# ITER Information Plant

## WHITE PAPER

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**Nina Putvinskaya[1], David Schissel[2], and Maurice Sabado[1]**

[1]Science Applications International Corporation (SAIC),
10260 Campus Point Drive, San Diego, CA 92121

[2]General Atomics (GA),
3550 General Atomics Court, San Diego, CA 92121

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## Introduction

This White Paper provides an input to the U.S. preparations for the International Thermonuclear Experimental Reactor (ITER) project. It is the result of the combined efforts of Science Application International Corporation (SAIC) and General Atomics (GA), and is based on the "Teaming Agreement for Cooperation in the Development of Informational Technology Systems for Plasma Physics and Fusion Energy" between the two companies.

**Data accumulated in ITER will be the major output of the project. An information system will be needed as an R&D tool to collect, process, manage, and interpret these data.**

**SAIC and GA propose to build an ITER Information Plant (ITER IP) as a centralized multi-component Information System for ITER.**

**The ITER IP will allow the U.S. to become the most informed ITER participant by providing detailed knowledge of all project components at all stages of ITER development.**

**The ITER IP will bring the highest return on investment (ROI) for the U.S.**

**The development of the ITER IP will require participation of teams with expertise in both fusion and large-scale IT systems.**

## Need for ITER Information System

ITER is by far the largest and most complex scientific project ever undertaken by mankind. It has two major goals: creation and control of burning plasma, and search for a commercially optimal containment technology. A high quality IT system will be an essential component for the rapid scientific and technological progress in all ITER experiments.

### *Burning plasma experiment*

Burning plasma will present new scientific challenges that must be explored and understood. Findings from previous studies may not be valid, as burning plasma will likely show new phenomena, such as exceedingly complex nonlinear behavior exhibited by regimes that are not possible in current experiments.

The scientific success of the burning plasma experiment will critically depend on the successful implementation of a high-quality IT system to minimize lost experimental time and accelerate the understanding, interpretation, and planning of ongoing fusion experiments. Simulations of the operating regimes, which would enable building of the projections for the operation of a burning plasma experiment, could play a particularly important role for understanding and predicting plasma performance.

The capability of Information Technology (IT) to accelerate the learning process by providing timely processing, graphical presentation of the processes, and multi-parameter analysis of the results, has been proven many times. This will be critical in the burning plasma experiment.

***Optimization of containment technology***

The ITER project could be viewed as transition from a fusion science program to a fusion device engineering program. Therefore, the burning plasma experiment is expected to be followed by development of all essential technologies needed for a fusion reactor. This would be a step towards the practical implementation of fusion power and commercialization.

High performance, safety, reliability, and maintainability will be the key objectives of the research at this phase, as they are fundamental to the development of attractive fusion energy systems. Multiple R&D activities will be carried out to achieve these objectives, including configuration optimization, materials testing, components testing, and performance optimization. The quality of the IT system will determine the efficiency of the R&D and play a significant role in intensifying them.

## ITER IP Overview

We propose to build an ITER Information Plant (ITER IP) as a centralized information system with various components (subsystems). They will be integrated within an infrastructure that provides support for the operating data marts, standardized means of communication between the subsystems, and a standardized environment.

An integrated environment will be needed to diminish redundancy of information and to optimize the performance of the system. An integrated environment will also be required to carry out a multi-dimensional analysis needed to answer complex questions from the fusion community.

One reason the ITER subsystems should not be developed independently is that they should be able to communicate with each other and exchange information. While each component will serve the user community directly, they will all work together seamlessly, being embedded in a cohesive and balanced integrated information environment. This is similar to the idea of building an ecosystem, but in this case, an information ecosystem that is balanced and healthy.

We believe that the ITER IP subsystems should be developed with the closest involvement of members of the fusion community. The list of ITER IP subsystems is not complete at this time. However, some suggestions have already been made. These include Data Acquisition, Data Management, and Remote Participation subsystems (proposed in Dr. Greenwald’s presentation), four CODAC subsystems described in the ITER documentation (Plant Control System, Plant Operation, Magnetic Configuration & Poloidal Field Scenarios, and Plasma Control), and a Modeling & Simulation subsystem. GA, PPPL, and MIT have been proposed as the prospective developers for the Data Acquisition, Data Management, and Remote Participation subsystems. The four CODAC subsystems and the Modeling & Simulation subsystem will need developers to be determined.

The initial set of all necessary subsystems should be defined in the nearest future in order to estimate the extent and pricing of the whole information system.

## Development of an IT system for ITER

Building the IT system for a complex international project such as ITER is not a trivial task. There are several factors that add to its complexity: the time factor, the international nature and large scale of the project.

Teams with diverse and complementary experience will be needed to tackle the unprecedented complexity of the integration of all necessary ITER IP components.

### *Time factor*

The building phase for ITER will continue for about ten years. During this time there will be:

- Inevitable and multiple changes in the Technical Requirements, such as adding new diagnostic systems, operating scenarios, etc.
- Advances and Innovations in Information Technology.
- Changes in computer hardware.
- Changes in computer software, such as OS version, databases, and tools.

To overcome the time factor problem, the system design should be done iteratively, through an evolutionary development process, which will allow the system design to evolve with the progress of the various project elements. An evolutionary development process will assure system stability for the whole duration of the project, so that upgrades/updates do not disrupt the functionality of the system. It will also provide a consistent documentation and stable performance at all times. Analysis, design studies, and exploration of innovative IT methods will be a continuing effort.

### *International nature of the project*

The international nature of ITER is associated with the use of diverse standards. To minimize the development chaos, development and modification procedures have to be standardized. International, national, and open systems industrial standards should be used for all management and engineering processes. This will pose challenging requirements on the IT development teams.

### *Large scale of the project*

The large scale of ITER implies diversity and complexity of the project tasks. To overcome this problem a uniform IT approach and standardized development environment must be used in the development of all subsystems. This will make maintenance of the information system easier in the future.

System and software development tools should be used in every design iteration to shorten the design process and to automate documentation maintenance.

***Qualifications of the development team***

The analysis of the factors affecting the information system development indicates that a specific knowledge in the fusion area, as well as an extensive experience in building large-scale IT systems, will be needed for successful ITER IP implementation.

Therefore, SAIC and GA propose to join expertise in fusion and information technology, thus bringing complementary strengths to this complex task:

- SAIC, with its extensive experience in building IT systems for the international community, will provide the most effective IT system solutions to assure uniform and standardized ITER IP design, development and modification.
- As a recognized leader in the international fusion community, GA can lead the formulation of Technical Requirements for ITER IP and provide an adequate testing environment to ensure system functionality, reliability, and performance.

## Benefits to the U.S.

The role of the ITER information system as an R&D tool will continuously grow as the project progresses. The party building the ITER Information Plant will get an exceptional opportunity to access and maintain the knowledge base of the entire project. Thus the U.S. will have the chance of becoming the most informed participant at all stages of ITER project development.

The ITER IP will bring the greatest return to the U.S. for a relatively modest investment. Building the Information System for ITER will need less than 10% investment, but will result in 100% knowledge. At least a ten times larger investment (i.e., an entire project cost) would be needed to gain the same knowledge from any other program.

For these reasons, building the ITER Information Plant represents a working package with the highest Return of Investment (ROI).

## Conclusions

**SAIC and GA propose to join expertise in fusion and information technology to successfully build an ITER Information Plant.**

**The ITER Information Plant will make it possible to reap maximum benefits from the data accumulated in the ITER project.**

**The ITER Information Plant will bring substantial benefits and the highest return on investment for the U.S.**

**Technical Point of Contact:**

Dr. Nina Putvinskaya
Science Applications International Corporation (SAIC)
Tel. (858) 826-5339
Fax: (858) 826-4993
nina.putvinskaya@saic.com