Immersive and interactive scientific visualization with SkyReal linked to OpenTURNS

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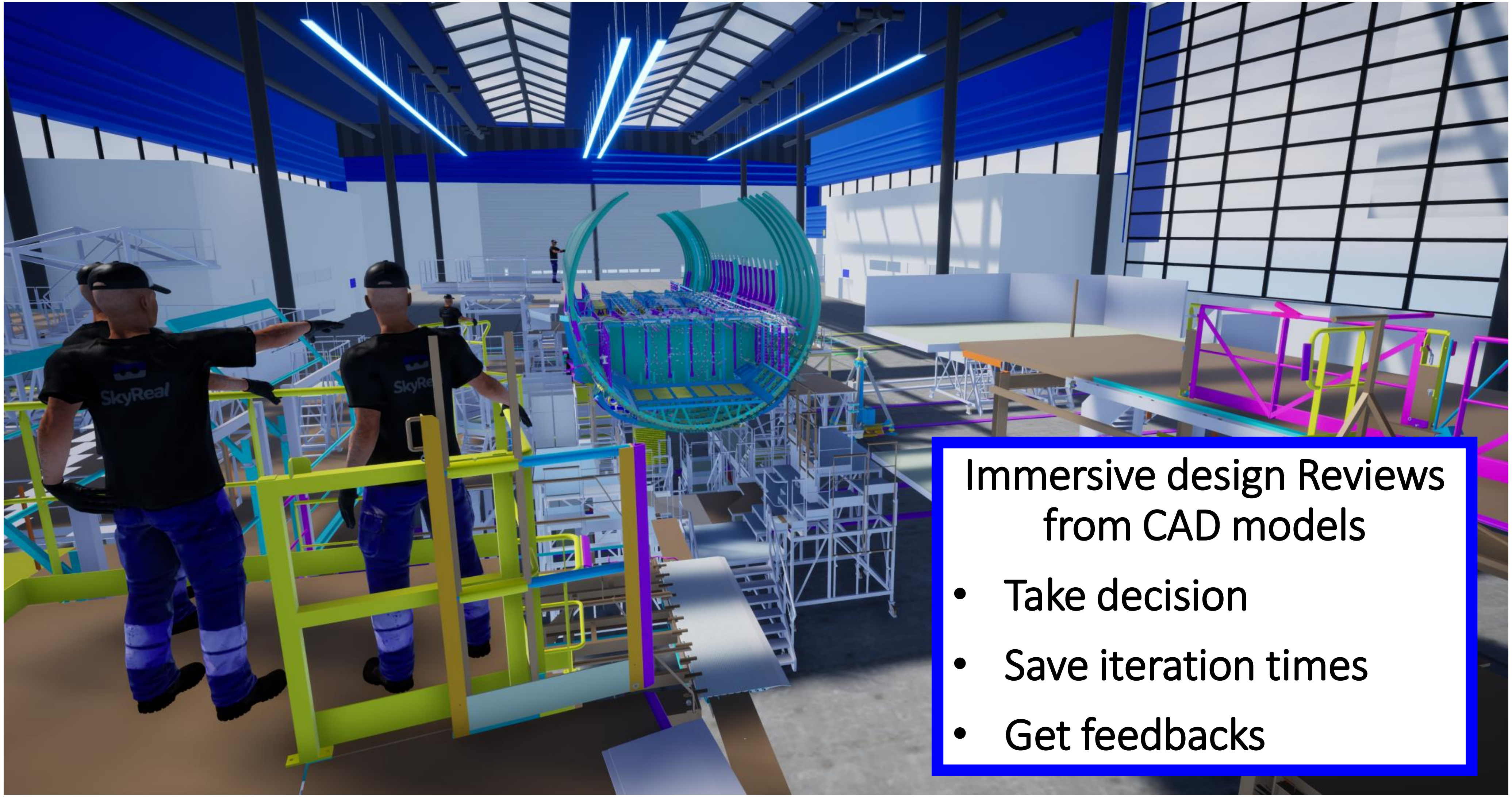
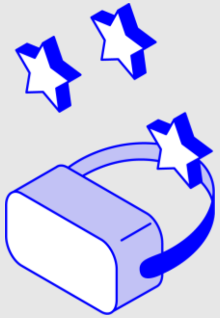


Immersive design Reviews from CAD models

- Take decision
- Save iteration times
- Get feedbacks

Revinventing Interactive Scientific visualisation

CAD Import	Meta-modelling	3D immersive	3D Game Engine
3D reference geometry	Interactive models accurate enough for decision making	Intuitive navigation Natural depth analysis	Unlimited Visual effects for new metaphors
			

4 pillars of project motivation

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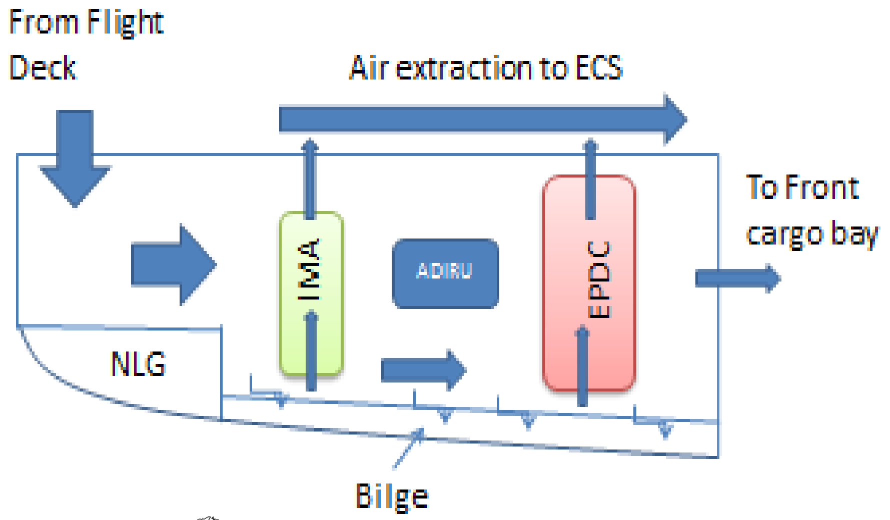
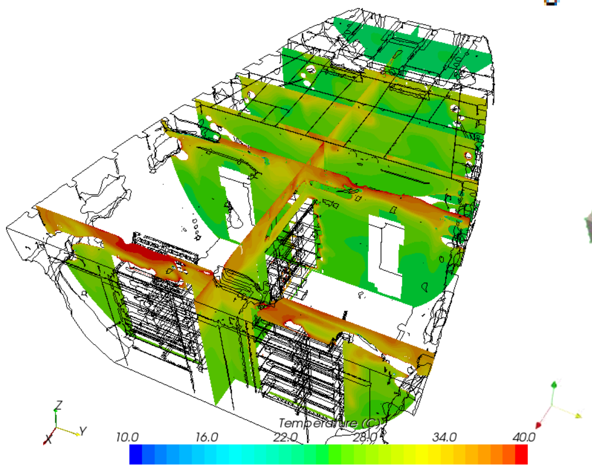
Use case : Zonal Thermal Model (CFD model)

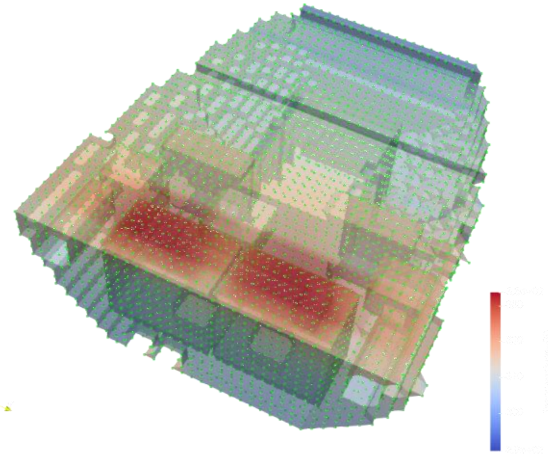
<u>High dimension modeling</u>

Objectives:
- Explore the design space of an equipment bay through 5 key parameters
- Build a meta-model of the velocity and temperature field as a part of an air conditioning regulation loop

Key figures:
- 5 input parameters
- Thermal simulation with convective flow: 8h/run on 8 CPUs, for a total of 1000 runs.
- Values gathered on a regular grid (11710 probes)







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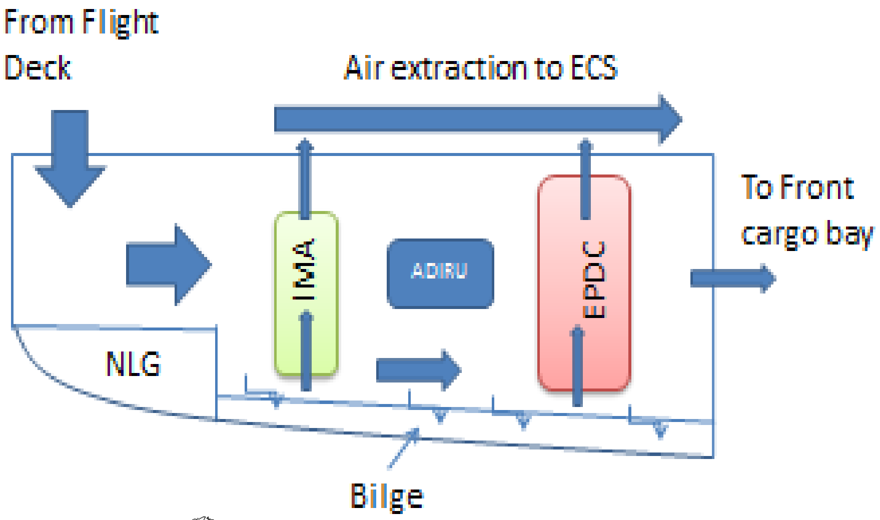
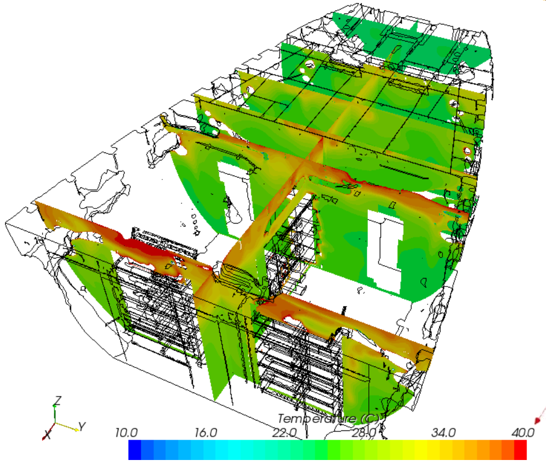
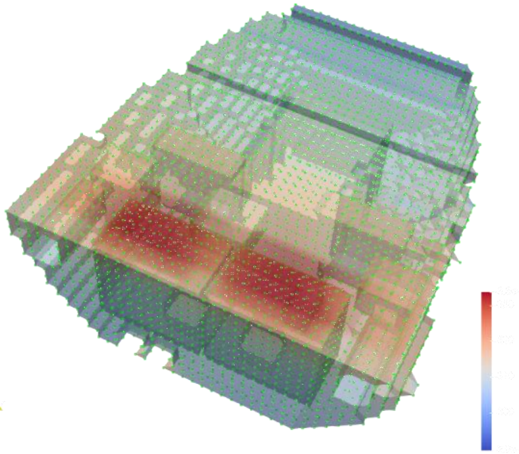


Objective of the project:

- Use CFD simulation results to analyse key parameter’s impact
- Define user friendly visualisation technics dedicated for stakeholder review





Use case : Aerothermal simulation

Meta-modeling methodology for a `PointToFieldFunction`

1. Compute the Karhunen-Loeve decomposition of the field $\vec{X} = (T, v_x, v_y, v_z)$ based on a `ProcessSample` of 10^3 realizations, using `KerhunenLoeveSVDAlgorithm`:

$$\vec{X}(\vec{u}, \vec{p}(\omega)) = \vec{m}(\vec{u}) + \sum_{k=1}^{\infty} \sqrt{\lambda_k}\xi_k(p(\omega))\vec{\varphi}_k(\vec{u})$$

   where $\vec{u}$ is the location in the domain, $\vec{p}$ is the random vector of input parameters, $\vec{m}$ is the mean field, ξ_k are the KL coefficients and $\vec{\varphi}_k$ are the KL modes.

2. Truncate the series to keep 99.99% of the variability: only $N = 38$ coefficients/modes are needed

3. Build a polynomial chaos expansion of the function linking the 5 input parameters $\vec{p}$ to the N coefficients $(\xi_1, \ldots, \xi_N)$ using `FunctionalChaosAlgorithm`.

Use case : Aerothermal simulation

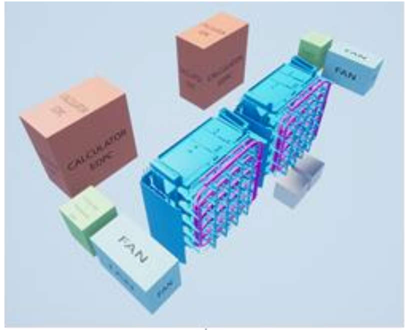
4. Build the meta-model of $\vec{X}$ using the composition of the `Function` obtained at the previous step and the `KarhunenLoeveLifting` class corresponding to the truncated sum (see `PointToFieldConnection`. Then we perform another composition with the `TrendTransform` to add $\vec{m}$.

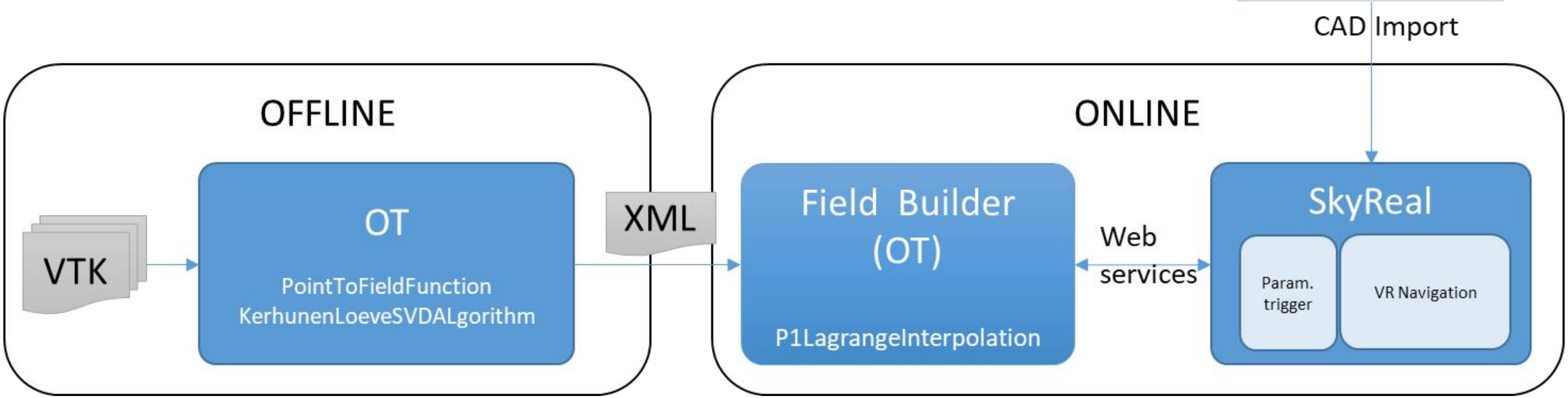
This meta-model can be extended outside of its spatial domain using the `P1LagrangeInterpolation` class in order to get meaningful values of the field in the nearby vicinity of the probes.

The performance is compatible with an interactive use (10 evaluations/s on a laptop)

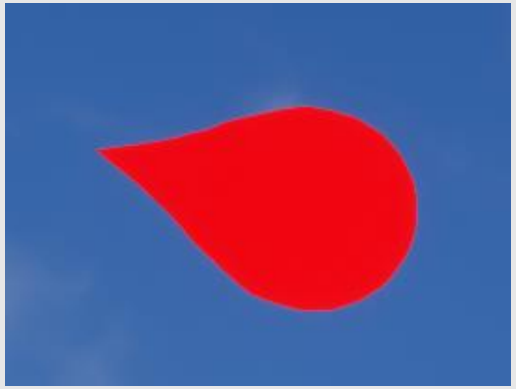
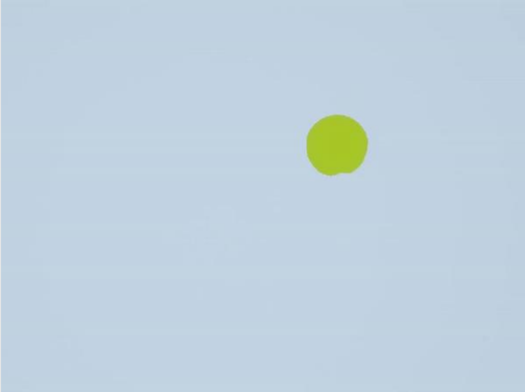
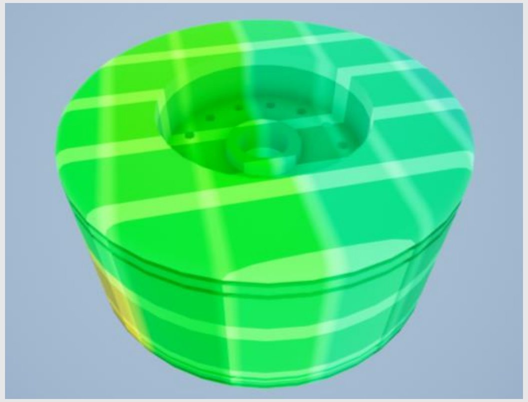
The meta-model is exported in the compressed XML OpenTURNS format to be loaded in the immersive environment.

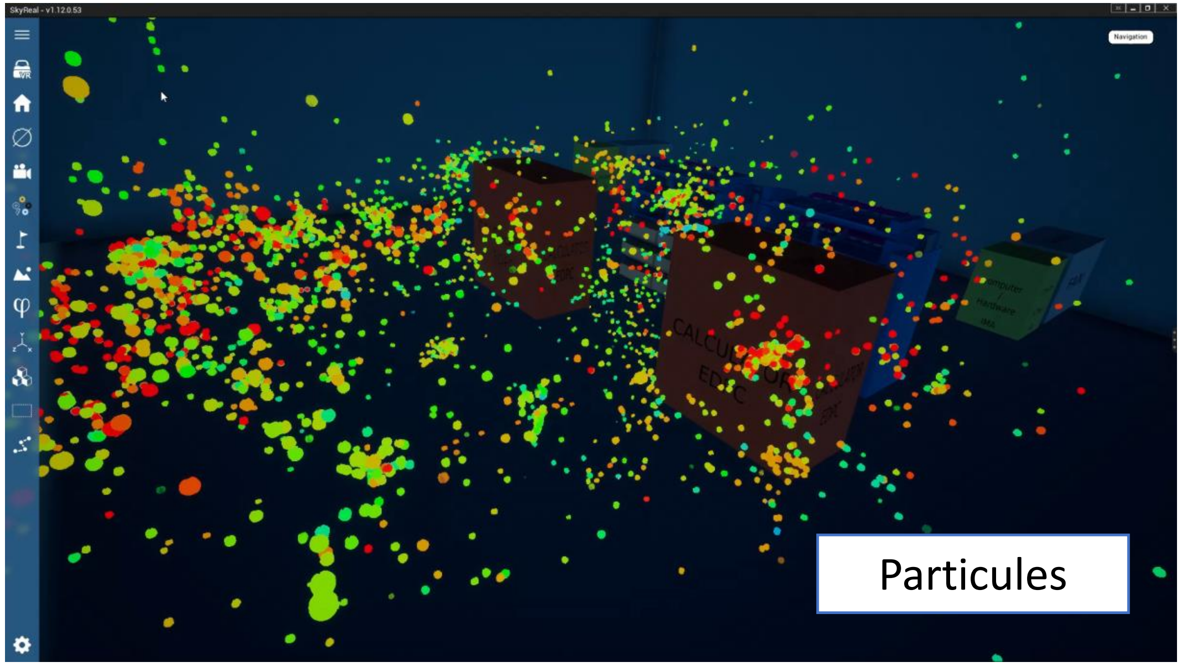
Coupling implementation

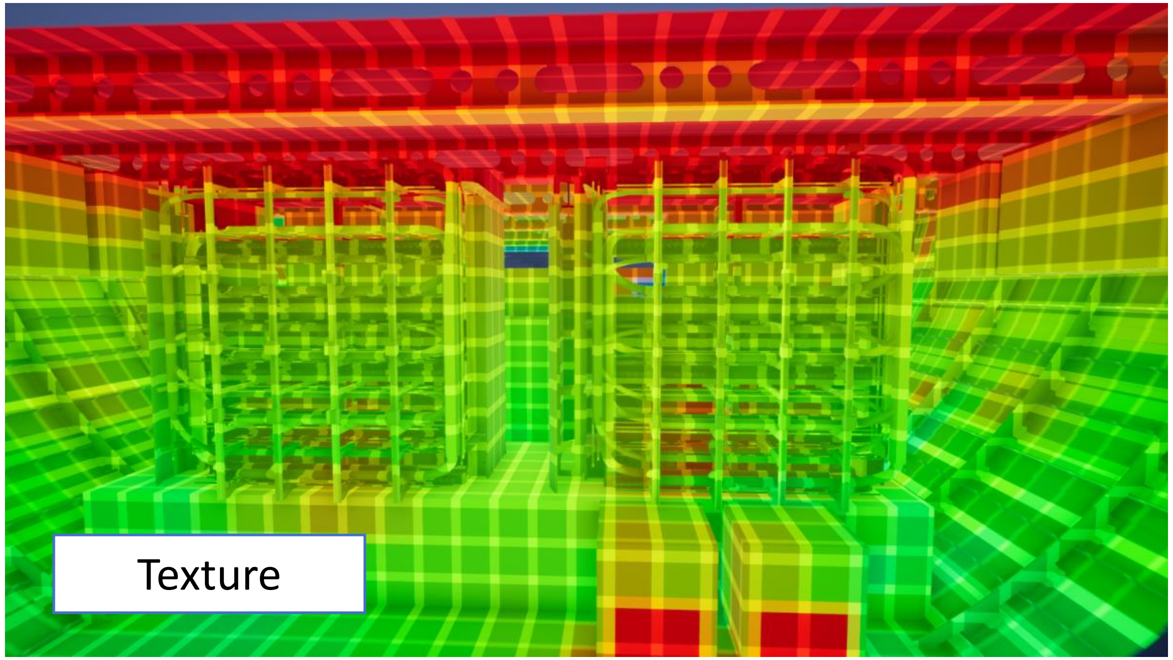


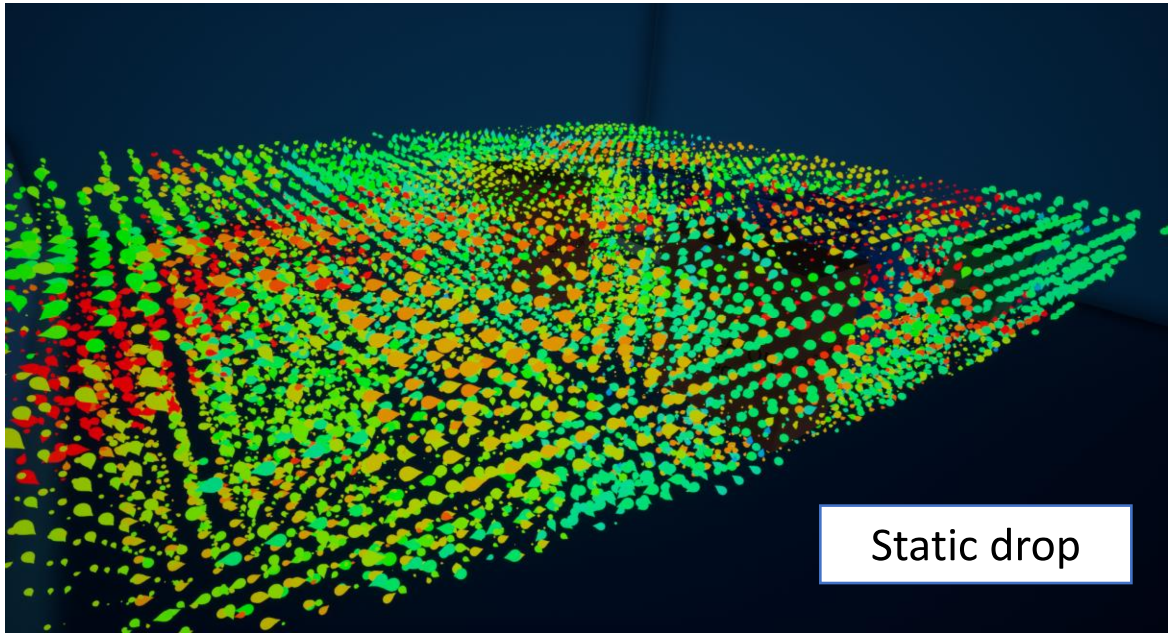


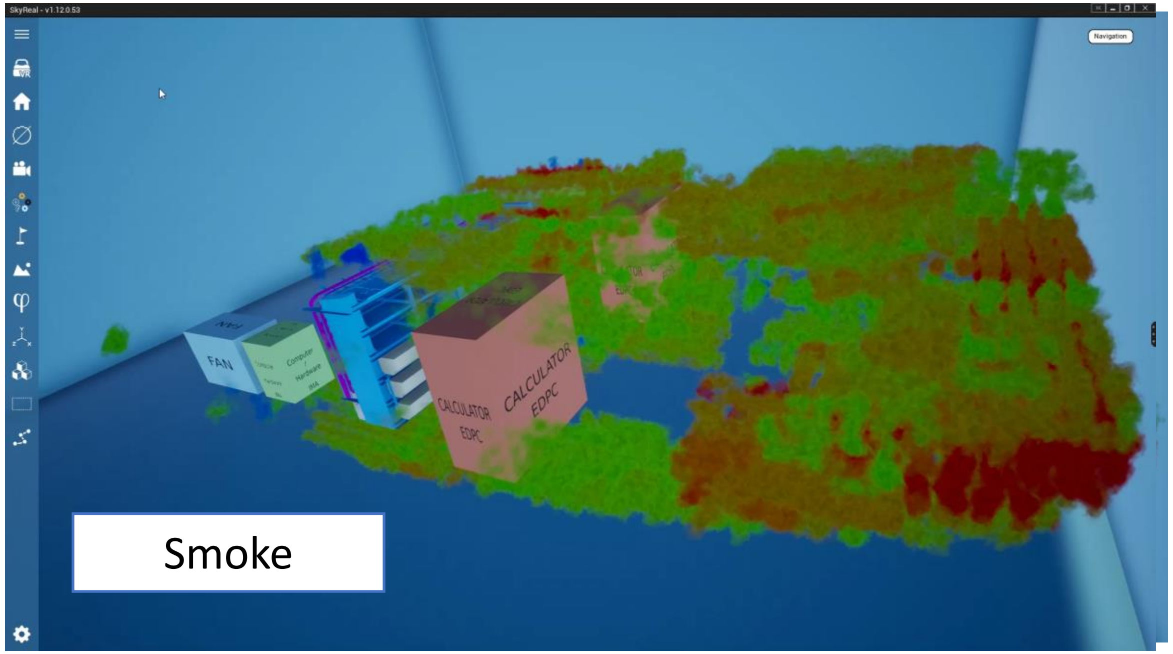
Visual metaphore

Static Drop « Arrow »	Particules	Smoke	Texture
- Temp -> Color - Speed -> Size - Dir -> Orientation	- Temp -> Color - Speed -> Speed - Dir -> Direction - Particules navigate through grid	- Temp -> Color - Speed -> Speed - Dir -> Direction - 1 smoke item / grid unit	- Temp -> Color - Speed -> Ø - Dir -> Ø - Texture applied on DMU
			









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Scientific Visualisation

Parameters

EDPC:	0.0232	0.0348	Value: 0.03	kg/s
Temperature de surface:	-13	-3	Value: -10	K
Heat Transfer Coefficient:	0.5	2	Value: 1	W/m2/K
Heat dissipation:	80	120	Value: 100	W/m2
Nose Landing Gear Temperature:	5	15	Value: 10	K

Apply Parameters

Key parameter trigger (x5)

Rendering

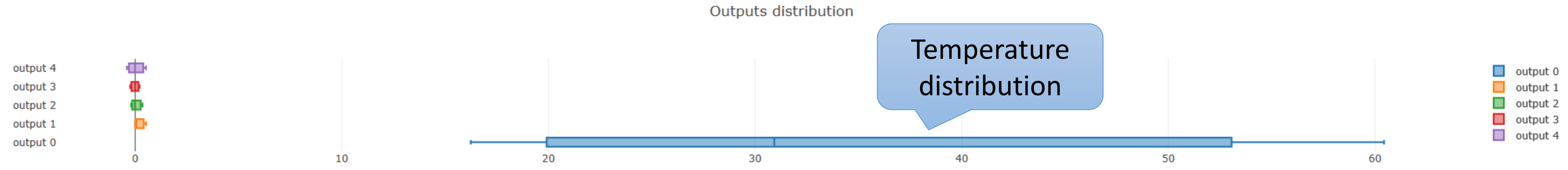
Visualisation Method:	Decals		
Model:	1000		
Particle Number:	3000		
Color Settings:	15	30	55
Speed	1		
Minimal Bound:	20	Maximal Bound:	35

Use Range

Apply Render Settings

Filtering
Above range threshold

Stats



Temperature distribution

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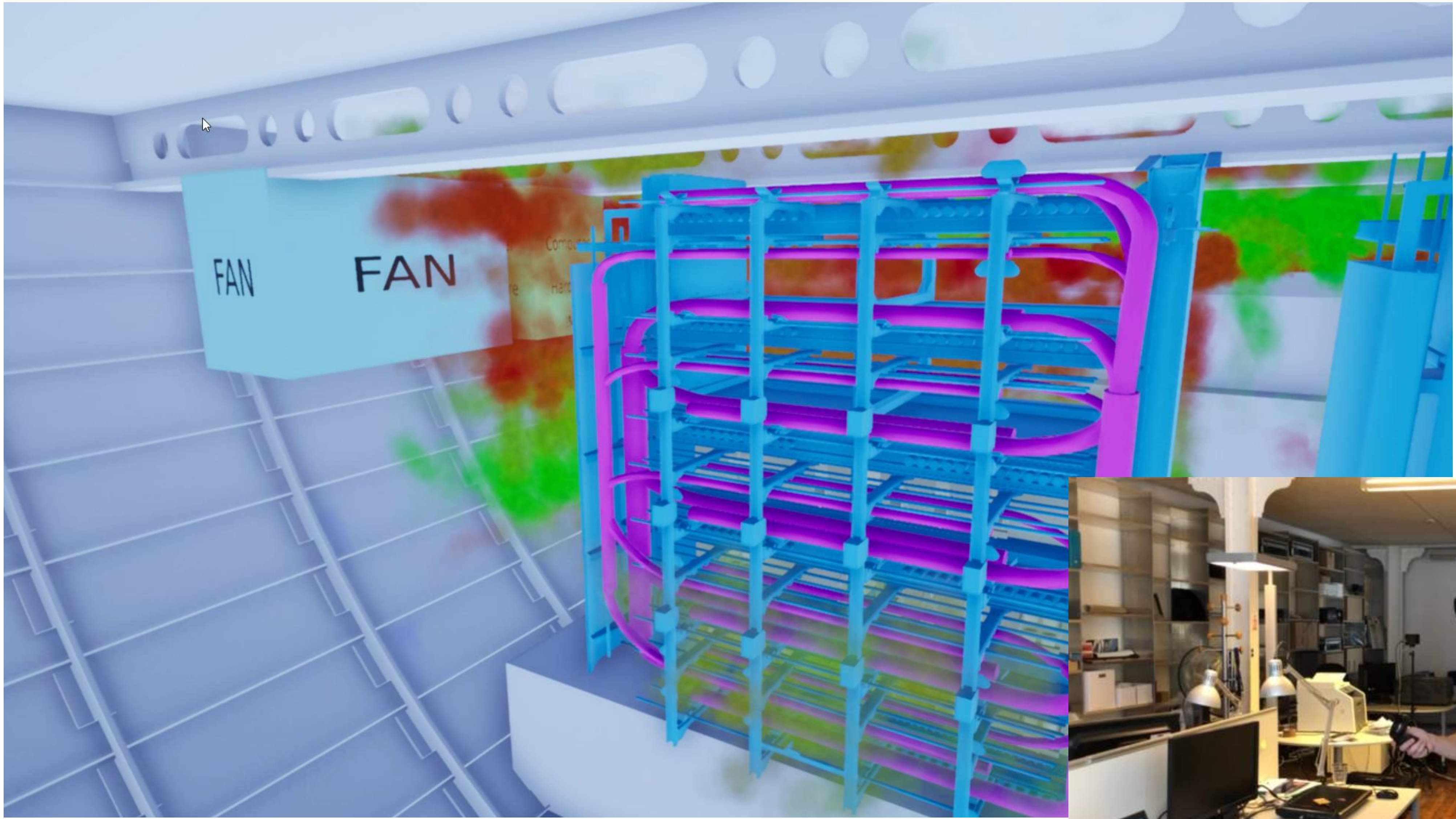
Demo



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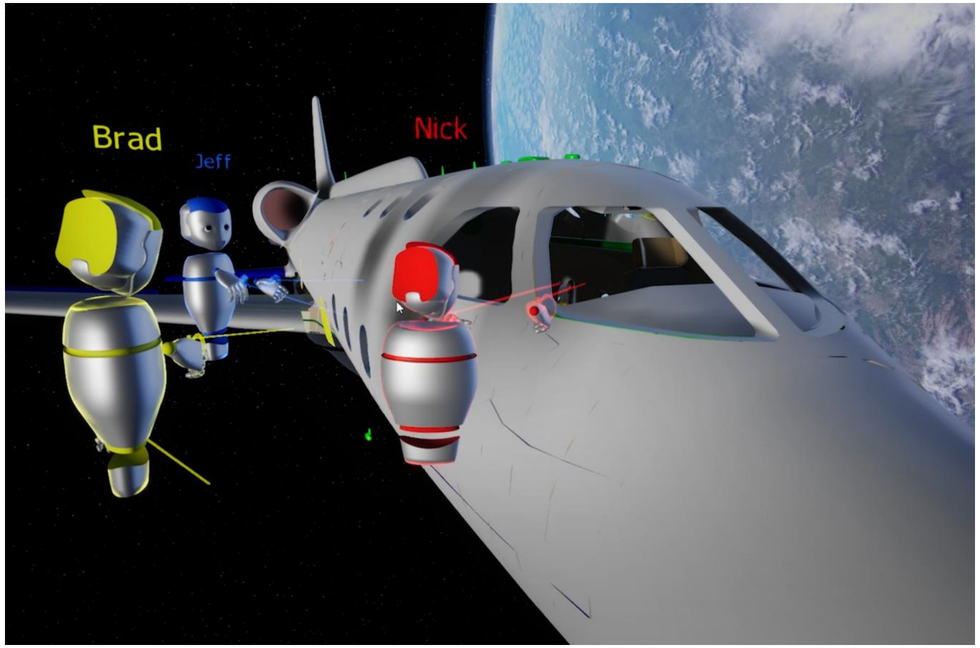
Feedbacks

- Immersive visualisation (VR) is a very convincing for quick analysis of 3D fields thanks to **natural depth perception**
- Effects with movements give “timeline effect”
- Visual effects should be adapted for each discipline

	Static Drop « Arrow »	Particules	Smoke	Texture
Feedbacks	Very good performance in VR	- Temp -> Color - Speed -> Speed - Dir -> Direction - Particles navigate through grid	- Good performance - Good effect for velocity and temperature field	- Very interesting rendering even if less values - Adapted for quick overview
Improvements	Add rendering density according to gradient	Reduce number of particles and use user’s hand as a sensor to generate particles	Adapt smoke particles density	

Conclusions & Next steps

- Good performance on model interaction (OT coupling)
- Positive feedbacks on immersive result analysis



Next steps:

- Multi-disciplinary use case
- Uncertainties visualisation for a given risk with margin representation

merci

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