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.

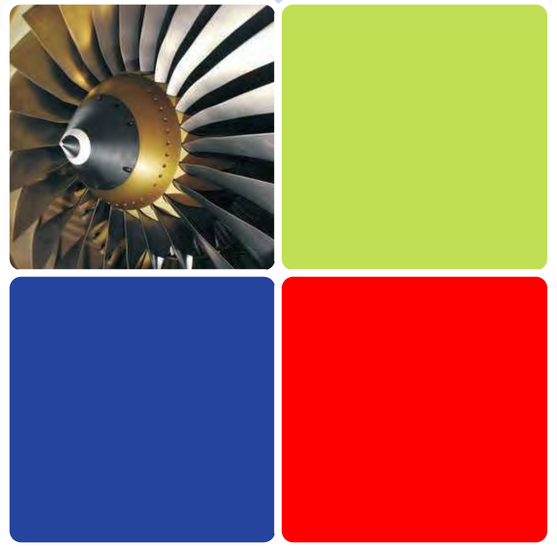
Any gas turbine engine configuration or system can be constructed graphically by 'dragging-and-dropping' the required component symbols from the included libraries to a schematic window. Using EL, users can also create new components and libraries, or extend the existing ones.

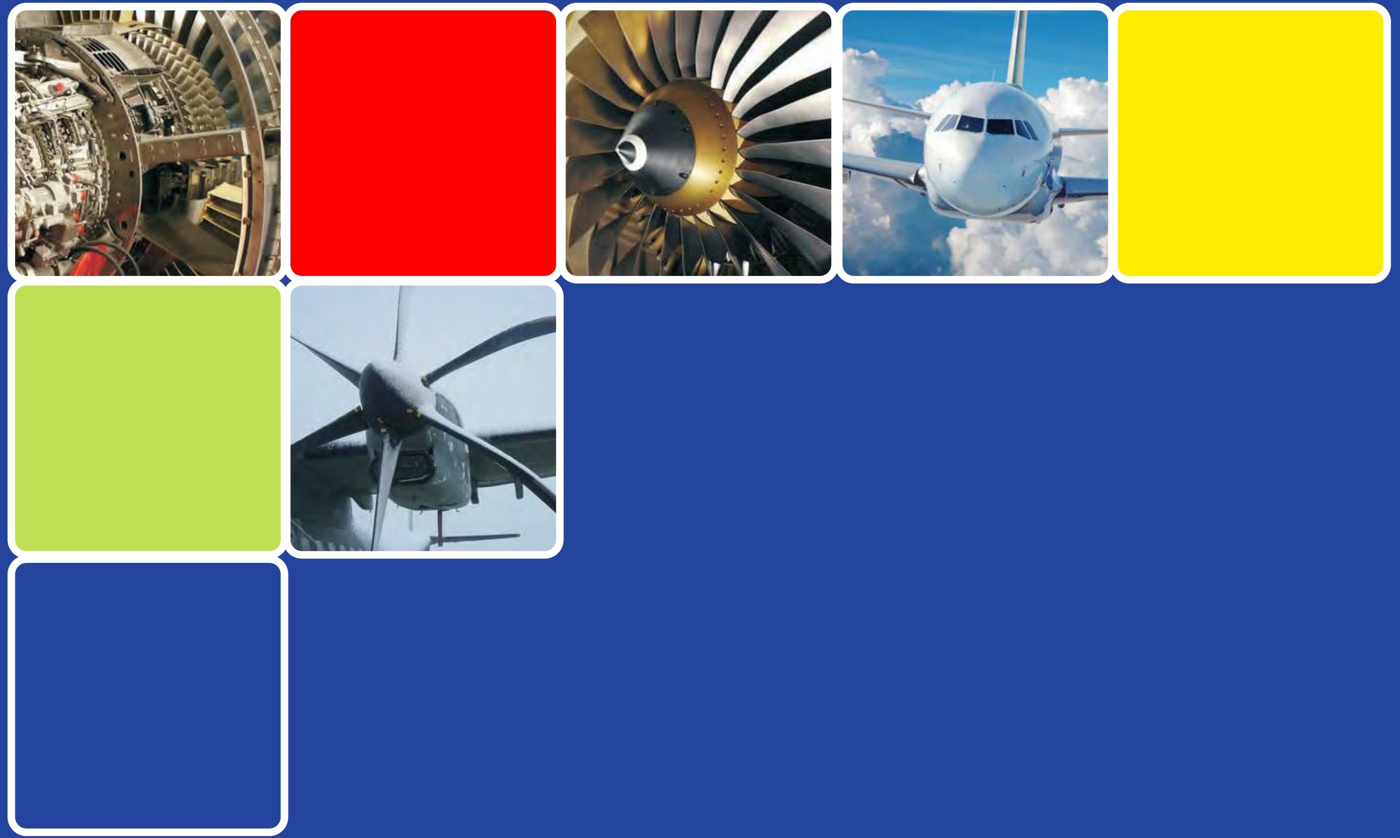
PROOSIS is capable of steady state and transient simulations as well as customer deck generation (dll, exe, ARP4868, AS4191). Different types of calculations can be performed (single or multi-point design, off-design, test analysis, sensitivity, parametric and optimisation studies, mission analysis,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





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PROOSIS
Aircraft System Simulation Platform

A first class multi-domain simulation platform for integrated modelling of gas turbines and aircraft systems

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Aircraft System Simulation Platform

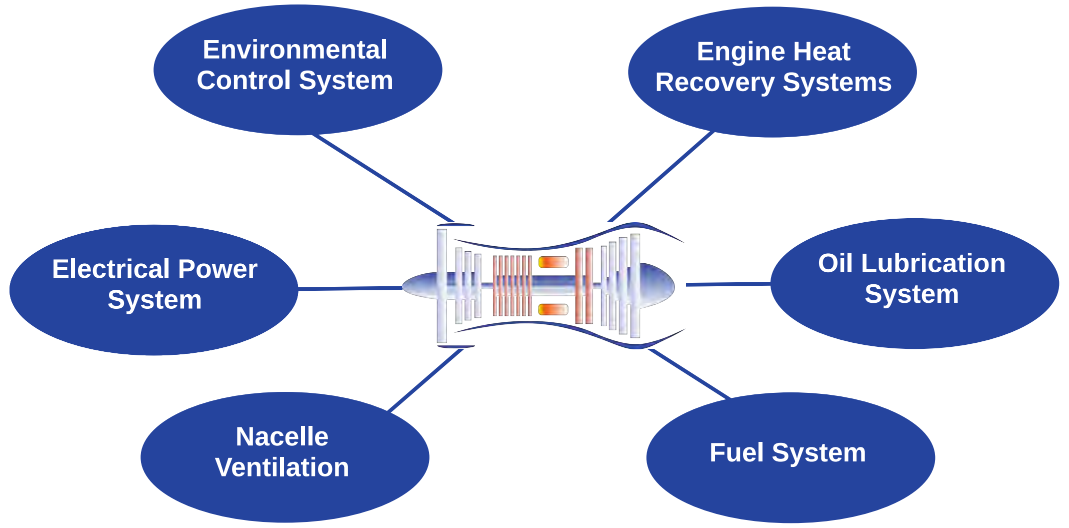
Aircraft and engine manufacturers are constantly researching new promising design concepts and technologies. However these new developments lead to more complex systems with higher number of interactions between the different aircraft sub-systems, such as the environmental control system (ECS), the power system, etc.

One of challenging issues of new design concepts for engineers is the integration and dynamic analysis (complex multi-system analysis) of the different aircraft systems, i.e. how they run together during start-ups and transients. Simulation tools that provide engineers with results about these interactions become therefore very useful/valuable.

PROOSIS does provide a multi-disciplinary simulation platform that is capable of integrating several aircraft subsystems around the engine and analyzing the different interactions (fluid, thermal, mechanical, electrical, etc) and their integral performance. In addition PROOSIS allows the control logics of the overall system to be designed and checked.

The flexible modelling capability of PROOSIS supports the simulation of any kind of gas turbine system, including new configurations such as open rotor and counter rotating or geared turbofans. Users can also assess new innovative heat recovery systems for use in onboard aircraft power generation, for example an Organic Rankine Cycle (ORC) that recovers "waste heat" from the exhaust gases of a turbofan engine.

PROOSIS provides aircraft engineers with a multi-domain simulation environment to validate and optimize the integration of the aircraft systems and their control logic.



Benefits

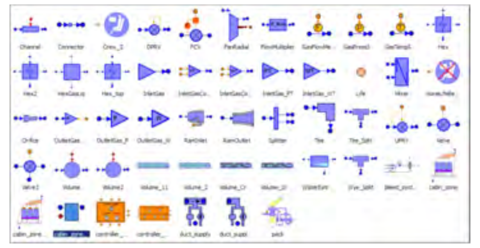
- Integral analysis of the aircraft systems (Multidisciplinary Modelling)
- Set of off-the-shelf libraries that can be easily extended
- Engineering Simulation Language: EcosimPro Language
- Optimal solution and better design decisions
- Requirement Verification of the subsystems at overall system level
- Easy evaluation of different alternatives
- External Connectivity and Co-simulation
- Collaborative environment

Environmental Control System

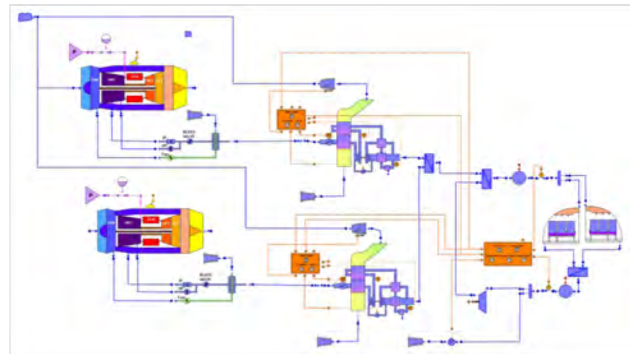
ECS is the system responsible for a great number of tasks such as pressurizing and ventilating the cabin, controlling the pressure and temperature onboard, etc. The development process of the ECS system can require the simulation of the ECS in order to: optimize the configuration of the system, support design and tuning of control system, verify the system requirements and support sizing of the components. This shows the great importance of having simulation models during the design phases of the ECS systems. PROOSIS and the ECS library offers a set of typical components and sub-systems for the modelling and simulation of the aircraft ECS including the cabin and the passengers.

Key Features

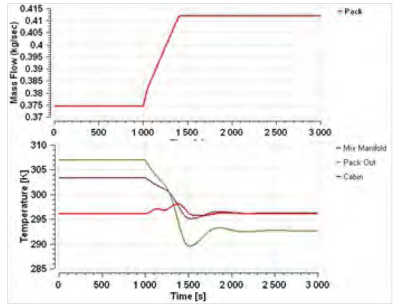
- Dynamic simulation & performance analysis of ECS
- Connection to the aircraft engine model
- Easy customization of the cabin layout
- Assessment of different architectures of cooling packs
- Analysis of the comfort of the passengers
- Easy customization or creation of new components



Component Palette of ECS library



Model Schematics of the ECS system coupled to the aircraft engines



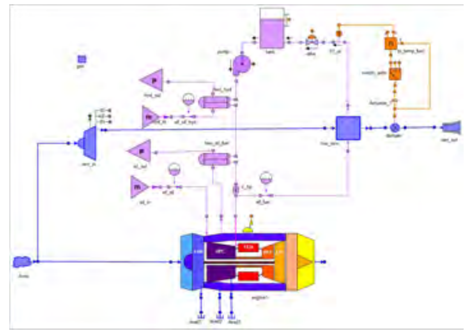
Simulation results of ECS performance

Thermal Management System

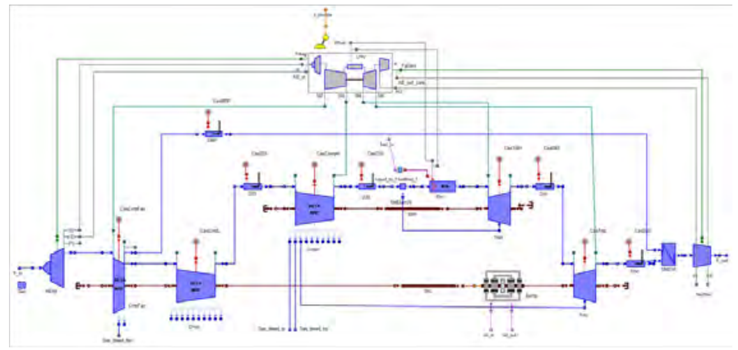
A significant functional interaction exists between different systems (fuel system, engine lubrication system, ECS, etc) on more advanced aircraft in order to reject and recover waste heat from aircraft. PROOSIS includes an off-the-shelf library that enables the hydraulic analysis of the fuel and lubrication oil fluid loops and their thermal integration with other aircraft systems and heat sinks. The simulation scenarios can be performed under different flight and environmental conditions.

Key Features

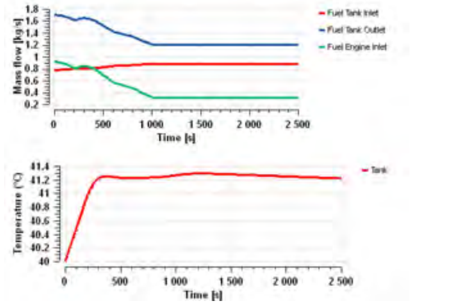
- 0D-1D flow model
- Several working fluids in the same model
- User-friendly option for adding new fluid properties
- Analysis of the expansion of the fuel inventory
- Implementation and tuning of the control loops
- Engine heat load model to the oil lubrication system
- Steady state and transient analysis
- Customization or creation of new components



Example of Thermal Management Model



Turbofan engine model with heat load to the oil system



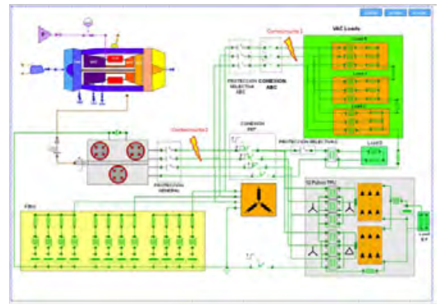
Simulation of Thermal Management Model

Electrical Power System

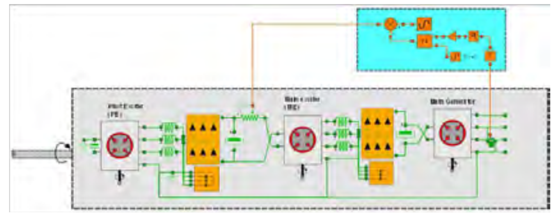
Moving towards a more electrical aircraft, the Electrical and Power System library provides a set of components to analyze both motors and generators coupled to the aircraft engines and the aircraft electrical network. PROOSIS allows the aircraft propulsion system, electrical system and the mutual influences between them to be analyzed simultaneously so as to guarantee the stability of the assembly under the worst case scenario. This library also allows short-circuits and protection systems to be modeled. Engineers can configure the aircraft electrical network and balance it. As aircraft become more and more electrical, new designs reduce fuel consumption and noise while improve comfort and reliability with more complex, coupled and integrated control systems.

Key Features

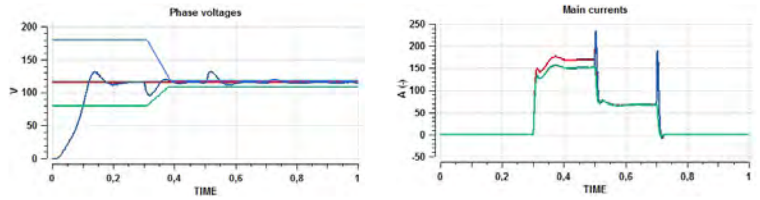
- Electromechanical actuators
- Electromechanical generators
- Power Converters: AC/AC, AC/DC, DC/AC and DC/DC
- Transformers and Transformer Rectifier Units
- Protection Systems
- Stability analysis
- Control loop configuration



Aircraft Electrical System Model



3-cage motor model



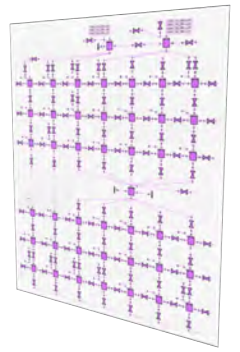
Simulation Result: Phase Voltages & Main Currents

Nacelle Ventilation

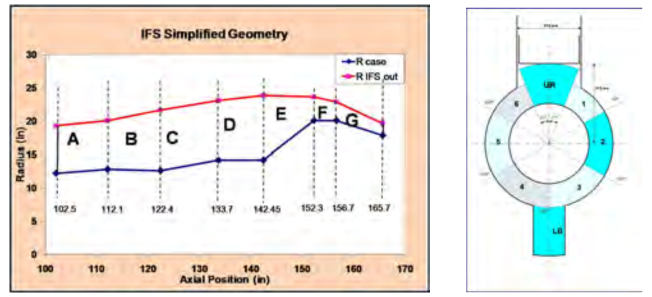
PROOSIS enables the thermal and ventilation analysis of an engine-nacelle following a 2D discretization approach. The Internal Fixed Structure (IFS) of an engine nacelle is broken lengthwise and crosswise into several elements. The model enables both steady state and transient calculations to be performed. The model parameters can be adjusted to experimental results using the PROOSIS optimization tool.

Key Features

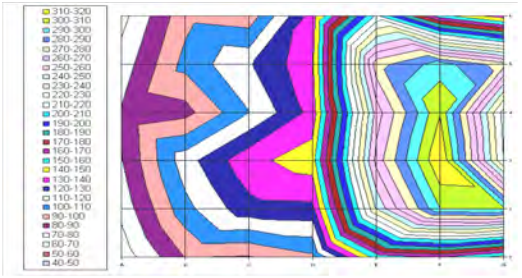
- 2D Flow Distribution (Axial Flow & Lateral Flow)
- Capability to calculate burst duct analysis
- Heat transfer calculation:
  - Convection between air & blanket
  - Convection from core to air
  - Radiation from engine case to blanket
  - Conduction through the blanket and the IFS
- Capability to calculate soak-back transients
- Non-uniform engine case temperature in radial direction



Nacelle Ventilation Model



Architecture and 2-D nodalization of the model of the IFS



Temperature distribution within the the case