Nuclear Power Plant Gösgen-Däniken LTD

- Built in 1979, Switzerland
- 1035 MW PWR
- **3 Loops**, KWU Design
- **Emergency Systems**: HPIS (4 pumps), 6 Accumulators, LPIS (4 pumps), EFWS (4 pumps), 4 Diesel Generators
- **Special Emergency Systems**: SEFW (2 pumps), SECC (2 pumps), 2 Diesel Generators
- **Containment**: Double (Steel & Concrete), UPES, CFVS

Full-Scope PSA Level 3 Of NPP Gösgen

Nuclear Power Plant PSA Model Features

Nuclear Power Plant (KKG) PSA Model Features

- KKG PSA Level 1 and Level 2
- PSA Level 3 – Model
- KKG PSA Level 3 – Selection of Accident Scenarios
- Interface Level 1 and Level 2 PSA to Level 3 PSA

KKG PSA Level 3 - Latest Developments and Results

"USNRC - IMUG 2020"

B.Askari[1], D.Papini[2], R. Kaulbarsch[2], S. Heussen[2]
1) SwissSafeTech AG, 2) Nuclear Power Plant Gösgen Däniken AG

Kernkraftwerk Gösgen Däniken AG

SST+ SwissSafeTech AG

Däniken
September 02, 2020

KKG PSA Level 3 - Latest Developments and Results

Contents

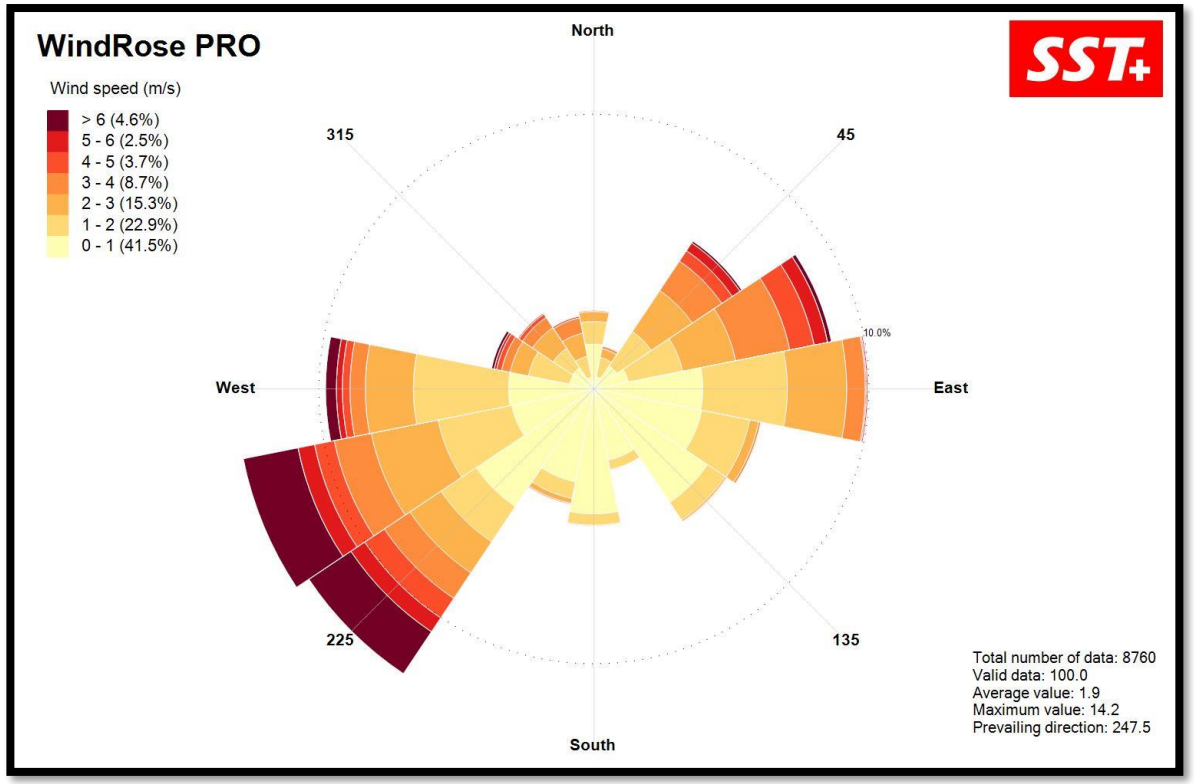
- New Meteorological Databases
- Meteorological Data Impact on
  - Dispersion and Contamination
  - Health Effects
- Fully Coupled PSA Level 3 Results
- PSA 2D Plots Generator (based on Phyton)
- Emergency Planning Applications
- On-Site Dose Assessment using CFD-based models

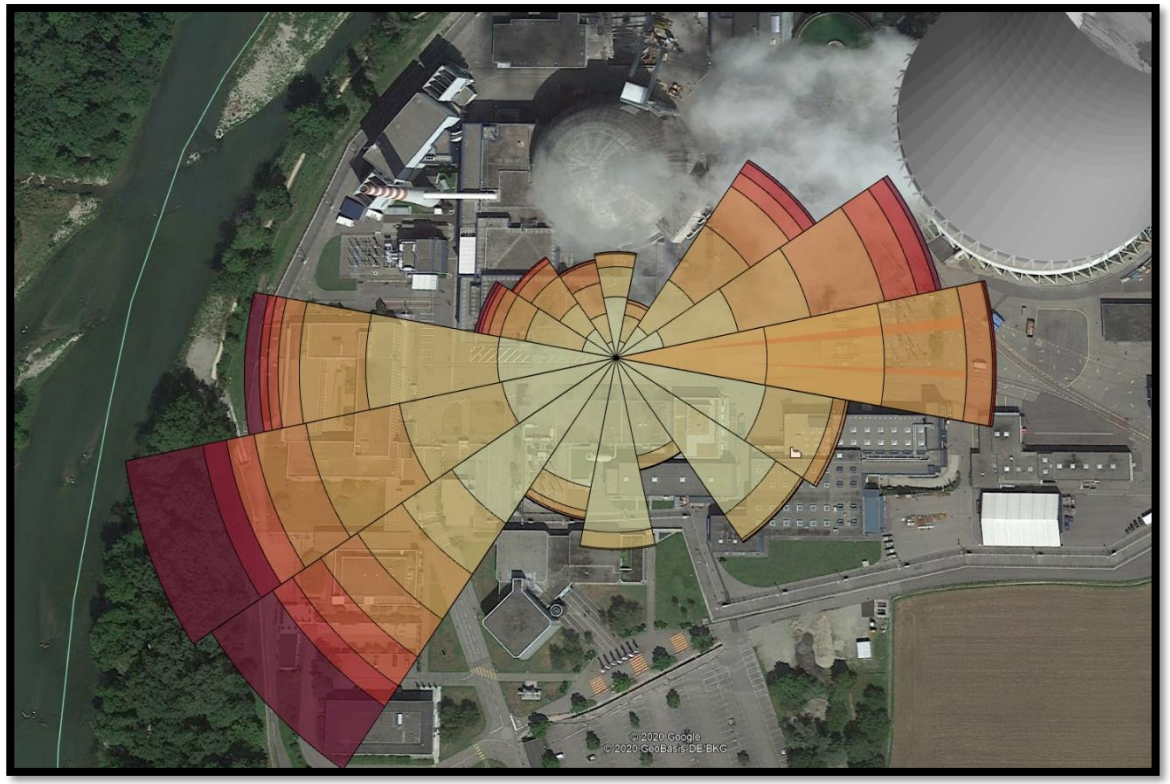
KKG PSA Level 3 - Latest Developments and Results

New Meteorological Databases

- New Meteorological Databases
  - Historical data 20 years hourly records, 1989 - 2008
  - 2011 hourly records
  - **2018 hourly records**
  - **New boundary layer height, based on the ETHZ measured data**

KKG 2018 Windrose





KKG PSA Level 3 - Latest Developments and Results

New Meteorological Databases:

ETHZ Pathfinder-TURB Algorithm

- Boundary layer height using the ETHZ Pathfinder-TURB algorithm
  - The algorithm analyzes the ceilometer backscatter data and the real-time detection of the vertical structure of the planetary boundary layer
  - Providing an accurate evaluation of the boundary layer height.

KKG PSA Level 3 - Latest Developments and Results

Meteorological Data Impact

Meteorological Data Impact: Dispersion and Contamination

- Results based on two sets of meteorological data (year 2011 and 2018) were compared. It has been found that:
  - The meteorological data can cause difference in the results up to 38%.
  - Boundary layer model (ETHZ Pathfinder-TURB algorithm) can also cause a difference in results of 32%.

KKG PSA Level 3 - Latest Developments and Results

Meteorological Data Impact

Meteorological Data Impact: Health Effects

- Early fatalities in 2011 were substantially higher than 2018 (up to one order of magnitude). The early fatalities were confirmed to be very small and very closed to the plant.
- Although the cancer fatalities between 0 – 2 km were higher in 2011, the difference in the fatalities remained very small.

KKG PSA Level 3 - Latest Developments and Results

Meteorological Data Impact

Meteorological Data Impact: Health Effects

- Two boundary layer models (original model and Pathfinder-TURB) were tested for the year 2018 meteorological data.
- The early fatalities were not affected by the boundary layer height model.
- The difference between the cancer fatalities evaluated by implementing the two boundary layer models were small (less than 14.5%)

KKG PSA Level 3 - Latest Developments and Results

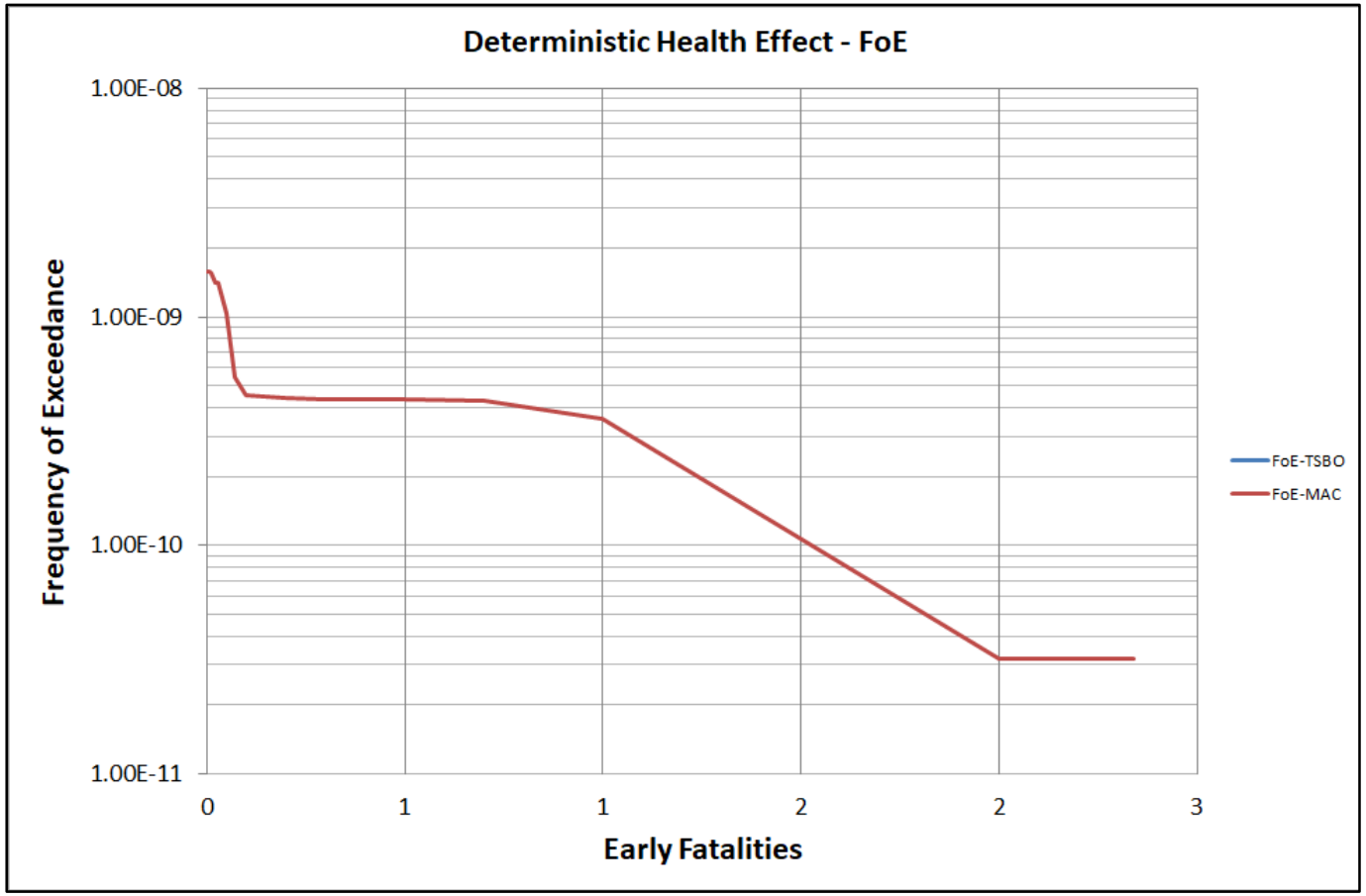
Fully Coupled PSA Leve 3 Results

Fully Coupled PSA Leve 3 Results

- A model have been developed for coupling PSA level 3 results to PSA Level 1&2
- It links the PSA Level 3 conditional probabilities to PSA Level 1&2 release frequencies
- The results are presented in terms of Frequency of Exceedance (FoE)
- Examples are provide for the MAC and TSBO severe accidents

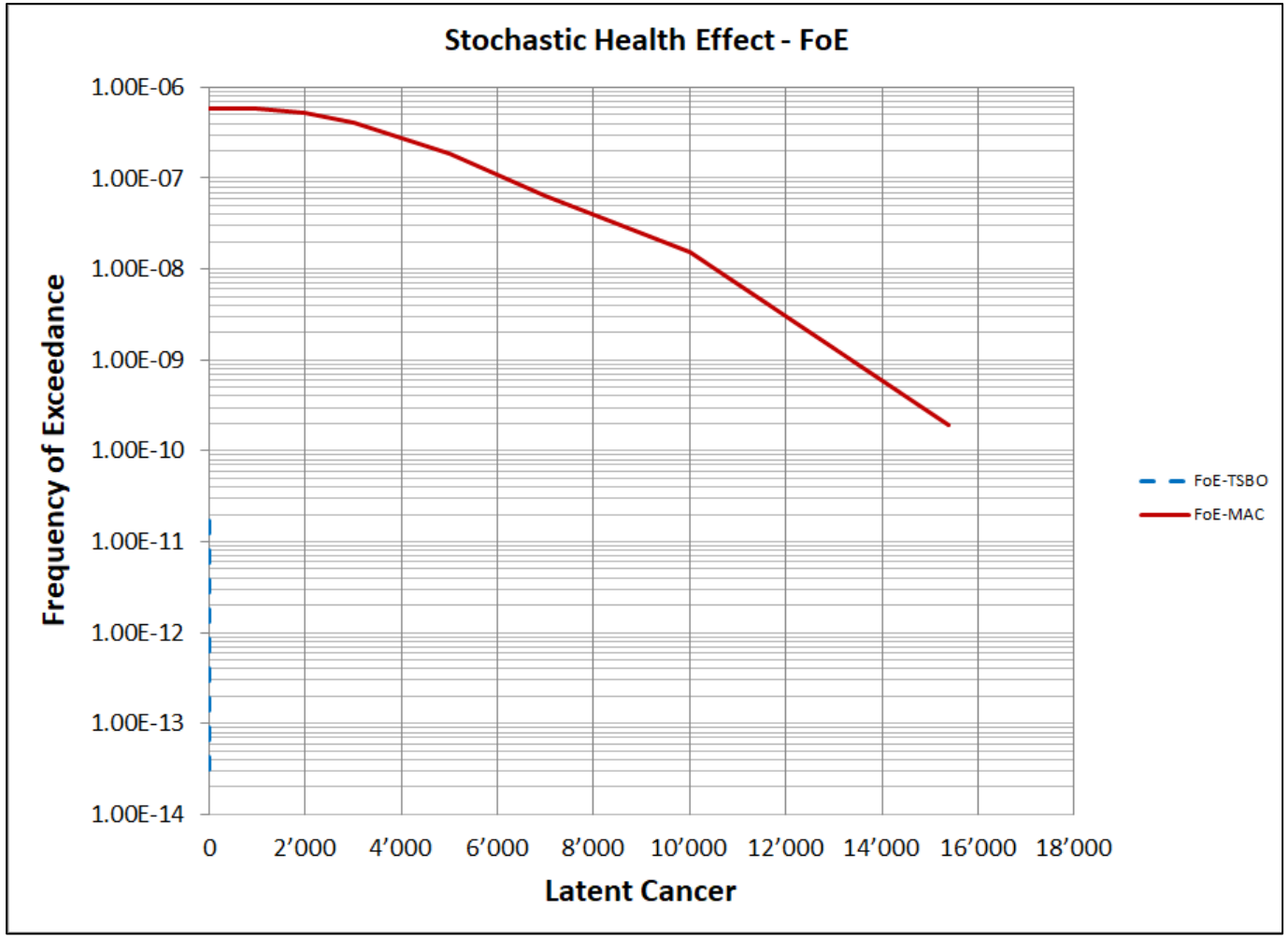
KKG PSA Level 3 - Latest Developments and Results

Fully Coupled PSA Leve 3 Results



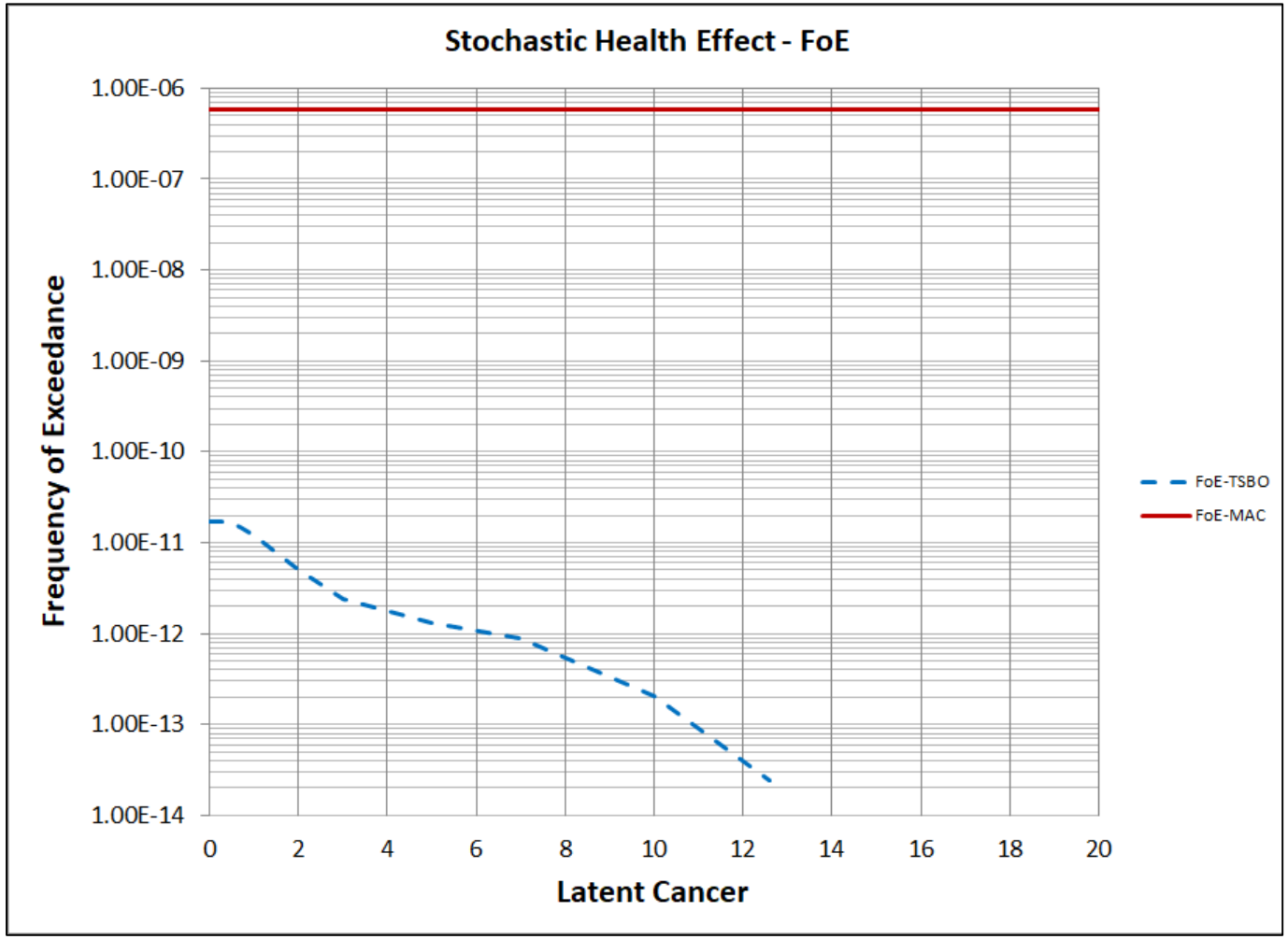
KKG PSA Level 3 - Latest Developments and Results

Fully Coupled PSA Leve 3 Results



KKG PSA Level 3 - Latest Developments and Results

Fully Coupled PSA Leve 3 Results



KKG PSA Level 3 - Latest Developments and Results

- PSA 2D Plots Generator (based on Phyton)

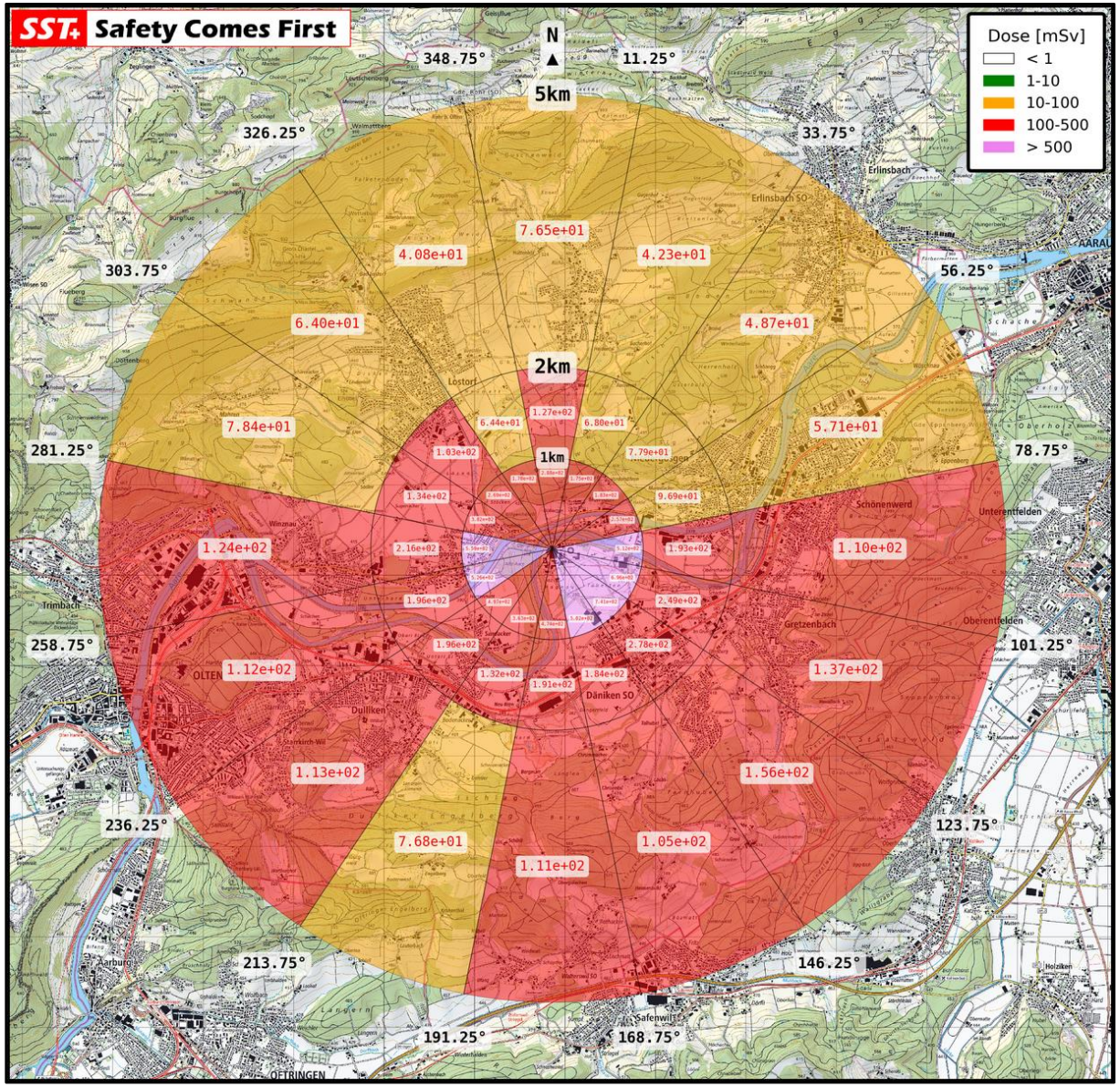
PSA 2D Plots Generator

- It is written in Phyton. No need for any external support libraries or installations.
- Several plots can be obtained automatically for a given case, such as:
  - Dose
  - Intervention Level
  - Air and ground Contamination (from Cs-137, I-131, Pu-241, Sr-89, and U-237)

KKG PSA Level 3 - Latest Developments and Results

PSA 2D Plots Generator

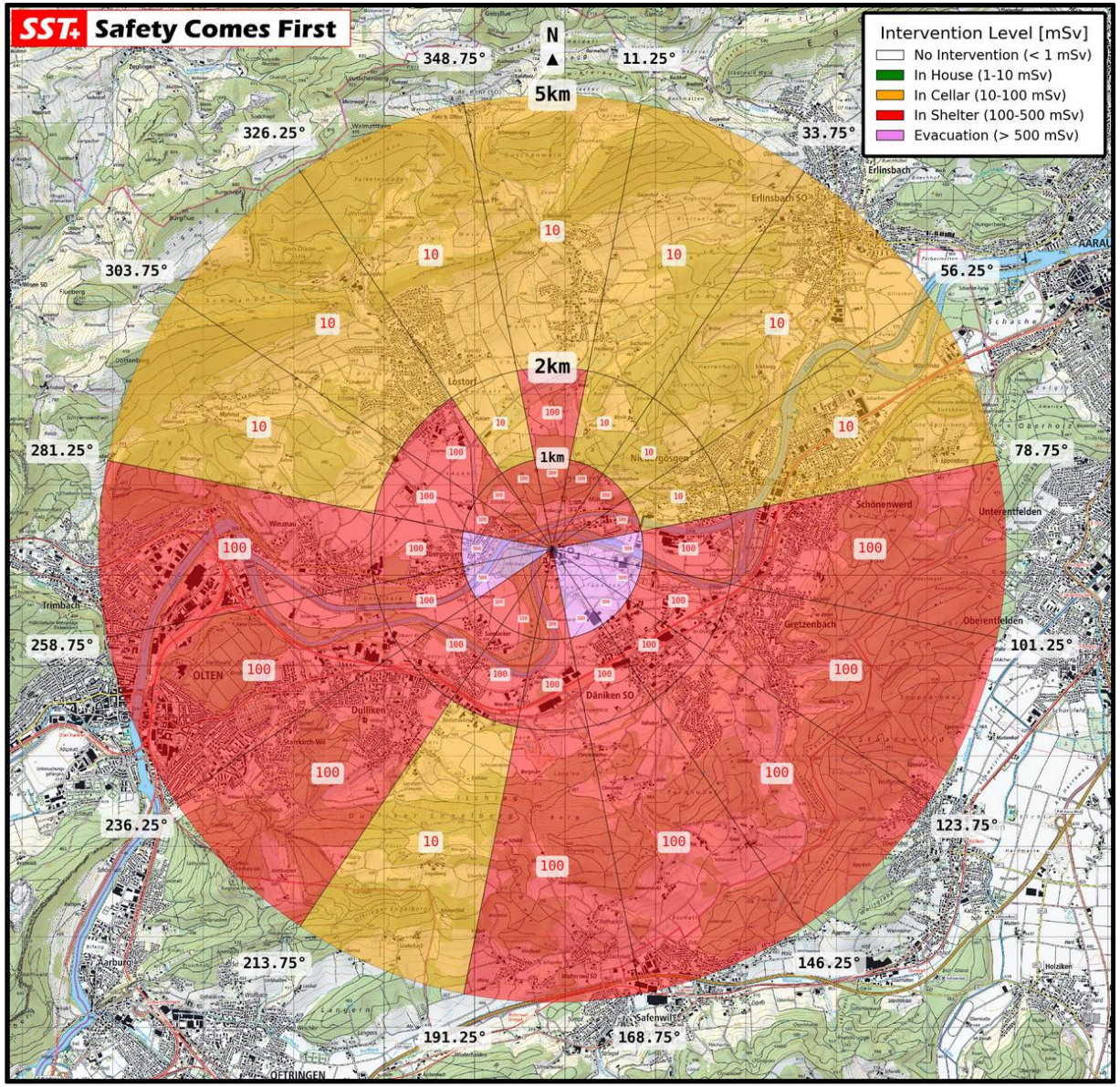
MAC 2019 Results: Dose, 5km



KKG PSA Level 3 - Latest Developments and Results

PSA 2D Plots Generator

MAC 2019 Results: Intervention Level



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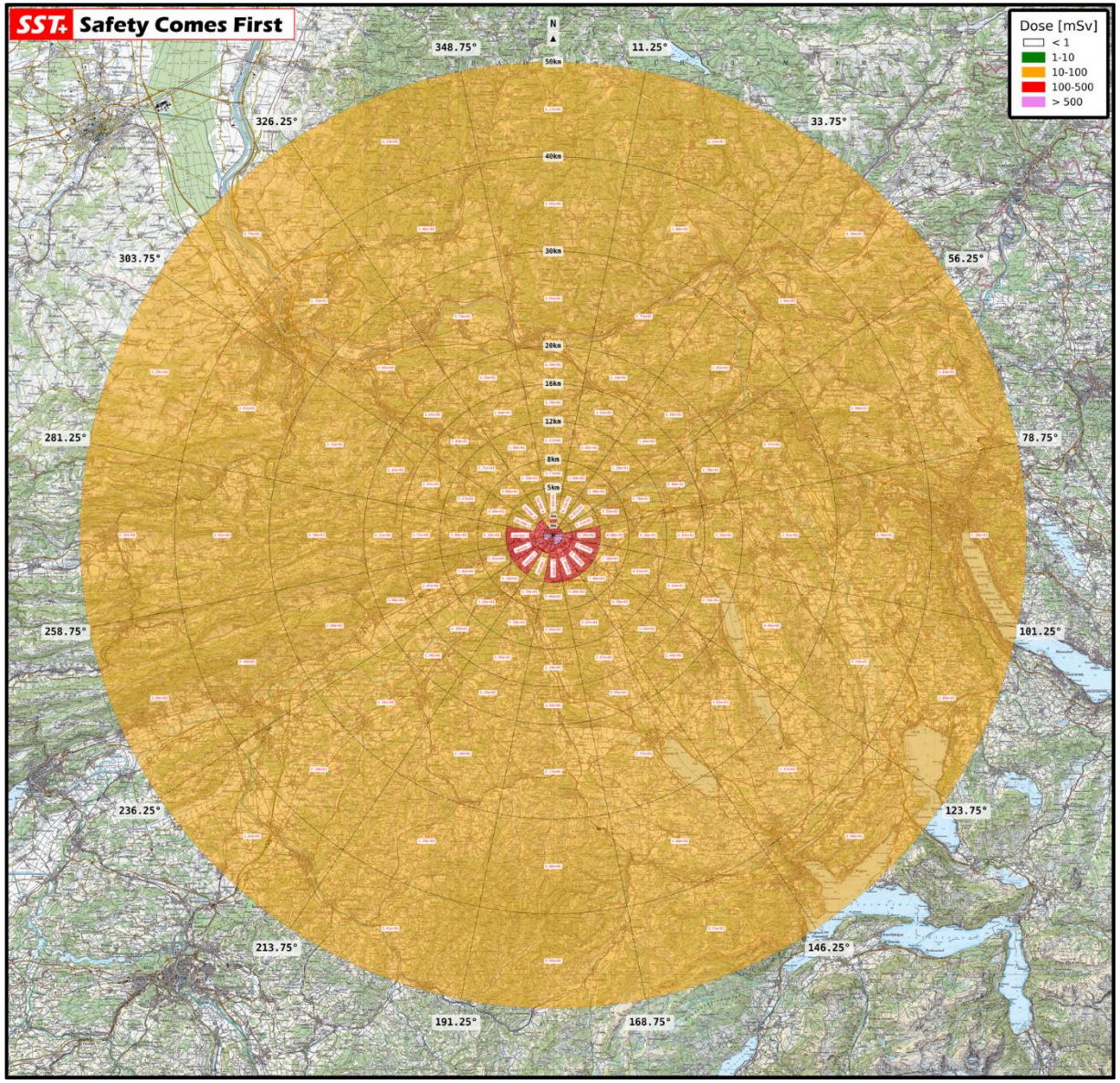
PSA 2D Plots Generator

MAC 2019 Results: Dose, 50 km



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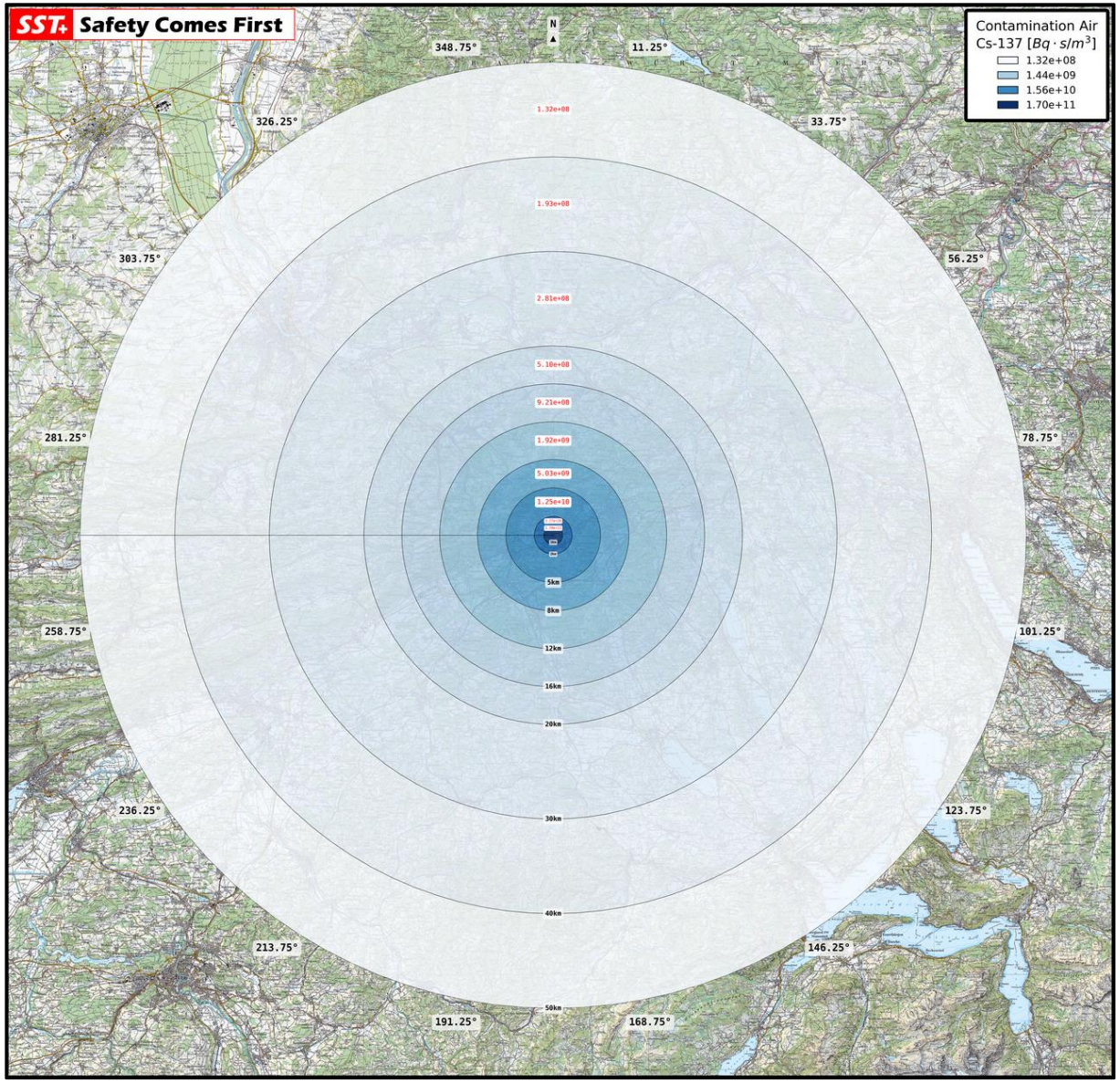
PSA 2D Plots Generator

MAC 2019 Results: Air Contamination Cs-137



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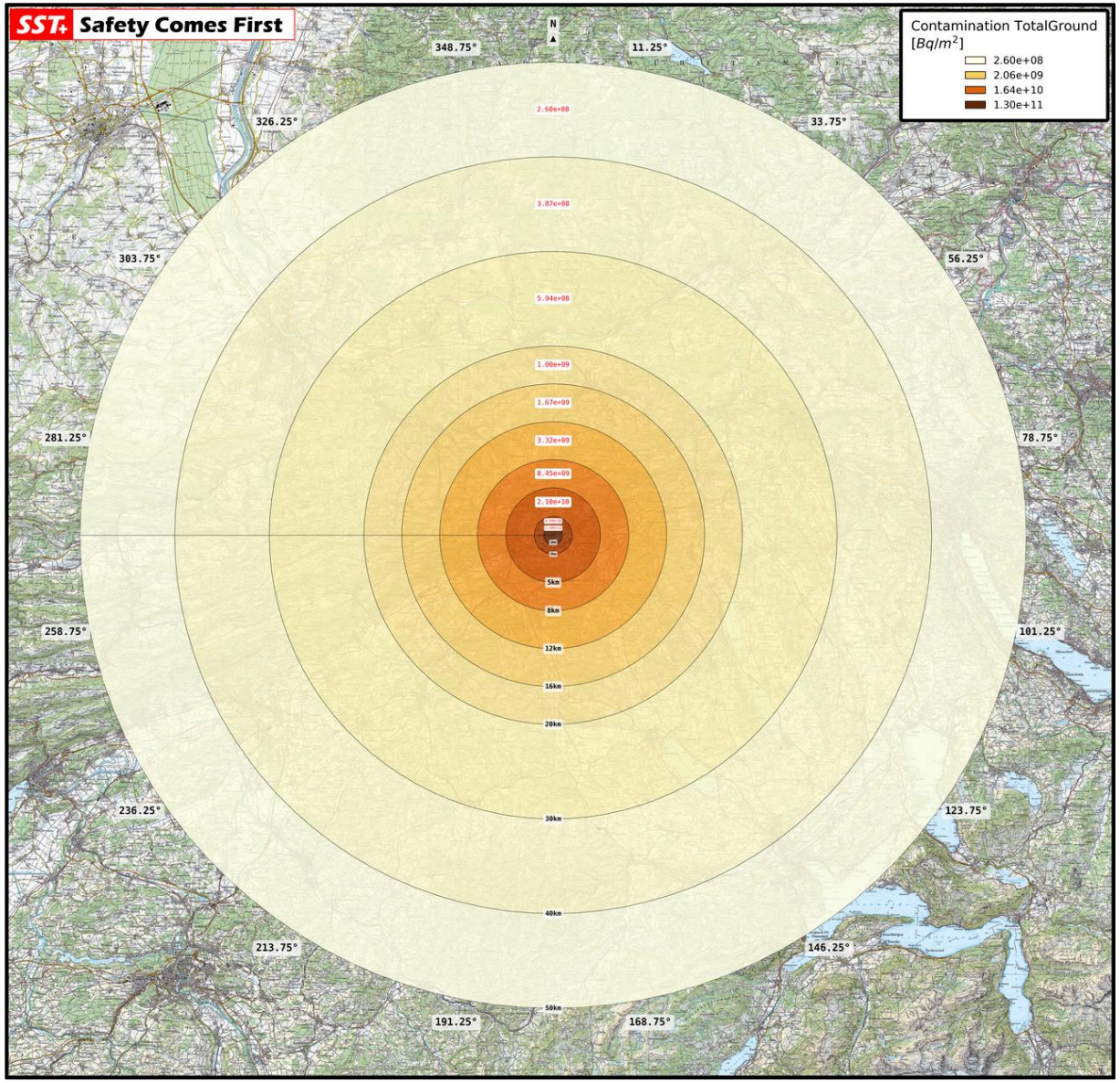
PSA 2D Plots Generator

MAC 2019 Results: Total ground Contamination



KKG PSA Level 3 - Latest Developments and Results

Emergency Planning Applications

Emergency Planning Applications

- Estimation of the dose and contamination level in a broad area
- Detailed information's within the Swiss two emergency zones (<5km & <20 km), and beyond (>20 km)
- First estimation of the Swiss Intervention Levels, covering:
  - ✓ Staying in house
  - ✓ Staying in cellars
  - ✓ Use of Swiss Shelters
  - ✓ Evacuation
- Countermeasures
  - ✓ Short-term actions
  - ✓ Long-term actions

KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models

CFD-based On-Site Dose Assessment

- Why CFD based?
  - Because WinMACCS, RASCAL or other Gaussian family based model do not provide the necessary and detailed information for the On-Site Emergency Planning.
  - Moreover, a realistic model of the plant buildings and the site is fundamental for the on site actions within and beyond the plant mission time (72 hours).
  - To provide an accurate estimation of the ground concentration of the released radioisotopes and the dose rates at more significant locations of interest for the On-Site Emergency Planning (ground level, roof of the buildings, and below the cooling tower).

KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models

KKG On-Site Dose Assessment Model

It has:

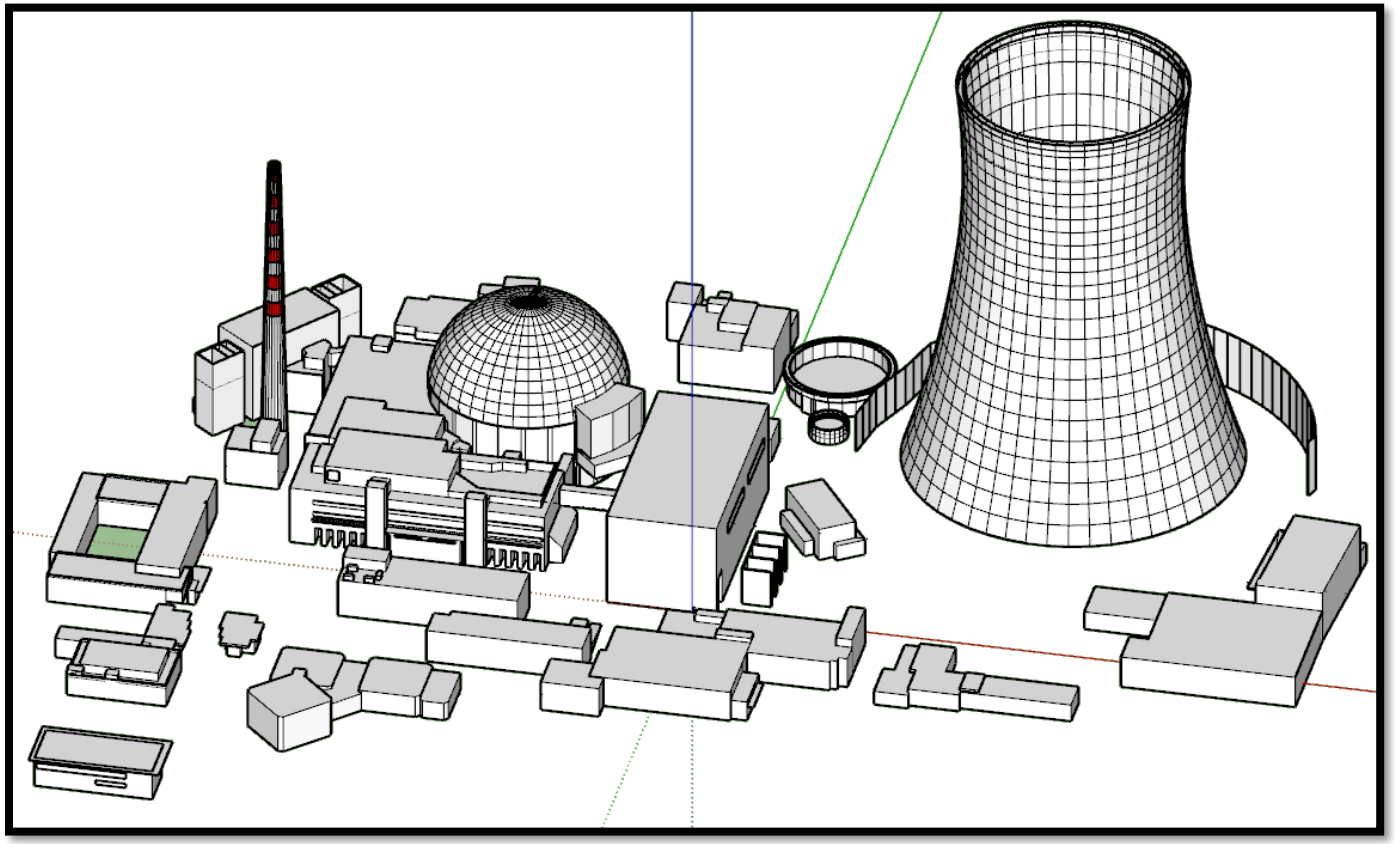
- A realistic model of the plant buildings
- A Site model including details (from GIS) of hills, valleys, forest, … Identified neighboring towns, roads, rail-roads, escape ways.

It is featured by:

- CFD evaluations of the wind flow
- Particle tracking simulations and determination of radioisotope group ground concentration
- 3D dose assessment
- 3D representation wind flow, dose rates
- Ground level concentrations and doses

KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models



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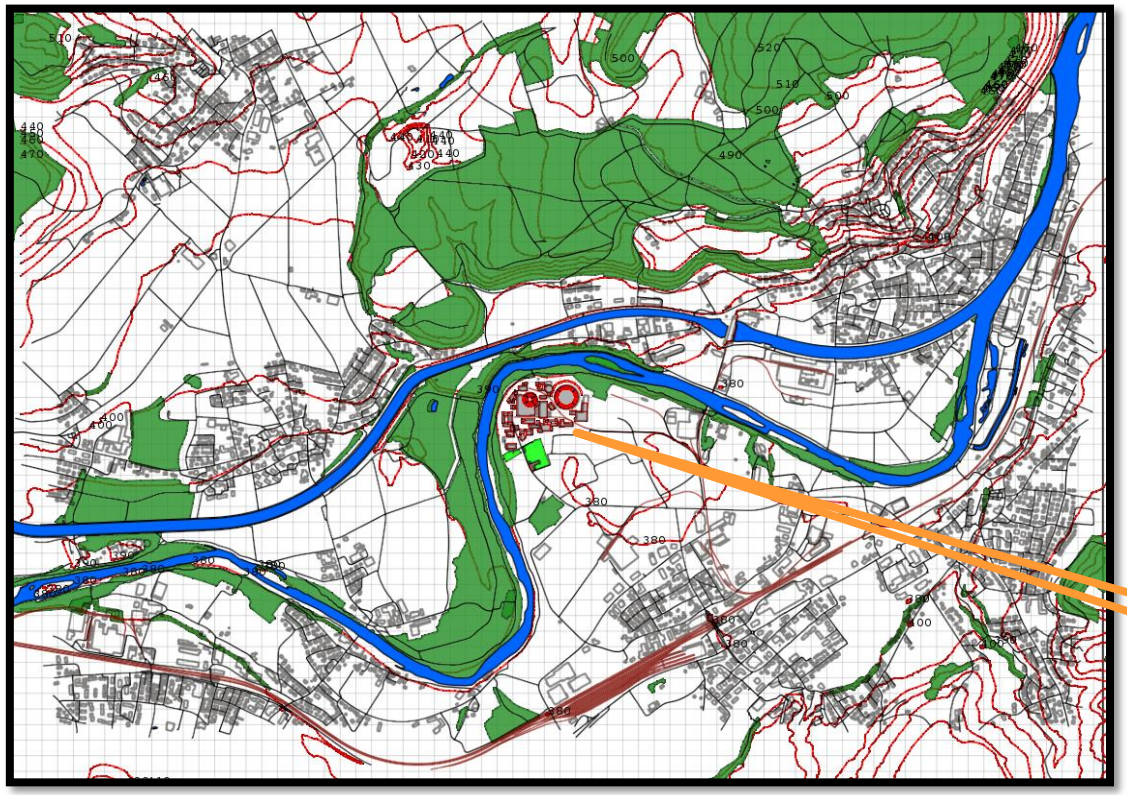
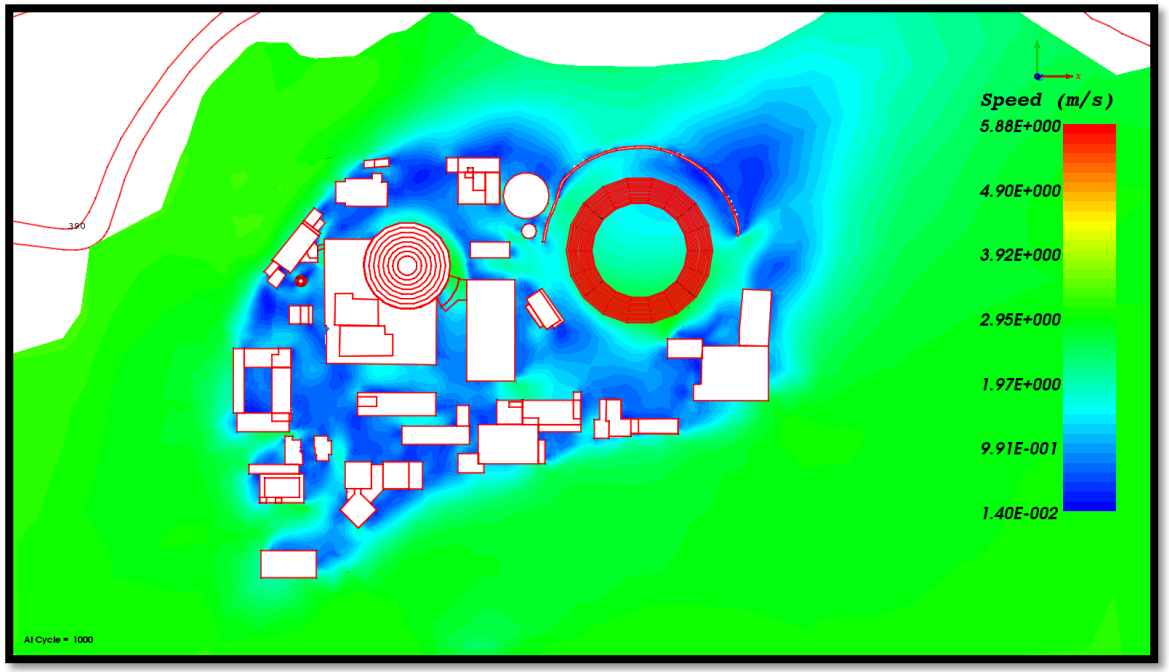
On-Site Dose Assessment using CFD-based models



KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models

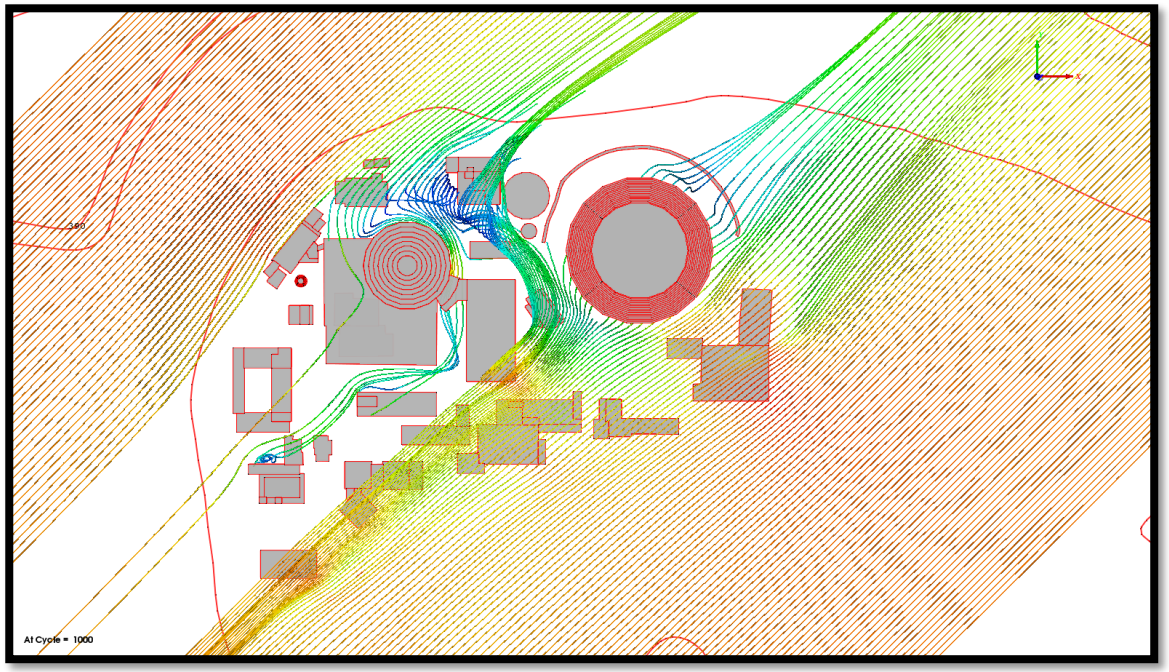
Wind speed contours at Z=+5 m



KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models

Wind streamlines at Z=+5 m



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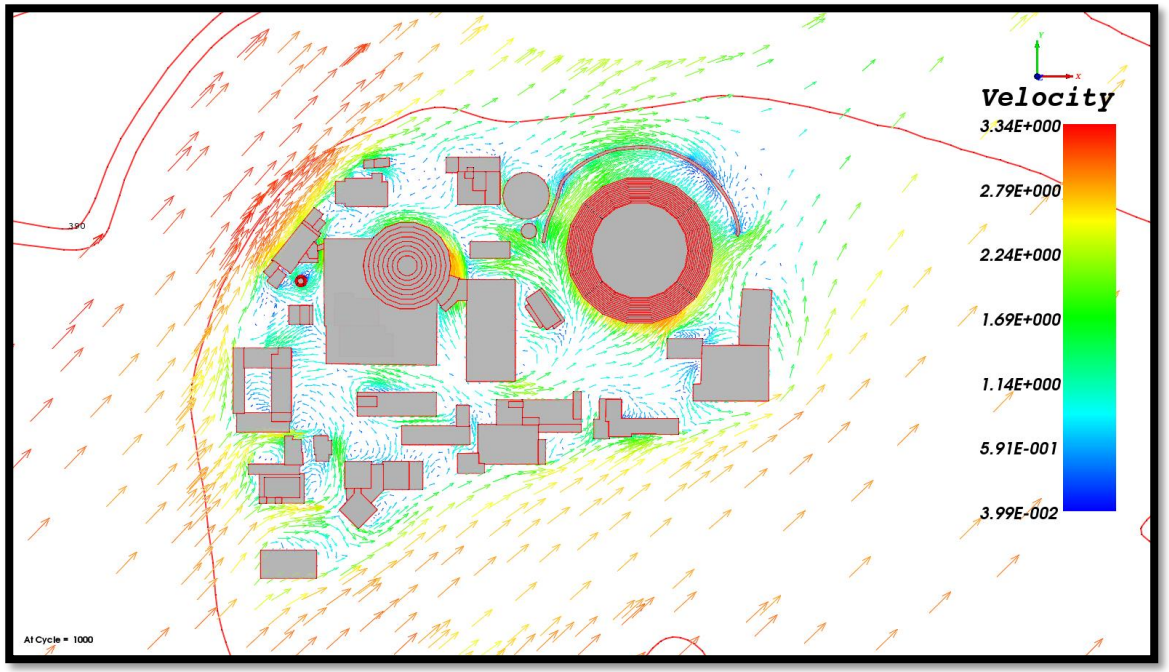
On-Site Dose Assessment using CFD-based models

Wind velocity Vectors at Z=+5 m



KKG PSA Level 3 - Latest Developments and Results

On-Site Dose Assessment using CFD-based models

Other results coming soon!!!

Thank you for your attention

NPP Gösgen LTD & SST SwissSafeTech AG LTD