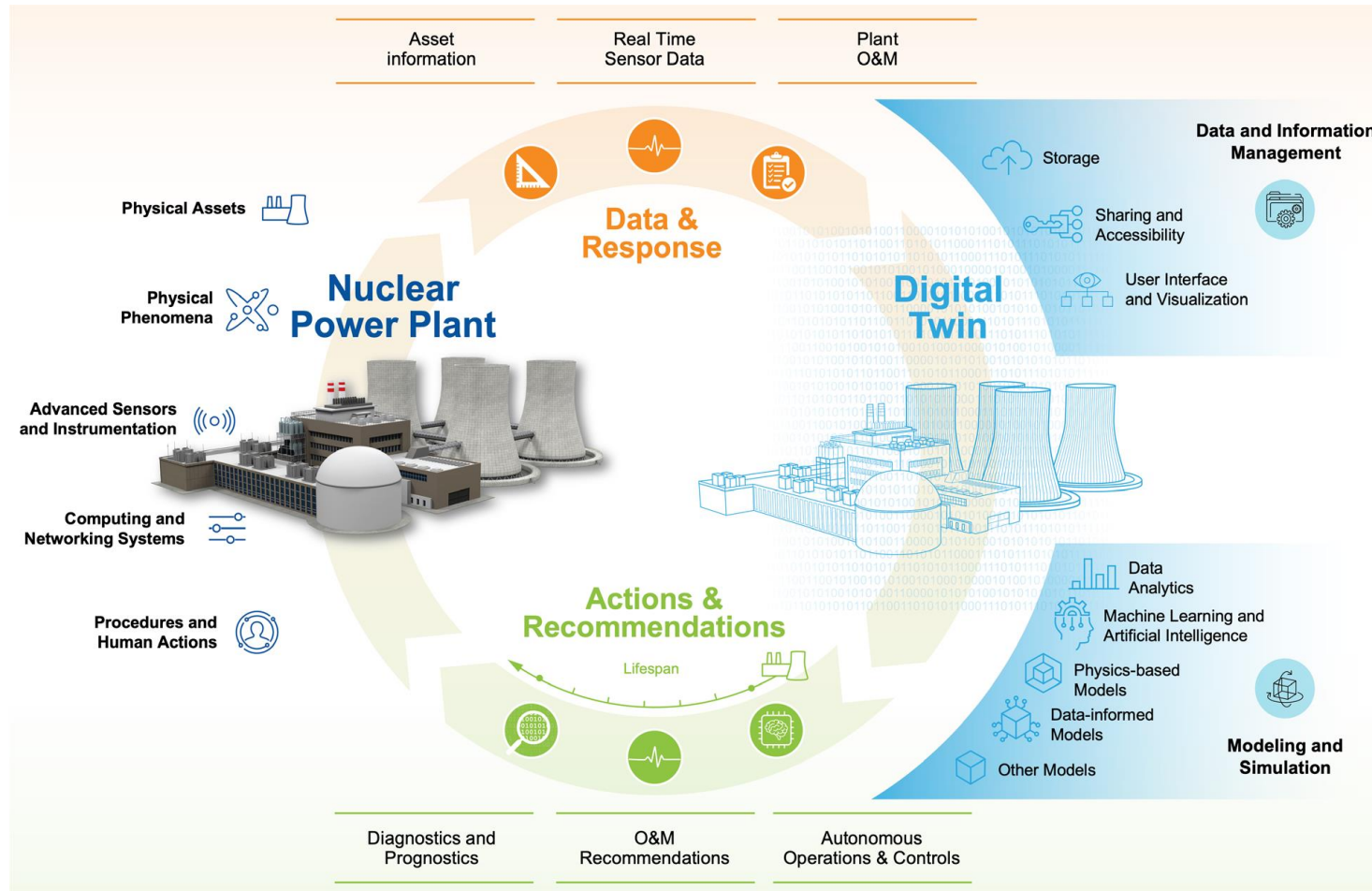


Implementation of digital twin functionalities in the Nuclear Industry: Tractebel case studies

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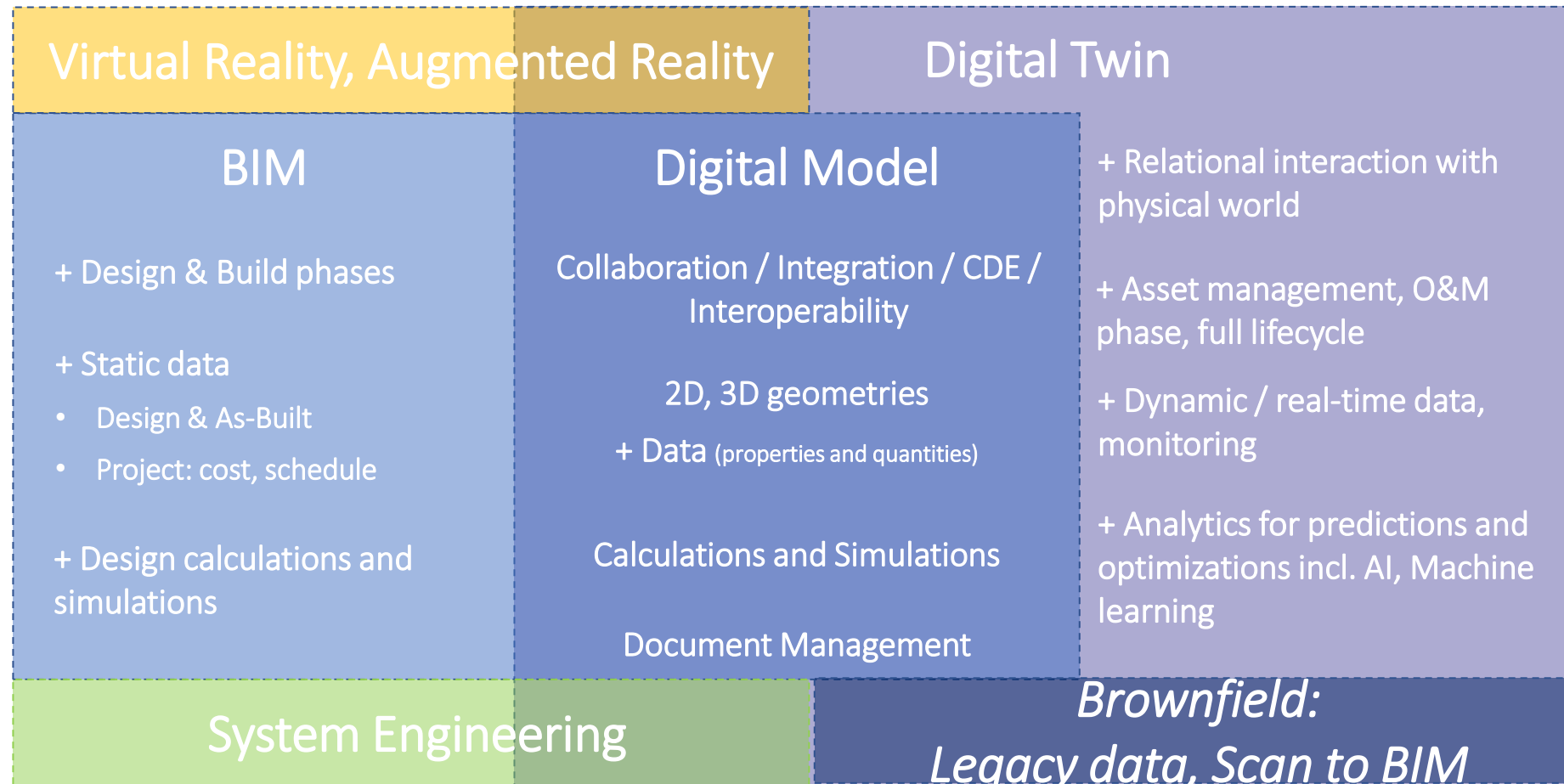
US-NRC definition of digital twin



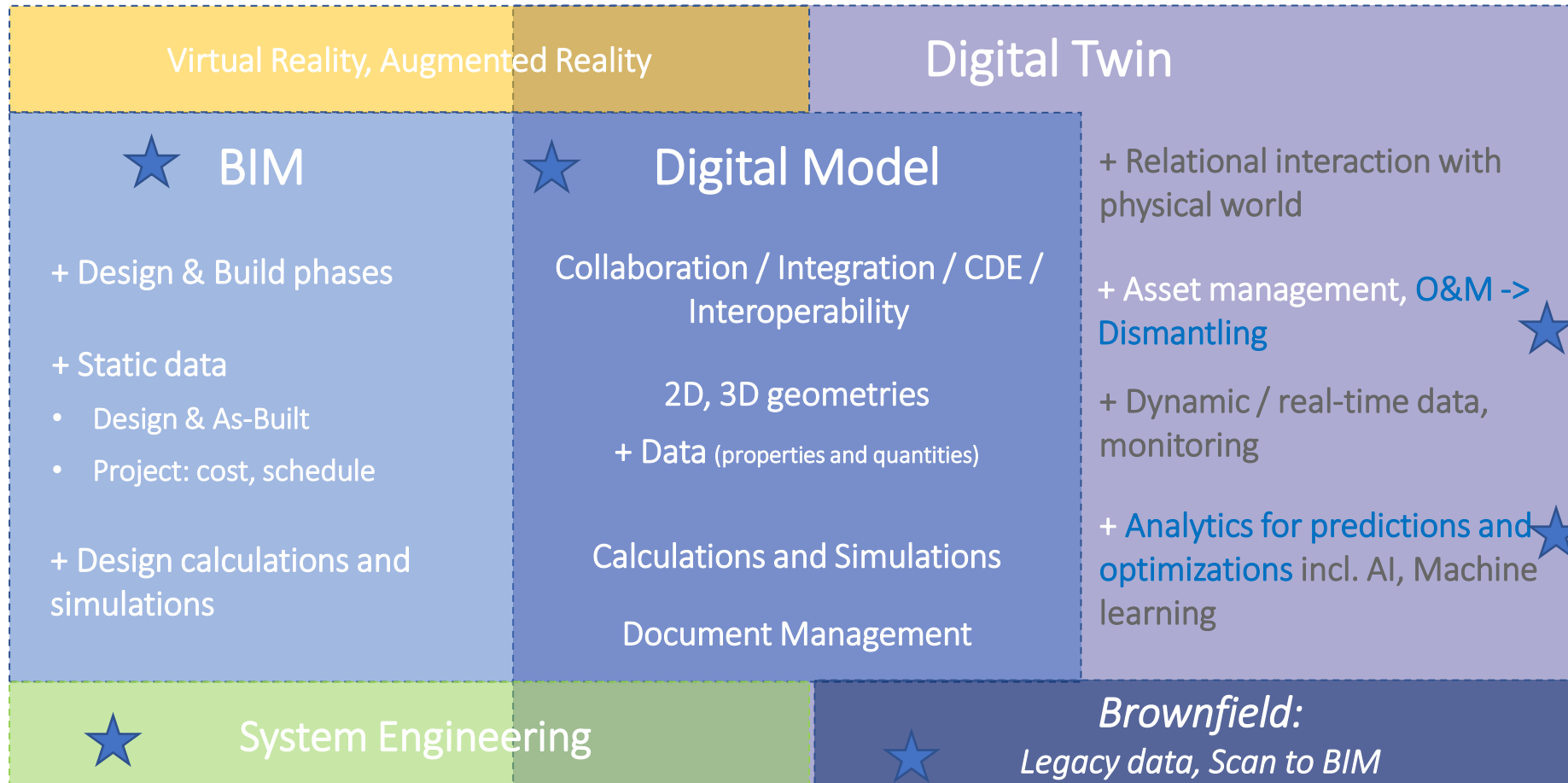
- Comprises the physical system, the virtual system, and the relationships between physical and virtual systems
- Three Conditions:
 - Digital form
 - State concurrency (real-time update)
 - Purpose related to NPP lifecycle activity

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

« BIM » & « Digital Twin »

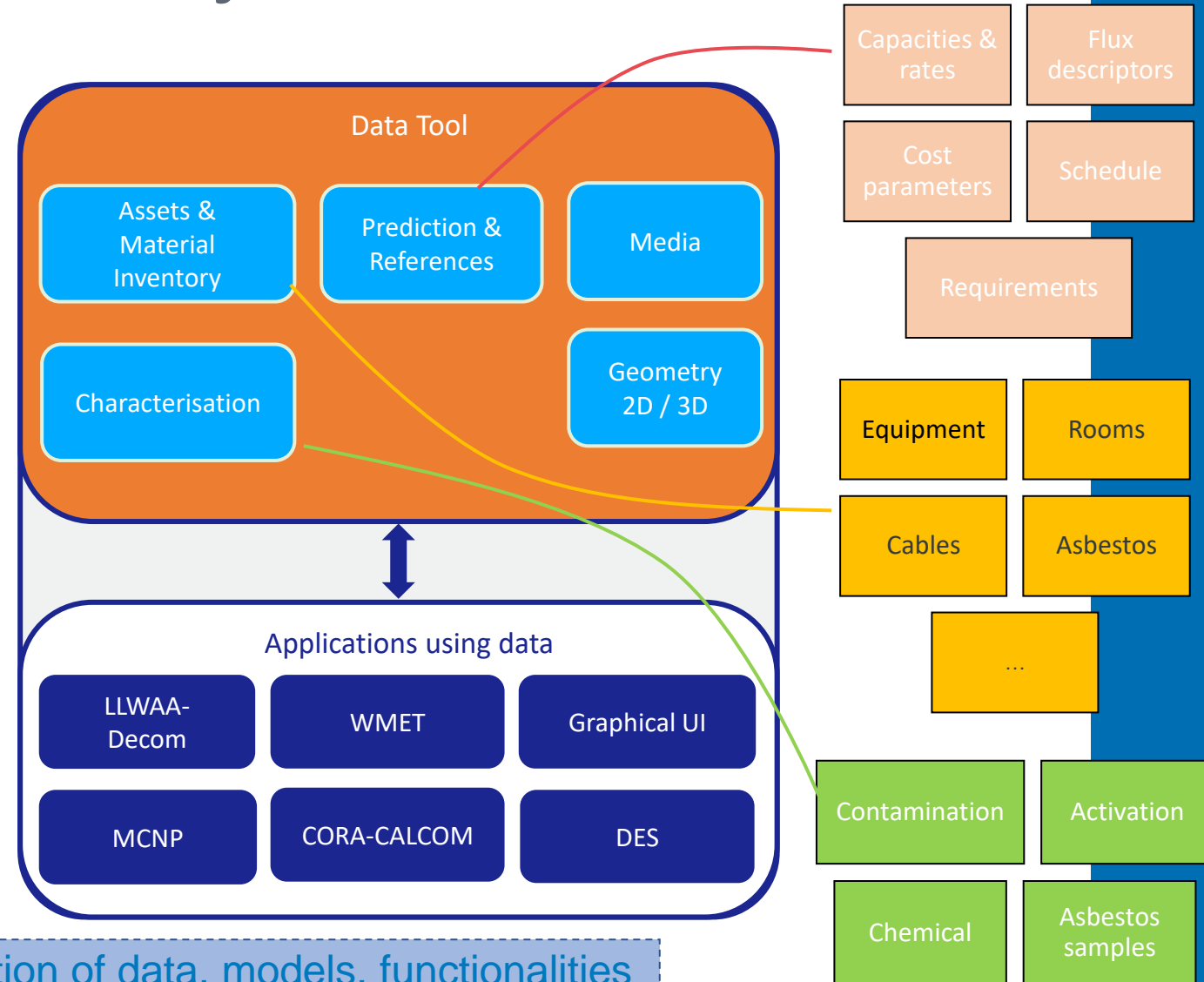


Dismantling Digital Twin



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



Consolidated Plant Inventory

The screenshot displays the DAMI (Data Acquisition and Monitoring Interface) Consolidated Plant Inventory. The interface is divided into a left sidebar and a main content area.

Left Sidebar:

- Location:** CNT2 > N > 5
- Search:** A search bar with a magnifying glass icon.
- ALL:** A dropdown menu showing the current selection.
- CNT:** A dropdown menu showing the current selection.
- CNT1:** A dropdown menu showing the current selection.
- CNT2:** A dropdown menu showing the current selection.
- A:** A dropdown menu showing the current selection.
- D:** A dropdown menu showing the current selection.
- E:** A dropdown menu showing the current selection.
- FY:** A dropdown menu showing the current selection.
- G:** A dropdown menu showing the current selection.
- N:** A dropdown menu showing the current selection.
- R:** A dropdown menu showing the current selection.

Main Content Area:

- My views:** All options, Contamination, Session 26-09-2021, Room/Type/Cont
- Filters:** Equipment Category 10+, NIS type 2, System 6, Mass, CLEAR ALL
- Drag a column header and drop it here to group by that column:** A message indicating that columns can be dragged to group data.
- Table:** A table with columns: FULO name, Equipment Category, NIS Type, Description, Room, and System. The table contains 15 rows of equipment data.
- Context Menu:** A menu is open over the table, showing options: Sort Ascending, Sort Descending, Lock column, and Hide column.
- Buttons:** COLUMNS SETTING, EXPORT TO XLS, DELETE ITEMS, ADD ITEM

FULO name	Equipment Category	NIS Type	Description	Room	System
CAB-C403	CAB-C	VAL	[NIS_ACRONYM=VAL] Rev 3 adding NIS Acronym	CNT2/N2/505	CAB
CAB-C403	CAB-C	VAL	[NIS_ACRONYM=VES] FILTRE 4" POIDS ESTIME SVT...	CNT3/D3/391	CAB
PCT3-CRC-F02	CRC	VES	[NIS_ACRONYM=SUP][NIS_ACRONYM=PUM]MALAXE...	CNT3/D3/106	CRC
PCT2-CR3-P46	PUMP	PUM	[NIS_ACRONYM=HEX] [NIS_ACRONYM=SUP] REFRI...	CNT2/N2/500	CRB
PCT2-CR3-Q09	HEAT_EX	HEX	[NIS_ACRONYM=EQPM] CONVOYEUR A CIMENT.TRA...	CNT2/N2/321	CRB
PCT2-TD5-V11	HANDLING	EQPM	[NIS_ACRONYM=RC-PMP] ESTIMED WEIGHT FOR T...	CNT2/N2/279	-
PCT3-CRP-P05	PUMP	RC-PMP	[NIS_ACRONYM=MOTR] CAB-PP02	CNT3/R3/411	CRP
PCT2-CAB-P02R-M	MOTORS	PUM	[NIS_ACRONYM=FAN] Rev 3 adding NIS Acronym	CNT2/N2/304	-
VEA-01	FANS	FAN	[NIS_ACRONYM=SUP][NIS_ACRONYM=PUM]MOTO-P...	CNT3/N3/430	VEA
PCT2-CAB-P02G	PUMP	PUM	[NIS_ACRONYM=SYS] COMPRESSEUR DES GAZ AV...	CNT2/N2/304	CAB
PCT3-TEG-K01	Compressors	COMP	[NIS_ACRONYM=MOTR] VENTILATEUR DE PULSION...	CNT3/D3/313	TEG
PCT3-VEA-A01-M	MOTORS	FAN	[NIS_ACRONYM=HAND] MONORAIL IPN 120	CNT3/N3/430	-
PCT3-MPA-D96	HANDLING	HAND	[NIS_ACRONYM=MOTR] POMPE DE CIRCULATION...	CNT3/D3/113	-
PCT1-CR3-P01DR1-M	MOTORS	PUM	[NIS_ACRONYM=RC-PRS] PRESSURISEUR	CNT1/N1/312	CRB
PCT1-RPP-B01PP	TANK/FILTER/SON EX	RC-PRS	[NIS_ACRONYM=FAN] VENTIL. CIRC. REFRIGERISS MC...	CNT1/R1/503	RPP

Inventory Schedule Digital Model

Tasks

Menu

WBS Setter Console

Delete Selected

Add to WBS

Apply Filter

Select All Deselect All Reset Filter

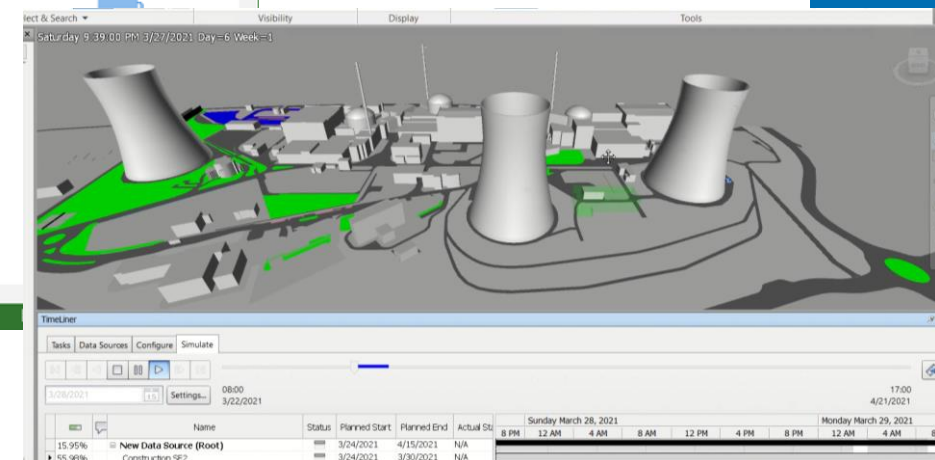
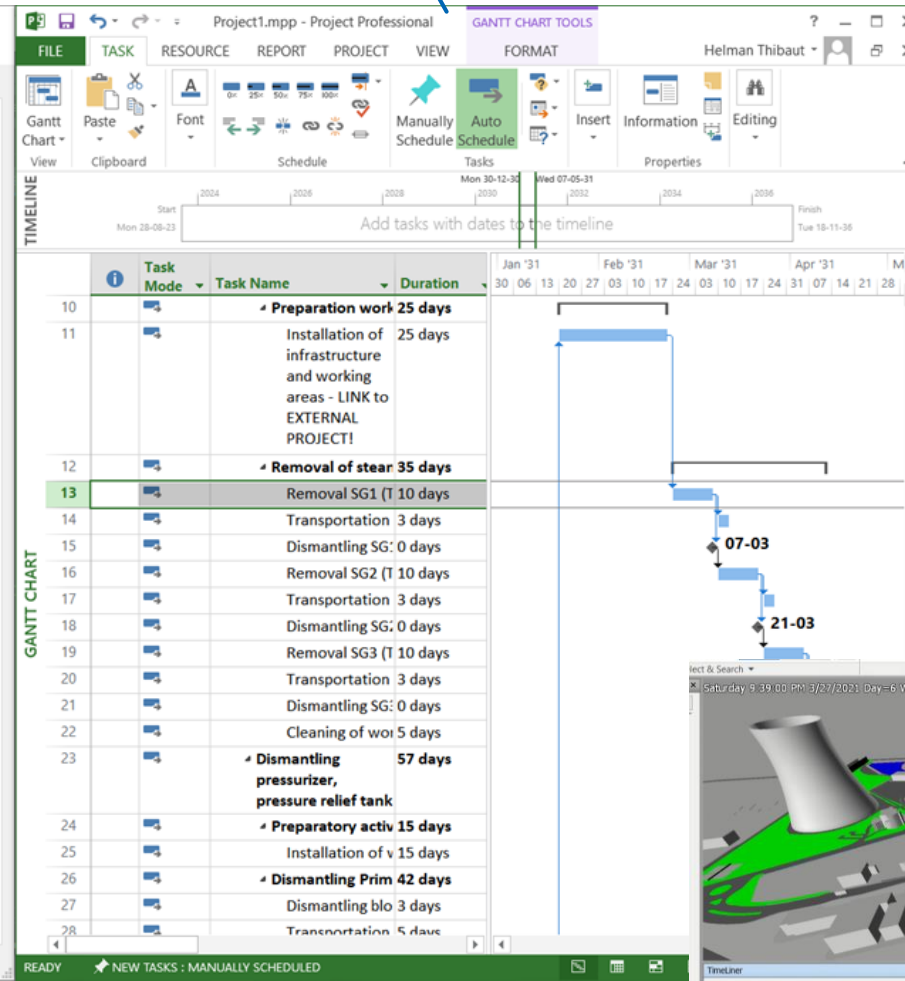
	InvSubTEID	InvRoomID	InvMass
0	<input checked="" type="checkbox"/> 1963-8-1	1963	2868.0
1	<input checked="" type="checkbox"/> 1963-9-1	1963	8930.0
2	<input checked="" type="checkbox"/> 1963-9-2	1963	2720.0
3	<input checked="" type="checkbox"/> 1971-19-1	1971	1.29
4	<input checked="" type="checkbox"/> 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 Data:



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

10:37:08 False

10:37:08 ["Touched"]

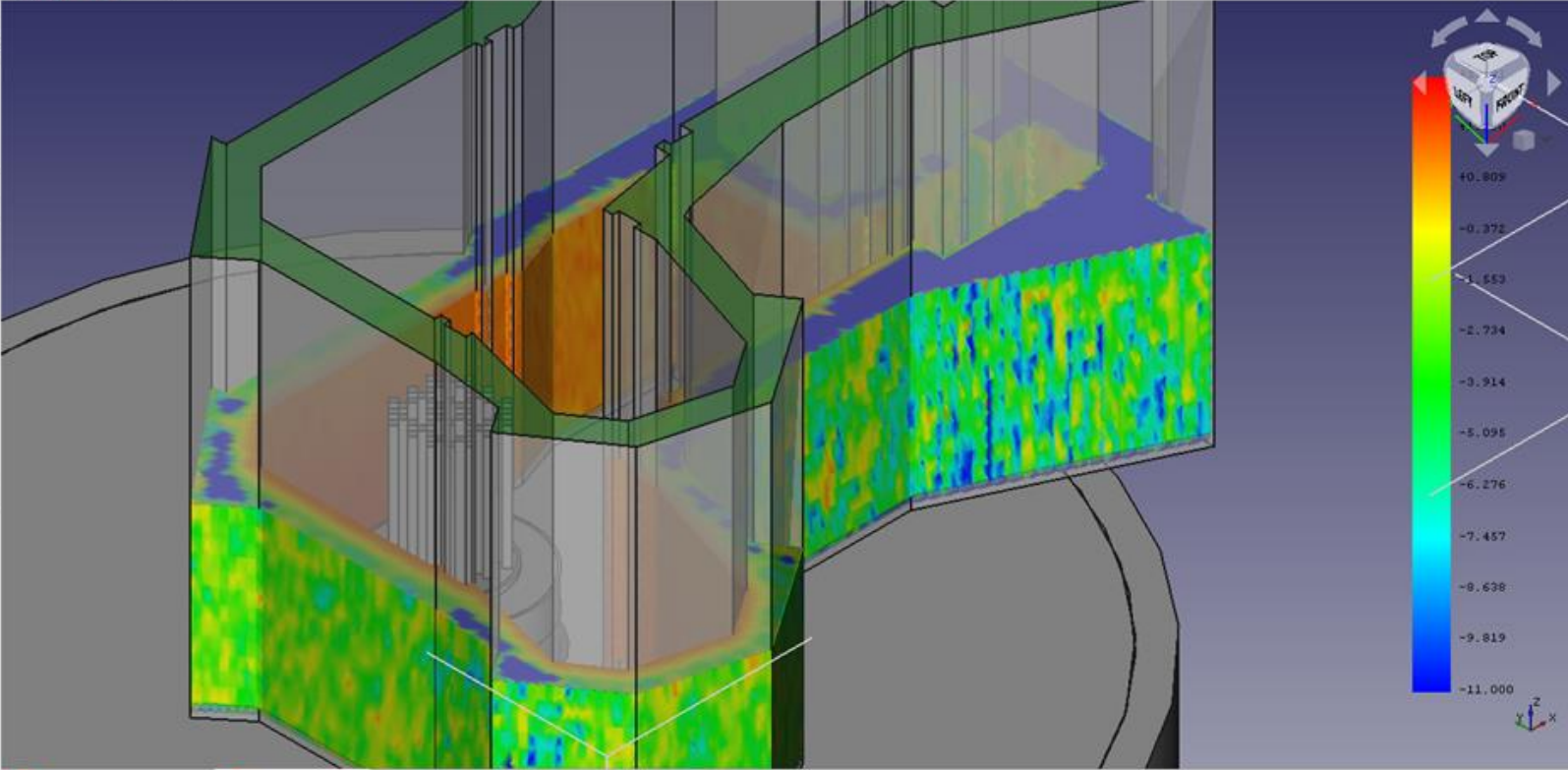
10:37:08 ["Touched"]

Console Python

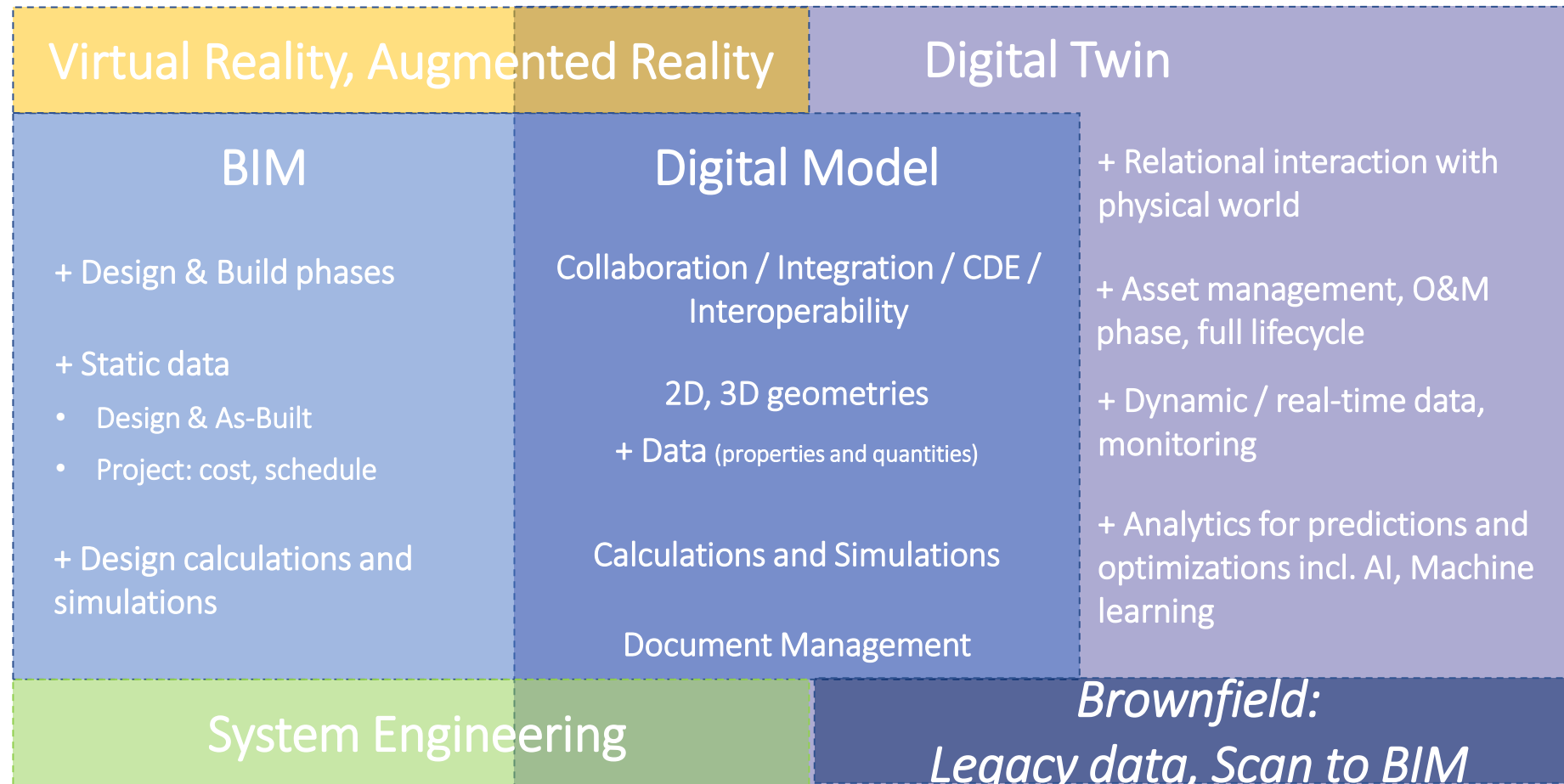
```
>>> # Gui.Selection.addSelection('demz','MCNP_Cell_1999')
>>> # Gui.Selection.clearSelection()
>>> # Gui.Selection.addSelection('demz','MCNP_Cell_1999','Face5',6772.67,-2902.89,19944)
>>>
```

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



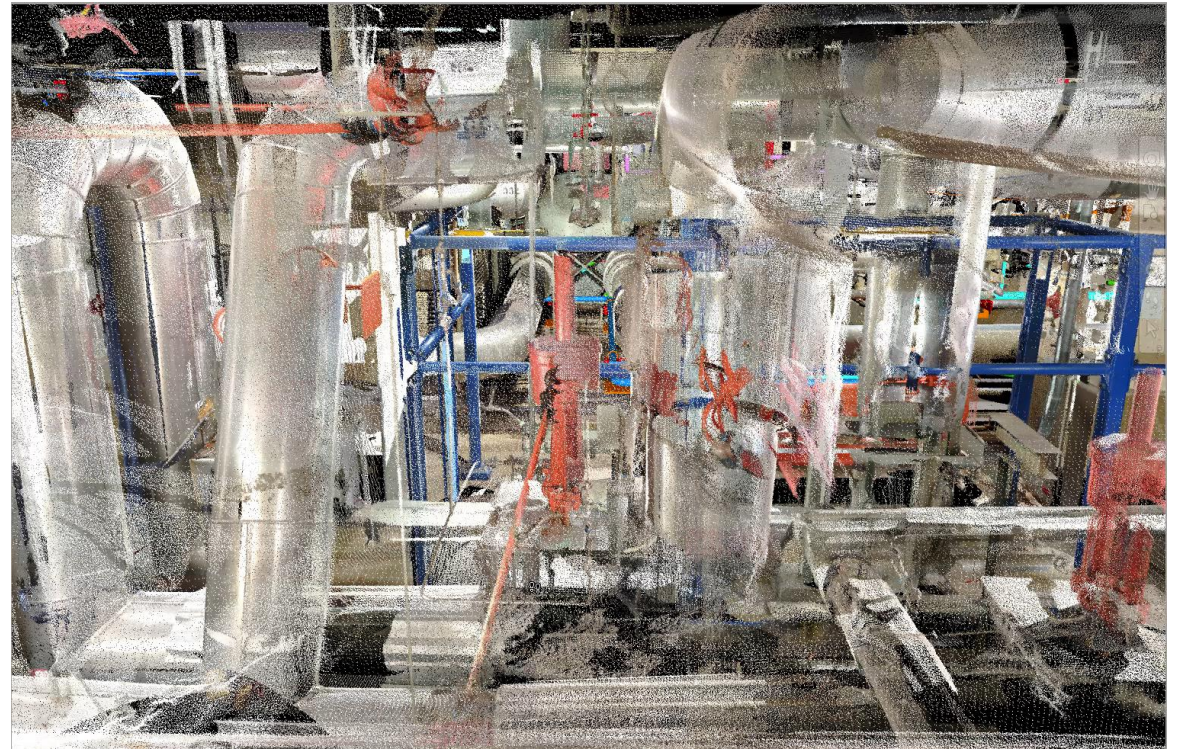
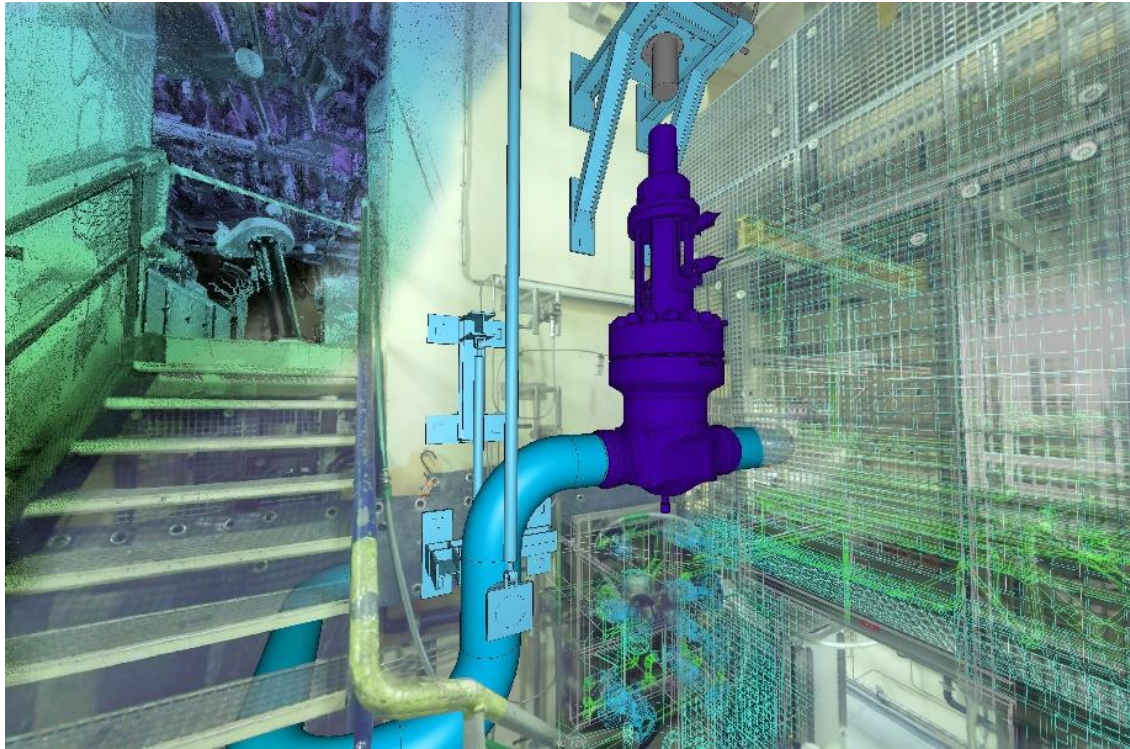
Features

- 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

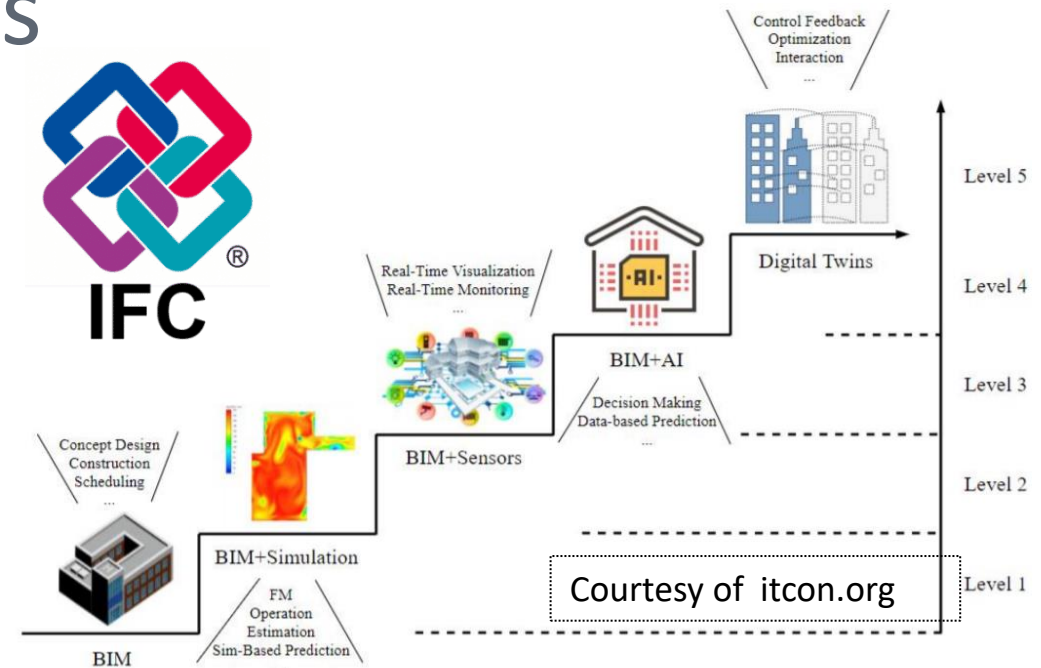


- **Nuclear specificities**

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

