HSI Spring School
Use Case 2
Designing an operation room for a fleet of robots on an oil rig.

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Introduction

- Oil Rigs are remote locations, with harsh conditions for human operators.
- Design production facility that can be operated without human on site during a long period
- Robotic operations are a game changer
- The study aims at defining the emerging human functions when introducing robotics in operations.

Robotic on oil rigs

https://totalenergies.com/media/video/getting-ready-robot-operated-oil-rigs

Argos project

- R&D project, Next Generation Facilities (NGF) (launched in 2013): rethinking the architecture of platforms, so that they are more reliable and require little maintenance.
- ARGOS (Autonomous Robot for Gas & Oil Sites) Challenge (2014 - 2017): designing and building the first prototype of an autonomous, ATEX (ATmosphères EXplosives) surface robot capable of operating on TotalEnergies sites autonomously, detecting anomalies and alerting operators.
- Development of three types of robot.

  1) Inspection robot.

  2) Robot capable of performing simple manipulations for operation tasks.

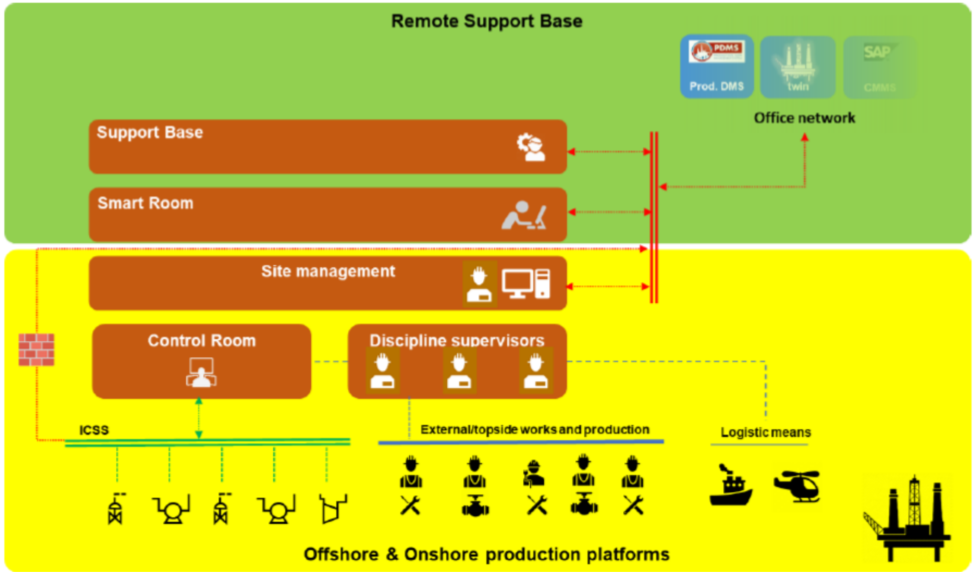
  3) Robot capable of performing complex manipulations for maintenance tasks.

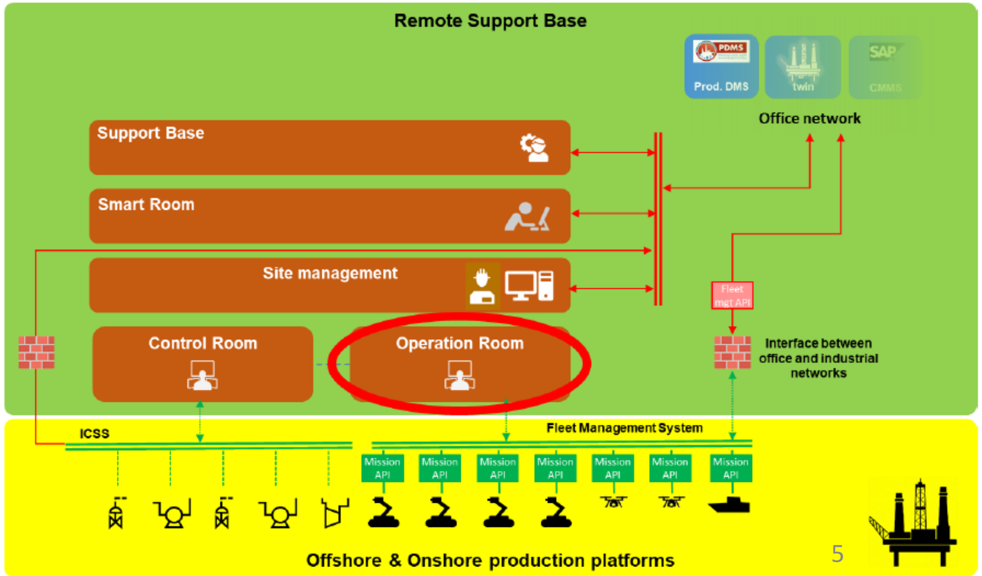
Redesign of the organization of the platforms

- Facilities operated by robots, which would be controlled remotely via the operating room.
- Operating room next to the existing control room, which would also become remote.
- No need for continuous human presence.
- From the operating room, remote supervision and coordination of the robots by the operators. The robots would autonomously perform the activities that field operators used to do on the installations: routine tasks, maintenance, emergency operations.
- Human interventions limited to short-term maintenance campaigns.

Objectives:

- To study the impact of the introduction of robotics in the management of operations, which will be carried out from the remote control room and operating room of the site.
- Specify the organization of the new "operating room" entity and identify the skills that the operators of this room must have.





Robot fleet

- Level of autonomy
  1. Remote controlled (you see the robot)
  2. Remote operated (you see through the robot)
  3. Semi-autonomous (supervision)
  4. Autonomous
- Heterogeneity / Homogeneity

  Fleet of different robots or swarm of identical robots
- Control structure

  Centralized, hierarchical or decentralized
- 6 Interaction models depending on fleet awareness and objectives

Interaction models

Modèle	Mutual awareness	Objectives	Dependency between objectives
Collective	no	Shared	yes
Cooperative	yes	Shared	yes
Collaborative	yes	Individual	yes
Coalitional	yes	Shared+ Individual	yes
Coordinated	yes	Individual	no
Competitive	yes	Shared+ Individual	no

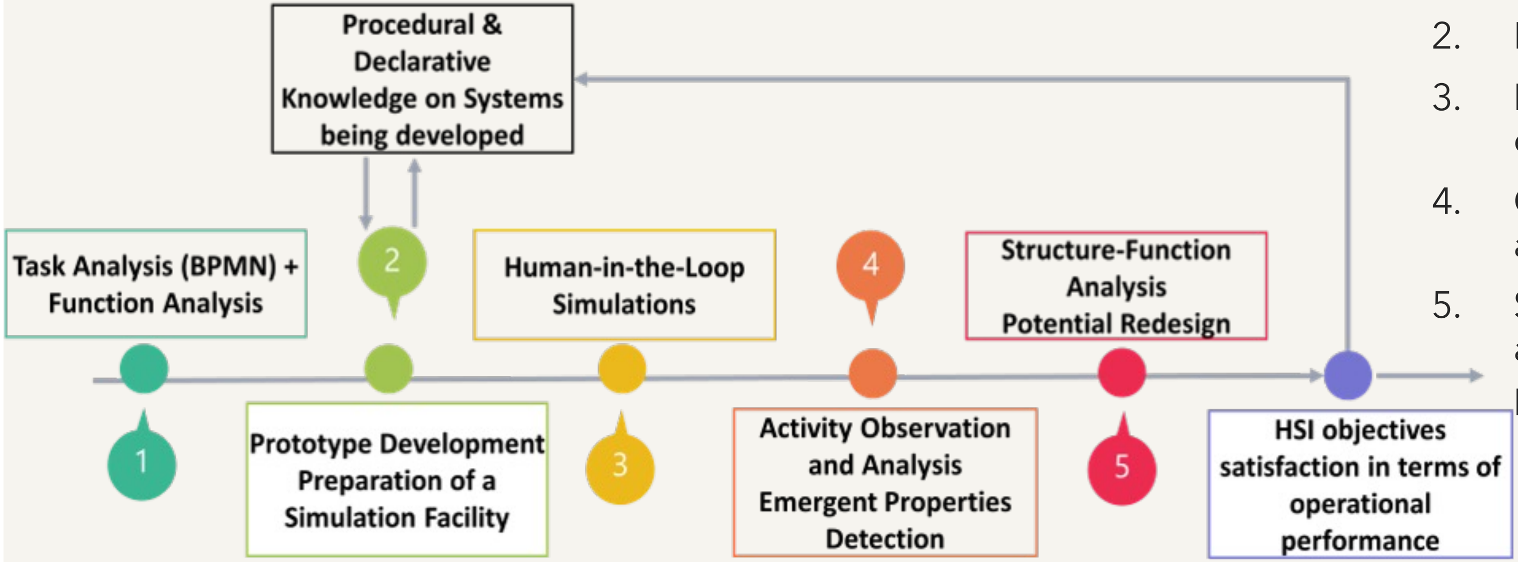
Depend on factors (Parker, 2007 ; Autefage, 2015)

- Mutual awareness between the robots to achieve their goals (not just collision avoidance)
- Nature of the objectives
- Dependency between the objectives

Project objectives

- Can you develop a control room for a fleet of robots before the robots exists ?
- What will be the impacts of controlling such a fleet on the overall organization ?
- Can we apply the PRODEC methodology from the MMT project to another case study ?

How do we go about



There is too many activities to cover them all

1. Select a pool of scenarios of increasing complexity.
2. Model one scenario
3. Identify necessary functions for each agents
4. Create one or several new allocation of these functions
5. Simulate these processes, analyse and add these to the pool of processes

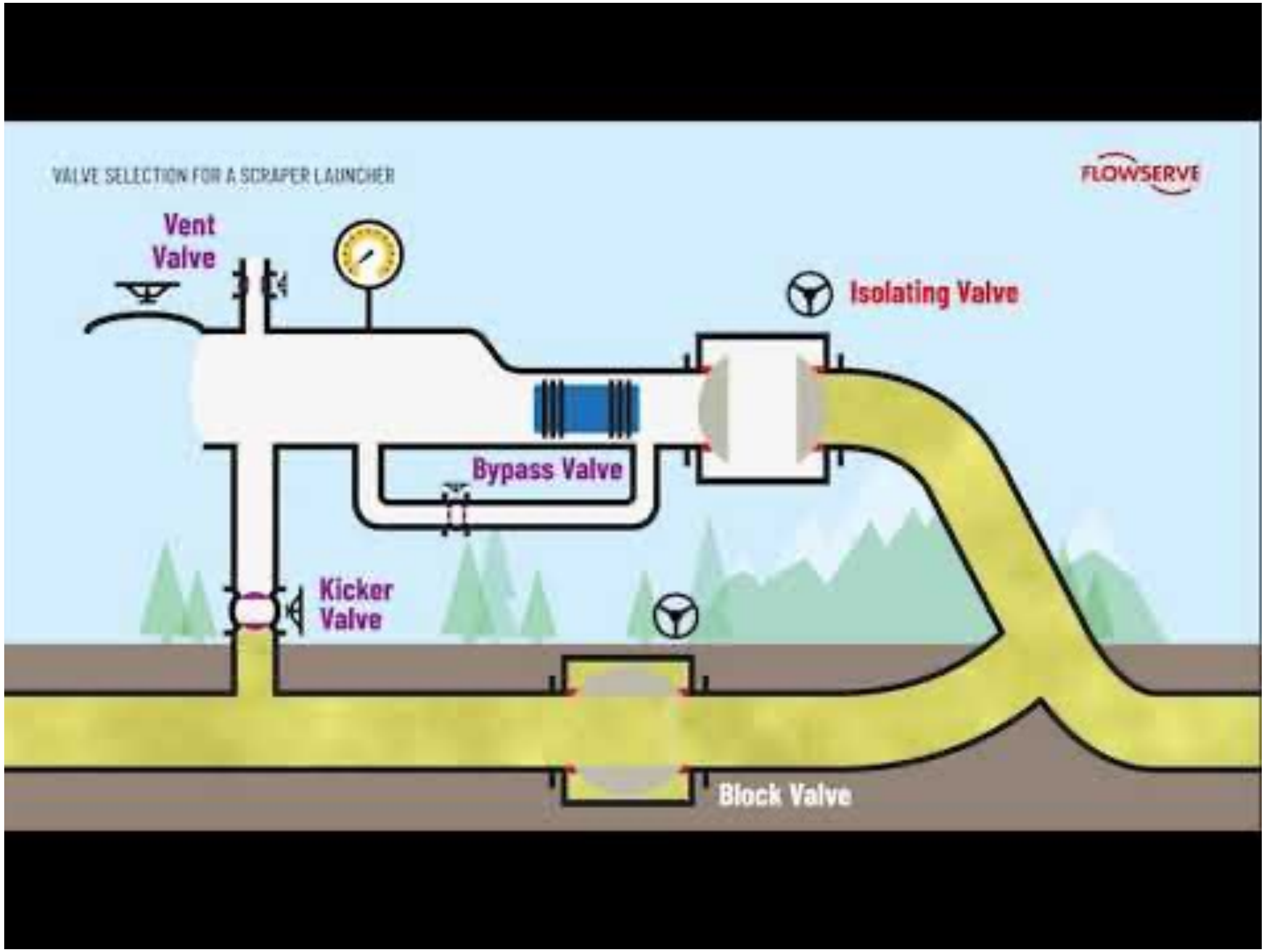
Pool of scenario

- Gas detectors calibration.

  A routine activity, with some manipulation and coordination with the control room

- **Pig launching**

  A more complex activity involving, many manipulation and coordination between agents



Pig launching

Collecting Usage - Interviews

Several experts are interviewed

- Gaz detector calibration
  - A former site manager
  - A former maintenance superintendent
  - A former maintenance supervisor
- Pig launcher
  - A former operations manager / production superintendent
  - A production supervisor
  - A driving technician

Info collected

- Actors involved
- Tasks realized
- Tools and resources necessary
- Temporal and spatial information

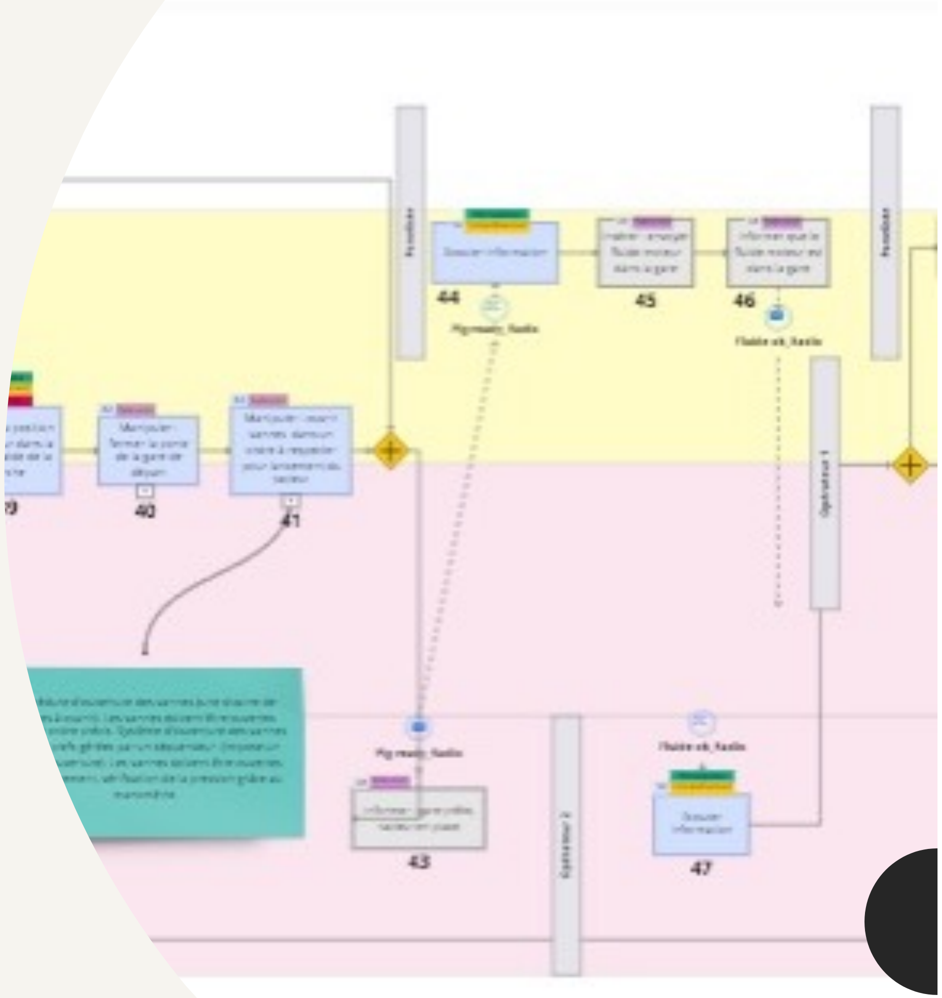
Modelling

- BPMN Modelisation :

  Multi-agents modelling

  Multi-level modelling

  Cross validation with the experts



Functional Analysis

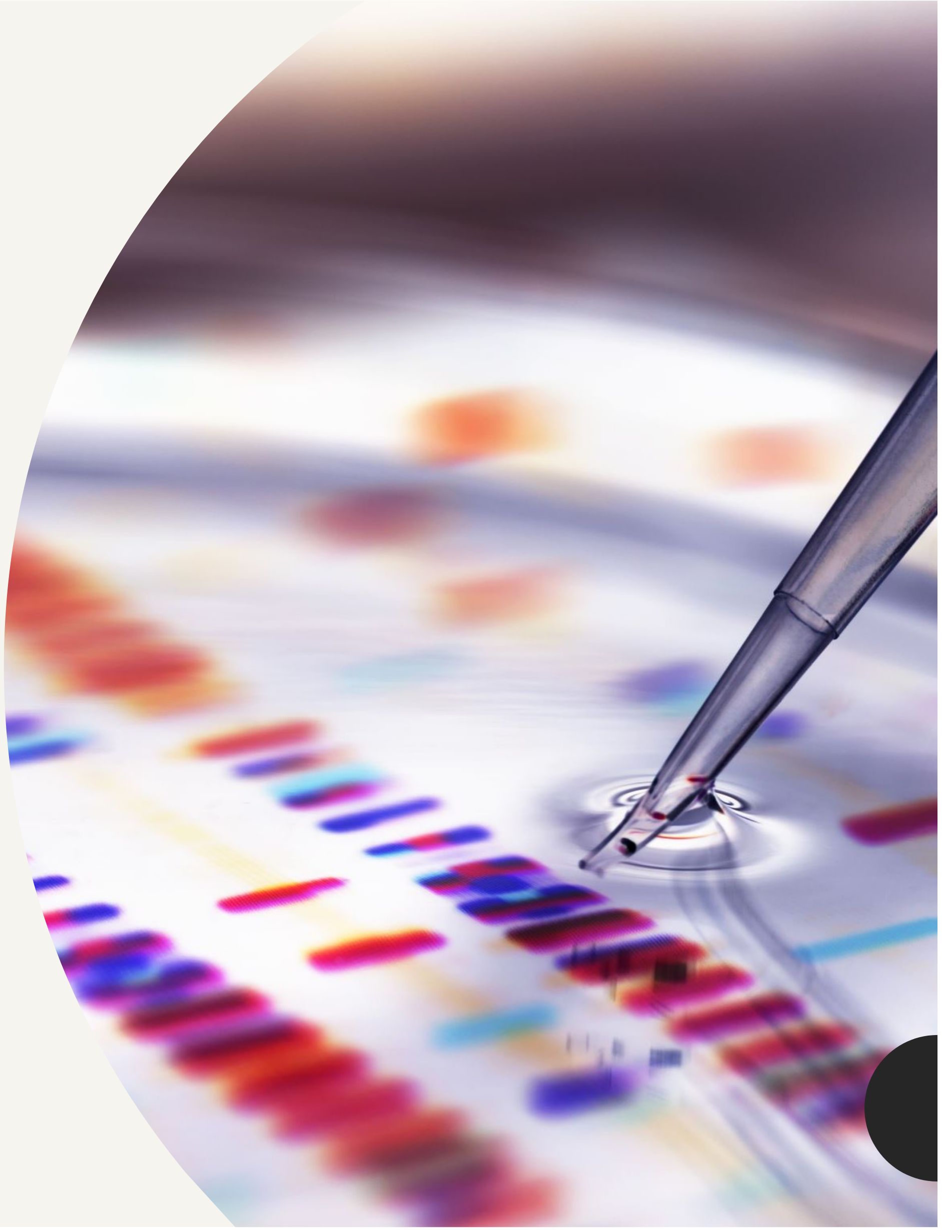
- Function are attributed to the different agents
- Ontological approach to generalize functions
- Classification according to

Situational Awareness Level *(Endsley, 1995)*

1. Situation Awareness (S)
2. Decision making (D)
3. Action (A)

Rasmussen levels of functions (Rasmussen, 1983).

1. *Skills based (1)*
2. *Rules based (2)*
3. *Knowledge based (3)*



New task allocations

- Based on As-is scenario
- Functional Analysis

  e.g. verification and inspection task are kept on human

  Listening and informing become receiving and sending information
- Predicted functional capabilities of the robots

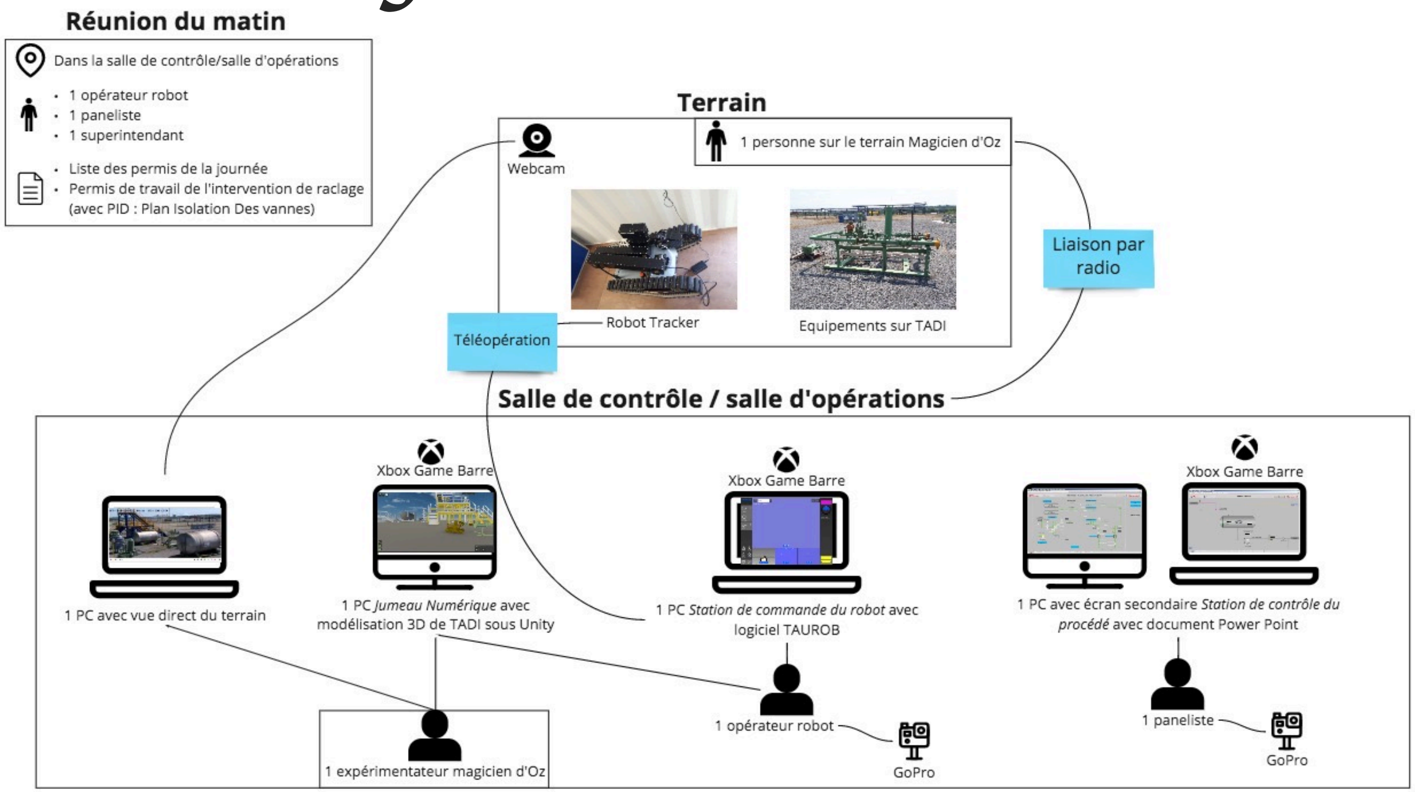
  We can predict from the analysis some capabilities (carrying, identifying etc..)
- Prescribed organisation of the oil rig (

  separation control room (process) / operation room (robot fleet)

  Iterative process involving experts and creative sessions

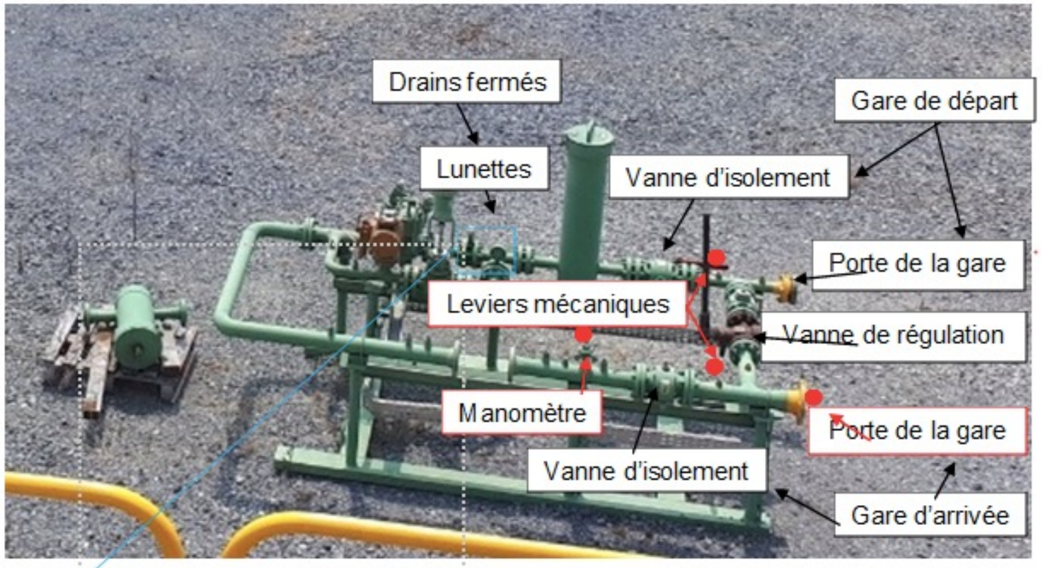
  Several concurrent scenario have been proposed and discussed for the simulations

Human in the loop simulations Wizard of Oz



Human in the loop simulations

Physical and digital twin

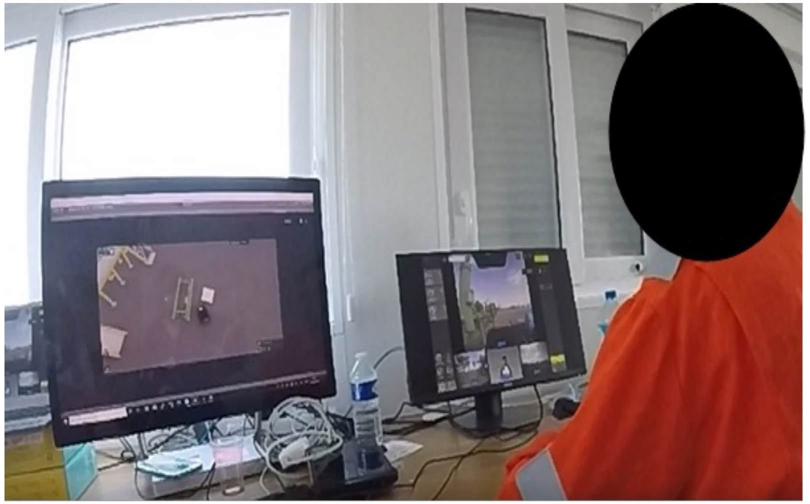


Fake equipement to simulate a pig launcher

Digital twin of the equipement and robot

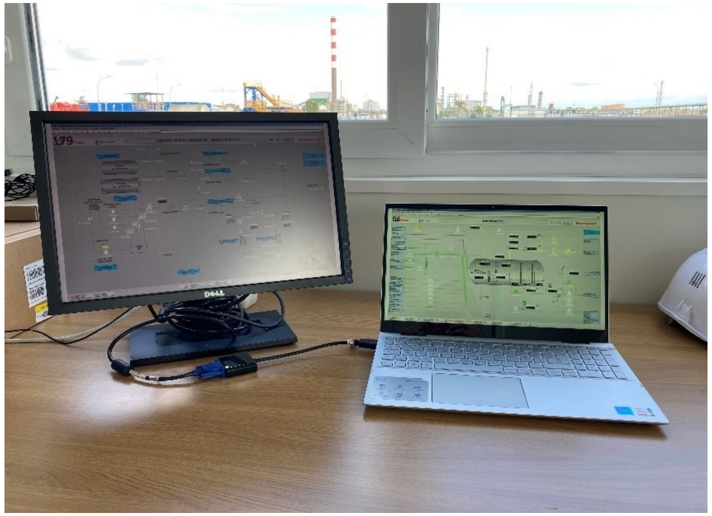
Human in the loop simulations

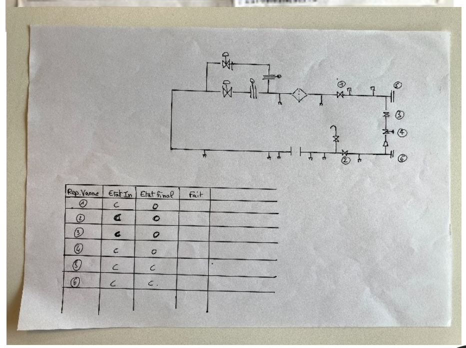
User interfaces and resources



Operation room :

Digital twin (left)
robot remote controler (right)





Control room :

Process controler (powerpointware left)
Work permits (right top)
Process Description (right bottom)

Human in the loop analysis

- **Interaction analysis : Type and direction of the interaction.**
  - **Efficiency (time)**
  - **Efficacy (repetition)**
  - **Feedback**
- **User assement**
  - **Situation awareness evaluation : SART (***Taylor, 1990)*
  - Individual Cognitive task load : **NASA-TLX** (*Hart 1988)*
  - Group Cognitive task load : **TWLQ** *(Sellers, 2013)*
  - User engagement *(Shah 2010)*
  - User interface **utilisabilité de l'interface: SUS**
- **BPMN Modelisation**

What's next ?

- The scenario tested was more of a teleoperation than operation room
- Errors or anomalies in the actual process
- Fleet of robots
- More operators / experts

Keys to success

Securing users, experts early for knowledge acquisition and evaluation

Multidiciplinary teams

Flexibility / Creativity – Working with sometime very low level of TRL (technological) and ORL (Organisational) Readiness Levels

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