

forward-looking energy



AREVA Computer Codes for Radiological Consequence Analysis

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IAEA, Vienna, 20th-24th April, 2015

E&P Communications, March, 2015 PCOM 2013/14



Agenda











Our activities encompass

- ► EPR[™] Power Plants
 - Olkiluoto 3
 - Taishan units 1 & 2

Installed base

Periodic safety review

Emergency response

Tools & methods





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Preparation of the safety analyses for licensing

Safety assessments for the design of our new products

Emergency response



Codes and methods

Radiological consequences assessments

Different purposes, different objectives, different analyses: customized tools

Purpose

- Design
- Licensing
- Emergency preparedness
- Emergency response

Scope

- Activity releases into the environment
- Activity in rooms and systems
- Atmospheric dispersion and dose assessment









Codes and methods

Radiological consequences assessments

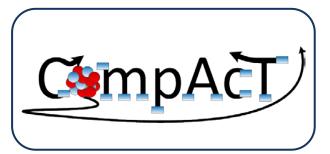
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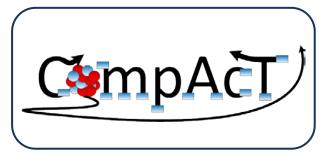
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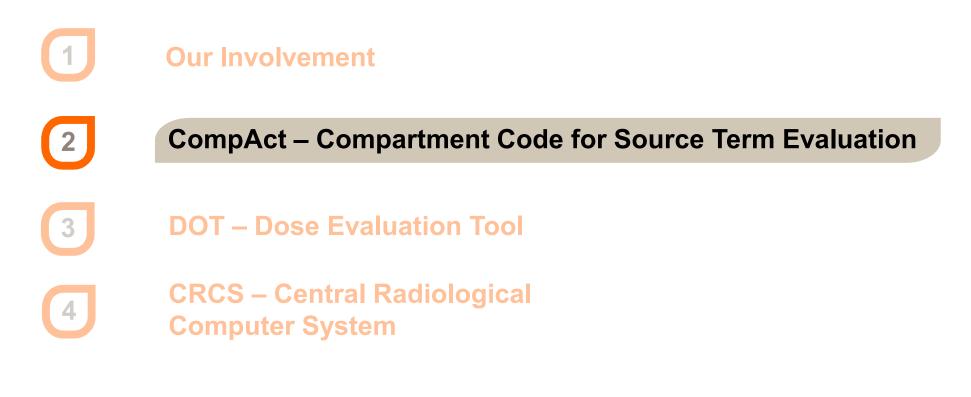
Codes and methods Necessary features



Tools must be versatile in order to address existing and foreseeable situations for design, licensing, emergency preparedness and emergency response



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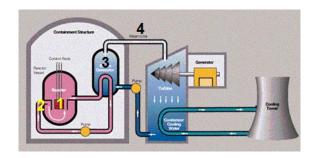
Integrated compartment model

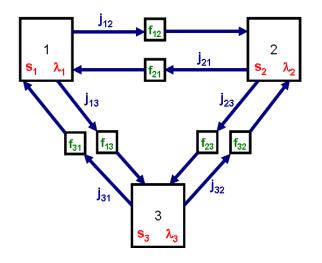
Airborne release

- Immediate or continuous
- Evaporation of liquids
- Equilibrium processes

Multi-compartment transport

- Active ventilation
- Leakage pathways
- Bypass
- Radioactive decay and ingrowth
- Removal processes
 - Filters
 - Dry deposition
 - Spray
- Individual chemical forms



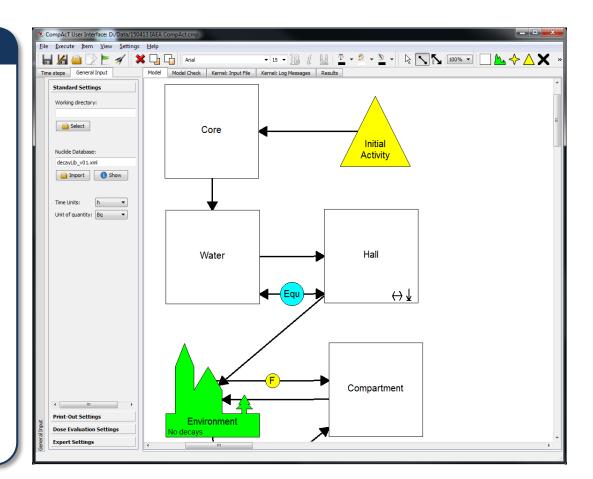






- State-of-the art solver for large, stiff ODE systems
- Internal verification of numerical precision
- Intuitive graphical user interface
- Easy adaptation to various requirements
- Arbitrarily complex models
- Convenient output
- Model checks itself for validity and completeness

ODE = ordinary differential equation







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.4	9.41000000E+00	0.0000000E+00	3.60821431E+16	3.14400594E+09	1.75686099E-12	1.05112855E+05	5.08020677E+15	1.17373725E+05	3.853965181
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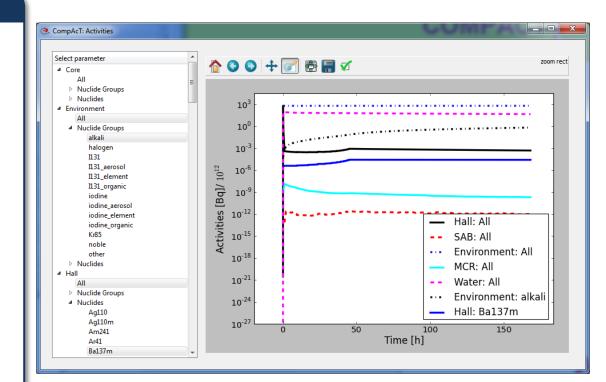




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Convenient output

Model checks itself for validity and completeness





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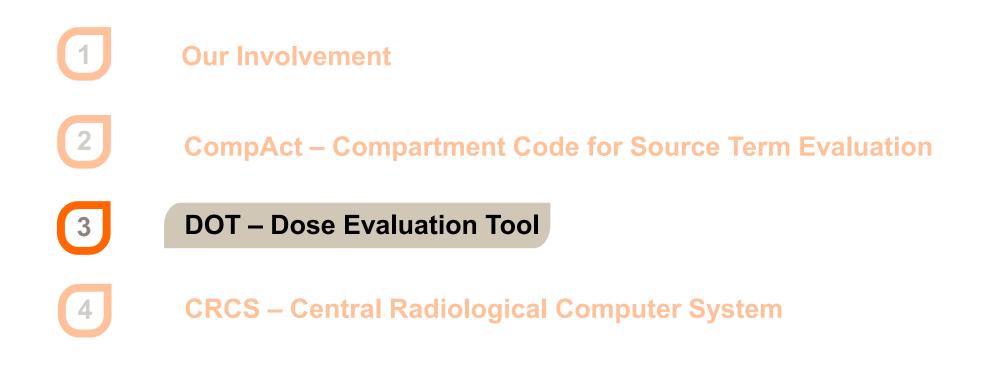
A few selected features

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Execute View Settings Help		
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	Time steps	E
Γ	No problems detected	
ment	Unique names	
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	Model consistency	
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Agenda

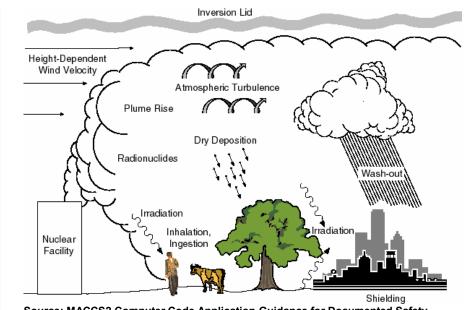






Radiological consequences assessments for design & licensing

- Gaussian atmospheric dispersion
- Dose calculations
 - Cloud-shine
 - Inhalation
 - Beta submersion
 - Ground-shine
 - Ingestion
- Contamination of foodstuff

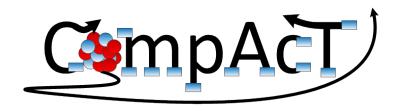


Source: MACCS2 Computer Code Application Guidance for Documented Safety Analysis, 2004





- Independent kernel and graphical user interface (GUI)
 - DOT kernel is a library (.dll)
 - The kernel can be re-used
- Interface with CompAcT
- Simplify
 - Calculations
 - Documentation
- User-friendly GUI





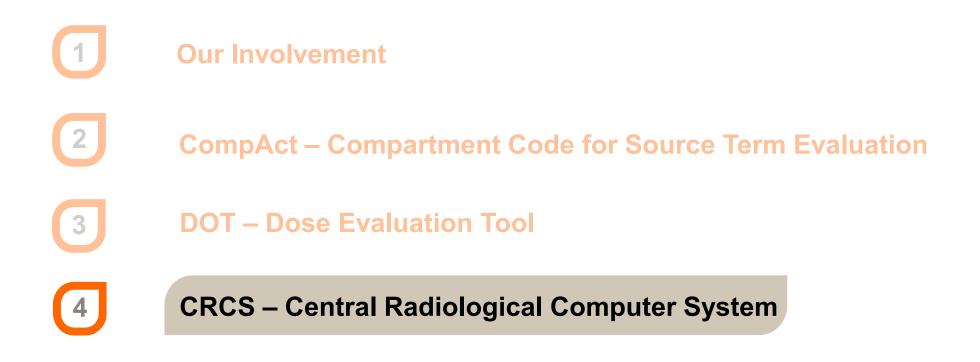


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he Environment								Levinel Status		
							A	iene status		
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ont Parameters Report Description						and the second se		release 3: 100.0 meters release 4: 100.0 meters		
Report fo	Report fornal used during the preparation of the ATMEA generic detailed design.							Building wake effect:	Building height: 67.4 meters Building width: 40.9 meters	
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n 500 meters cloudshine, a submersion 0.031	9 0.15	0.15	0.13	0.11	0.070	10 mBy		Considered pathways	Inhalation yes Cloudshine yes Sets submarsion yes Groundshine no	
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s 2000 meters · cloudshine, ubmersion, gestion									7 - 12a 2.6E-04 m3/s 1.8E-04 m3/s 12 - 17a 3.3E-04 m3/s 2.3E-04 m3/s > 17a 3.8E-04 m3/s 2.4E-04 m3/s	
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cloudshine, ummersion, gestion . sge 1.7 s 2000 meters cloudshine, ummersion, gestion . s coldent 15.6 s coldent . so .	20.7 21.1 500 meters @ Liy products	1.3 13.3 13.6 Due to direct Leaf vegetab	1.1 7.2 7.6 deposition blue 1	1.1 5.4 5.0 6 (Bq/kg) (1) 2845, sausage	0.96 3.1 3.5	50 mBy (2) 50 mBy (2) 50 mBy (2) Plant products(1)		Reference precipitation rate for th calculation of the wet deposition	Engents no App Group e B hours > B hours +1 -1.10-01 and/s > 1.10-01 and/s -1 -1.10-01 and/s > 1.00-01 and/s	



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Motivations

A real life accident will not follow a fixed scenario and will deviate from the assumptions of the safety analysis report

- What is the radioactive source term of a design-exceeding event?
- What is the impact of such an event on the surrounding areas?
- How can the impact on the population be assessed and minimized?











Objective, Benefits, and Application of CRCS

- CRCS is a modular tool for supporting the radiological staff of a Nuclear Power Plant with Radiological Surveillance and Emergency Preparedness (Crisis Center)
- ► CRCS is part of the EPRTM Design for Taishan 1+2 and Olkiluoto 3
- CRCS is easily adaptable to site-specific needs

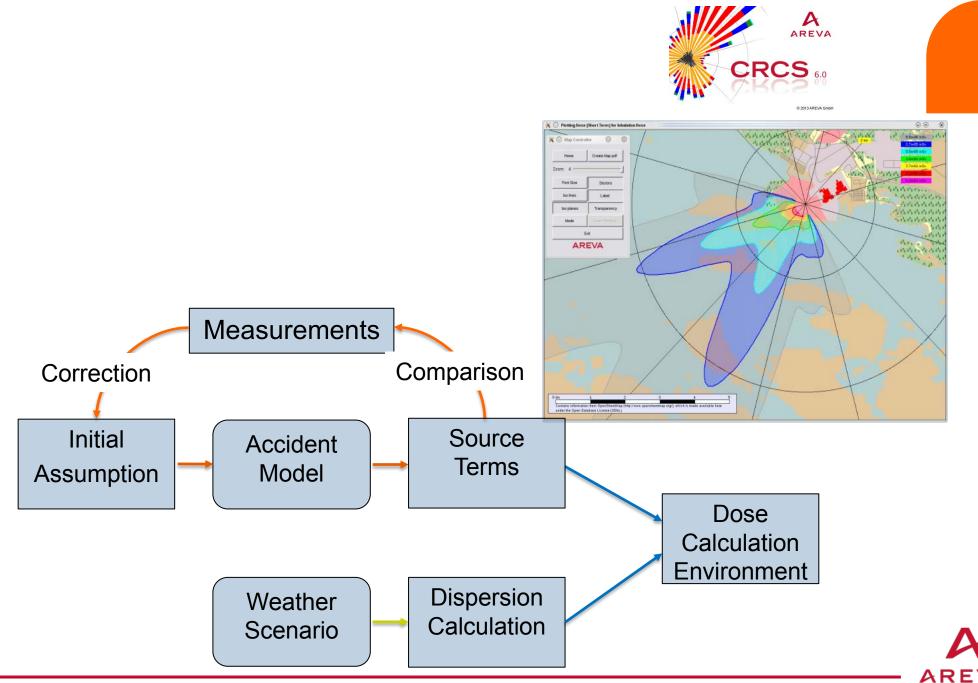




Approach

- Starting Point
 - Power-plant-specific <u>activity source term</u> (PC, core, etc.), <u>system parameters</u> (ventilation rates, leakage rates, etc.) and thermo-hydraulic data (core release fractions, deposition fractions, etc.)
 - Modelling the <u>accident sequence</u> in terms of a system of differential equations
 - Definition of modifiable key parameters for adaptation of the release calculation to real case
- Adaptation of model parameters to reproduce measurements
 - Real sequence is reflected by the model
 - Activity measurements and system parameters within the plant
 - Meteorological and dose rate measurements (environment)





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Accident selection among pre-defined scenarios

Activity releases into the environment

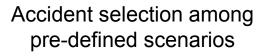
Meteorological conditions

Radiological consequences assessment

- Large Break Loss of Coolant Accident
- Small Break Loss of Coolant Accident
- Rod Ejection Accident
- Steam Generator Tube Rupture
- Loss of Condenser Vacuum
- Long Term Loss of Offsite Power
- Locked Rotor Accident
- Loss of Coolant outside Containment
- Leakage in the Gaseous Waste Processing System
- Fuel Handling Accident
- Effect of Earthquake on Nuclear Auxiliary Building
 / Waste Building
- Core Melt Sequence: initiated by a Large-Break Loss of Coolant Accident
- Core Melt Sequence: initiated by a Loss of Offsite Power



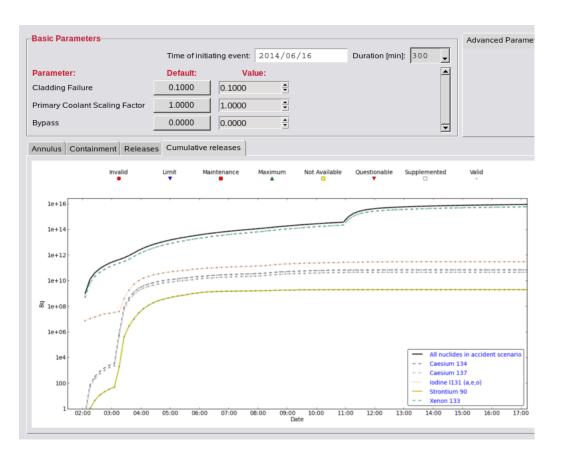




Activity releases into the environment

Meteorological conditions

Radiological consequences assessment







Accident selection among pre-defined scenarios

WindRose

Availability: Dates: Available:

Not available:

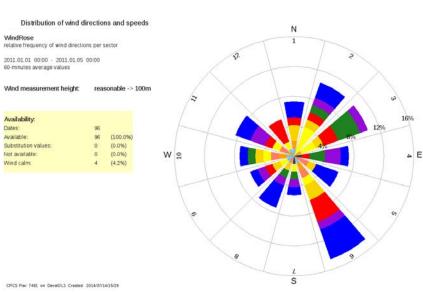
Wind calm:

Substitution values

60-minutes average values

Wind measurement height:

Activity releases into the environment





Meteorological conditions

Radiological consequences assessment



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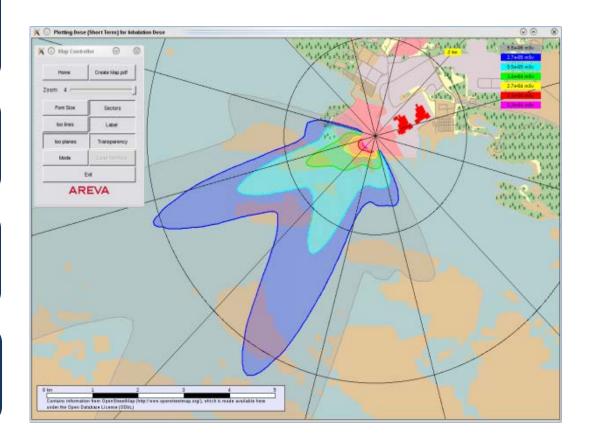


Accident selection among pre-defined scenarios

Activity releases into the environment

Meteorological conditions

Radiological consequences assessment

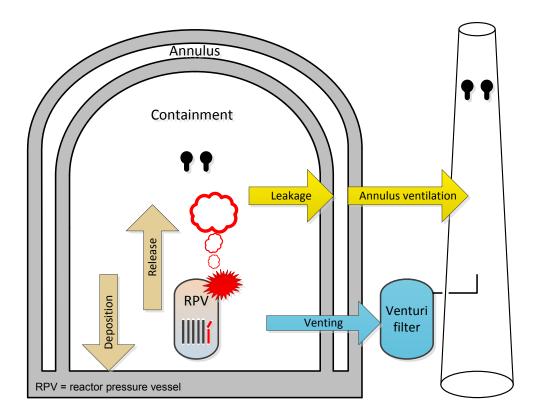






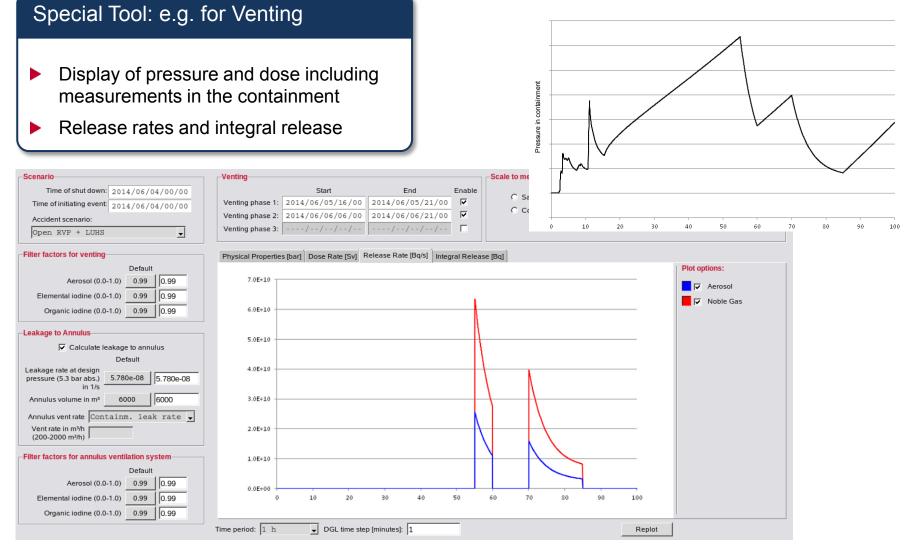
Special Tool: e.g. for Venting

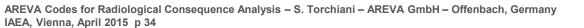
- Pre-calculated accident sequence and correction due to venting process and real conditions (measurements: pressure, dose rate)
- Release fractions and depositions taken from thermo-hydraulic calculations
- Transport calculation of venting and leakage into the annulus









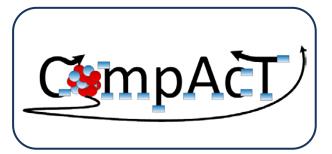




Summary Codes and methods

Different purposes, different objectives, different analyses: customized tools

- Purpose
 - Design
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 - Emergency response
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