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Progress of ITER Remote Experimentation Centre based on the BA activities
BA活動に基づくITER遠隔実験センターの進展

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Construction of ITER remote experimentation center (REC) based on the broader approach (BA) activity of the joint program of Japan and Europe (EU) has been started. Objectives of REC activity are 1) to identify the functions and solve the technical issues for the construction of the REC for ITER at Rokkasho, 2) to develop the remote experiment system and verify the functions required for the remote experiment by using the Satellite Tokamak (JT-60SA) facilities in order to make the future experiments of ITER and JT-60SA effectively and efficiently implemented, and 3) to test the functions of REC and demonstrate the total system by using JT-60SA and existing other facilities in EU. Progress of the remote experiment centre is presented.

1. Introduction

ITER is one facility for the experimental reactor to demonstrate the scientific and technological feasibility of fusion energy, which is made in Cadarasche and is operated, as a joint program of world seven parties. Therefore, a remote participation of experiments is a crucial issue in ITER. Also this is a common issue for the large facilities in the international joint program.

Broader Approach (BA) Activities is the joint implementation based on the agreement between the Government of Japan and the EURATOM for support of ITER project and an early realization of fusion energy. International Fusion Energy Research Centre (IFERC) is the one of three projects of BA activities. IFERC project consists of three sub-projects of a) DEMO Design and R&D Coordination Centre, b) Computational Simulation Centre and c) ITER Remote Experimentation Centre.

ITER Remote Experimentation Centre (REC) is being made in Rokkasho, Aomori Prefecture for the remote participation to ITER experiments. The overall plan was made in 2012 by the preparatory working of EU and Japan experts. [1] The construction of the REC has been started according to the overall plan.

2. Objectives and scope of the ITER remote experimentation centre

Objectives of REC activity are to identify the functions and solve the technical issues for the construction of the REC for ITER at Rokkasho, and to develop the remote experiment system and verify the functions required for the remote experiment by using the Satellite Tokamak (JT-60SA) facilities in order to make the future experiments of ITER and JT-60SA effectively and efficiently implemented. In the end, the functions of REC will be tested, and the total system is demonstrated by using JT-60SA and existing other facilities in EU.

Scope of the REC activity was identified based on the objectives. Technical issues to be solved in the REC are to produce an effective remote experiment system that is easy to use for users, effective data access/viewing, and effective shot analyses with simulation. Also, an effective data transfer of the huge amount of plasma data, an effective storage method of huge data, and the related issues are included.

Functions to be developed for REC are identified as follows: 1) Secure remote experiment system, such as setting of experiment parameters, shot scheduling, real time data streaming, communication by video-conference between the remote-site and on-site, where the streaming of the main time-dependent plasma data of experiments is a minimum requirements, 2) Effective data transfer system that is capable of fast transfer of the huge amount of data between on-site and off-site and the network connecting to the REC system, 3) Storage system that can store/access the huge amount of data, including a data mining issues, 4) Data analysis software for the data viewing of the diagnostic data on the storage system in a user-friendly manner, 5) Numerical simulation for preparation and estimation of the shot performance by the appropriate implementation of the simulation code, such as the integrated simulation code, and the analysis of the plasma shot.

3. Progress of REC

The concept of shot schedule of remote experiment is identified. The sequence of the procedure of the remote participation will be like that in Fig. 1. Shot parameter prepared by the on-site researcher will be sent to the shot schedule storage, and the experiment will be executed by using this shot parameter after the validation check from the viewpoints of the safety and the operation of the facility. After the execution of experiment, the measured data are acquired and stored. In the remote site, the remote-site researcher will access the data storage of the remote site or the main site, analyze the previous shot data and then prepare the next shot parameters with the aid of simulations. Remote-site researcher will prepare the shot parameters in the same manner as the on-site researcher, and the shot parameter will be sent to the same shot schedule storage through a remote experiment server.

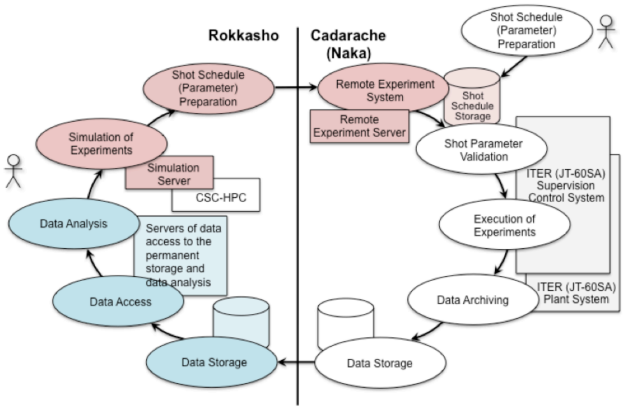

Fig.1. Concept of the shot schedule of the remote experiment: The left side is the remote-site (Rokkasho) and the right side is the on-site (Cadarache)

Remote experiment system: The remote experiment system (RES) will be made based on the JT-60SA control system for the test of the function of the RES from Rokkasho site. On the remote site, it is important to perform fusion experiments under the same condition as the on-site researchers. Main functions to achieve this are preparation and setting of shot parameters, viewing the status of control data, streaming of the plasma status, data-exchange function of shot events, and monitoring of the facility operation. Functions of the RES are provided by the remote experiment server (RESV), which connects the discharge control supervisor and synchronize the discharge parameter file. The RESV can be accessed from the outside through the JT-60SA firewall by the web-based software. The development of the software of discharge control supervisor, has been started as the main work with a part of Human-machine Interface Server.

Fast data transfer: In ITER, the amount of data to be experimentally measured can be expected to increase up to more than 1TB per discharge, and the amount of the accumulated data will be an order of 1PB in a year. Therefore, the fast data transfer and the large storage are critical issues in the remote site. For the network connection, broadband network system with larger than 10 Gbps is necessary for REC. The network in Rokkasho site has been connected to the nearest data center (Hirosaki) of SINET4 by 10 Gbps line in 2012. The 10Gbps line has been extended to the Tokyo data center in 2014 in collaboration with National Institute of Informatics (NII). Further upgrade of the network bandwidth would be expected when the experiments in ITER are carried out in future.

To obtain the fast data transfer, investigations of effective data transfer method, development of accelerators, etc. are needed. Tests of fast data transfer from IFERC in Rokkasho site are ongoing by collaborators in NII and NIFS. Especially, new fast data transfer programme developed by NII staff is tested between Amazon EC2 in Ireland and REC at Rokkasho site, where 23 GB data is used and 0.910 Gbps was recorded for the specified transfer rate of 0.996 Gbps.

Data analysis software and simulation: For the data analysis software, analyses of experimental data should be done from the remote site using the on-site and also the remote-site software. Functions of the data viewing of plasma diagnostics, statistical analyses of diagnostic data and mapping of diagnostic data are necessary. The development of the experimental data analysis software has been started for several fundamental applications for data analysis. The unified software infrastructure to access data stored both at on- and remote- sites and the documentation management system are also being developed. Objective of this simulation is to analyze plasma shots and to support decision process of shot parameters for later shots. The customisation of an Integrated Transport Code for JT-60SA and ITER, the customisation of a 2D magnetic equilibrium code for JT60-SA and ITER, the design and the prototyping of an ITER-relevant plasma boundary reconstruction code are proposed.

Summary: The construction of the REC has been started in the collaboration with JT-60SA, experts of informatics, activities of plasma simulation and data analysis, and ITER-CODAC&IT.

References

[1] T. Ozeki, S. L. Clement, N. Nakajima, Fusion Eng. Des. **89** (2014) 529-531.