Latest advances in EcosimPro Simulation Tool

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EA INTERNATIONAL

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http://www.ecosimpro.com

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History of EcosimPro

- The project started in 1989 with funds from the European Space Agency (ESA) to simulate Environmental Control and Life Support Systems for manned spacecraft (Hermes y Columbus)
- Since then, it has been used in many other fields: fluids, chemical, control, electrical, propulsion, etc
- Version 3.0 in December 1999 for PC-Windows.
- Version 3.1 in November 2000.

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EcosimPro OVERVIEW

What is EcosimPro?

- EcosimPro is a mathematical tool for modeling and simulating continuous and discrete systems.
- It represents the state-of-the-art in continuous non-causal simulation

Applications of EcosimPro

- EcosimPro is applicable to any problem domain which can be represented by Differential-Algebraic Equations (DAE) and Discrete Events.
- For example: chemical, thermal, control, hydraulic, electrical ,propulsion etc.

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EcosimPro Capabilities (I)

- Symbolic handling of equations and numeric solvers for differential-algebraic equations and discrete events
- Object-oriented modeling language with the latest capabilities such as multiple inheritance, assertions, virtual equations, etc
- Calculation of transient and steady states

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EcosimPro Capabilities (II)

- Visual development environment (similar to Microsoft Visual Studio)
- Graphical modeling tool based on dragging and dropping symbols from a palette
- Creation of reusable and non-causal components
- Very powerful equation solvers (nonlinear and differential-algebraic equation systems)
- Optimized to work with large models (thousands of equations)

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EcosimPro Capabilities (III)

- Math wizards to help define boundary conditions, solve algebraic loops and high index math problems
- C++ and OCX (COM) code generation
- Results are easily exported to Excel and Word

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Reuse of Models

- Non-causal modeling implies that at the time of modeling there is no a priori knowledge of the known and unknown variables. The user only writes the laws governing the phenomenon (e.g. v= R*i or i= v/R or 0 = v - R*i)
- The modeling is therefore very universal and reusable, causality is defined at the end of the process
- EcosimPro allows creation of reusable component libraries
- Until now, the simulation analyst was 80% programmer and 20% modeler. The situation is reversed with EcosimPro

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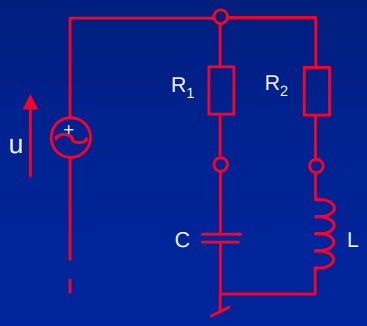
EcosimPro (non-casual) versus Simulink (causal)

In Simulink, the first step is to write the equations by hand, then sort them with their causality and finally draw them.



Electrical DIAGRAM

$$i_C = (U - U_C) / R1$$
$$U_L = U - i_L \times R2$$
$$U'_C = i_C / C$$
$$i'_L = U_L / L$$

EQUATIONS IN SIMULINK DIAGRAM

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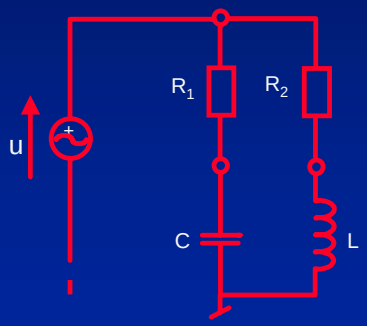
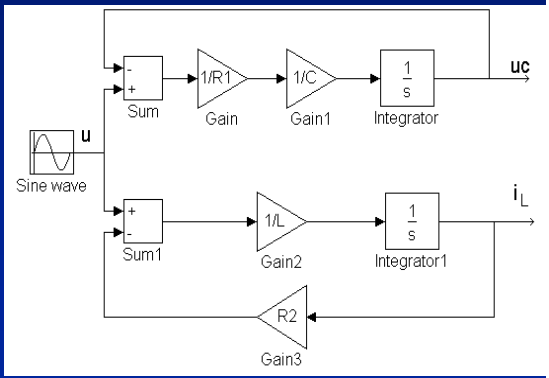
EcosimPro versus Simulink

In Simulink the modeler “draws” the equations but not the system to be modeled.



Electrical DIAGRAM



SIMULINK DIAGRAM

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EcosimPro versus Simulink

In EcosimPro the modeler first creates the basic components and then reuses them:

```
COMPONENT Capacitor IS_A Twopins
  DATA
     REAL C = 1e-6  "Capacitance (Farads)"
  CONTINUOUS
     v' = i / C      -- Capacitor law
END COMPONENT
```

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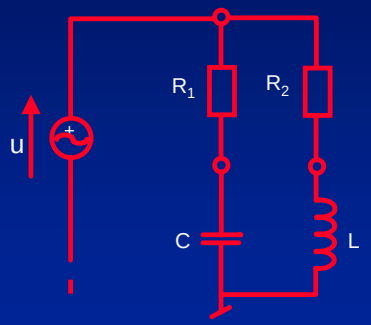
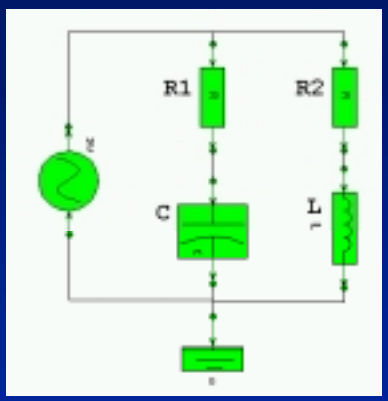
EcosimPro versus Simulink



Electrical DIAGRAM



EcosimPro DIAGRAM

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Object-Oriented Dynamic Modeling

Advantages:

- 1- It allows non-causal modeling
- 2- It is easier to reuse
- 3- It is easier to maintain and extend (compare with old FORTRAN programs).
- 4- At last the modeler models dynamic systems, it is not only a low level programmer!

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EL (EcosimPro Language): The Modeling Language

- Very intuitive syntax
- Object oriented (multiple inheritance, aggregation, etc)
- Enumeration type data
- Multidimensional arrays
- 1D, 2D and 3D tables
- Connection with FORTRAN, C and C++ functions
- Use of assertions to check consistence at all times
- Representation of DAEs, ODEs and discrete events
- Simple and intuitive concept of components library

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EL: Example of Point Mass Movement

```
COMPONENT  point
    DATA
        REAL m = 1                  "mass (Kg)"
    DECLS
        REAL F                      "force (Newton)"
        REAL  x                     "space (m)"
    CONTINUOUS
        F = m * x´´             --  Newton's law
END COMPONENT
```

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Heater Component of ECLSS Library

```
COMPONENT  Heater  IS_A HeatStorageChannel
PORTS
    IN  analog_signal  s_pow  "Power signal"
DATA
    REAL dp_ref   "Reference pressure loss (Pa)"
    REAL w_ref    "Reference mass flow for pressure loss data (kg/s)"
    REAL rho_ref  "Reference density for pressure loss data (kg/m^3)"
    REAL dp_lam = 10 "Pressure drop for laminar flow (Pa)"
DISCRETE
    ASSERT (abs(f_out.rho - f_in.rho) / f_in.rho  < 0.1) WARNING \
        "Density change too high for uncompressible flow formulation”
CONTINUOUS
            --  Momentum
    f_in.w  = w_ref * ssqrt((f_in.p - f_out.p)* f_in.rho / rho_ref)
            --  Energy equations
    q = s_pow.signal
END COMPONENT
```

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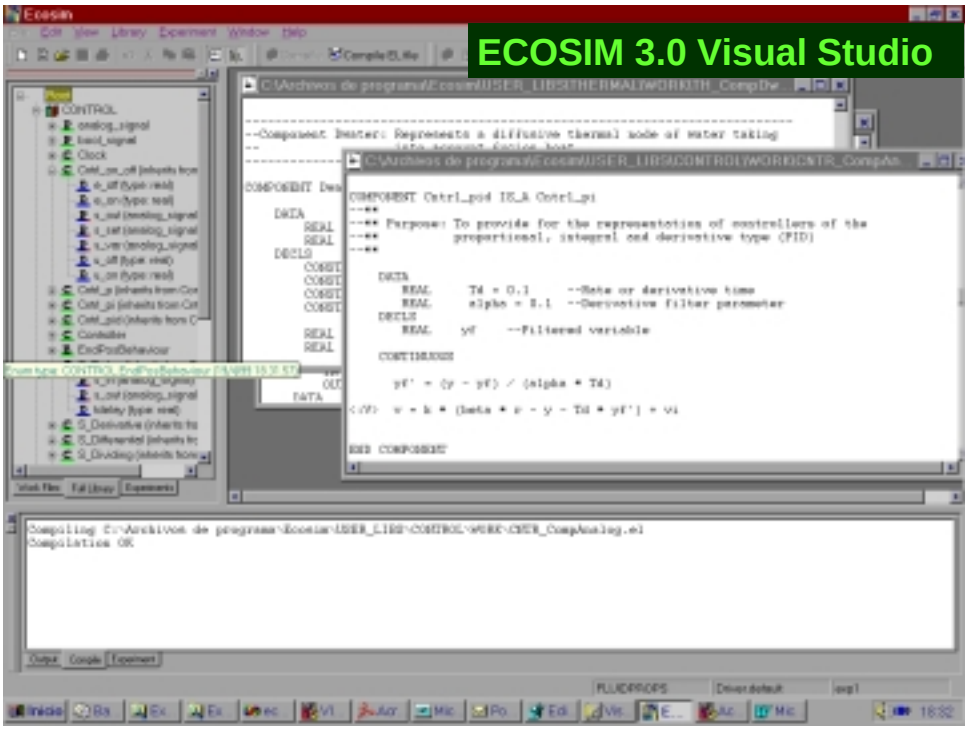
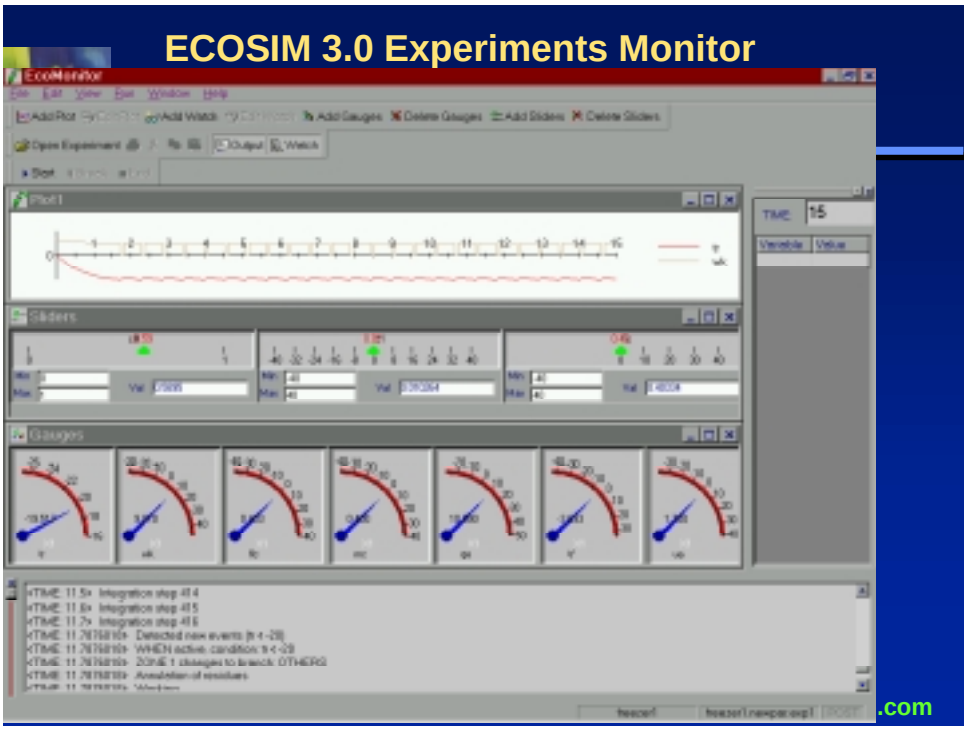
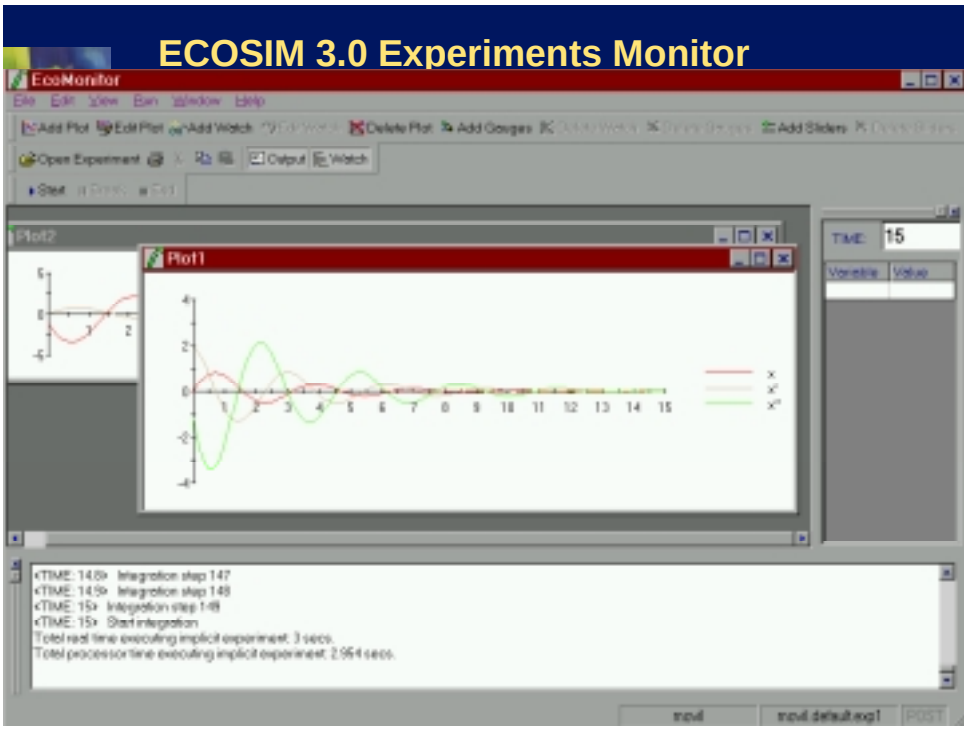
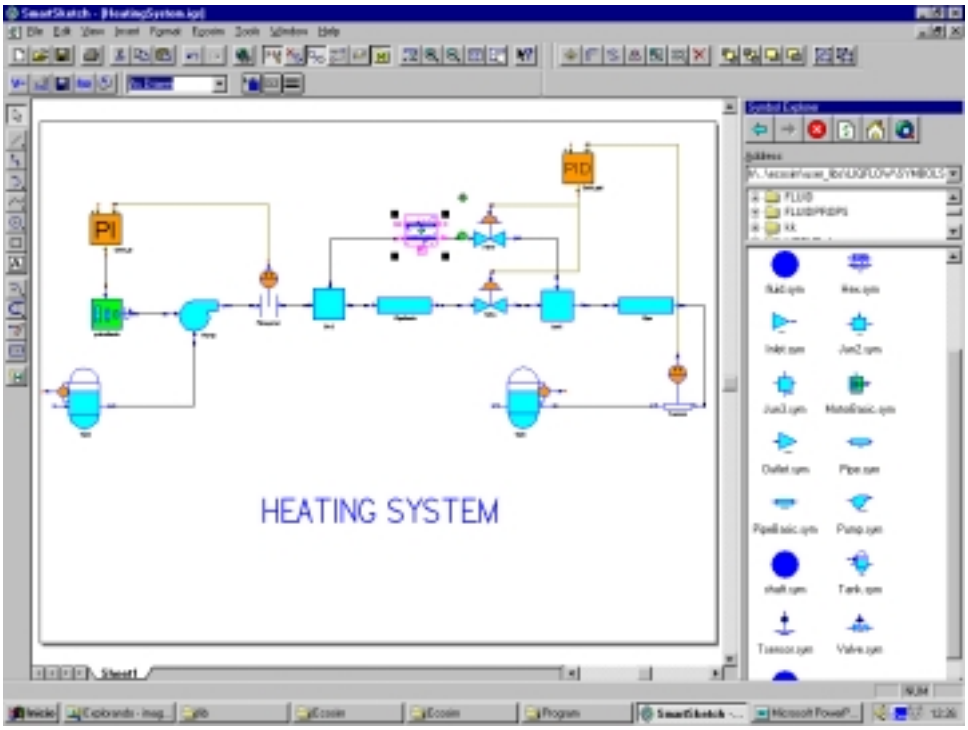

ECOSIM 3.0 Visual Studio


ECOSIM 3.0 Experiments Monitor


ECOSIM 3.0 Experiments Monitor
EcoMonitor
Plot1
TIME
15


PI
PID
HEATING SYSTEM

New features in Version 3.1 (I)

- Sparse solver for handling problems with thousand of state variables. There are disciplines where the number of state variables is very large (thermal, chemical, etc.), previous version (3.0) had a limitation about 350 state variables. New version can handle models with thousands of state variables.
- Implemented a classical four order Runge-Kutta solver for simple applications (very fast!).
- Automatic generation of an ActiveX DLL to connect any EcosimPro model to Microsoft applications. Typically the user can run the simulations from Excel. He can create quickly a macro to associate an EcosimPro model to an Excel sheet.

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New features in Version 3.1 (II)

- Faster and more reliable interaction with graphical tool SmartSketch.
- New object editors in SmartSketch. They are more simple to use. The units and description of data are displayed now.
- Improvement in the automatic “update” feature (makefile in UNIX).
- Improved editors for 2D and 3D tables
- Clever handling of external libraries (eg FORTRAN)
- Better suggestions from the mathematical wizards
- More intelligence detecting equivalent variables in systems

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New features in Version 3.1 (III)

- The wizard for high index able to solve more complex problems.
- New EXPAND_BLOCK statement for generating in a single block many equations (like EXPAND for a group of equations)
- More than 100 small bugs solved
- Many small improvements suggested by users implemented
- Saving of graphics configuration now saves all changes

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New features in Version 3.1 (IV)

- Improved log info when no covergence in models occurs
- Better control of convergence for steady states
- Access to all Ecosim Manuals from the GUI
- New plots versus TIME and any other variable
- New thermometer gauge for experiments
- Simplified the regular expressions mechanism for reporting variables

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EcosimPro Libraries

- ECLSS Library
- Thermal Library
- Control Library

Other Libraries:

- Propulsion Library
- Pipe Network Library
- Electrical Library
- Heat Balance of Power Plants

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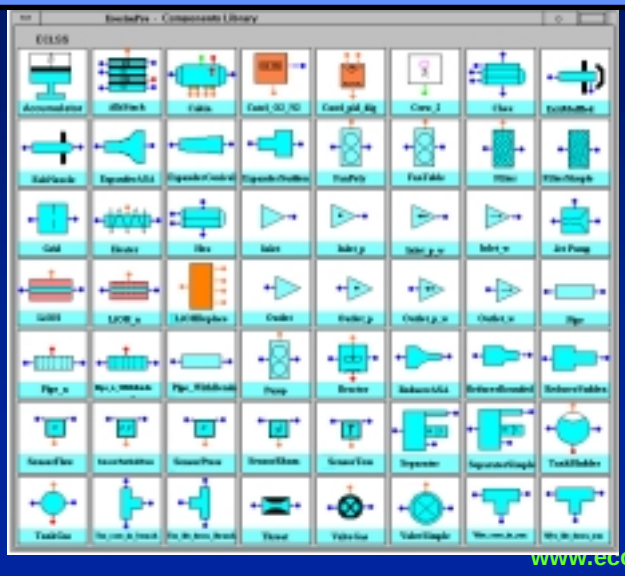
ECLSS Library - Palette of Components



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Control Library - Palette of Components

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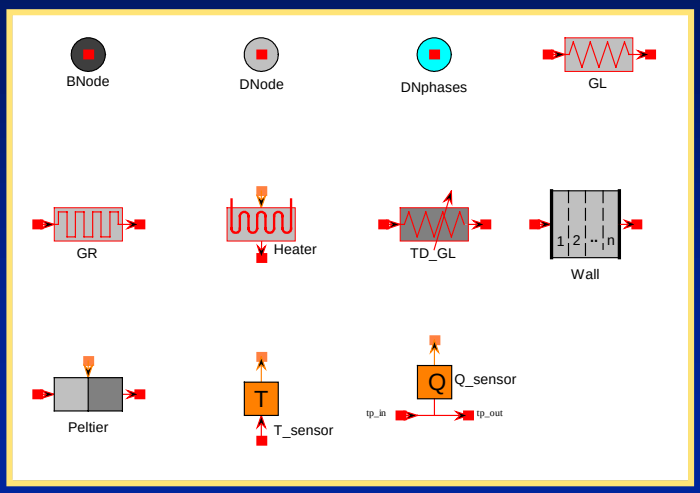
Thermal Library - Palette of Components



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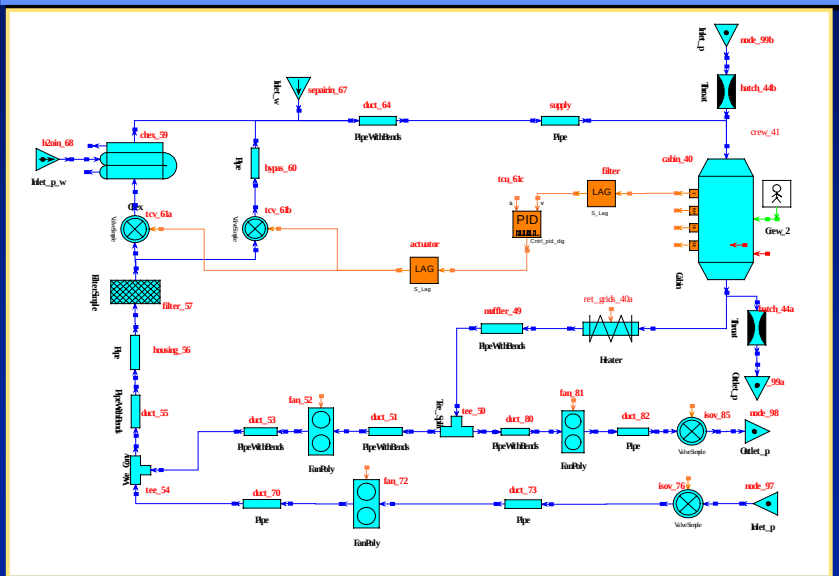
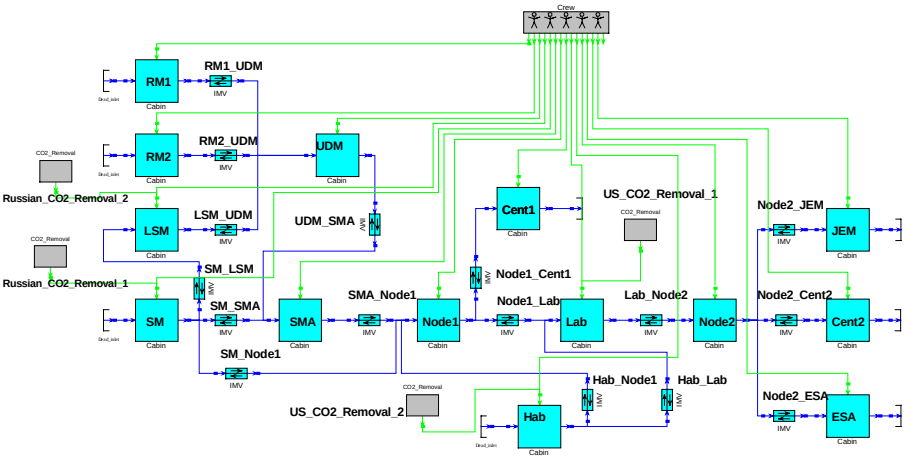
APM Cabin Air Loop Model by Astrium / ESA



ISS IMV Model by NASA



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Aerospace Organisations Using EcosimPro (Oct-2000)

- ESA-ESTEC (Holland)
- NASA Marshall Space Flight Center (USA) is using EcosimPro for all new ECLSS models for the ISS
- Astrium, Germany (ECLSS and Propulsion)
- ALENIA, Italy (ECLSS)
- SNECMA, France (Gas Turbines)
- Hurel Dubois, France (Thermal and Propulsion)
- ITP, Spain (Control and Propulsion)
- Evaluanting now: Rolls Royce (Fluids and Hydraulics), EADS Spain (Thermal), Boeing (ECLSS), Lockeed Martin (ECLSS), British Aerospace

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Conclusions

- EcosimPro is a flexible tool, that can be adapted to multiple fields.
- It supports physical modelling (the model looks like the actual system)
- The user can create new components and new Libraries (he does not depend on the software developer).
- New version 3.1 implements many new capabilities requested by users
- New versions will include optimisation, parameter estimatitions, modelling of some PDE's, etc.

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More Information...

- New web from September 2000 with full information about existing libraries, applications, support, resellers, etc.

WEB: www.ecosimpro.com

E-Mail: ecosim@empre.es

- It exists an Internet group to be informed about modeling issues, new releases, etc. It is free to join the group. Visit the page www.coollist.com and join the group "ecosim-group".
- Free evaluation version valid for 30 days

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EcosimPro COURSES

- Special courses for ECLSS, Thermal and Propulsion engineers.
- The course takes three days
- New courses are organized every four-five months. Updated info in our web page.
- Next course by Jan-Feb-2001 (ESTEC or Madrid?).
- Price: around 450 EUROS
- Contact P. Cobas (pce@empre.es) or Olivier Pin (Olivier.Pin@esa.int)

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PRICES

- 1 permanent license: 2500 USD
- 1 University Depart. license: 1500 USD
- 1 Limited Edition(60 equations): 240 USD

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