EcosimPro PROOSIS

Modelling and Simulation Software

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FROM THE EDITORS

The folks at EcosimPro/PROOSIS have kept themselves very busy over the last few months making enhancements to simulation tools and application toolkits alike. These products are becoming ever more sophisticated and complex, which means that every aspect of their testing must be enhanced as well.One of the areas being improved the most in the new version involves numerical solvers. We have added fast and powerful new solvers that make more efficient use of the resources of the new multi-core processors to make the simulations run much faster and much more efficient.

Meanwhile, new improvements and capabilities are also being added to the products. One, which will be released in the 2016 version, will let users simulate directly from the schematic diagram, so that the results can be seen on the graphically designed system. This will be especially helpful to novice users who want a quick look at the simulation results without having to make partitions or run sophisticated experiments. Other improvements for the coming version are a faster Monitor simulation tool, improvements in the post process area, Monte-Carlo simulation tool, automatic testing capability, etc.

In the area of libraries, we are enhancing the toolkits, including with this newsletter the main improvements to them and examples of applications.

Furthermore, we've taught a number of courses on different areas of application and customers over the last few months. The experience has been overwhelmingly positive: not only have many engineers been trained in how to use our products, but valuable feedback has been acquired for further enhancements that will undoubtedly be added to upcoming versions.

Lastly, I would like to mention that we had the pleasure of attending last October, in Cleveland, Ohio, the SAE committee on standardizing Gas Turbine programs. The invitation to participate on this committee is an acknowledgement of the effort made by the EcosimPro/PROOSIS team. It also lets us take part in defining the standards for using this type of programs as well as confirming that PROOSIS is internationally recognized as a cutting-edge tool in this area for designing aeronautical gas turbines.

Pedro Cobas (pce@ecosimpro.com)

Head of the Development Team EcosimPro/PROOSIS

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1. SIMULATION FROM SCHEMATIC DIAGRAMS

ANTONIO RIVERO, ECOSIMPRO/PROOSIS

In EcosimPro the Monitor its intuitive interface lets users interact with the simulations and view the data by means of charts, graphs, lists, files of results, etc.

However, to be able to make the most of all these capabilities in the Monitor, it needs an itemized work list that starts closing the model mathematically to then define the execution scenarios, i.e., to establish the initial conditions of the model, state the type of run and the integration algorithms, etc., which, for regular users of EcosimPro is known as generating partitions (endowing the model with causality) and creating EL experiments.

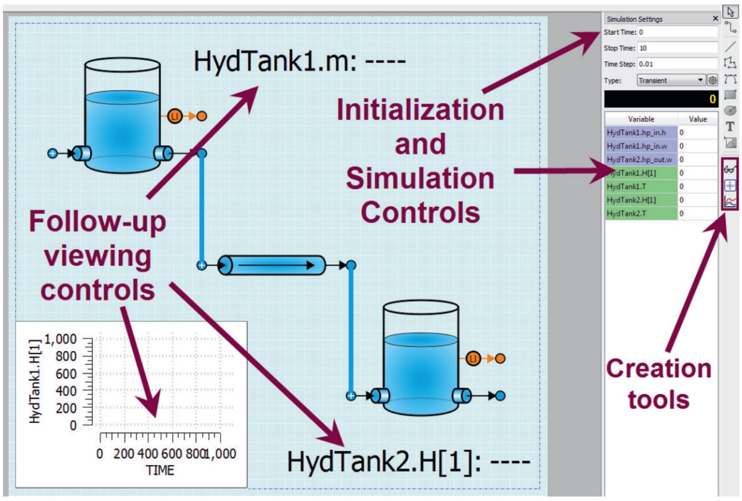
When the user sets out to do complex analyses, these partitions and experiments are the ideal way to work in EcosimPro, but in simpler cases, or at the beginning of building a model, it is helpful to have an agile, quick and visual way to simulate it from the model itself, so that, for instance, it is easy to understand the dynamics of the processes being modeled or to adjust the parameters of the components.

In future EcosimPro versions the will be the capacity of doing "direct" simulation.

What is Simulation from Schematics?

This is the name given to the new capability of EcosimPro software to execute simulations from schematics without having to create partitions or experiments.

For that reason, starting from a schematic, the user need only initialize the values he deems suitable for the simulation, add viewing controls for variables and define the running conditions: time, communication interval, etc.

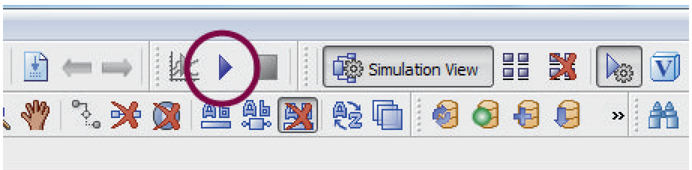


The figure shows the difference clearly:

- The initialization controls of the initial conditions of the model
- The follow-up viewing controls of the variables in the model
- The controls defining the running scenario: starting time, ending time, CINT, etc.

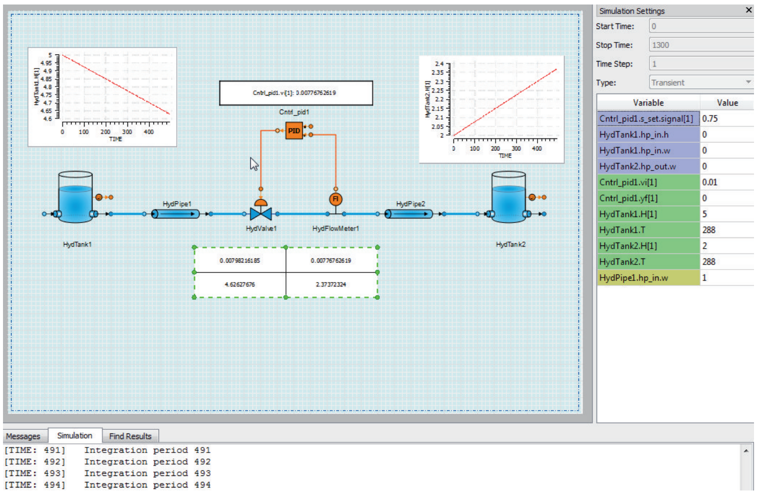
How to simulate from schematic?

The process is as simple as activating the simulation view and pressing PLAY on the simulation bar. In other words, it is only two mouse clicks away.



Of course, in cases requiring it, these default conditions can be modified by dialogs and setup systems.

The end result is a schematic in which the viewing controls are updated during the simulation:



What Simulation of Schematics does?

There are many advantages to this new tool, mainly:

- The chance to associate physical or logical concepts represented on the schematic with the mathematic variables of the model and the results from the simulation.
- Being able to group together data so as to organize information on the basis of user criteria (order, location, ease of use, etc.)
- The capacity for synthesis permitted by the graphs and monitoring tags, by displaying only values that are considered relevant
- The improved spread and presentation of the results to third parties, who can use the relations between graphic and variable elements to better understand the models and their results.

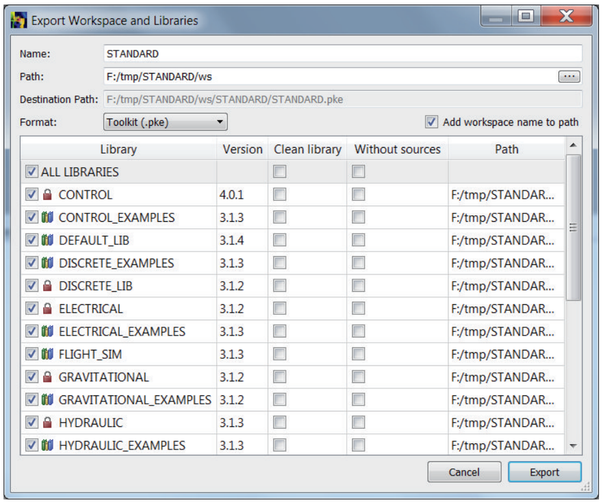
In short, the new tool will give the end user many different possibilities for interaction, presentation and handling of data from a schematic diagram. The tool makes it possible to customize the simulations and their presentation.

Moreover, it is a platform on which even more enhancements can be added in the future, such as animated schematics in which for instance the elements on the drawing interact with the variables (tank levels that rise and fall, alarms lighting up, etc.).

2. IMPROVEMENTS IN THE USE OF WORKSPACES

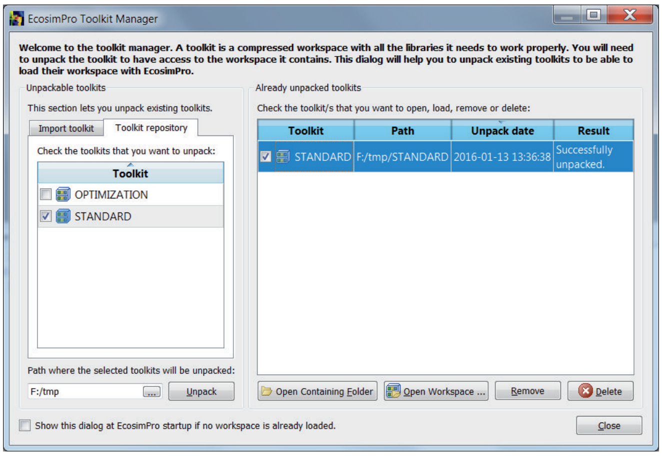
FERNANDO PUECH, ECOSIMPRO/PROOSIS

EcosimPro now includes a new feature that makes exporting and importing both the workspaces and the libraries that they load much easier. This feature is based on a new EcosimPro concept known as the toolkit. A toolkit is a file that contains a workspace and all the libraries needed for the workspace to function. As it is just one file containing all the information, it is very easy to share with colleagues and/or end clients. Following is a screenshot of the export wizard for generating the toolkit:



As can be seen, the wizard allows users to generate the toolkit with all or only some of the libraries, to clean the libraries, or not to export the source code of the libraries. In order to generate the toolkit it is sufficient to indicate the name you want to give it and to specify the .pke extension in the format.

Following is a screenshot of the wizard for importing toolkits in EcosimPro.



This wizard allows users to select a toolkit from any folder in the hard drive or to select one from a list of pre-existing toolkits. The toolkits cannot be used directly; they have to be unpackaged in a folder so that the worksape and libraries can be loaded. The toolkit import wizard allows users to select one or more workspaces and to unpackage them simultaneously in a folder chosen by the user. Once it has been unpackaged, a list is displayed with the dates and locations where different toolkits were unpackaged, so that users can load workspaces or delete them along with the related libraries. The wizard allows users to unpackage toolkits as many times as necessary, so that it is easy to reinstall the workspaces and libraries, or simply to unpackage a new copy, in a different location.

3. HARDWARE IN THE LOOP (HIL) APPLICATIONS WITH ECOSIMPRO MODELS

J.M. Zamarreño, R. Martí & C. de Prada, Valladolid University (UVA) & F. Carbonero, V. Pordomingo, EcosimPro/PROOSIS

In the industry these days it is becoming increasingly necessary to simulate complex systems. These systems are often modules that require individual testing, both at simulation level, and also as a physical prototype or plant testing. To perform these physical tests by module, it is not necessary to have all the elements in place ready for use; it is enough to have one of the components (the engine, for example) and the rest can be simulated by computer (eg. control, the plant, etc). This incorporation of a physical element into a simulation environment is what is known as HIL (Hardware In the Loop).

EcosimPro / PROOSIS has incorporated a model export mechanism for use in a HIL system. By means of a DECK, the model can be easily exported to Simulink, and once there, via the Simulink Coder tool, a package is obtained that is ready for use on National Instruments PXI platforms.

The University of Valladolid (UVA) in Spain, in collaboration with National Instruments, has carried out a series of tests to check the process from beginning to end, from the EcosimPro model to the final test with software and hardware elements.

Specifically, two different configurations were used:

- In the first configuration (Fig.1) there is an engine simulated by means of an EcosimPro model controlled by a physical device, a PLC. Fig.2 shows the cabling between the different elements. In this test, different models with different degrees of complexity were used, in order to see the capacity of the PXI to simulate in real time. The integration step was also modified to take the computational load to the limit. In both cases, satisfactory results were obtained.
- In the second configuration (Fig.3) a real laboratory engine was used. In this case, an EcosimPro model implemented in a PI control was used for control purposes. The results obtained were adequate and the engine was taken to the desired operating points.

In conclusion, it can be said that the stated goals were attained, i.e., a complete system comprising software elements (EcosimPro model) and physical elements was tested.

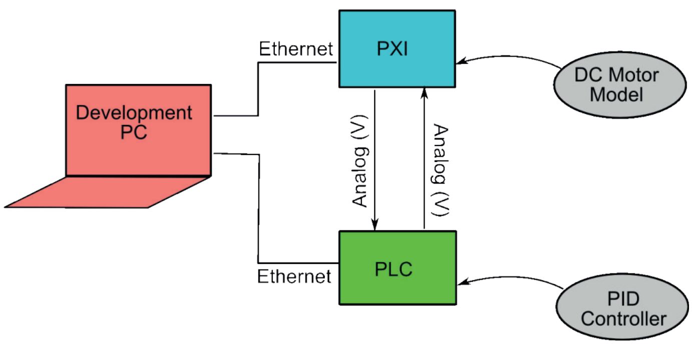


Figure 1. Configuration: Simulated Engine / PLC (physical control)

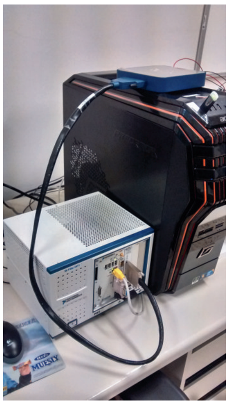


Figure 2. Connection PXI Simulation / PLC (physical control)

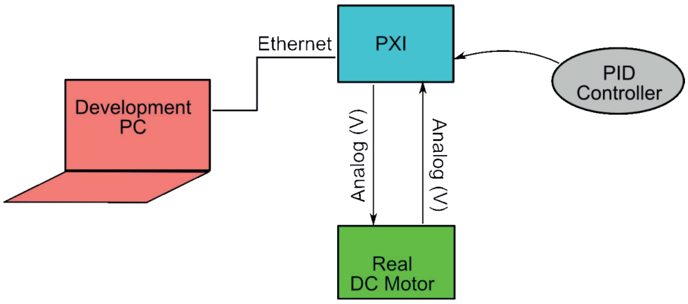


Figure 3. Configuration: Physical Engine / Simulated Control Model

4. NEW VERSION OF ESPSS

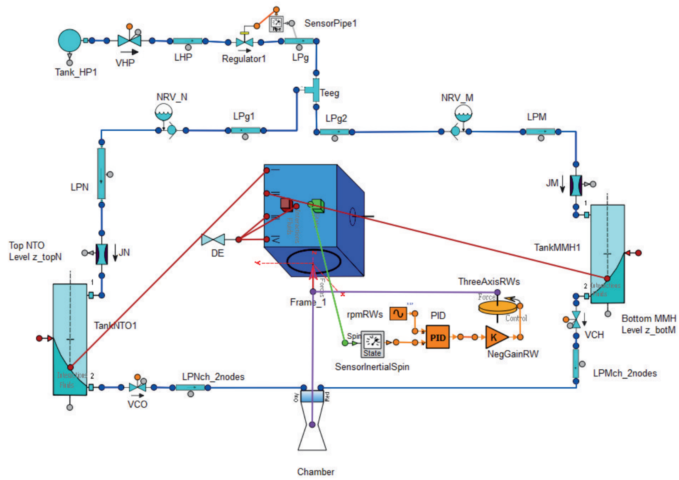
José Moral & Javier Vilá, EcosimPro/PROOSIS

The new Version 3.1 of the ESPSS toolkit is now available. It contains significant improvements derived from the recently concluded third phase of the maintenance program, along with some new developments from the Multiphase Flow Modelling project.

One of the most important issues covered by this maintenance program was the adaptation of the libraries to 64-bit compilers. This has resulted in a notable reduction in simulation time, especially in complex models. Other points worthy of mention are the inclusion of new components, like a pressure regulator and a hydraulic turbine, as well as the expansion of the STEADY library with estimates of mass, the inclusion of thermal conduction in liquids, and the possibility of using real properties for non-condensable gases.

The usual maintenance tasks have also been carried out, such as the elimination of bugs in the source code, the implementation of new options requested by users, and the improvement of the documentation and examples.

Specifically, with regard to the developments as a result of the Multiphase Flow Modelling project, new features include the incorporation of the Hump Effect and the scale factor for solid/hybrid motors, the development of a new numerical AUSM function, the extension of the SATELLITE library with new scenarios and its coupling with the propulsion system.



Coupling of the vehicle with the propulsion system

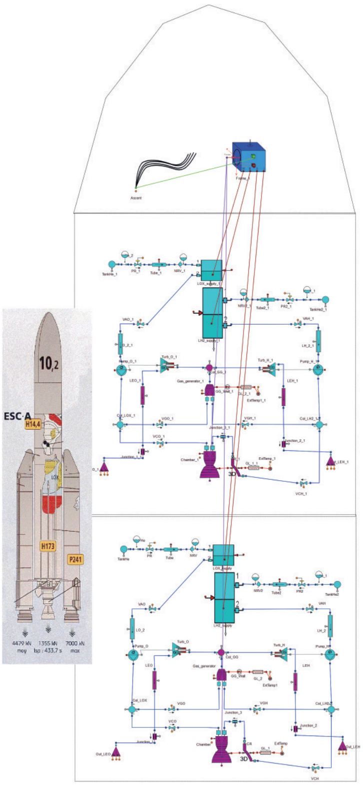
We trust that these improvements will be useful for our users, while we continue working on the development of new capabilities and on improving existing features via new projects.

5. FUTURE PLATFORM FOR A SATELLITE SIMULATION

José Moral & Javier Vilá, EcosimPro/PROOSIS

With the goal of expanding the range of application and capabilities of the ESPSS libraries, we have proposed a new project to ESA with the help of specialized collaborators. This project consists of the development of a complementary ESPSS toolkit to provide the libraries with new simulation capabilities in three areas:

- Guidance during the ascent of a launch vehicle, with control of the startup and shutdown sequence of the motors, the separation of the different stages and payloads, and optimization of the orientation of the thrust vector.
- Improvement of AOCS simulation capabilities, including a greater level of detail in the perturbations and dynamics of the vehicle sub-systems.
- Advanced capabilities of satellite simulation, including simulation of flexible bodies and simplified models of in-tank fuel movements.



Vehículo lanzador de dos etapas y satélite

This project is a first step in the expansion of the classic field of simulation of ESPSS propulsion systems and conversion of these libraries to a satellite simulation platform that is valid for any simulation need that may arise in a space mission, including:

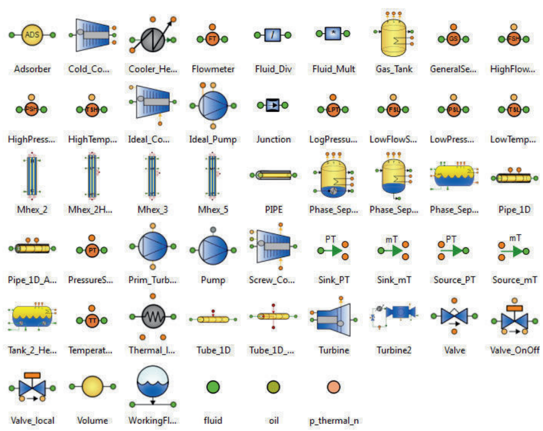
- Propulsion and guidance systems of the launcher
- Orbital and attitude control
- Thermal Analysis
- Thermal Control
- Power systems

6. NEW VERSION OF CRYOLIB

Ana Veleiro, EcosimPro/PROOSIS

Version 1.2.4 of the CRYOLIB toolkit includes many upgrades from v1.1. Chief among these is the optimisation of the fluid property calculation functions, which has substantially improved calculation times. In addition, the new version supports 64-bit compilers. This improves the information handling capabilities, which is especially useful for large models.

v1.2.4 of the toolkit includes new components, such as for 'tube' components (fluid paths with no associated walls), that allow the connection of CRYOLIB to the standard THERMAL library, and modifications to some of the existing ones for the same purpose. The library can therefore be used to exploit the capabilities of the THERMAL library for thermal analysis. For instance, it will be possible to connect the new 'tube' components to the 'cylinder' component of the THERMAL library to analyse the effect of conductivity in both radial and axial directions. A further example is the plate heat exchangers. Users may now select between calculating the losses to the atmosphere based on user-defined design data, as has been the case up to now, or calculating them in more detail using components of the THERMAL library to model the shell and its exchange with the atmosphere.



Palette of the CRYOLIB library

Other new elements include the possibility of defining the configuration of the valves as a function of the valve Cv or of its specific geometry (orifice area and pressure drop coefficient) depending on the users' preferences.

Furthermore, the law for the valve opening has been modified to improve accuracy for small valve openings.

New functions have also been introduced in the calculation of the friction factor because of the elbows on the pipes. The possibility for the user to include additional pressure drops has also been added. The debugging of the library has also continued thanks to the feedback received from the users.

Two new models of coolers have been added and documented in the Toolkit example library: a He cooler at 80K and another one of LN2. This will allow new users to rely on a larger collection of examples so they can become familiar with the library and its multiple capabilities.

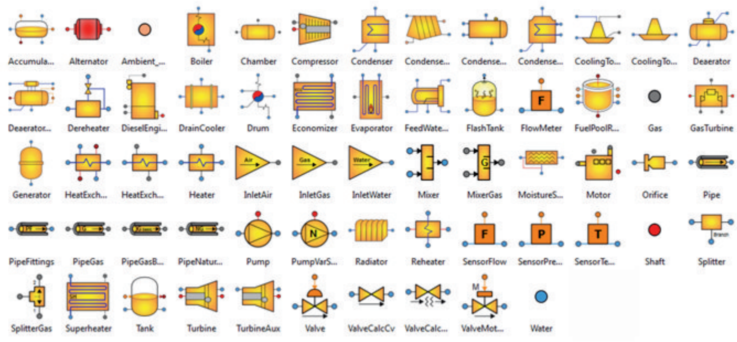
7. NEW VERSION OF THERMAL_BALANCE

RAÚL AVEZUELA, ECOSIMPRO/PROOSIS

A new version of the THERMAL_BALANCE library (4.0) is now available. The data input, user interface and documentation of this library have all been thoroughly remodelled. It has also been adapted to operate with 64-bit compilers.

The THERMAL_BALANCE library allows heat balances from power plants to be evaluated and sensitivity analyses to be performed under various plant operating conditions or parameters. Although the library is mainly designed for steady-state calculations of the model, it can also be used to analyse the dynamic evolution of the system upon slow changes in the operating conditions or in the control system.

The new component palette of the library is shown below. It includes components that can be used to model both the water-steam cycle section and the air-gas part of the system.



8. NEW VERSION OF FLUIDAPRO

JOSÉ MORAL, ECOSIMPRO/PROOSIS

A new version of the FLUIDAPRO toolkit will be released shortly, including some highly anticipated new updates. Version 3.4 includes upgrades to both FLUID_PRO and FLUIDAPRO, its two main libraries.

The first one, which is used to calculate properties, includes new elements such as:

- The remodelling of the status equations. It is now possible to select user-defined fluids with simplified gas or liquid properties for use as fuel.
- Adding of fuels JP_10 and kerosene with simplified properties, and the possibility of selecting some existing fluids, such as MON1, MON3, meta- and para-hydrogen, as fuels.
- The possibility of selecting real properties for the non-condensable gases.

The FLUIDAPRO library has been updated with the incorporation of components such as the new plate heat exchanger, the improvement of the generic maps of the turbine machinery for the extrapolation of beyond design basis points, the addition of new options in valves, joints and other components and the elimination of some bugs.

The result is that new cases for application have been added, such as the satellite propulsion system normally used in space applications.

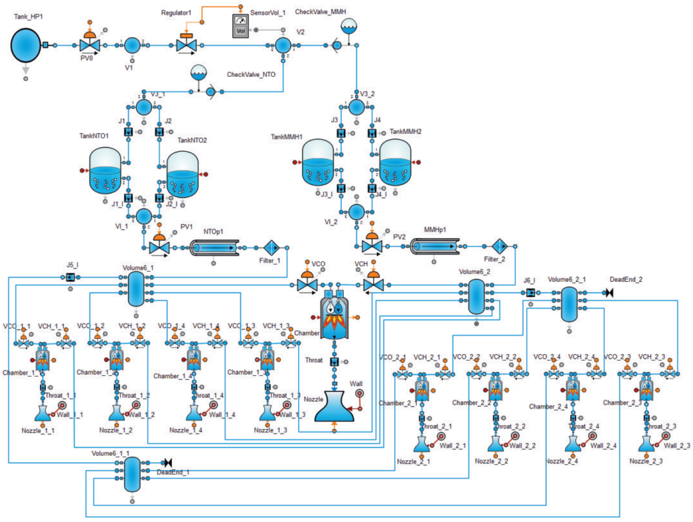


Figure 1. Complex model of satellite propulsion

Two variants of satellite propulsion have been added: one is complex with combustion chambers and nozzles, while the other one is simplified with the 'RCT' component that calculates a thrust and approximate specific impulse that depends on simple correlations. The goal of the first case is to analyse the combustion (pressures and temperatures in the chambers, design of different geometries, etc), while the second one aims to study the priming and water/steam hammers, pressure drops and the responses of valves and thrusters.

For instance, the following chart lists the pressure and temperature results obtained in the cavities of the main combustion chamber with the complex model.

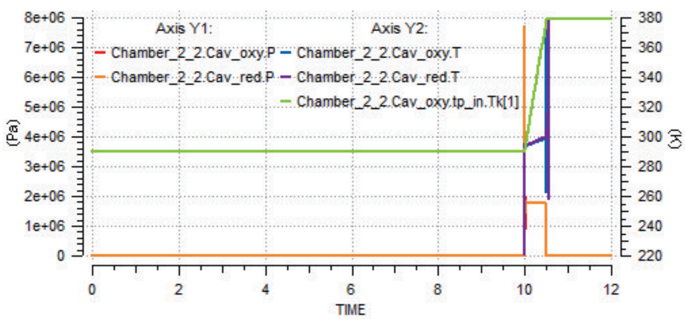


Figure 2. Resultas of the complex model

Finally, the chart below shows the response of the thrusters of the simplified model, which is constant for the main thruster and 0 for the rest up to time=1500. From that moment on, the main thruster is switched off and the secondary thrusters start operating.

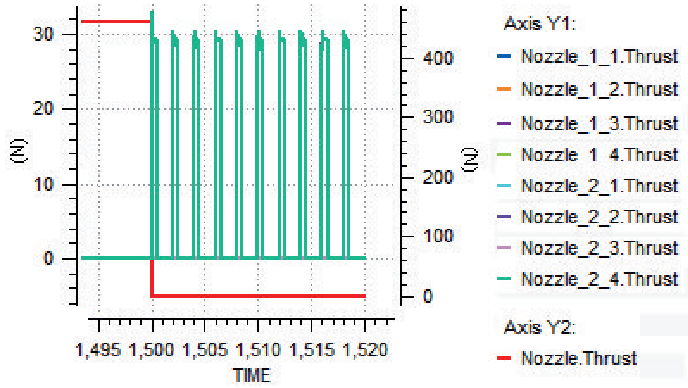


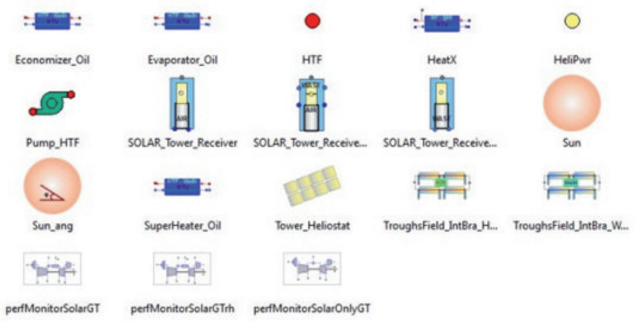
Figure 3. Resultas of the simplified model

9. THERMOSOLAR LIBRARY IN PROOSIS

Chris Kalathakis & Alexios Alexiou, National Technical University of Athens (NTUA)

The need to reduce dependency on fossil fuels led to the consideration of renewable energy power plants such as the Solar Thermal Power Plants (STPP). These materialize a Brayton, Rankine or combined cycle and substitute in part (or even in total) the fuel thermal energy with solar thermal energy.

In order to predict the behavior of these plants and consequently estimate their economic aspects, accurate performance models are mandatory. There are available tools to perform this task but either lack the necessary fidelity or are limited to simulate certain types of plants or unequally weight the power production and solar parts. Therefore, the Laboratory of Thermal Turbomachines at the National Technical University of Athens (LTT-NTUA) developed the SOLAR library in PROOSIS which equally weights the power production and solar parts at the desired level of fidelity. The SOLAR library uses ports from other libraries (e.g. TURBO) and thus can be used in cooperation with these libraries to model and simulate STPPs. The following figure shows the component palette of SOLAR library.



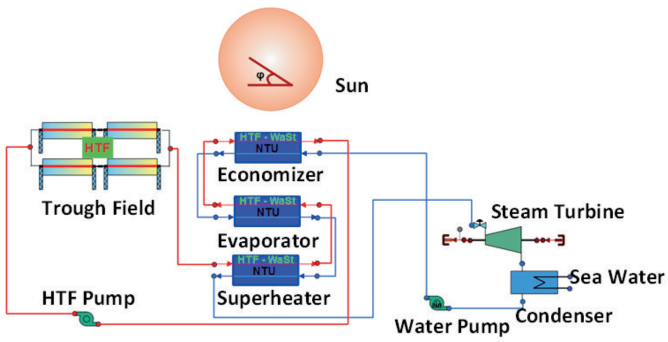
Component palette of SOLAR library

The SOLAR library contains the following components: heat transfer fluid and water heat exchangers, air and water tower receivers, Sun, troughs, heliostat field and performance monitors. Ports are used to transfer the properties of the Heat Transfer Fluid and the solar thermal power. Heat exchangers are modeled with the NTU method and are accounting for sensible and latent heat transfer. The Sun component permits the calculation of the solar beams vector by computing zenith and azimuth angles for every desired hour. Furthermore, if no irradiation data is available, the Sun component is able to estimate the irradiation amount for the desired location using a clear sky model.

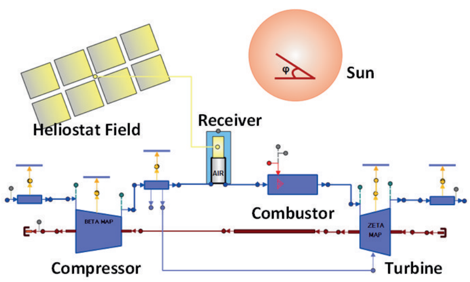
Trough component can simulate the heating of the working fluid and the resulting pressure loss with parabolic mirrors equipped with vacuumed receiver. The working fluid can be either oil or water. In the case of water, appropriate equations are used for the two-phase flow in order to simulate the Direct Steam Generation operation. The simulation is performed by dividing the trough's length in user defined parts and performing a heat balance accounting for losses (cosine, conduction, convection and radiation) and efficiency factors (optical and absorptivity). This heat balance permits the determination of the temperature of each receiver's layer and therefore the computation of the working fluid outlet thermodynamic state.

The Heliostat component permits the calculation of the reflected solar power to the tower receiver taking into account sun–mirror and the mirror–receiver vectors (which are computed for every mirror in the field) and cosine, reflectance, shading–blocking and attenuation efficiencies. Furthermore, if no heliostat field is available, there is the ability to determine each mirror's coordinates in order to minimize shading and blocking. Tower receiver components assume a pressurized volumetric receiver which is modeled as a black body and compute the outlet pressure and temperature of the working fluid. The working fluid (air or water) outlet thermodynamic state is computed with a heat balance taking into account the reflected beams from the heliostat field, the absorptivity and optical efficiencies and radiation losses. Also, there is the ability to select a limit for the outlet temperature by appropriately reducing the used solar power and thus simulating mirror defocusing.

An example of a solar-only Rankine cycle and a solar hybrid gas turbine modeled in PROOSIS with the aid of SOLAR library can be seen in the next two figures.

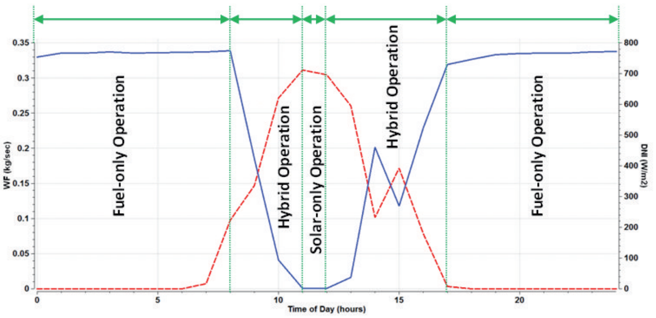


Model of solar-only Rankine cycle



Model of solar hybrid gas turbine

As an example for the solar-hybrid gas turbine case, a fuel-only design point is chosen and real atmospheric data is used to examine its performance. Sun beams are reflected by the heliostat field to the receiver which heats the air before its entrance in the combustion chamber. The scenario of operation is to keep the TIT constant. If no irradiation is available, the engine operates as fuel-only. If the amount of irradiation is adequate to heat the air to the desired TIT there is solar-only operation with zero fuel consumption. Any other amount of irradiation will result to a hybrid mode for which the desired TIT is achieved by the solar heating and the burning of fuel. The following picture shows the fuel consumption and the irradiation during a day.



Variation of fuel consumption and Direct Normal Irradiation through a day

10. PROOSIS COURSE IN THE ISAE, TOULOUSE

David Castaño, EcosimPro/PROOSIS

PROOSIS has become a widely used tool in the European aerospace industry in recent years. Proof of this is growing interest not only from the companies in the sector, but also from the most prestigious schools, who view PROOSIS as an excellent tool both for the training of future engineers and for use in scientific research.

The Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), an internationally recognized school, is focusing on providing a first-class education to its engineering students with a view to their future careers. Last December the school ran an advanced course on PROOSIS, covering the design and simulation of aeronautical motors. The course was given by the team that developed the tool, and was attended by both instructors at the school and Master and Doctorate students.

11. ECOSIMPRO COURSE IN ESA/ESTEC

Ana Veleiro & Victor Pordomingo, EcosimPro/PROOSIS

Last December a general course on ECOSIMPRO was given in ESTEC, the main technological center of the European Space Agency (ESA). It was attended by engineers of the Power Systems Department, responsible for the generation, storage, conditioning and distribution of power for ESA space missions.

ECOSIMPRO has been used for several years in Power Systems to verify the design of the batteries of the satellites and to ensure that the power available is sufficient to cover the requirements of all the sub-systems of the satellites for the duration of the mission, using libraries developed by ESTEC. The multi-disciplinary nature of the tool and its versatility allows it to simulate this type of model in which it is necessary to integrate different elements, such as the battery, solar panels, electronics and the calculation of the solar flux as a function of the orbit, attitude and geometry of the satellite, among other factors.

12. ASME SAE GAS TURBINE STANDARDISATION COMMITTEE

Pedro Cobas, EcosimPro/PROOSIS & Alex Alexiou (NTUA)

EA participated in the ASME SAE S-15 Standardisation Committee on “Gas Turbine Performance Simulation Nomenclature and Interfaces” in Cleveland, USA, between 20th and 21st October 2015. Representatives from some of the most important aeronautical R&D companies and centres (General Electric, NASA, Lockeed Martin, Pratt Witney, Rolls Royce, MTU, NLR, etc) were in attendance.

This was the first time that EA had been invited to participate in this committee, where it gave a detailed presentation of PROOSIS. Similarly, EA presented the implementation status of the various international standards in the latest version of PROOSIS, including the following:

- ARP 5571 and AS755 on the standardisation of the identification of variables, stations and objects.
- ARP468 for the standardisation of an API to access the engine models from C and Fortran

- AS4191, which implements an API to provide special access from Fortran programs

The reference documents of all the standards were discussed over the two days, and new modifications were agreed on for some of them.

The latest additions to NPSS and GSP simulation tools were also presented, both are motor performance simulators that are similar to PROOSIS. NPSS has been developed by a consortium of companies led by NASA ad under the execution of the Southwestern Research Institute (SWRI), and GSP is a program developed by NLR (Netherlands).

These meetings were fruitful for all attendees of the aeronautical engine industry because they served to exchange points of view on different aspects of these programs. They will certainly be taken into account in the new versions of our PROOSIS product.

Furthermore, participation in the development committees of the standards will allow us to keep to date on their evolution and facilitate their incorporation into PROOSIS. It will also allow EA to suggest improvements to future versions of the standards based on our experience with PROOSIS users.

13. SYMPOSIUM ON SPACE FLIGHT DYNAMICS (ISSFD)

Fernando Rodríguez, EcosimPro/PROOSIS

EcosimPro attended the 25th International Symposium on Space Flight Dynamics held in Munich from 19th – 23th October. The symposium brought together the foremost international experts in space flight mechanics from the main agencies and space research centres, such as NASA, JPL, ESA, JAXA, Johns Hopkins University, DLR, etc.

Over these four days, participants shared their experiences in the operation of space probes and satellites, mission analysis, space debris mitigation techniques, etc, as well as their associated mathematical challenges and the methods and tools used for their resolution.

The EcosimPro team, in collaboration with the Space Dynamics Group (SDG) of the Universidad Politécnica de Madrid, took part in the symposium presenting a poster based on the “Novel dynamical model for an object-oriented space tether simulator” article that can be found on our web page. We also presented a new set of libraries for the simulation of Space Tether Systems (several satellites joined by cables) and for common space mechanics applications, such as orbit and dynamic propagation, attitude control, formation flying, etc.

14. SIMULATION OF ADVANCED THERMO-SOLAR SYSTEMS

Raúl Avezuela, EcosimPro/PROOSIS

On 23rd October 2015, EA participated in a conference called "Analytical Tools and Experiences in the Production of Advanced Thermo-Solar Systems in IMDEA" organized by Instituto Imdea Energía, in the framework of the European projects STAGE-STE and ALCCONES, included in the R+D Activities Program of the Madrid Regional Government.

The conference focused on the presentation of simulation tools and experiences applicable to new formats and concepts of thermo-solar power plants. The conference was very successful both in research centers and companies involved in that sector.

EA presented the paper "Cases of Application of EcosimPro in Thermo-Solar Power Plants", which covered some simulation studies of thermo-solar systems carried out using EcosimPro, among these:

- Development of an engineering simulator in a parabolic trough concentrating solar power plant
- Analysis of the operating strategy of a thermo-solar power plant, with central receptor with steam accumulators

The presentation was well received by the audience due to the flexibility and multi-disciplinary character of EcosimPro.

Photo courtesy of IMDEA

15. SPACE PROPULSION CONGRESS 2016

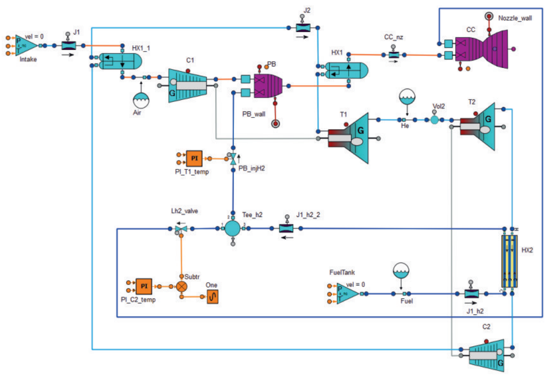
José Moral & Javier Vilá, EcosimPro/PROOSIS

As in previous years, the EcosimPro-ESPSS team will be at the upcoming Space Propulsion Congress this May in Rome. On this occasion we will present several papers based on the ESPSS simulation library improvement works carried out in the Multiphase Flow Modeling project, in which some of the most renowned European space propulsion companies and institutions participated.

The following aspects will be covered by the various partners:

- Implementation of the AUSM numerical method in order to attain greater precision in the results of the models, by reducing the simulation time in comparison to other similar applications, by the Universidad "La Sapienza" de Roma.
- Development of a non-homogenous two-phase flow model in ESPSS, based on the AUSM numerical method, by the Von Karman Institute.
- Development of a code for calculating the evolution of the complex geometries of the fuel in solid-fuel rocket engines, by ONERA.
- Improvements in the simulation of the dynamics of a spacecraft and its coupling to the propulsion system, by KopooS.

The ESPSS team will present an additional paper entitled "ESPSS Model of a Simplified Combined-Cycle Engine for Supersonic Cruise", showing the capabilities of the libraries for simulating a high speed engine. The model combines an atmospheric engine with a liquid fuel rocket engine, also including a closed helium cycle with a system of heat exchangers to increase its efficiency.



Drawing of the high-speed combined engine

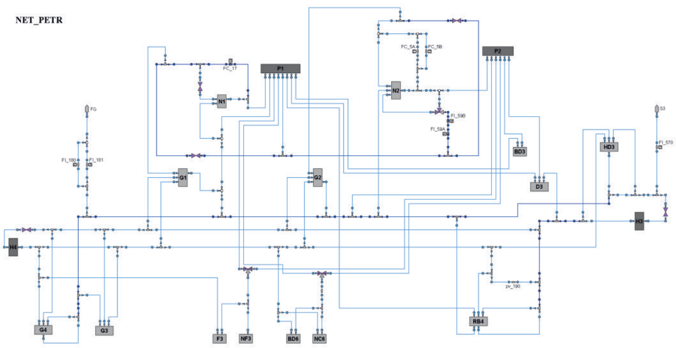
In addition, the team will have a stand to present live demonstrations of EcosimPro and will organize a workshop where users can present their models and requirements, and the developers can present their latest additions to the libraries.

16. ECOSIMPRO LIBRARY FOR MODELLING, DATA RECONCILIATION & OPTIMAL OPERATION OF HYDROGEN NETWORKS

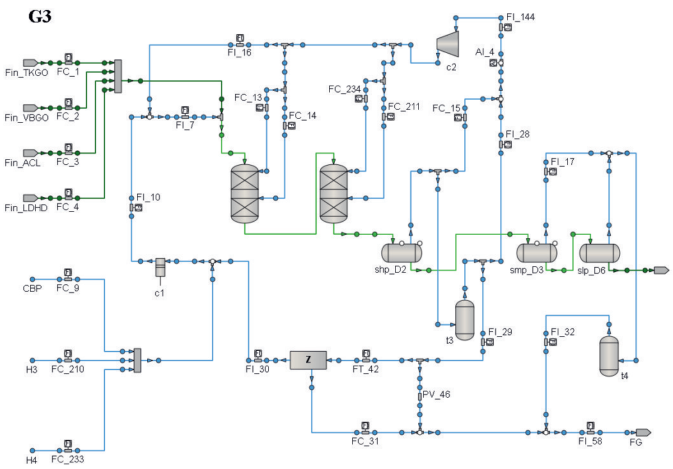
Elena Gómez Sayalero & César de Prada, Valladolid Univ. (UVA)

Hydrogen is an expensive utility used in several processes in oil refineries, mainly in desulphurization and hydrocracking plants, and which is gaining increasing importance in the global refinery economic balance. Within the framework of a project aimed at the optimal operation in real-time of the Petronor refinery H2 network, an EcosimPro library H2NET has been developed. The H2NET library comprises first-principles models of the main equipments and operations involved in the network management: gas streams, reactors, high-pressure separators, low-pressure separation processes, tanks, membranes, compressors, meters, valves, and mixers and splitters supporting also pipes with unknown direction for flow.

The network model built with the H2NET library has been used for different purposes. For What-If analysis in simulation; in a cooperative project with the Repsol Technology Center in Móstoles (Madrid) aiming at the revamping of the Petronor H2 network, where new connections and alternatives were considered and assessed; as case study for the formulation of real-time resource efficiency indicators REIs in the European project MORE; as well as for the network optimal operation in real-time.



Petronor H2 network, with consumer and producer plants and the different headers



Process flow diagram of a diesel hydrodesulphurizer consumer plant

Regarding this last target of on-line decision support, firstly a data reconciliation problem is solved by optimization techniques, formulated as the minimization of the measurement-model deviations taking advantage of all the redundant flowmeters available; model parameters are calibrated at this stage and measured and unknown variables estimated. The optimal operation has been addressed with a real-time optimization RTO approach as the minimization of the H2 production cost based on the network model once calibrated in the data reconciliation stage, and including all process constraints and specifications. Reasonable results, ready to be implemented as decision-support for the operation, has been achieved and analysed regarding the production rates in producer plants, the make-up flow rates to consumer plants from the different headers, as well as the high-pressure purges and membranes flow rates. Snopt, based on a SQP algorithm, is used as NLP solver for both optimization problems.

The H2NET library includes several additional features: i) configuration structure to enable an easy link with the SCADA for process data acquisition; ii) functions to perform the corresponding data treatment and initialization of variables; iii) functions for the automatic generation of the code needed to implement both optimization problems; iv) management of the linear constraints to conveniently bound the search region in both optimization problems, exploiting model structure.

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EcosimPro
Modelling and Simulation Software

PROOSIS
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