

# Implementation of digital twin functionalities in the Nuclear Industry: Tractebel case studies

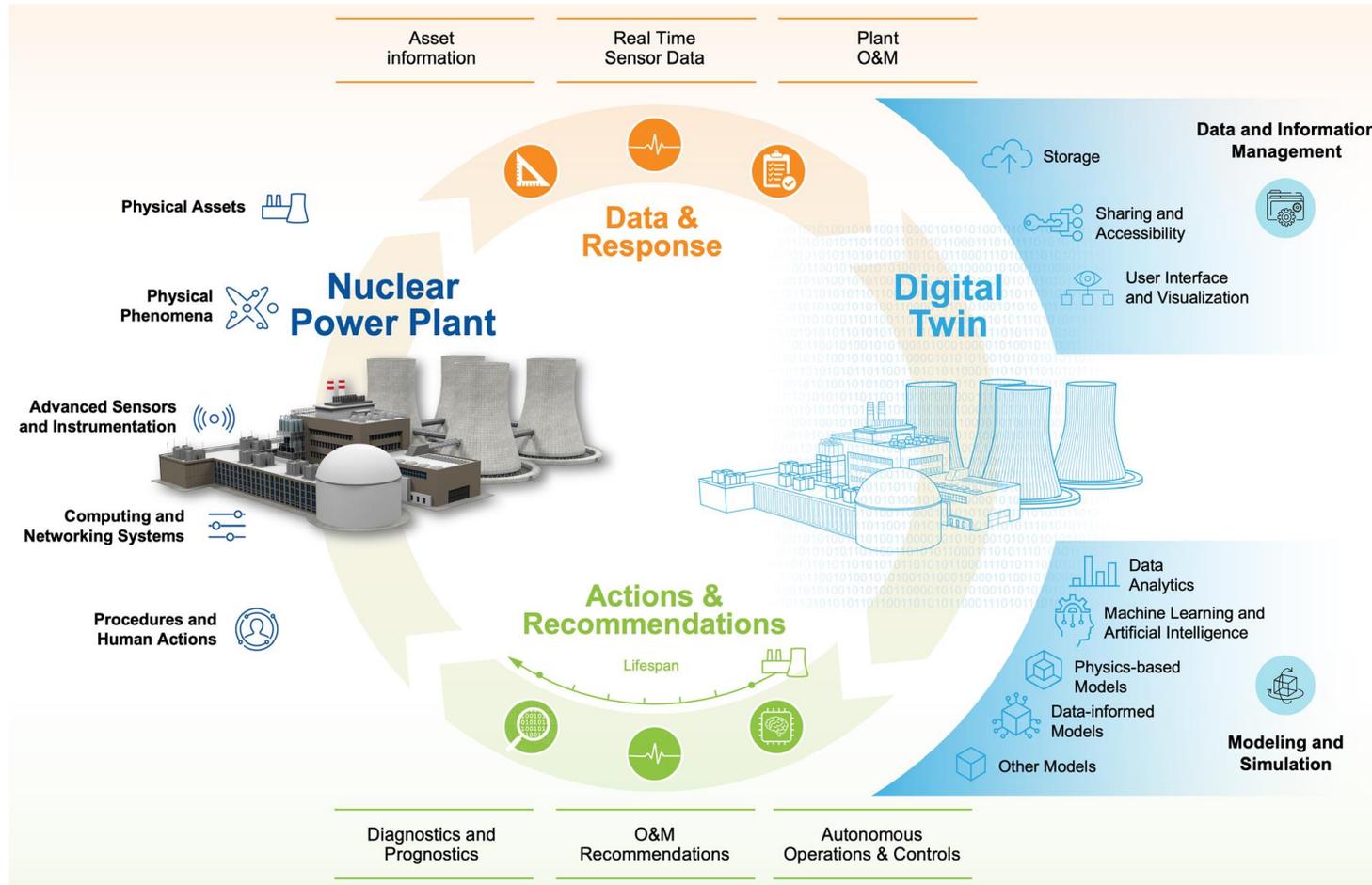
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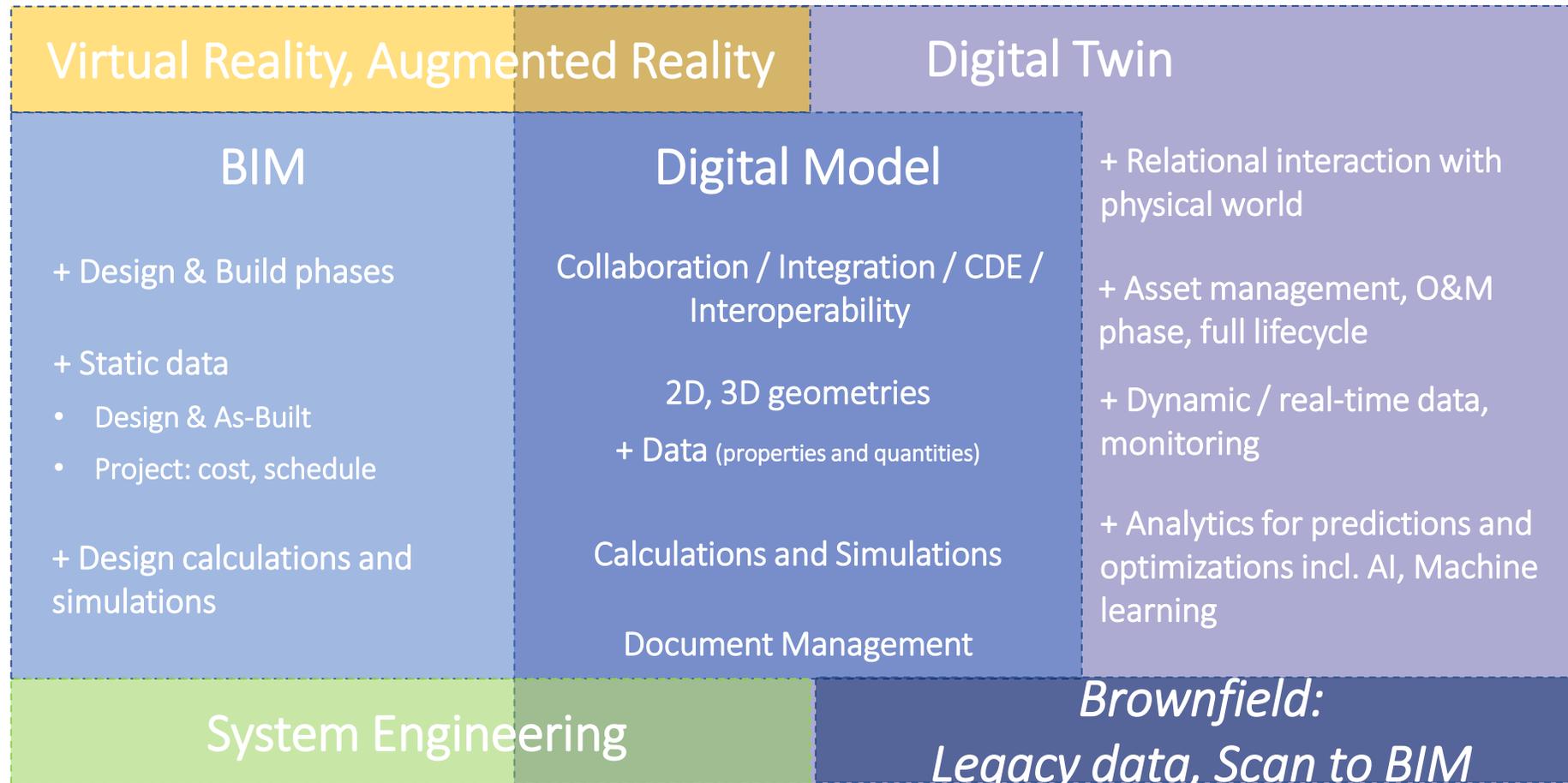
# US-NRC definition of digital twin



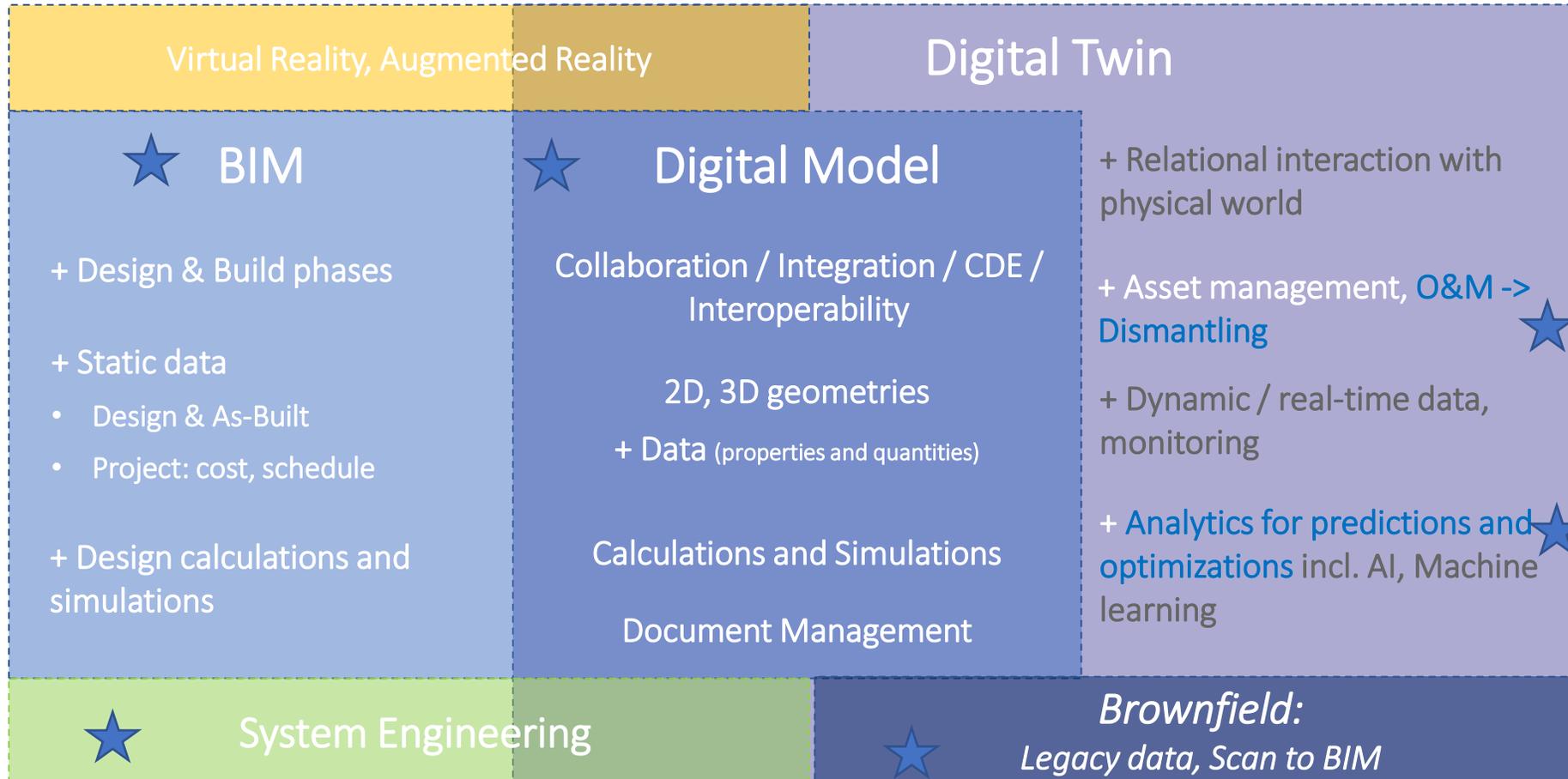
- Comprises the physical system, the virtual system, and the relationships between physical and virtual systems
- Three Conditions:
  - Digital form
  - State concurrency (real-time update)
  - Purpose related to NPP lifecycle activity

US-NRC TLR/RES-DE-REB-2021-17

# « BIM » & « Digital Twin »

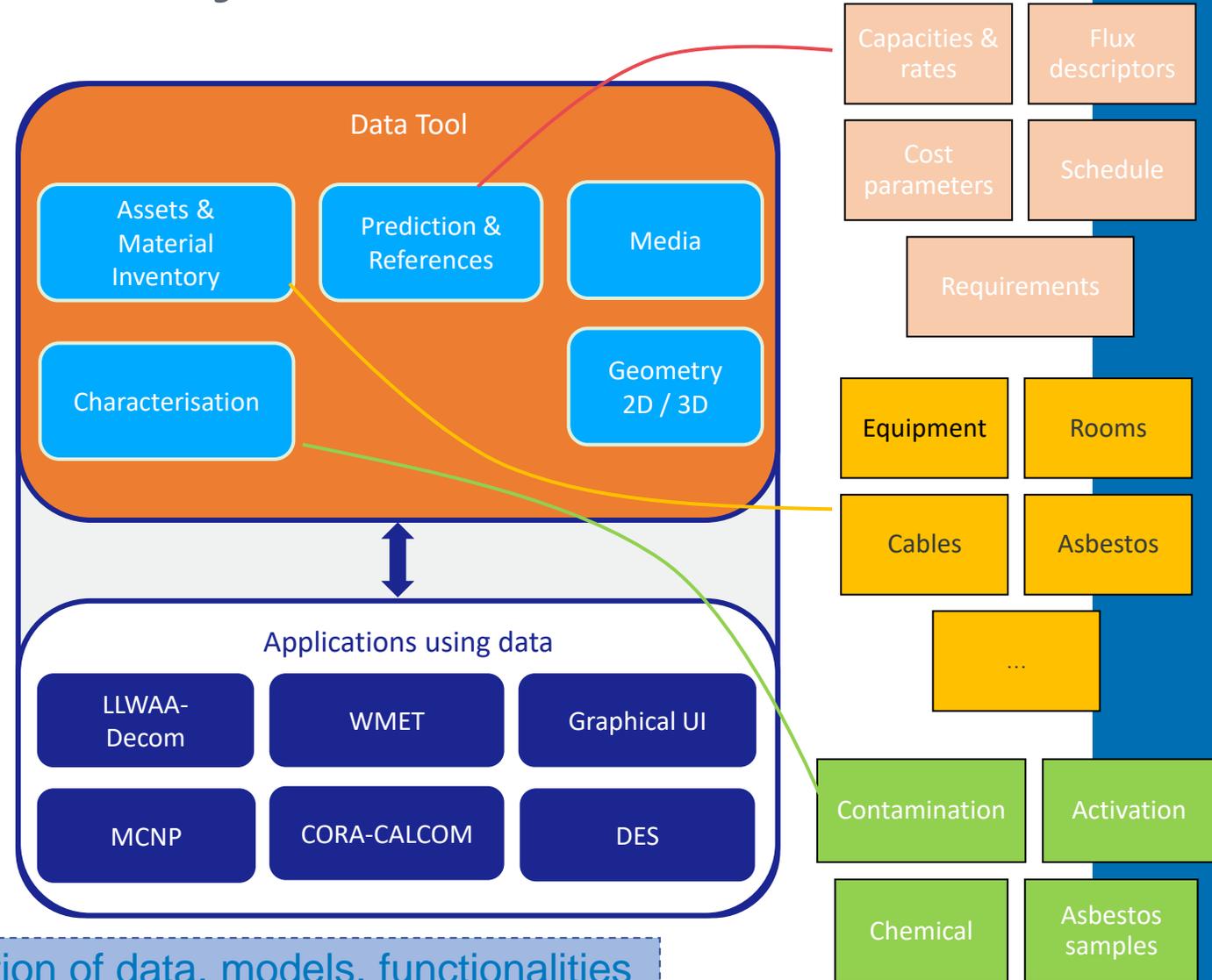


# Dismantling Digital Twin



# Dismantling Digital Twin Objectives

- Consolidated Plant Inventory and Digital model
- Predictions and optimisations: Waste quantities, Dismantling schedule, cost and resources
- Simulation & characterisation of contamination and activation
- Design of new waste management facilities + modification of existing installations
- System engineering



Interoperability and integration of data, models, functionalities

# Consolidated Plant Inventory

The screenshot displays the DAMI (Data Acquisition and Monitoring Interface) Consolidated Plant Inventory. The interface is divided into several sections:

- Navigation:** A left sidebar shows a tree structure under 'Location' with 'CNT2' selected. Below it, a search bar and a list of components are visible, including 'PCT2-BAT-D 362' through 'PCT2-BAT-D 553'.
- Filters:** At the top, there are filter buttons for 'Equipment Category 10+', 'NIS type 2', 'System 6', and 'Mass'. A 'CLEAR ALL' button is also present.
- Table:** The main area contains a table with columns: 'FULO name', 'Equipment Category', 'NIS Type', 'Description', 'Room', and 'System'. A context menu is open over the 'Equipment Category' column, showing options: 'Sort Ascending', 'Sort Descending', 'Lock column', and 'Hide column'. The table lists various equipment items such as 'CAB-C403', 'PCT3-CRC-F02', 'PCT2-CR1-P46', etc.
- Controls:** Above the table, there are buttons for 'COLUMNS SETTING', 'EXPORT TO XLS', 'DELETE ITEMS', and 'ADD ITEM'. A 'No components yet' message is visible at the bottom left of the table area.

# Inventory Schedule Digital Model

Tasks

Menu

WBS Setter Console

Delete Selected

Add to WBS

Apply Filter

Select All Deselect All Reset Filter

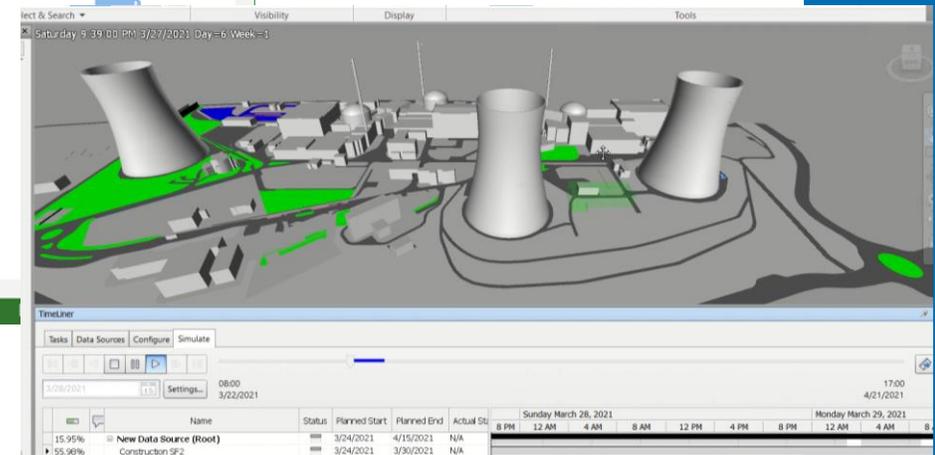
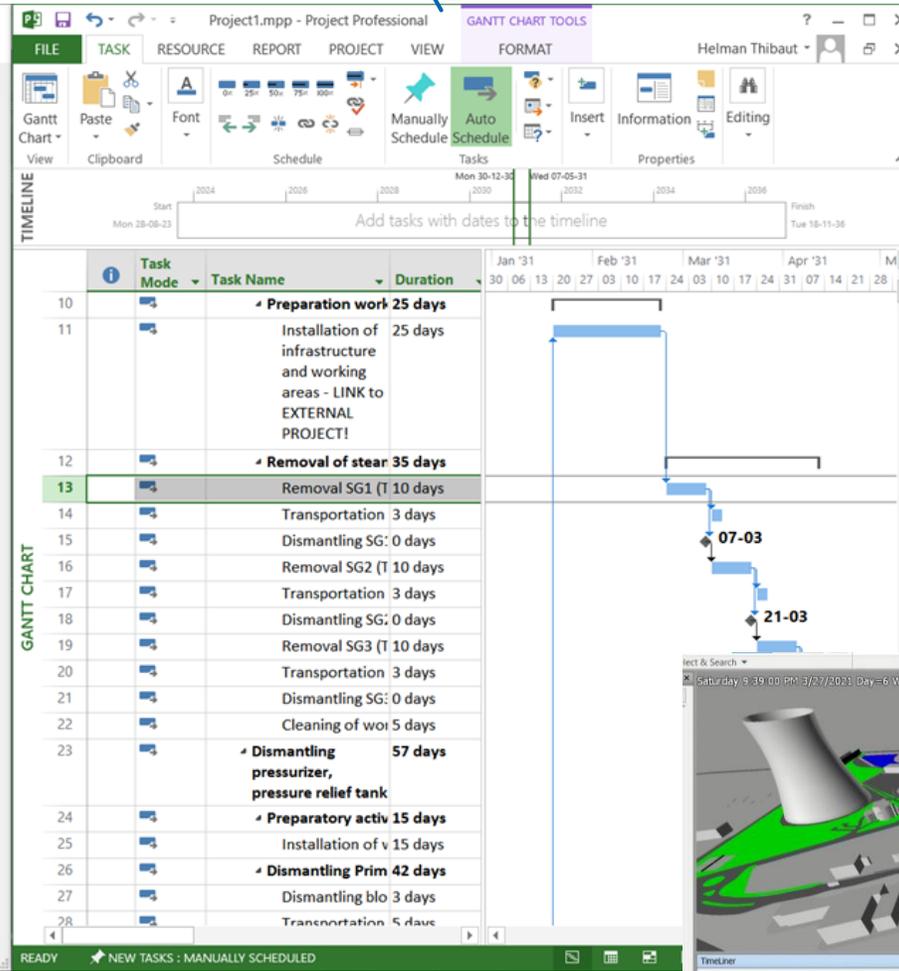
	InvSubTEID	InvRoomID	InvMass
0	<input checked="" type="checkbox"/> 1963-8-1	1963	2868.0
1	<input checked="" type="checkbox"/> 1963-9-1	1963	8930.0
2	<input checked="" type="checkbox"/> 1963-9-2	1963	2720.0
3	<input checked="" type="checkbox"/> 1971-19-1	1971	1.29
4	<input checked="" type="checkbox"/> 1971-17-1	1971	3.01
5	<input checked="" type="checkbox"/> 1971-18-1	1971	12.72
6	<input checked="" type="checkbox"/> 1971-9-1	1971	10.0
7	<input checked="" type="checkbox"/> 1972-19-1	1972	17.901
8	<input checked="" type="checkbox"/> 1972-17-1	1972	41.769
9	<input checked="" type="checkbox"/> 1972-18-1	1972	28.408
10	<input checked="" type="checkbox"/> 1972-9-1	1972	908.0
11	<input checked="" type="checkbox"/> 1979-19-1	1979	0.528
12	<input checked="" type="checkbox"/> 1979-17-1	1979	1.232
13	<input checked="" type="checkbox"/> 1979-18-1	1979	4.86
14	<input checked="" type="checkbox"/> 1980-19-1	1980	0.528
15	<input checked="" type="checkbox"/> 1980-17-1	1980	1.232
16	<input checked="" type="checkbox"/> 1980-18-1	1980	4.86
17	<input checked="" type="checkbox"/> 1981-19-1	1981	0.528
18	<input checked="" type="checkbox"/> 1981-17-1	1981	1.232
19	<input checked="" type="checkbox"/> 1981-18-1	1981	4.86

SELECT \* FROM inventory\_data

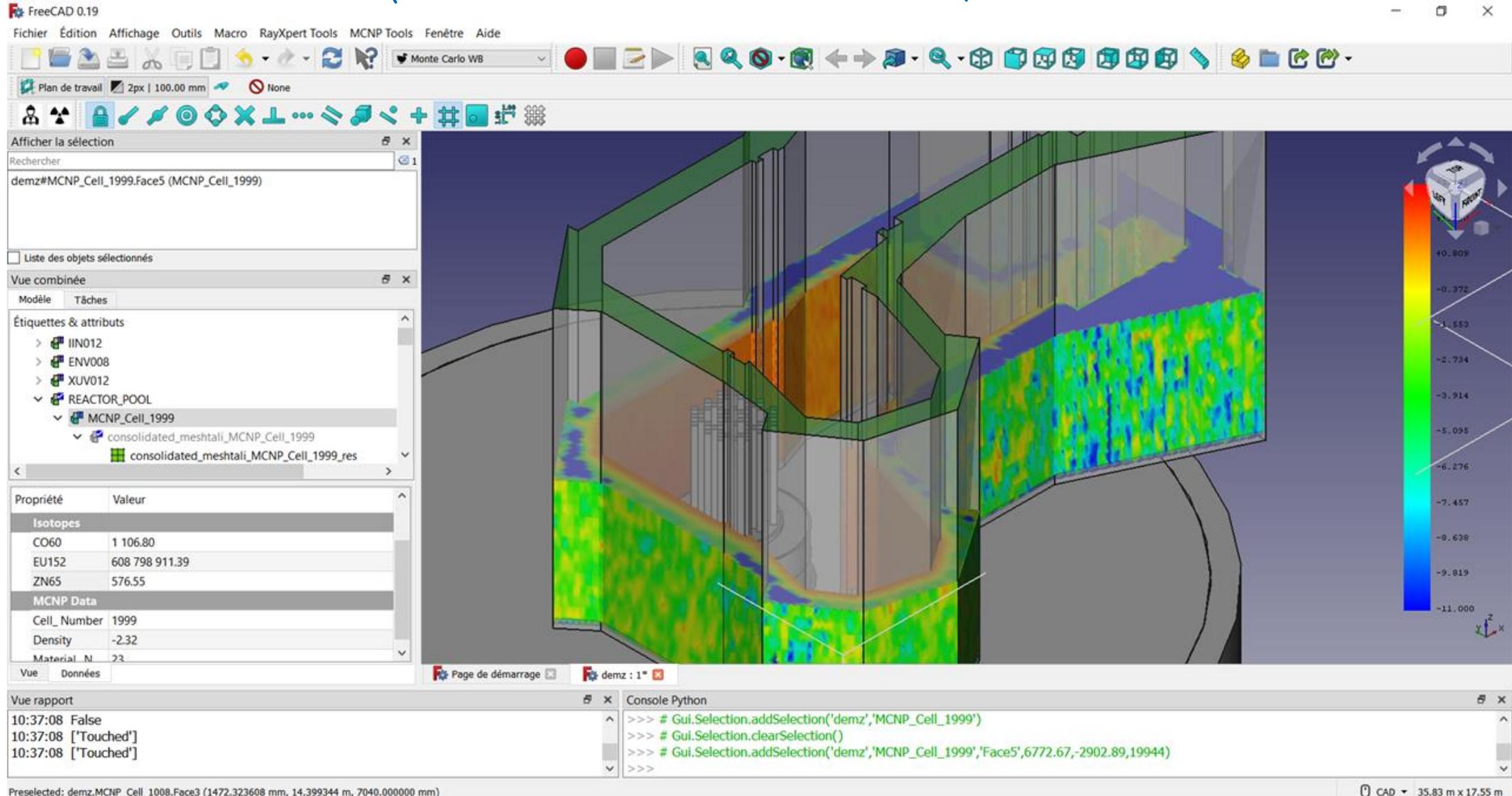
Run Query

Set Grouping Collapse All Expand All

Base Date:



# Inventory Digital Model Simulations



FreeCAD 0.19

Fichier Édition Affichage Outils Macro RayXpert Tools MCNP Tools Fenêtre Aide

Plan de travail 2px | 100.00 mm None

Afficher la sélection

Rechercher

demz#MCNP\_Cell\_1999.Face5 (MCNP\_Cell\_1999)

Liste des objets sélectionnés

Vue combinée

Modèle Tâches

Étiquettes & attributs

- IIN012
- ENV008
- XUV012
- REACTOR\_POOL
  - MCNP\_Cell\_1999
    - consolidated\_meshtali\_MCNP\_Cell\_1999
    - consolidated\_meshtali\_MCNP\_Cell\_1999\_res

Propriété Valeur

Isotopes	
CO60	1 106.80
EU152	608 798 911.39
ZN65	576.55

MCNP Data

Cell_Number	1999
Density	-2.32
Material_N	23

Vue Données

Page de démarrage demz : 1\*

Vue rapport

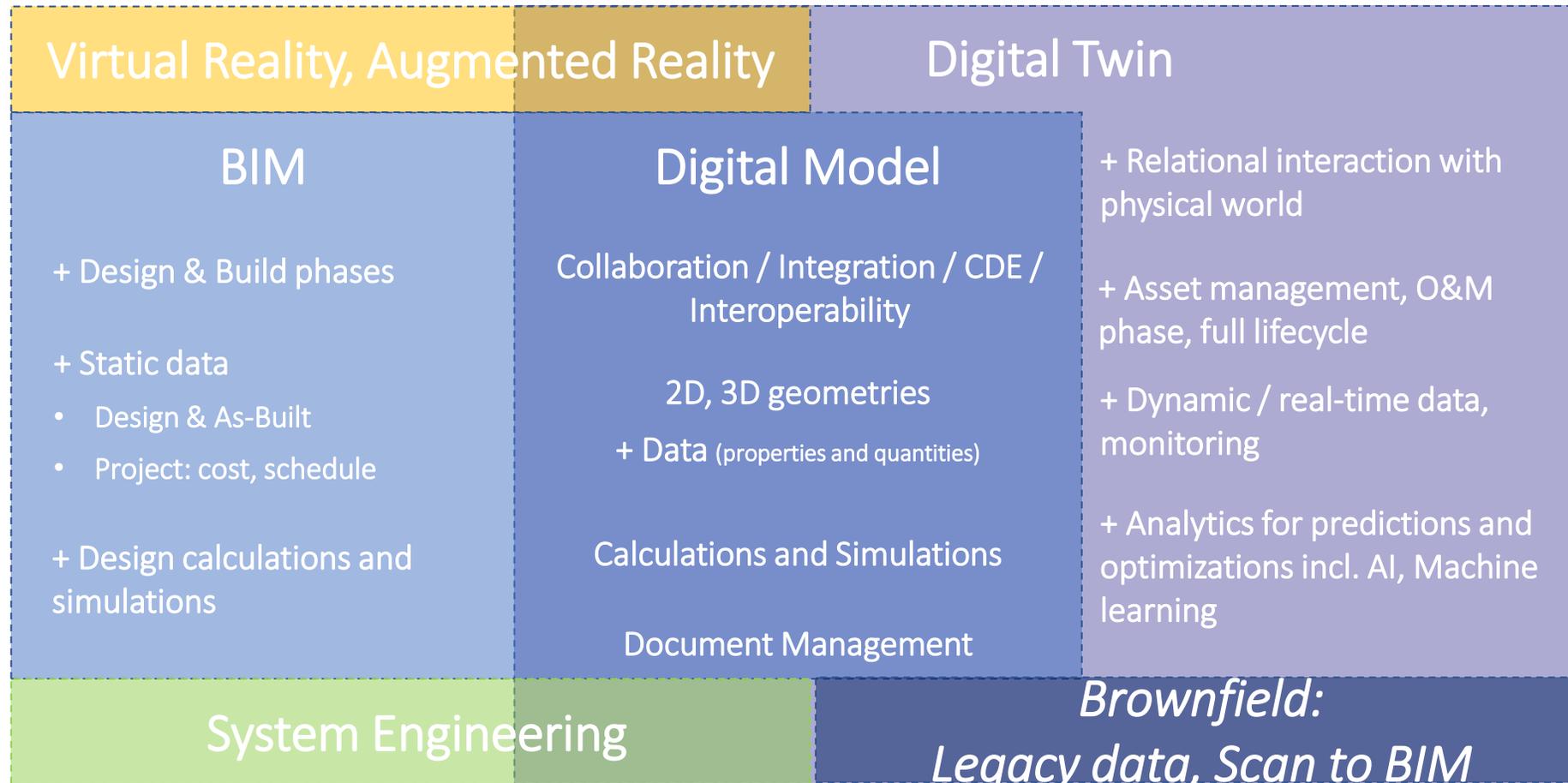
Console Python

```
>>> # Gui.Selection.addSelection('demz','MCNP_Cell_1999')
>>> # Gui.Selection.clearSelection()
>>> # Gui.Selection.addSelection('demz','MCNP_Cell_1999','Face5',6772.67,-2902.89,19944)
>>>
```

Preselected: demz.MCNP\_Cell\_1008.Face3 (1472.323608 mm, 14.399344 m, 7040.000000 mm)

CAD 35.83 m x 17.55 m

# « BIM » & « Digital Twin »



# System Engineering

- Integrated data base with following functionalities:
  - Functional Breakdown Structure, Product Breakdown Structure
  - Requirement Management including assumptions and inputs
  - Interface Management (between studies, documents/ deliverables, SSC, contractual lots)
  - Configuration Management and Design Change Process (project data management, design choices, design modifications, BOM/BOQ)
  - Engineering Management workflows (task assignment, action lists, deliverable lists)
  - Layout, 2D/3D/BIM models
  - Filtering and Visualisation of database relationships



# Augmented and Virtual Reality

## VR – Virtual Reality



### Features

- Being fully immersed in the virtual environment
- Most immersive solution

### Project phases

- Design and Design review
- Commercial and marketing

## AR – Augmented Reality



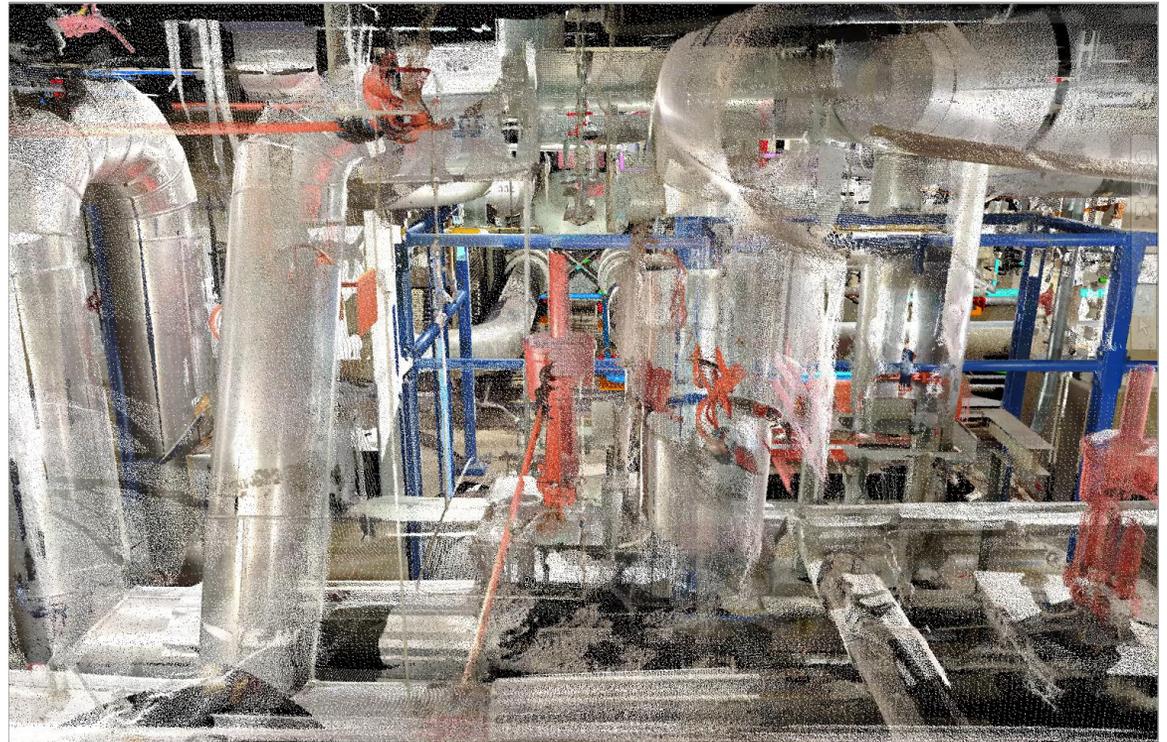
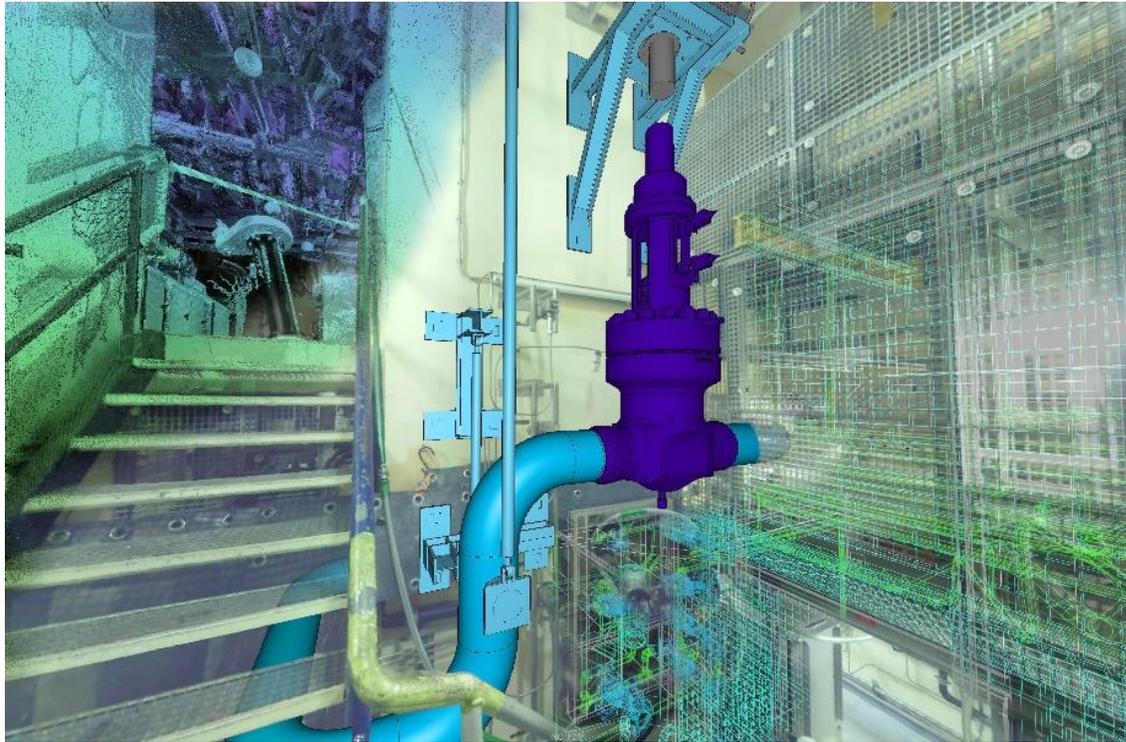
### Features

- View and interact with virtual data superimposed on reality (incl. BIM model)
- Most collaborative solution

### Project phases

- Site follow-up
- Enhanced TEAMS collaboration

# Brown field: scan to BIM (laser scan)



# Digital twins in the Nuclear Industry

- Fuzzy definition of Digital Twin

- Importance of user story, **definition of the needs** and requirements

- Digital Twin is all about **data**

- Importance of CDE, integration, interoperability

There is no off-the-shelf “one size fits all” technological solution



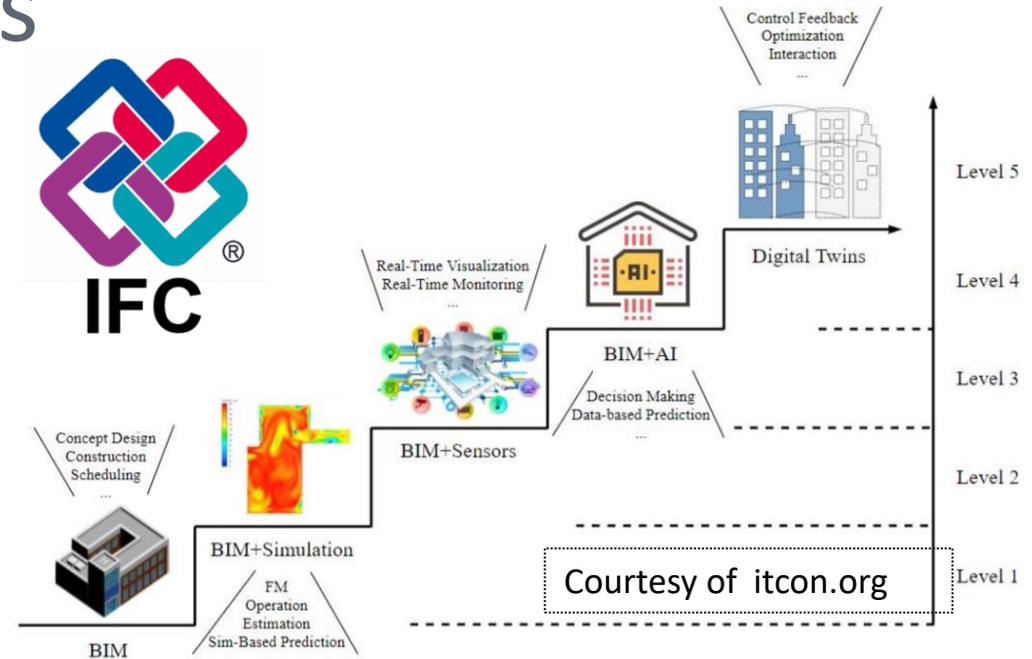
- **Nuclear specificities**

- Need complex **simulations**
- **Extended** use of data (static... dynamic)
- Existing assets: challenge of **legacy data** (decentralized, unstructured, inconsistent, incomplete, outdated,...)

- (Huge) Limitations from **confidentiality** and **accessibility** rules

# Future development trends

- Improvement of Data quality, **Interoperability**, Standardisation and openness
- Increased integration of models & functionalities, stronger **ecosystem**
- More complex and transverse Multiphysics **simulations**
- Integrating data from **sensing** and **real-time** monitoring (IoT)
- **AI/ Machine learning** for real-time simulations and predictions



Virtual Reality, Augmented Reality		Digital Twin
<p><b>BIM</b></p> <ul style="list-style-type: none"> <li>+ Design &amp; Build phases</li> <li>+ Static data                             <ul style="list-style-type: none"> <li>• Design &amp; As-Built</li> <li>• Project: cost, schedule</li> </ul> </li> <li>+ Design calculations and simulations</li> </ul>	<p><b>Digital Model</b></p> <ul style="list-style-type: none"> <li>Collaboration / Integration / CDE / Interoperability</li> <li>2D, 3D geometries</li> <li>+ Data (properties and quantities)</li> <li>Calculations and Simulations</li> <li>Document Management</li> </ul>	<ul style="list-style-type: none"> <li>+ Relational interaction with physical world</li> <li>+ Asset management, O&amp;M phase, full lifecycle</li> <li>+ Dynamic / real-time data, monitoring</li> <li>+ Analytics for predictions and optimizations incl. AI, Machine learning</li> </ul>
System Engineering		<b>Brownfield:</b> Legacy data, Scan to BIM



# Digital twins tools