INGESCAPE
by Ingenuity i/o

A breakthrough tool suite for Extended System Engineering, Systems Interoperability and Human-System Integration

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How to **break the complexity wall** in modern systems and
support multidisciplinary teams at all steps of **complex systems lifetime**?

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https://ingescape.com

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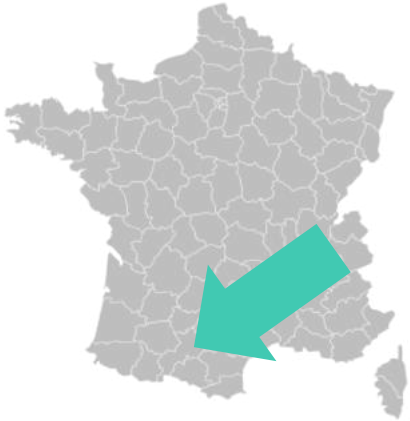


- Toulouse, France
- Since 2012
- Designers + human factors specialists + engineers + software developers

design, develop & deploy

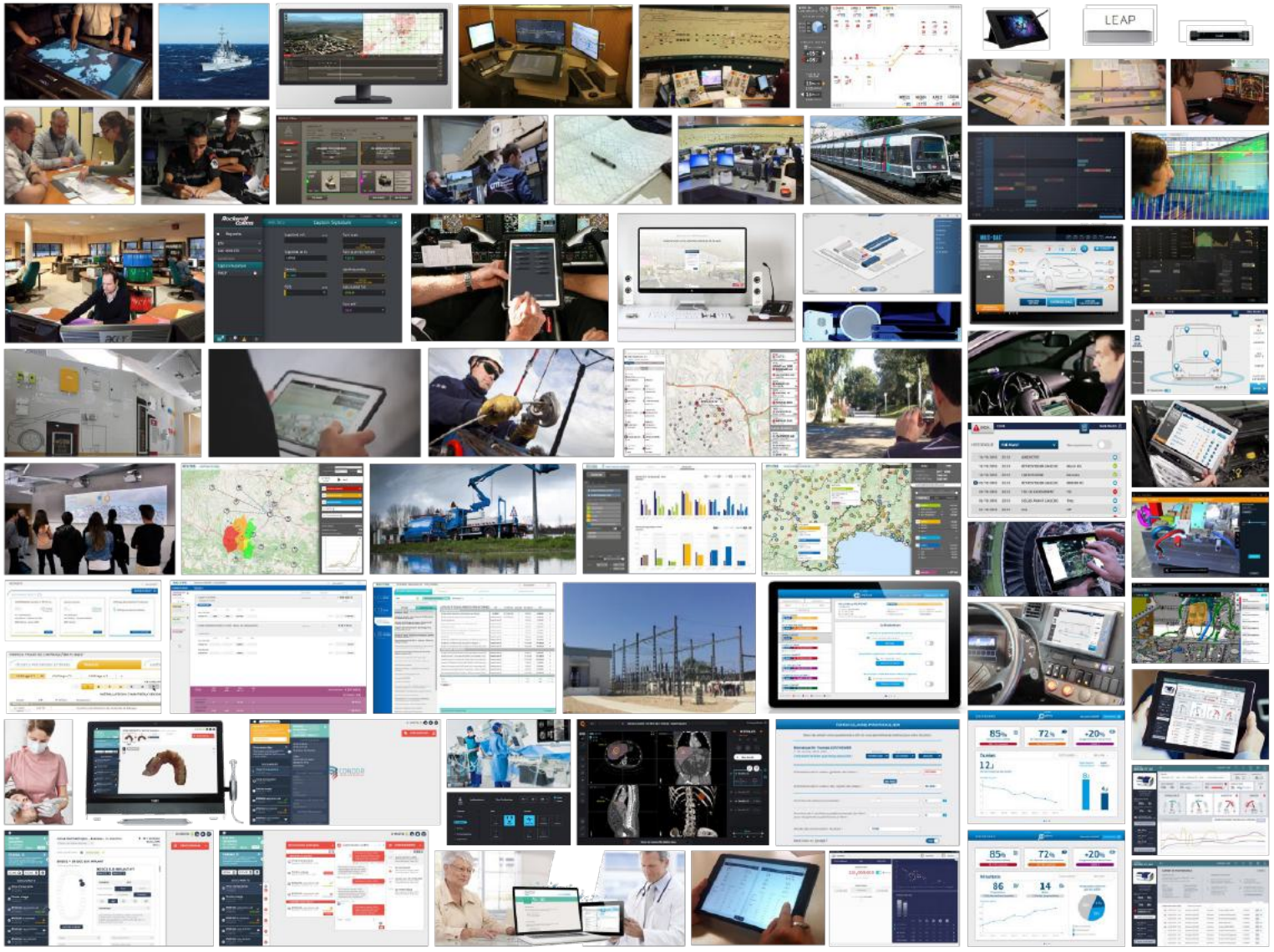
complex systems of systems

with humans & automation in the loop,

in the real world, for projects of various sizes

Ingenuity I/O

- More than 60 projects, 75% of them deployed in production



Breaking the complexity wall
in modern systems ?

Model-based representations
Iterative & **agile** approaches
Simulation & progressive **integration**

Humans & **automation** in the loop
(scenarios, activities, metrics, etc.)
Multidisciplinary teams (HF, HCI, etc.)
Whole projects **lifecycle**

Extended MBSE

+

Human-System Integration

Model-based HSI

+ TANGIBILITY

Practical support for Model-Based SE & HSI
during the whole project lifecycle

Making
Systems of Systems

observable
actionable
measurable
verifiable

INGESCAPE

The Ingescape solution

Open-source

INGESCAPE
Library

https://github.com/zeromq/ingescape

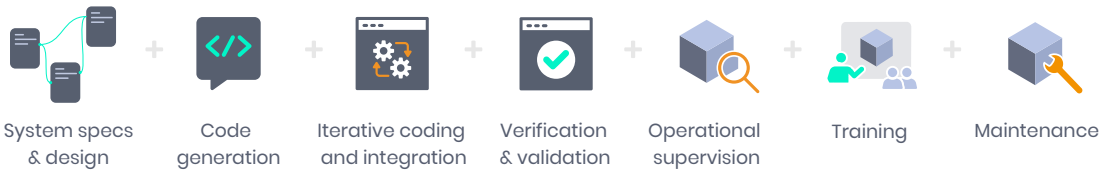
- Interoperability for any language, any OS, web, mobile, cloud & edge
- Highly supervised + fully decentralized
- Model-based

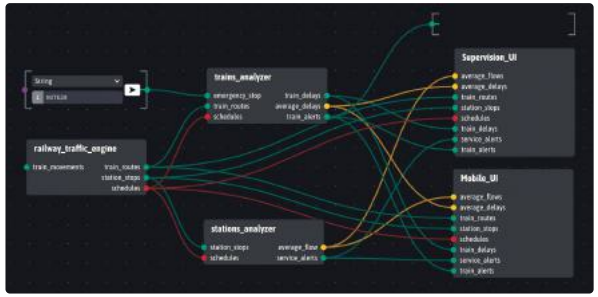
Commercial

INGESCAPE
CIRCLE

https://ingescape.com

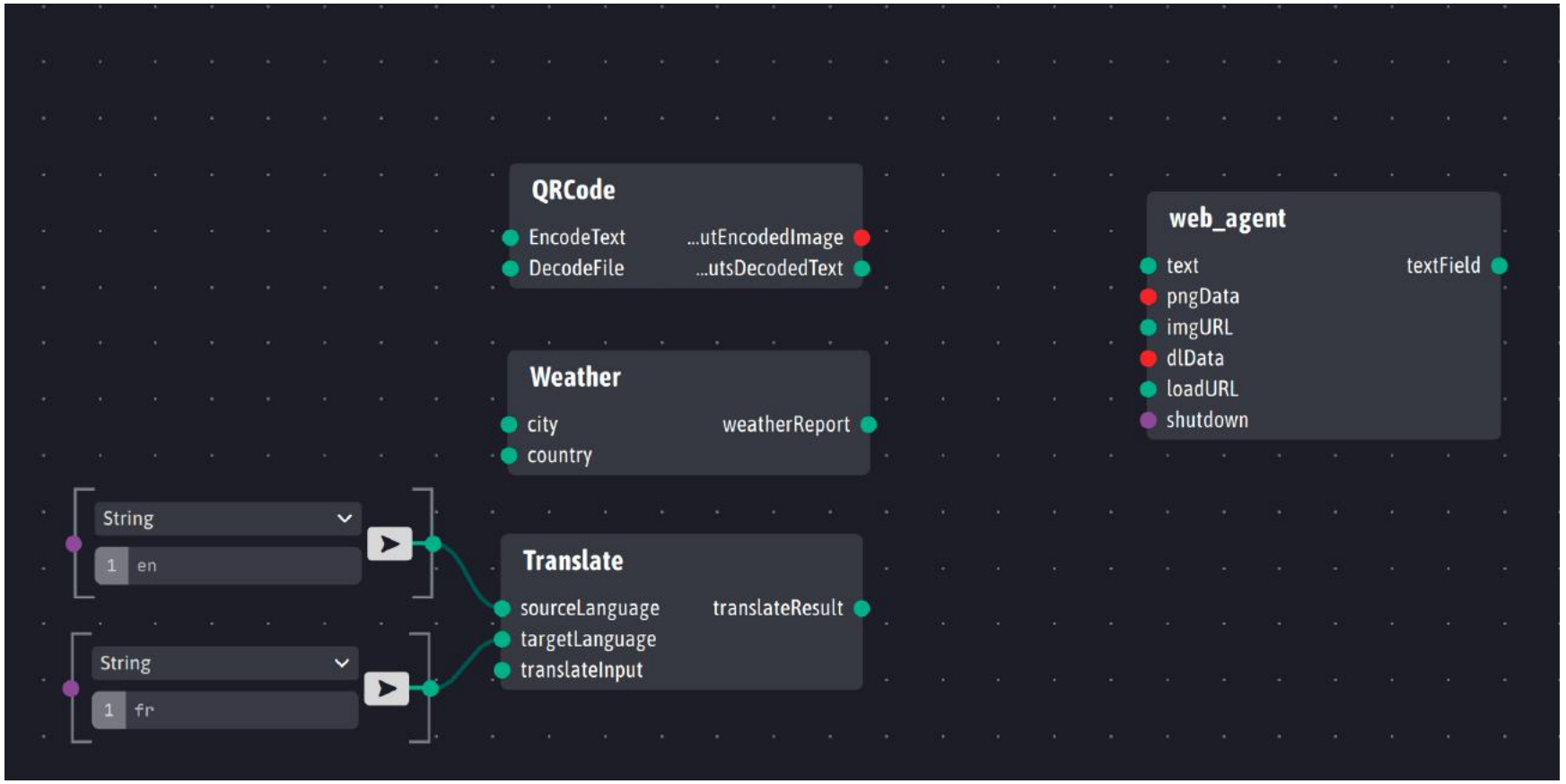
- Very innovative productivity & collaboration tool suite addressing the whole lifecycle of complex systems, involving all stakeholders continuously and iteratively





Demo #1

- A sample Ingescape platform



Ingescape is already used in many demanding industries

RATP

NATO OTAN

AIRBUS

sopra steria

Atos

EUROCONTROL

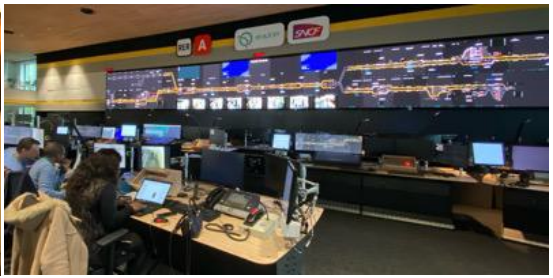
AIRBUS DEFENCE & SPACE

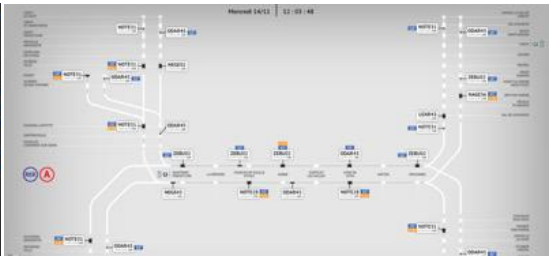
ENEDIS L'ELECTRICITE EN RESEAU

DGA

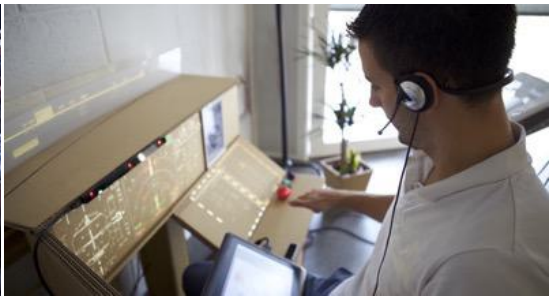
THALES

DASSAULT AVIATION

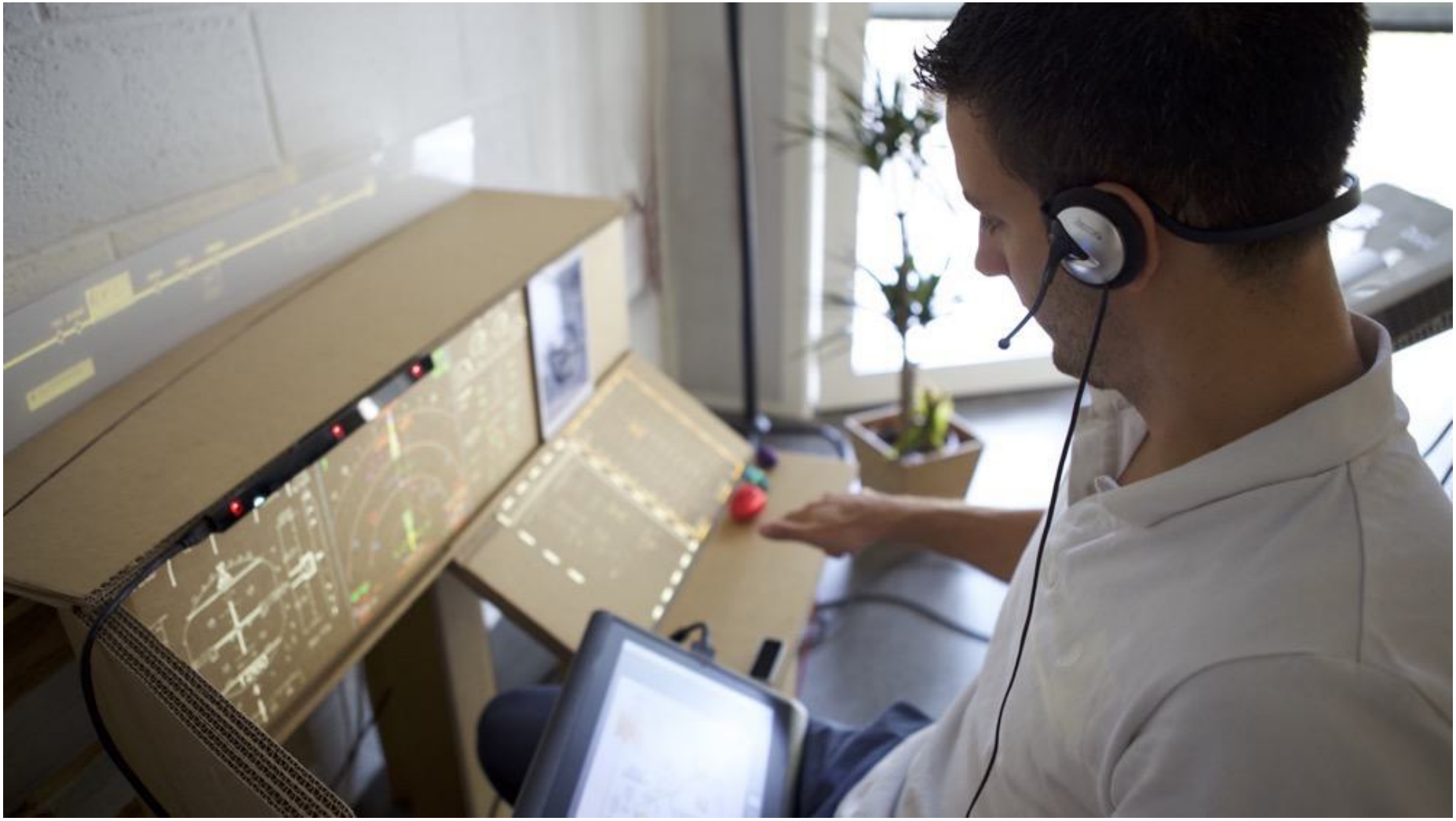









How it all started with Airbus…



https://www.youtube.com/watch?v=9Gr1Le_F7jU

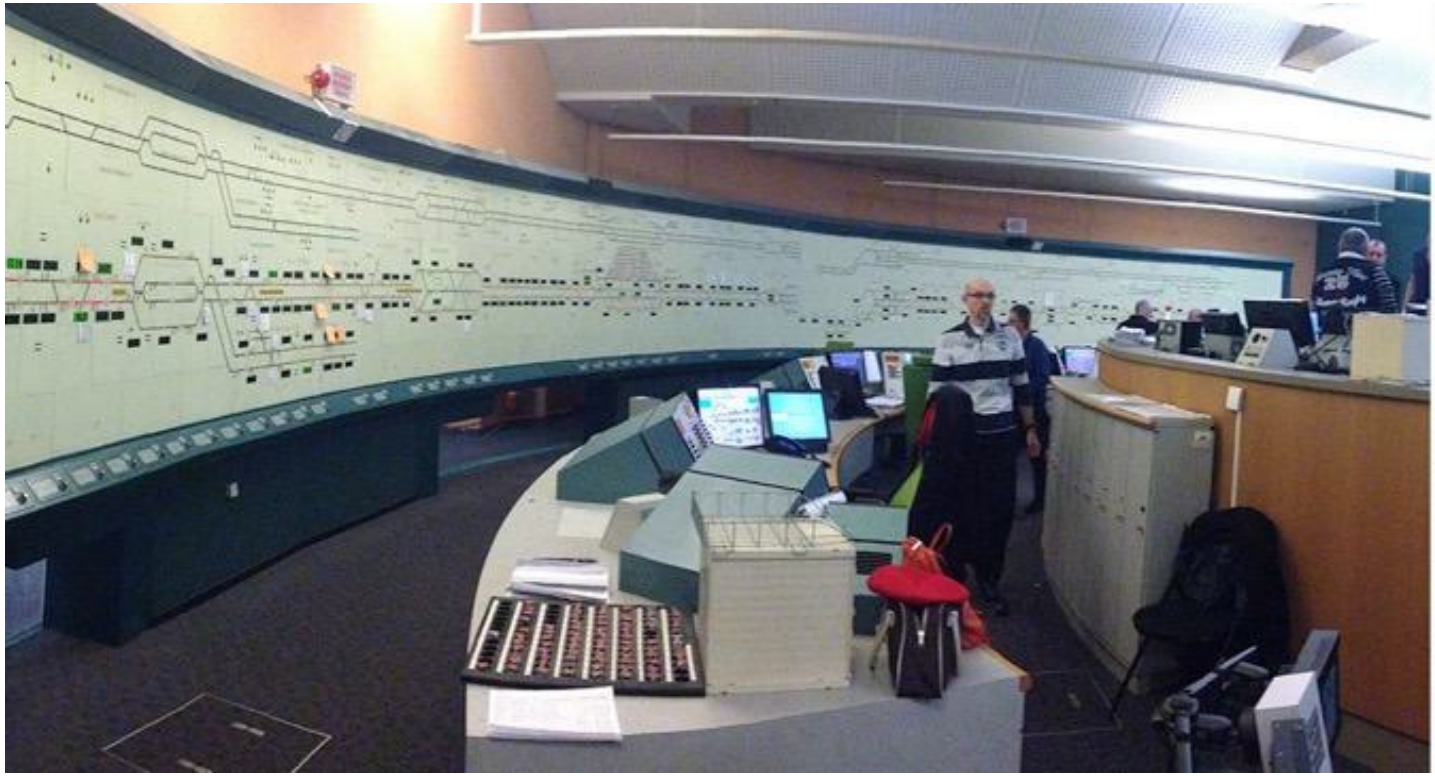
A non-exhaustive list of software, hardware and gateways already orchestrated with Ingescape

Operating Systems	macOS iOS, Windows, Linux, FreeBSD, ROS, android
Languages	C, C++, C#, python, JavaScript, Java, HTML, Rust
Frameworks & environments	node.js, unity, Qt, Apple, Microsoft .NET, eclipse, LLAMA C++, TensorFlow
Gateways with network	TCP UDP, ØMQ, kafka, MQTT, RabbitMQ, {REST:API}, Websockets
Gateways with protocols	protobuf Protocol Buffers, SNMP Simple Network Management Protocol, Modbus, VRPN

A real-world railway operational system designed & developed using MBHSI

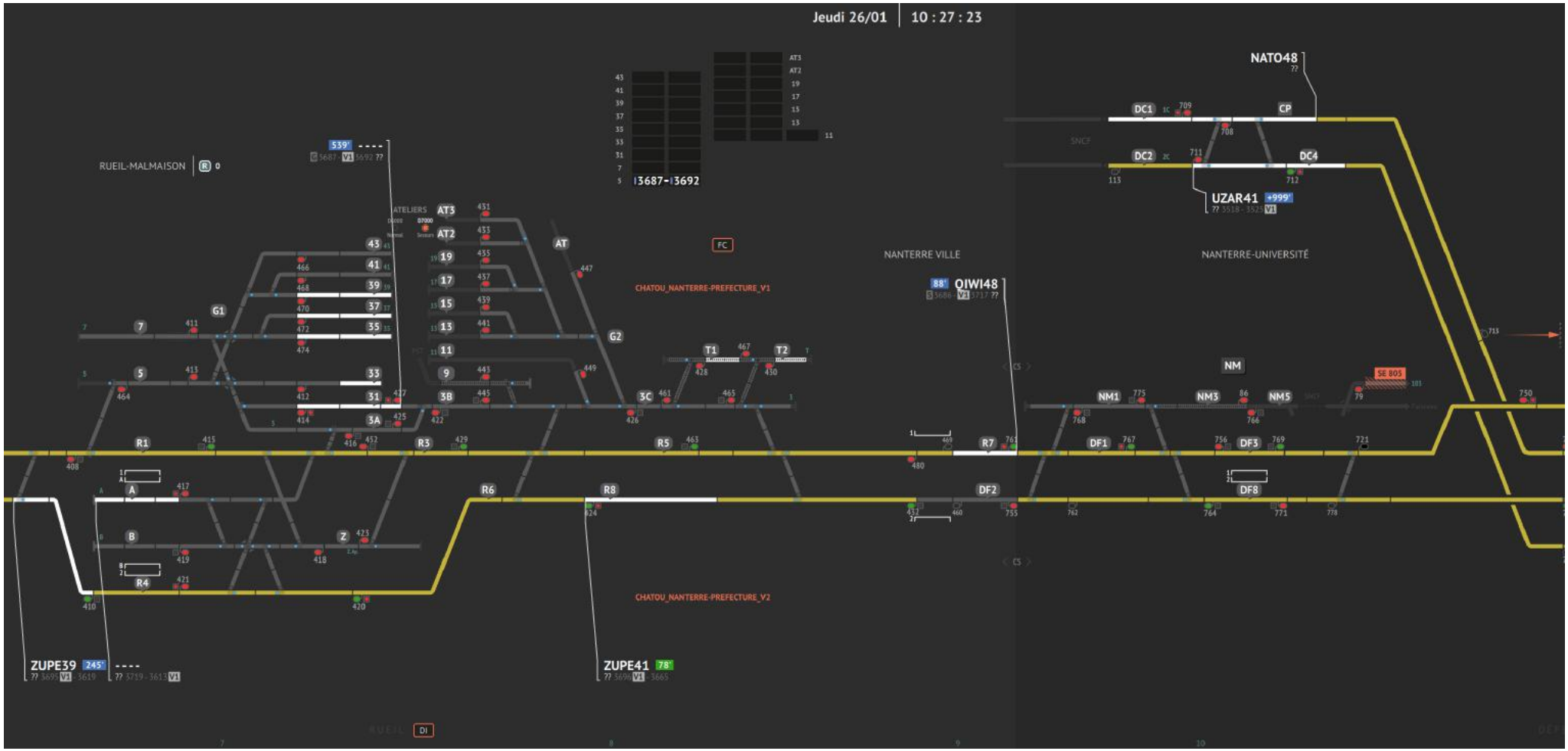
- **RATP RER A in Paris**
  - Largest urban train line in Europe (1.2M pax/day, more than 250 trains/day)
  - New system deployed in January 2024
- **64 systems orchestrated with Ingescape**
  - Field equipment command & control, alerting, authentication, archiving, itineraries, trains parking, missions/trains/drivers management, etc.
  - 598 inputs/outputs
  - 438 services
  - 6664 monitored field equipment
  - 1580 messages/second
- **21 real-time gateways to external systems**
- **9000+ applicable requirements**
- **16 workstations and an 18-meters wide LED display (5 x UHD)**

How it was before...

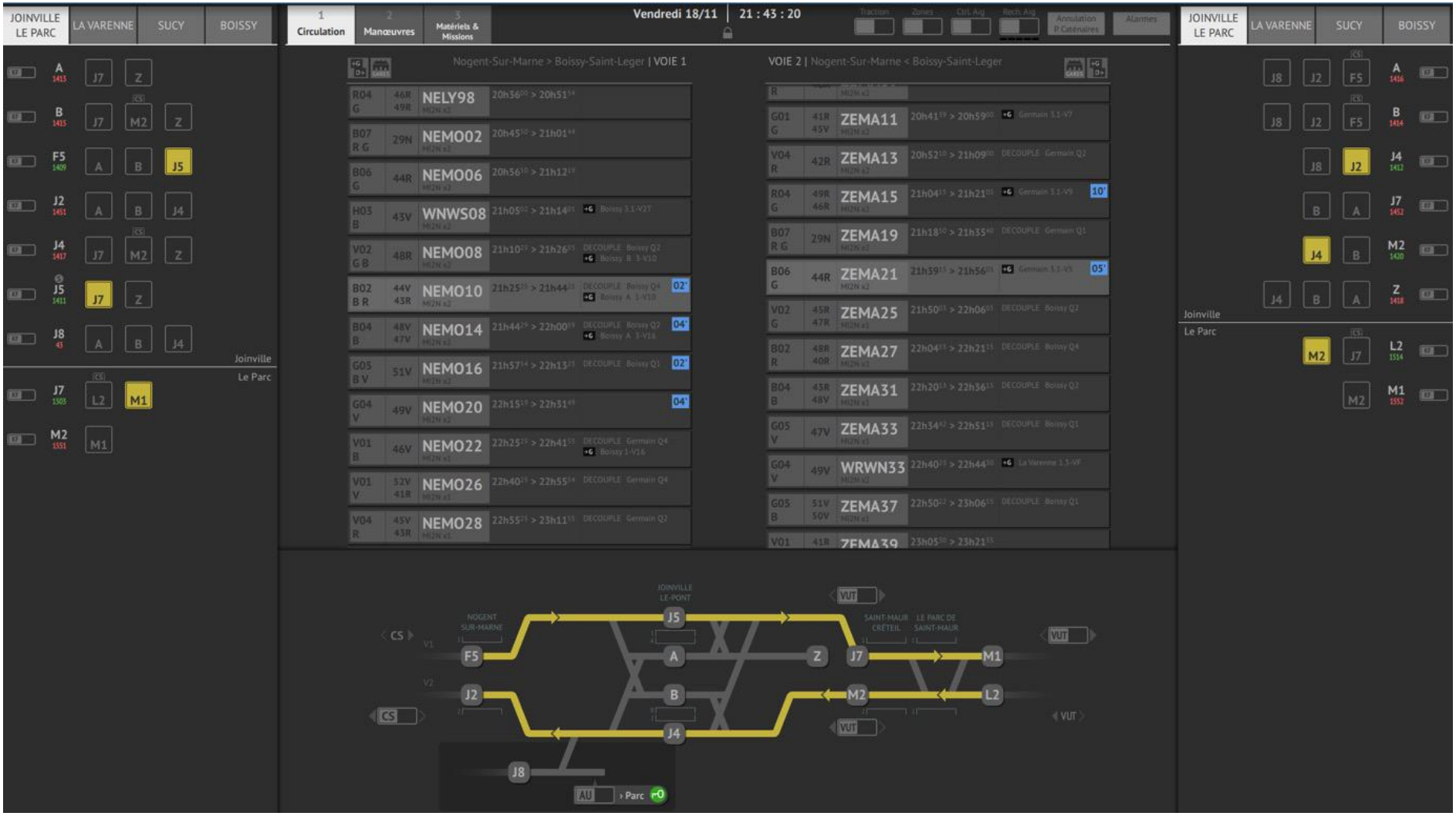


Activity analysis + Participatory design + Iterative prototyping + Formative assessment

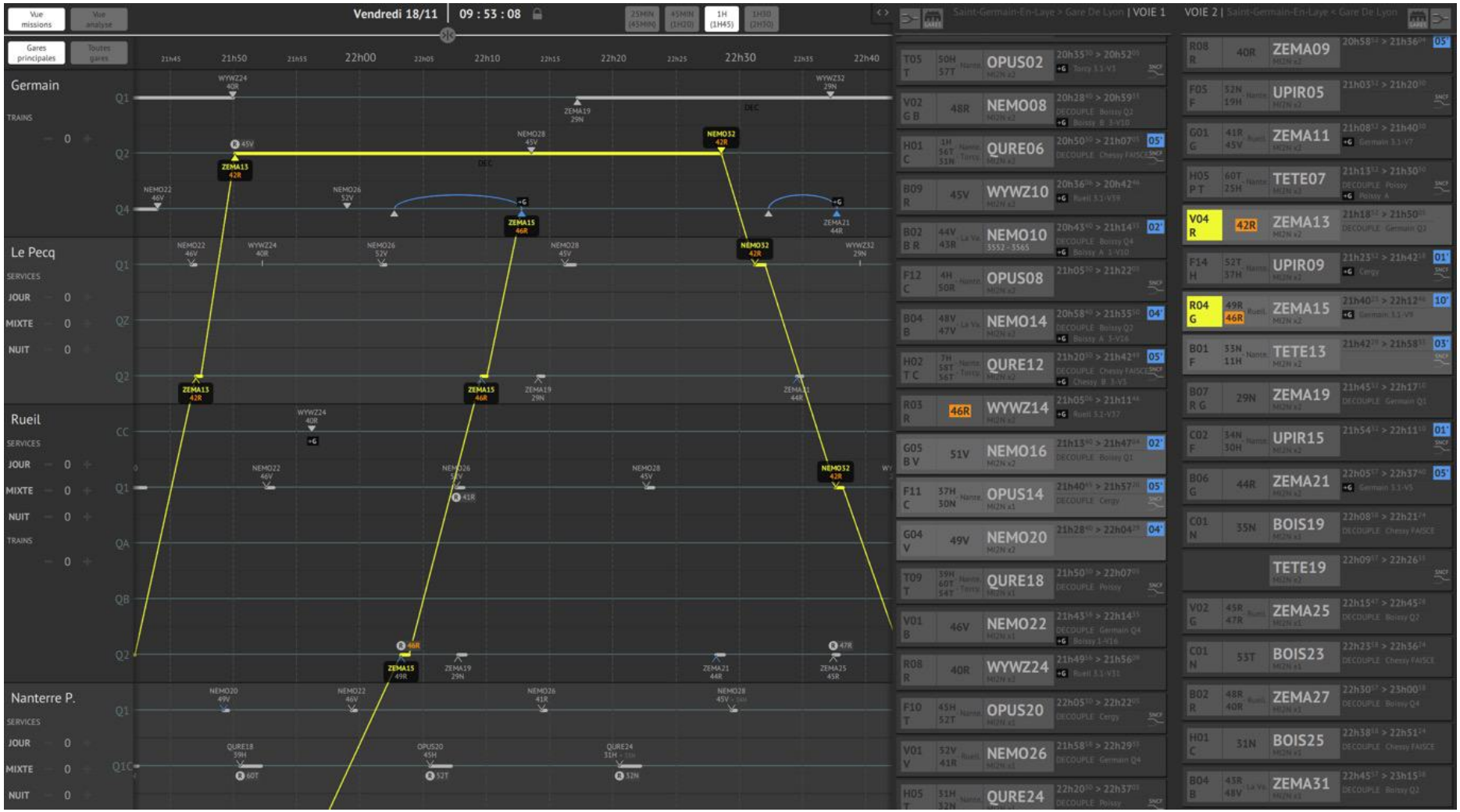
Real-time supervision



Command application on a touch tablet



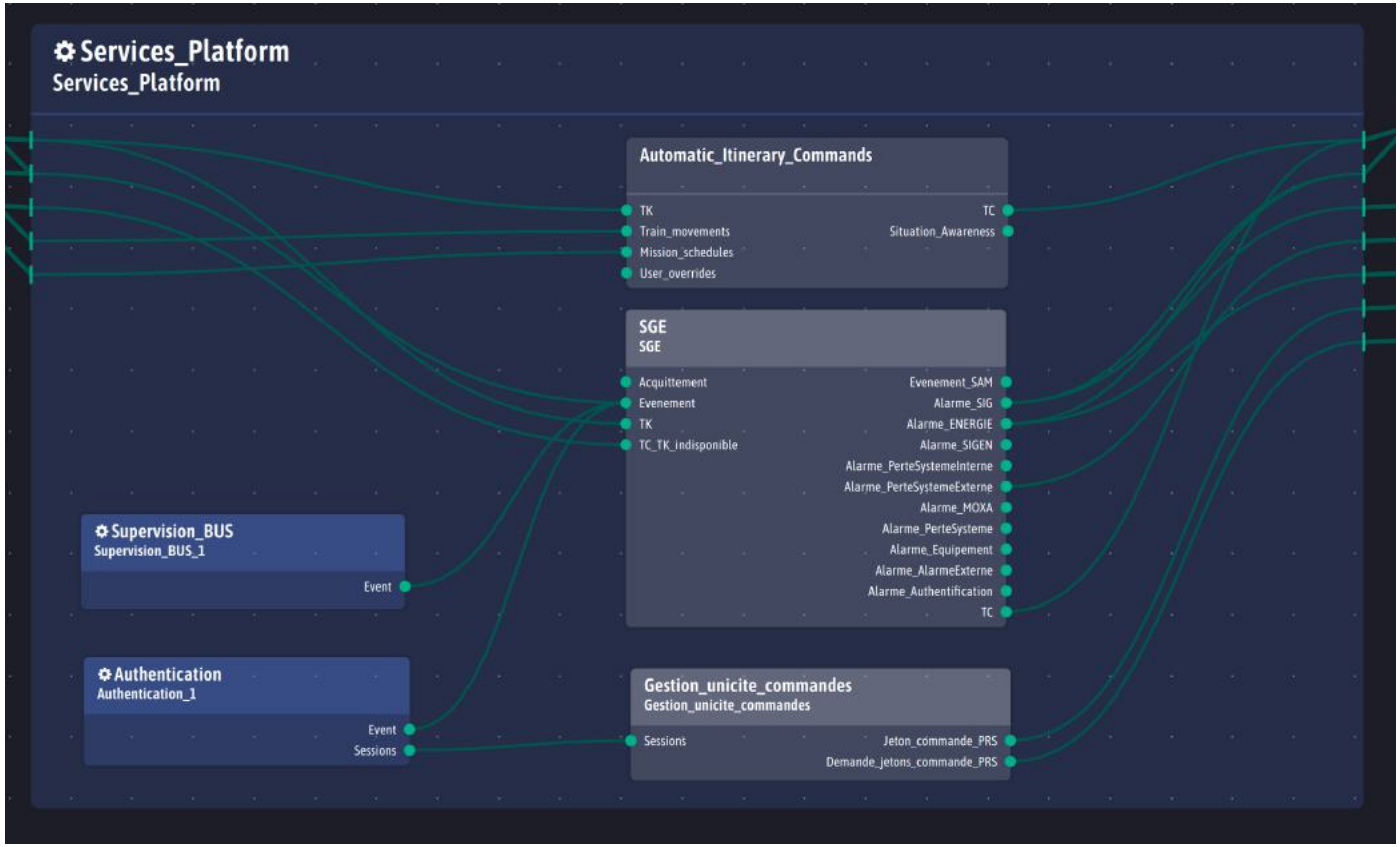
Real-time regulation with decision helpers



Overview of the resulting control room

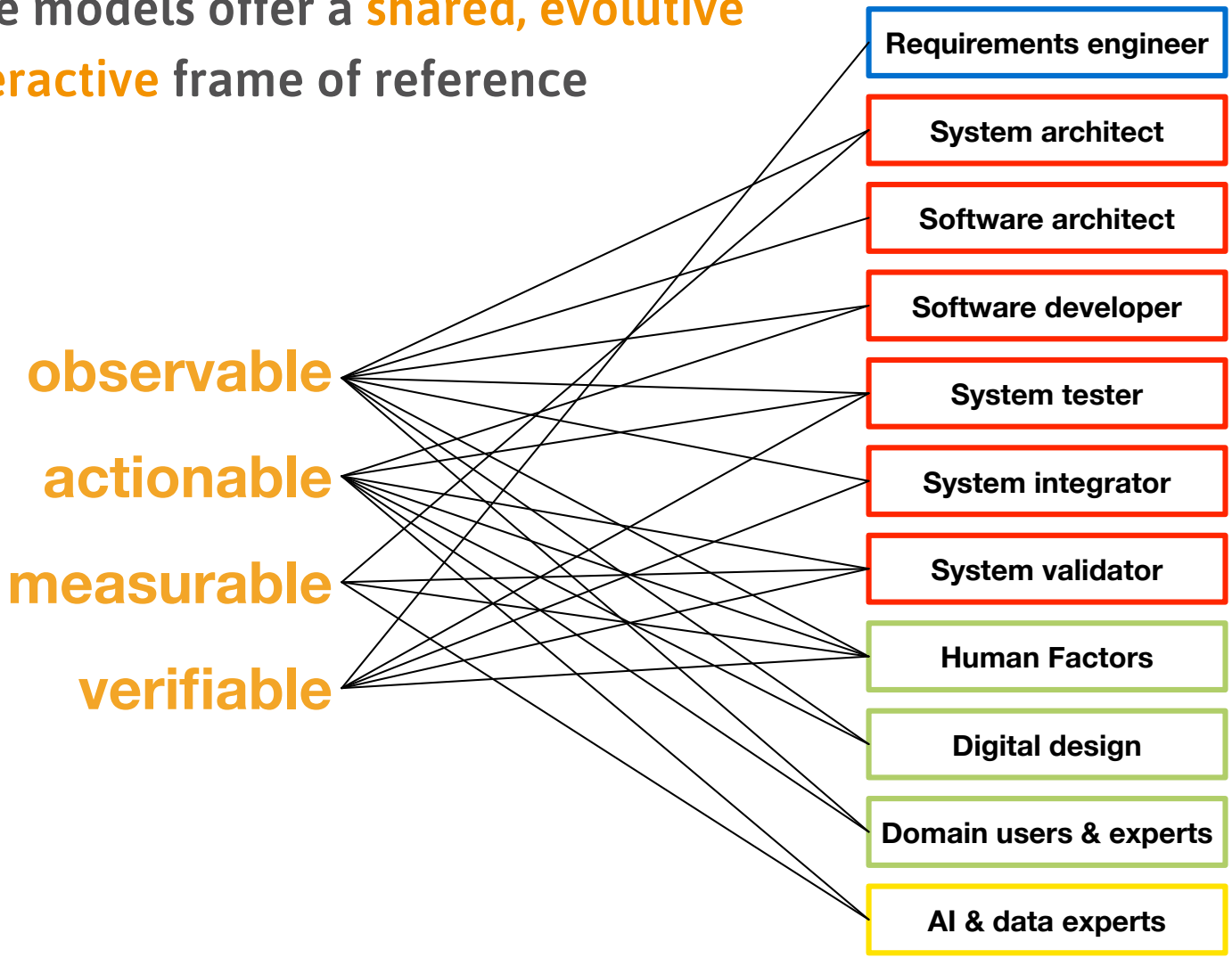
Demo #2

- **Three examples of Ingescape systems**
  - An import from Capella
  - An activity structure from the spring school use cases
  - The railway operational system

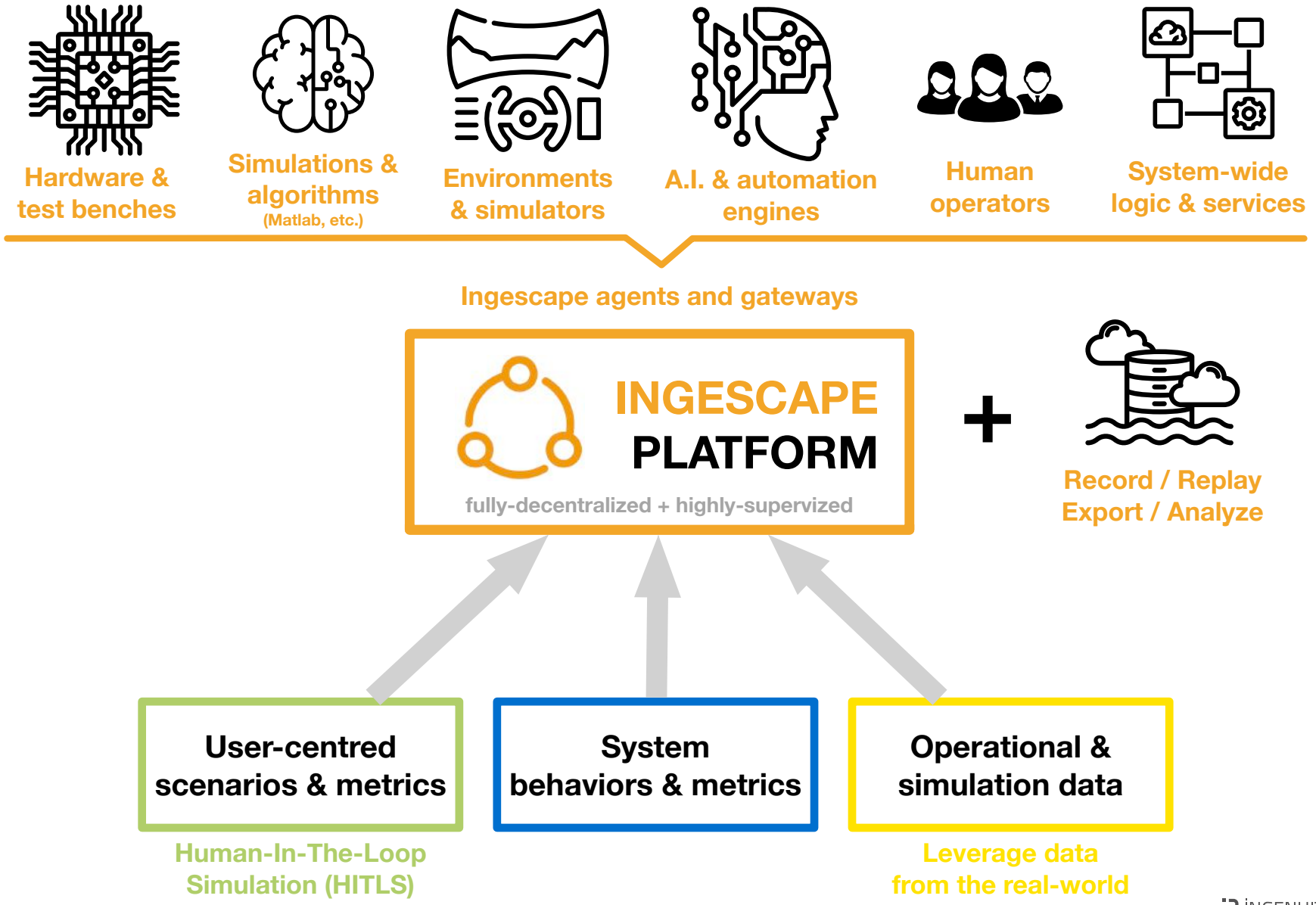


Make all profiles collaborate together

- Tangible models offer a **shared, evolutive and interactive** frame of reference

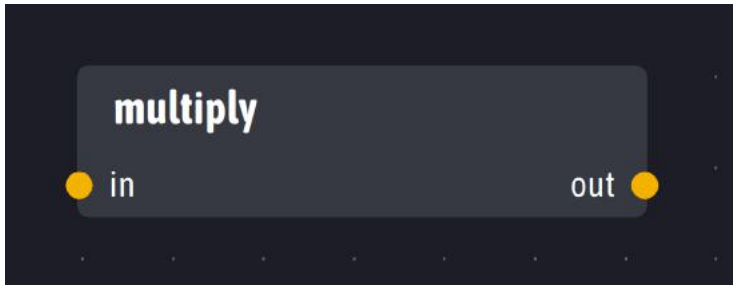


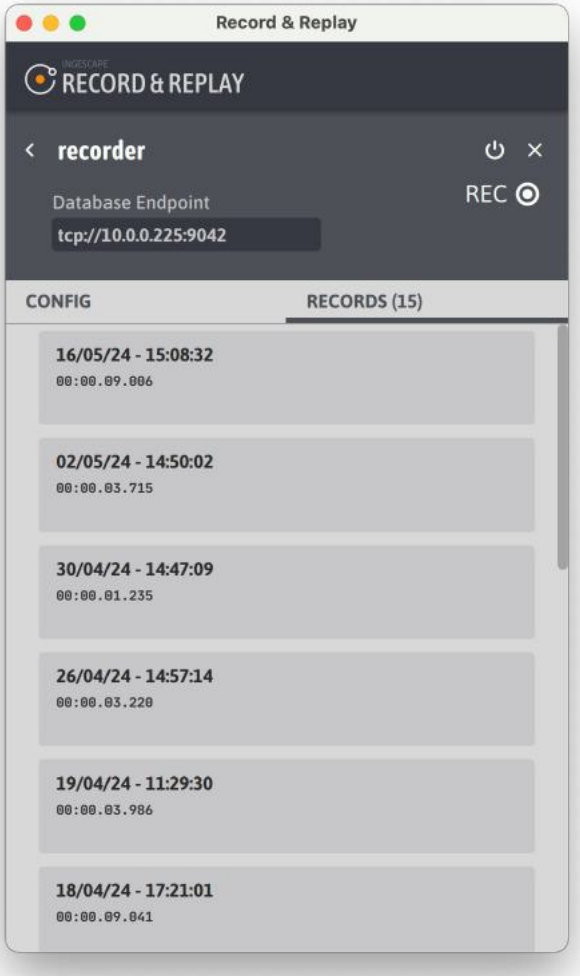
Unified platforms for
Simulation & Integration & Operations



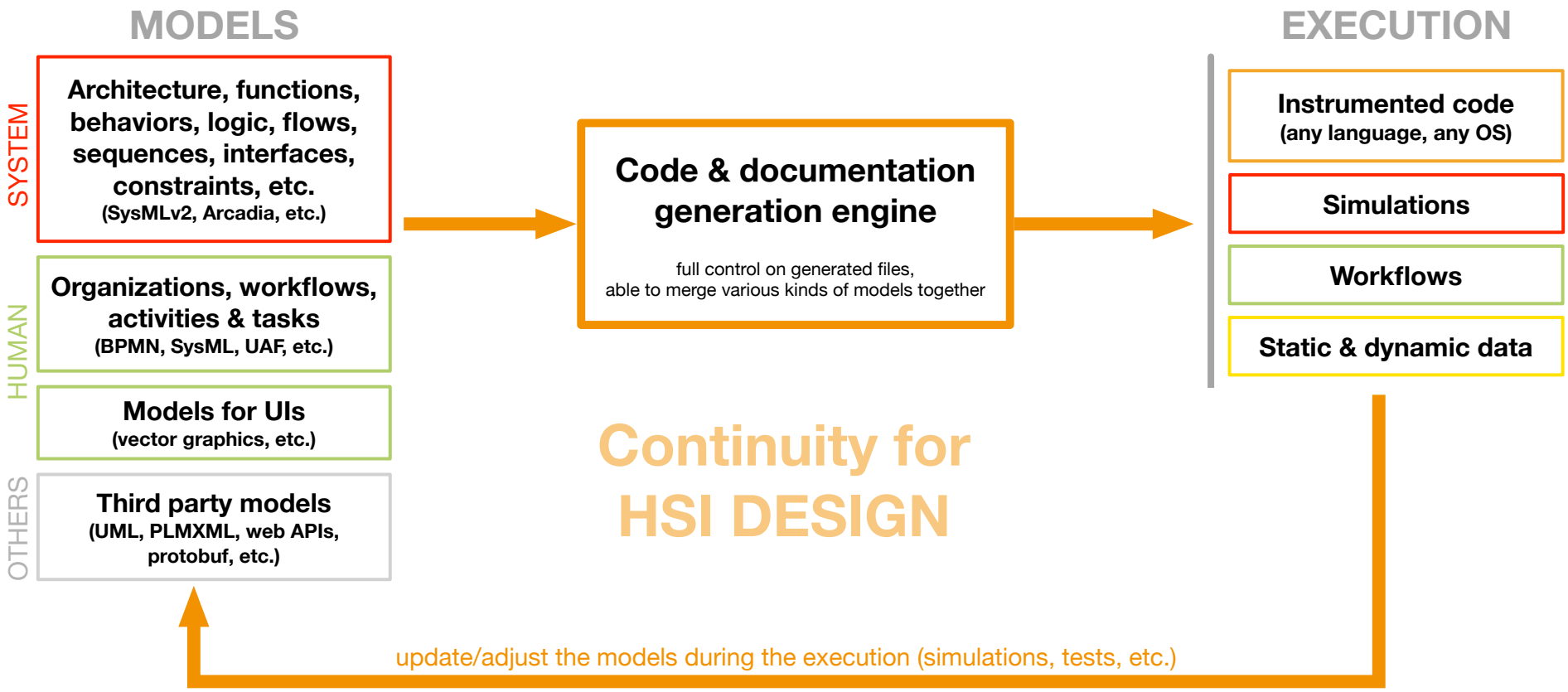
Demo #3

- Creating a new agent using code generation
- Global record/replay features





Continuous & iterative
model-based design



Capturing & measuring
organizations, workflows, tasks and activities

OMG SYSTEMS MODELING LANGUAGE SysML™

BPMN™

UAF® OMG UNIFIED ARCHITECTURE FRAMEWORK®

Workflows

Branch

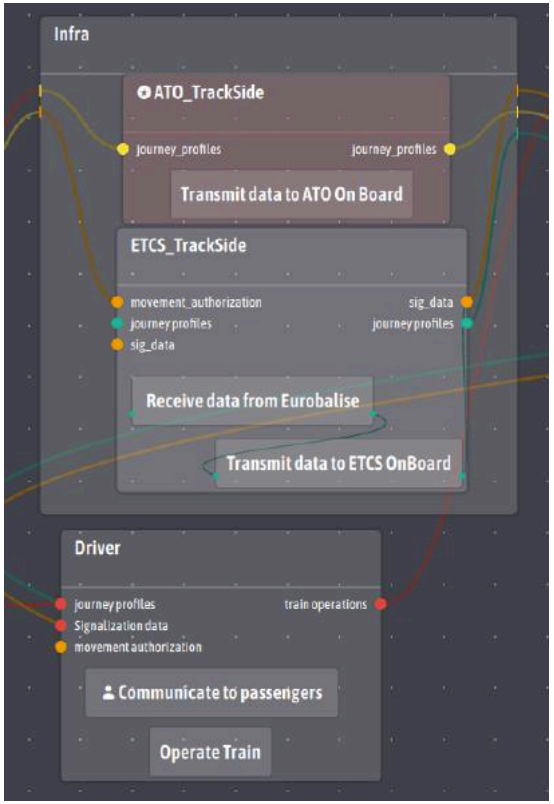
Loop

Synchro

Timer

Task

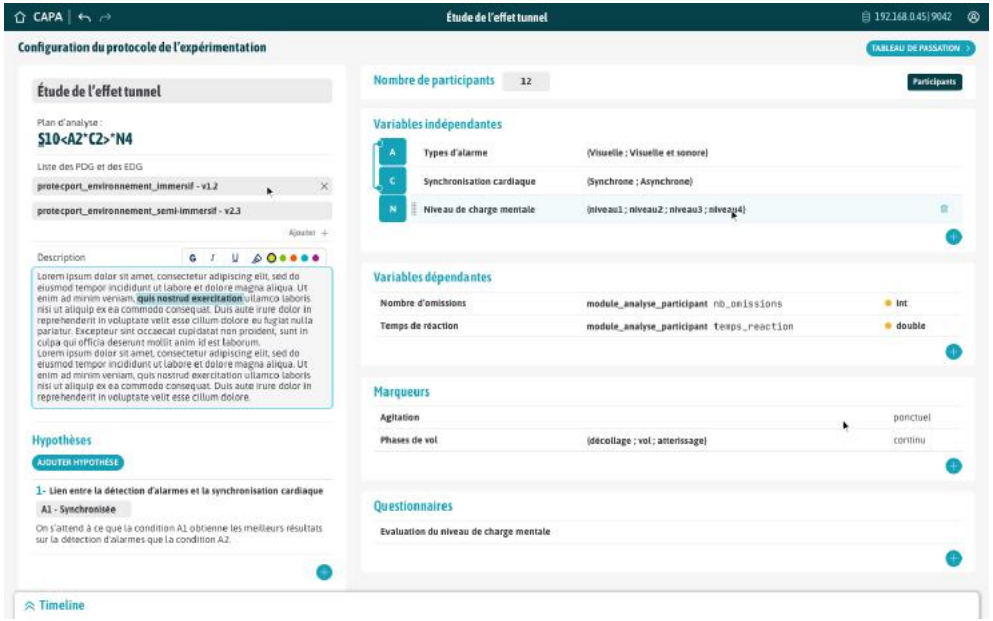
Organizational structure

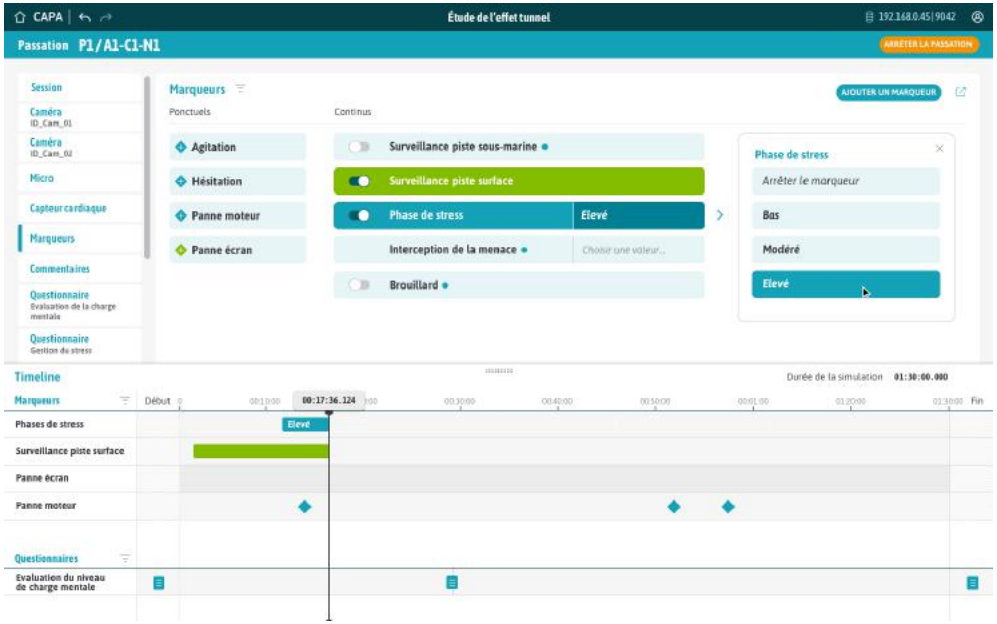


Timelines & scenarios

Metrics & resources

Scientific assessment





- **Detailed protocols for scientific proof**
  - Hypotheses
  - Scenarios
  - Variables
  - Participants
  - Markers
  - Questionnaires
- **Assistance to live evaluation sessions**
- **Automatic data collection & structuration with statistics**
- **Easy export to advanced statistics & data analysis solutions**
- **Assistance to data analysis and reporting**

Demo #4

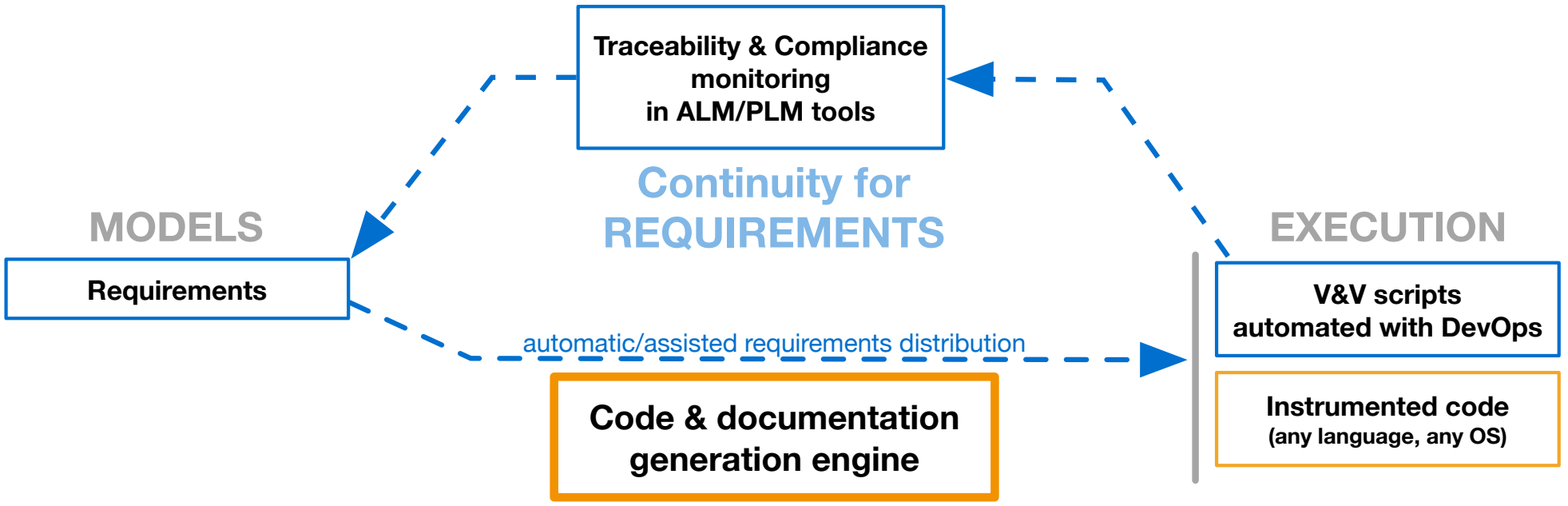
- Let’s do some Verification & Validation

```
"REQ 1.0.1" "range of values"{
    multiply.in = 2.5
    assert multiply.out == 5.000000
    multiply.in = 0
    assert multiply.out == 0.000000
    multiply.in = -2.5
    assert multiply.out == -5.000000
}
```

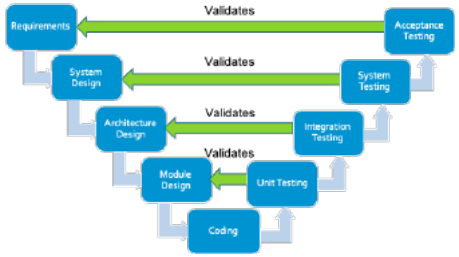
- https://ingescape.com/verification-validation-using-ingescape/

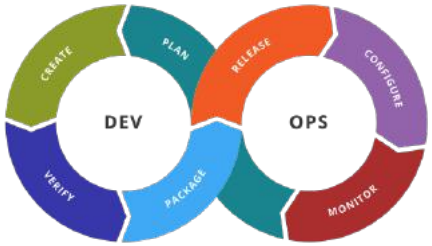
Continuous and automated
Verification & Validation

- A dedicated language for V&V, accessible to all profiles
- Involving system + human metrics

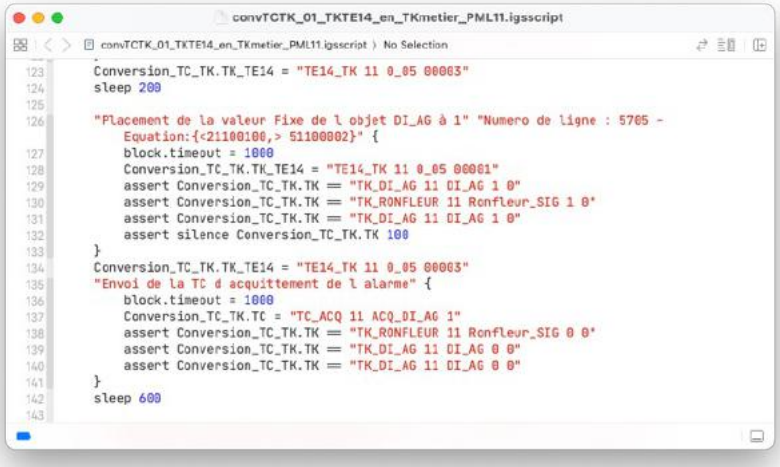


V&V automation for the RATP RER A project





- 116 scripts
- 144 392 lines
- 20 189 test blocks
- 320 requirements with human-assisted verification
- 2537 requirements verified automatically
  - Tested via DevOps at every change
  - Results sent to HP ALM after each DevOps cycle



Ingescape measured benefits

Model-based architecture and interface contracts

up to 75% 50%
Time & effort reduction

Continuous and iterative Testing

up to 90%
Effort reduction

Verification & Validation

up to 80%
Effort reduction

Global gains

in projects range between
30% and 47%

Bootstrap software projects

In a few seconds
In full accordance with your practices

Real-time system supervision

100% Automated
No additional code

Thank you!

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https://ingescape.com