2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

CREATING A CIRCULAR FUTURE

SPACE GREENHOUSE DESIGN: TOWARDS A SYSTEMATIC METHODOLOGY

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SERENITY

Space & Earth Reliable greENhouse desIgn meThodologY

- Marie Skłodowska-Curie Actions Postdoctoral Fellowship
- Partner: IPESE - EPFL
- Collaboration: ESA MELiSSA, NASA KSC, Sherpa Engineering, Interstellar Labs
- Open science: data management and publications

Deliverables

Data Management Plan

- Data management life cycle for all data sets
- What data with which methodology and standards
- Data sharing, curation and preservation

Career Development Plan

- Joint document by supervisors and researcher
- Research objectives + training and career needs
- Planning for publications and conferences

Communication, Dissemination & Outreach Plan

- Activities, use and the benefits for citizens
- Planned measures to maximize project impact
- Target groups

Gantt Chart

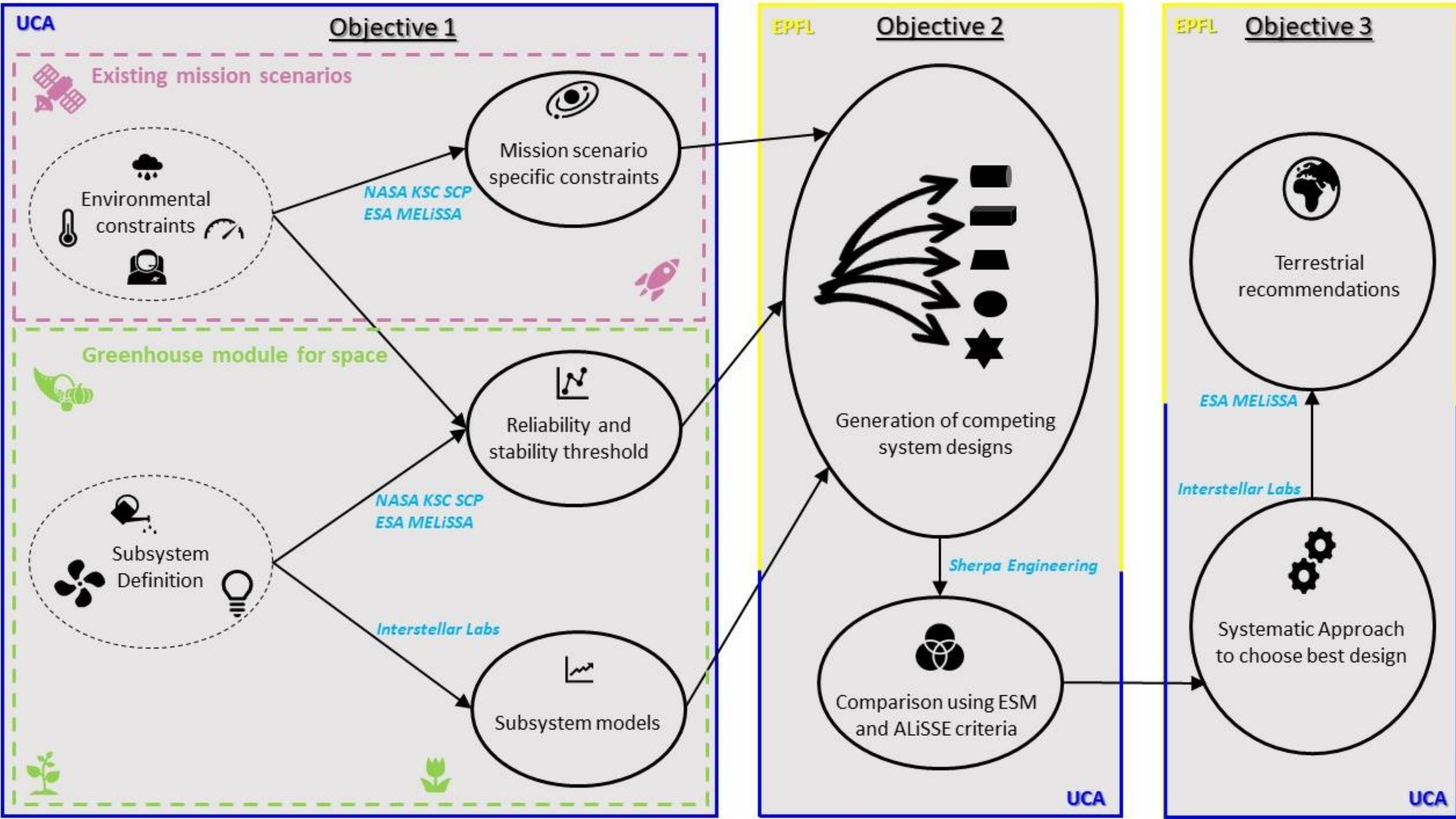
		Year 1												Year 2											
Work Package	**Tasks**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
WP 1 - Analysis of constraints and objectives						D1.1																			
	Identify mission scenario constraints			MS1.1																					
	Define reliability and stability threshold					MS1.2																			
WP 2 - Creation of subsystem models								MS2.1 D2.1																	
WP 3 - Generation & Interpretation of results																D3.1									
	Generation of competing designs											MS3.1													
	Design ranking with ALiSSE and ESM criteria															MS3.2									
WP 4 - Decision on a systematic approach																									D4.2
	Development of systematic approach																				MS4.2				
	Recommendations for terrestrial GHM											MS4.1													MS4.3
WP5 - Dissemination and Communication																									
	Dissemination			D5.1				D5.4		D5.5								D5.11		D5.13 D5.14	D5.15			D5.17	
	Communication and Outreach activities			D5.2		D5.3				D5.6	D5.7		D5.8		D5.9		D5.10		D5.12				D5.16		D5.18
WP6 - Project management				D6.1		MS6.1	D6.2	MS6.2				MS6.3					MS6.4					MS6.5			MS6.6

Context & Main goal

- Return to the Moon, preparing for Mars
  - Need for larger Greenhouse Modules (GHM)
  - More reliability and sustainability
- Goal: a systematic methodology to design space and terrestrial GHM
  - Chemical & Systems engineering approach
  - Based on modeling and simulation tools
  - Systems in systems method (see OSCAR project)
  - ALiSSE criteria

Needed approach

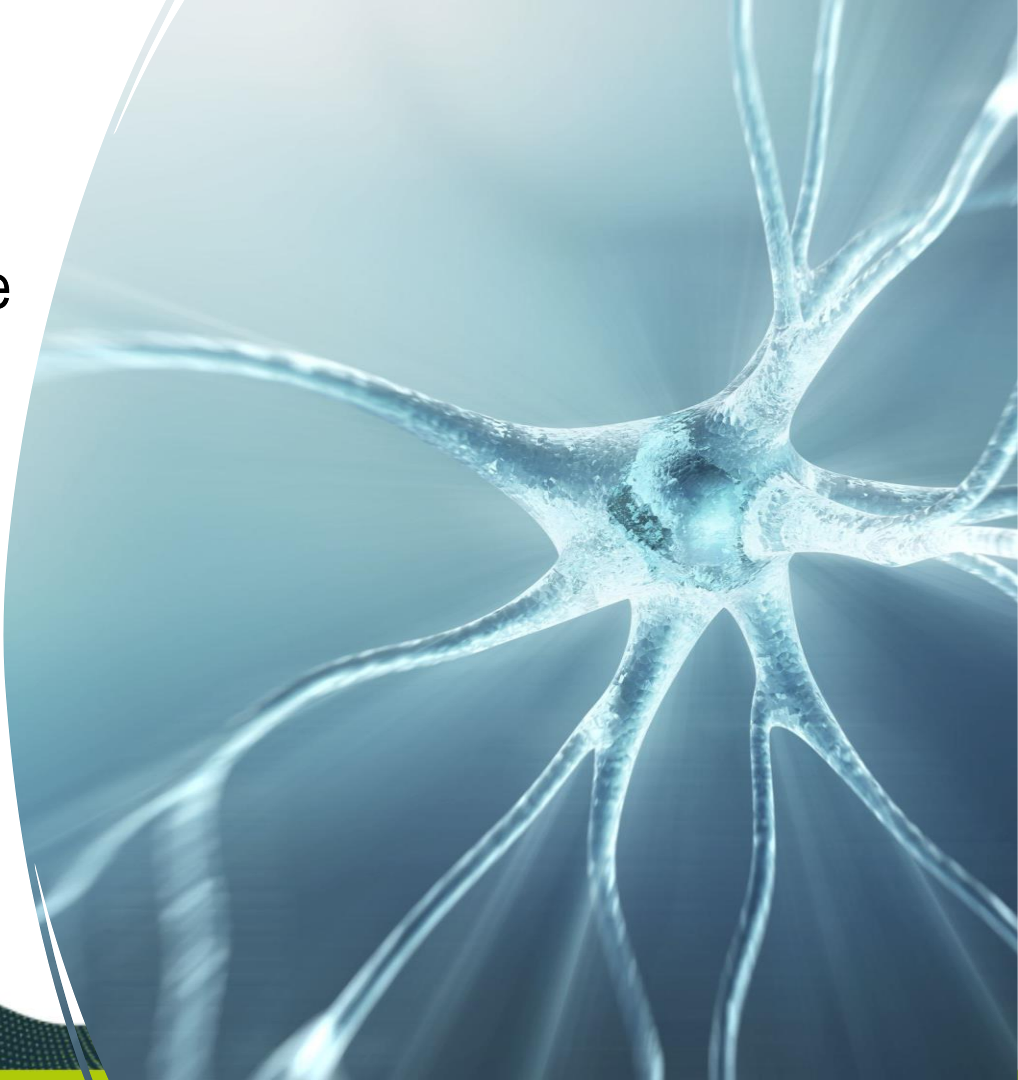
Current approach



UCA
Objective 1
Existing mission scenarios
Environmental constraints
Mission scenario specific constraints
NASA KSC SCP
ESA MELiSSA
Greenhouse module for space
Reliability and stability threshold
Subsystem Definition
NASA KSC SCP
ESA MELiSSA
Interstellar Labs
Subsystem models
EPFL
Objective 2
Generation of competing system designs
Sherpa Engineering
Comparison using ESM and ALiSSE criteria
UCA
EPFL
Objective 3
Terrestrial recommendations
ESA MELiSSA
Interstellar Labs
Systematic Approach to choose best design
UCA

Best design approach

- Exergy diagnostics: evaluation of the main sources of irreversibility
- Numeric test of best configurations by simulation
- Use of radiative energy for converting minerals and CO_2 into consumable products (O_2, recycled water and food)



Review of Mission Scenarios

Type	Location	Gravity	Radiations	Sun profile	Magnetism	Resources
Moon	Shackelton	0.16 g			No	
Mars	Multiple	0.38 g			No	
Interplanetery travel	Solar system	µg			No	
Space station	LEO Cis-Lunar	µg			Yes No	

Work in progress

Work in progress

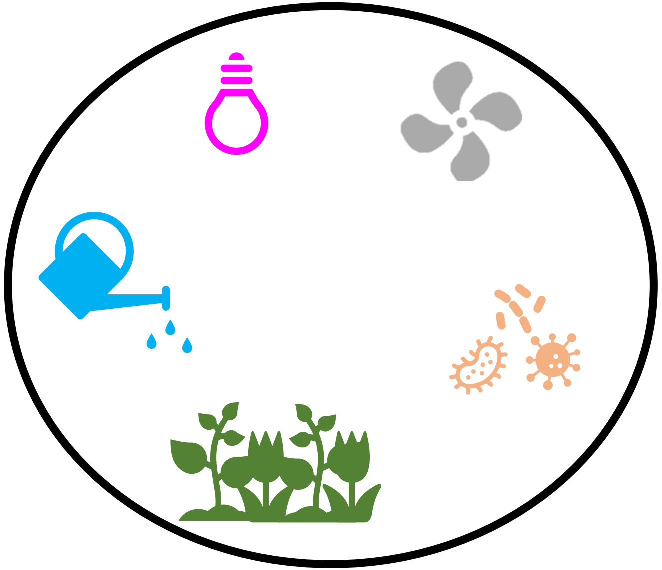
Work in progress

Subsystem identification & modelling

Mission Scenario

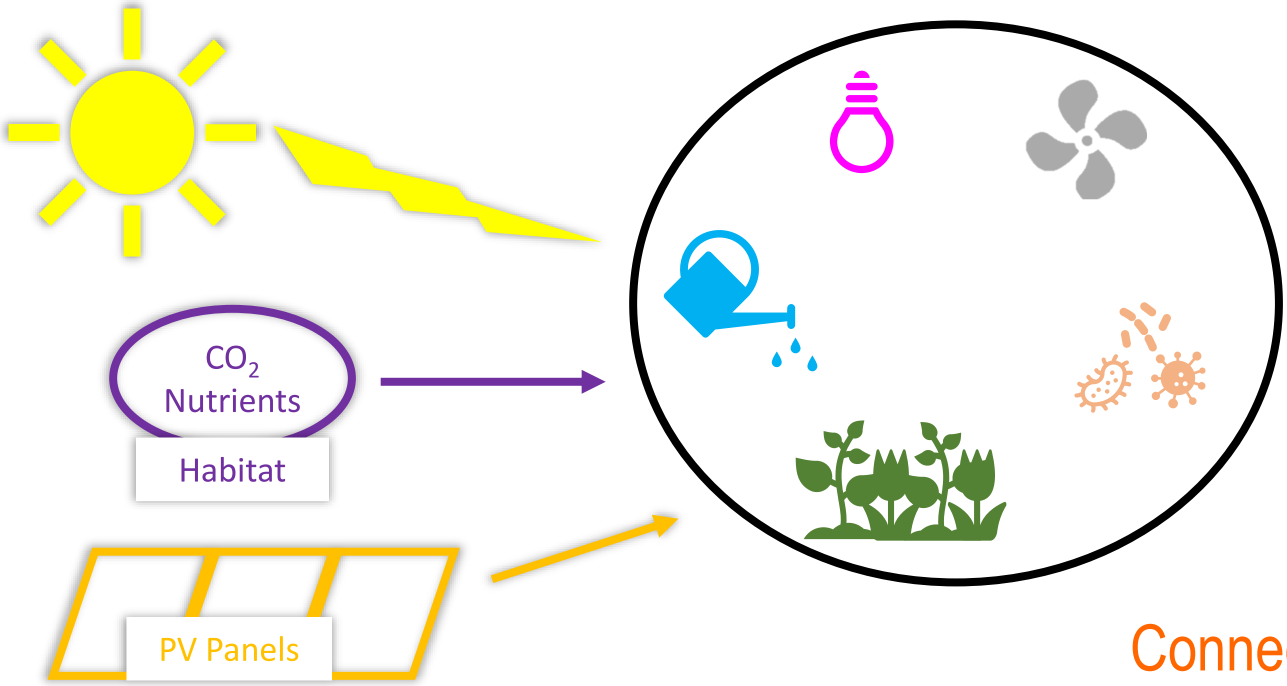
Location
- Gravity
- Radiations
- Sun profile
- Magnetism

Module pressure
People
Duration



System Boundary definition
Subsystem Identification

Subsystem identification & modelling



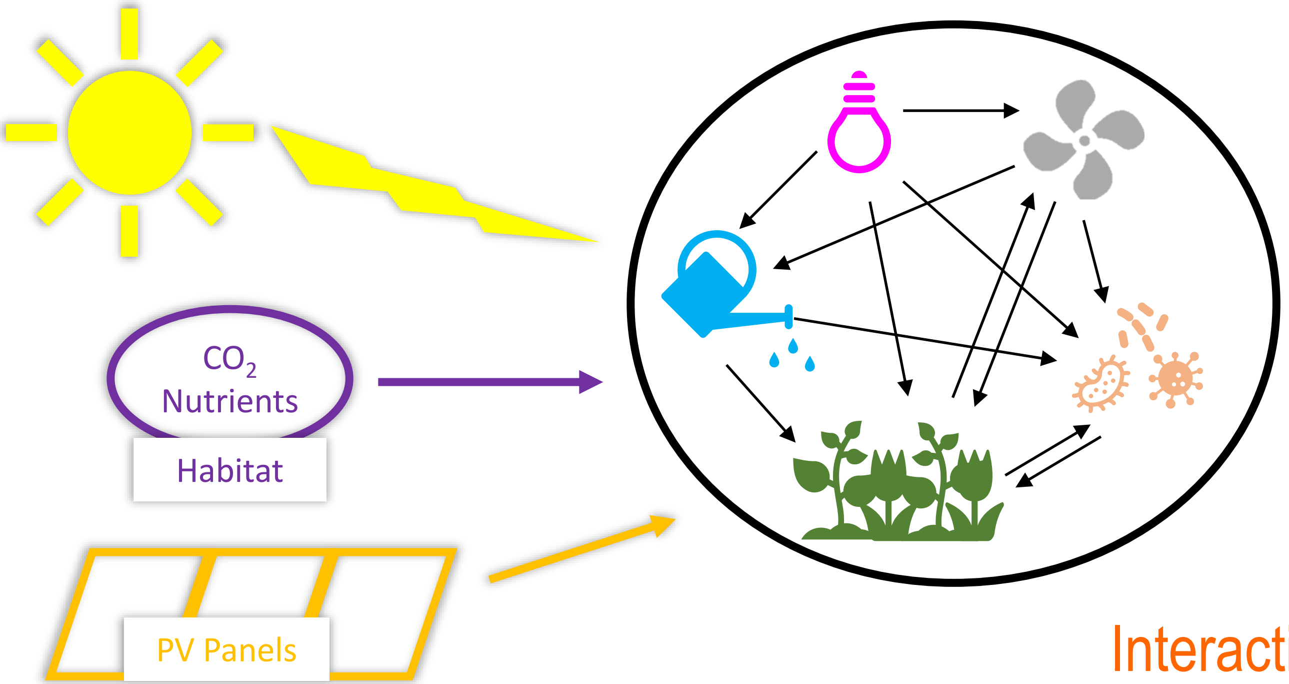
Mission Scenario

Location
- Gravity
- Radiations
- Sun profile
- Magnetism

Module pressure
People
Duration

Connection and interaction with outside systems

Subsystem identification & modelling

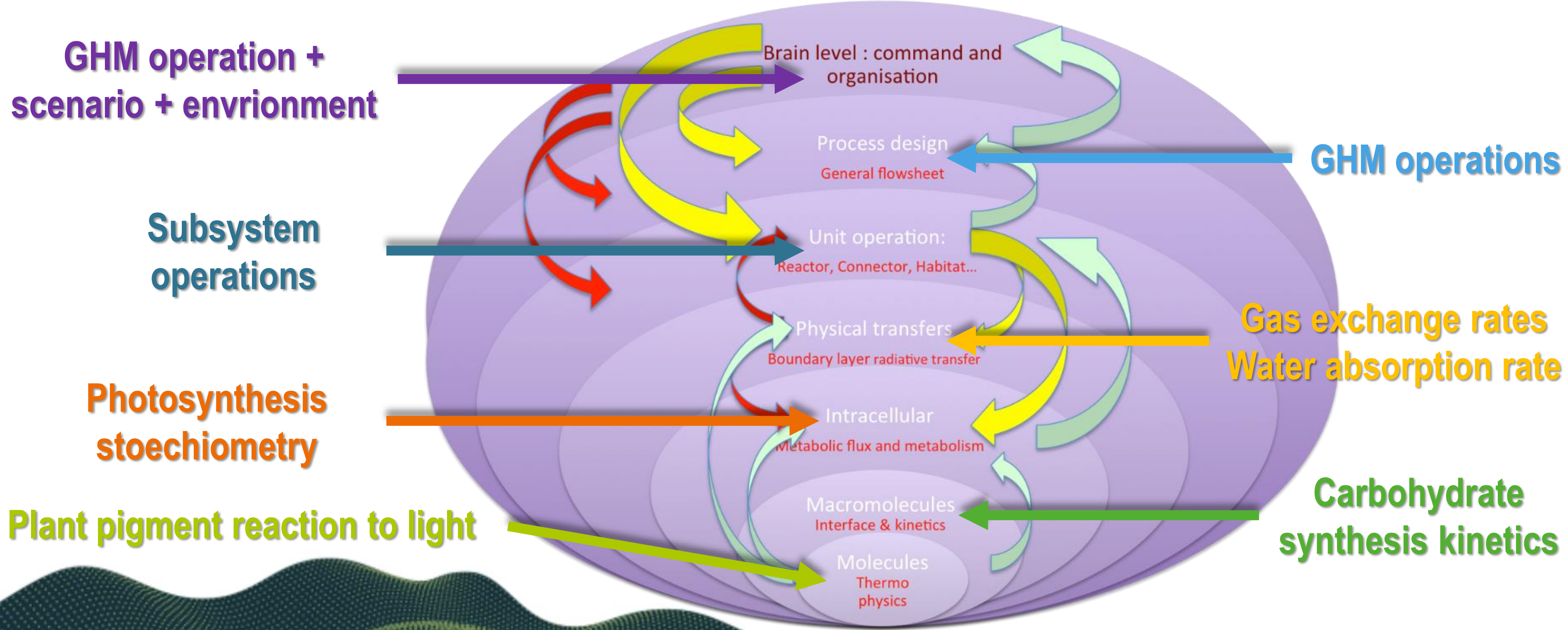


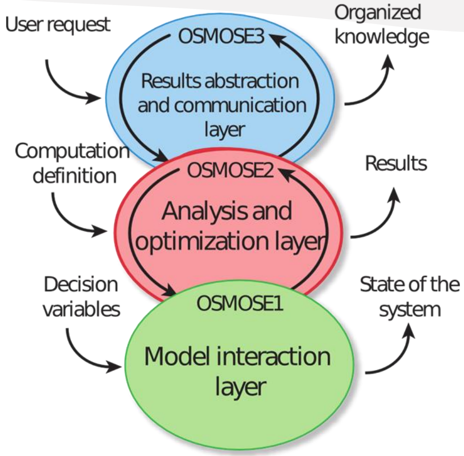
Mission Scenario

- Location
  - Gravity
  - Radiations
  - Sun profile
  - Magnetism
- Module pressure
- # People
- Duration

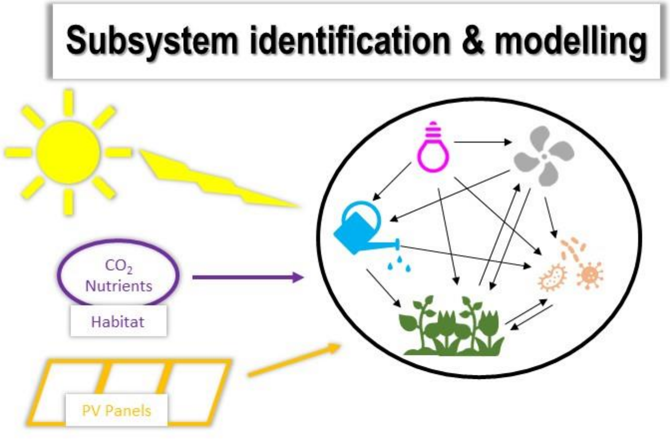
Interactions between subsystems

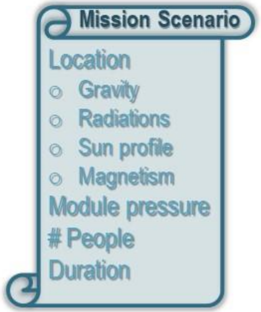
Multi-scale and multi-layer models

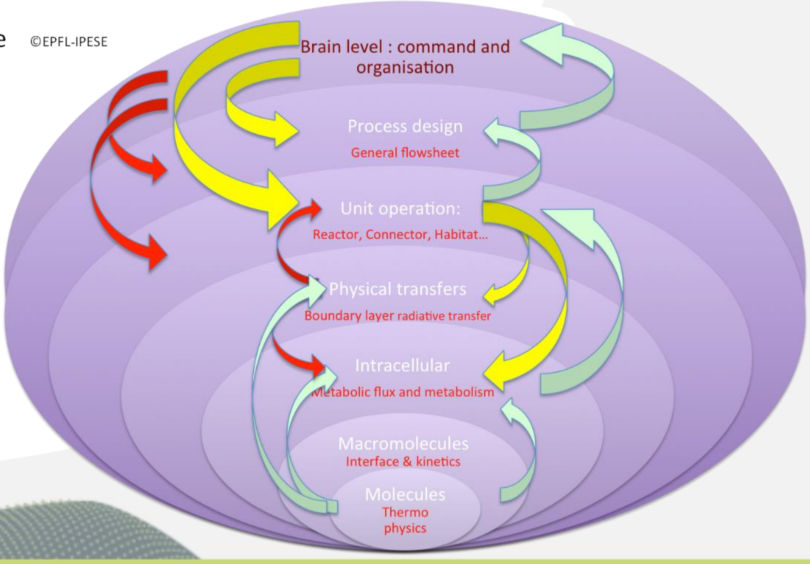




Osmose structure ©EPFL-IPESE





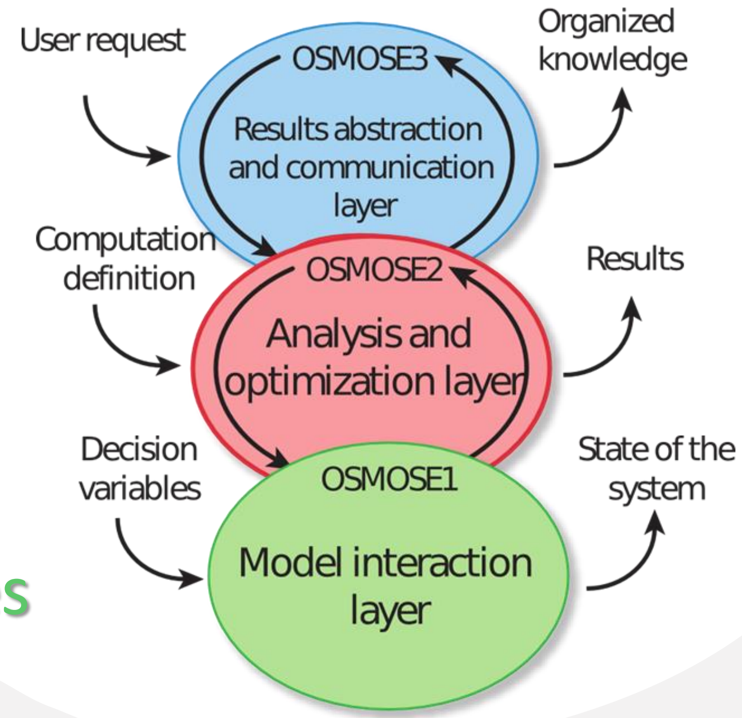


OSMOSE: multi-objective optimization analysis of integrated energy systems

Methodology
Development

ALiSSE criteria

Mass
Energy Balances
Exergy



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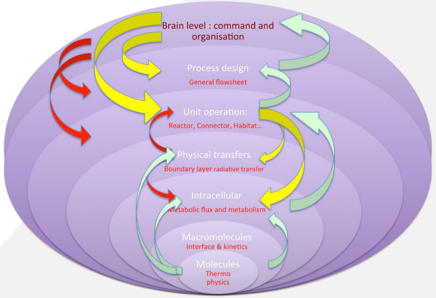

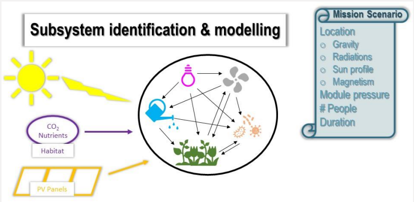

Conclusion

- Coupled chemical, process and systems engineering approach with mutli-objective optimization.
- A methodology towards a systematic approach for GHM design.
- Integrated models and ALiSSE criteria.
- Terrestrial applications.

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THANK YOU.

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