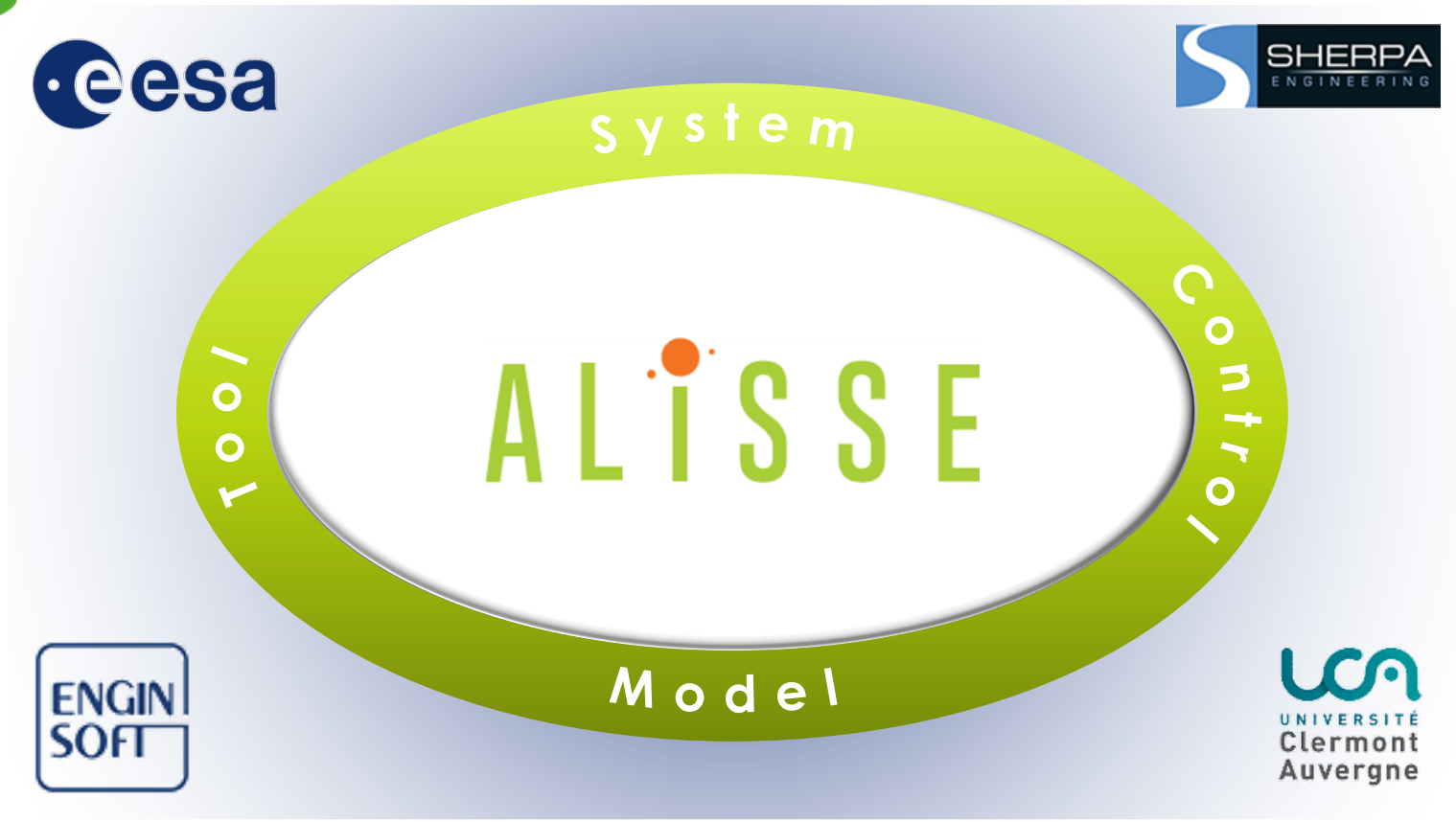
MELiSSA
MICRO-ECOLOGICAL
LIFE SUPPORT SYSTEM
ALTERNATIVE

CREATING
A CIRCULAR
FUTURE

ALiSSE Tool

Status and Perspective for Space and Earth development

Consortium

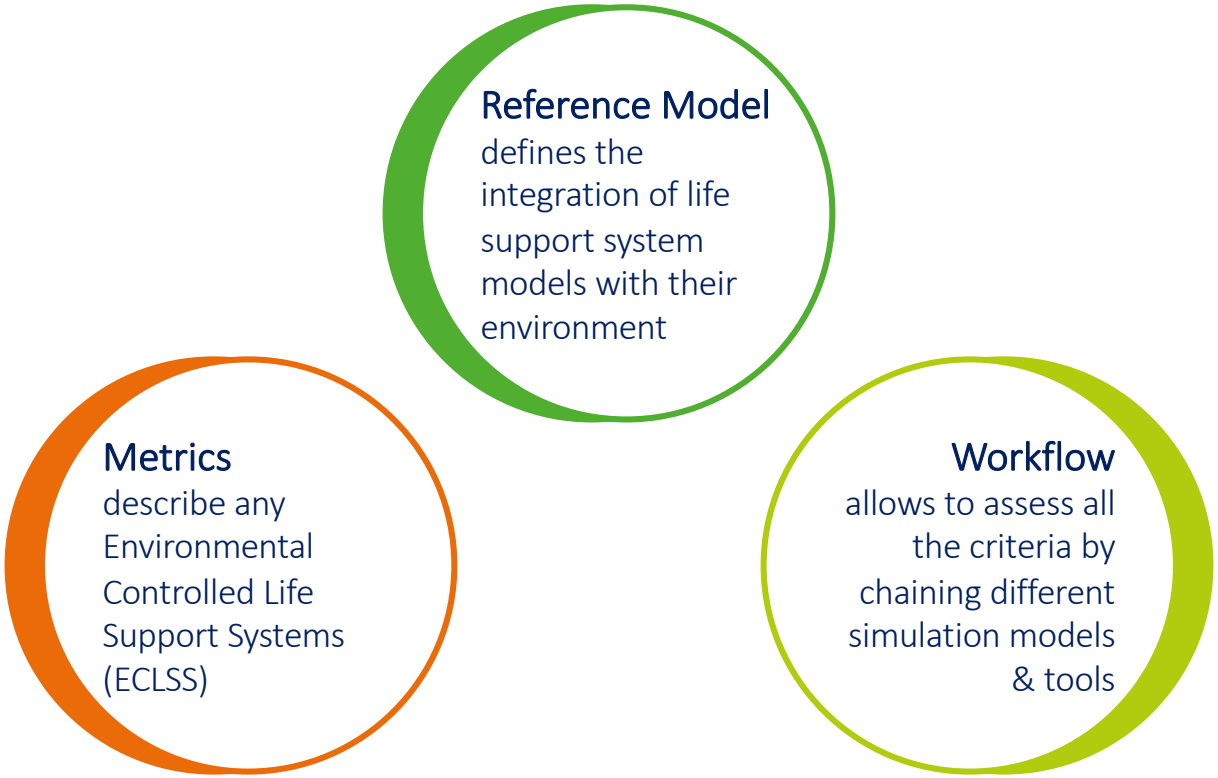

esa
SHERPA ENGINEERING
System
Control
Model
Tool
ALISSE
ENGIN SOFT
UCA UNIVERSITÉ Clermont Auvergne

Environmental Controlled Life Support Systems

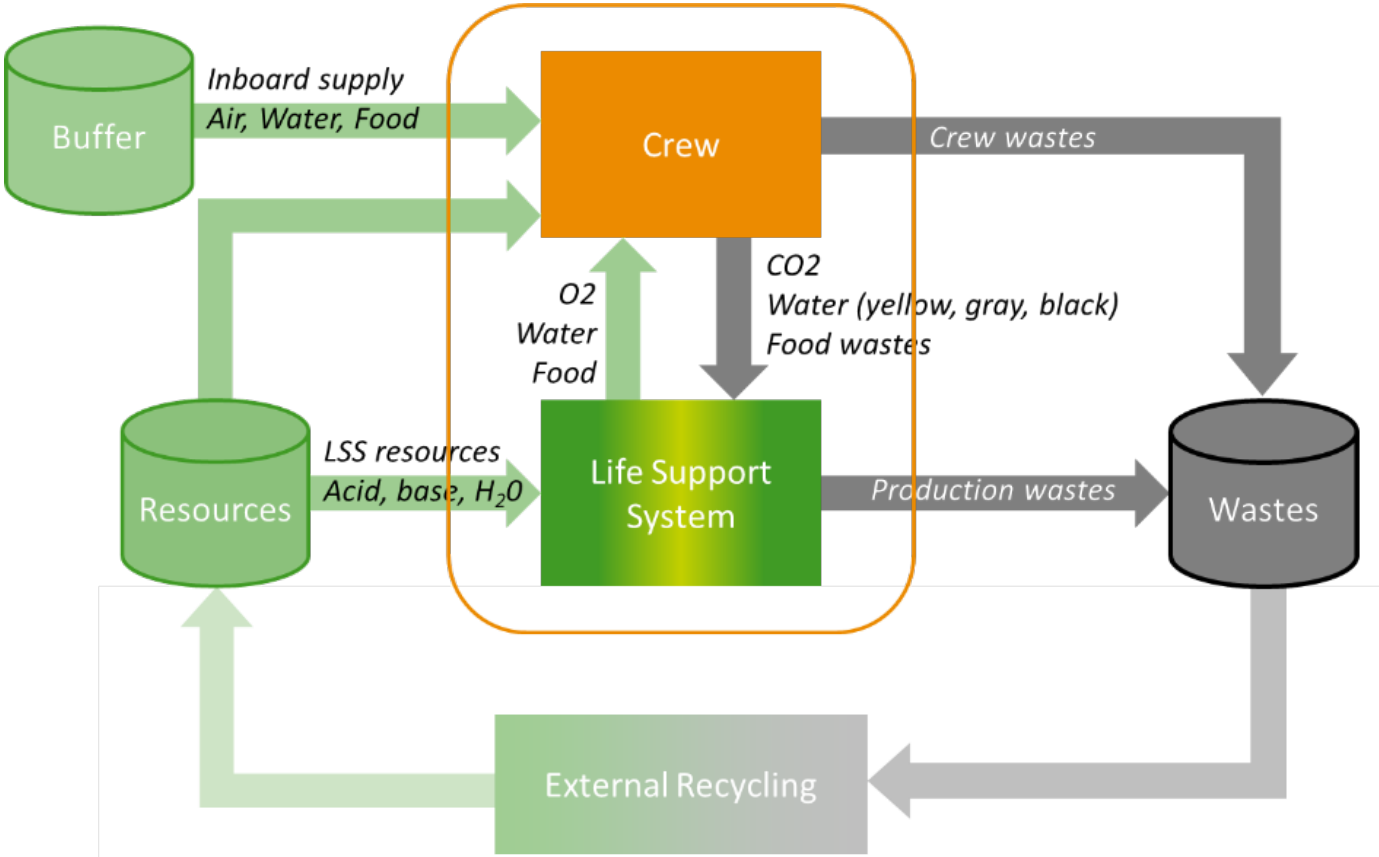
- Long duration space missions
  - Long duration space missions, such as the establishment of permanent bases on the lunar surface or the travel to Mars, require an amount of life support consumables that cannot be supplied from Earth.
  - Regenerative Life Support Systems are therefore necessary to sustain long-term manned space mission in order to increase recycling rates and thus reduce the mass to be launched.
- Environmental Controlled Life Support Systems
  - ECLSS are systems that enable the survival of humans being in space, by providing, among other functions, the crew supply with oxygen, water and food.
  - The architecture of such an ECLSS widely depends on the mission scenario.

ALiSSE – a tool-based methodology

Provides a decision-making tool to support ECLSS trade-off for a space mission



Reference-Model



Metrics

Evaluation and selection of ECLSS architecture is a comprehensive trade-off between mass, technology, safety, lifecycle cost and strategic considerations.

Mass
Coverage Mass Ratio: total system mass over total allocated mass

Energy & Power
Mean & Max power consumed in mission

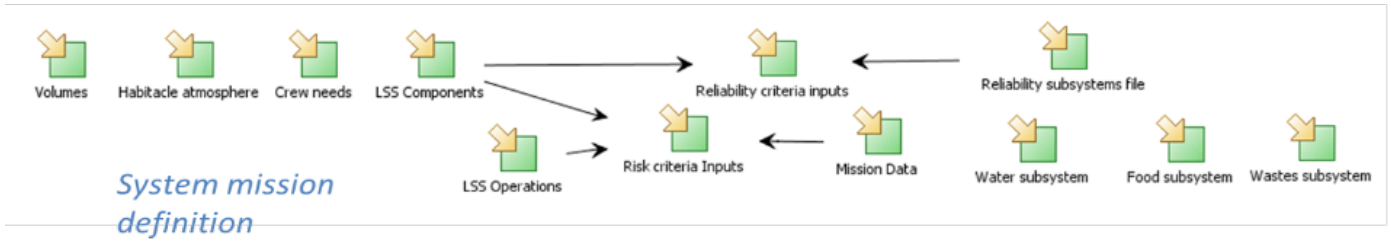
Crew Time
Total Crew Time for operation and maintenance of the ECLSS

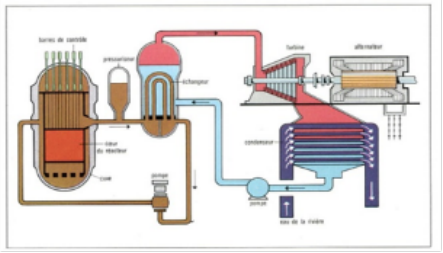
Risk for Human
Global risk index

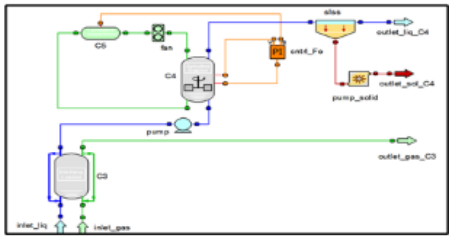
Reliability
Global system reliability

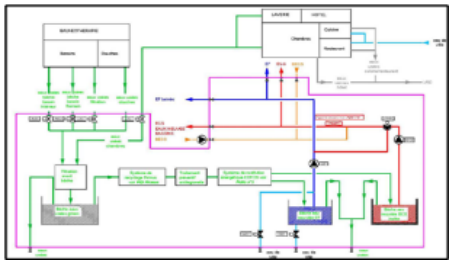
Sustainability
Need coverage level. Energy/Matter external dependence

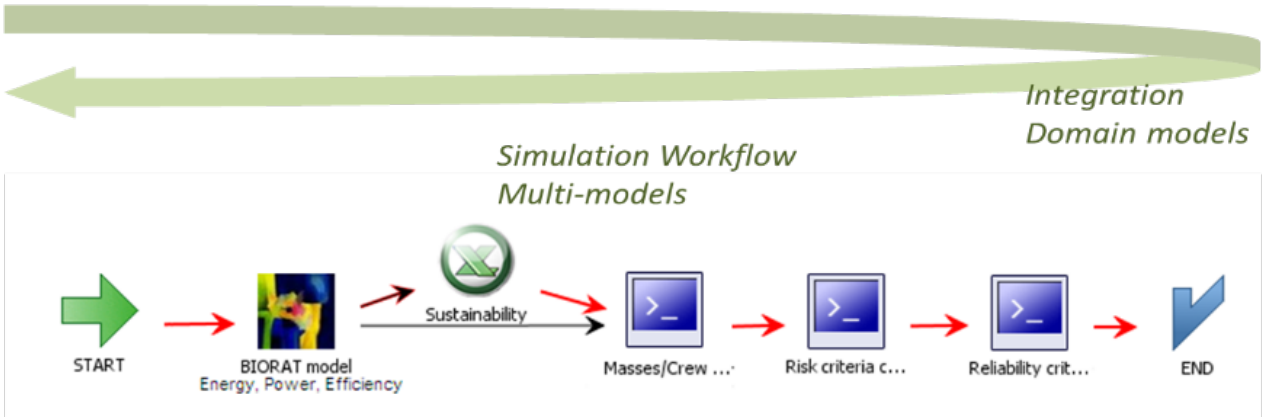
Workflow


Volumes
Habitacle atmosphere
Crew needs
LSS Components
Reliability criteria inputs
Reliability subsystems file
LSS Operations
Risk criteria Inputs
Mission Data
Water subsystem
Food subsystem
Wastes subsystem
System mission definition

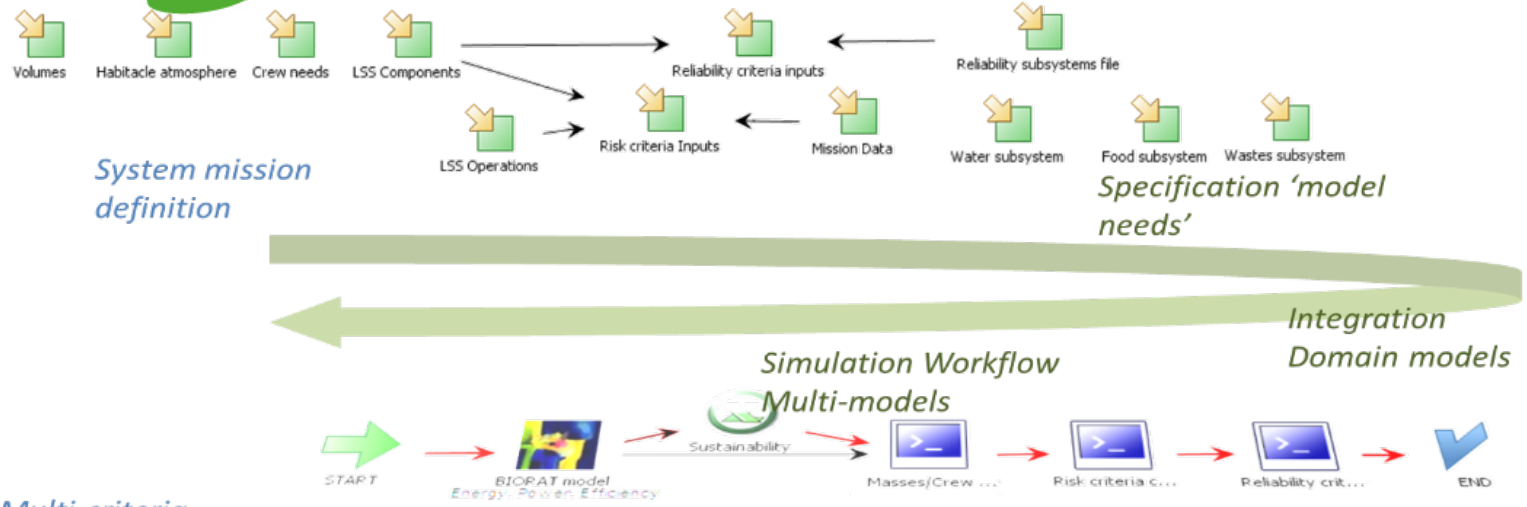


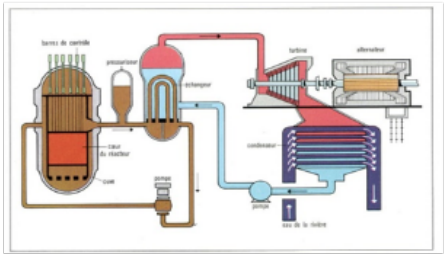


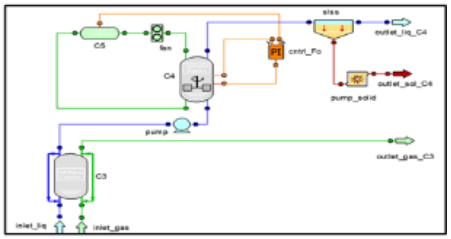


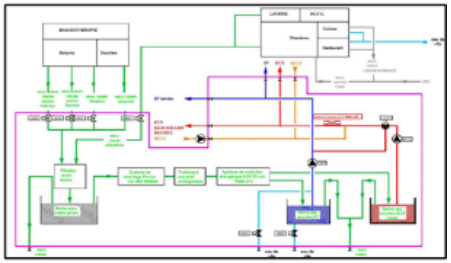

Specification 'model needs'
Integration Domain models
Simulation Workflow Multi-models
START
BIORAT model
Energy, Power, Efficiency
Sustainability
Masses/Crew ...
Risk criteria c...
Reliability crit...
END

Workflow



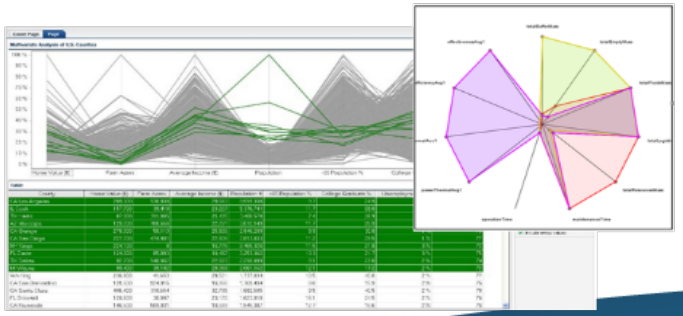






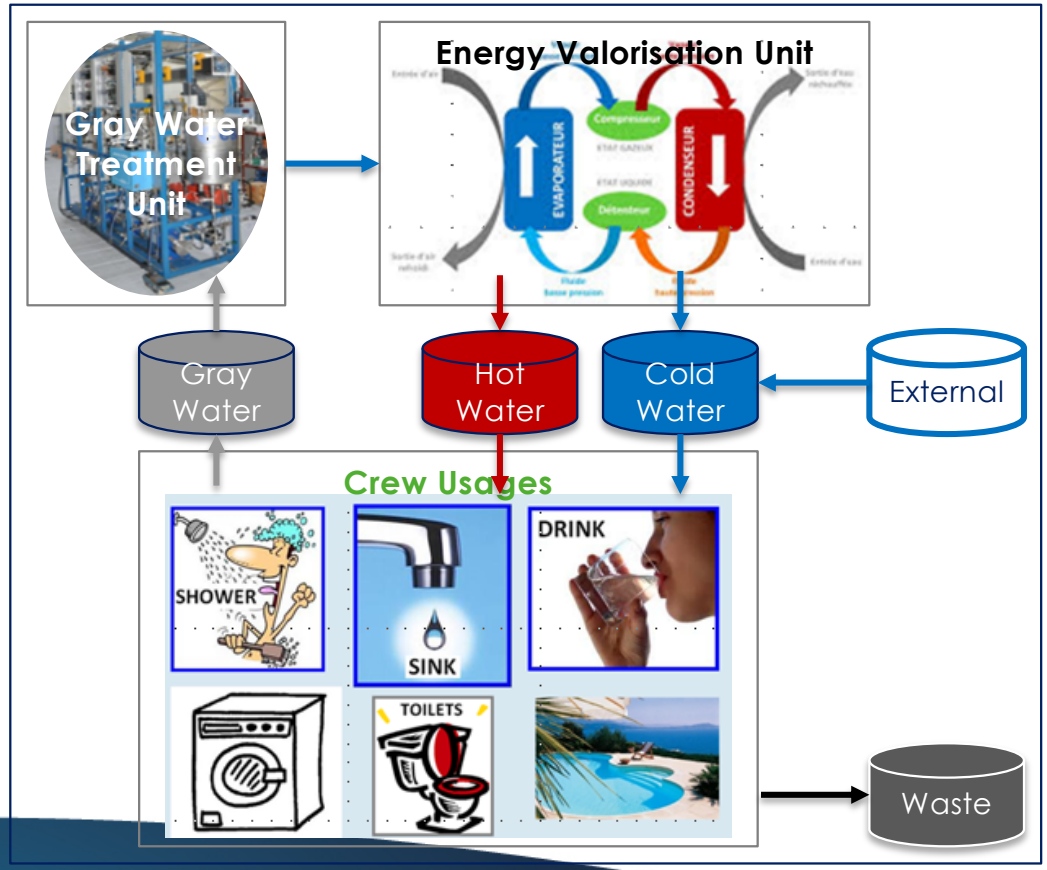
Multi-criteria optimization and decision

Criteria aggregation



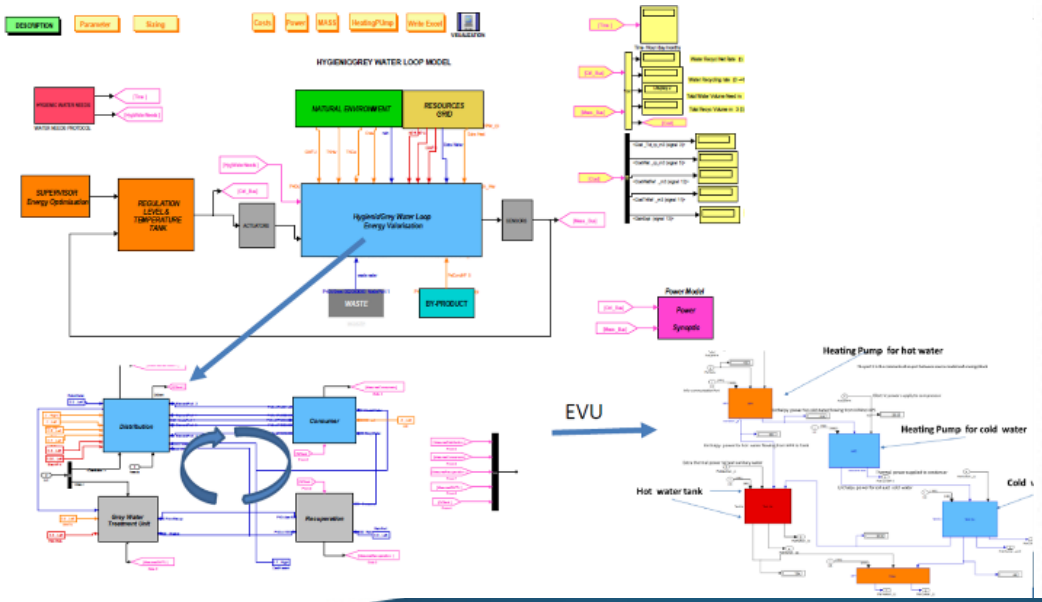
Grey Water Loop Management

- The closed loop includes a water recycling unit and an energy valorization unit to heat and cool the water.
- The loop is circular and semi-closed because of losses and down sizing of the recycling system.
- The buffers give the flexibility for the system. Their volumes must be minimized.

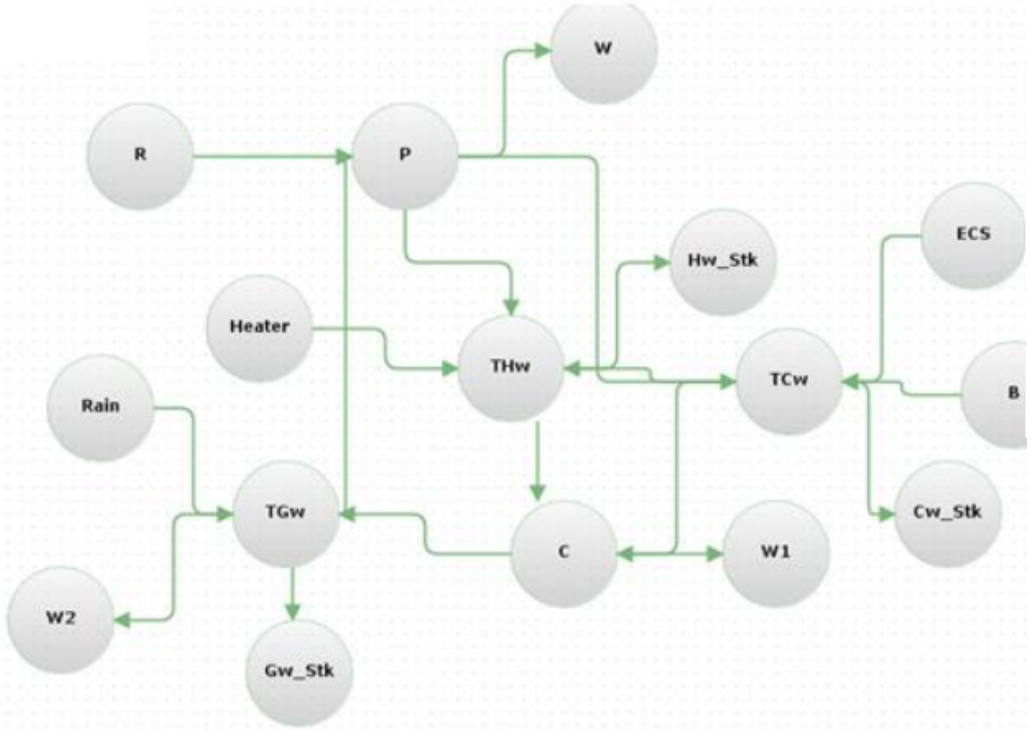


Grey Water Loop Management

- Dynamic multi-physics model used for performance analysis and control design



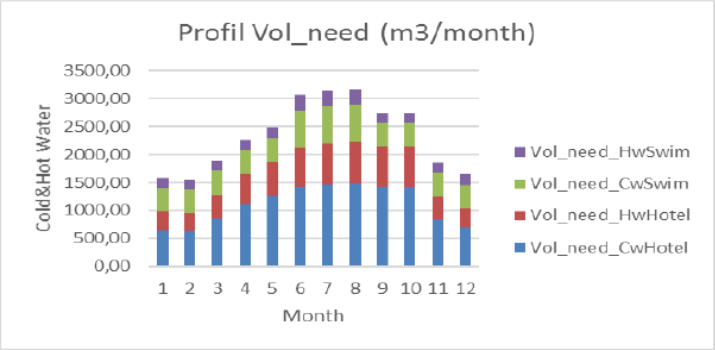
- Energy and water flow representation



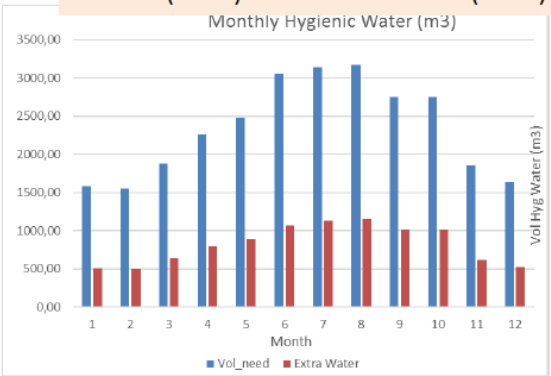
Grey Water Management

Water and Energy balances (use case hotel)

Needs for hot and cold water in function of month

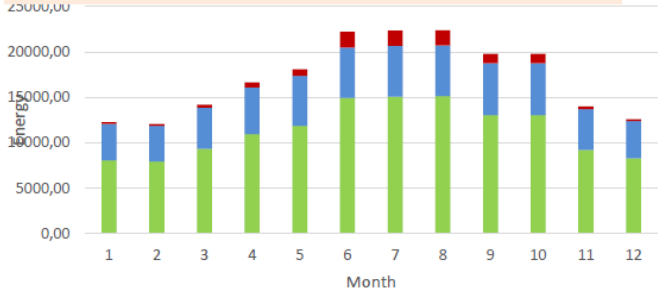


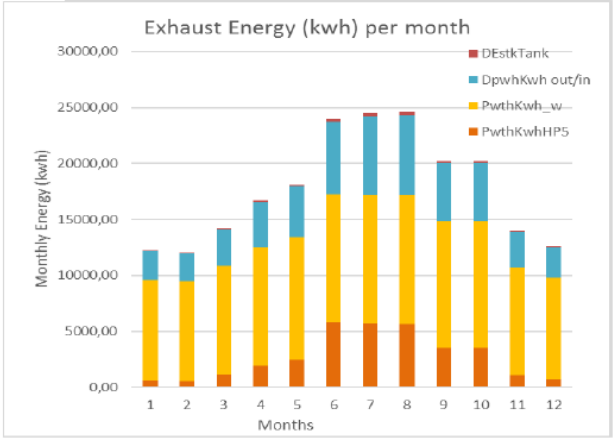
Needs (blue) and extra water (blue)



PwElec Kwh

Pwelec GWTU(green) HP4 (blue) HP5 (red)





Space and Earth development

OSCAR

VARSITY

iHab

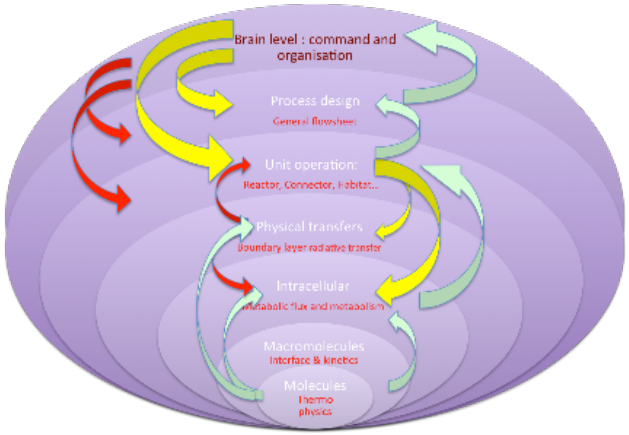
CentraleSupélec

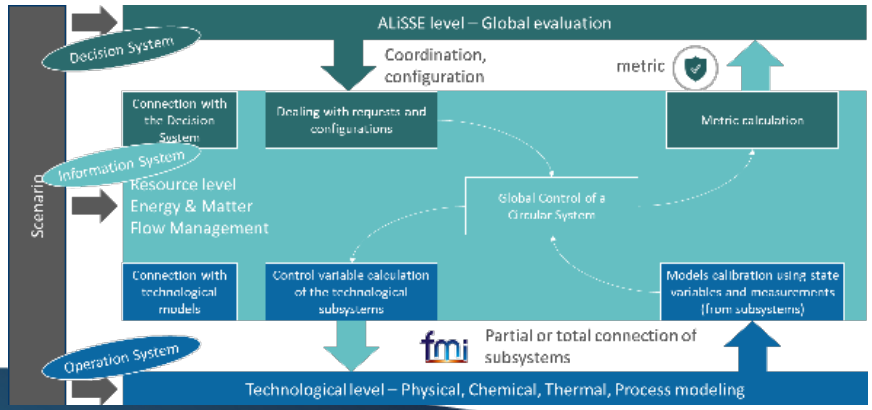
SystemX AMC

OSCAR

Optimal **S**ystem-in-system **C**ontrol & **Ar**chitecture

- Consolidation of modelling requirements of bio-inspired systems
  - Stability definition, Simulation Tools
  - Mass Balance, Metabolic pathways, Thermodynamics,
  - Control laws
- Identification of modelling limitations and critical issues
  - Compounds properties (thermophysical properties, kinetics and interfacial properties at molecule and macromolecule levels)
  - Local phenomena description (metabolism and physical transfers)
  - Unit operation and process level
  - The brain-level and the decision maker system

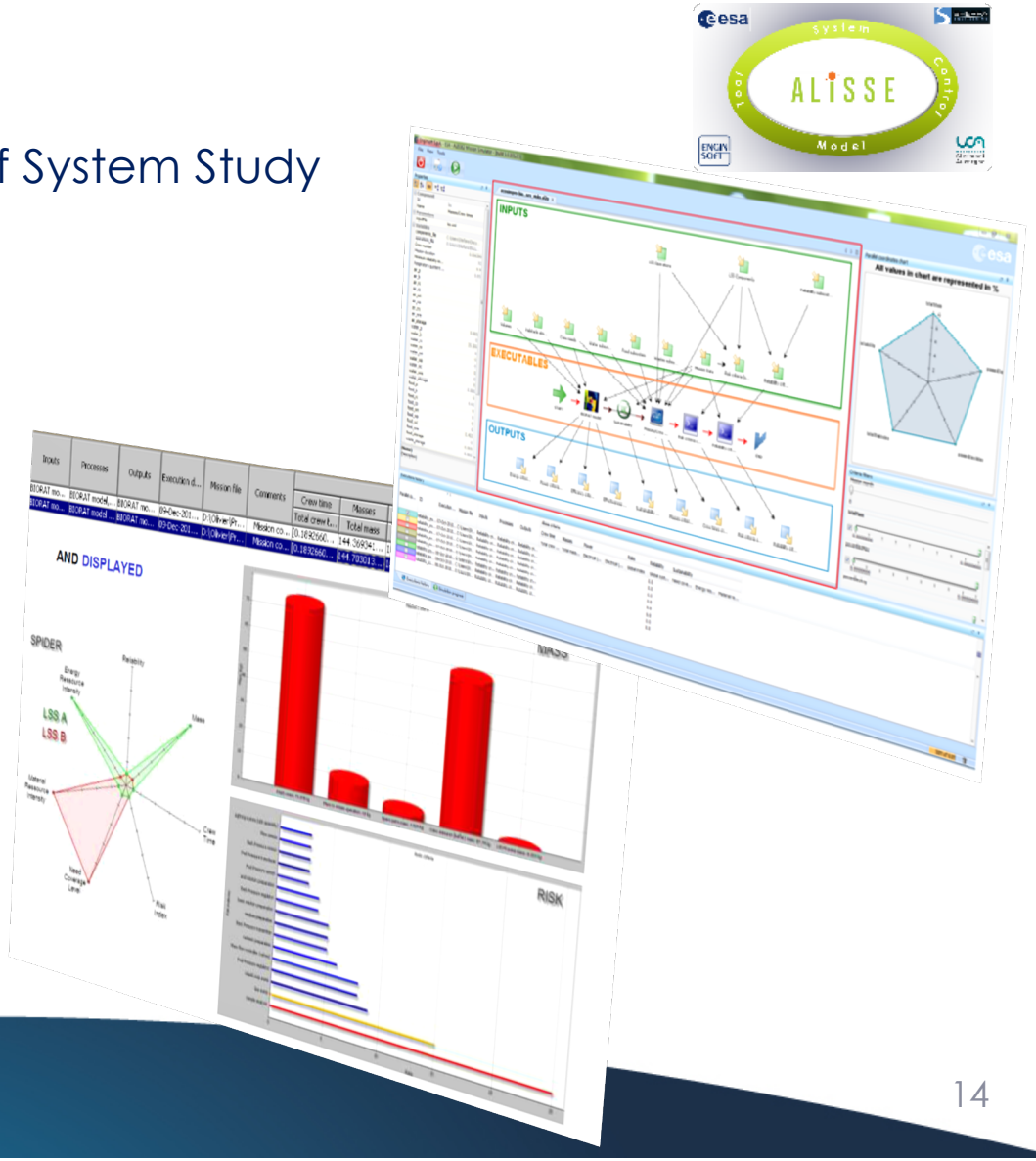




VARSITY

Various Integration of System Study

- Mathematical modelling of physical processes review and loop-network connections
- Overall control loop strategy
- ALiSSE industrial deployment
  - Make ALiSSE deployable for an industrial user
  1. Critical discussion about the strength and the criticalities of ALiSSE version 1 between the developers (Sherpa and EnginSoft) and the end user (Thales-ASI)
  2. Debugging and development phase of the software, the interface will be updated for user-friendliness



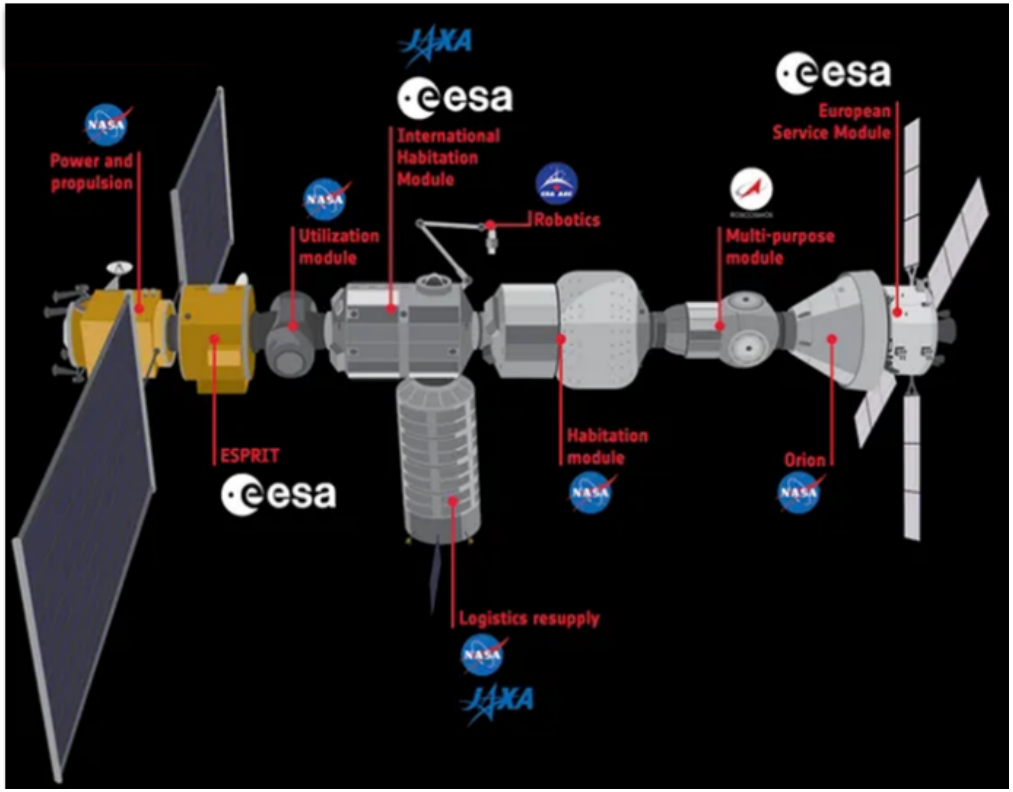
Lunar Gateway

International habitation module

- The Lunar Gateway is a planned mini-space station in lunar orbit intended to serve as a communication hub, science laboratory and short-term habitation module
- In November 2019, the European Space Agency received authorization and funding to support its planned contributions to the Gateway including habitation and refueling

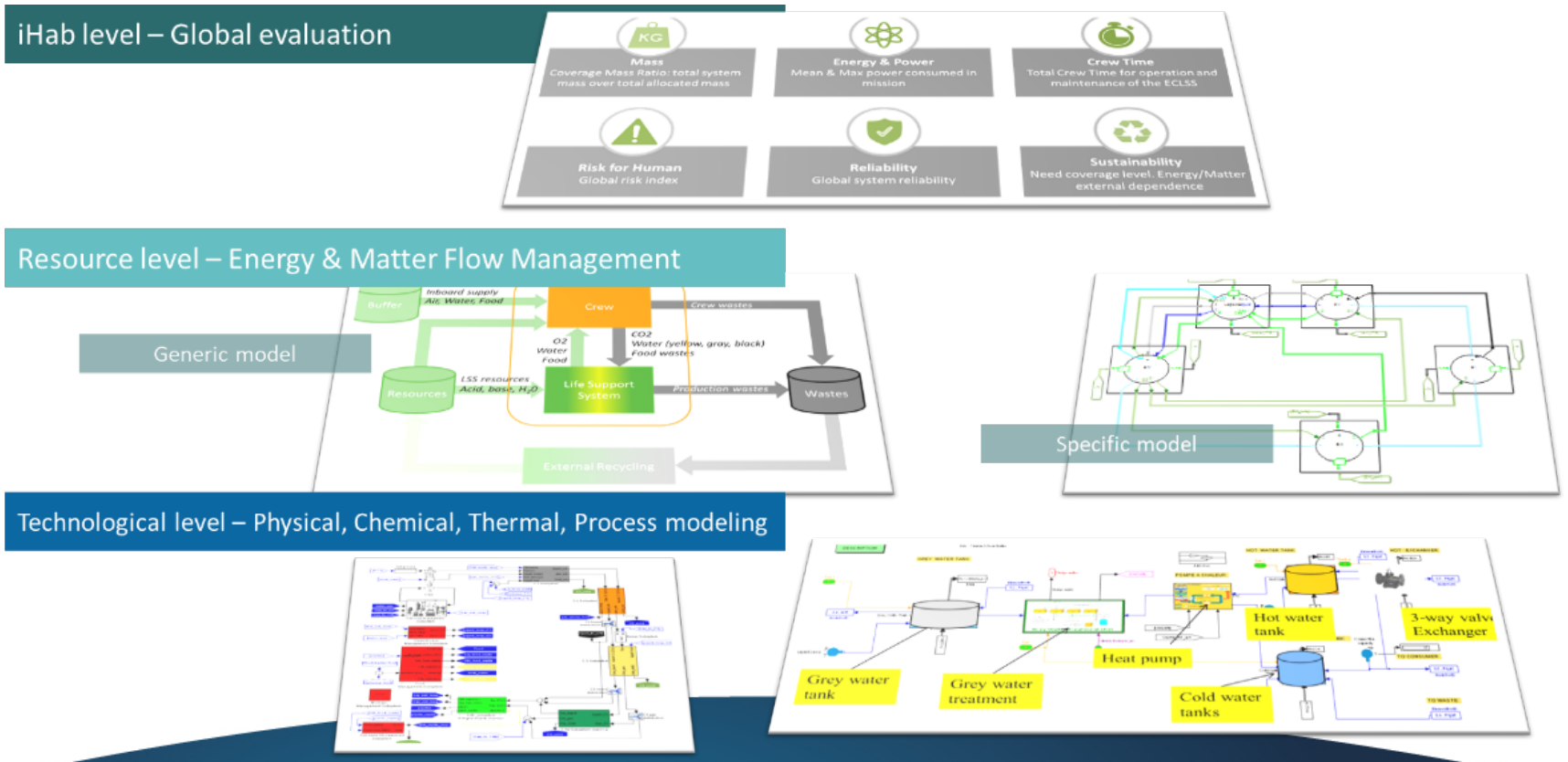
Lunar Gateway

- Gateway is a complex assembly composed of different modules
  - With specific functions (i.e. PPE – Power&Propulsion, ESPRIT - Refueling&Telecom, Airlock - EVA)
  - With similar functions (i.e. iHab, US-Hab - Habitation)
- Given current schedule for Gateway development and deployment
  - Having representative mock-ups of all modules fully outfitted at same location will not be possible
  - Validation and verification of integrated stack performance cannot be performed by tests: use of simulation!



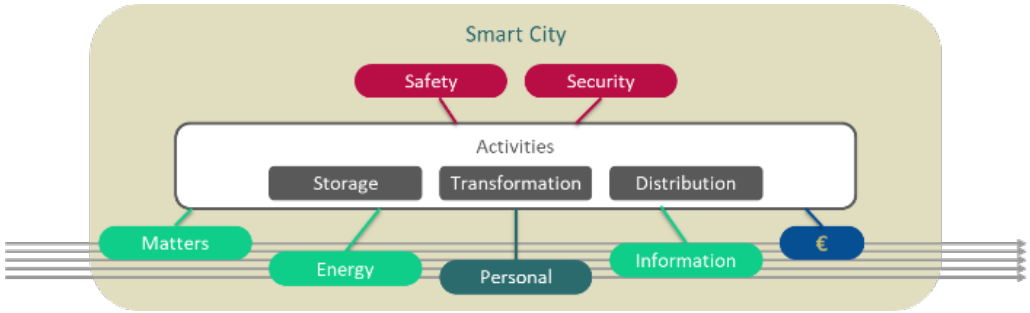
Simulation model for the iHab

Using a simulation model to evaluate the iHab based on ALiSSE metrics.



Terrestrial application

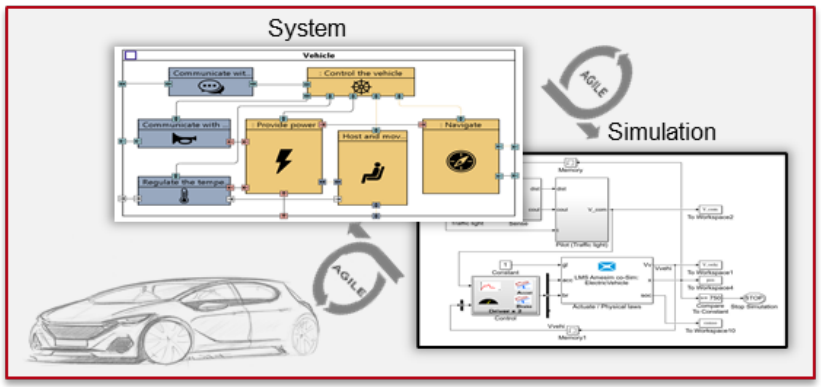
- Terrestrial application of an ESA space technology
- A partnership with CentraleSupélec and The city of Le Havre (Normandy)
  - A decision-support tool for multi-domain flow management



- Adapt and consolidate metrics for terrestrial applications
- Define the reference model for the multi-domain representation of Smart City flows
- Data analytics & statistical modelling – Data visualization

An automotive analogy

From system architecture to numerical simulation



Simulation Architect: new engineering role to support simulation activities

- Enhancement of the link between system architects and numerical simulation experts

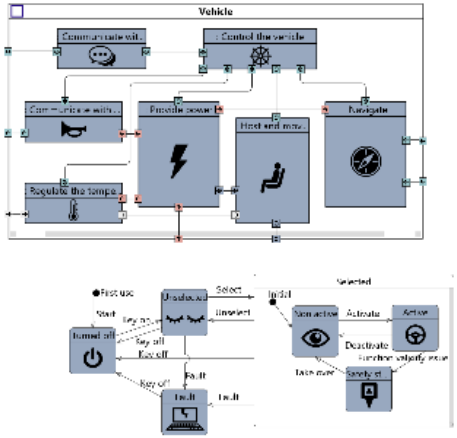
An automotive analogy

SYSTEM ARCHITECT

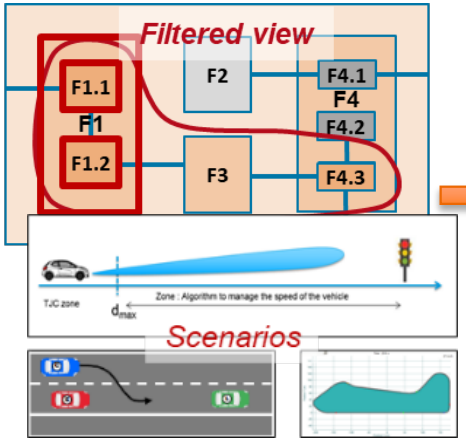
SIMULATION ARCHITECT

SIMULATION EXPERT

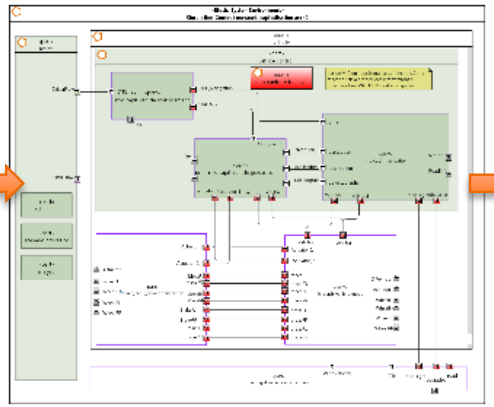
System architecture



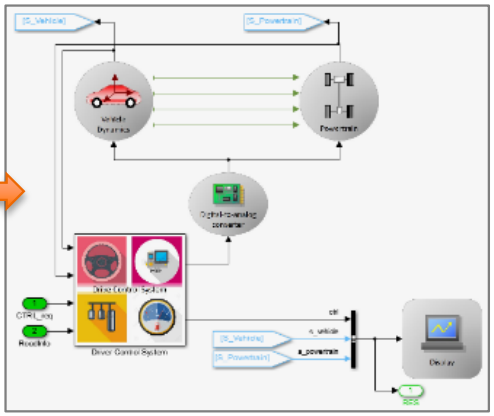
Simulation request



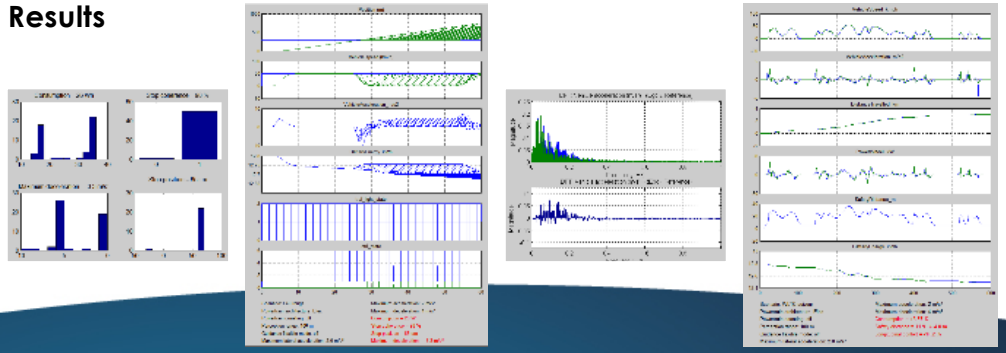
Simulation architecture



Numerical simulation



Results



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THANK YOU.

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