Closed loop system: a safety challenge for the crew as well as for the life support processes.

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Facing the huge resources challenges of manned mission on Earth our in Space

WATER, FOOD, OXYGEN, CO2, WASTE, ENERGY

CIRCULARITY IS THE SOLUTION

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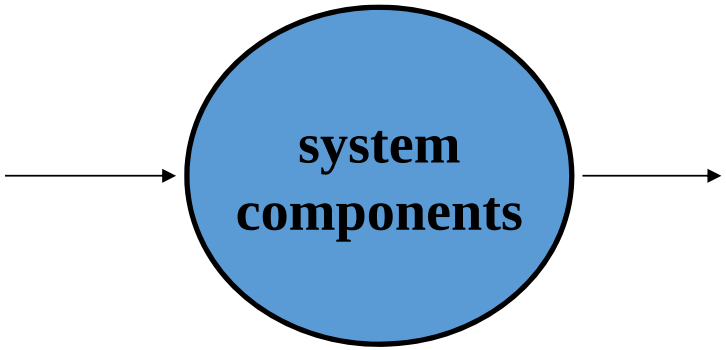
Today → Tomorrow

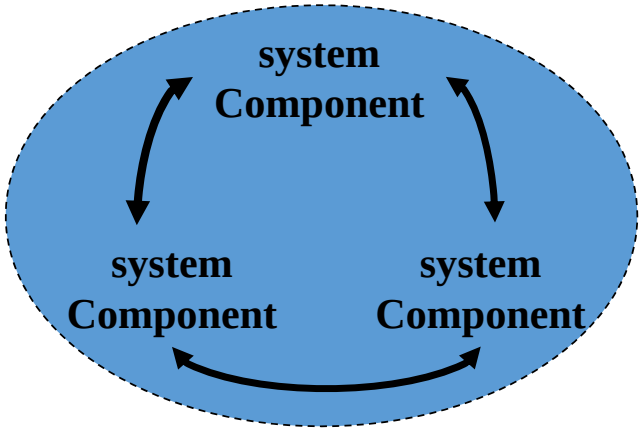
«Juvenile» system



Unlimited Resources

Unlimited Waste

«Mature» system



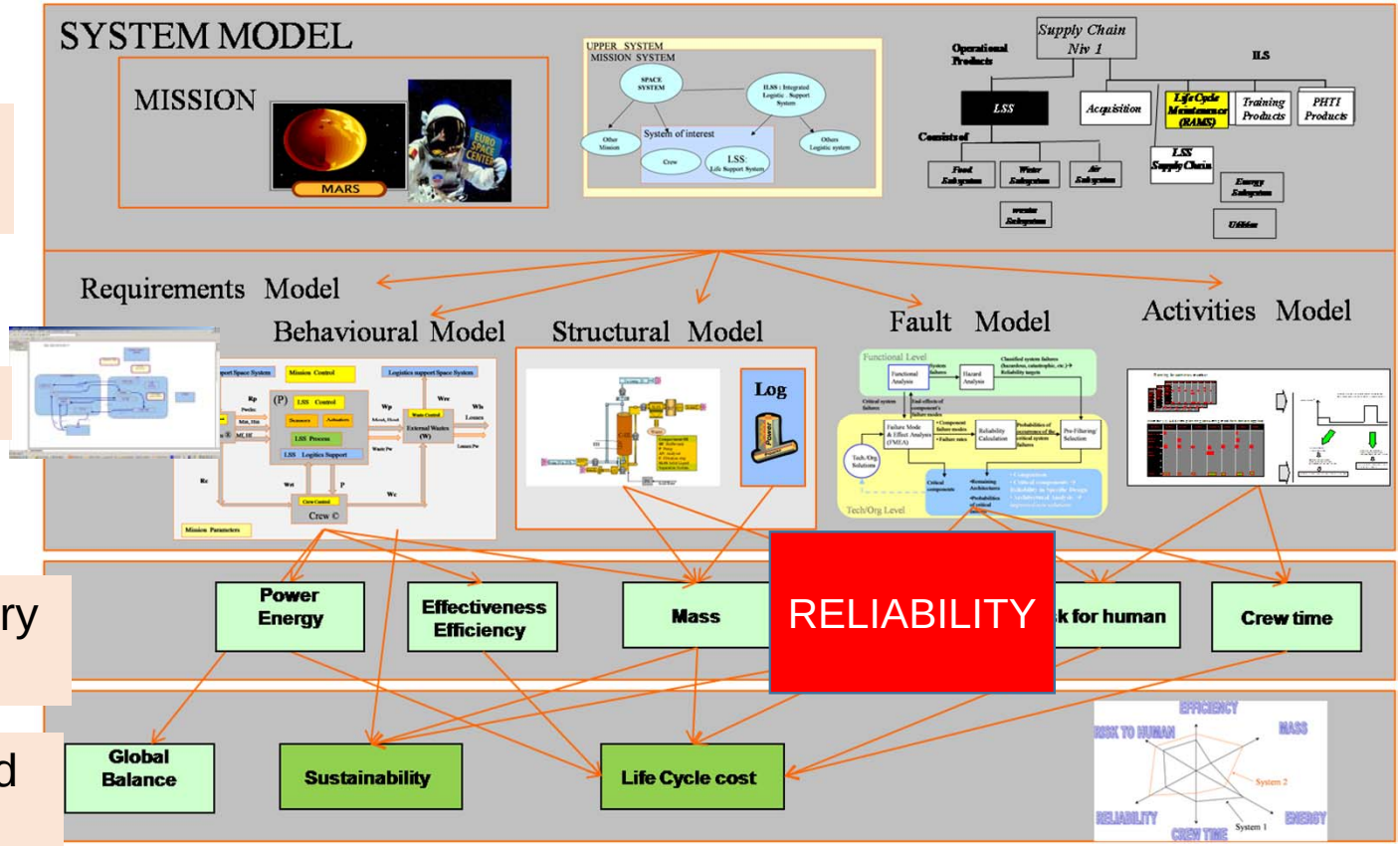
- Low consumption of resources
- Quasi-cyclical flows of materials

How will look a Closed Life Support ?

- An Assembly of sub-systems,

- Partially Biological, for 2 reasons:
  - You can’t sterilize the crew members,
  - Today, you cannot chemically synthesize all food molecules

Alisse Integrated Model



Alisse requires definition of mission and integration of different technical & economical models to compute criteria of different nature

What does it means in terms of Risks ?

Characteristics of Compartmentalised System

- Highly fragile and Unstable by nature,
- Require Complex Control strategy,
- Mainly continuous, but not only,
- Limited buffer,
- High development cost
- Characterisable,
- Can meet (in theory) Space requirements,
- Highly dynamic,
- Optimizable,
- Intrinsically Fault tolerant,

Characteristics of Biological Processes

- High/Slow dynamic,
- Complex inputs/outputs mat rice,
- Multiphasic,
- Subject to nature changes,
- Sensitive to entrants,
- Dependent of traces elements :
  - Toxicity,
  - Limitations
- Highly resistant,
- Evolutive,
- Can be generally restarted with micro-grammes,

Risks to the Crew

- Physical,
- Chemical,
- Biological,
- Radiations,

- Today all standards are defined for ISS and limited duration exposure,
- Some of these values will probably have to be revisited

- Pr Flandrois will touch on this !

Risk to the Life Support System

- Low quality Control law,
- Evolution of the nature of the process:
  - Stress,
  - Radiation,
  - Highly specialization of our strains,
- Fragility to entrants:
  - Phages, virus, mobile elements,
  - Cleaning agents, biocide,
  - Material degradation (Ag, Ni,..)

A bit of Bibliography

Whether for stabilization or for optimization, the design of a global control system offers interesting challenges. One of these is the basic performance measure for a CELSS--survival. To design a control scheme, a quantitative measure for the probability of survival must be defined. Then a computational procedure must be devised to predict the probability of survival, with specified confidence limits, for a system subject to varieties of statistically possible events. In principle, this is not that much different from a safety analysis and control for a nuclear power plant, for example, but in a CELSS it is complicated by the very long-term dynamics inherent in such systems as growing plants. Furthermore, the control system in a CELSS must be capable of adapting to changes and events that were not anticipated at the time the system was designed. This implies that the control system must be a synthesis of man and machine--computers will be a necessary part, but human interaction in decision-making will be vital.

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LNCS 4280

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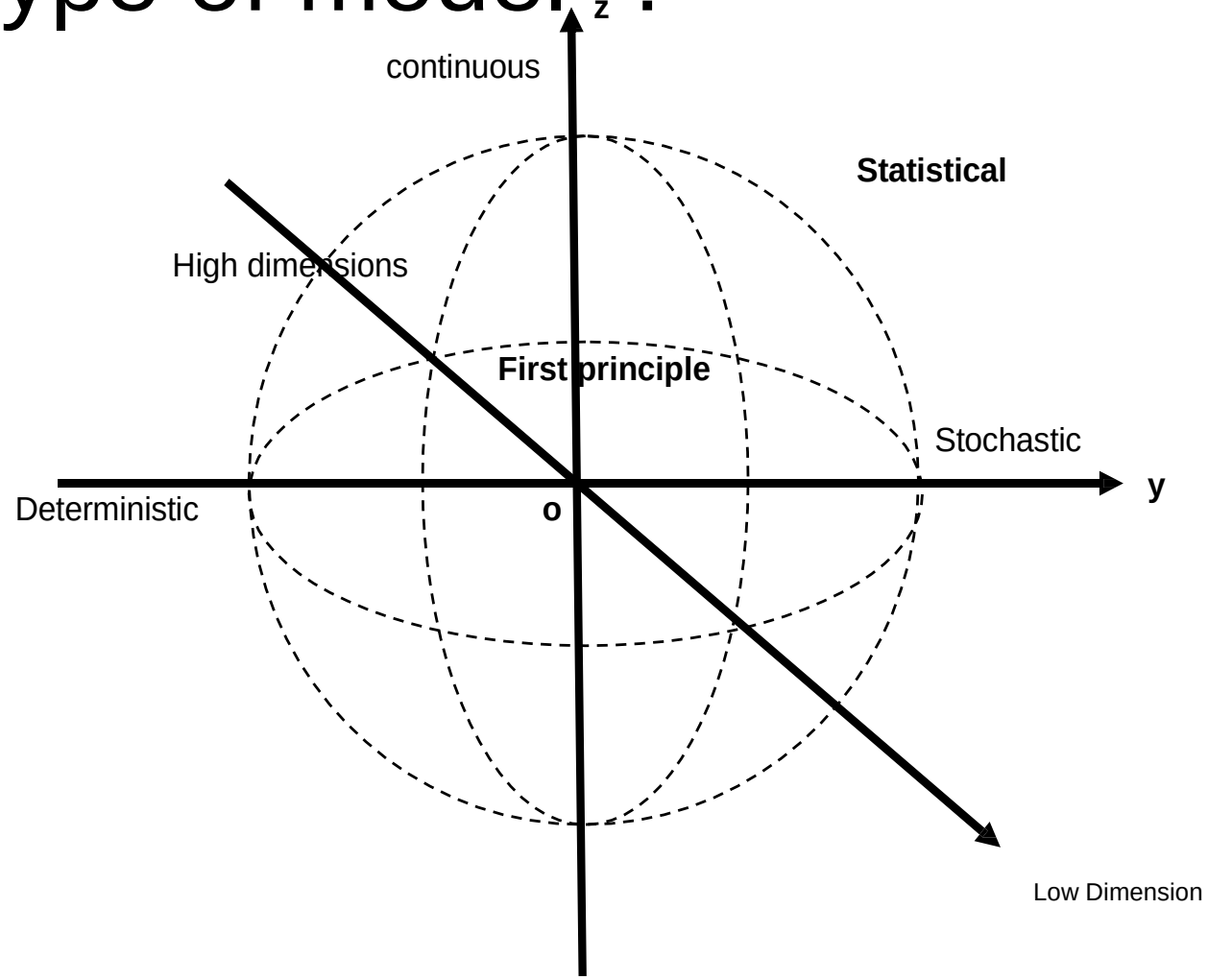
Which Type of model ?



Conclusion

- Today, despite ~70 years of research, Nobody has demonstrated on Earth a highly closed life support system for a long duration period (~1 year),
- What will be the final design, it will have to pass the space Agencies safety and Robustness boards with convincing VALUES !!
- To our knowledge, (but we are eager to learn), there is not today a way to characterize and quantify the robustness of biological processes,
- A new approach has to be considered and harmonize with the existing MELiSSA system tools.



14 MELiSSA PARTNERS





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