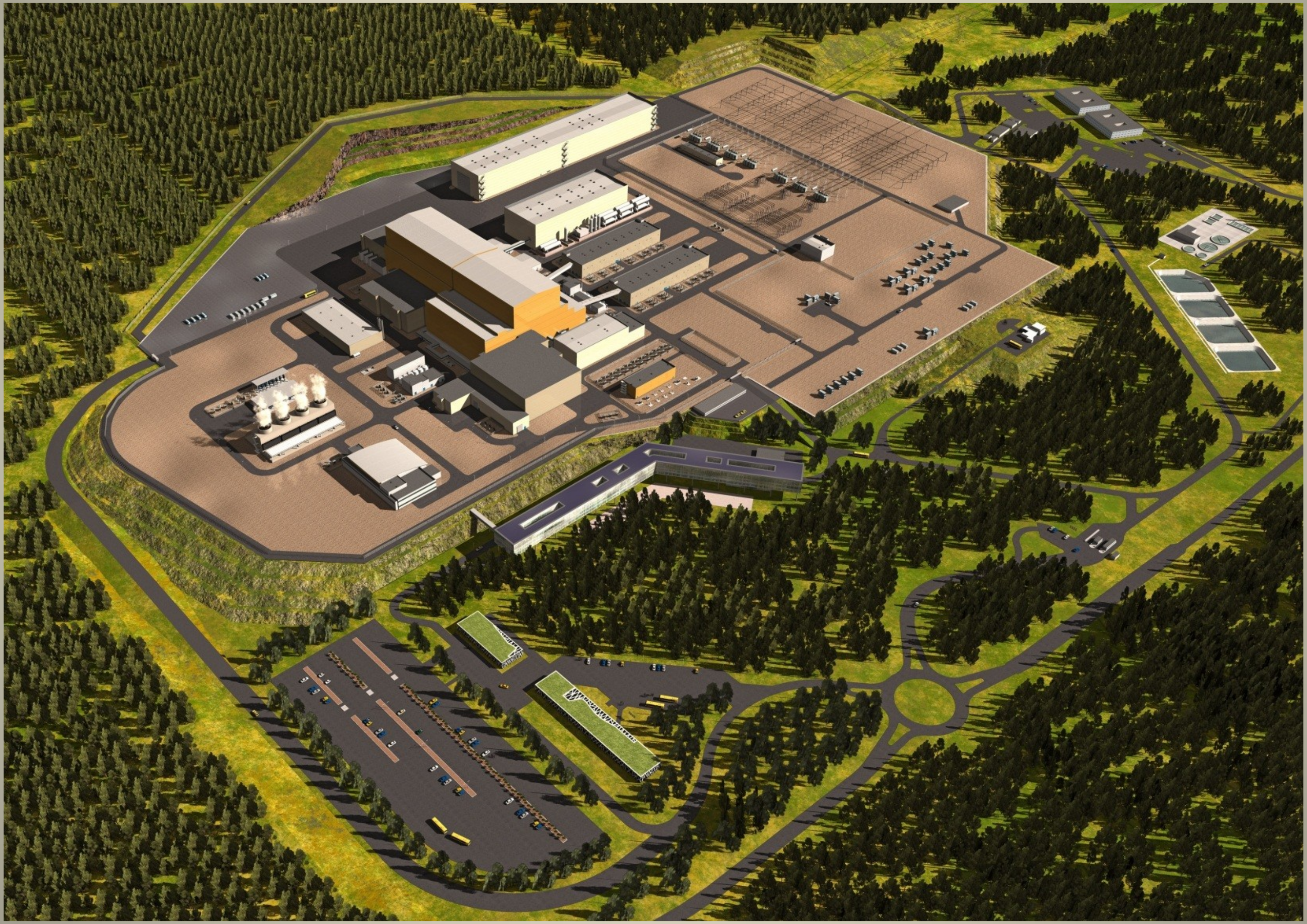
Hot Cell Facility



- A substantial concrete, stand-alone building of four floors above ground and one basement. 70m×62m and about 22 to 24m high. Current volume is about 91,000 m^3 above ground.

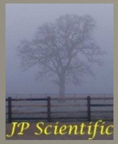
Aerial View in June 2010

Artist's Impression of the Site



Construction

- March 2011 – the Tokamak pit – 17 m deep, 120 m long and 90 m wide - will house the anti-seismic foundations for the Tokamak Complex



Buildings

- April 2011 – the Poloidal Field Coil Winding Facility – 49m wide and 17m high – for ITER's largest components.

Technical Development

- In 2001 the design was sufficiently advanced for a ‘Generic Site Safety Report’ (GSSR) to be prepared. This was updated in early 2005, prior to the site decision.
- The aim of the document was to provide site-independent input for an environmental impact assessment and for safety characterisation.

GSSR Contents

1. Safety Approach
2. Safety Design
3. Radiological and Energy Source Terms
4. Normal Operation
5. Radioactive Materials – Decommissioning and Waste
6. Occupational Safety
7. Analysis of Reference Events
8. Ultimate Safety Margin
9. External Hazards Assessment
10. Sequence Analysis
11. Safety Models and Codes

A total of some 1200 pages.

Design Evolution

- Final Design Review 1998
- Final Design Review 2001
- 2004 Baseline established
- 2007 Complete review of the design
- 2010 New baseline agreed/approved
  - Cost
  - Management
  - Schedule
  - Scope
  - Technical

Agreement with the Host State

- ITER is established as an international organization, like CERN and the United Nations.
- France has agreed that at the end of operation and deactivation, they will assume responsibility for dismantling, waste and the site (funded by ITER Organization).
- ITER Organization has agreed to submit to the French licensing process and to be an INB (Installation Nucléaire de Base).

ITER Agreement

Article 14

Public Health, Safety, Licensing and Environmental Protection

The ITER Organization shall observe applicable national laws and regulations of the Host State in the fields of public and occupational health and safety, nuclear safety, radiation protection, licensing, nuclear substances, environmental protection and protection from acts of malevolence.

Responsibilities

- Licensing is between ITER Organization and France
- Design is the responsibility of ITER Organization and the domestic agencies
- Operations will be run by ITER Organization but Members will participate in physics experiments (pulses) remotely.
- Waste and dismantling will be the responsibility of the host (France).

Licensing Process

- The procedure will be the standard 'INB' procedure in the context of the Nuclear Transparency and Security (TSN) Law of 2006.
  - INB licensing procedure plus, local information committee, strong relations with regional and national bodies etc.
- The request for authorization of creation (Demande d'Autorisation de Création) was sent in March 2010 and included
  - Preliminary Safety Report (RPrS)
  - Impact Study
  - And 12 other documents, totalling >5000 pages.
- Public enquiry – summer 2011
- Examination by IRSN for ASN – now
- Review by the 'Groupe Permanent' – autumn 2011
- … the 'decree' – 2012 ?

Ongoing Licensing

- The current stage will culminate with approval to start construction, which covers the period to 2019.
- Before startup (non-active) there will have to be approval (examination, GP and decree) based on a Provisional Safety Report, General Operating Regulations and a Waste Study.
  - The documents will have to be submitted a couple of years ahead of the planned startup.
- A few years after startup the definitive versions (how it really is) of Safety Report, General Operating Regulations and Waste Study will be submitted. Because there will be a phased startup (H-H, D-D and finally D-T in ~2027) there will be further major stages in the licensing process.

2007 - 2012

2012 - 2017

2017 - 2027

2027 – 2037
D-T

Safety Activities

- Analysis of design and operation
- Environmental impact study
- Zoning (security, radiological, magnetic, fire, ventilation, anti-deflagration, chemical …)
- Identification of risks
- Mitigation of risks
- Accident analyses
- Mitigation of accidents

Accident Analysis

- The situations adopted for study were selected in a deterministic manner.
  - A significant loss or transmission of energy may destabilise the facility and initiate a sequence of events leading to a release.
- Sequences of events were selected by a deterministic approach.
- Initiating events were selected using two complementary approaches to ensure exhaustiveness:
  - Inductive bottom-up (Failure Mode and Effects Analysis): identifying possible equipment failures and the consequences for safety functions
  - Deductive top-down (Master Logic Diagram): hypothesizing loss of safety functions, assessment of equipment failures

Main Safety Features

- Confinement of tritium
- Explosion risks (dust and hydrogen)
- Radiation protection (remote handling, hot cell facilities, …)
- Waste

Preliminary Safety Report

- Volume I Description of the Facility and its Environment
  - General description of the facility and surroundings
  - Detailed description of the buildings, facilities and systems
  - Operations, human factors, controls, zoning
  - Shut down and dismantling
- Volume II Safety Demonstration
  - Description of normal operation
  - Identification of risks
  - Accident analyses
  - Radiological consequences
  - Emergency plans
  - Analysis of accidents resulting from malevolence

Technical Features

- The tritium inventory brings security aspects as well as confinement challenges.
- Detritiation, tritium storage and fuelling
- Nuclear pressure equipment
- Huge superconducting magnets
- Plasma control
- Remote handling in the tokamak vacuum vessel as well as the hot cell/maintenance and waste facilities
- Neutral beam accelerators (33MW beam power initially)

Fusion not Fission

- ITER is an INB, but *it is not a fission device*.
  - Have to fight the prejudices in the various communities
  - Have to specifically educate some independent experts
  - Even internally, people from other disciplines (especially the nuclear power industry) have to be re-educated

Language

- ITER has one official language – English
  - Reminder – the members are:
    - China, Europe, India, Japan, Korea, Russian Federation, USA
- The licensing process is French and all documents have to be in French for this process.

- This requires patience and understanding and resources.
- Additional time is required for writing and reviewing, which affects planning and scheduling.
- Expert help is needed (Language + technical understanding).

In-kind Contributions

- Most of the components (and all of the major components) are being manufactured outside France.
- However the regulatory requirements (norms and standards e.g. pressure vessels) are French (or European).

- It is therefore essential to have very good integration of the Headquarters team and the engineers in the field. In some cases there will be regulatory consultants stationed in the field during design and manufacture.

Dynamic Design

- The design is evolving and some ‘improvements’ may have safety implications
  - This is pretty much the case for any project

- This requires strict change control mechanisms (documentation, review and approval) which cover both the technical changes and the safety repercussions.

Waste

- The composition of ITER waste is unusual, if not unique (the level of tritium content).
- Disposal channels are something of a problem.
- The absence of release thresholds in France presents further problems.

- The current detailed analysis of the waste is the basis for ongoing discussions with the French authorities. Plans are being prepared to make disposal possible.

Personal View of Safety Management

- At the head there should be a high level (very senior manager level) and respected decision maker from the project team (not from safety).
- There have to be sufficient resources for:
  - Analysis
  - Iterations/feedback in the licensing process
  - Follow up of design during the licensing process and follow up during operation and evolution of the facility
  - Quality control and procedures
  - Documentation
- A project needs strict and formal change control procedures which define the impact on safety and the associated changes required in safety.
- Operations personnel should be integrated in the safety team to make sure that the facility will remain operable with all of the proposed safety features.

Conclusions I

- The management of safety is key to its successful implementation.
- Clearly defined and appropriate structures are required for:
  - – Safety management within an organisation
  - – Relationships with national safety authorities at various levels:
    - Top level political
    - High level management
    - Technical level

Conclusions II

- The INB process
  - Reflects a philosophical approach
  - The process of analysis, identification of risks and definition of measures to mitigate risks and manage safety is fundamental
  - Is writing your own ‘rule book’ the best way ?

Conclusions III

- A pragmatic approach to safety will lead to:
  - A better safety culture within an organisation
  - Better acceptance of safety procedures
  - Savings in resources

If something in the safety and licensing process does not contribute to making things safer, then why do it ?

Conclusions IV

- The ITER project brings many safety challenges which are common to large scale international nuclear projects.
- Rather than the French system applied in ITER, I would recommend a more pragmatic and less doctrinal approach for an international project like EUROnu.
  - This would lead to adequate safety levels (equivalent to those achieved with the INB system) but a better safety culture throughout the organisation and better acceptance of safety procedures with the additional benefit of savings in resources.