PROOSIS

Propulsion Object Oriented Simulation Software

PROOSIS is a stand-alone, flexible and extendible object-oriented simulation environment for modelling gas turbine engines and other systems (control, electrical, thermal, hydraulic, mechanical, etc.). It was originally developed by Empresarios Agrupados Internacional S.A. and an aeronautics consortium of European universities, research institutes and corporate companies. It is based on EcosimPro, the European Space Agency's preferred tool for rocket propulsion, environmental control and life support systems, among others.

PROOSIS has an advanced Graphical User Interface and uses a high-level, "engineer-friendly" object-oriented language (EL) for modelling engine systems and state-of-the-art technologies in areas such as numerical solvers, non-causal modelling of reusable libraries, XML file formats, map handling etc.

Any gas turbine engine configuration or system can be constructed graphically by 'dragging-and-dropping' the required component symbols from the included libraries to a schematic window. Using EL, users can also create new components and libraries, or extend the existing ones.

PROOSIS is capable of steady state and transient simulations as well as customer deck generation (dll, exe, ARP4868, AS4191). Different types of calculations can be performed (single or multi-point design, off-design, test analysis, sensitivity, parametric and optimisation studies, mission analysis, diagnostics, control system design and test, etc).

PROOSIS can also perform multi-fidelity, multi-disciplinary and distributed simulations. These are greatly facilitated by its open architecture, which allows it to connect to external commercial (Excel, Matlab, COM)) or in-house tools and link with codes written in C, C++ and FORTRAN.

These features make PROOSIS a useful tool for all phases of the engine life cycle, from preliminary and detailed design to post-certification and in-service support, and allow it to serve as a common framework in multi-partner collaborative engine projects providing common standards and methodologies.

Lastly, PROOSIS also provides a multi-domain simulation platform for the simulation of gas turbines, engine/aircraft systems and power plants.

EA Internacional S.A.
Magallanes, 3 Madrid
28015 Spain
URL: http://www.proosis.com
E-mail: info@ecosimpro.com
Phone: +34 91 309 81 42
Fax: +34 91 591 26 55

EMPRESARIOS AGRUPADOS

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A first class simulation tool for modelling gas turbines and other engine/aircraft systems

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BASIC CONCEPTS

The most important concept in PROOSIS is the "Component". A "Component" contains a mathematical description of the corresponding real-world component (compressor, turbine, burner, nozzle, etc.). Components communicate with one another through their Ports. Ports define the set of variables to be interchanged between connected components. Components and ports are stored in reusable Libraries, like the TURBO library for gas turbine modeling.

The development of libraries requires a user (Level 1) expert on the physical and mathematical formulation of component models and with deep knowledge of the PROOSIS modelling language EL.

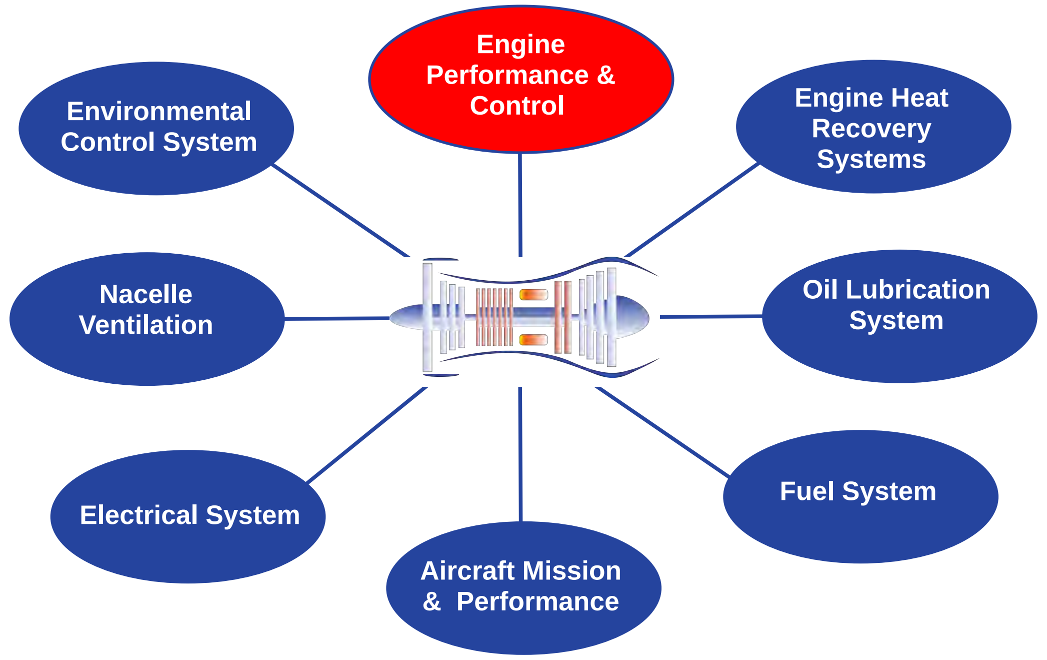
Using existing libraries, a user (Level 2) can construct a model graphically by 'dragging-and-dropping' the required component icons from one or more library palettes to a schematic window, connecting the components through the appropriate ports and editing their attributes. A model, for example, could be a single component, a sub-assembly or a complete engine and its subsystems (oil, fuel, control, etc.).

The mathematical representation of a model is called a "Partition" in PROOSIS and it is set with the help of wizards. For a given "Partition", a user (Level 3) can define different simulation cases ("Experiments") using either wizards or the object-oriented language EL.

Experiments can run either in batch mode or graphically using the Monitor application. A log file with the user-defined level of information is produced for debugging.

From a working experiment and through a wizard, different types of Decks can be generated for delivering a model to a customer (Level 4 user).

PROOSIS also gives engineers a multi-domain simulation environment for modeling gas turbines and engine/aircraft systems, as shown below:



PROOSIS and its application libraries
for an integral system simulation

MAIN FEATURES

- EL modeling language for the creation of new components and libraries. Its non-causal approach allows the modeler to focus on the physical formulation instead of coding issues. Its object orientation allows developing extendible and easy to maintain libraries. Furthermore existing C/C++ and FORTRAN functions can be called from the EL language, and interaction with XML files is easy through the XML parser.

- The symbolic mathematical kernel automatically extracts the mathematical model from the graphical schematic. The user selects the governing input variables (e.g. thrust, turbine inlet temperature, etc) and the internal algorithms generate robust mathematical models through symbolic manipulation and equation re-ordering. The tool also allows selecting any iterative variables when non-linear equation systems are formed, and provides valuable information about the mathematical problem to be simulated by the solvers.

- The available internal solvers allow dealing with stiff or non-stiff dynamic problems (DASSL, RK4 and Adams-Moulton). The algebraic problems are tackled by an improved Powell's hybrid based method. Inequality groups (conditional equations or limiters) can be used in both steady and transient simulations. Convergence issues can be addressed with the help of the simulation log, in which the evolution of the variables, residues, simulation errors and statistics are summarized.

- Common calculations, such as transient and steady simulations, single or multi-point design, parametric, sensitivity, and optimization calculations can be quickly configured through the intrinsic graphical experiment wizards. Any type of calculation can be performed using EL language.

- Models and calculations can be encapsulated and encrypted in a stand-alone application (deck) with user-defined accessible input/output variables. The deck can be used in command line mode, through a graphical user interface, or integrated into C or FORTRAN applications by means of standard interfaces (SAE ARP 4868 and SAE AS4191).

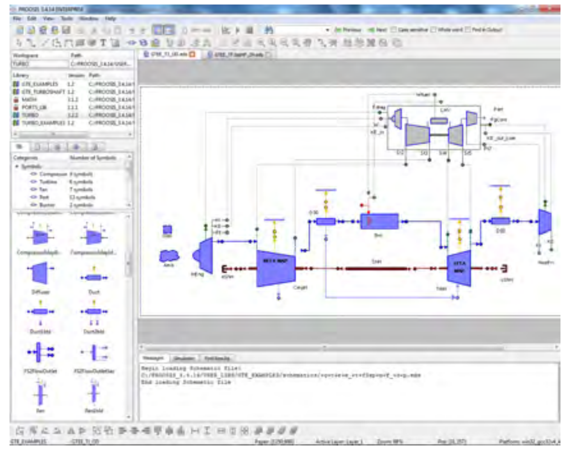
- Moreover, with the PROOSIS toolbar for Ms Excel, models can be directly integrated into stand-alone spreadsheets.

- It is also possible to interact from MATLAB with PROOSIS models. What's more, the model can be exported as an encapsulated S-Function block, which means it is possible, for example, to develop the engine with PROOSIS and the control system with Simulink.

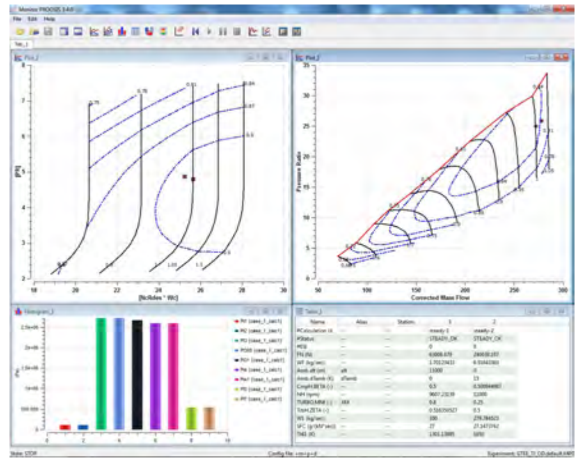
- A model can also be exported ready to be used in a HIL system through Simulink. Or it can be connected to SCADAs, other models or hardware using OPC technology.

- PROOSIS offers a platform for collaborative work within and between companies. The included source code versioning control system (SVN) integration allows tracking and managing all changes to libraries, models and calculations made by any user. The deck exporting and external tools integration allows safe sharing of models between companies.

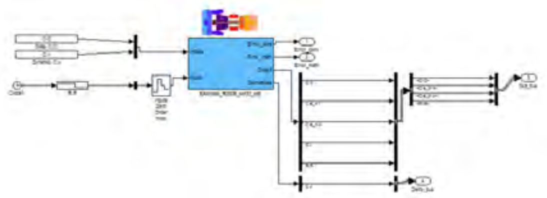
Level 1: Modelling new components libraries



Level 2: Graphical modeling of complex systems



Level 3: Simulation results visualization



Level 4: Simulating a PROOSIS engine model from Simulink

APPLICATION FIELDS

The existing PROOSIS application libraries make it a useful tool in a wide range of applications:

Engine performance simulation

PROOSIS has the TURBO library for the modeling of gas turbine systems. It includes most of the components used in any gas turbine system, thus making it possible to simulate any complex configuration.

The flexible object-oriented based modeling approach allows extending the library with new components or in-house correlations.

Together with TURBO/PROOSIS, the included GT sample libraries of models and calculations offer a ready to use engine performance tool.

Please refer to the TURBO/PROOSIS brochure for more information.

Integrated engine/aircraft systems simulation

Several off-the-shelf libraries are available for the simulation of other stationary and aircraft gas turbine related systems, such as Organic Rankine Cycles, fuel and lubrication oil fluid loops and their thermal integration with other systems, as well as electric systems (electrical machines, power electronics, electrical networks) and environmental control systems.

Please refer to the PROOSIS Aircraft Systems brochure for more information.

Power Plant simulation

Several off-the-shelf libraries are available for all sorts of analysis of industrial gas turbines and power plants (transient and steady state as well as thermal balance).

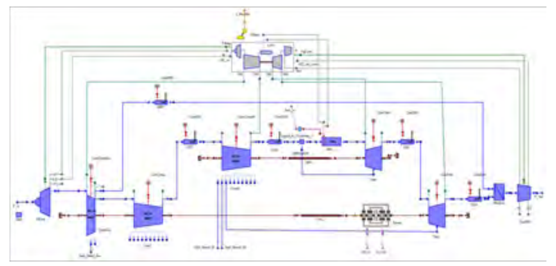
Please refer to the PROOSIS Power Plants brochure for more information.

Other applications:

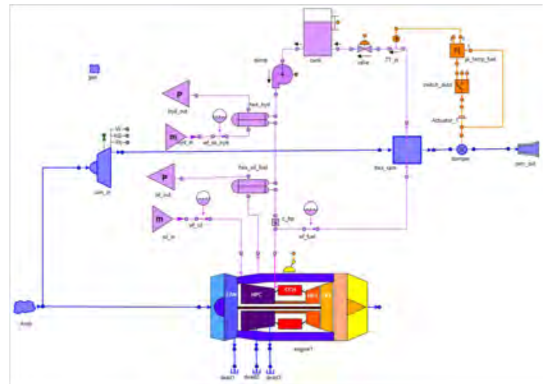
- Space propulsion systems: cycle design, analysis and dynamic simulation of liquid, solid and hybrid rocket engines.

- Environmental control and life support systems in manned spacecraft

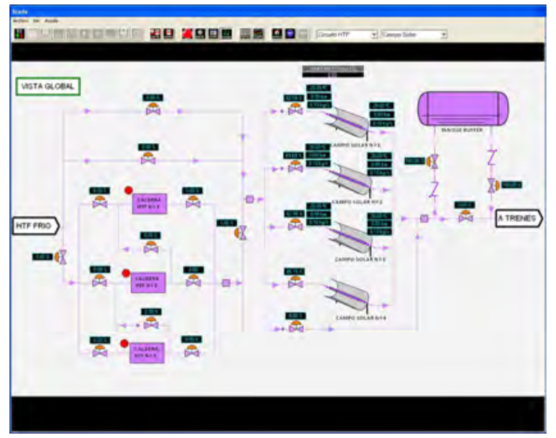
- Cryogenic systems: dynamic simulation of large cryogenic installations



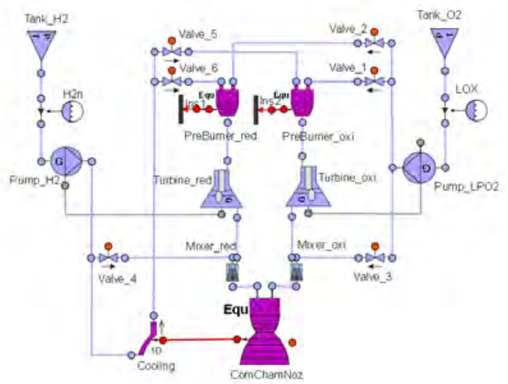
Turbofan model with heat load to the oil system



Simulation of Thermal Management Model



SCADA panel of the solar collector field of a thermosolar power plant



SSME staged combustion cycle model