Simulation Assisted Automation Testing During Loviisa Automation Renewal Project

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Abstract: In simulation assisted automation testing, an automation system is connected to a process simulator that provides a realistic process response. Under this circumstance, automation testing becomes intuitive since the automation system can be operated as at the actual plant. *Testing Station* software has been developed to support simulation assisted automation testing. It provides tools for simulation control; simulation can be started/stopped, initial conditions saved/loaded, and malfunctions launched/reversed. Furthermore *Testing Station* is used to design and report the results of the tests. Simulation assisted automation testing has been successfully used during automation renewal project of Loviisa nuclear power plant. *APROS* process simulation software has been used to implement the process model needed for the testing.

Keywords: Process simulators, Automatic testing, Nuclear plants

1. INTRODUCTION

An automation system must be thoroughly tested before it can be installed into the process plant. Simulation assisted automation testing provides a new way to execute tests that are not possible, hard to implement or expensive to do by using traditional testing methods (Laakso et al. 2005). It is "virtual commissioning"; the automation system is installed on a simulated process plant, I/O is checked, and tests are done to the automation system. In practice it means that such kind of tests are done in test field and factory acceptance tests that are done in commissioning (see Figure 1). Especially integral tests require a realistic process response that earlier has not been available before automation system installation to the plant. The development of simulation tools, automation system emulations and communication software has made simulation assisted testing more effective. As a latest step the development of working methods and tools for simulation assisted automation testing has been started.

This document focuses on simulation assisted automation testing in automation renewal project of Loviisa nuclear power plants (Välisuo 2005). The Loviisa nuclear plants are nearly thirty years old and their current automation systems are getting outdated; the number of automation component malfunctions is increasing and it is hard to get new spare parts. However, the process equipments of the plants are in good condition and they do not prevent using the plants for decades. Consequently it is possible to extend the life time of the plants considerably by renewing the automation system.

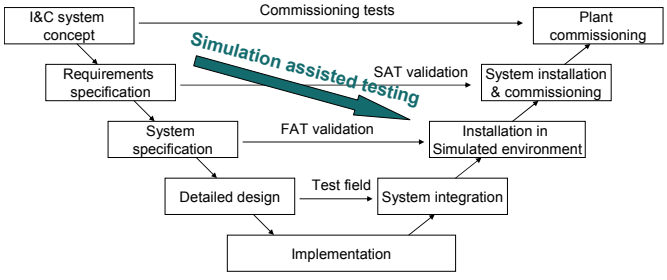

Figure 1 V-model of I&C system design life cycle (IEC & IEEE), simulation assisted testing makes it possible to test the kind of tests earlier that are done in commissioning.

In simulation assisted automation testing a process simulator is connected to the automation system that is under testing. A virtual copy of the automation system can be used which means that the automation system is emulated and the automation application is run on a standard PC. The process simulator provides a realistic process response to the

automation system. With this arrangement the automation system can be operated the similar way as at the actual plant. In consequence, simulation assisted testing is very intuitive. One can see on the operator displays if the automation is working correctly or if there is a need for corrections.

Simulation assisted automation testing is an addition to the more conventional tests that are done to the automation system. However, it is possibly the only reasonable way to test the automation system as a whole so that the cross-dependencies between the different parts of the system are also taken into account. The initial data of the renewed automation system is thirty years old and it is hand-written to a large degree and therefore it contains errors, it is not fully up to date and some parts of the initial data is difficult to interpret. The errors originating from the initial data can be discovered effectively by simulation assisted automation testing.

The fewer errors are in the automation system, the more reliable it is and the shorter commissioning time will be achieved. The shorter the commissioning time the faster the plant is back in production. Moreover, nuclear power plants are required to have a training simulator to be able to train the operators. Therefore the simulator that corresponds to the new automation system has to be developed in any case. The same simulation model that is used in automation testing can also be used in training simulator. Therefore additional costs for simulation assisted automation testing are low.

Simulator aids in automation testing has been used previously e.g. in Narva modernization project (Rinta-Valkama et al. 2000) carried out by Fortum Engineering in 1999 - 2000. During the project, simulator was used to test and tune the controllers and also logics were tested to some extent. In consequence, the automation system had fewer errors before installation and therefore commissioning time was shorter.

2. SIMULATION ASSISTED TESTING ENVIRONMENT

The process simulator contains models of the process, measurements, and field devices. The automation system is connected to the process simulator (See Figure 2) so that it acquires the measurement signals and sends control commands to the simulated field devices. With this arrangement the automation system can control the simulated field devices like it would control them at the actual plant and it gets a realistic process response. When the automation system opens a valve, it gets the feedback from the simulated valve. Moreover the opening of the valve causes other changes in the simulated process containing measured and signals that transferred to the automation system. E.g. after a valve is opened fluid starts to flow through it and liquid level of a tank starts decreasing.

The scope of the process simulation model defines how big part of the automation is included in the tests. The interconnections between the control loops are taken into account by the process simulation. The different controllers control the same process simulation model and therefore their actions affect to each other. The computing power and memory of the computer used to simulate the process model limit the scope and accuracy. The larger and more accurate the model is the slower the simulation speed becomes. To speed up the simulation speed, process model can be divided into several computers. Process simulation model that includes every essential processes of Loviisa nuclear plant can be simulated over real time speed with a standard desktop PC.

The automation system connected to the process simulator can be the actual system or so-called virtual automation system (Kettunen and Paljakka 2006) that is computer software being able to execute automation applications similarly to the actual automation system. In addition, virtual automation system implements the basic features typically needed in simulation such as run/freeze and save/load initial condition. Normal process displays and control systems can be connected to virtual automation. Virtual automation runs often on a standard PC.

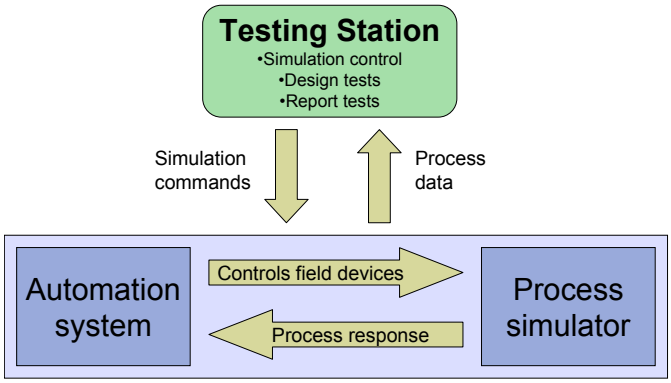

Figure 2 In simulation assisted testing environment, automation system controls the field devices that are simulated on the process simulator where it also gets a realistic process response.

In Loviisa automation renewal project APROS (Advanced PROcess Simulator) (Juslin 2005a, b, Laakso et al. 2005) is used to model the process. APROS is a simulation software product of VTT Technical Research Centre of Finland and Fortum. It is meant for full-scale modeling and dynamic simulation of industrial processes. It provides tools, solution algorithms and model libraries of generic components suitable for various purposes like design, analysis and training. These tools enable full-scale modeling and simulation of power plant, including automation and electrical systems.

The total simulation system meant for testing or training contains usually many separate components that need to be managed simultaneously. Typical components include process simulator, virtual automation system, communication software and operator displays. Testing Station visualizes the state of the different components and gives simultaneous simulation control commands like start and stop to all components. Testing Station also takes care of time synchronization between the process simulator and virtual