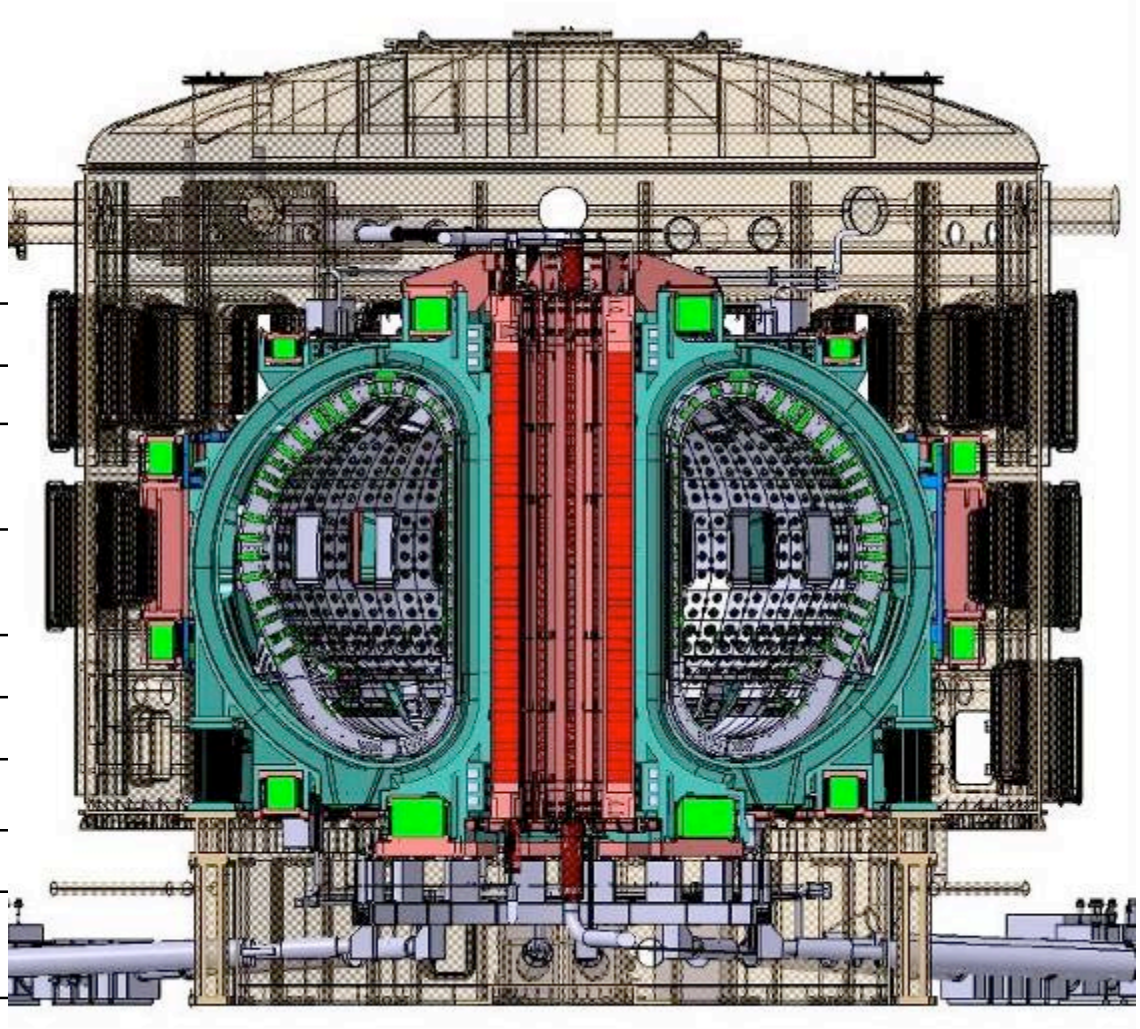
Status of ITER

Fusion Power Associates
Thirty-year Anniversary Meeting and Symposium
Washington, 2 December 2009

Norbert Holtkamp
Principal Deputy Director General of the ITER Organization

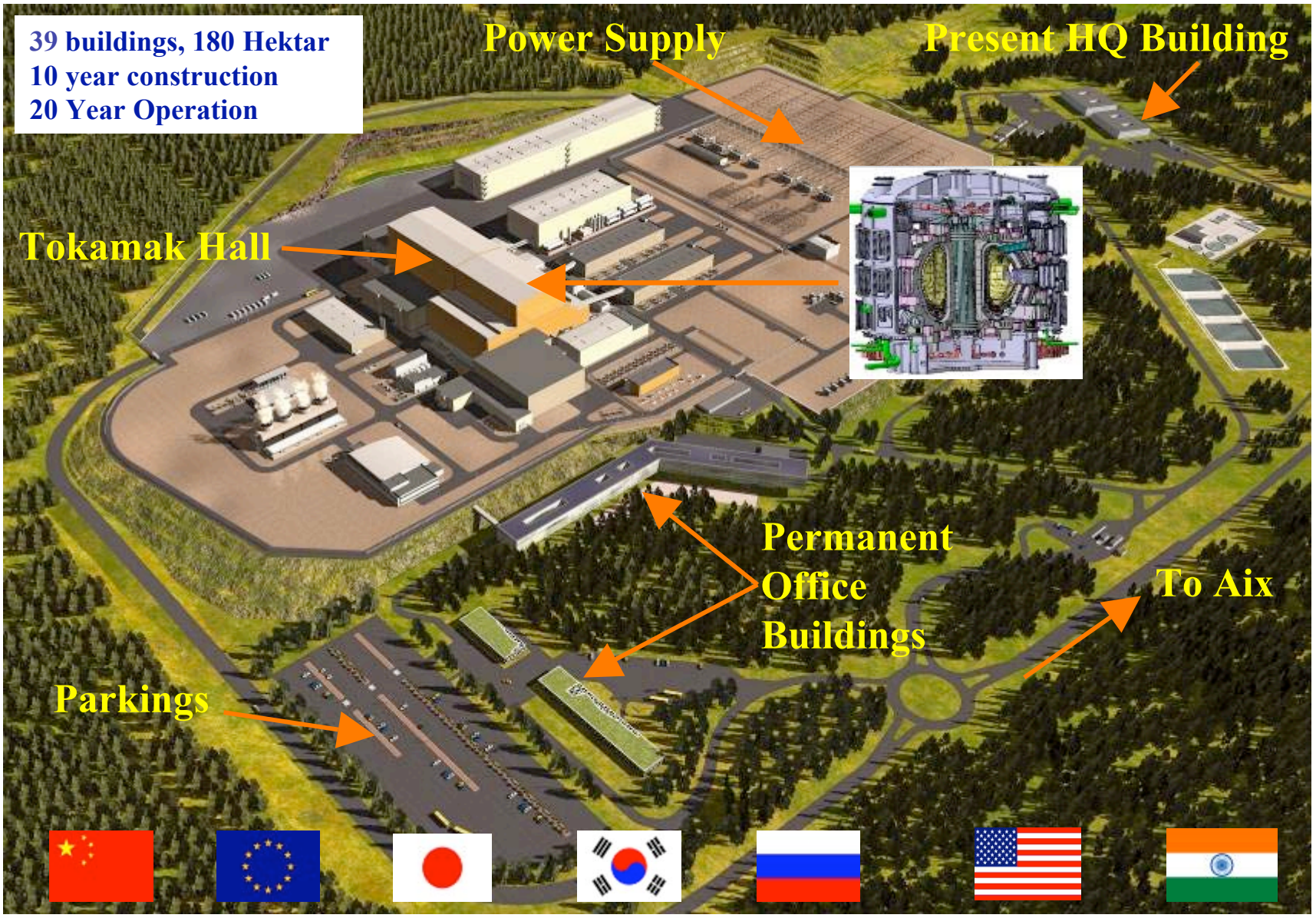
The Core of ITER

Total fusion power	500 MW
Additional heating power	50 MW
Q - fusion power/ additional heating power	≥ 10
Average 14MeV neutron wall loading	≥ 0.5 MW/m^2
Plasma inductive burn time	300-500 s *
Plasma major radius (R)	6.2 m
Plasma minor radius (a)	2.0 m
Plasma current (I_p)	15 MA
Toroidal field at 6.2 m radius (B_T)	5.3 T



Machine mass: 23350 t (cryostat + VV + magnets)
- shielding, divertor and manifolds: 7945 t + 1060 port plugs
- magnet systems: 10150 t; cryostat: 820 t

The Final ITER Site



Wo ist ITER?

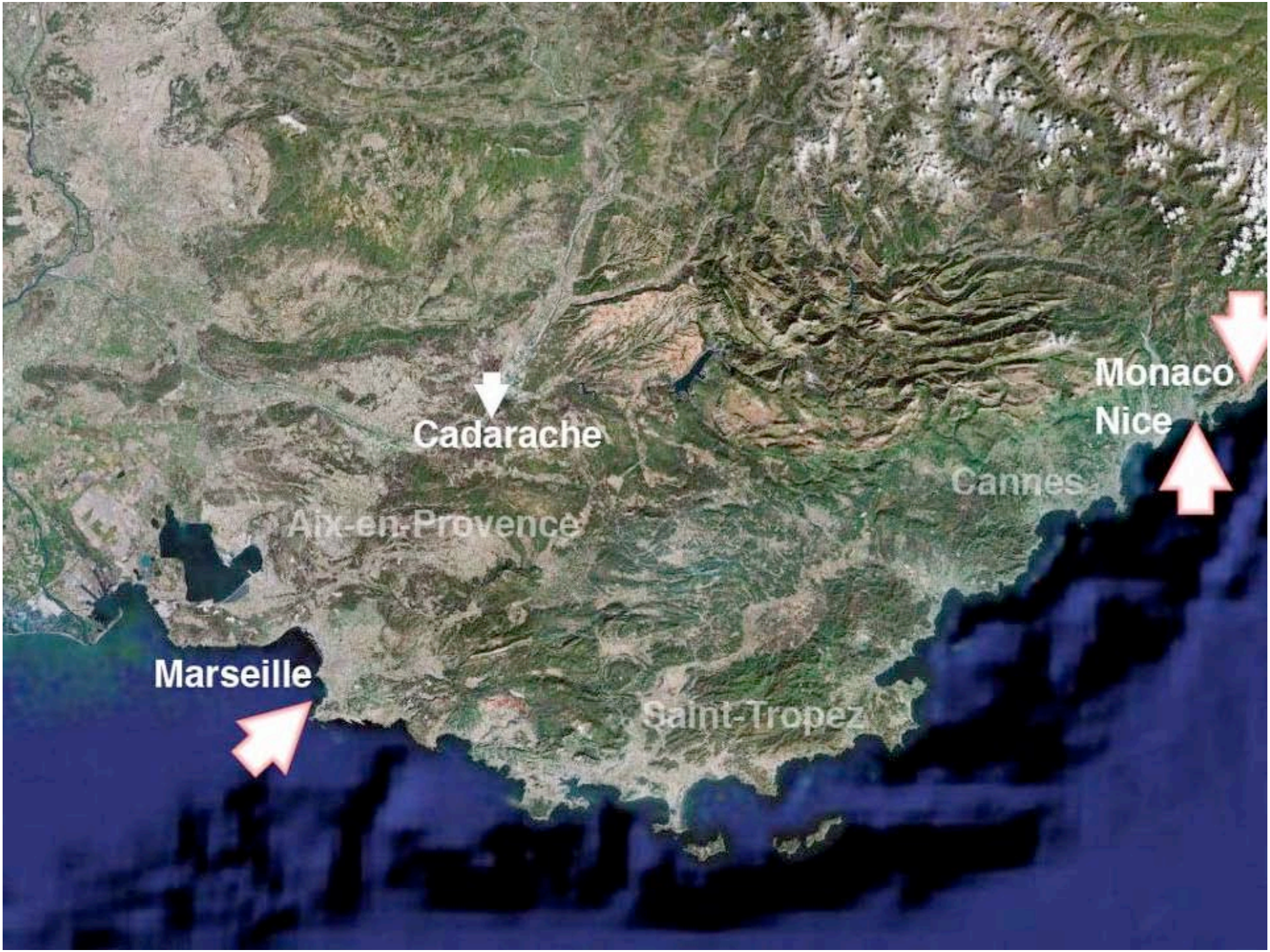
Cost: Financial Resources

- **The Construction cost: 3 578 kIUA (~5 400 M€)**
  - Including 80 kIUA R&D (~120 M€)
  - Including 477 kIUA Project Team (~700M€)
  - Fund Procurement (~330 kIUA) to be executed by IO (CODAC, Cryo, water cooling assembly, installation)

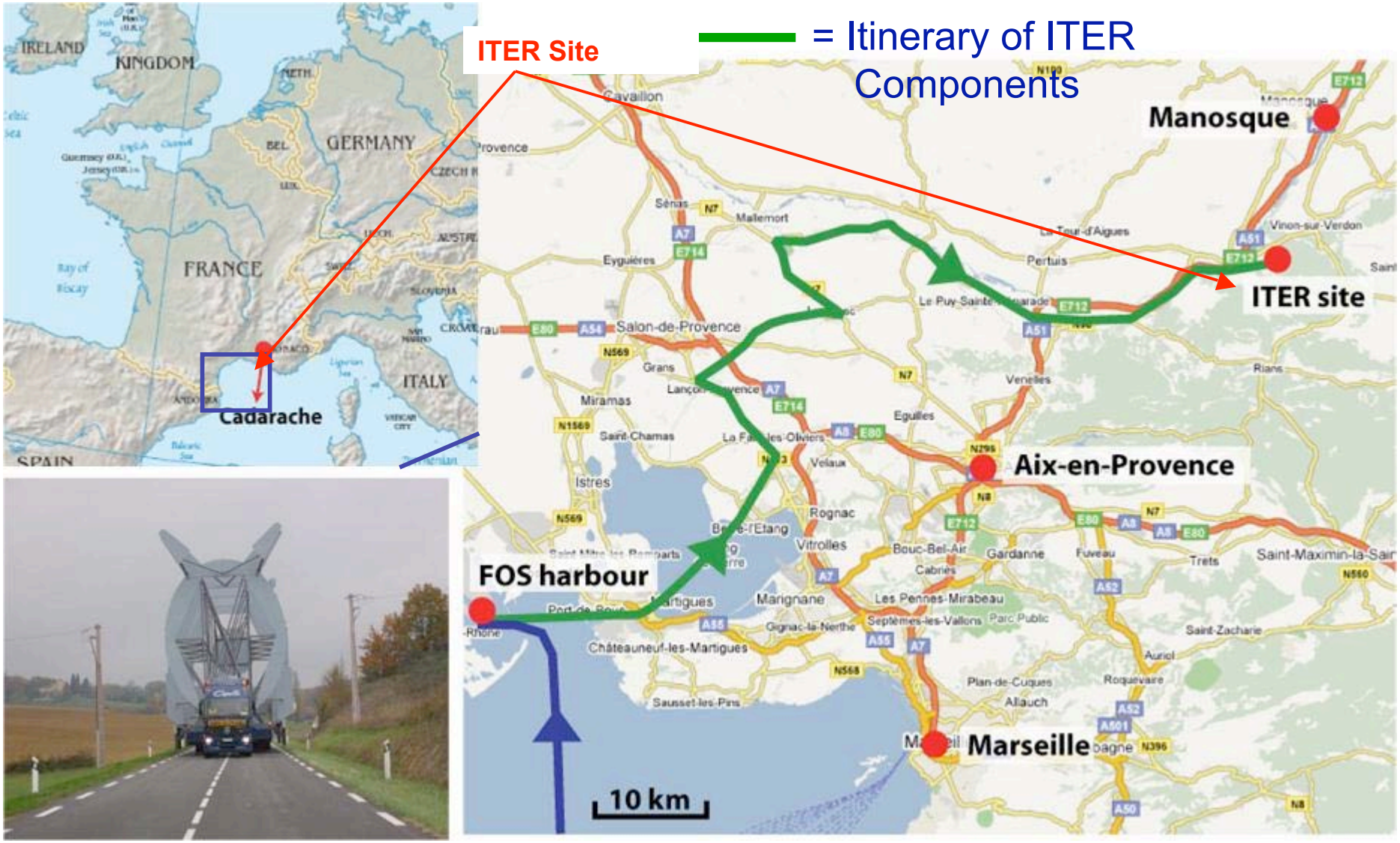
- Reserve: 358 kIUA on request by DG
- Operations cost for 20 years: 188 kIUA/year
- Deactivation for 5 years: 281 MEuro

- Not sufficient budget or no budget for:
  - **Finishing the design**
  - **Infrastructure (workshops, storage, tools, labs, test facilities etc)**
  - **Large contracts (engineering, design, integration, installation support, etc)**
  - **Cost for operation of buildings, systems and infrastructure during construction period**
  - **Site services cost (Security, storage, transport, shipping and receiving)**

- Credit Value (kIUA) for in Kind components does not cover actual cost and therefore does not allow parties to plan budgets.


Monaco
Nice
Cadarache
Cannes
Aix-en-Provence
Marseille
Saint-Tropez

Itinerary of ITER Components




ITER
Tokamak

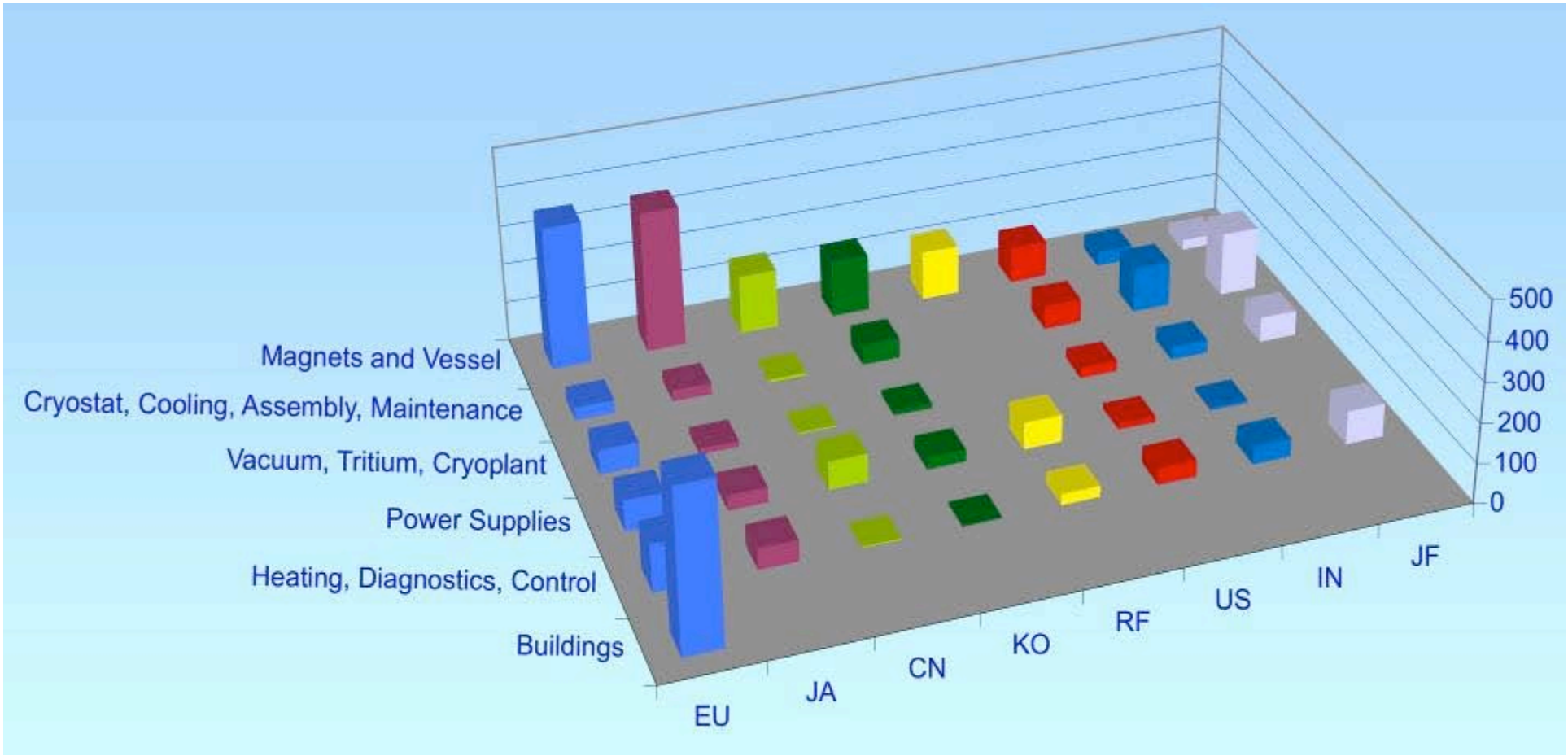

ITER
Tokamak

The ITER Project Team is Growing

- The ITER Organization ~440 people by end 2009
- Another 450-500 people in the DAs working on ITER
- IO and DA's started on "Green Field sites" and are operational for about 1.5-2.0 years.

Procurement Sharing

- A unique feature of ITER is that almost all of the machine will be constructed through *in kind* procurement from the Parties with essentially every party involved in every component.



9 PAs Signed since IC-4 (June, 2009)

No.	REFERENCE	Signature date	kIUA value
20	1.1.P6A.US.01 TF Conductors	18 June 2009	16.80
21	2.6.P1A-1B.US.01 Tokamak Cooling Water System	18 June 2009	65
22	1.7.P2A.JA.01 Divertor Outer Vertical Target	17 June 2009	28.5
23	1.1.P3A-B PF Magnets 2,3,4,5,6 (EU)	19 June 2009	41.4
24	5.3.P6.EU.01 Power Supply for Heating Neutral Beam (Low Voltage)	13 July 2009	19.5820
25	2.2.P2A.KO.01 Machine Assembly Tooling	3 August 2009	22.00
26	1.5.P1B.IN.01.0 VV In-Wall Shielding Block Assemblies	24 September 09	37.3
27	1.1.P6C.RF.01 PF Conductors	2 October 09	16.96287
28	4.1.P1A-P8B.EU.01 SSEPN and PPEN Detailed System Engineering Design	26 October 09	7
	TOTAL value of all 28 signed PAs		**970.52947**

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97.10 kIUA in 2007
470.25061 kIUA in 2008
403.17887 kIUA in 2009

PAs to be signed by the end of 2009 according to IPS

	REFERENCE	IPS DATE (and projection date if any)	KIUA VALUE
1	5.1.P3.IN.01 IC H&CD Radio Frequency Power Sources	14 October 2009 (**will be signed at Iter Council**)	18
2	5.1.P4.IN.01 IC H&CD Radio Frequency Power Supply	04 December 2009 **(Tentative date after Council approval of DCR-118)**	6
3	5.3.P7A.IN.02 Diagnostic Neutral Beam Line	10 December 2009 **(should be signed mid-December)**	13.1
4	1.5.P1A.EU.01 Main Vessel including Blanket Manifolds and Hydraulic Connectors	30 October 2009 **(should be signed in November)**	85.1* done
5	2.6.P2A.IN.01 Component Cooling Water System (CCWS) Chilled Water System (CHWS) and Heat Rejection System (HRS)	18 November 2009 **(should be signed in December after India Empowered Board approval)**	42
6	1.1.P6B.JA.01 CS Magnet Conductors	26 November 2009 **(will be signed in December)**	90

*if PCR-0207 approved by Council

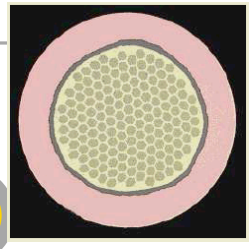
PAs to be signed by the end of 2009 according to IPS

	REFERENCE	IPS DATE (and projection date if any)	KIUA VALUE
7	5.3.P6.JA.01 NB H&CD Power Supply for Heating Neutral Beam	10 December 2009 **(January 2010)**	22.622*
8	1.1.P3A.RF.01 PF Magnet 1	18 December 2009 **(beginning of February 2010)**	6.8
9	1.1.P4A-B.US.01 CS Magnet	23 December 2009	37.1
10	1.1.P3C.CN.01 Correction Coils	23 December 2009	2.6
11	1.1.P6C.CN.02 Conductors for CC/ feeders	09 December 2009	1.21
12	5.1.P2.US.01 IC H&CD Main Transmission Line	03 December 2009	7.35**
13	1.7 P2D.RF.01 PFC High Heat Flux Tests	14 June 2010 **(should be signed in December 2009)**	14
		TOTAL	**348.482**

*PA was split in two parts

**If PCR-090 approved by Council

Conductor



Strand

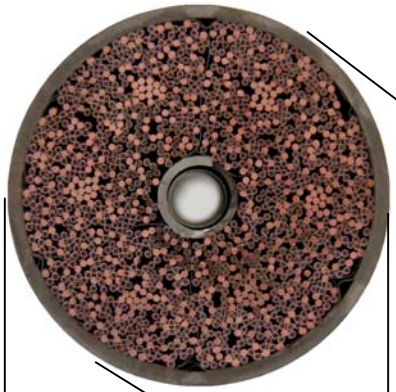
1st Stage

3rd Stage

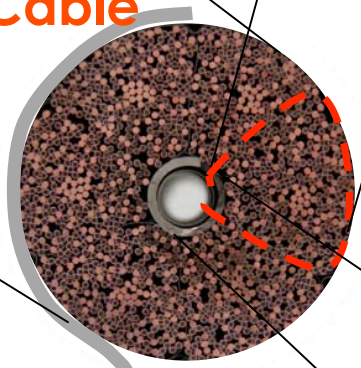
Sub-Wrap

Cu Wire

2nd Stage



Cable



4 th Stage

Cu Core Cable

Cu Sub-Cable

Wrap

Jacket Assy

Central Spiral

Jacket

TF and CS Jacketing in JA

TF & CS Jacketing Lines (Jun. 09)

TF Jacketing in RF

TF Jacketing Line at ÌHEP (Nov. 08_May 09)

TF and PF Jacketing in CN

TF & PF Jacketing Lines at ASIPP (March – June 09)

The ITER Baseline: Scope-Schedule-Cost

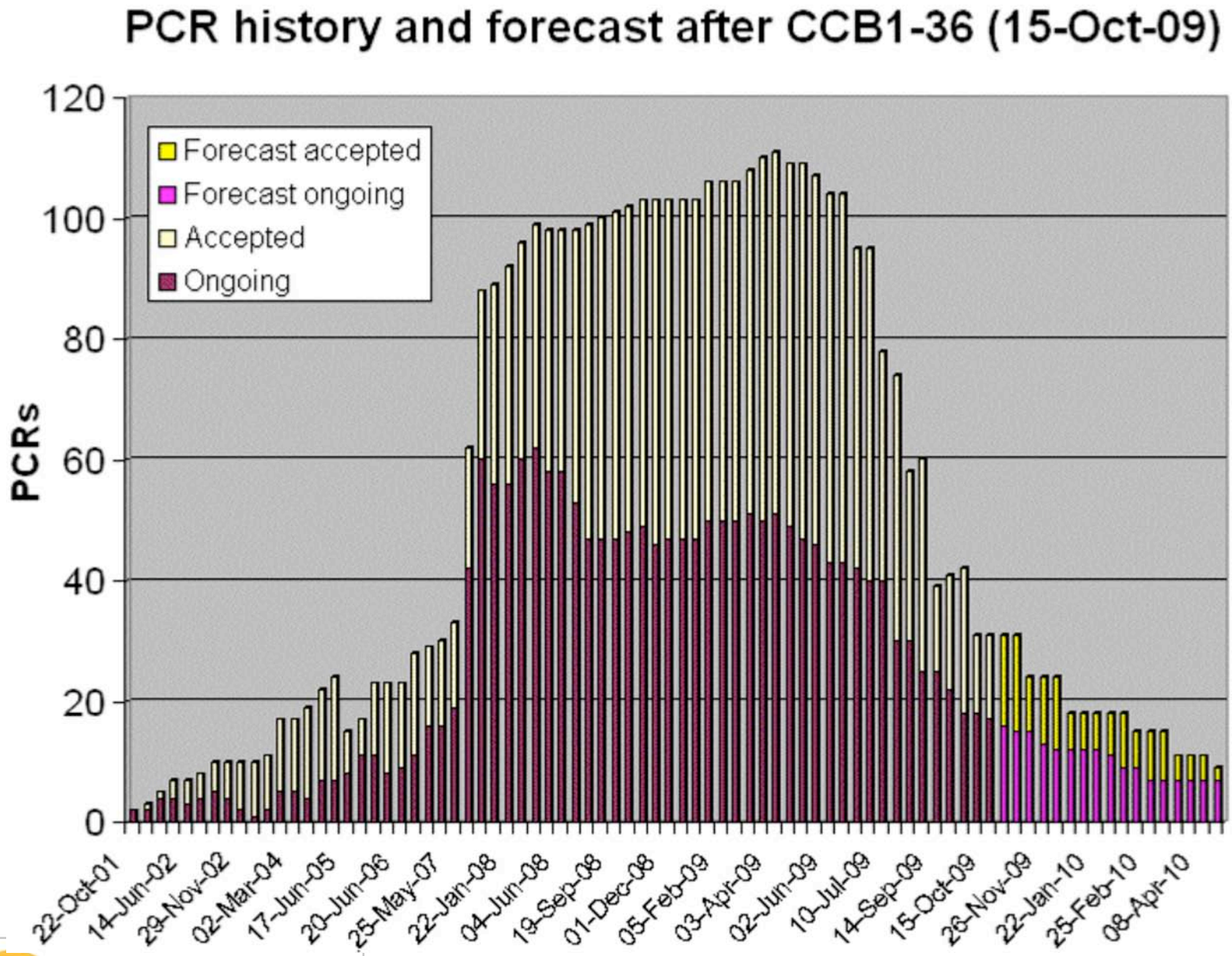
- Original Agreement was made on the basis of the 2001 Baseline design;
- The ITER Design Review resulted in approximately 80 design changes as necessary, of which only a few have a major impact, e.g. cold test of the magnets, NBTF etc.;
- November 2007 the results of the Design Review were reviewed and further 13 issues identified, such as ELM control, vertical stability etc. In May 2008 STAC supported the IO proposal to incorporate design changes into the 2007 Baseline design; - As a result, the Project Specifications (PS) were approved in June 2008;
- Consistent with this scope, and within the boundary conditions set by the Council, IO has prepared an Integrated Project Schedule and a Cost Estimate which forms a consistent set of documents that were presented recently

Major Risk Reduction resulting from Design Revie

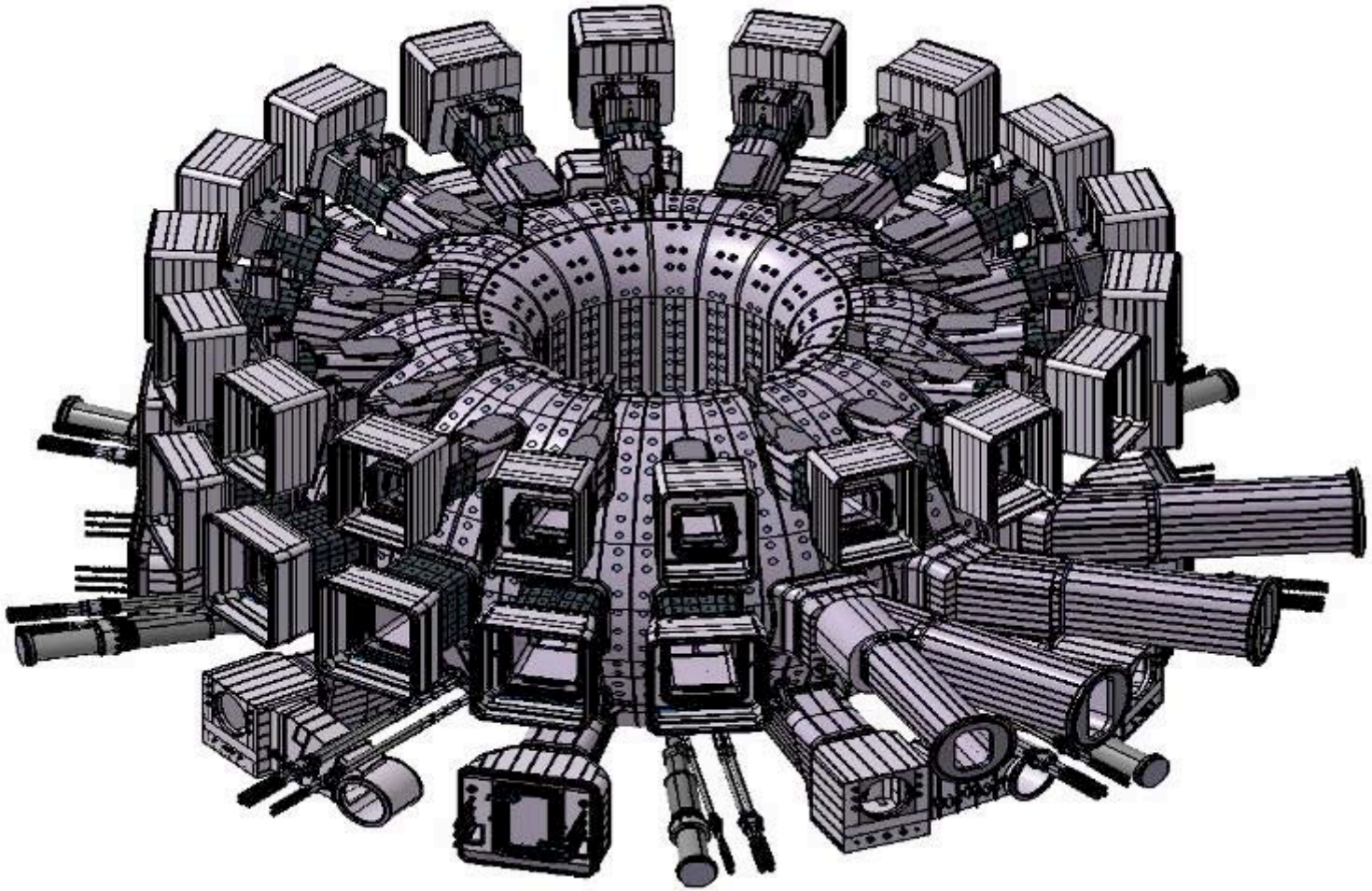
=solved =path forward clear =not solved

1	*Vertical Stability*	
2	*Shape Control / Poloidal Field Coils*	
3	*Flux Swing in Ohmic Operation and CS*	
4	*ELM Control*	
5	*Remote Handling*	
6	*Blanket Manifold Remote Handling*	
7	*Divertor Armour Strategy*	
8	*Capacity of 17 MA Discharge*	
9	*Cold Coil Test*	
10	*Vacuum Vessel / Blanket Loading Condition Test*	
11	*Blanket Modules Strategy*	
12	*Hot Cell Design*	
13	*Heating Current Drive Strategy, Diagnostics and Research Plan*	

Baseline is stable



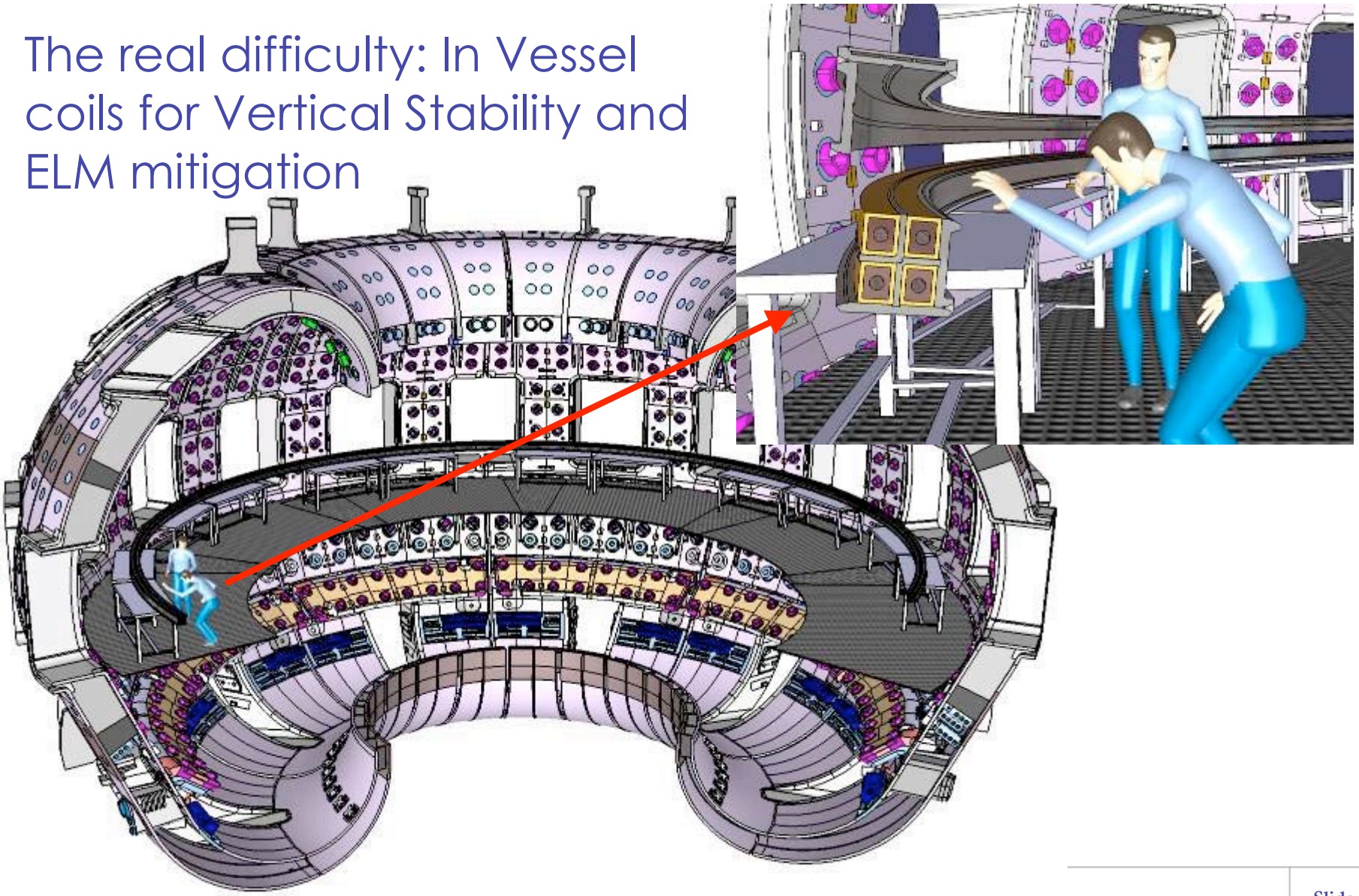
ITER Vacuum Vessel



KO out for bid end of the year
EU out early next year

VS Coil Construction and Assembly Concept (

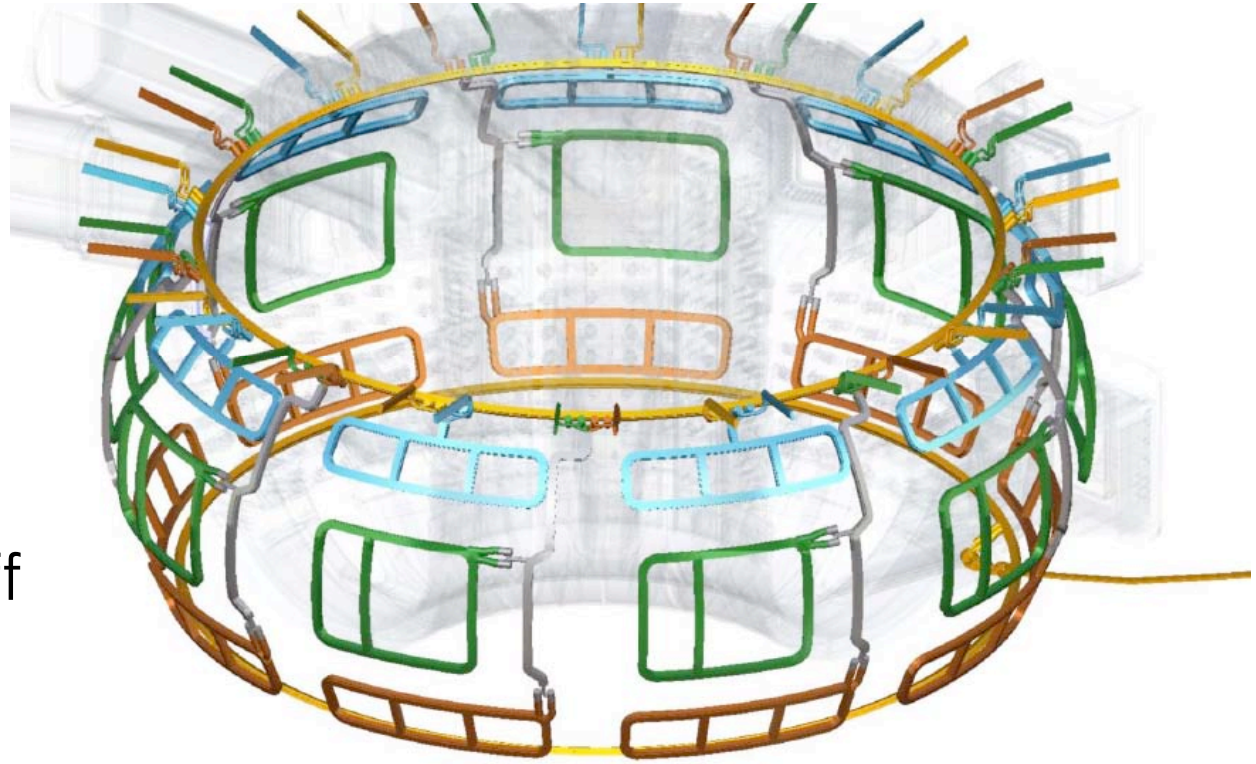
The real difficulty: In Vessel coils for Vertical Stability and ELM mitigation



ELM Mitigation

27 in vessel coils fed by independent PS

Production of the coils (and their cost)



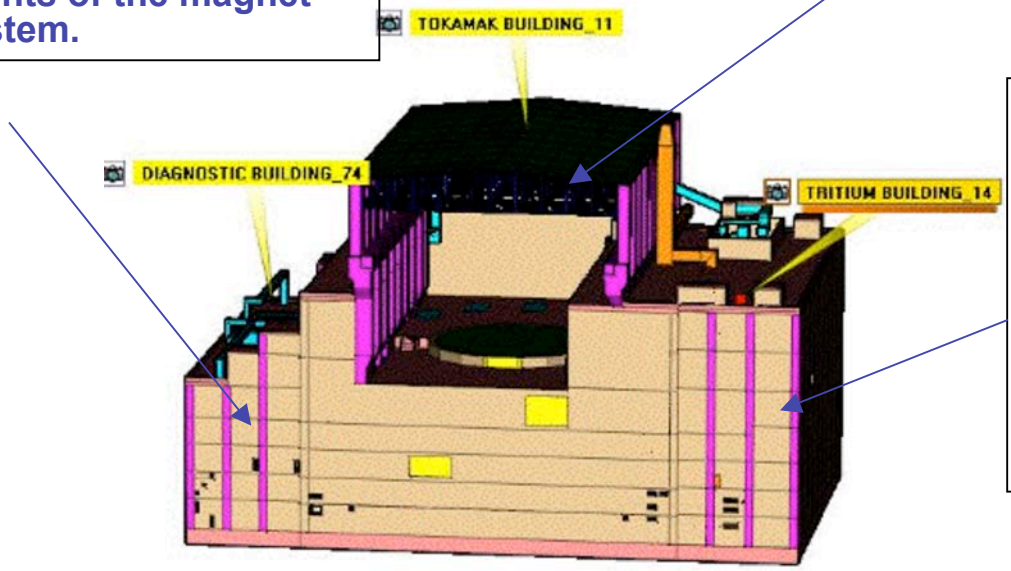
N. Sauthoff

Scope of the system

The Tokamak Complex System provides the necessary physical support, protection, environment, confinement and shielding functions to allow the complex and the plant systems that it contains to operate. It is a Nuclear building licensed under French law.

Building 74 - Diagnostic Building
Main function is to house the diagnostic systems. It also supports elements of the magnet coils power system.

Building 11 - Tokamak Building
Contains the Tokamak. It provides the necessary access to the Tokamak for operation, maintenance and amendments to the configuration.



Building 14 - Tritium
Contains the fuel cycle process. Also contains systems servicing the Tokamak, notably the extension of the Tokamak cooling water system vault. It also houses Tritium confinement system for the Tokamak and Tritium Buildings

Need Dates for Major Components
Updated Schedule: these are the highest risks for the updated schedule

System		Updated Schedule
Tokamak Hall (RFE)	**EU**	**Apr-2014**
Vacuum Vessel (First Sector)	**EU**	**Mar-2014**
Vacuum Vessel (Last Sector)	**EU / KO**	**Jul-2015**
First PF Coil	**EU**	**Sept-2014**
Last PF Coil	**EU**	**May-2017**
First TF Coil	**EU**	**Jul-2014**
Last TF Coils	**EU / JA**	**Nov-2015**
Central Solenoid	**US**	**Jan-2017**
Cryostat first section (Base)	**IN**	**May-2014**
Cryostat last section (Lid)	**IN**	**Mar-2018**

Development of Schedule and Cost

- When the agreement on the establishment of the ITER Organization was signed in Nov. 2006, it foresaw a First Plasma and construction complete with all subsystems and components installed within 10 years of construction begin. It was assumed to be 2016;

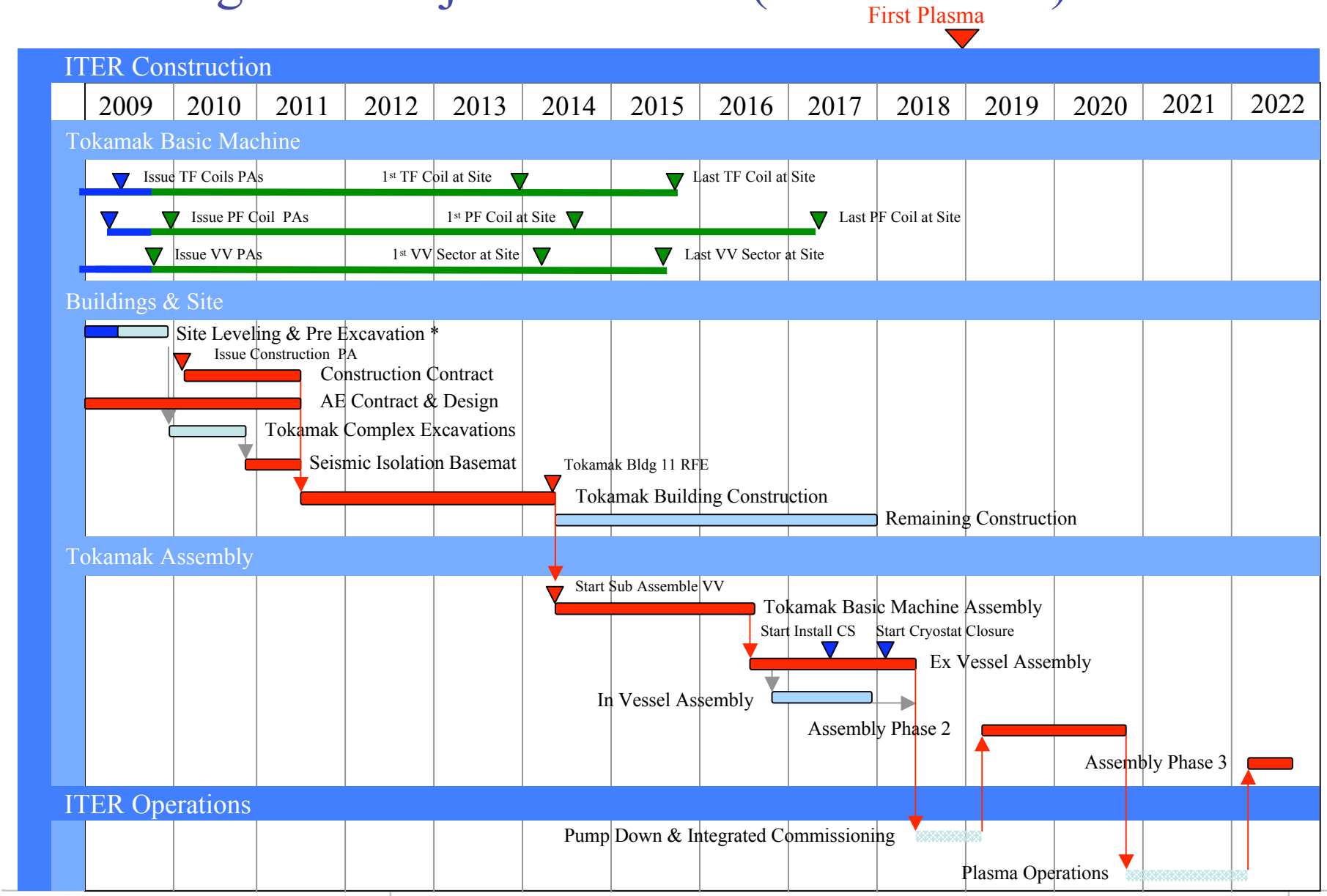
- In June 2008, after the Design Review, IO presented to the Council an IPS which foresaw First Plasma in 2018 and beginning of DT operation in 2026; in addition the need for a large increase in resources was indicated;
- The design effort to finalize the procurement arrangement was underestimated and they were delayed as a result;

- A variance analysis showed that First Plasma would be delayed to 2021 without management action being taken; In order to maintain the date 2018, IO proposed an Updated Schedule with a different approach to assembly;

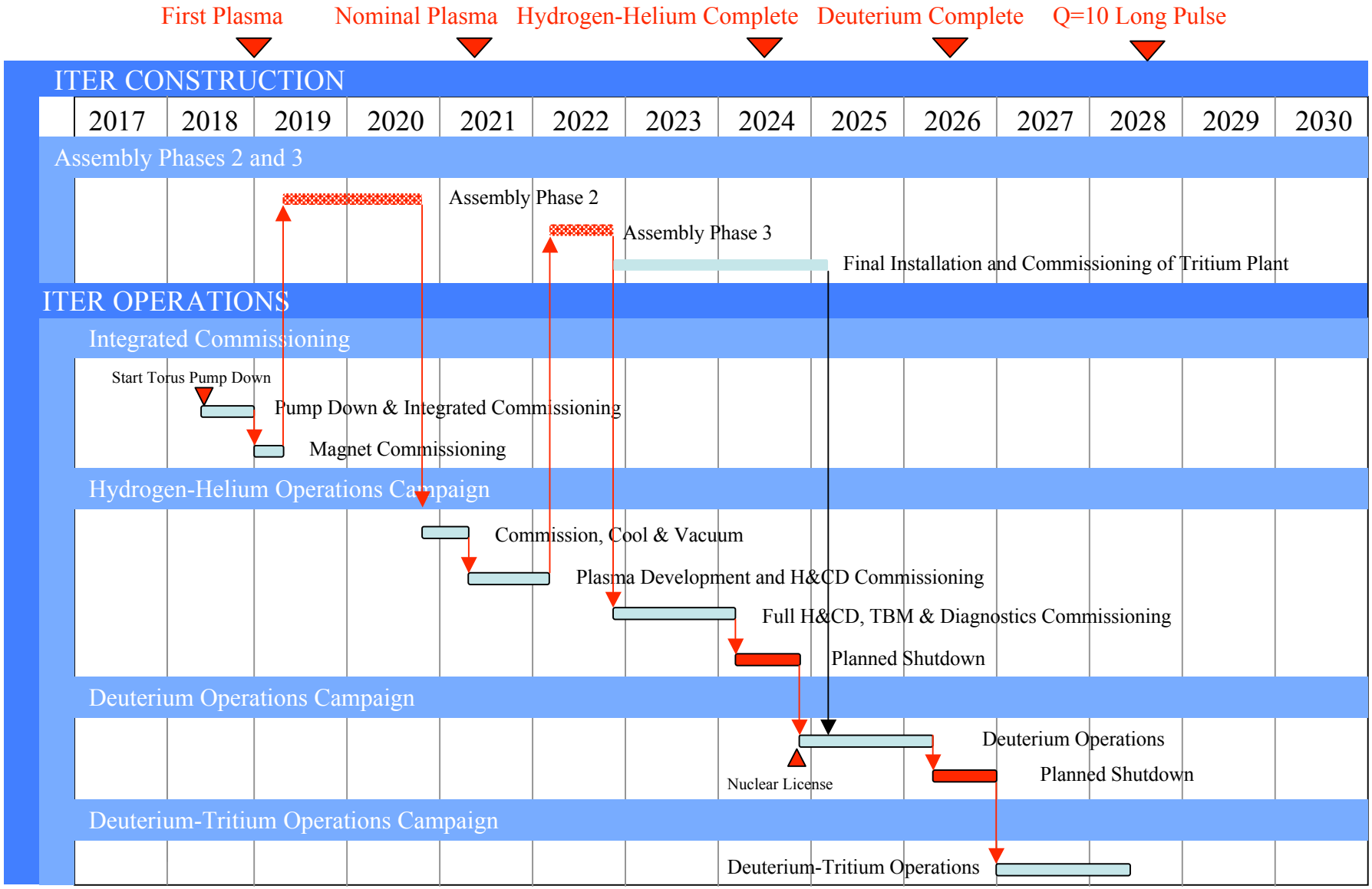
- The proposed Updated Schedule allows ITER to achieve a First Plasma operation in 2018;

- Within this Updated Schedule, a construction and assembly sequence is proposed in which reduction of risk and cost to the project and maintaining D-T operation in 2026 are the key drivers.

The Integrated Project Schedule (Construction)



IPS (Operations)



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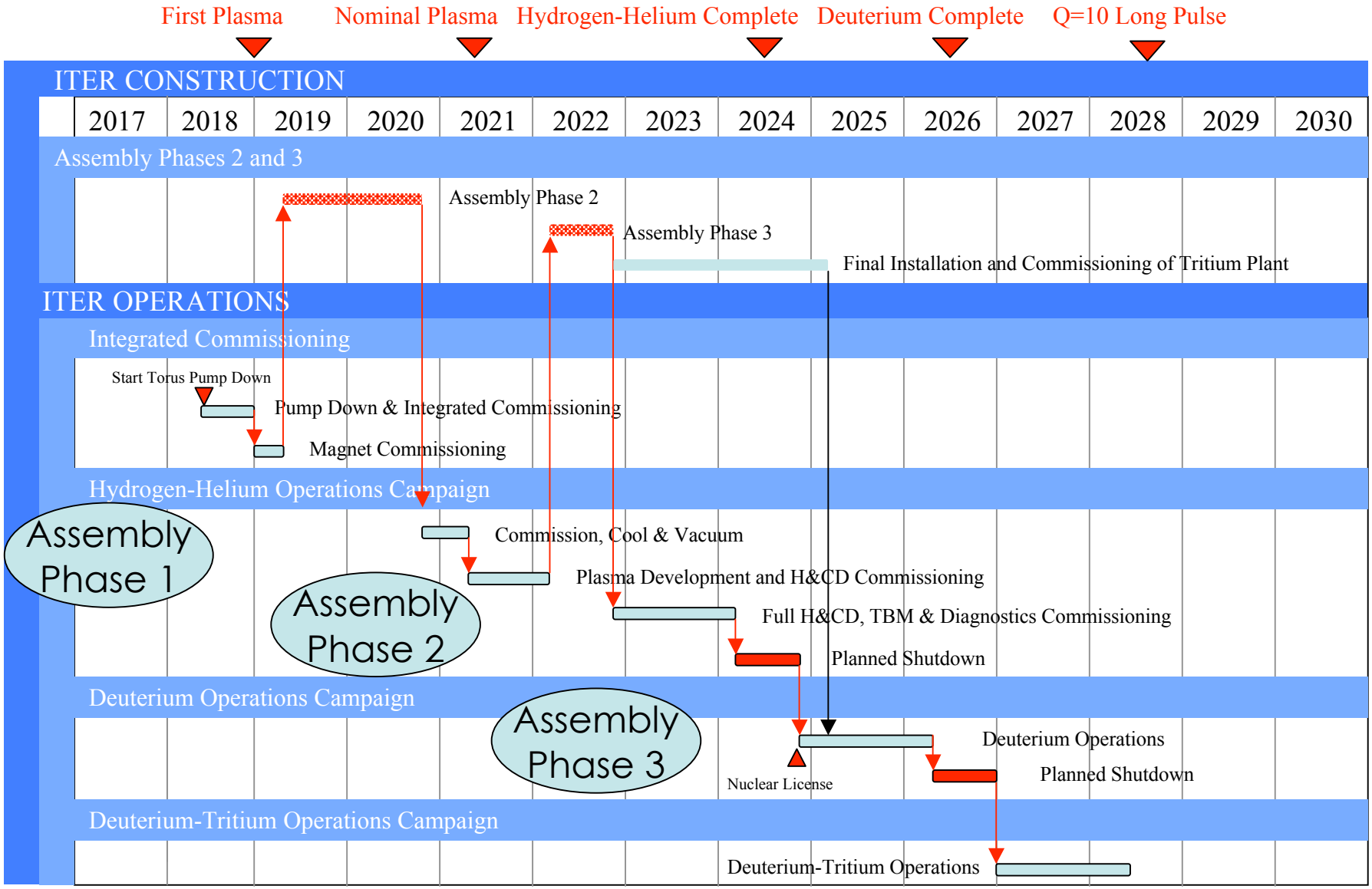
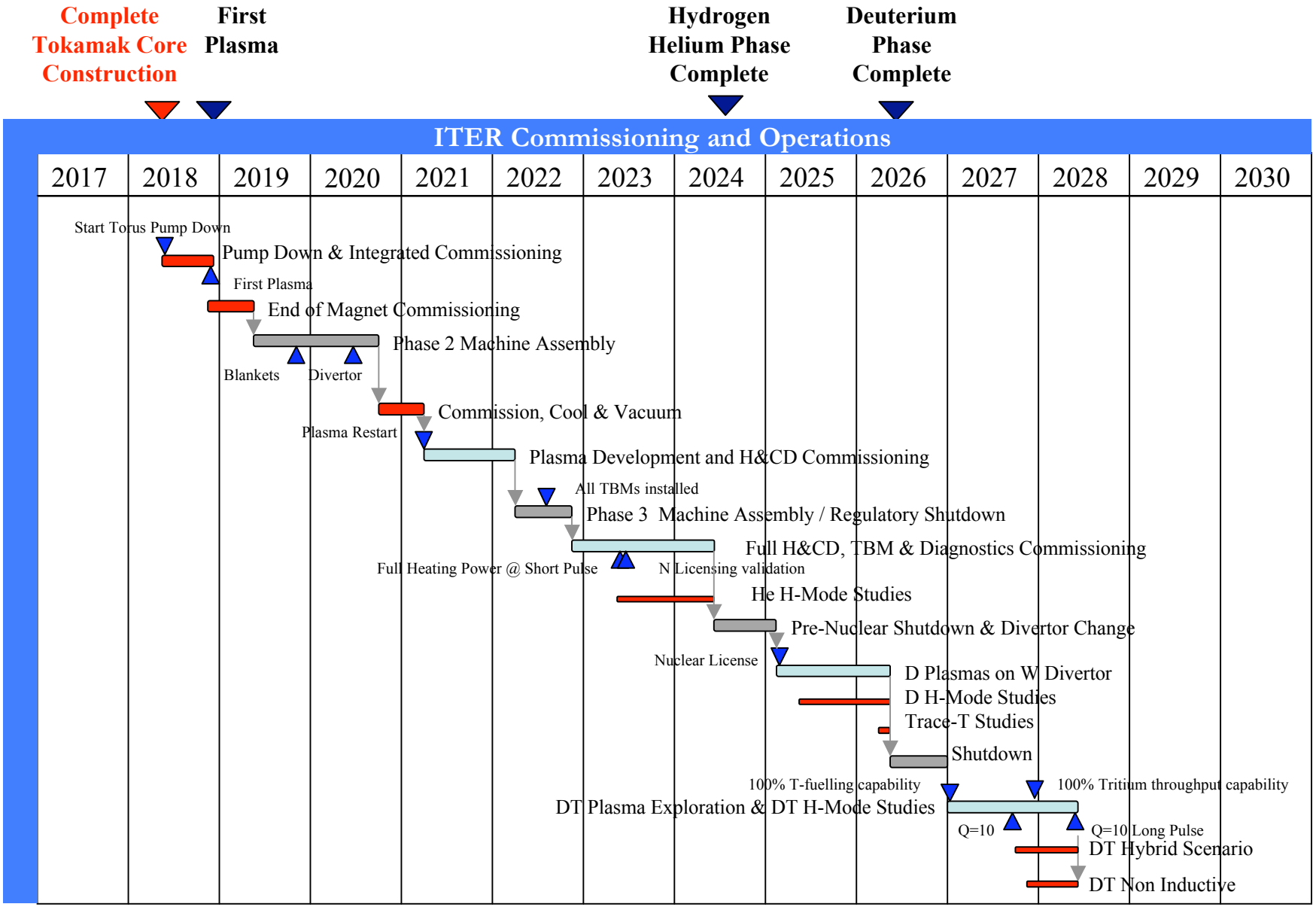
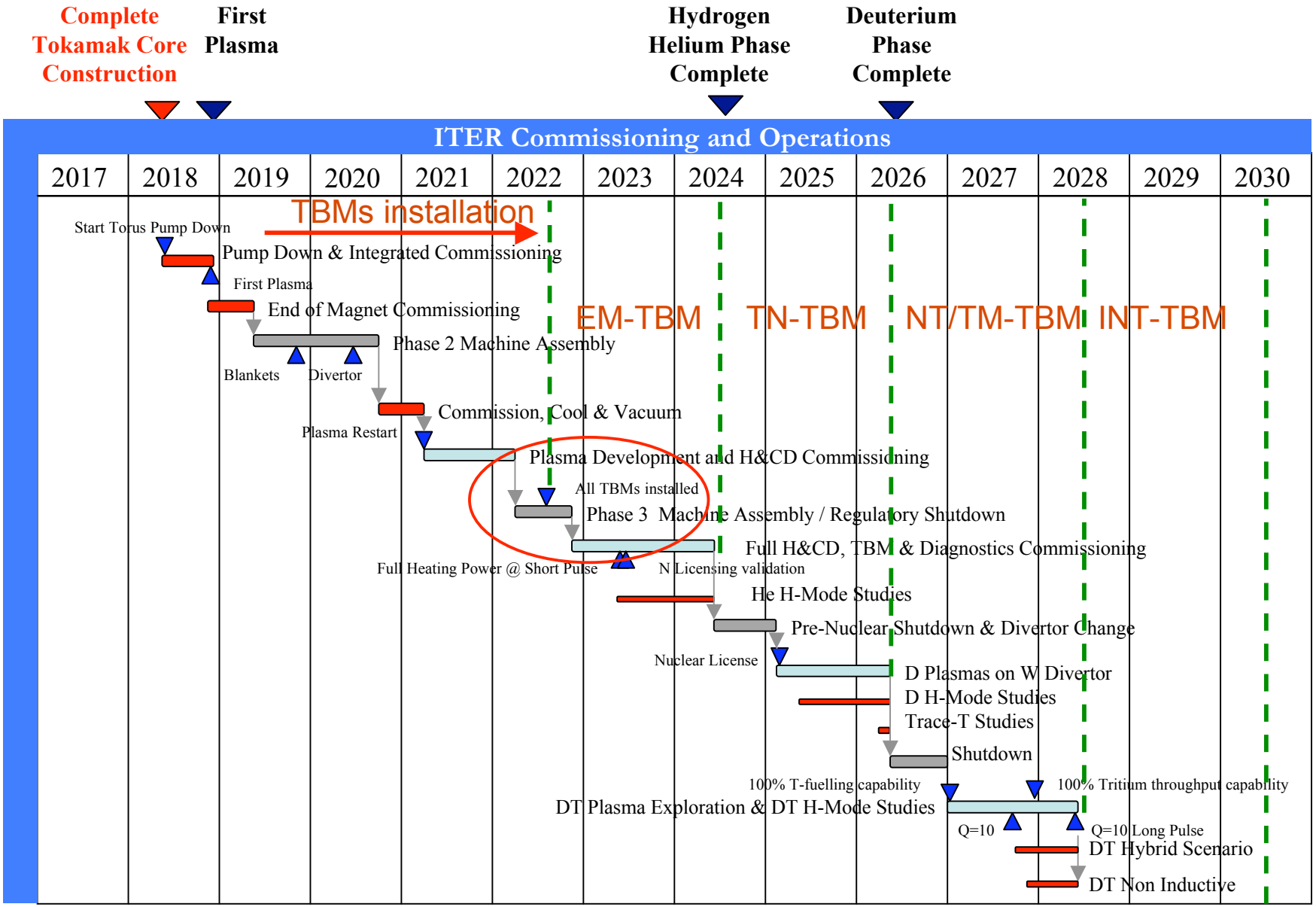


- **Updates of Integrated Research Plan**
  - Integrated Commissioning programme
  - RAMI analysis for 3-shift operation
  - additional details on H&CD commissioning
  - analysis of possibility of improved fuel retention measurements via deuterium seeding in non-active phase
  - clearer identification of main activities in each phase
  - assessment of key risks to research programme schedule

Updated Schedule - Operations



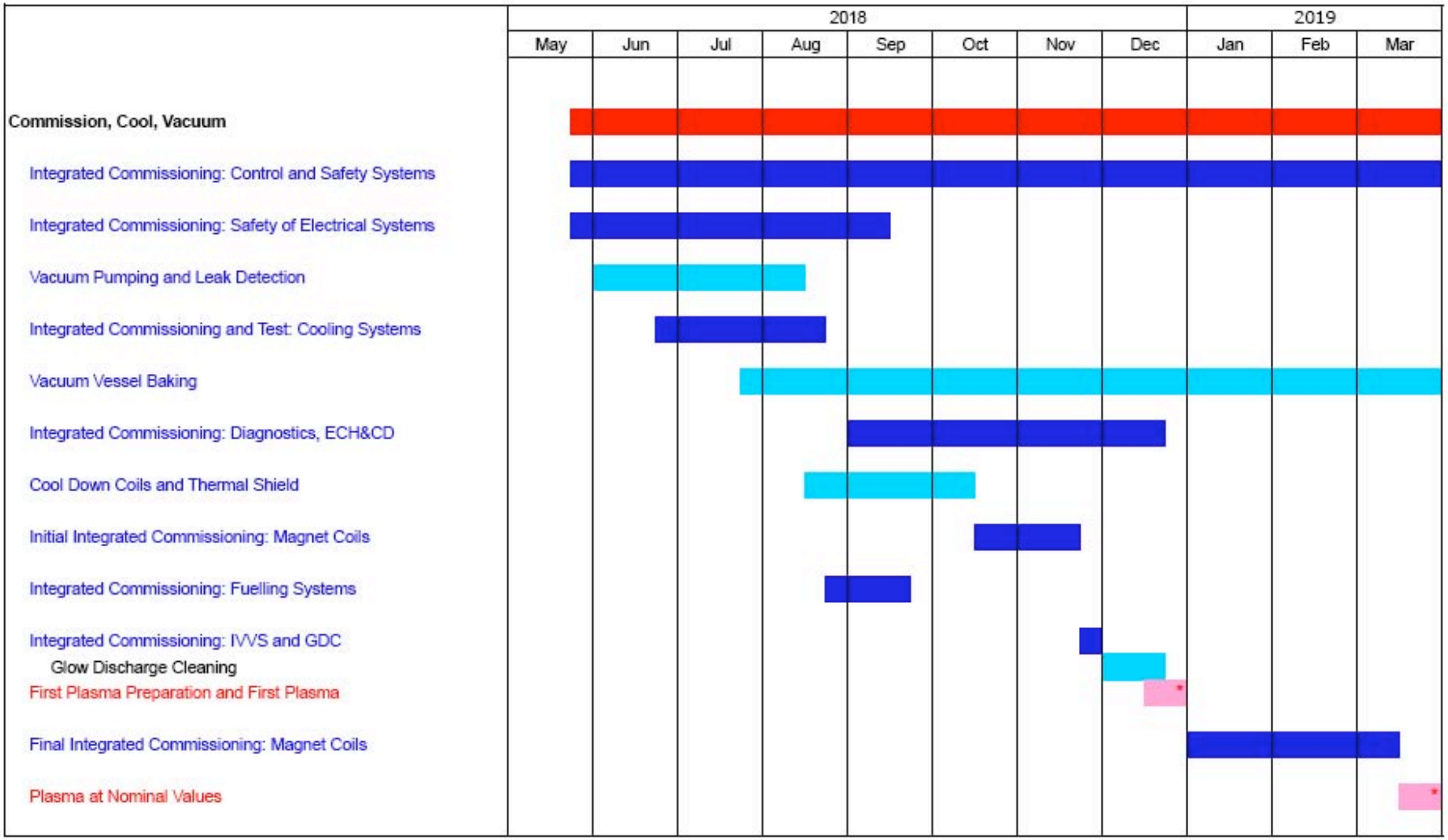
Updated Schedule - Operations



Major features of IRP in Updated Schedule

- **Phased assembly and commissioning of tokamak:**
  - allows integrated tests of core tokamak systems at earliest possible date
  - pre-installation testing and commissioning of many auxiliary systems can proceed in parallel
- **H/ He phase focussed on:**
  - integrated commissioning with plasma - H&CD in particular
  - validating licensing information
  - demonstrating H-mode, ELM mitigation and disruption mitigation
- **D phase focussed on:**
  - establishing plasma on tungsten divertor
  - testing DT-relevant scenarios, including trace tritium experiments
- **Transition to DT operation in late 2026/ early 2027:**
  - achievement of long-pulse Q=10 goal by mid-2028
- **TBM programme integrated**

Research Plan Updates



- **Initial Magnet System commissioning prior to First Plasma, followed by magnet commissioning to full performance and second plasma attempt**

Challenges of the Updated Schedule

- **EU: In order to meet the construction time requested by the Updated Schedule, the following assumptions/measures have been adopted for the 3 EU components on the critical path (buildings, TF coils, vacuum vessel):**
  - duplication of fabrication lines for series production;
  - adoption of more than one shift of work;
  - decrease in the number of mock-ups or prototypes;
  - exclusion of any float between different manufacturing phases

- **US: The schedule needs some more work to establish a baseline meeting US/DOE standards for US share**
  - Missing scope
  - Lack of detailed installation planning outside of the tokamak
  - Activity durations are very aggressive with no float
  - Many independent near critical path components.

- **The IO agrees that all points raised represent risks with respect to meeting the delivery dates of the Updated Schedule;**
- **Delaying some elements in this schedule is one way to mitigate the risks. Accepting the risks, or partially mitigating them, is another possibility. This remains a management decision.**

What is the Path Forward?

- Council in November had difficulties to accept the baseline as presented and requested IO/DA's to go see what some of the risk mitigation measures, if implemented, would mean.
- IO/DA's are asked to minimize any further schedule slip but present a realistic schedule achievable by all DA's.

- This discussion is ongoing and the resulting schedule will be submitted in February probably followed by an interim Council meeting in March.
- The phase between FP and First DT should be optimized to shorten or maintain the 2026 DT date as much as possible.
- Baseline approval is expected in June with improvements included.

- In the meantime its essential to get all critical path components and especially the building construction started

Overview of the Major Development of the ITER Project

May 2006	ITER Management Structure decided at IPC-8 Meeting in Goa, India
21 November 2006	The ITER Agreements signed in Paris
Dec. 2006-Dec. 2007	ITER Design Review began
24 October 2007	ITER Organization formally established
28 November 2007	First PA with Japan signed on TF Conductor
18 December 2007	First PA with EU signed on TF Conductor
End January, 2008	Submission of DAC files including RPrS to Nuclear Safety Authority
12 February 2008	First PA with Russia signed on TF Conductor
April 2008	Construction Permit for nuclear buildings was awarded
7 May 2008	First PA with Korea on TF Conductor
16 June	Briscoe Panel to review revised cost estimate was formed
16 June 2008	First PA with China on TF Conductor
October 2008	All DAs were established
March 2009	ITER Site Platform completed
19 April 2009	First PA with India on DNB Power Supply
17 June 2009	First PA with US on TF Conductor
October 2009	Briscoe Panel Review on the new cost estimates concluded

February 2009	Finalized the preliminary design of all buildings through Jacobs engineering contract;
May 2009	Proposed and integrated common Annex Building approach between, France, EU and IO;
July 2009	Finalized the close out of all Vacuum Vessel issues;
July 2009	Implemented a major Value Engineering program especially on buildings but also on all major components;
July 2009	Established Integrated Project Teams (IPTs) for virtually all areas of high integration;
August 2009	ITER management assessment began and finished in October
September 2009	Agreed on a redistribution of sharing to optimize interfaces (example VV sector 4 from EU→KO);
September 2009	Distributed the new workscope (coming from design review and "missing items" among all DAs, maintaining the fair share;
January 2009 – October 2009	Fostered agreement between all DAs on new schedule which substantially reduces risk, flattens the manpower and cost profile and is consistent with detailed work schedules;
October 2009	Achieved detailed integration and hand-off between the DAs and IO on components as part of Integrated Project Schedule development
November 2009	Excellent progress on licensing with RPrS ready to go in Jan 2010 consistent with building construction start;

Summary

Summary

- Integration with DAs has made significant progress on: schedule, scope, design, handoff and management;
- The IO has assembled a full package which comprises a complete ITER Baseline, which would allow approval even if improvements remained to be done;
- The closeout of the design review items is essentially finished and they are almost all integrated into the present design.
- Approximately 1/3 of the total ITER value is under contract now.
- Tendering and construction on critical path items has either started or will in the next few month.