



RÉPUBLIQUE  
FRANÇAISE

*Liberté  
Égalité  
Fraternité*

**IRSN**

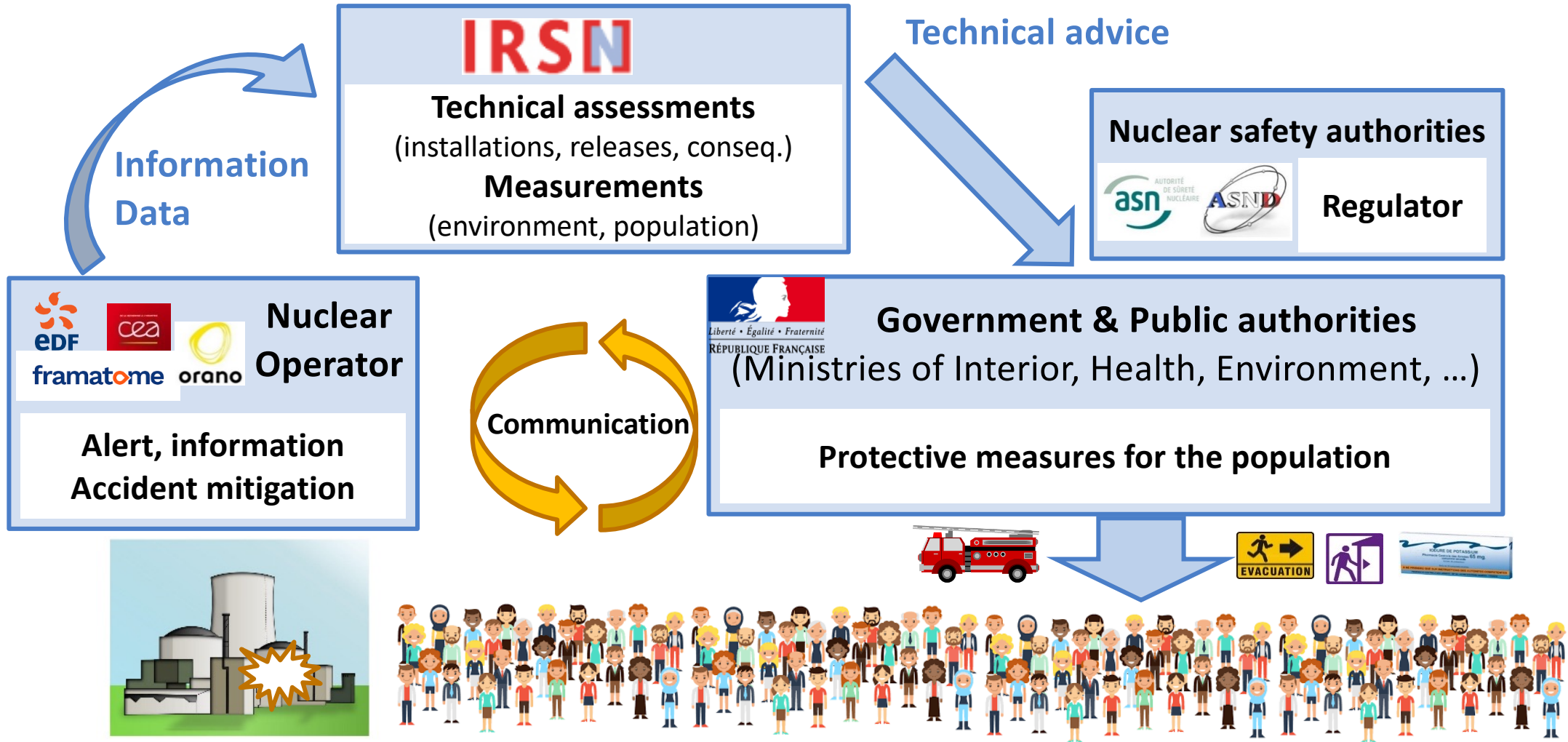
INSTITUT DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE



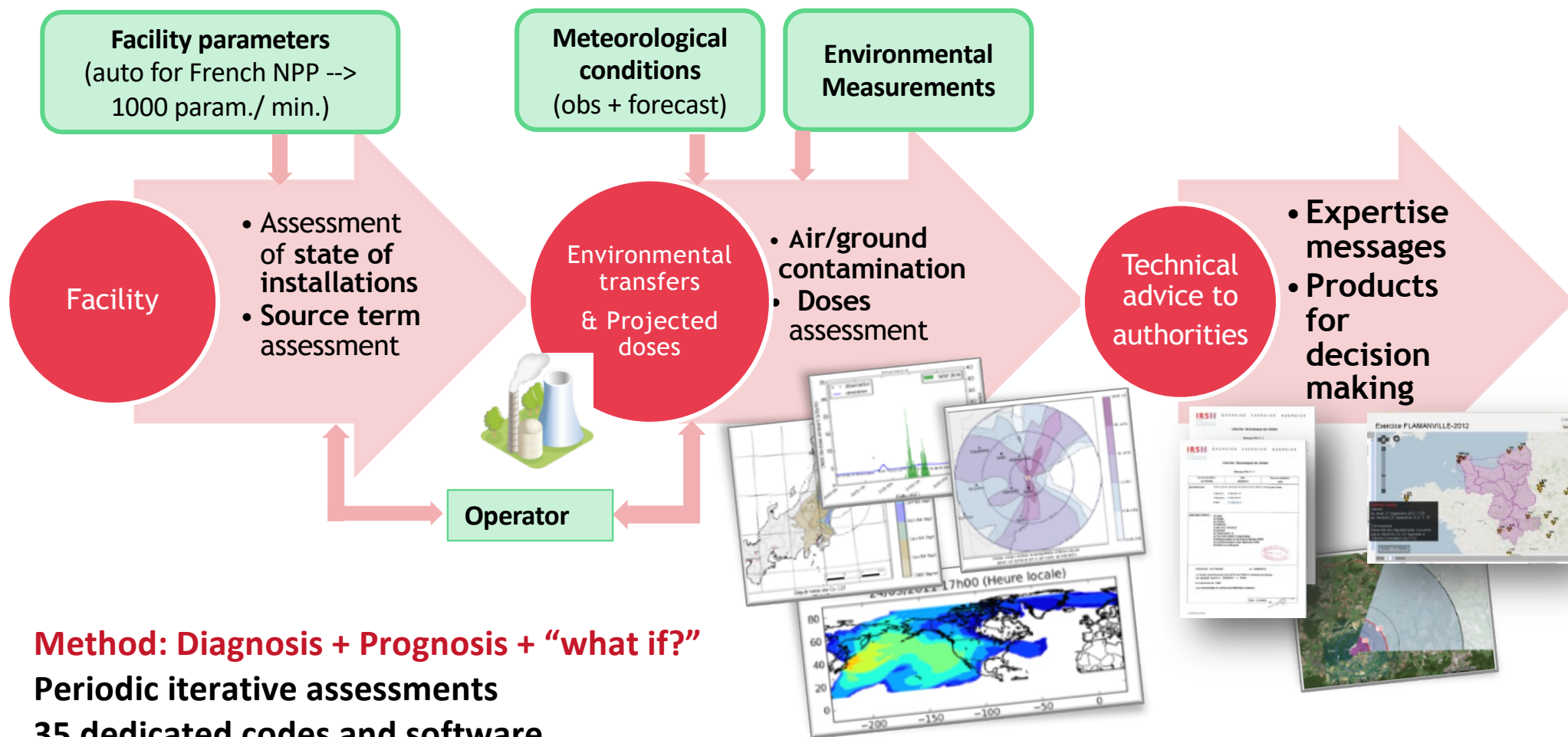
# THE IRSN C3X-RESPONSE PLATFORM : INTEGRATING FEATURES FROM R&D TO FACE CHALLENGES IN EPR AND RECOVERY

M. TOMBETTE, O. SAUNIER and E. QUENTRIC

# IRSN's role in the French National Emergency Response

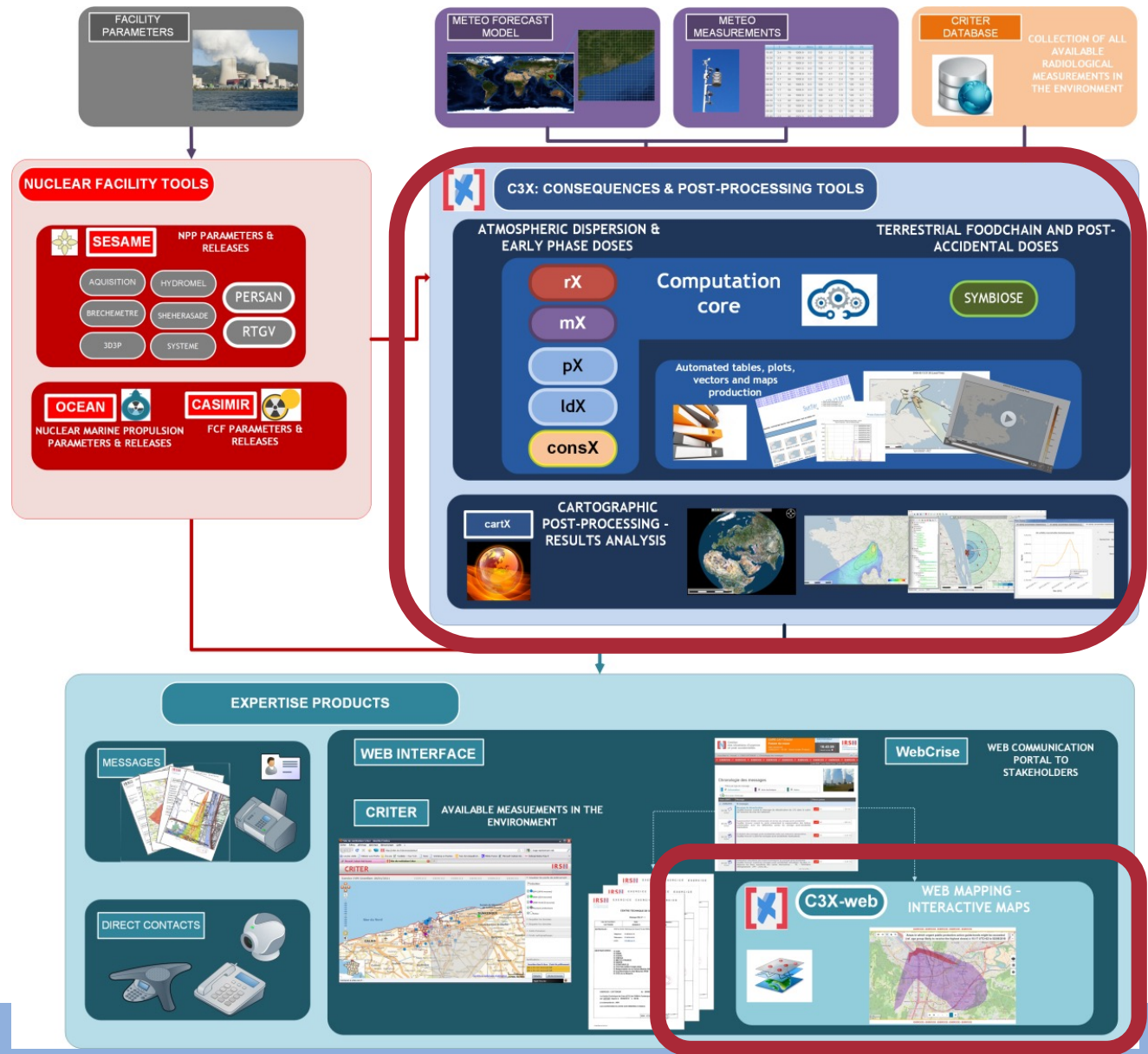


# IRSN's Emergency response assessments



# The C3X Platform

- 15 years of operations & regular upgrades
- Policy and regulatory compliance
- Client-server architecture
- Calculations rely on state-of-the-art validated models developed by IRSN R&D, encapsulated in a GUI developed externally by IT company
- Ambitious roadmap adding new scientific and technical capabilities
  - Model-measurement comparisons
  - Uncertainty quantification \*
  - Inverse modelling method for source term assessment\*\*
  - Water contamination (river\*\*\*, sea\*\*\*\*)
  - Waste management / decontamination
- Ergonomics & richness of features



\* Korsakissok et al, 2020. Uncertainty propagation in atmospheric dispersion models for radiological emergencies in the pre- and early release phase: summary of case studies. Radioprotection 55, S57–S68.

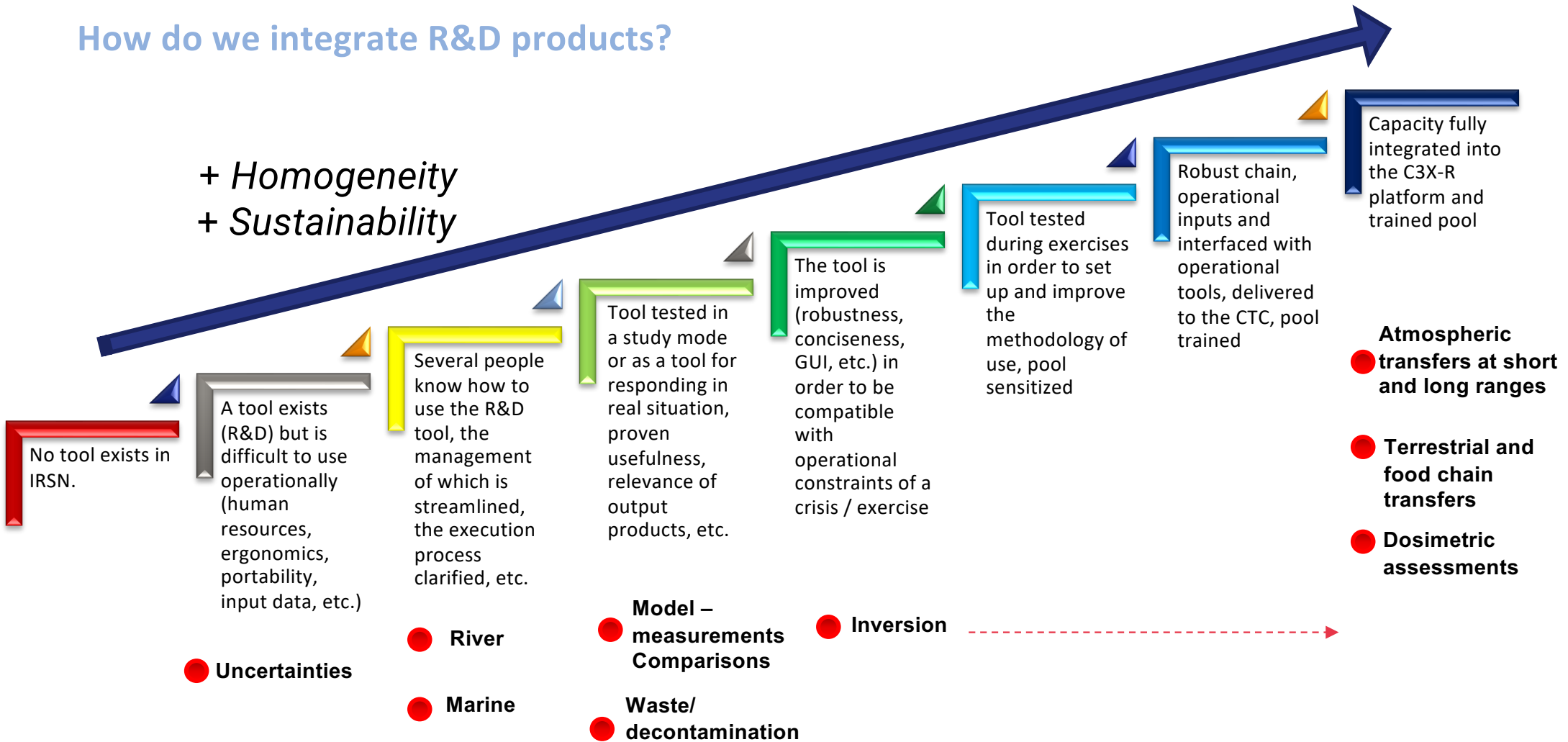
\*\*Olivier Saunier, J J Ingremeau, Ian Hoffman, Pawel Mekarski, Jing Yi, et al.. Methodology for the investigation of undeclared atmospheric releases of radionuclides: Application to recent radionuclide detections in Northern Europe from 2019 to 2022. Annals of Nuclear Energy, 2023, 192, pp.109907.

\*\*\* Beaugelin-Seiller et al, 2002. CASTEAUR: A simple tool to assess the transfer of radionuclides in waterways. Health Physics, 0017-9078/02/0.

\*\*\*\* Duffa et al, 2015. Development of emergency response tools for accidental radiological contamination of French coastal areas. Journal of Environmental Radioactivity, <http://dx.doi.org/10.1016/j.jenvrad.2015.04.019>.

# How do we integrate R&D products?

+ Homogeneity  
+ Sustainability



## How do we integrate R&D products?

+ *Homogeneity*  
+ *Sustainability*



- ✓  **git**
- ✓  **GitLab**
- ✓  **GitLab CI**
- ✓  **sonarqube**
- ✓  **Nexus**
- ✓  **squash**
- ✓  **Squish**

**manages** the source code

**shares** the source code in repositories

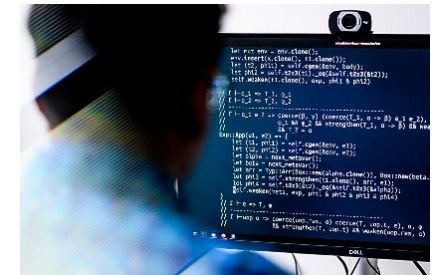
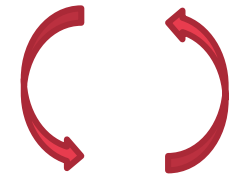
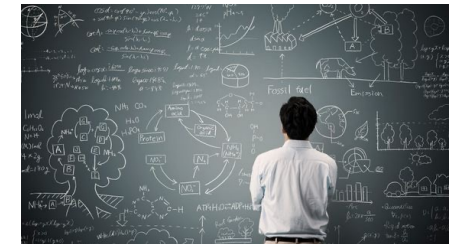
**runs continuous integration jobs**

**dev** quality indicators

**centralizes** the produced executables

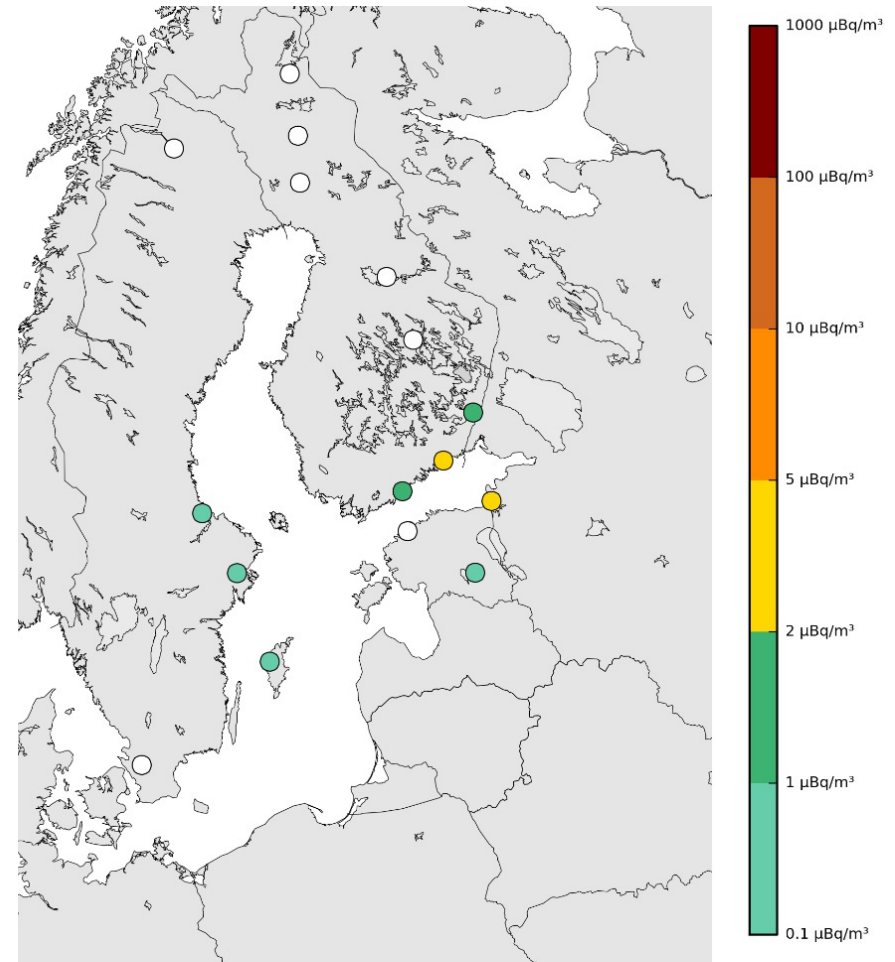
**manages** the tests

**automate** the tests



## Case study: Detection of traces of several radionuclides in Scandinavia

- **Detection period:** Between the end of May and the beginning of June 2023, several stations monitoring airborne radioactivity in the air recorded a very slight increase in the concentration levels of several radionuclides in Scandinavia, **without any health issue**
- **Extent of detections:** Abnormal detections were reported in Finland and Sweden, while other countries in Europe, including France, detected nothing. Maximum concentrations were very low, generally around  $\mu\text{Bq}/\text{m}^3$  in air.
- **Radionuclides detected:** Radionuclides detected include  $^{60}\text{Co}$ ,  $^{106}\text{Ru}$ ,  $^{103}\text{Ru}$ ,  $^{141}\text{Ce}$ ,  $^{54}\text{Mn}$ ,  $^{59}\text{Fe}$ ,  $^{95}\text{Nb}$ ,  $^{95}\text{Zr}$  and  $^{134}\text{Cs}$ .
- **Objective: Identify** the most probable origin of the detections using inverse modeling technique.



Maximum observed  $^{134}\text{Cs}$  air concentration ( $\mu\text{Bq}/\text{m}^3$ )

# Study case with C3X « Origin search »

The screenshot shows the C3X software interface. On the left, a list of stations is displayed with checkboxes for selection. The 'Kotka\_C3X' station is highlighted. The main area shows the 'Informations' for this station, including its name, coordinates (Longitude: 26.900600, Latitude: 60.494000), and a table of activity data.

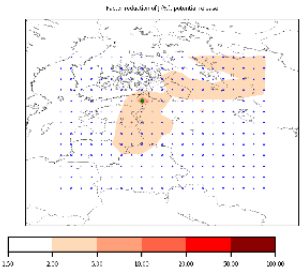
Début de palier (UTC)	Fin de palier (UTC)	Cs-134 (Bq/m³)
15/05/2023 07:00	22/05/2023 07:00	1.85e-07
22/05/2023 07:00	29/05/2023 06:00	2.709e-06

This screenshot shows the 'Données activité volumique' section with a bar chart for 'Runs Impulsionnels', 'Météo', 'Dispersion', and 'Inversion'. Below it is the 'Cohérence spatiale' section with a world map showing a highlighted region in Northern Europe.

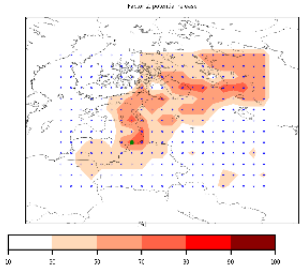
Retrieval of likely source locations, validated by comparisons with R&D use

## Analyse

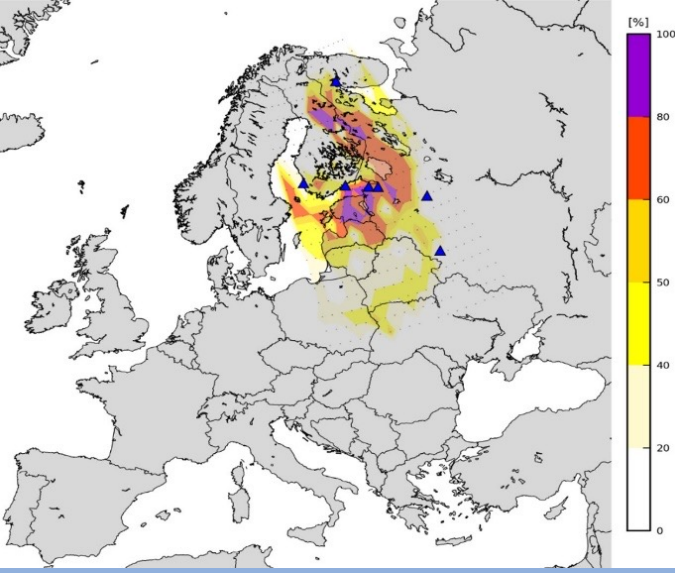
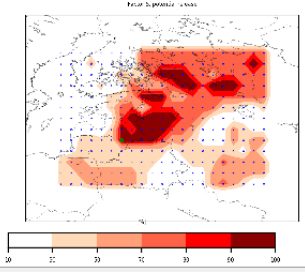
[cost\\_function\\_global.txt](#)  
[source\\_location\\_map\\_cost\\_function.png](#)



[source\\_location\\_map\\_FAC2.png](#)



[source\\_location\\_map\\_FAC5.png](#)



On production servers (use of 48 processors)  
 Calculation duration ~48 h  
 -> Optimization to do with IT developer  
 -> Integration of retro-plume calculations

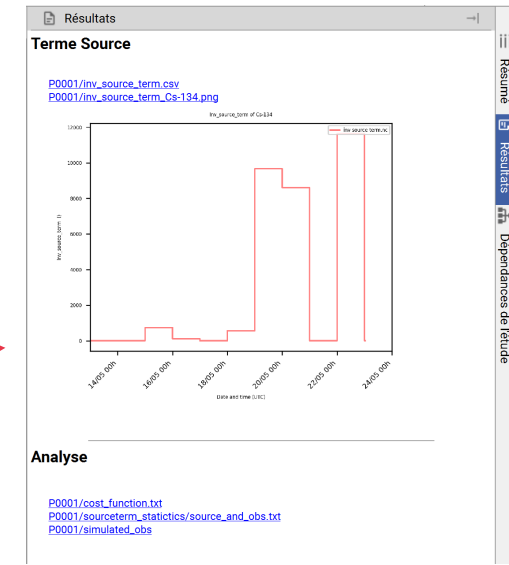


# Case study with C3X « known origin »

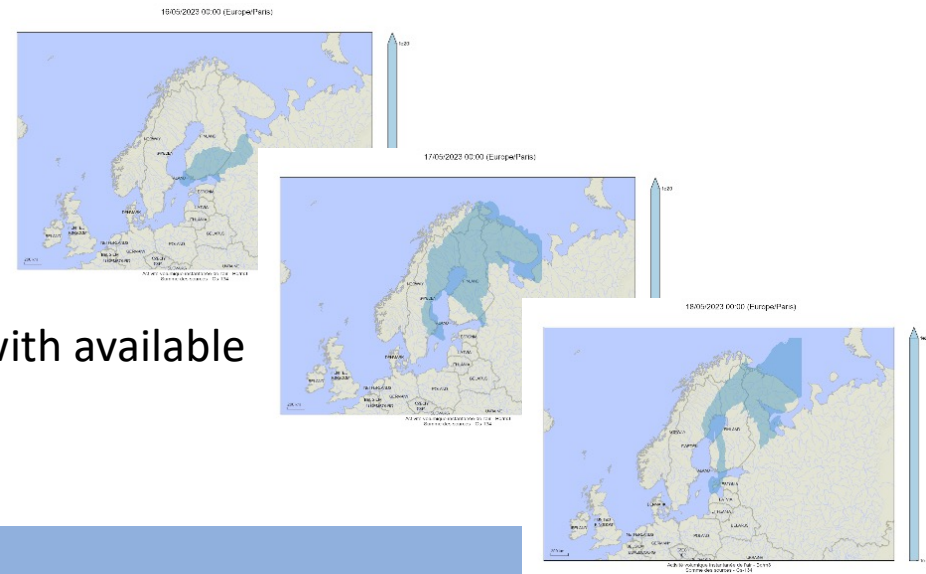
The screenshot shows the C3X software interface with the following details:

- Header:** C3X-Response - v4.5.0 - OrigineConnueFinlandeCs134
- Navigation:** Accueil, CTC (distant), Test\_BMCA, MT, OrigineConnueFinlandeCs134
- Left Panel (Runs Impulsionnels):**
  - Identifiant: MT RechercheFinlandeCs134
  - Debut: 15/05/2023 00:00 - UTC
  - Palier d'impulsion: 24.0 h
  - Nombre d'impulsions: 11
  - Fin: 24/05/2023 00:00 - UTC
  - Produits des observations: Cs-134
- Right Panel (Cohérence temporelle):**
  - Timeline for 2023 (mai, juin)
  - Données activité volumique: Leningrad / Installation 1, Source 1, Runs Impulsionnels, Météo, Observation
- Bottom Panel (Cohérence spatiale):**
  - Map showing locations in Finlande, Suède, Danemark, Allemagne, and Kazakh.
  - Scale: 0 km to 2000 km
- Bottom Panel (Cohérence des paramètres):**
  - Validation de la phase "Observations": Ok
  - Validation de la phase "Runs Impulsionnels": Avertissement
  - Validation de la phase "Météo": Avertissement
  - Validation de la phase "Dispersion": Ok
  - Validation de la phase "Inversion": Ok
- Bottom Panel (Paramètres de rejet):**
  - Point de rejet: Système de coordonnées, Longitude: 29.043334, Latitude: 59.833480
  - Paramètres de rejet: Hauteur/Id pour la source, Dilution
- Bottom Panel (Navigation):** Observations, Runs Impulsionnels, Météo, Dispersion, Inversion

- Retrieved source term available for a forward calculation
- > allow to produce continuous fields in good agreement with available measurements
- > confidence in consequences assessments



Total:  
2,7 GBq





Thank you for  
your  
attention