Status of ITER Remote Experimentation Centre

Presented by JW Farthing

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1. Engineering Validation and Engineering Design Activities (EVEDA) for the International Fusion Materials Irradiation Facility (IFMIF)

2. Satellite Tokamak Programme
   Participation in upgrade of JT-60 Tokamak to JT-60SA and its exploitation

3. International Fusion Energy Research Centre (IFERC) - Project Leader: Noriyoshi. Nakajima
   1. DEMO Design and R&D coordination Centre
   2. CSC (Helios) (ended Dec 16)
   3. ITER Remote Experimentation Centre (REC)
REC Activities / Tasks

1. **Equipment and environment for REC room**: Layout, Furnishings, Services, IT equipment – machine agnostic remote experimentation centre
2. **Networks**: LAN, Security, Internet connection
3. **Investigation of the fast data transfer**: software-based methods for high-speed data transfer
4. **Remote Experiment System (RES)**: software to perform remote experiments using JT-60SA
5. **REC Functional test and demonstration using EU Tokamaks**: JET and WEST
6. **Large-capacity data storage system**: demonstration via re-use of part of the CSC tape library
7. **Data analysis software**: data visualization, data analysis, remote data access
8. **Plasma simulator**: customisation of existing software, development of Tokamak Simulator
Status of ITER Remote Experimentation Centre

Task 1 - REC Room
1. Building, HVAC, Power, Furnishing
2. Configurations of main working area
   1. Remote experimentation islands
   2. Seminar style
   3. “Board room”
3. Video wall
4. Meeting rooms / Exhibitions
5. Visitors area (public)
6. Visitors area (researchers)
7. Refreshment area
8. IT Equipment – servers, work stations

Task 2 – Networks
1. LAN, Security, Internet

Work completed – March / April 2017
Status of ITER Remote Experimentation Centre

REC Room Construction

Mar 27 2014
Dec 8 2015
Dec 14 2015
Dec 15 2015
Dec 18 2015
Dec 18 2015
Dec 22 2015
Dec 25 2015
Jan 8 2016
Jan 29 2016
Mar 8 2016
Mar 23 2016
Task 2 – Networks

SINET4 → SINET5 – April 2016

100Gbps mesh network

IFERC REC connected at 10Gbps

New line to EU via Siberia 20Gbps

Latency reduced from 300ms to 200ms
Task 3 – Fast Data Transfer
ITER – REC data transfer tests Aug, Sep 2016

1 TB data transfer every 30 min. over 50 hours
New inter-continental long data transfer speed record; 50 TB/day.
• ITER Newsline, October 10th 2016, “ITER to Japan at breakneck speed”
• Nakanishi et al, “High Performance Data Transfer for Full Data Replication between ITER and the Remote Experimentation Centre”, 21st IAEA FEC, Kyoto
• K.Yamanaka, H.Nakanishi, T.Ozeki, N.Nakajima, S.Abe, S.Urushidani, T.Yamamoto, Y.Ishi, “On-demand file transfer for ITER remote experiments”, this meeting
Status of ITER Remote Experimentation Centre

Task 6 – Data Storage
F. Robin, J. Noe, H. Nakanashi

The server has the ports to connect the SSD for the data storage. Also the data transfer server with SSD can be connect by 10GbE.

Disk-to-tape tests complete April 2017
End-to-end tests with fast data transfer to be planned

Server (SGI Rackable CH-C2112-GP2-EX x1)
- Intel Xeon E5-2620 v4 Eight Cores 2.1GHz (85W) x2
- 8GB memory x8
- 1.6TB SSD x2 *For system disk
- 6TB SATA HDD x10 *RAID6 configuration
- Quad port 16Gb FC PCIe Gen3 HBA x2
- 10GbE port(onboard) x2
- RedHat Enterprise Server 7 x1
- DMF 6 x1 *500TB license include
- SGI Foundation software x1

Fiber Channel 16 Gb FC x4

Magnetic Tape
LTO5 Tape cartridge x 6940volume
※1.5TB (in-compressive)、3.0TB (compressive)
**Task 4 – Remote Experiment System (RES) using JT60-SA**

Makoto Matsukawa et al.

RES provides the same functions remotely as available locally at Naka.

<table>
<thead>
<tr>
<th>No</th>
<th>Typical HMI functions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overall Operational Status Monitor</td>
<td>Monitoring the JT-60SA discharge sequence, operational state, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Plasma Shape Viewer</td>
<td>Monitoring plasma shape and status during the discharge in real time, etc..</td>
</tr>
<tr>
<td>3</td>
<td>Plant Data Monitor</td>
<td>Monitoring the Plant data such as temperature of superconducting coils, vacuum vessel, etc.</td>
</tr>
<tr>
<td>4</td>
<td>Discharge Result Data Viewer</td>
<td>Access to the control result data after a plasma discharge and their display.</td>
</tr>
<tr>
<td>5</td>
<td>Discharge Schedule Viewer</td>
<td>Monitoring the progress of discharge schedule, main parameters of each discharge.</td>
</tr>
<tr>
<td>6</td>
<td>Discharge Parameter Editor</td>
<td>Setting the discharge parameters (Ip, Rp, Zp, gas injection, heating power, etc.).</td>
</tr>
</tbody>
</table>
**Status of ITER Remote Experimentation Centre**

**REC users** participate in JT-60SA experiments using same functions available in the JT-60SA control room.

**Local users** execute main experiment operation in the JT-60SA control room using HMPCs.

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**International Fusion Energy Research Centre (IFERC)**

Remote Experiment Centre (REC)

Data communication

REC-Network

HMPC

**Naka Fusion Institute**

Interface Point for RES

Naka-backbone network

Remote experiment server (RESV)

QST-Network

QST-FW

Chiba DC

Router

FW

SINET5

Hirosaki DC

Access to the RESV by SSL-VPN

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**Network connection was changed.**

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**Control system-Network**

Discharge control server (DCSV)

Plant monitor server (PMSV)

Discharge sequence controller (DSQC)

**Other supervisory computers, Each subsystem**

**HMPC**

**HMI network**

**HMI server (HMSV)**

**Local users**

**REC users**
Status of ITER Remote Experimentation Centre

- **Role of web-server**
  - Reception of HTTP request from client **HMPC**
  - Transmission of **HMI-functions** (Java application) to client **HMPC**

- **Role of server-function** (for remote HMI)
  - Connection of a TCT/IP communication port with **remote HMI-function** of client **HMPC**
  - Connection of a TCT/IP communication port with **server-function** of **HMSV**.
  - Relay of an operator-request from **remote HMI-function** to **server-function** of **HMSV**
  - Relay of a reply from **server-function** of **HMSV** to **remote HMI-function**

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**Diagram:**

- **HMPC**
  - Web browser: http://www..
  - Remote HMI-function (Java app.)

- **QST Firewall**
  - HTTP request
  - TCP/IP connection
  - Connection with QST Intranet using VPN

- **RESV**
  - Web-server
  - HMI-functions (Java app.)
  - Server-function (for remote-HMI)

- **L3-SW(Router)**
  - Telnet
  - FTP
  - Rejection
  - TCP/IP connection
  - Only particular IP address and communication ports is possible.

- **HMSV**
  - Web-Server
  - HMI functions (Java app.)
  - Server-function (for local HMI)
  - Data Files

- **SINET 5, the Internet**
- **QST Intranet**
- **JT-60SA control system network**
Discharge control server (DCSV)

**Functions of the DCSV**
- Discharge parameter file
- Discharge sequence history file
- Consistency check result file
- Control result data file

HMI server (HMSV)

**Functions of the HMSV**
- JT-60SA Operational status file
- Plant data file
- Alarm data file

Plant monitor server (PMSV)

**Functions of the PMSV**
- JT-60SA Operational status file
- Plant data file
- Alarm data file
- Discharge parameter file
- Discharge sequence history file
- Consistency check result file
- Control result data file

Remote experiment server (RESV)

**HMI functions**
- Access to all data available
- Setup of discharge parameter
- Transfer of data

**Transfer of data**
- Creation of the data files

**Setup of the parameter**
- Operation order / request results

**Information of the plant monitor results**
- Creation of the data files

**Notification of sequence event during discharge sequence**

**Execution function of the JT-60SA discharge sequence**

**Operation order / request results**

**Status of ITER Remote Experimentation Centre**
Demonstrate against JT-60SA mock-up from REC May/June 2017
Task 5 - Functional test and demonstration using EU Tokamaks

- The original BA period ends May 2017
- The main mission of the REC will be completed as planned
- ITER and JT-60SA will not yet be operational
- Proposed to demonstrate the REC functionality against EU Tokamaks – JET and WEST
Task 5 – Verification tests with JET – October 2016

1. Aim
   1. Confirm working of RP technologies with JET
      • RCA, RDA, Control room screens, Documentation - Users web pages, Intranet, Experiment planning ..., VC
   2. Comparison of different RCA technologies
   3. Collaboration between CCFE and QST IT staff
      • JET RP technologies, IT security measures

2. Outcome
   • Functional tests were successful
   • Performance v. good, 1Gbps to desktop
   • RTT 180ms measured, xpsedit cursor hover time

3. Outlook
   • Visiting JET SLs for campaign sessions
   • Depending on EUROfusion / JET schedule
   • Early 2018?
Task 5 - Proposal to prototype the control of WEST from REC

1. Japanese Plasma Facing Units (PFU) are being installed on WEST
2. Proposal
   1. Access to WEST servers from REC (RCA)
   2. Control / follow-up of WEST Experiments and Diagnostics
   3. Full access to data and exploitation tools (applications: Timeline, Roster, LogBook, Shot Listener, Incident Reporting)
3. Discussions ongoing
Status of ITER Remote Experimentation Centre

Task 7 – Data Analysis Software – Data Visualisation

Development of the experimental Data Analysis Software (eDAS)
Shunsuke Ide, Hajime Urano, Nobuhiko Hayashi, Arimitsu Wakasa, Masakazu Namekawa

- eDAS has been designed and developed for the experimental data analysis in order to allow both local and remote participation.

- eDAS provides the participants with two data access methods:
  Remote Computer Access (RCA) with a virtual desktop of data analysis server, etc
  Remote Data Access (RDA) which supports remote data retrieval with identical local / remote APIs

Demonstrate from REC against JT-60U May/June 2017
Task 7 – eGIS: waveform visualiser

- eGIS illustrates the discharge waveforms by retrieving the time sequential data array of the requested operational and diagnostic data.

- eGIS has implemented the spectrum analysis function for MHD instabilities accompanied by fast sampling data.

- Output data of analysis codes will also be visualized in eGIS.
Task 7 - eSURF: Plasma equilibrium viewer

- eSURF calculates the plasma equilibrium and stores it in the DB. eSURF shows the poloidal cross section of the plasma equilibrium with equilibrium information by retrieving the equilibrium data.

- eSURF shows the diagnostic viewing chords, NB beam lines and RF resonance positions.

- eSURF has implemented the animation function of the time sequential equilibrium data.
Task 7 - eSLICE: Spatial profile analyzer

- eSLICE retrieves the equilibrium data and diagnostic data and illustrates the spatial profiles of diagnosed physics quantities by mapping the diagnostic data on the equilibrium data.

- eSLICE provides the required dataset for the next step analysis codes by fitting the mapped diagnostic data.
Task 7 – Data Analysis Software - RDA

REC-related MDSplus development


“Assessing remote data access feasibility for the ITER REC”, this meeting

Demonstrate from REC against RFX, Tore-Supra, JET May/June 2017
Task 8 – Plasma Simulation

1. Tokamak Simulator (eTos) – S. Ide, Y. Miyata, N. Hayashi, A. Wakasa, T. Suzuki
   • SW development is complete
   • Demonstration at REC May/June 2017
2. CREATE-NL 2D magnetic equilibrium code - G. de Tommasi, M. Mattei, A. Mele (CREATE)
   • Customise for ITER and JT-60SA, user-friendly graphical interface, deploy REC
   • Work completed, Site acceptance tests at REC – May/June 2017
3. METIS fast transport code - J.F. Artaud, F. Imbeaux, G. Giruzzi (CEA)
   • Customise for JT-60SA, reference scenarios, benchmark with CRONOS simulations, improve GUI, deploy at REC
   • Work ongoing. Demonstration at REC May/June 2017. Final delivery March 2018
Task 8 – Plasma Simulation – eTos – Tokamak Simulator

Status of ITER Remote Experimentation Centre

4th functionality (Plasma parameters)

- $P_{\text{heat}}$ [MW]
- $\beta_p (t)$
- $I_p$ [MA]
- $d_{\text{outer}}$ [m]

1st functionality (Plasma equilibrium)

- Given heating power
- Evaluated poloidal beta
- Evaluated plasma current
- Outer gap

1st functionality (Plasma equilibrium)

L-mode → H-mode

1st functionality (Plasma equilibrium)

20.0s → 20.7s

1st functionality (Plasma equilibrium)

EF1, EF2, EF3, EF4, EF5, EF6

FPPC1, FPPC2, CS1, CS2, CS3, CS4

Outer gap

20.0s

20.7s
Task 8 – Plasma Simulation - CREATE-NL Code

- Deliver and deploy in Rokkasho and then in Naka a user-friendly version of the CREATE-NL equilibrium code customized for both JT-60SA and ITER
- Automatic generation of plasma/circuits linearized models to be used for magnetic control design/test/validation (in the Simulink environment)
Task 8 – Plasma Simulation – METIS Code

Delivery and deployment of a user-friendly version of the METIS code

- Activity started mid-September 2016
- Final delivery March 2018
- JT-60SA configuration included
- Initial set of simulations carried out
- GUI improved: JT-60SA customization + standard/expert mode
- To be done: finalization of scenarios, benchmark with CRONOS, documentation
Outlook

1. The main mission of the REC will be completed in 2017 as originally planned
2. Completion of REC activities within BA period
   1. Final verification tests – May / June 2017
      • Tasks 1, 2 and 6 – REC room and equipment, Networks and Storage
      • Task 4 – JT-60SA RES from REC
      • Task 7 – Data analysis software – EDAS, MDSplus
      • Task 8 – Plasma Simulation – eTOS, METIS, CREATE-NL
   2. REC review meeting – autumn 2017
   3. Demonstration ceremony – autumn 2017
3. Further activities within the extended period, to end-2019
   • Task 3 - Fast data transfer development / tests (Ongoing)
   • Task 5 - Integrated tests with EU Tokamaks (JET, WEST)
   • Task 8 – Completion of METIS development – March 2018
4. REC is device agnostic
   • ITER, JT-60SA, ... re-use of the REC as the IFMIF control room is being considered
Thank you
どうもありがとうございます

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