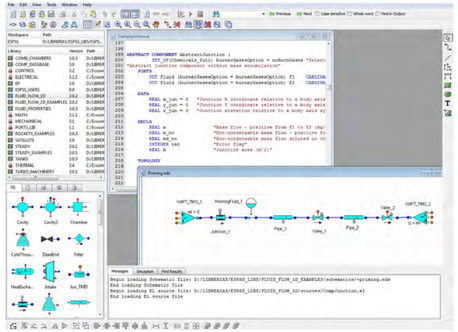
About ESPSS

The European Space Propulsion System Simulation (ESPSS) is an ESA initiative that aims to create a European simulation platform for spacecraft and launch vehicle propulsion systems. It consists of a set of libraries based on the EcosimPro simulation environment. ESPSS provides a state-of-the-art tool for analyzing different phenomena in propulsion systems validated successfully with experiments entailing priming cases, two-phase tank filling processes and the Ariane 5 ESC-A upper stage.

ESPSS libraries are delivered along with the source code, thus allowing the users to either modify or reuse any of the library components. Empresarios Agrupados Internacional S.A. (EAI) is the official distributor of the ESPSS libraries, while ESA holds the proprietary rights. Any entity interested in using ESPSS needs prior approval from ESA.

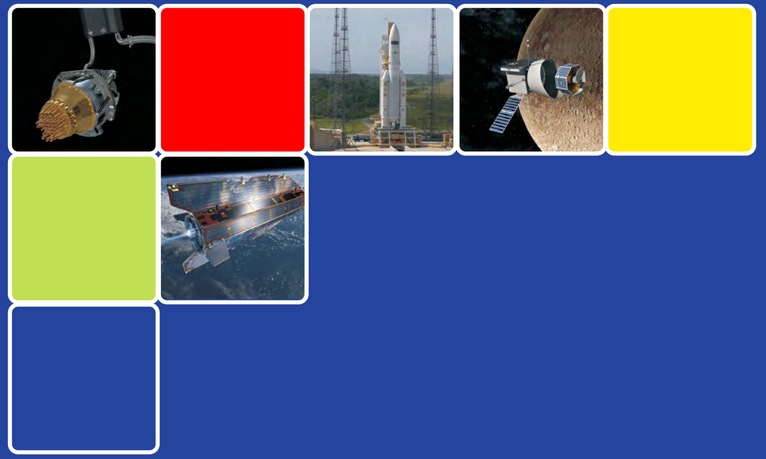
Backed by the technical support of ESA, EAI is responsible of the development of ESPSS thanks to its expertise in the design and production of software simulation tools, leading and coordinating the partners of the project.



EcosimPro

EcosimPro is a commercial simulation tool developed by EAI for modeling and simulating multidisciplinary continuous and discrete systems. It incorporates an object-oriented programming language, a powerful DAE solver and a friendly Graphic User Interface that enables the user to easily display simulation diagrams and carry out transient and stationary studies.

EcosimPro is presently used in other areas appart from space propulsion such as environmental control and life support in manned spacecraft, power plant systems, biological simulation, loop heat pipes, etc.



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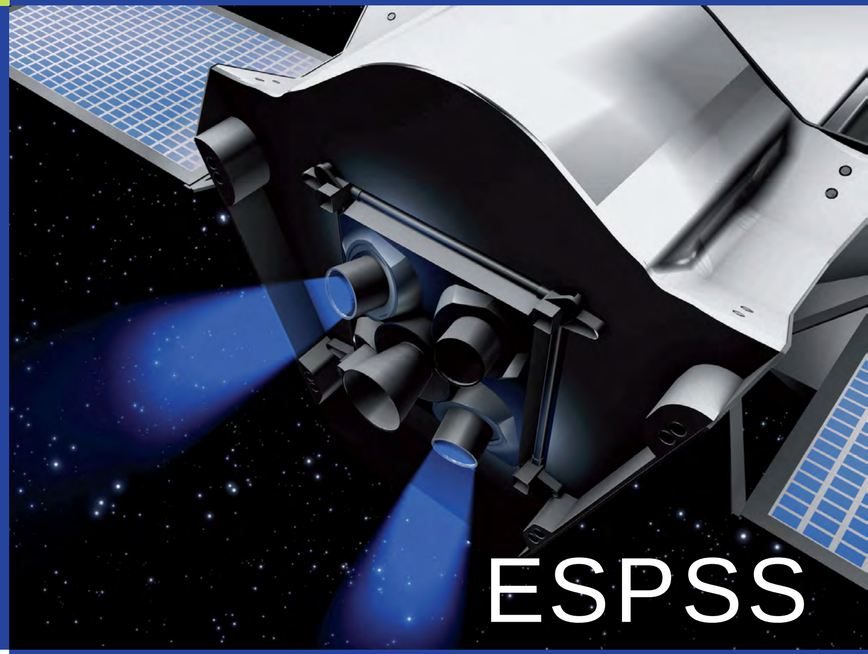
EMPRESARIOS AGRUPADOS

EcosimPro
Modelling and Simulation Software



ESPSS

European Space Propulsion System Simulation

ESA simulation libraries based on EcosimPro for modelling propulsion systems

esa
European Space Agency

EcosimPro
Modelling and Simulation Software

ESPSS SIMULATION PLATFORM

ESPSS provides a standard set of libraries with components and functions for the simulation of launch vehicle and spacecraft propulsion systems. Some of the application domains are:

- Pressurization systems including priming processes, tank behaviour, heat transfer, mechanical or electronic pressure regulators, etc.
- Liquid, hybrid and solid rocket engines with one or more combustion chambers, including turbo-machinery and two-phase cooling systems
- Air-breathing engines with subsonic and supersonic combustion
- Priming phenomena, with or without a non-condensable gas travelling in a liquid
- Stationary performances of liquid rocket engines
- Movement and attitude of satellites, orbital transfers and orbit control
- Electric propulsion systems

FLUID_PROPERTIES library

This library contains a set of thermodynamic functions returning the properties of most of the fluids used for rocket applications. Fluids are supported in different categories depending on the type used:

- Perfect gases properties according to CEA code or interpolated in external temperature dependent properties files (user modifiable)
- Simplified liquids interpolated in external temperature-dependent properties files (user modifiable)
- Van der Waals functions
- Real fluids properties directly interpolated in external 2D properties files (user modifiable), normally obtained running the REFPROP code (NIST)

Mixtures are also supported in different categories:

- Perfect gases mixture
- Van der Waals gases mixture
- Homogeneous equilibrium model: Real fluid with a non-condensable gas (quality, void fraction, etc.) in case of two-phase two-fluid flow

Functions calculating real properties interpolate in 2D property tables. Two kind of interpolations are available:

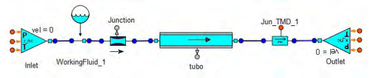
- Direct, using the couples P-S, P-H, etc., and returning a property
- Reverse, using the couples T-S, H-S or rho-U and returning pressure

FLUID_FLOW_1D library

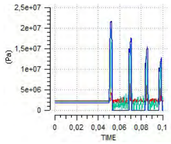
This library provides components for simulating 1D two-phase two-fluid transient systems:

- Hydraulic or pneumatic systems with coupled heat transfer networks and controllers
- Hydrodynamic cavitation with or without a non-condensable gas travelling in a liquid using real properties fluids.

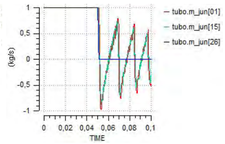
Programming of the components is non-dependent on the working fluid: conservation equations are stated in a general way, the fluid phase and the quality being calculated by the properties functions.



Simplified priming model



Pressure surge peaks



Mass flow surge peaks

TURBO-MACHINERY library

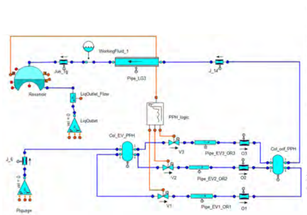
This library contains a set of components for the simulation of pumps, compressors and turbines:

- Two different types of turbo-machinery are available: one "generic" model if the off-design characteristics are unknown, and one specific model for well-defined turbo-machinery which can only be used with user-defined maps
- Compressor and turbine maps are general because their parameters are scaled with the mean radius and the speed of sound. Therefore, given characteristics remain valid for geometrically similar compressors/turbines and different fluids

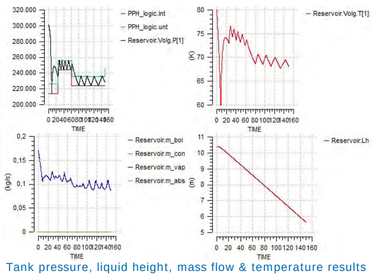
TANKS library

This library contains different tank types used in rocket engines and spacecrafts:

- The Tank_Bladder component models two different fluid cavities, one for the liquid and another for the gas mixture. It also calculates the bladder movement separating the liquid from the gas
- 1D tanks calculate the temperature variation along a "vertical" axis. The pressurization of the gas part by boiling inside the liquid or by filling processes is included in the formulation. The heat and mass transfer at the liquid/gas interface is also calculated



Pressurization system model

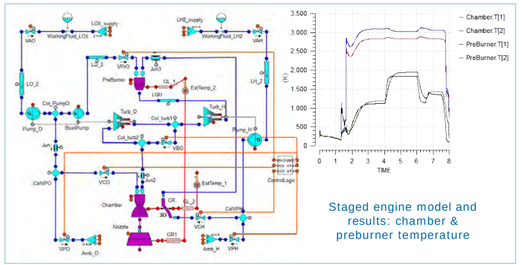


Tank pressure, liquid height, mass flow & temperature results

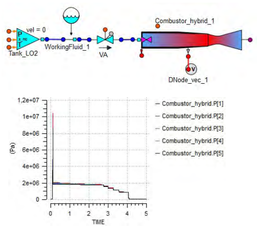
COMB_CHAMBERS library

This library provides a set of components for the simulation of liquid, solid and hybrid combustion chambers, with and without nozzle:

- Models with one or more chambers can be evaluated under quasi-steady or transient conditions (start-up and shutdown) where the valve sequences are critical.
- Wall heat transfer, pressure drops, cavity priming and vaporization phenomena (progressive consumption of injected liquid) are taken into account.
- The Cooling Jacket components completely model 3D geometries built by means of several 3D walls around the channels (1D fluid component).



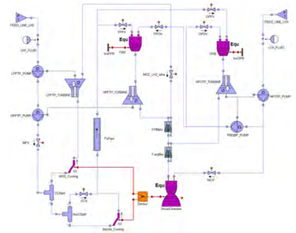
Staged engine model and results: chamber & preburner temperature

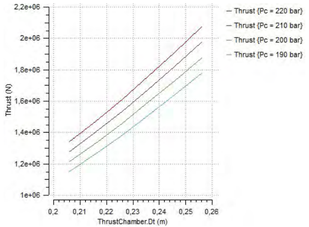


Hybrid engine model and results: chamber pressure

STEADY library

This library contains a complete set of components for calculating the stationary performances of liquid rocket engine cycles under design and analysis (off-design) conditions.





Steady model and parametric analysis of the Space Shuttle Main Engine

SATELLITE & EP libraries

The SATELLITE library allows the simulation of the orbital movement and attitude of satellites. Typical scenarios like orbital transfer, orbit control with thrust or perturbation effects due to J2 coefficient, Moon and Sun can be simulated.

The EP library (Electric Propulsion) contains components for the simulation of electric propulsion systems such as Hall Efect or Gridded Ion thrusters.