ITER Construction
Implementation of Site-works

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for the
Assembly and Operations Division

Disclaimer: The views and opinions expressed herein do not necessarily reflect those of the ITER Organization
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- Background
- Tokamak Assembly
- Plant System Installation
- Construction Scope and Organization
- Construction Contracts
Key Facts

The “in-kind” nature of the ITER Project means that the different Parties will deliver equipment to the ITER site where it will be integrated, assembled, tested and commissioned under a number of responsibility models.

The ITER Organization (IO) has overall responsibility for integration.

7 Members: China, EU, India, Japan, Korea, Russia & US

Designed to produce 500MW of fusion power for an extended period of time

10 years construction, 20 years operation

Cost reported to be 15 billion Euros*

* TGV line from Marseille to Nice (16bn€)
  London Olympics 2012 (14bn€)
  CERN LHC (9bn€)
Background Information

• In terms of Construction scope, the site-wide installation of the plant systems constitutes the majority of the site works to be performed

• The ITER Machine comprises around 1 million parts, and is the most complex and technically challenging assembly task

• The ITER Organization will manage site Construction, coordinating the assembly and installation activities of IO and DA Contractors

• Site work in IO scope, and numerous horizontal support functions will be centralized to ease coordination, improve resource profiling and efficiency, and reduce cost

• Around four thousand people are expected to be working on the site during the peak Construction period
The ITER Tokamak

Major Systems

- Magnets & Feeders
- Vacuum Vessel and Port
- Structures
- Blanket
- Divertor
- Cryostat
- Cooling Water
- Thermal Shields
- Vacuum Pumping
- Diagnostics
- Remote Handling
Magnet System (CN, EU, JA, RF, US, IO)

- 18 TF coils (16.6 x 9.0 x 2.7, 325 t)
- 6 PF coils (to Dia. 25.1 x 1.3, 627 t)
- central solenoid (Dia. 4.4 x 17.8, ~1000 t)
- 18 correction coils (to 7.9 x 7.2 x 0.8, 27 t)
- feeders and structures
- mechanically connected: shimmed, keyed, and bolted

Assembly tolerance: low to sub-mm
• Double walled, all-welded structure
• SS 316L(N) – IG
• 9 x 420 tonne 40° main vessel sectors
• 18 upper, 17 equatorial, 9 divertor port structures
• Construction Code: RCC-MR 2007

Assembly tolerance: mid-mm
Thermal Shields (KO, IO)

Vacuum Vessel Thermal Shield
- SS 304L (main structure)
- 9 IB, 18 OB sectors
- bolted assembly

Assembly tolerance: mid-mm

Cryostat Thermal Shield
- SS 304L (main structure)
- sub-divided for pre- and final assembly
- silver plated panels
- cooling tubes doubled for redundancy
- bolted assembly

Assembly tolerance: high mm
Cryostat (Supply and on-site assembly IN DA)

- single walled, all-welded structure
- SS 304 L
- ASME VIII, Div 2
- site fabricated from 40° or 60° sectors
- in-situ assembly from 6 sections

Assembly tolerance: mid mm

- central lid, Dia 10.7 x 3.7 (110 t)
- main lid, Dia 29.0 x 4.1, 558 t (6 or 9 sectors for transport)
- upper cyl, Dia 28.6 x 9.1, 583 t (6 or 9 sectors for transport)
- lower cyl, Dia 28.6 x 9.9, 523 t (6 or 9 sectors for transport)
- base, Dia 29.0 x 6.0, 1105 t
- base plug, Dia 4.3 x .06 (6.8 t)
Assembly Drivers

Tolerances
• plasma performance (Toroidal Field coils aligned ~ 2mm)
• component stresses (TFC nose stress, > 800 MPa)
• functional limits (clearances, adjustment capabilities)

Construction codes
• RCC-MR, ASME

Constraints and practical considerations
• pit geometry (assemble from the bottom up: foundations, lower components, sectors…)
• available facilities
• tooling requirements
• kinematics
• handling capability
  – surface mounted vehicles and air pallets
  – overhead bridge cranes, 2 x 750 t main (4 x 375 t hoists), 2 x 50 t aux
  – max lift height (incl. tooling) 21.35 m
• physical interfaces between machine systems
• integration with site plant installation activities
Assembly Implementation

• Machine assembly is the most technically challenging of the site-works

• Assembly studies ongoing from the time of EDA to, typically:
  – establish technical feasibility, including tooling
  – ensure system configuration, and design developments compatible with assembly
  – determine the optimum sequence of operations
  – optimize schedule and cost

• IO will thus be more prescriptive is the specification and implementation of the Contract for machine assembly than others
  – the assembly sequence will be mandated where necessary
  – enabling technologies developed by IO may be imposed, such as brazing processes
  – major tooling will be supplied (IO / KO DA)
  – IO will carry out independent controls to confirm achievement of critical requirements
  – IO will directly contract specific specialized work, such as VV welding, superconducting joints
In-kind Assembly Tools (KO)

Sub-assembly tool
1/5 scale mock-up concept validation system development
Ongoing Call for Tender for In-vessel Handling Tools
Alignment & Metrology

Large volume metrology, reverse engineering and best-fitting techniques will be combined to ensure positioning of components within tolerance requirements.

Typical datum system uncertainty $\sim 0.2$mm
Local measurement uncertainty $\sim 0.05$-$0.1$mm

Framework Contract for Alignment and Metrology Support awarded 2013
Phased Assembly Approach – Phase 1

- Cryogenic, cooling water & electrical plant
- Vacuum Vessel, Cryostat, Thermal Shield
- Superconducting magnets
- In-vessel magnetic control coils
- Basic diagnostics
- Limited Electron Cyclotron (EC) heating
- Large “captured components” in buildings
Phased Assembly Strategy – Phase 2

Following First Plasma

- In-vessel components: blanket, divertor
- Remaining diagnostics
- Remaining Heating (IC and Neutral Beam)
- Pellet Injection & Disruption Mitigation System
Tokamak Plant
ITER is not only a Tokamak, but includes many plant systems needed to cool, power, fuel, pump, diagnose, maintain, and control the plasma.
Plant Systems
Site-wide Plant Systems – Auxiliary Buildings
Basis for schedule preparation

- Detailed schedule for Tokamak Assembly is now being updated:
  - Schedule developed in 2001 with design developments included up to 2006
  - Excluded designs not in the baseline or with no design basis

- Major developments of the schedule include:
  - WBS developed as executable CWPs
  - Structured to interface with Intergraph and materials management software
  - Consistency with new/changed ITER system designs
  - Loading of resource crews and non-labor resources
  - Addition of site materials management activities
  - Addition of pre-installation and in-process testing activities
  - Detailed identification of risks and opportunities
Inputs to ITER Construction Contracts

• Each contract will contain the following main elements:
  • Main section comprising:
    – Contractual requirements
    – Management requirements
    – Environment, Health and Safety requirements
    – Quality requirements
    – Regulatory requirements

• Construction Worksite Baseline* documents comprising:
  – Requirements
  – Scope
  – Schedule
  – Construction Process Descriptions (CPD) and outline procedures

• Design basis documented in:
  – System Construction Specifications (using CSI Master Format)

* An ITER scale Tokamak has not been built before therefore the worksite baseline is effectively the “Handbook of how to build a Large Tokamak”

The IO estimating and planning must be robust and detailed enough to enable industry to accurately tender with minimal RFIs
Construction Scope
ITER Organization

• Construction Management
• Machine Assembly
  – Mechanical, structural steel
• Tools
  – Lifting, handling, standard tools, welding, access equipment
• Piping installation
  – Nuclear and non-nuclear cooling water systems
  – Vacuum piping
  – Site networks, buried pipes
• Cryogenic Plants – Liquid Helium
• CODAC, Central Interlock and Safety Systems
• Electrical, High Voltage, cabling
Construction Organization
Construction Site

- ITER Site encompasses entire area of ITER platform
  - Platform divided into Independent Worksites (“Chantier clos et Independant” according to the Decree of 26 December 1994*)
- Independent Worksites encompass a single building, area, group of related buildings, access paths and laydown areas which will be isolated within a perimeter (physical or not)
  - Independent Worksites will be managed under the authority of the Construction Site Manager
  - Boundaries of Worksites will vary during the lifecycle

* The Decree of 1992 will apply from the time the risks imposed by plant operations predominate within the worksite
Independent Worksites
2-tier Contract Strategy

• Tier 1: Framework contract for Construction Management Support
  – Industrial support to the management of construction
  – Reinforce IO staff with the necessary external expertise and resources
  – IO maintains responsibility and control

• Tier 2: Limited number of discipline-specific contracts
  – Execution of the actual works
  – e.g. mechanical installation, piping, scaffolding, electrical, cabling, civil finishing and specialized works.
  – Supply resources to execute work packages across the site, under the control of the IO assisted by the Construction Management Support Contractor.
Construction Contracts

- Engineering
  - Approval
  - Construction Specification
  - Field Engineering
  - Procurement
  - Design

- Assembly & Installation
  - Project
  - Contract Management
  - Coordination
  - Construction Engineering
  - Expediting

- Construction Management Support

- Supervise
  - Domestic Agency Works
  - Machine Assembly Works
  - Piping & Mechanical Works
  - Electrical, Cabling, I&C Works
  - Special Contracts
    - Superconducting Joints
    - Cryogenic Equipment
    - Special Techniques
    - Specialist Suppliers
    - VV Welding

- Surveillance
  - Domestic Agencies / IO Suppliers
  - Alignment & Metrology Equipment
  - Lifting & Handling
  - Storage & Logistics
  - Scaffolding / Access Equipment
  - Civil & Finishing
  - QC, Testing
  - Tools, Plant Hire
ITER Organization – Cash Procurement

• IO Procurement Process is based on International Public Procurement Rules

• Most of the contracts placed through a Call for Tender process
  – starting by call for nomination published through the DAs

• The award criteria are of two types:
  – Cheapest technically compliant offer
  – Best value for the IO

• Other Procedures in place:
  – Call for Expertise
  – Request for Quotation
  – Competitive Dialogue
  – Restricted Tender
# Construction of ITER Machine & Plant (Tier 1 & 2 Site Works)

**Services: Construction Management support framework**  
To support the preparation, planning, coordination and supervision of plant and tokamak assembly and installation works on the ITER site. Requires expertise in the construction of large scale nuclear facilities.  

<table>
<thead>
<tr>
<th>Q1-2015</th>
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</thead>
</table>

**Works: Mechanical & Piping**  
Framework contract to execute site erection works of mechanical, process and piping systems, including vacuum, cooling water, tritium processing systems and associated mechanical structures. Experience in nuclear systems will be required.  

<table>
<thead>
<tr>
<th>Q2-2015</th>
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</table>

**Works: Machine Assembly**  
Framework contract to execute assembly works for the ITER tokamak, including large scale mechanical assembly works and installation of related cooling water and vacuum piping, specialised cabling and sensor systems, including related lifting and handling. Experience in construction of nuclear plant will be required.  

<table>
<thead>
<tr>
<th>Q2-2015</th>
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</thead>
</table>

**Works: Electrical, Instrumentation and Control, and Cabling**  
Framework contract to execute site installation works of electrical, instrumentation & control systems and cabling. Experience in nuclear systems will be required.  

<table>
<thead>
<tr>
<th>Q3-2015</th>
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</thead>
</table>

*Note: This information is indicative*
## Construction of ITER Machine & Plant (Supply Contracts)

<table>
<thead>
<tr>
<th>Supply Contract: Metrology Laboratory</th>
<th>Q1-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and construction of pre-fabricated modular structure to house metrology equipment and workspaces, to be installed inside Assembly Building.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Contract: Purpose built tools, equipment &amp; platforms</th>
<th>Q1-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework contract for the design and supply of the purpose built tools including heavy lifting beams, personnel access platforms, specific installation tools, transport trolleys and equipment.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Supply Contract: Metrology Laboratory Equipment</th>
<th>Q2-2015</th>
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</thead>
<tbody>
<tr>
<td>Supply of standard metrology equipment including laser scanners, photogrammetry and other measurement equipment.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Contract: Standard Tools and Equipment</th>
<th>Q2-2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework contract for procurement and rental of common, off-the-shelf construction tools and equipment, access equipment, lifting equipment, personal protection equipment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Contract: Vacuum Vessel access and ventilation System</th>
<th>Q2-2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and supply of a personnel access and ventilation system for the vacuum vessel. Experience with such facilities for confined spaces and atmospheric control of beryllium will be required.</td>
<td></td>
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</tbody>
</table>

Note: This information is indicative
Integrating the Machine

<table>
<thead>
<tr>
<th>Works: Finishing/Civil Works</th>
<th>Q3-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framework contract to execute civil and finishing works required during assembly and installation of installation of plant, including concrete closure of temporary openings, sealing of penetrations, back-filling, painting and repairs. Experience of concrete works in nuclear buildings will be required.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Services: Site Materials &amp; Logistics</th>
<th>Q3-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract to provide construction site materials management and logistics support including warehouse management, good inwards, site transport and handling.</td>
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</table>

<table>
<thead>
<tr>
<th>Scaffolding &amp; Access Equipment</th>
<th>Q3-2015</th>
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<tbody>
<tr>
<td>Framework contract for the services and supply of scaffolding and access equipment, including design, erection, alteration, dismantling of scaffolding, mobile towers, powered access equipment, podium platforms, pop-up platforms and safety netting. Experience in relevant safety legislation will be required.</td>
<td></td>
</tr>
</tbody>
</table>

More on the IO Procurement Portal

Note: This information is indicative
Thank You for your Attention