

*International Experts Meeting on  
Strengthening Research and Development Effectiveness  
in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant  
16–20 February 2015, Vienna, Austria*

# **Code for European Severe Accident Management (CESAM) - Overview on the EC project on ASTEC code improvement and applications -**

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(GRS)*



# Content

- What is CESAM?
- Where does CESAM rely on?
- What is the Scope of CESAM?
- What will be done in the Working Packages?
- Examples of what has been done by GRS.
- Summary

# What is CESAM?

**Code for European Severe Accident Management -> ASTEC**

## Project in the 7<sup>th</sup> R&D EC Framework Programme (FP7)

- Topic: Impact of the nuclear accident in Japan on Severe Accident Management
- **Coordinated by GRS with a strong IRSN support**
- Duration: April 2013 – March 2017, in total work of about 56 person.years
- **19 partners (TSO, research, universities, industry):**  
GRS, KIT, USTUTT, RUB (Germany), IRSN, AREVA NP SAS, EDF (France), CIEMAT (Spain), ENEA (Italy), VUJE, IVS (Slovakia), LEI (Lithuania), NUBIKI (Hungary), INRNE (Bulgaria), JSI (Slovenia), VTT (Finland), PSI (Switzerland), JRC (EC) and BARC (India)

## Objectives

- **Improvement and further common validation of the integral code ASTEC**, jointly developed by IRSN and GRS since almost 20 years
- **Application of ASTEC for Severe Accident Management** analyses of European Gen. II and III/III+ NPPs
- **Progress towards an ASTEC “diagnosis” version** interfacing with atmospheric dispersion tools

## Where does CESAM rely on? -> SARNET EC projects



**Severe Accident  
Research NETWORK  
of excellence**

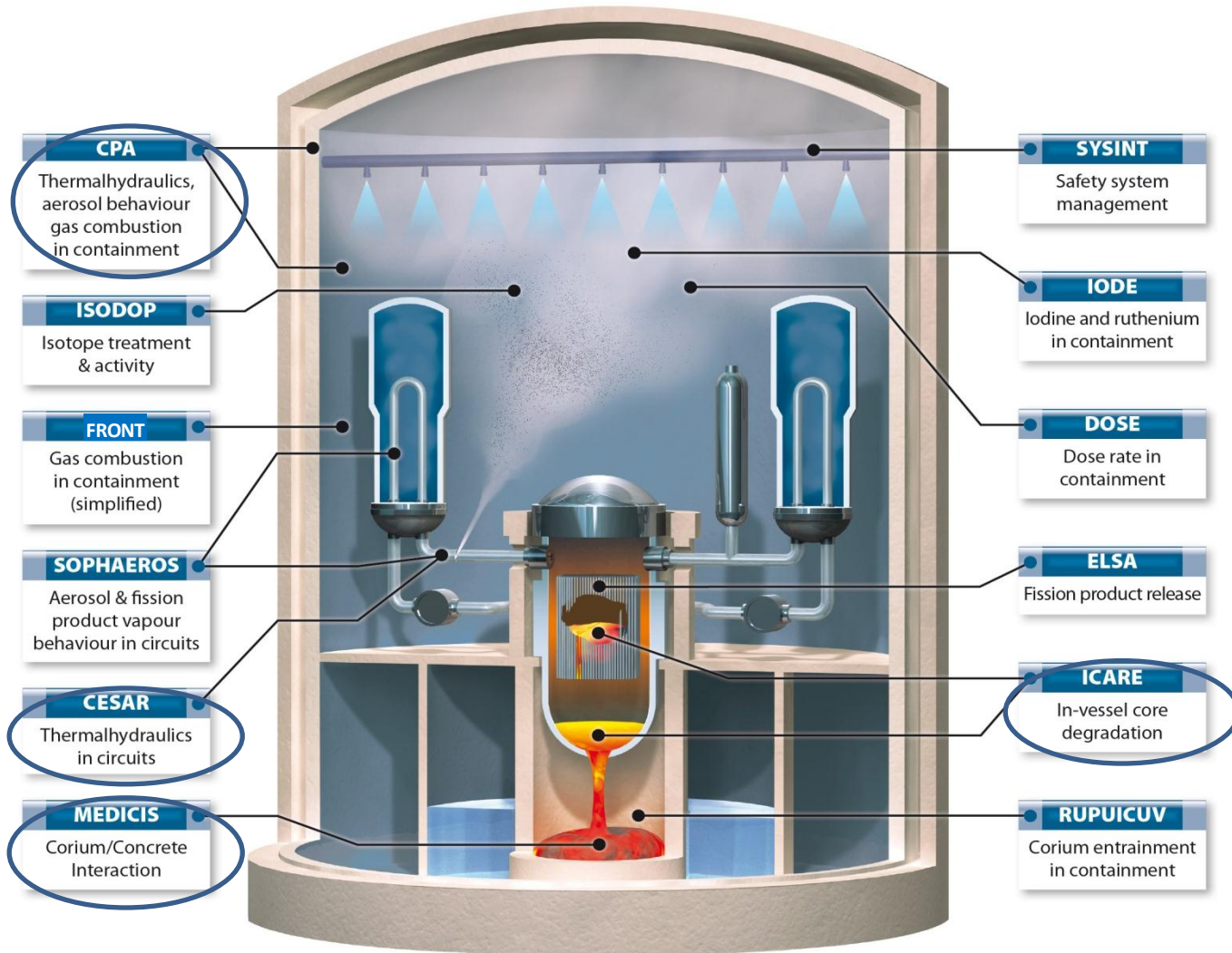
- Integration of top scientists & dissemination of knowledge, research & development activities on severe accidents & ASTEC code, and identification of research priorities and common research programmes
- **WP4: ASTEC** code development, assessment, application -> **CESAM** group
  - 1st project in FP6 2004 - 2008, 2nd project in FP7 2009 – 2013
  - Both under IRSN coordination, work ≈ 40 full-time persons/year
  - Partners:
    - 24 countries (Europe, Canada, Korea, India)
    - 47 organizations : TSO, safety authorities, research, industry, vendors, universities

# What is the Scope of CESAM?

- **CESAM benefits** from the previous SARNET projects, especially WP4 “ASTEC improvement” and WP1 “SARP – Severe Accident Research Priorities”
- **ASTEC model** development in CESAM will focus on specific high-priority issues raised after Fukushima-Daiichi and by SARP in SARNET FP7
  - reflooding of degraded cores and core degradation in BWR
  - pool scrubbing and filters
  - hydrogen combustion
  - spent fuel pools behaviour and others
- Project is oriented towards **ASTEC plant applications** and **SAM evaluation**
- **Three main types of research activities (work packages):**
  - **Validation (in WP20):** ASTEC validation vs. experiments, with particular focus on selected specific phenomena and BWR
  - **Code development (in WP30):** Further ASTEC code improvement towards the 2<sup>nd</sup> ASTEC major release version V2.1 and its subsequent updates
  - **Plant applications (in WP40):** ASTEC applications to SAM scenarios for the main types of European NPPs and benchmarks with other codes
- ⊕ **Dissemination of Knowledge, Education and Training (in WP50)**

# WP20: ASTEC modelling assessment and validation

Main activities related to the assessment and validation of modules marked below



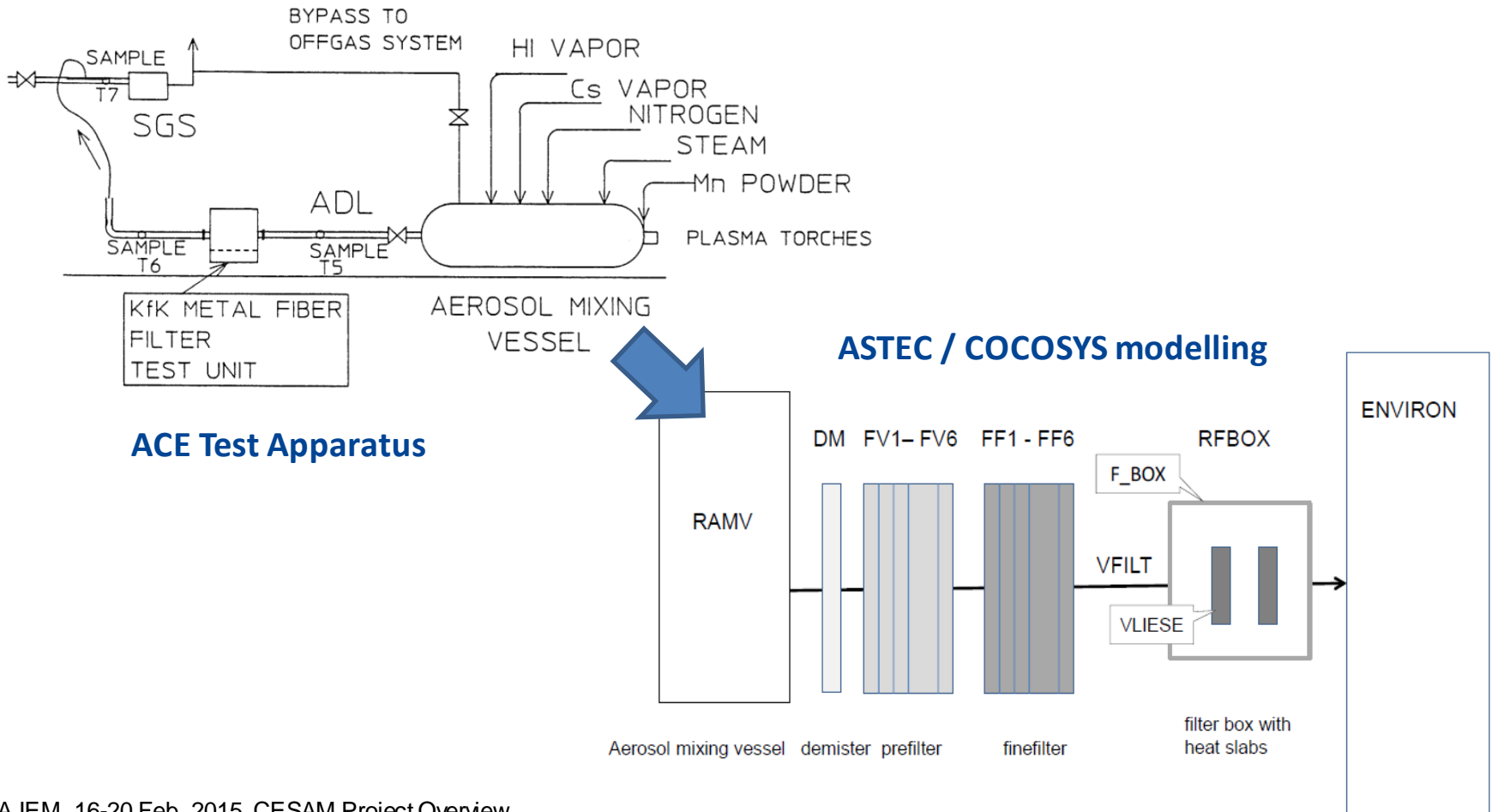
## WP20: ASTEC modelling assessment and validation

- **Main objectives:** assessment and improvement of ASTEC models, especially those important for SAM and those dominant in Fukushima  
 ⇒ *specification of new models and/or modelling improvements*
- **Focus:** improving existing models on following issues with high relevance as identified in SARP, validation with available experiments:
  - **Core reflooding:** QUENCH, CORA, PRELUDE-PEARL, TMI
  - **IVR by external cooling** LIVE, BALI, MASCA/RASPLAV, SULTAN, ULPU
  - **MCCI - Corium coolability:** VULCANO, MOCKA, OECD-CCI, SSWICS, COMET
  - **BWR core degradation:** CORA BWR, SANDIA DF-4
  - **H<sub>2</sub> containment risk mitigation devices:** OECD THAI, HYKA
  - **FCVS efficiency, pool scrubbing:** Insights from EC PASSAM project
  - **SFP behaviour:** OECD-SFP experiments, PAKS accident
- **Results:** delivery of report on “Identification of available Experiments for ASTEC Validation and needs of new Experiments”, and final preparation of report on “Synthesis of Validation of ASTEC V2.0rev3 Version”



# WP20: ASTEC modelling assessment and validation

- **Assessment example (GRS):**  
**ASTEC model of Metal Fibre Filter** used in German containment venting system based on ACE results and current COCOSYS modelling

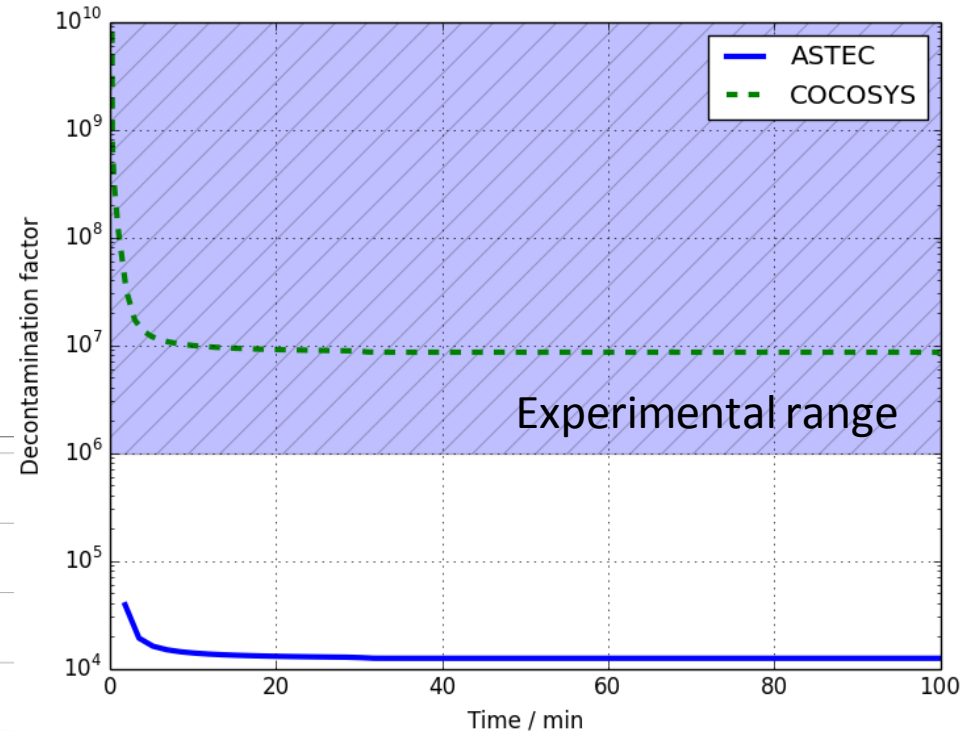
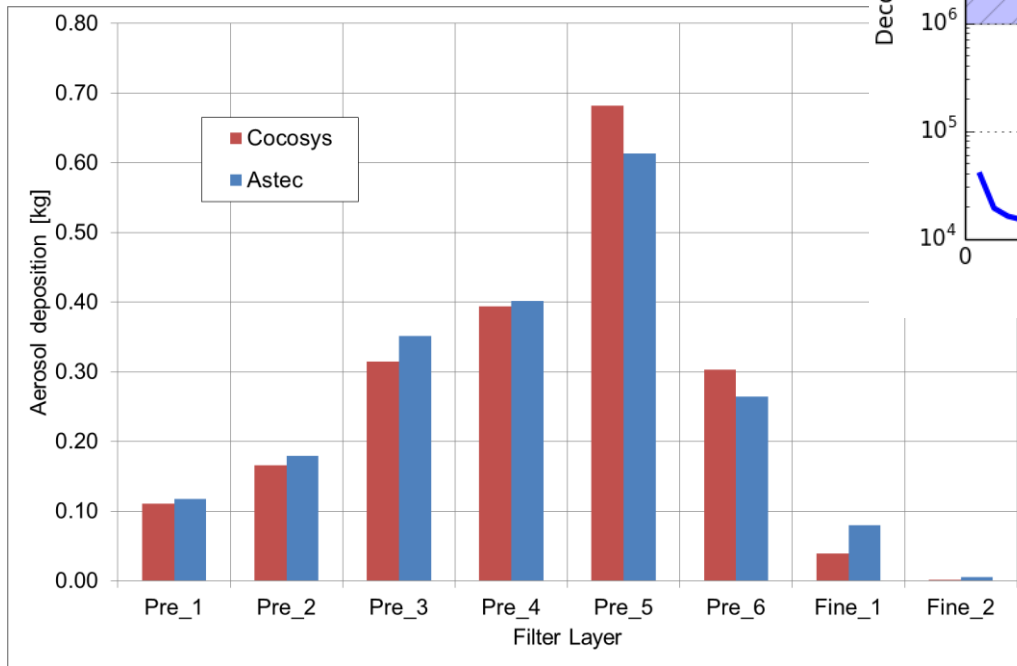




# WP20: ASTEC modelling assessment and validation

## ➤ Assessment example (GRS): ASTEC model of Metal Fibre Filter ACE AA19 Experiment

- Similar aerosol retention in different pre and fine filter layers (no measured data)

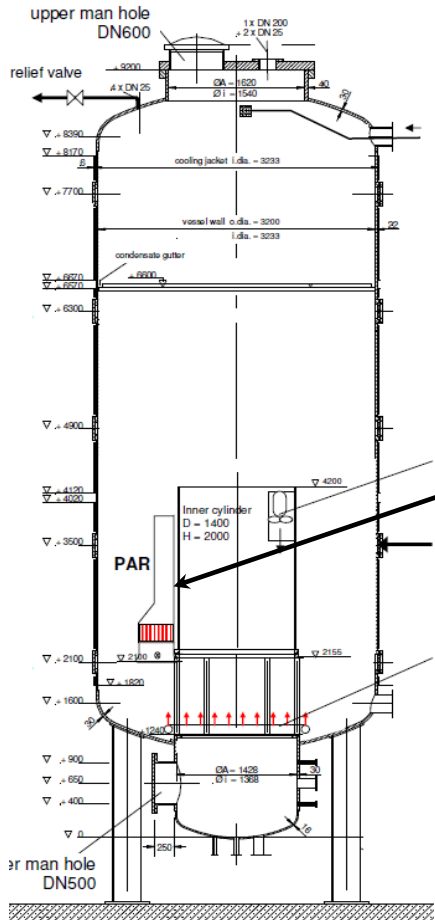


- Underestimation of DF by ASTEC, but DF = 10000 = 99.99 % retention is above filter design limits
  - COCOSYS is in experimental range, caused by automatic calibration to real filter data
- => Model transfer to ASTEC possible

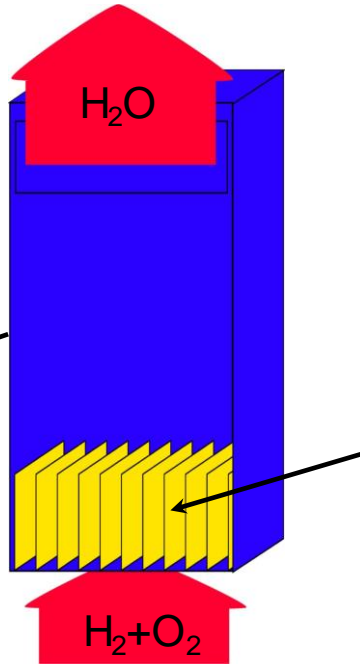
# WP20: ASTEC modelling assessment and validation

## Validation example (GRS):

**NIS recombiner (PAR) behaviour** based on OECD THAI results, using existing plate type PAR model in ASTEC



**ASTEC modelling**



**NIS recombiner**

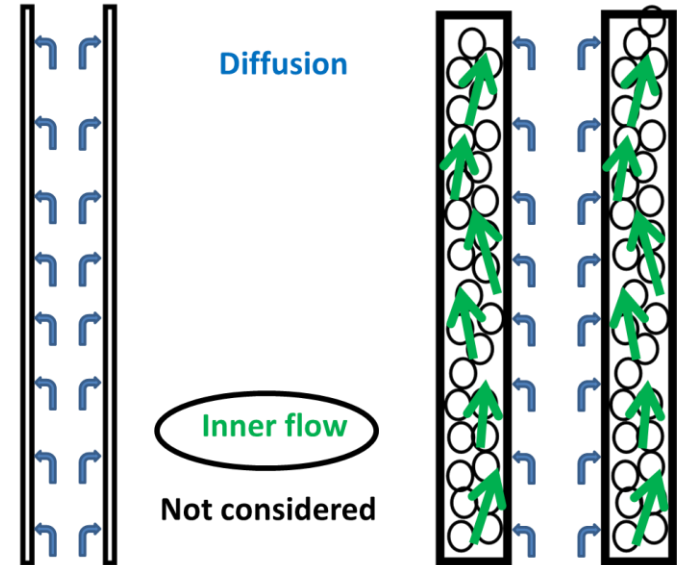


plate type

<->

pellet type

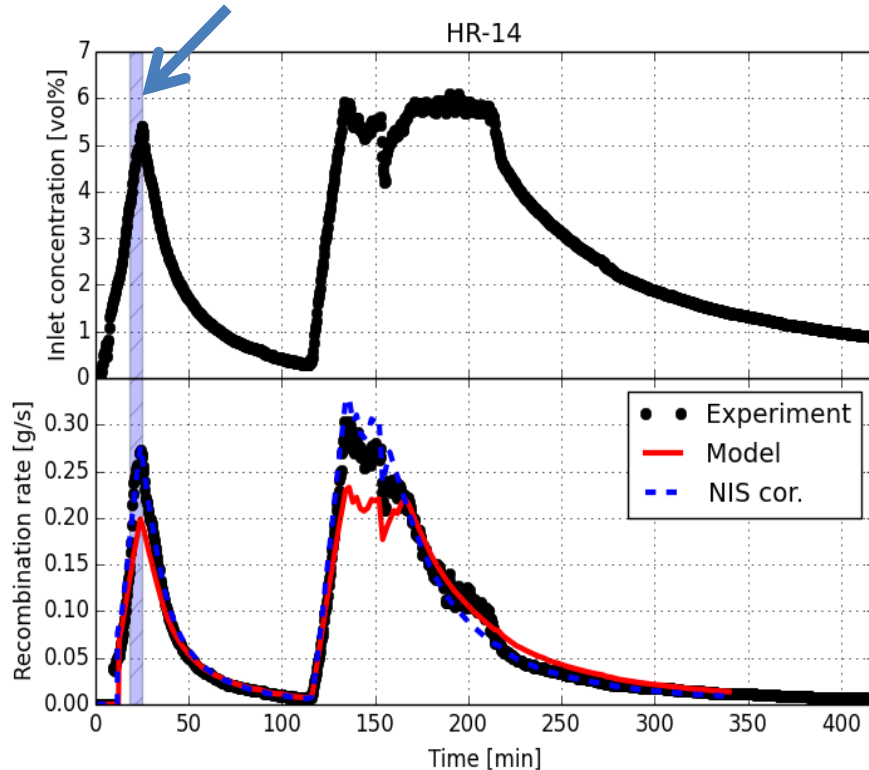
# WP20: ASTEC modelling assessment and validation

## ➤ Validation example (GRS):

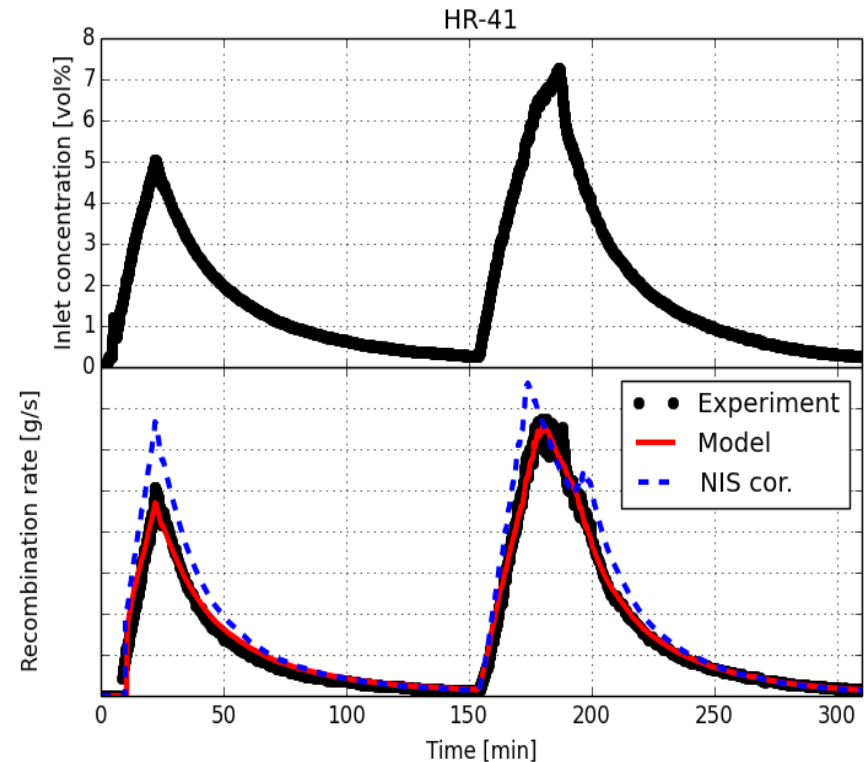
**NIS recombiter (PAR) behaviour based on OECD THAI results**

**Experiment at 1.5 bar,  
25 vol% steam, 74 °C, => 100 % sat.**

Glow worms observed



**Experiment at 2.0 bar,  
40 vol% steam, 105 °C, => 66.2 % sat.**



## WP30: ASTEC development

### ASTEC V2.1 - multi-design reactor code for SA applications

#### ➤ Topic 1 : ASTEC code modelling improvement (mainly done by IRSN)

- Improved **ASTEC V2.0 version (V2.0rev3)**
  - Providing notably feed-back from SARNET2 extensive assessment of previous versions
  - Common starting point within the project released in June 2013
- Active assessment of the next **ASTEC major version V2.1**
  - V2.1 beta version for CESAM partners released in June 2014 to start the building-up of V2.1 plant input decks; release of full version in February of 2015
  - **New CESAR/ICARE coupling** (unique TH in whole RCS, 2D core model)
  - First version of a **mechanistic model for reflooding of degraded cores**
  - Specific **core models for BWR and PHWR** (canisters, multi-channels, ...)
- Activities to **improve code user-friendliness**, especially for plant applications:
  - New user-friendly Graphical User Interface, improvement of code numerical performances and users' documentation

## **WP30: ASTEC development**

### **ASTEC V2.1 - multi-design reactor code for SA applications**

#### ➤ **Topic 2 : ASTEC code extension for diagnosis** (mainly done by IRSN)

- Progress towards **an ASTEC “diagnosis” version**

- Interfacing with atmospheric dispersion tools to enhance capabilities of direct comparison with on-site measurement
- Coupling to French dispersion tools and German tool RODOS

#### ➤ **Results:**

- Delivery of report on  
 “Synthesis of needs of ASTEC models improvements for ASTEC V2.1”
- Preparation of release of ASTEC major version V2.1

# WP40: Plant applications and SA Management

## ➤ Building “reference” ASTEC input decks

- Combine the best knowledge of the different teams using ASTEC in Europe and India for PWR, BWR, VVER and CANDU with the advices of the ASTEC code developers (IRSN/GRS)
- To serve as a basis for ASTEC users to build its own plant deck

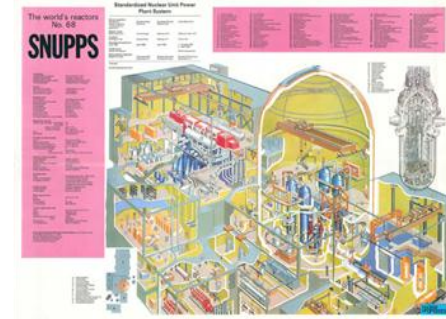
## ➤ ASTEC applications for SAM

- Various analysis and possible improvements of SAM measures accounting for the lessons drawn from the Fukushima accidents
- Benchmarks with other codes: MELCOR, MAAP, ATHLET-CD

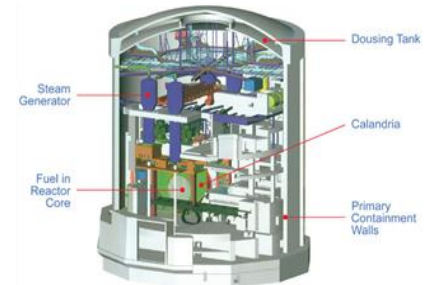
## ➤ Results: Progress on input decks & delivery of a report on

- “Review of current SAM approaches in Europe and identification of related modelling requirements”

### Western PWR



### CANDU



### VVER-440

### VVER-1000

### BWR Mark 1

### Konvoi PWR

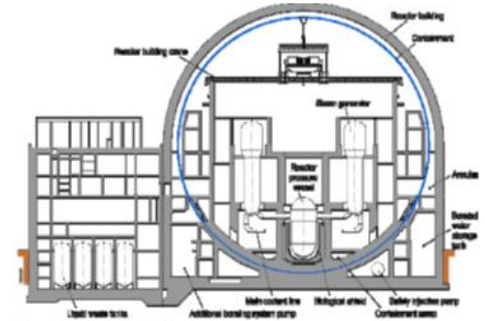
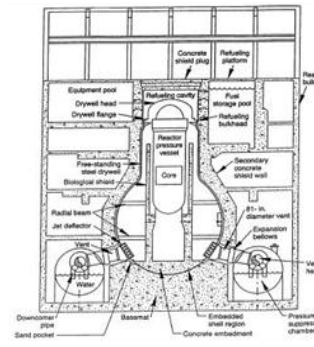
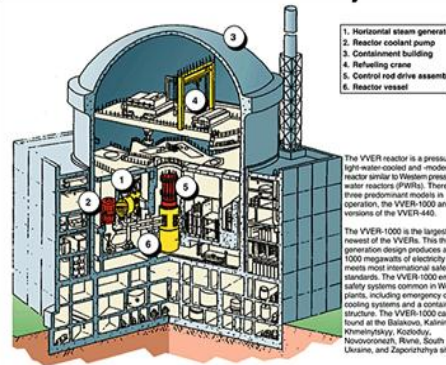
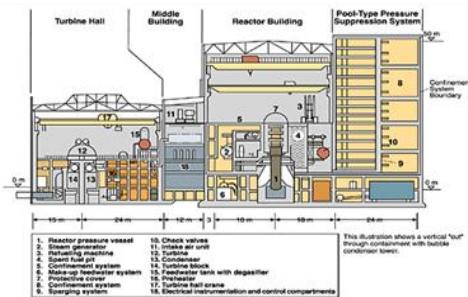


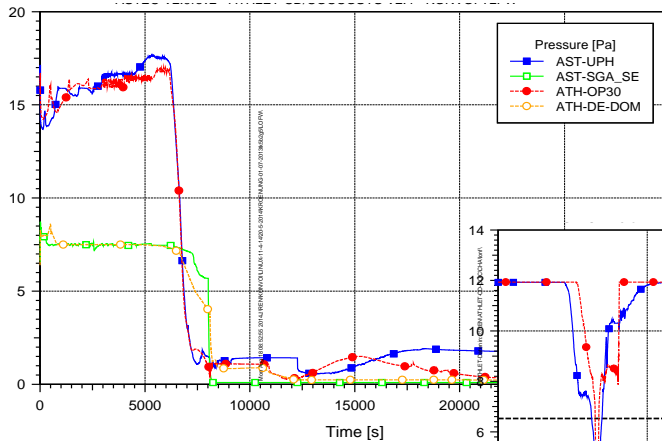
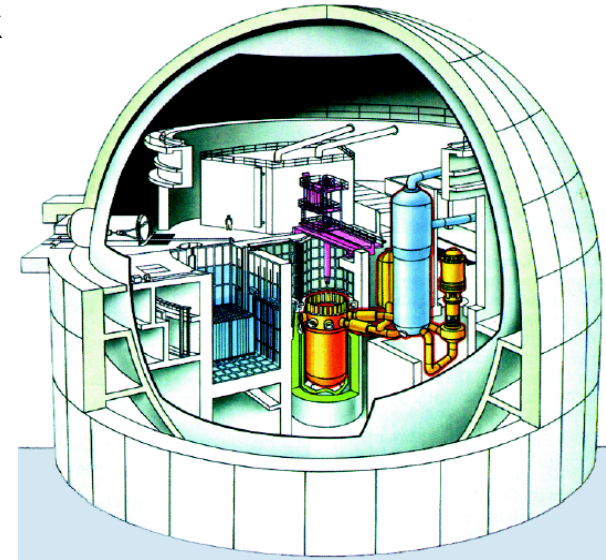
Figure 1-1: Cross-section of a PWR



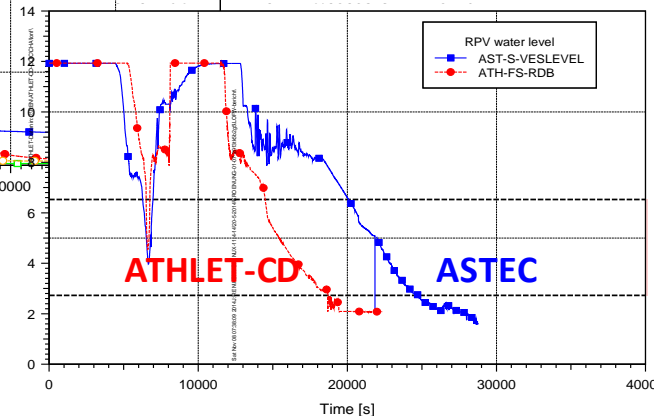
# WP40: Plant applications and SA Management

## ➤ GRS contribution for KONVOI PWR (example)

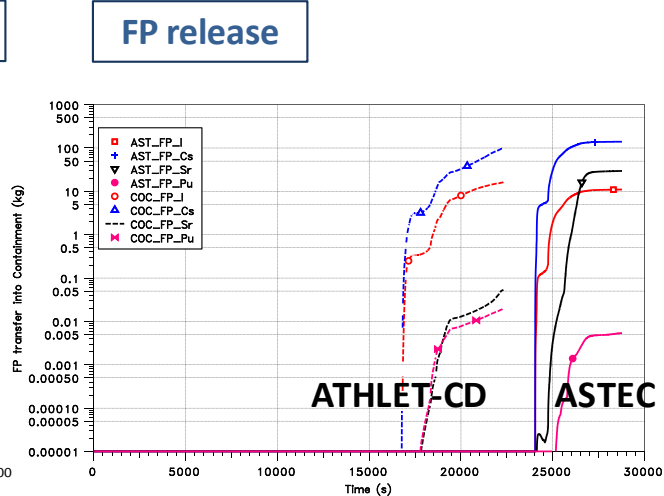
- Partners have been provided with a generic input deck
- Qualification done by code comparison:  
**ASTEC** <-> **ATHLET-CD/COCOSYS**
- Scenario: “Total loss of feedwater with primary bleed & feed (*AM measure*)”
- Similar trends in early phase, later on larger deviations due to differences in core degradation modelling -> later in ASTEC



**Pressure**



**PRV water level**



**FP release**



# WP50: Dissemination of Knowledge, Education and Training

## ➤ Dissemination of knowledge:

- Public web site ([www.cesam-fp7.eu](http://www.cesam-fp7.eu))
- Establishment of ASTEC “end-users” group
- Periodic newsletters incl. other topics related to ASTEC development and use

## ➤ Education and training programs:

- Mobility program for PhD students and researchers among partners
- Update of training sessions on ASTEC use

## ➤ Communication between partners and the public:

- Intranet website created for internal communication
- Organization of yearly workshops, open also to ASTEC end-users
- Creation of a multimedia e-learning module



**ASTEC Newsletter N°1** November 2013

**cesam**  
Code for European Severe Accident Management

**ASTEC Newsletter**  
Accident Source Term Evaluation Code

Editorial Board: V. Sanchez (KIT), L.E. Herranz (CIEMAT), J.P. Van Dorsseleere (IRSN), H. Nowack (GRS), G. Pascal (JRC/IET)

**Introduction**

The goal of the Newsletter is to disseminate information on the progress of the European Commission (EC) CESAM project and to share the new advances of the ASTEC integral code and the experience of its applications for the assessment of the safety aspects of nuclear power plants (NPP). The ASTEC (Accident Source Term Evaluation Code) software package is jointly developed by the French Institut de Radioprotection et de Sûreté Nucléaire (IRSN), German counterparts (KIT, CIEMAT), and Austrian counterparts (GRS). Despite the measures adopted for accident scenario probability circumvention in Severe Accident melting and plant disintegration of radioactive material, representing a serious hazard for the public health and for the environment. This hazard was underlined by the accidents in the Japanese Fukushima-Daichi NPPs in March 2011. This Newsletter will contribute to spread out the knowledge in modeling and simulation of severe accident sequences of any reactor type among the ASTEC end-users within Europe and worldwide with the

**ASTEC Newsletter N°2** July 2014

**cesam**  
Code for European Severe Accident Management

**ASTEC Newsletter**  
Accident Source Term Evaluation Code

Editorial Board: V. Sanchez (KIT), L.E. Herranz (CIEMAT), J.P. Van Dorsseleere (IRSN), H. Nowack (GRS), G. Pascal (JRC/IET)

**Introduction**

This is the second issue of the ASTEC Newsletter that is published in the frame of the CESAM project of the FP7 of the European Commission. CESAM started in May 2013 for the duration of 4 years. The first Newsletter was published in November 2013. The main event of the project since November was the 1<sup>st</sup> CESAM Technical Workshop that was held in the reactor centre of Jozef Stefan Institute in Ljubljana (Slovenia) in March 2014. In total, 35 participants presented and discussed their work on all technical CESAM work packages during the two and a half days workshop. 17 of 18 CESAM partners sent a representative to the workshop and 22 presentations were given by 14 CESAM partners. The following sections show what has been conducted in the different CESAM work packages on ASTEC validation, model implementation

**Inside this Issue:**

Introduction	1
Model assessment, improvement and validation	2
Modeling implementation into ASTEC	4
ASTEC plant applications	5
Other ASTEC applications	6
The first open workshop of the PASSAM project	7
Final CESAM workshop	8
NED ASTEC special issue	8
ASTEC ENSTTI Training course	8
New publications	10
Conferences, workshops	12

**CESAM F**

CESAM (Code for Accident Manager project in the 7<sup>th</sup> Programme of development, coordination) started in May 2014. It aims at the development of the European ASTEC towards an Accident Management analysis. The Fukushima highlighted that understanding of and the development of measures is essential to increase the safety of reactors operated in Europe. The development of SAM measures

## Conclusions

- **CESAM will contribute to enhance the ASTEC applicability for SAM analysis and to continue cooperation**
  - **Continuation of general ASTEC strategy**
    1. Fast-running and numerically robust code for plant applications
    2. Repository of knowledge, with mechanistic models at the state of the art
  - **Important steps with next major ASTEC V2.1 version**
    1. BWR, PHWR, plus SFP capabilities, in addition to PWR and VVER today
    2. New user-friendly Graphic User Interface
    3. Interface with atmospheric dispersion tools
  
- **ASTEC is the European reference code since it capitalizes the European knowledge on severe accidents**
  - Largely used in Europe - particularly TSOs - and about 40 partners
  - Key tool in international projects: CESAM, NUGENIA, OECD/CSNI ...
  - “Reference input decks” for the main types of European NPPs are build
  - Ongoing efforts towards larger “industrialization”

# Acknowledgements

- **To all CESAM partners and ASTEC users**
- **To the European Commission for the financial support to CESAM (project N°323634)**
- **To the German Ministry BMWi for support of the GRS work**