Europe’s contribution to ITER Remote Handling

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Outline

- EU Remote Handling Procurement Packages (PP)
- Work Organisation
- Overview of the status the various PP
- Procurement scenario
- Discussion
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(2) New packages: Multi-purpose deployment system MPD; cold RH test facility
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Those EU activities in support of ITER that were previously specified and managed by EFDA Garching until end of 2007, have been handed over to F4E (http://fusionforenergy.europa.eu/) and are presently being closed.

F4E is the EU Domestic Agency, mostly based in Barcelona – Spain, in charge of managing the EU in kind contribution to ITER, broken down in 46 procurement packages (plus the so-called “broader approach”).

At full workforce, F4E should be staffed with ~200+ people (professionals and support staff).

The F4E Remote Handling Group is currently composed of 6 professionals: Carlo Damiani, Salvador Esqué, Carmen Gonzalez, Darren Locke, Luigi Semeraro and Marco Van Uffelen, who are dealing with the started-up new activities and the completion of the last few EFDA tasks still running (“seamless” transition).

We have planned to recruit other 3 engineers during 2010.

At regime, considering the 4 PP we are in charge of, the RH group should be 15 professionals (TBC), mixed senior-junior personnel, quite evenly distributed in the management and technical coordination the various PP.

The RH group should grow up gradually with time in the next ~1.5 years in order to keep our duties balanced between project implementation and newcomers’ training.
The RH group belongs to the Machine Systems Division that, in turn, is part of the ITER Department (the “main unit” of F4E).
By its nature and mission, F4E will have to outsource most of the tasks related to design, development and procurement of components for ITER, keeping for itself key functions like liaison with IO and other DAs, scheduling, technical coordination and monitoring; this holds in particular for RH that is a significantly complex procurement.

The IO-F4E relationship is regulated by ITA (ITER Task Agreement, typically for design and R&D prior to the signature of the PA) and PA (Procurement Arrangement – for EU RH should be 1 for each of the 4 PP) which are the formal start of the procurement activities by F4E for a given PP.

F4E tasks implementation: typically, RH design studies, testing and technical support to procurement follow-up will be performed by/with the help of EU national laboratories via Grant contracts, or in some cases by selected companies with engineering support contracts, whereas the detailed design (build-to-print) and hardware procurement (both for prototypes and final production for ITER) will be via industrial contracts.
**F4E RH work organisation - 4**

**Integrated Product Team**

**F4E RH Team**
(RH group + professionals from C&P, planning, engineering, DO, QA) detailed work break down and scheduling, implementation through Grants and industrial contracts, follow-up, management of interfaces within EU responsibilities, liaison with IO and the other DAs.

**IO Team**
general policies, integration and scheduling, implementation (ITA/PA), input data, functional specifications validated by conceptual design, leadership in management of interfaces (to-be-handled components, VV, HC, building, services etc.).

**CN TCS Team**
prototyping, testing, procurement and delivery of TCS casks and pallets.

**JA IVT Team**
prototyping, testing, procurement and delivery of in-cask IVT system.

**Industries**
Prototypes and final product preliminary and final design (build-to-print) and integration of technologies; components procurement, machining, assembly, commissioning and testing; delivery to site until final acceptance; fulfilment of fail-safeness/recoverability/rescue-ability, rad-hard and spare policy requirements.

**National laboratories**
Design and R&D; definition and hosting of test facilities and prototypes; support to F4E in prototypes and test mock-ups specification and procurement (including control-command); test programme implementation in the test facilities and feedback to the design; support to F4E in final system specification and procurement.
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• Since the early stages of JET operations (1983) the JET RH has been progressively developed and has operated in real nuclear conditions during the 1998 shutdown following the D-T campaign in 1997 (today’s γ radiation level ~100s μSv/h > “green” 25 μSv/h)
• Basically the RH in-vessel interventions are based on a force-feedback manipulator (MASCOT) on board of a boom, with another boom serving in support, and with extensive use of Virtual Reality from the control room where the operators are performing their tasks (following intensive and systematic rehearsal with mock-ups on a test stand)
## ITER RH PP as defined in 2001

### ITER RH 2001 Baseline systems

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(1) Originally 50-50 EU-CN, now has been allocated entirely to Europe
(2) New packages: Multi-purpose deployment system MPD; cold RH test facility

- IO will be in charge of defining the functional specifications (FS) – supported/validated by a conceptual design – and of all interface requirements for the PP assigned to EU
- EU will be in charge of PP preliminary/final design, procurement and delivery to ITER site until final acceptance and hand-over to IO
Present scope *(details to be confirmed)*:

- 1 Cassette Multi-functional Mover (CMM, consisting of CMM tractor, end effectors and umbilical) + 1 spare
- 1 right-hand-side cassette toroidal mover (CTM) and umbilical + 1 spare
- 1 left-hand-side cassette toroidal movers (CTM) and umbilical + 1 spare
- 1 set of tools for cassette cooling pipes + 1 spare
- 1 set of tools for cassette locking system + 1 spare
- 2 Manipulator arms (MAM) + 1 spare
- *other tooling, dust cleaner, rescue devices?*
Current achievements on design and R&D

• Procured a CMM proof-of-principle prototype, not full relevant for ITER (Manipulator and tooling are being fully integrated, ITER-relevant viewing system not implemented), already extensively tested in DTP2 (VTT-IHA Tampere, Finland)
• Remote control and tests
• Design of the CTM and end-effectors (and DTP2 extension)
• Feedback from-to DIV design

Near and long term activities

• Integrate and test CMM-MAM and some tooling in DTP2 (on going)
• Complete DIV RH conceptual design
• Specify, design and procure a full ITER-relevant CTM prototype (mover, manipulator, tooling) and test it in DTP2 (with toroidal extension and cassette updates)
• Feedback from-to DIV design and DTP2 tests
• Finalise specifications, design and procure final DIV RH for ITER up to final site acceptance and hand-over to IO (it could be staged)
An example of RH test facility: the Divertor Test Platform 2 (DTP2)
Hot Cell Facility

Lift

Transfer cask

Tokamak building

PP Overview
23P3 – Transfer Cask System
The TCS consists in a fleet of mobile units able to dock to the VV ports on the one hand, and to the ITER Hot Cell docking areas on the other hand. In-cask devices are able to take on board the to-be-transported components and transfer them to the Hot Cell for refurbishment or disposal. The radioactive content is enclosed in the leak tight cask (with double doors and ventilation/filtration system) and therefore the spread of contamination during transportation is limited to the acceptable level in order the corridors are still “green” after the passage of the casks.

Present scope (under revision):
- 14 (+1) cask platforms with enclosure, front and rear double shield doors and air transfer systems (ATS)
- up to 7 rescue cask platforms with enclosure, front and rear double shield doors and transfer systems
- 14 (+1) in-cask handling systems (e.g. for divertor RH and divertor cassettes)
- up to 7 (+1) in-rescue cask handling systems
- 4 (+1) Hot cell adaptors
- Spares (30% of supply – spare parts)
Current achievements on design and R&D

• Studies performed on: TCS layout, some in-cask devices like the plug tractor, ATS layout and FMEA

• On-going tasks on TCS trajectories, virtual models and HMI, TCS-ATS test facility definition, and ATS prototype specification (guidance, air cushion, connectors ...) and layout

Near and long term activities (TCS 100% to EU-DA)

• Review and update the TCS concept (double door, connectors, in-cask layout, tractors etc.) – on going

• Complete TCS conceptual design

• Specify, design and procure a complete ITER-relevant TCS prototype (ATS, pallet and cask & in-cask; it could be staged) and test it in a specifically build test facility

• Feedback from-to ITER design

• Finalise specifications, design and procure final TCS for ITER up to final site acceptance and hand-over to IO (it should be staged)
Present scope *(to be confirmed)*:

- 6 IVVS systems(*) each consisting of probe, deployer and housing (shared with Glow Discharge Cleaning System)
- Spares TBD (spare parts and/or 1 spare system)
- 6 Provisional IVVS endoscopes (TBC)

(*) only 3 were foreseen in the ITER Project Integration Document at start of operation
Current achievements on design and R&D

- Preliminary studies performed on IVVS-GDC plug layout
- On-going tasks on IVVS present probe tests, IVVS new probe design, IVVS test bed definition, IVVS mapping; IVVS-GDC plug neutronic analysis and CAD works and mechanical analysis of IVVS-GDC plug; IVVS-GDC TCS layout

Near and long term activities (assuming early delivery of IVVS provisional)

- Perform the IVVS-GDC plug conceptual design
- Complete the above activities and specify, design and procure an ITER-relevant IVVS to be tested in an ad-hoc facility, feedback from-to the ITER design
- Define the basic concept of a provisional IVVS device (non final nuclear technology)
- Specify and procure 6 IVVS-GDC plugs (spares TBD) including provisional IVVS up to the final acceptance and hand-over to IO, design integration with GDC needed
- Specify, design and procure the 6 final IVVS systems (spares TBD) to be integrated later into the IVVS-GDC plugs, up to final acceptance and hand-over to IO
Present scope *(to be finalised)*:

- monorail crane serving the NB cell, equipped with specific lifting interfaces for the NB components (and compatible with DIA plugs/tubes)
- source/accelerator transport cradle
- DIA tube transporter
- MAM and tooling (Cs Oven tool, pipe tooling, lid lip seal tooling etc.)
- *ground-based vehicle?*
- *rescue devices?*
- TBD spares
Current achievements on design

- Preliminary design activities performed on NB RH
- The core of the system (monorail crane, MAM, source support cradle, Caesium Oven tooling, pipe tooling) has been identified and taken into account in the current NB cell layout

Near and long term activities (assuming limited prototyping TBC)

- Review, update and extend the current NB RH design concept – on going
- Specify and procure the complete NB RH system, including a proof-of-principle mock-up of the CS Oven exchange tool (other prototypes could be envisaged TBD) devices, up to final acceptance and hand-over to IO (it could be staged)
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The ITER remote maintenance is unprecedented, because of the number of to-be-handled components and remote handling (RH) systems involved, of the number of different technologies to be integrated together, and of the technical and managerial complexity.

These challenges require a systematic and integrated approach to design, validation and procurement of RH systems and of to-be-maintained components.

Important issues to be taken into account are, in particular:

- variety of massive components that require maintenance with millimetric accuracy (e.g. divertor cassettes, heating and DIA plugs etc.)
- full compliance of the to-be-handled components with the remote maintenance requirements since the early design phase (the first assembly of these components will have to be performed with the RH systems)
- combination of various technologies (moving machinery, force-feedback manipulators, special end-effectors and tools, advanced viewing systems and virtual reality, radiation-tolerant sensors and components) into each of the RH systems with space constraints
- very complicated system logistics and challenging time limits during the ITER shutdown
- hostile environment, with human access totally precluded soon after the start of the D-D operation (hence all hardware/software problems/bugs must be solved/fixed before)
- multiparty, complex organizational system for the design and procurement of the RH devices (this also induces design proliferation!)
• For the RH PP, IO will only issue Functional Specifications (validated by conceptual design), supported by the needed R&D

• These FS must be complemented by the definition of a set of interface requirements: the geometrical interfaces of the components to be handled, VV ports and ducts, hot cell, building, the interfaces with the ITER CODAS, etc.

• The level of integration and consistency of the current ITER design is not yet at a stage that would allow proceeding now with in-kind supplies of the EU RH PP (through the PA)

• Still design and R&D work is required in order to get to the PA (the 1st should be in early 2011, the others to follow in ~ 1 year); this is a shared effort between IO and F4E (with help of those national labs beneficiaries of Grants and those firms providing engineering support through ESC)

• After the PA, detailed design, finalisation of the interfaces, prototyping and testing prior to final production are required
In terms of design, each of the 4 PP requires the integration of the various technologies involved (largely exceeding the F4E engineering capabilities).

We have to assign the role of integrator to the industrial supplier of that particular PP.

In terms of manufacturing, we consider vital to proceed with the final design and production of the RH systems for ITER only after a phase of prototyping and testing on ITER-relevant prototypes.

The use of prototypes and test facilities like DTP2 has many values:
1) verify that the proposed design fulfils the specifications (prototyping could be also required by the nuclear safety authority, especially for the TCS)
2) check the interfaces between the to-be-handled component and RH system, and provide feedback/green-light to the final production for ITER
3) prepare and validate the operational sequences and the operator software interfaces
4) train operators in view of the building up of the IO team
5) the prototypes/facilities could be delivered to ITER (as part of the cold RH test facility)

A key issue is the radiation resistance of the RH components (but with dose rates spanning over four orders of magnitude!); this requires a systematic approach and a specific strategy under elaboration (see also next slide).

Two other important issues: standardisation; change management.
- blanket remote handling (~500 Gy/h)
- divertor remote handling (~100-150 Gy/h)
- Transfer Cask System (~50-100 Gy/h)
- In Vessel Viewing System (~1.5 KGy/h)
- NB remote handling (~1 Gy/h)
- Hot cell (~100 Gy/h)

Src: SCK-CEN

Procurement scenario – 4
radiation tolerance issues

Radioactivity at the start of a shut down

Decay Co-60 (half life 5.27 y)

Radioactivity above the divertor

Table 2.3-1 Neutron I

radioactivity above the divertor
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Conclusive remarks for discussion

- ITER RH is of outstanding complexity both from the technical and managerial standpoint

- The role of F4E, in order to provide the required contribution to ITER RH, is to define strategies, implement them with the support of national laboratories (preliminary design, R&D, test facilities) and of EU suppliers (detailed design, integration of technologies, prototyping, final production), in liaison with IO and the other DAs involved

- The procurement of the EU RH PP requires a coordinated effort from the various actors mentioned for several years

- This holds in particular for the industrial suppliers which will have to keep themselves committed for a long-term involvement, starting with the selection process, passing through design, qualification of components and validation of prototypes, up to final production and delivery & acceptance to ITER site

- There are many challenges in front of us ...
Thank you for your attention!
A key element of the ITER RH strategy is the hot cell facility HCF (~100 000 m²), where the various in-vessel components are either refurbished before new utilisation in the VV (e.g. divertor, heating plugs) or prepared for storage as rad-waste. The HCF includes a fleet of cranes, manipulators, tools, trolleys, tanks, rad-waste equipment etc. in various levels of the HC building. The HCF hosts the “yellow” remote handling test stand where the RH systems are tested before use in the VV (e.g. after a scheduled maintenance on them).
Hot & Cold Remote Handling Test Facilities

HOT RHTF hosted by HC building → verification of RH systems after repair before new in vessel tasks

Cold RHTF hosted by Assembly Hall building → train personnel, validate tasks in cold conditions, develop and test unplanned tasks
An additional System: the Multi Purpose Deployer (MPD)

- Transporter
- Transfer Cask System
- Task Module
- Manipulator