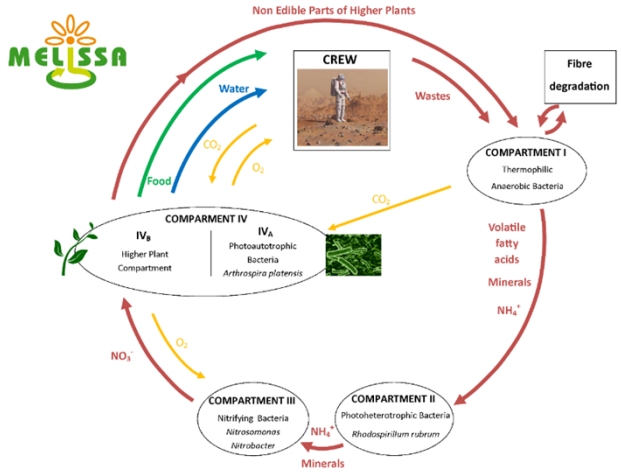
ALiSSE A MULTI-CRITERIA TOOL FOR LIFE SUPPORT SYSTEM EVALUATION AND COMPARISON



ALiSSE – Advanced Life Support System Evaluator

esa European Space Agency

ENGIN SOFT

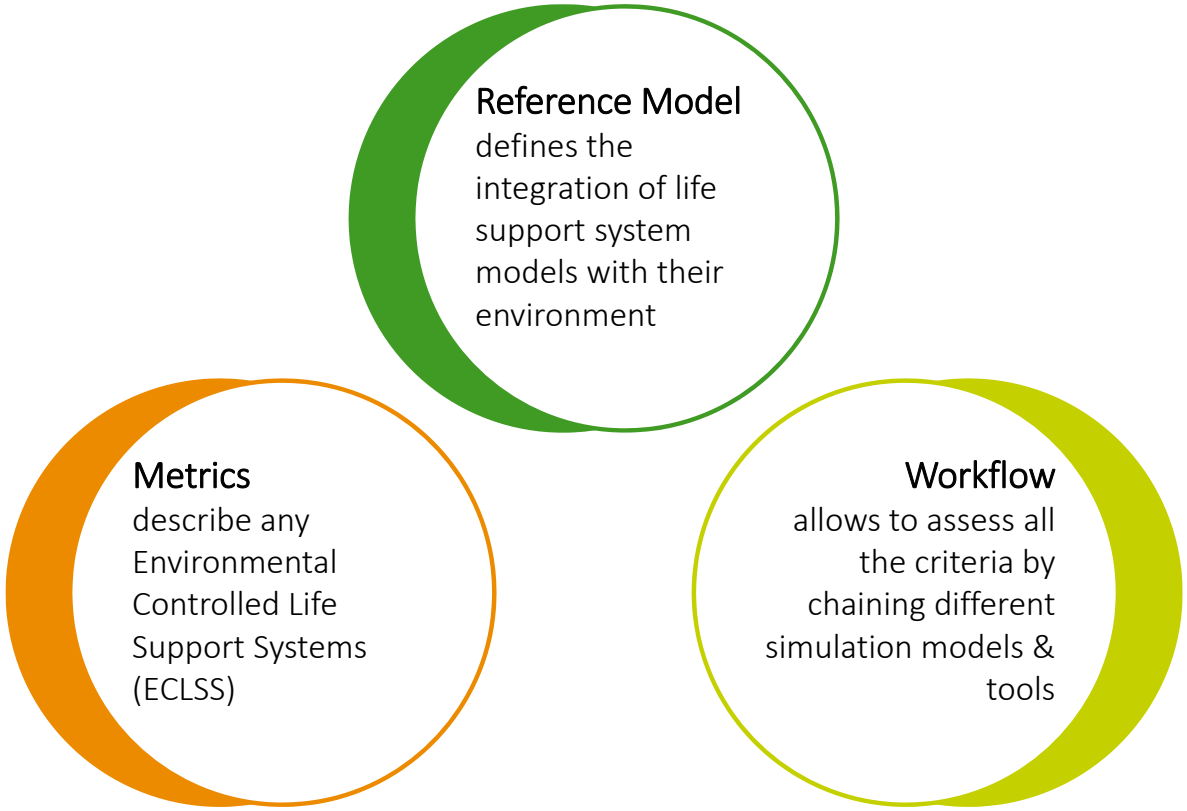
SHERPA ENGINEERING

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.

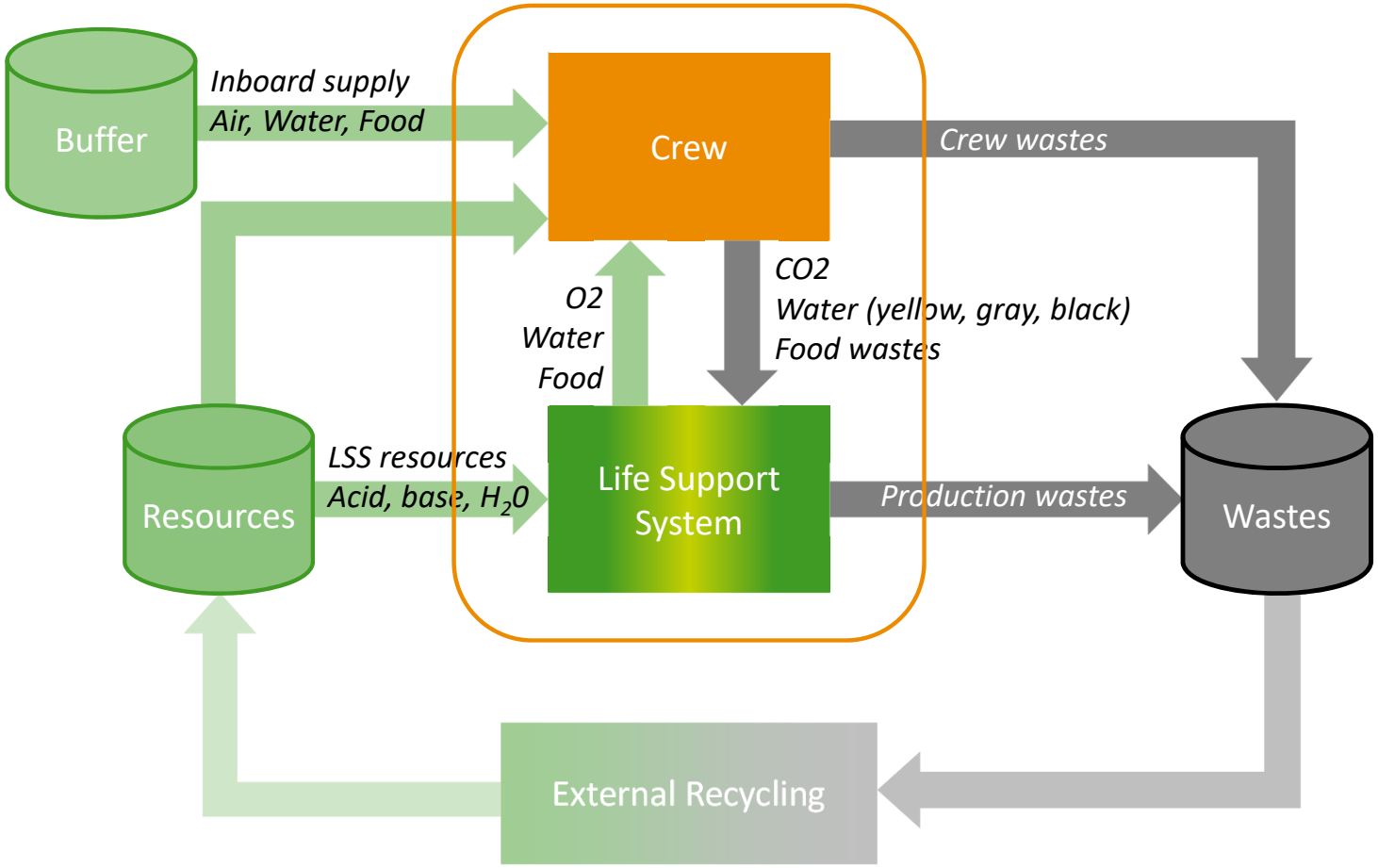
ALiSSE – a tool-based methodology

ALiSSE provides a decision-making tool to support ECLSS trade-off for a given Space Mission



ALiSSE is developed by a consortium led by ESA

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

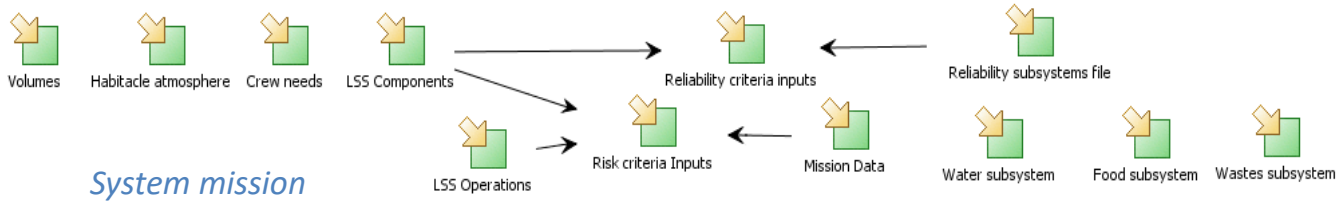
Risk for Human
Global risk index

Reliability
Global system reliability

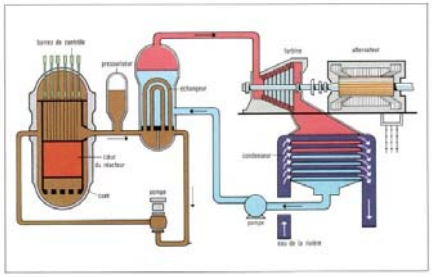
Sustainability
Need coverage level. Energy/Matter external dependence

Workflow

System Design & Analysis	Global Loop Modeling & Simulation	Physical Modeling

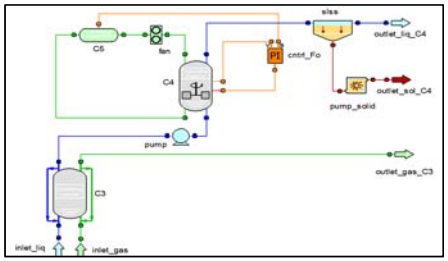


System mission definition

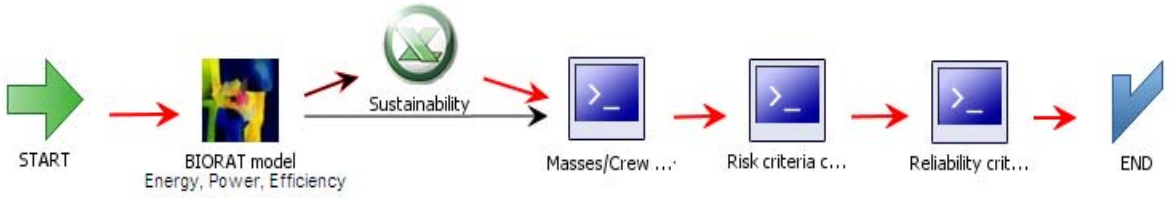


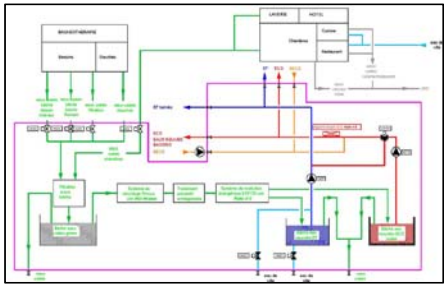
Specification 'model needs'

Integration Domain models



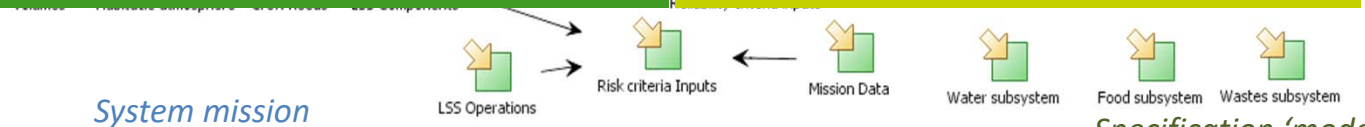
Simulation Workflow Multi-models





Workflow

System Design & Analysis	Global Loop Modeling & Simulation	Physical Modeling

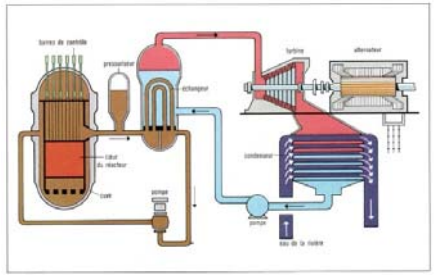


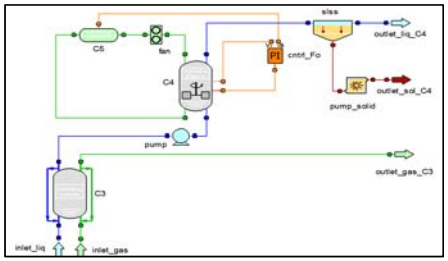
System mission definition

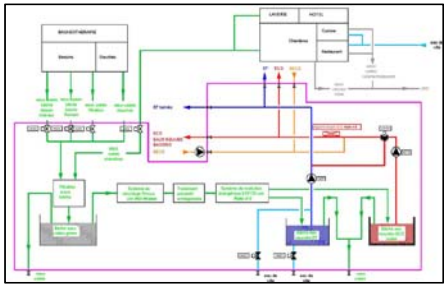
Specification 'model needs'

Integration Domain models

Simulation Workflow Multi-models

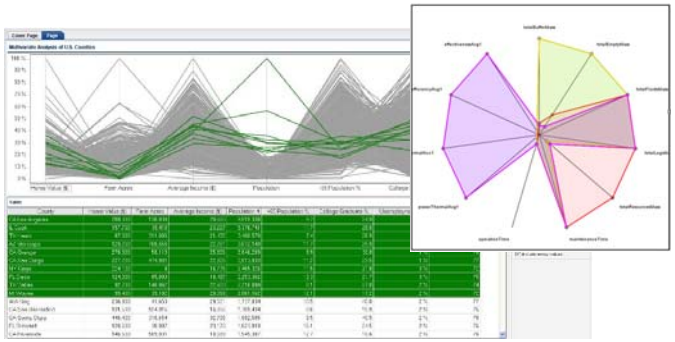






Multi-criteria optimization and decision

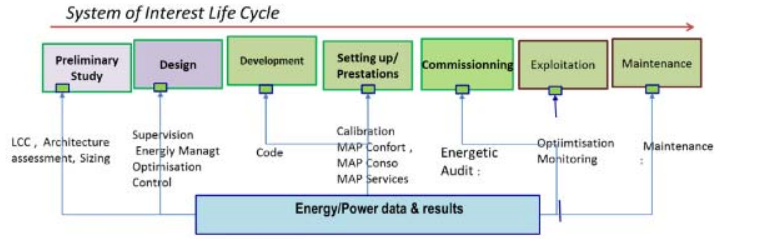
Criteria aggregation



From ALiSSE to …

Various tool-based methodologies were derived from ALiSSE

ENRUM
Energy Resources Utilisation Mapping



A Model-Based Tool for System Design and Analysis of Regenerative Systems

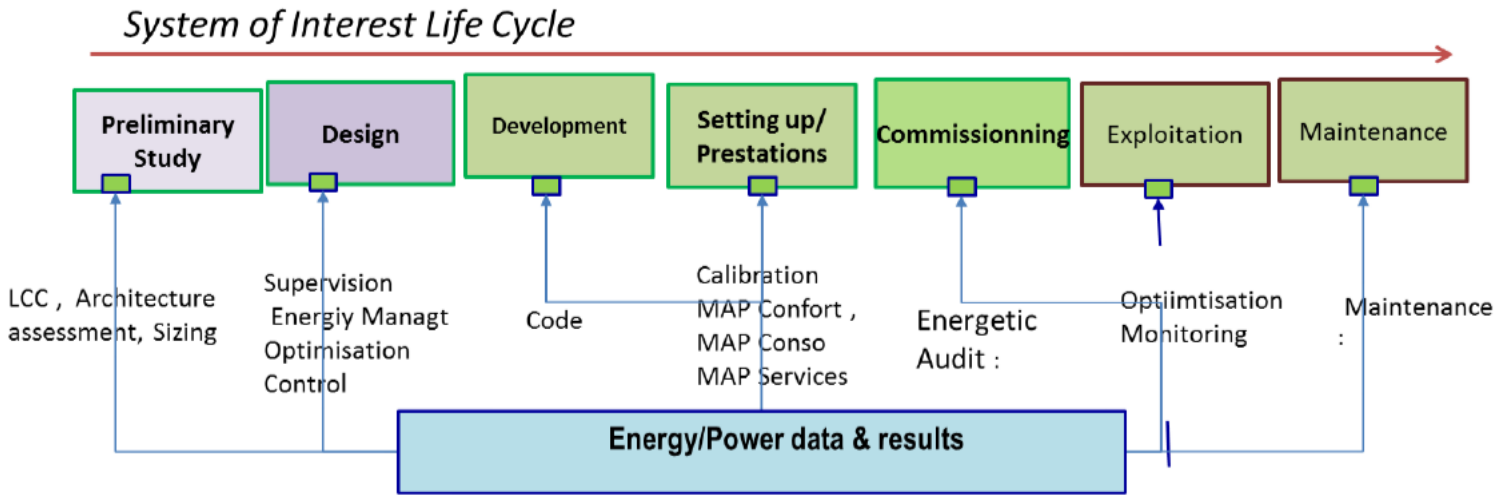
esa European Space Agency — ENGIN SOFT — SHERPA ENGINEERING

MELiSSA – Control System Design

Global Control Loop of the Life Support System

ENRUM

ENERGY RESOURCES UTILISATION MAPPING



A Model-Based Tool for System Design and Analysis of Regenerative Systems

esa European Space Agency

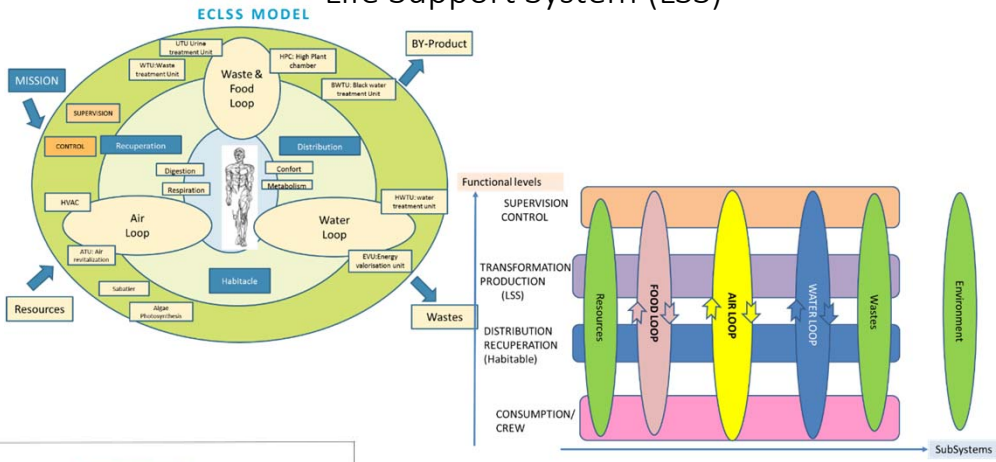
ENGIN SOFT

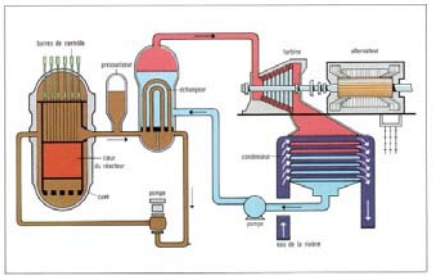
SHERPA ENGINEERING

Circular Regenerative Systems

- ENRUM provides models and tools for system design and analysis of complex energetic systems
- ENRUM enables
  - To do mass and energy balances
  - To compute some performance criteria: index of mass and energy closure, recycling rate, resources intensity, autarky degree
  - To allow some functional design
  - To assess different architectures and technology choices with the same mission

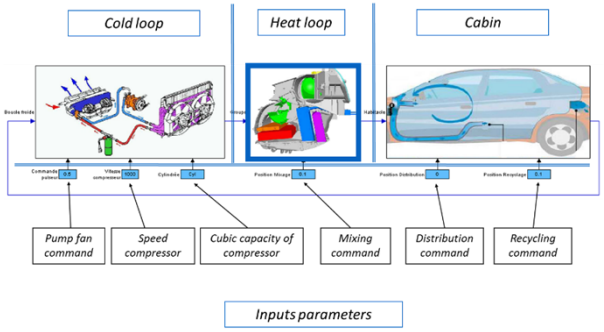
Life Support System (LSS)



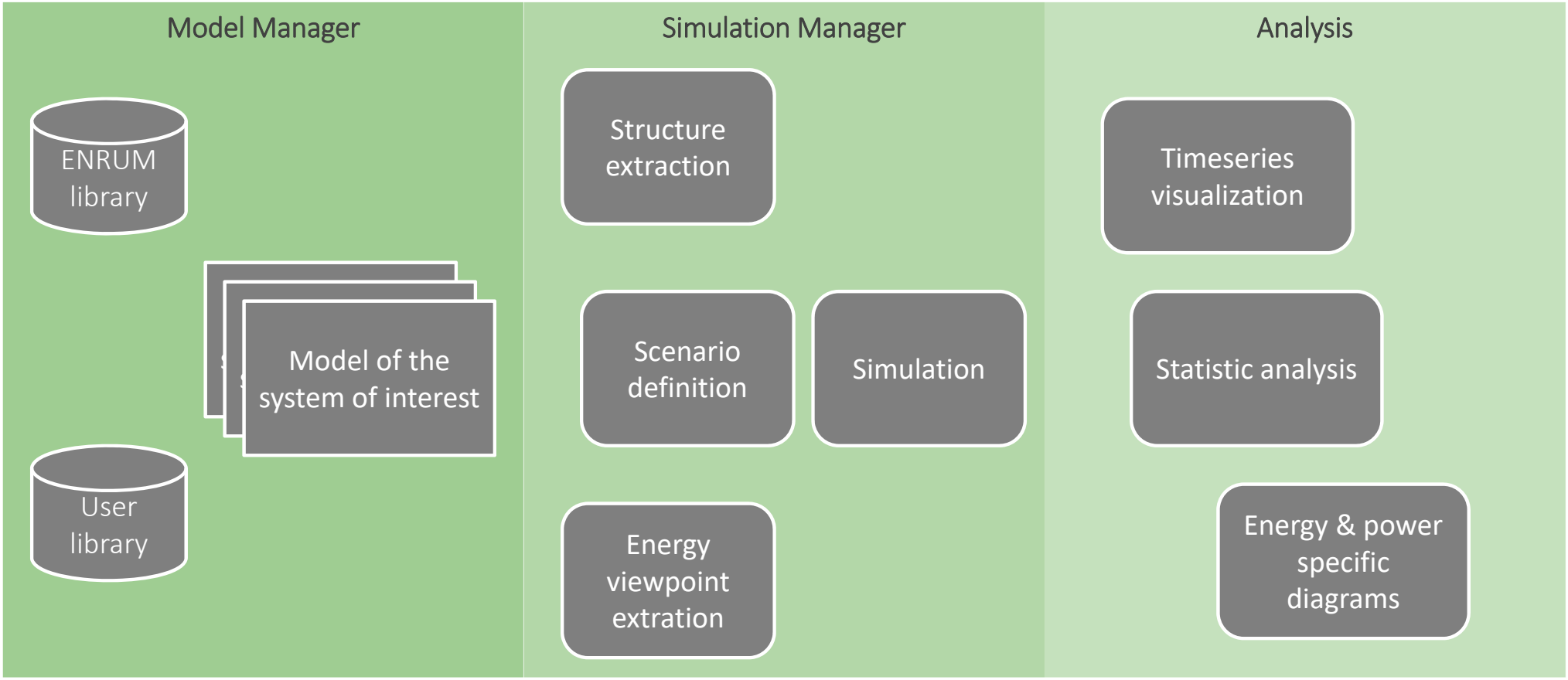


Powerplant
(electricity production from Rankine thermal cycle)

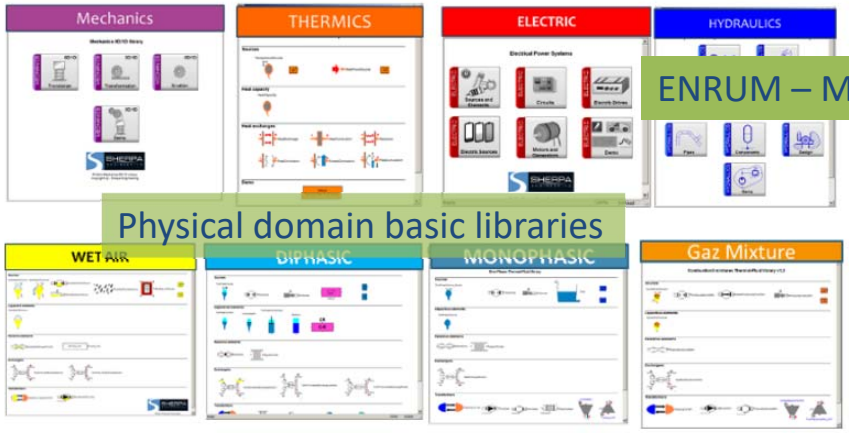
HVAC



ENRUM Features – a global view

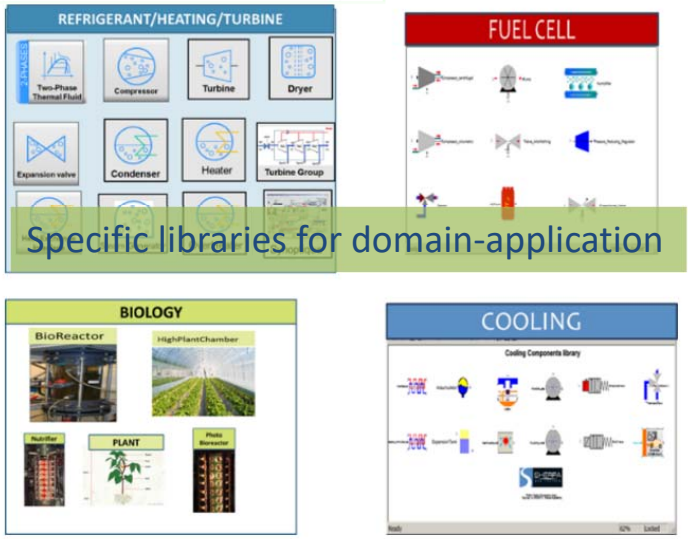


Model & Simulation management

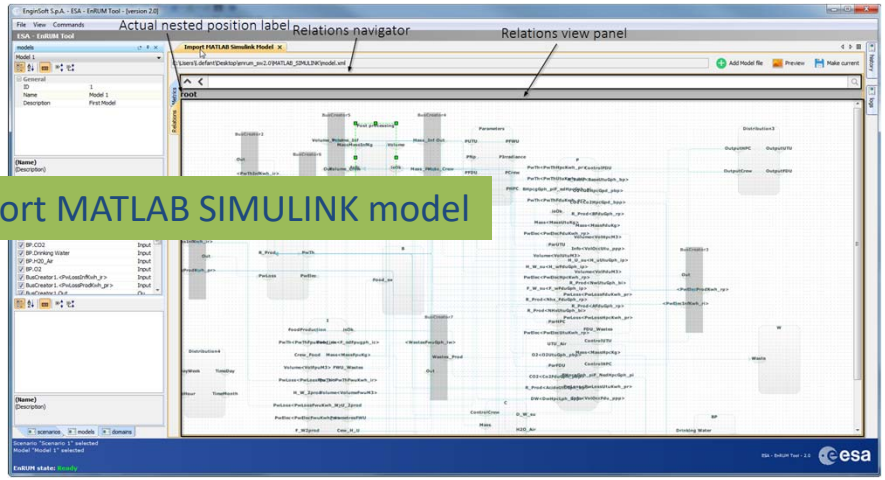


ENRUM – Model libraries

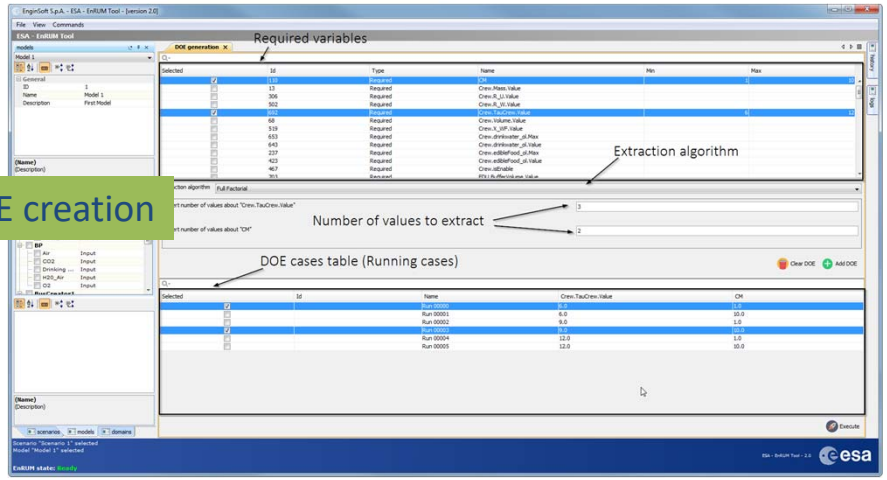
Physical domain basic libraries



Specific libraries for domain-application



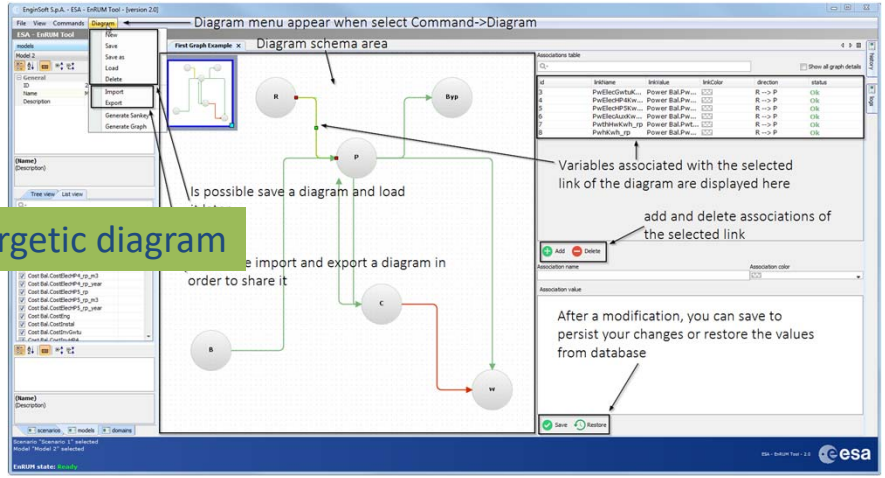
Import MATLAB SIMULINK model



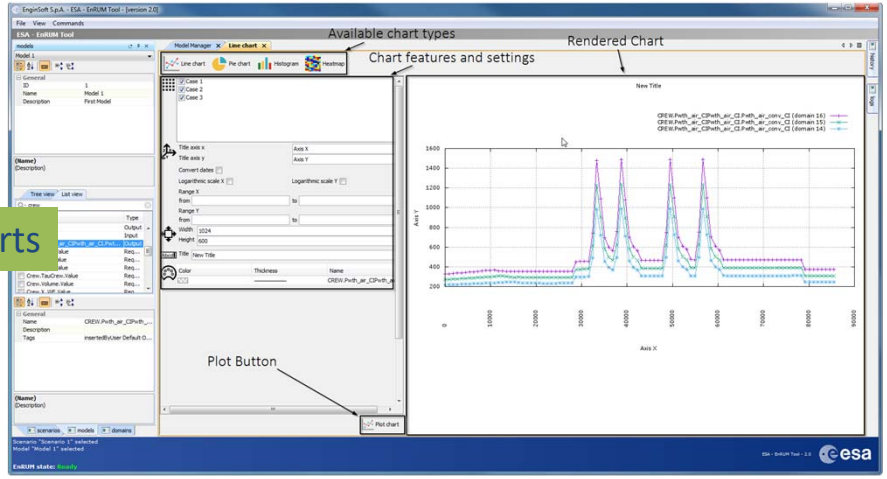
DOE creation

Timeseries and energetic analysis

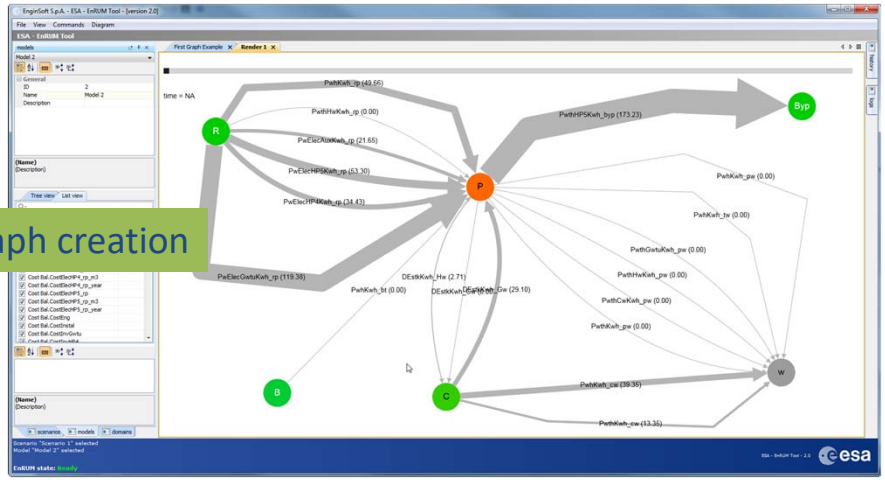
Energetic diagram



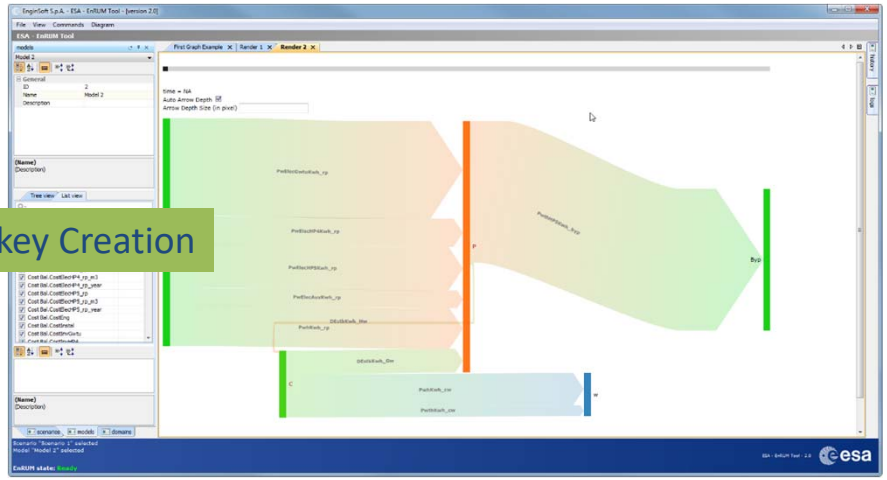
Charts



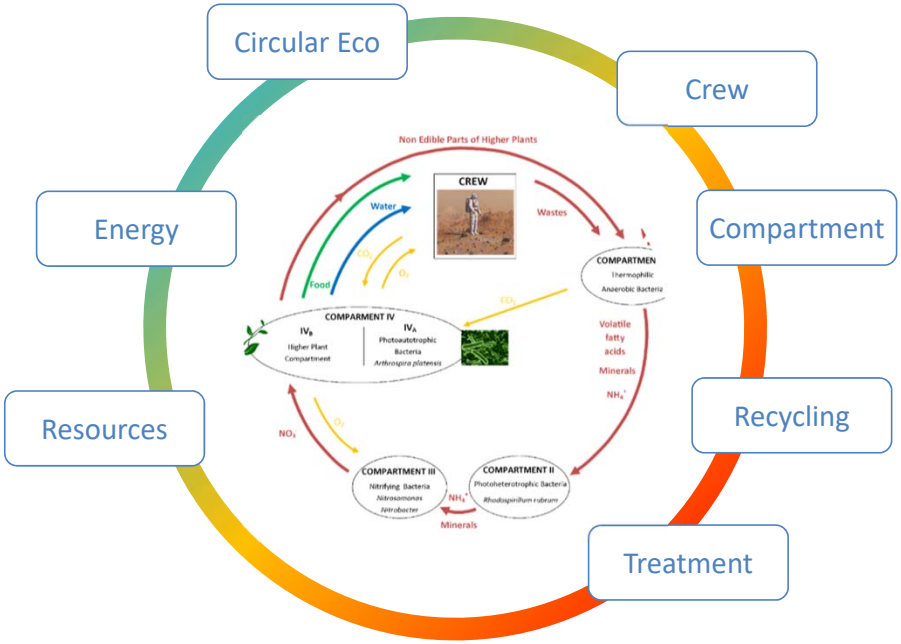
Graph creation



Sankey Creation



MELiSSA – Control System Design



Global Control Loop of the Life Support System

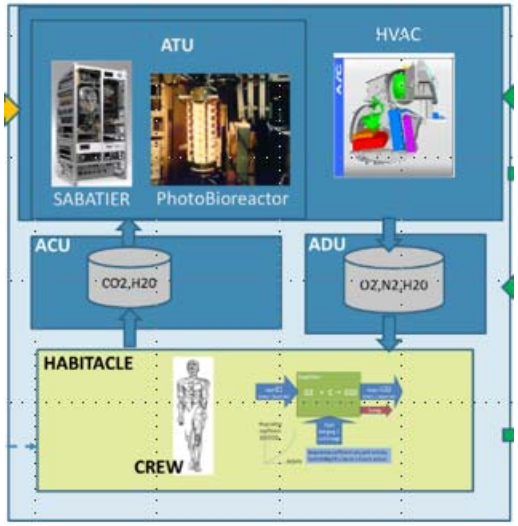
How to manage the complexity of the LSS

Compartments: Crew, Plant, Nitrification, Degradation

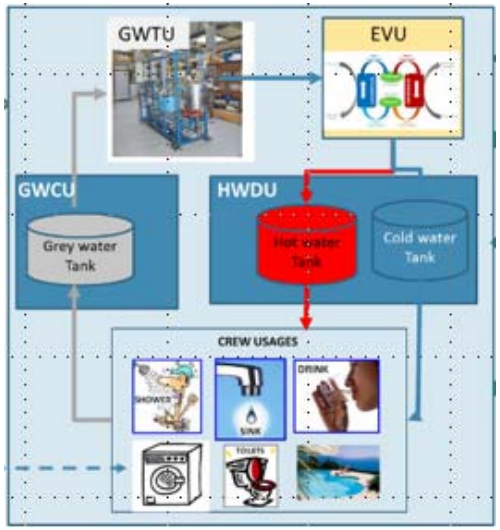
Control: from needs to actions

Effectiveness: chemical reaction to satisfaction

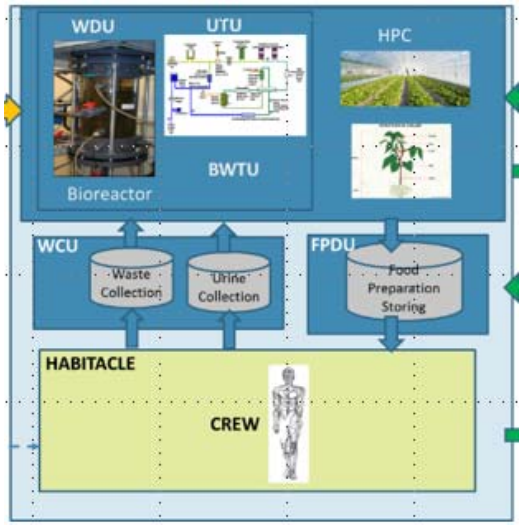
Air loop



Water loop



Food loop

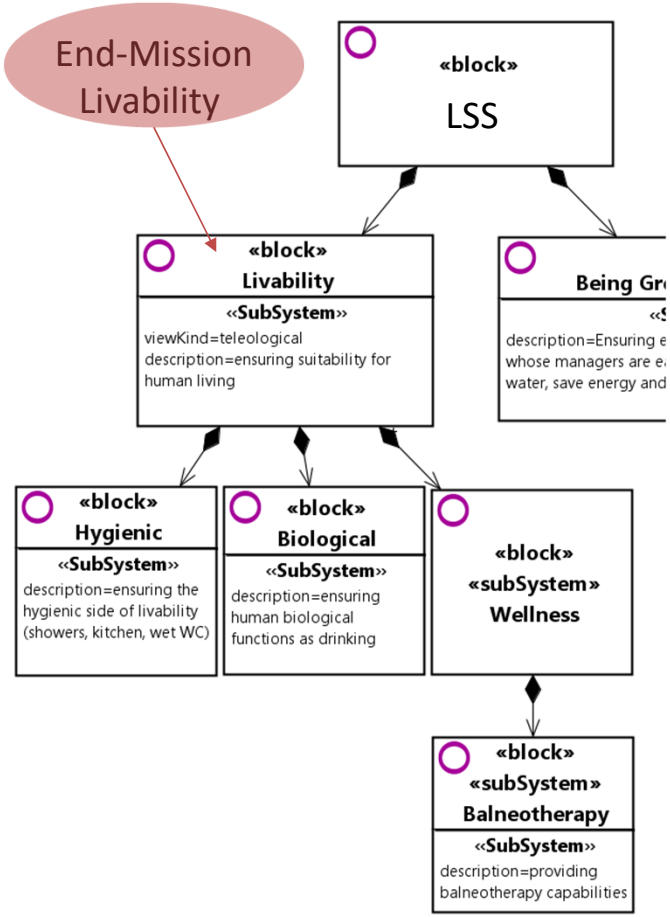


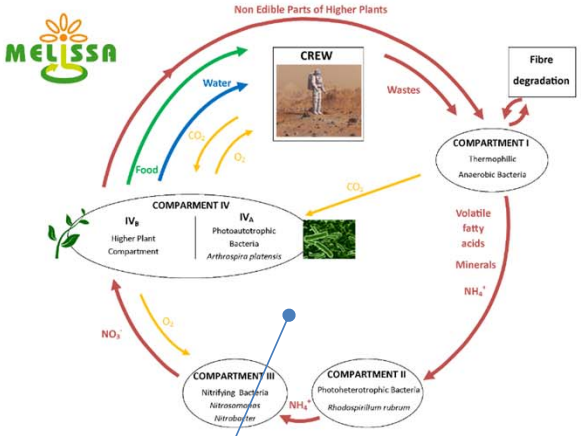
Crew Needs = f(crew number, activities …)

Systemic Modeling

To design and evaluate
the global loop

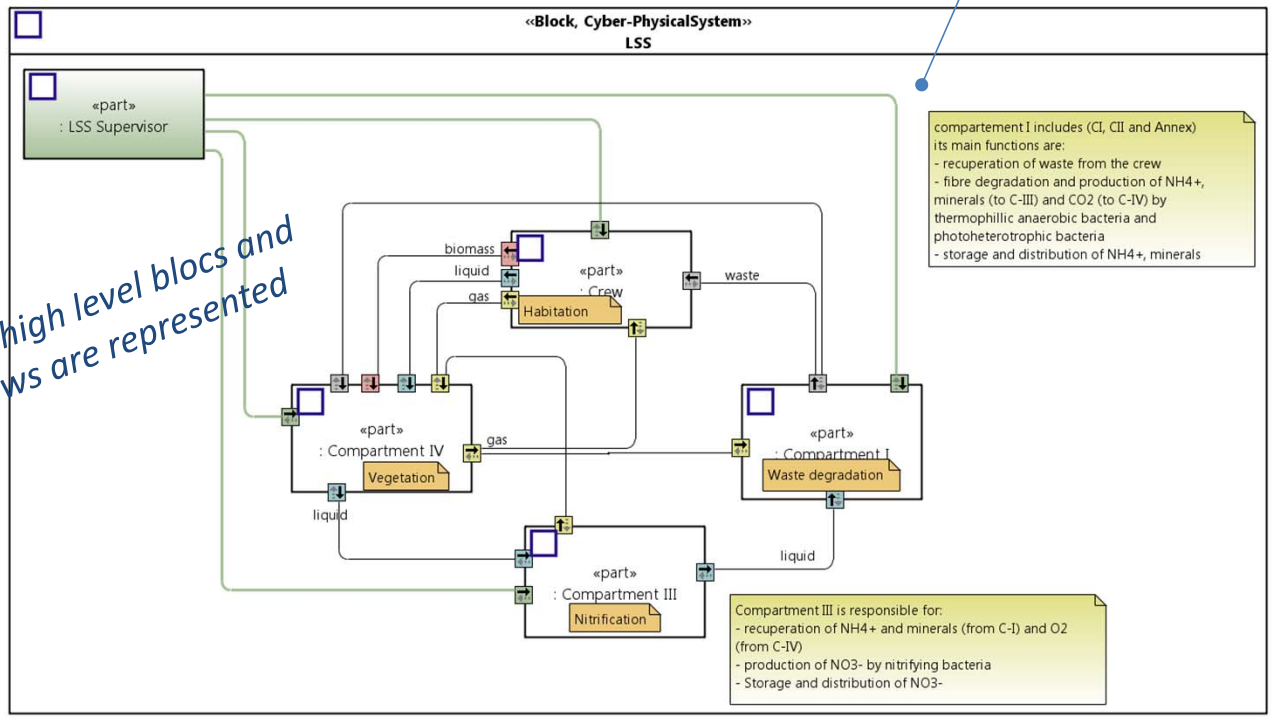
End-Mission
Livability





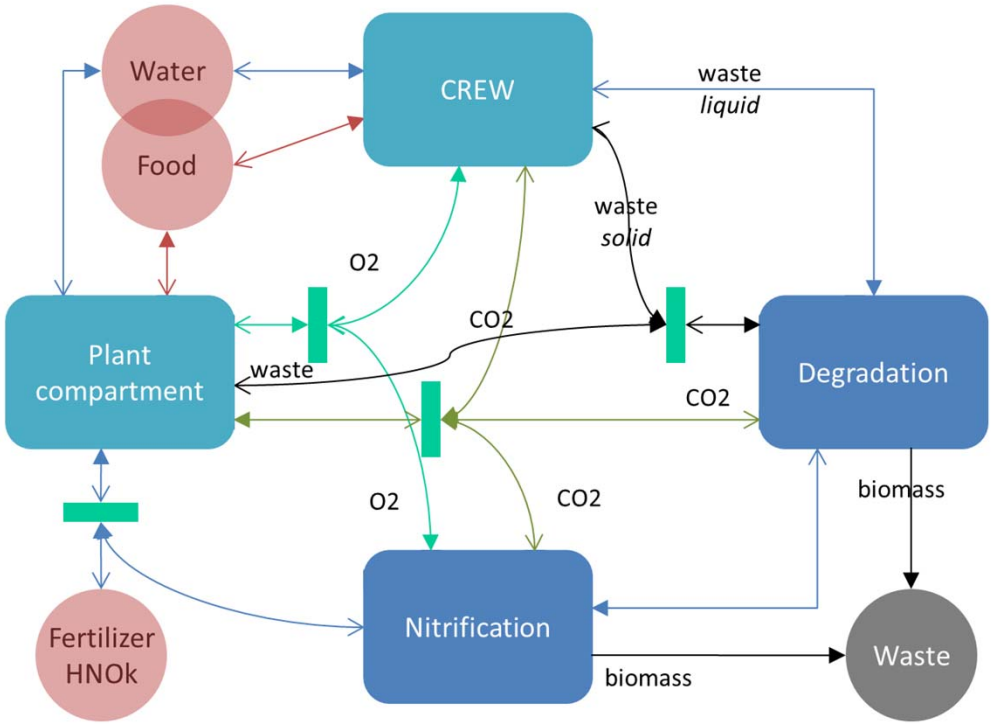
Functional model: MELiSSA loop

Only high level blocs and flows are represented

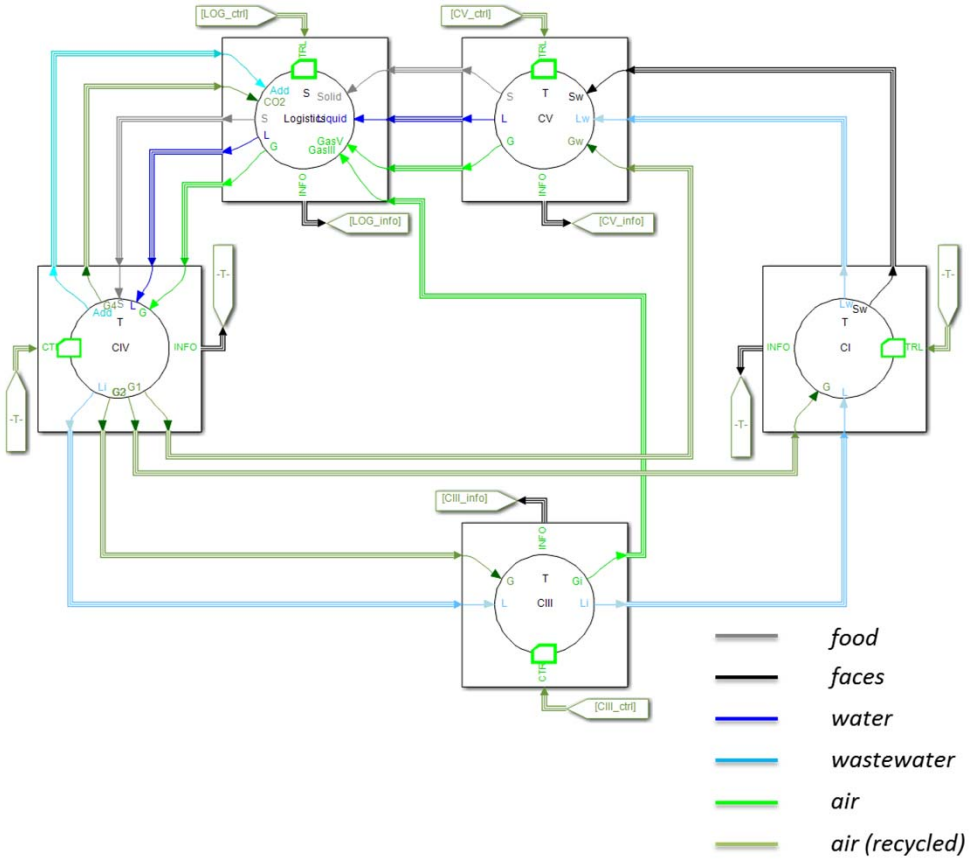


Control of the Global Loop

Flow definition – Global loop

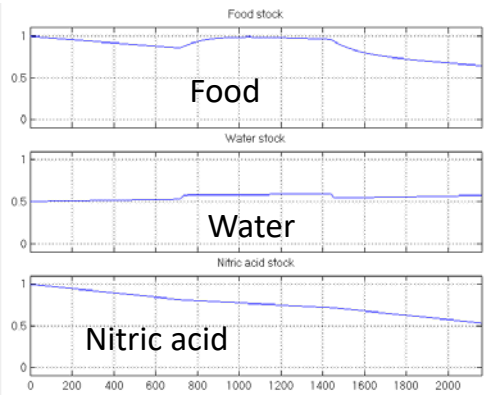


Simulation model

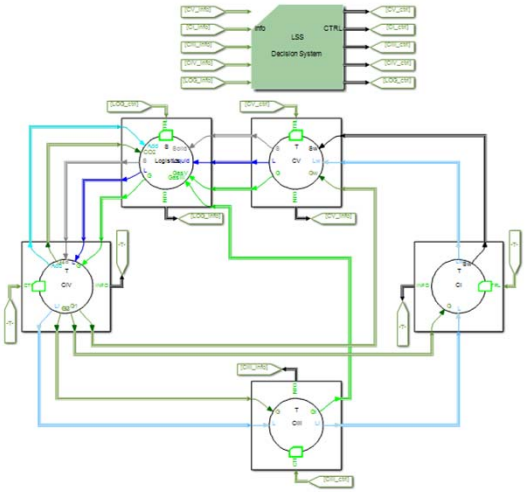


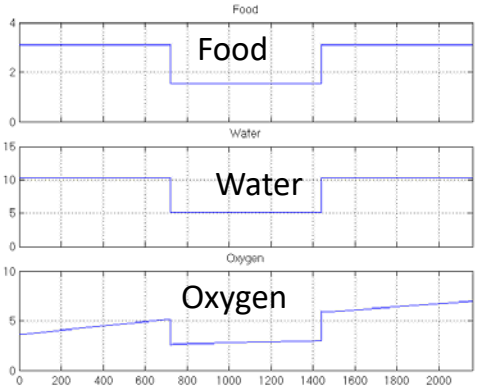
Simulation Model

Stocks

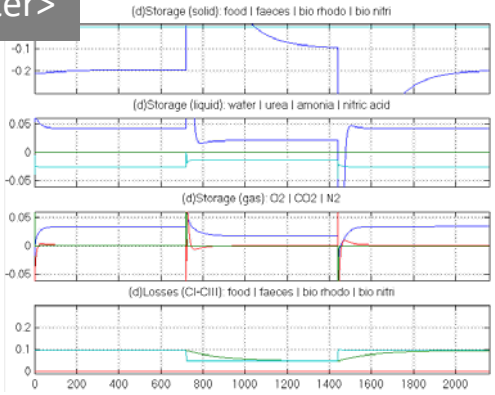


CREW

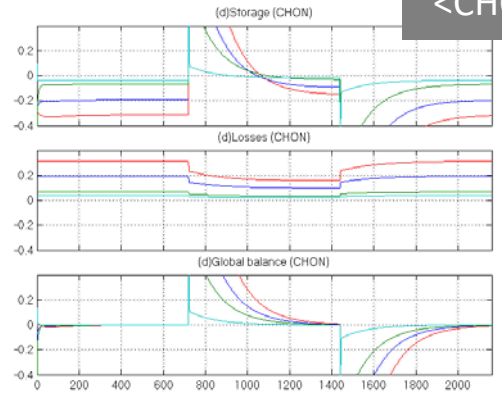




Balance <Matter>



Balance <CHON>



ALiSSE
Advanced Life Support System Evaluator

- More than a tool, ALiSSE is a system approach to design and evaluate ECLSS
- For more than 8 years now, all MELiSSA activities refer to ALiSSE metrics

- The latest *by-products* are
  - ENRUM: focus on energy and matter viewpoints for space and terrestrial applications
  - Control System of the global MELiSSA loop

Future works

ENRUM

- Industrialization & commercialization
- Customization to specific applications

Control of the MELiSSA loop

- Connection to detailed simulation models
- Implementation of the Air loop control in the pilot plat of Barcelona

ECLSS: Environmental Controlled Life Support Systems

Thank you

FOR YOUR INTEREST

The MELiSSA Consortium

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www.uliege.be

www.empresariosagrupados.es

ENRUM: other partners

www.csem.ch

www.uliege.be