Application of EcosimPro® to Bio-regenerative Life Support Components

Alexander Rodriguez, ATOS ORIGIN & Luis Ordonez Inda, ESA ESTEC / TOS-MCV

EcosimPro®

Is a software package for modeling and simulating dynamic systems, which could be represented by differential-algebraic equations and discrete events

Is developed and maintained by EA International, Spain with ESA support

Unique Features

•Easy interconnection of components by user- or pre-defined PORTS

•Non-causality of equations

a=f(b) ó b=g(a) a=b'+c" ó c"=a-b'

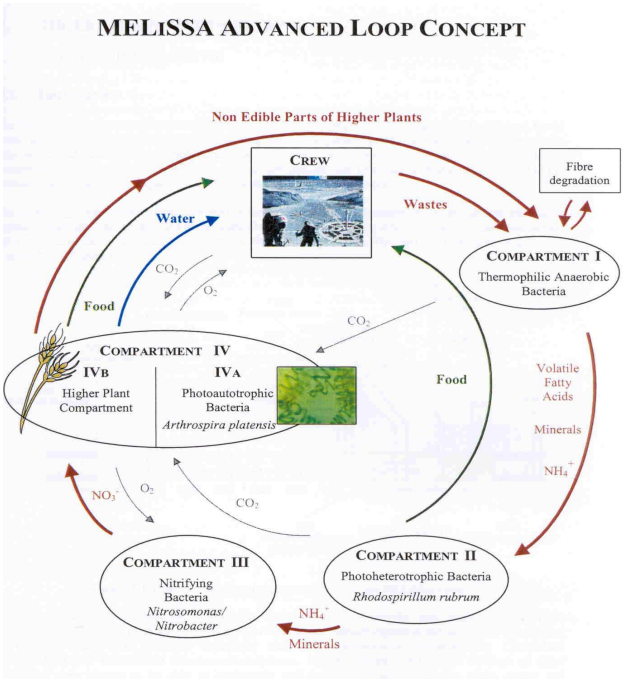
Bio-regenerative life support system (BLSS)

DEFINTION

BLSS is a system that is capable of recovery of edible biomass, water and oxygen from waste, carbon dioxide and minerals based on processes driven by biological entities.

•To date, a BLSS with a high degree of closure for all material flows does not exist

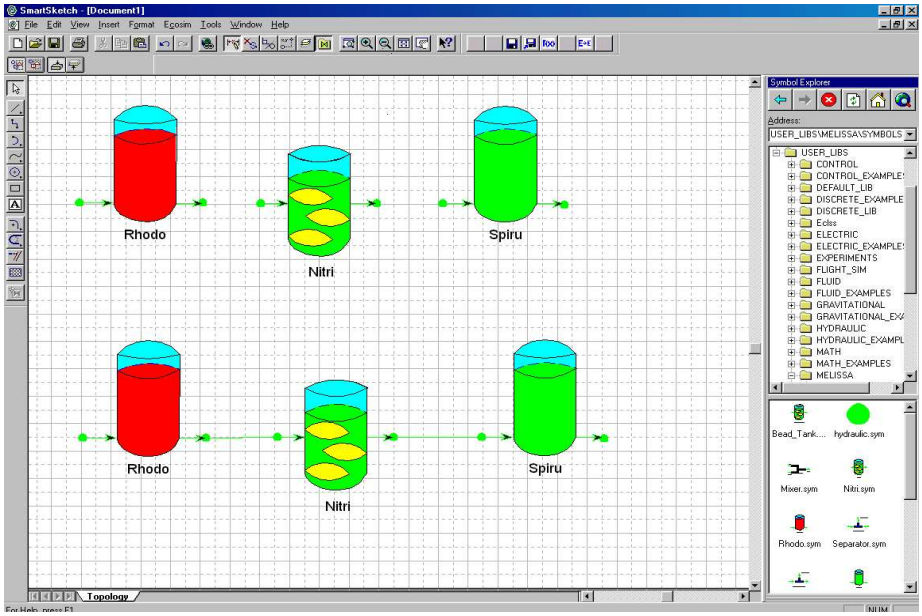
•MELiSSA has been conceived as a micro-organisms and higher plant based ecosystem intended as a tool to gain understanding of the behavior of artificial ecosystems, and for development of the technology for a future bio-regenerative life support system



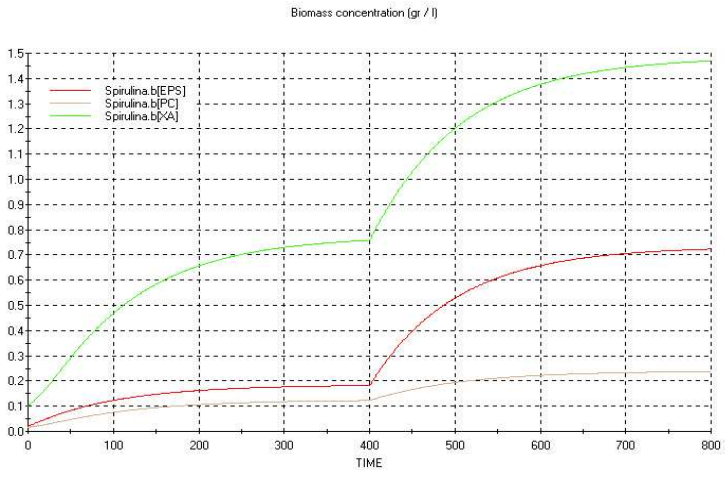
Simulations so far have been concentrated on compartment II, compartment III and compartment IVa

Simulations have been run as continuous and batch cultures using EcosimPro® and Matlab® /Simulink®

Screenshot of EcosimPro® Pre-processing Tool Smartsketch ®

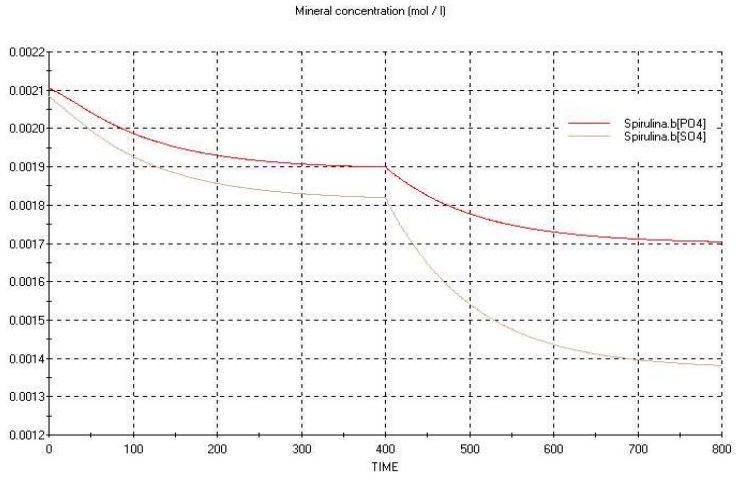


Simulation Results for a Photoautotrophic Compartment (1)



- proper concentration evolution of multiple compounds
- capability of handling step changes in the light flux satisfactorily
- Graph automatically generated using an included post-processing tool

Simulation Results for a Photoautotrophic Compartment (2)



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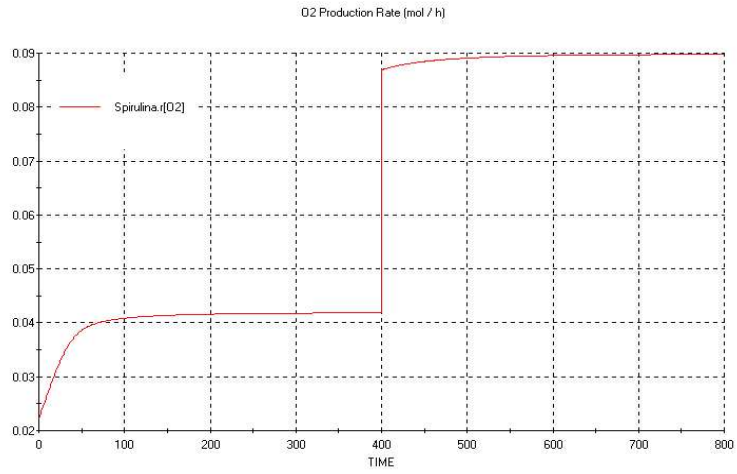
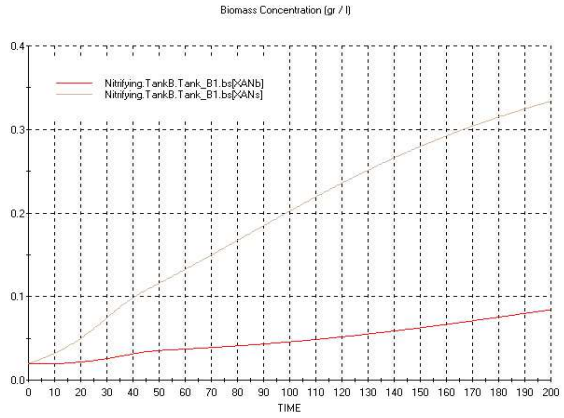
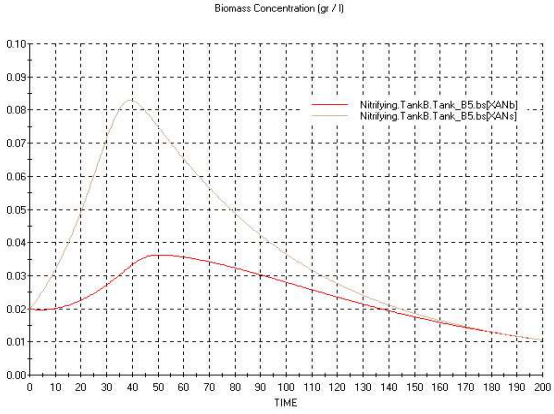
Simulation Results for a Photoautotrophic Compartment (3)



- proper rate evolution even at step changes
- capability of handling step changes satisfactorily

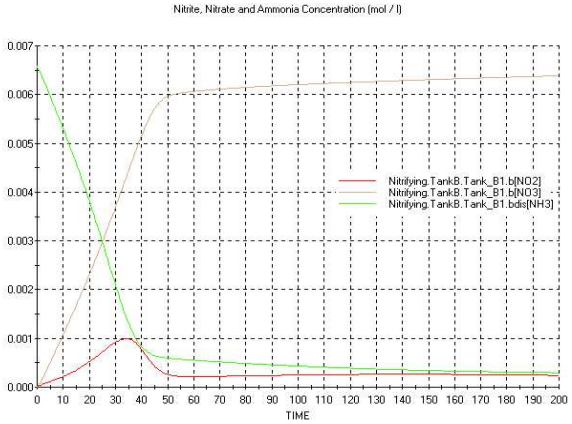
Simulation Results for a Nitrifying Compartment (1)

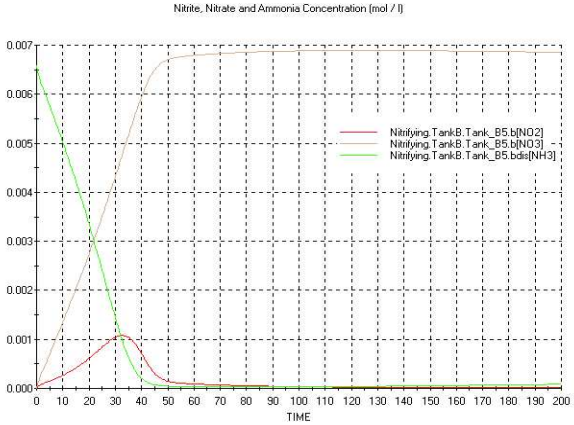




proper spatial and time resolution of concentrations of two kinds of biomass

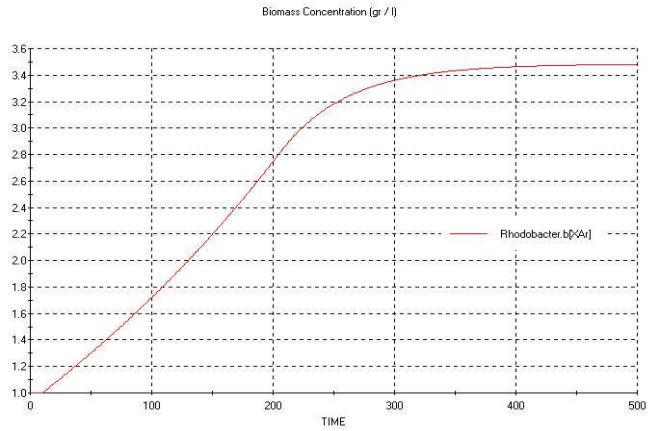
Simulation Results for a Nitrifying Compartment (2)





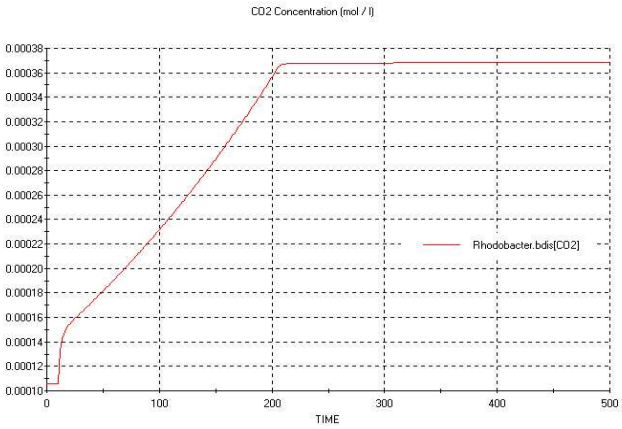
proper spatial and time resolution of concentrations of nitrogen containing compounds

Simulation Results for a Photoheterotrophic Compartment (1)



- proper concentration evolution of multiple compounds
- capability of calculating an initial steady state and start a subsequent transient analysis

Simulation Results for a Photoheterotrophic Compartment (2)



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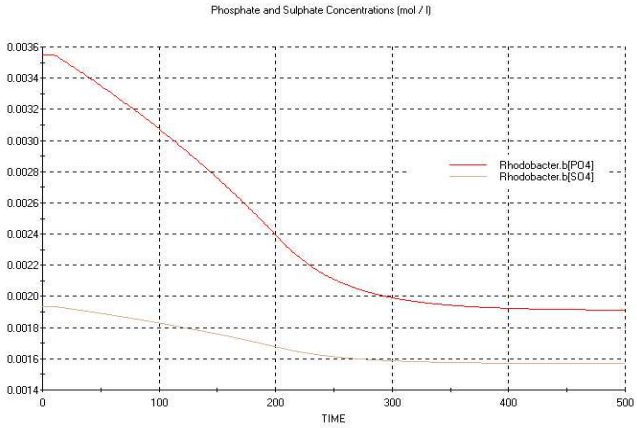

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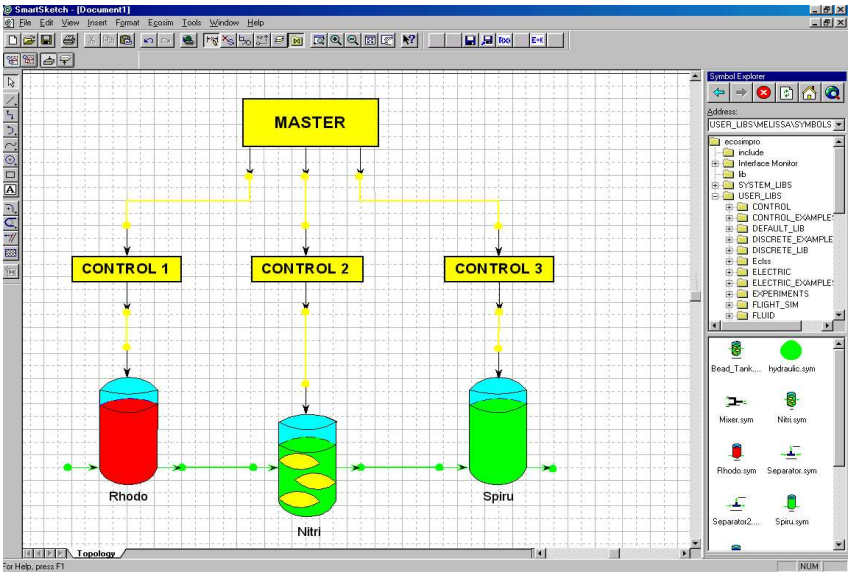
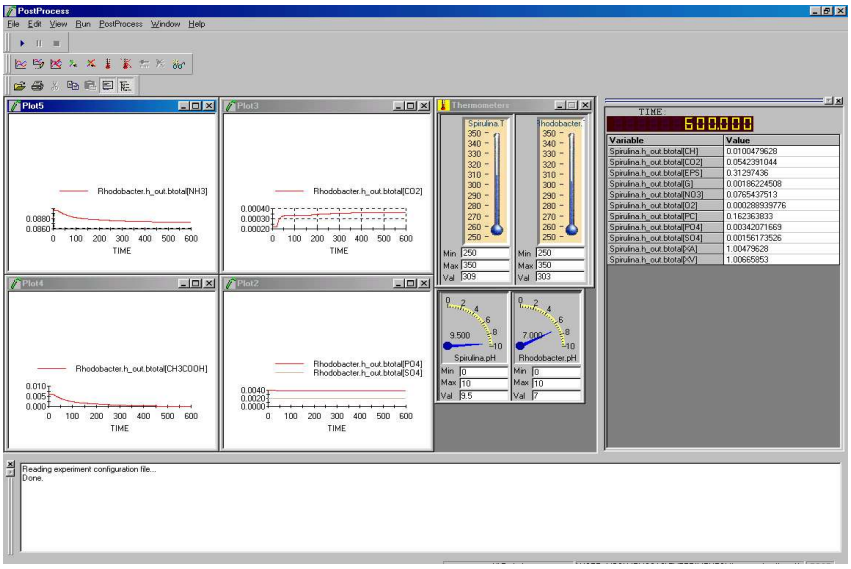
Screenshot of EcosimPro® Preprocessig Tool Smartsketch ®



- 2level control structure implementation
- each component automatically generates c++code during compilation

Screenshot of EcosimPro® Postprocessig Tool EcoMonitor®



- results can be displayed in suitable form during and after simulation
- dynamic variables can be changed during simulation using the EcoMonitor®

Conclusion (1)

EcosimPro®

- Is capable of simulating components of bio-regenerative life support system components
- Could predict accurately the steady state and transient behavior of bio-regenerative elements
- Performs reasonably efficient and accurate
  - no thorough comparison to other suitable tools has been made yet
  - DDASSL solver has been chosen after Trade-off analysis by EA International

Conclusion (2)

EcosimPro®

- Object oriented capabilities allow simulation of single components or entire systems
- Object oriented capabilities allow simulation of control strategies in different layers
- Easy-to-use pre & post processing tools are included
- C++ code could be exported to run stand alone applications
- External C++ code could be implemented fairly easily in EcosimPro® components