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The 3rd ATLAS Domestic Standard Problem for Improvement of Safety Analysis Technology

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1. Introduction

Since 2009, a domestic collaboration program with the integral effect test data from ATLAS, called ATLAS DSP (domestic standard problem exercise), has been promoted to improve safety analysis technology as well as to establish a common network among the safety experts in Korea. The third ATLAS DSP was launched at the end of 2012 in response to the strong need for continuation of the ATLAS DSP. A guillotine-break of a main steam line without LOOP at a zero power condition was selected as a target scenario, and it was successfully completed in the beginning of 2014.

2. Overview of the Project

2.1 Background

The first ATLAS DSP started in 2009 and lasted for two years with the ATLAS data for a guillotine break of one of the DVI lines. In the first ATLAS DSP, great user effects were turned out to play a key role in the code calculation. In addition, several key phenomena challenging the code developers were identified such as loop seal clearing phenomena, ECC bypass, critical flow, etc. Thereafter, the second ATLAS DSP followed with the ATLAS data for 6-inch cold leg break LOCA, where special code assessment activity was promoted to minimize the user effects as well as to assess the physical models embedded in the safety analysis code. In the previous two DSP exercises, quantitative index for code calculation accuracy was made based on the FFTBM (Fast Fourier Transform Based Method).

In 2012, the third ATLAS DSP started where a guillotine-break of a main steam line without LOOP at a zero power condition was selected as a target IET data set.

2.2 Organization and Objectives

The 3rd ATLAS DSP was operated by KAERI in collaboration with KINS as an open calculation. KAERI was responsible for general coordination of the program, data provision, receipt of submission, result comparison, arranging progress meeting and workshop. As a joint operation agency, KINS was responsible for coordination support, code calculation and workshop. As a participant, 17 organizations signed the Agreements, including research institutes, a regulatory authority principal, nuclear industry principals, and universities. The participants of the 3rd ATLAS DSP is shown in Table 1. A leading organization for each sub-group was elected in the progress meeting to make analysis more efficient and the outcome more productive. And, three secretariats from the operating agency were elected for each group for easy communication with a lot of participants.

Table 1 Participants of DSP-03 and codes used

	Participants	Code
A (4)	<u>KHNP CRI</u>	SPACE
	ACT	MARS-KS
	RETECH	MARS-KS
	UNIST	MARS-KS
B (7)	<u>KEPCO NF</u>	TRACE
	KHNP CRI	CFX
	EN2T	TRACE
	SNU	MARS-KS
	KAIST	MARS-KS
	FNC	MARS-KS
	SENTECH	SPACE
C (7)	<u>KEPCO E&C</u>	SPACE
	KAERI	SPACE
	DOOSAN	MARS-KS
	PNU	MARS-KS
	KINS	MARS-KS
	HYU	MARS-KS
	KINGS	MARS-KS

*Underlined organization was invited as a leader of each group

Due to increased number of participants, the objectives of the 3rd ATLAS DSP were categorized into three different topics as shown in Table 2.

- **Group A**: Scaling-up analysis with simultaneous cal culations for ATLAS and APR1400, development of the scaling-up guideline of the IET data
- **Group B**: In-depth 3D analysis, 3D modeling is requ ired especially for the downcomer and the reactor pr essure vessel, comparison of 3D analysis with the ty pical 1D analysis
- **Group C**: 1-D analysis, development of the standard nodalization guideline

2.3 Progress and remaining schedule

Since the 3rd ATLAS DSP was launched, five progress meetings were held to share information and code analysis expertise of the participants.

- Kick-off meeting: October 09, 2012
- 1st meeting: December 12, 2012

- 2nd meeting: April 24, 2013
- 3rd meeting: July 11, 2013
- 4th meeting: November 28, 2013
- 5th meeting: March 13, 2014

Table 2 Organization of ATLAS DSP-03

Grp. (#)	Topic	Analysis Area
A (4)	Scaling-up	- ATLAS & plant analysis - Scaling distortion analysis - feasibility for extrapolation
B (7)	3D analysis	- CFD analysis for asymmetric mixing - Comp. with 1D calculation
C (7)	1D analysis	- Sensitivity study - Development of standard node guideline for SLB

In the course of the 3rd ATLAS DSP, a Café was opened on the Web. for more convenient information sharing and feedback between operating agency and participants. From the 2nd progress meeting, a sub-group technical meeting was arranged to reduce the user effects and to avoid any user input errors.

So far, all the calculation results were collected from each group. The draft integration report is being prepared by operating agency. Once the draft integration report is issued, a review process will be taken by participants. The final integration report is scheduled to be issued at the end of 2014.

3. Major Findings of Each Group

While detailed calculation and analysis results will be included in the final integration report, the major results for each group can be summarized briefly as follows;

3.1 Group A

As agreed in the progress meeting, two calculations were conducted in this group with two models: one for ATLAS and the other for APR1400. The effects of different steam pipeline configuration between two models were avoided by adopting the facility configuration to the real plant by scale-up. Heat loss inevitable in the reduced facility was carefully modeled to investigate the scaling distortion. Heat loss on the steam generator was found to be one of the major causes resulting in difference between two models. On the whole, it turned out that the integral effect test data from ATLAS can be extrapolated to the real power plant, APR1400 only if a careful modeling is made.

3.1 Group B

3D behavior was not so significant in the core during the simulated SLB scenario. Not so much 3D effects were found even in the lower down-comer region. The coolant with large temperature difference injected from intact and affected loops was well mixed in the down-comer region and it was well predicted by the code. Utilization of three dimensional components such as VESSEL in TRACE-3D and MARS-3D did not make great difference compared with 1-D calculation.

A CFD calculation was made to investigate the velocity profile inside the down-comer and reactor pressure vessel. Detailed velocity stream lines and vortex across the flow skirt and spacer grid were clearly identified. The local pressure drop coefficient inside the reactor core was obtained and fed back to the other participant who utilizes 3D components to improve the prediction accuracy.

3.1 Group C

User effects from the same code users and difference from different codes were focused. In particular, the main cause of the oscillation observed when the feedwater injected into the steam generator was investigated. And, separator model and entrained droplet during the SLB were analyzed by different modeling sensitivity.

4. Conclusions

In the 3rd ATLAS DSP, comprehensive utilization of the integral effect test data was made by dividing analysis with three topics; (1) scale-up where extrapolation of ATLAS IET data was investigated (2) 3D analysis where how much improvement can be obtained by 3D modeling was studied (3) 1D sensitivity analysis where the key phenomena affecting the SLB simulation were identified and the best modeling guideline was achieved.

Through such DSP exercises, it has been possible to effectively utilize high-quality ATLAS experimental data of to enhance thermal-hydraulic understanding and to validate the safety analysis codes. A strong human network and technical expertise sharing among the various nuclear experts are also important outcomes from this program.

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