

## Modelling and Simulation Software

EcosimPro/PROOSIS · Newsletter Nº9 · February 2014

### EDITORIAL



ESA

In this new newsletter regarding our simulation tools EcosimPro and PROOSIS, we are continuing with our usual editorial policy and will discuss both the new features included in the latest versions of the tools and the new applications and libraries that our team is now developing.

In the area of space propulsion, good progress has been made with the ESPSS libraries being developed by a consortium of companies, led by Empresarios Agrupados Internacional (EAI) and the European Space Agency (ESA). The latest version includes new capabilities demanded by users, such as a new modelling library for steady propulsion systems (called STEADY), new components such as solid/hybrid and ramjet/scramjet combustors, an electric propulsion library called EP and a new orbital mechanics library called SATELLITE that allows users to calculate the position of a satellite, effects of the sun and moon, etc. These new capabilities of the ESPSS expand our libraries' fields of usage. Many European companies now use EcosimPro/ESPSS to create their space propulsion models.

We have also issued the first version of a new library for electrical systems to model the electrical parts of an aircraft. This new library can

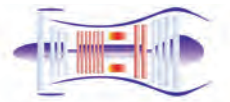
be used for joint analysis of the aircraft's propulsion system (TURBO library), its electrical system (ELECTRIC\_SYSTEMS library) and other systems such as the Environmental Control System (ECS) or the Fuel System. PROOSIS is now a multi-purpose tool that can be used to model multi-disciplinary systems of an aircraft in the same tool.

As far as new software capabilities are concerned, a new text editor was released, much more versatile and intuitive than the previous version. There is also a new tool to export and import data from diagrams, which users had been demanding for a long time. Now all the data of a model can included be in an Excel spreadsheet that users can import into EcosimPro automatically.

The new tool's connection to Excel has also been improved, and now users without any experience with EcosimPro can simulate any model directly in Excel intuitively and easily. Users can now create their own Excel spreadsheets and include graphs, diagrams, etc. that interact with the results of the simulation that EcosimPro provides automatically.

Lastly, we would like to remind you that in 2014 we will be participating in two important Trade Fairs: Space Propulsion 2014, from 19th to 22nd May in Cologne (Germany), organized by the ESA; and ASME Turbo from 16th to 20th June in Dusseldorf (Germany). We will have a stand at both of them where anyone interested can listen to our presentations. At the Space Propulsion fair, a workshop for EcosimPro/ESPSS users will be organized by the ESA and EAI. And at the ASME fair, we hope to meet experts from throughout the gas turbine industry, as ASME is this sector's top international trade exhibition.

Pedro Cobas Herrero (pce@ecosimpro.com)  
**Head of. EcosimPro/PROOSIS Development Team.**  
**EA Internacional**



## LATEST NEWS ECOSIMPRO/PROOSIS

### 2014 EUROPEAN SPACE PROPULSION

As in previous years, the EcosimPro team will be attending this year's 2014 Space Propulsion Congress, to be held in Cologne, Germany, from 19-22 May. The event, organised by the European Space Agency and other European space organisations, will be attended by the main European and global space industry companies. Besides presenting the new version of the ESPSS and work done with ESPSS/EcosimPro, the Ecosim team will host its now-traditional Workshop for users of ESPSS/EcosimPro.

The Space Propulsion congress is recognised as the "forum" for obtaining support in the preparation of future activities and work plans in all realms of European space propulsion. As such, the event programme is organised to provide assistance with technical queries and promote the exchange of opinions and information in the two main areas of spacecraft propulsion and space transport. The EcosimPro team will have a stand for displaying the latest capabilities of EcosimPro/ESPSS in space propulsion. Also an EcosimPro/ESPSS workshop organised by ESA and EA is planned.



### ASME TURBO EXPO 2014

From 16-20 June, the PROOSIS team will be attending the 59th edition of this renowned event for turbine machinery professionals, to be held this year in Düsseldorf, Germany. The PROOSIS team can be found in stand 1005 of the trade fair exhibition area. The team will present the latest version of PROOSIS and demonstrate its capabilities for modelling gas turbines and other parts of aircraft, including the electrical and environmental control (ECS) systems. ASME Turbo Expo has a well-earned reputation for bringing together the world's best

and brightest experts to share the latest in gas turbine technology.



### NEW CAPABILITIES OF THE ESPSS LIBRARIES

By Javier Vilá. *EcosimPro/PROOSIS Applications Team. EA Internacional.* The European Space Propulsion System Simulation (ESPSS) libraries are an initiative of the European Space Agency (ESA) whose purpose is the creation of a European platform for the simulation of the propulsion systems of spacecraft and shuttles. These libraries have been significantly updated and improved since their official first version in March 2008; not only have their capabilities been constantly increased but they have also been made more robust and reliable thanks to the experience gained over these years.

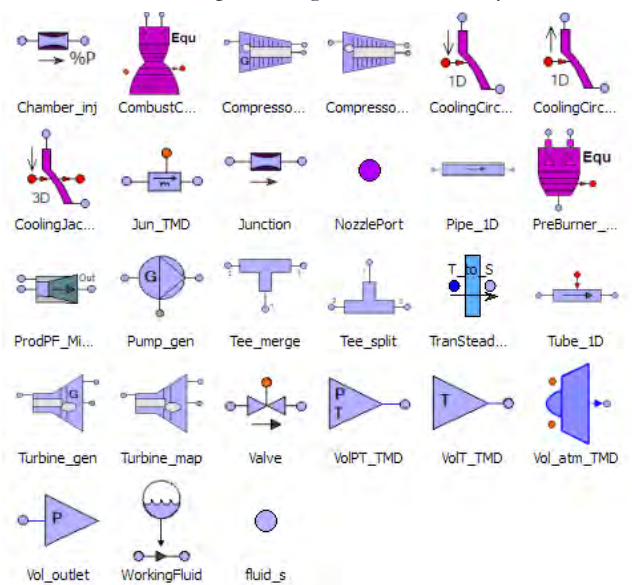
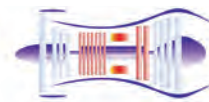


Figure 1.- Components of the STEADY library



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The latest update of the libraries, ESPSS Version 3.0, was issued recently and represents an important milestone in the development of this simulation platform, as several options of great interest to users have been added that allow the modelling of systems more in accordance to their needs. Some of these new capabilities are described below:

### New STEADY library

The STEADY library contains a complete set of ready for use components (combustors, nozzles, turbines, valves, piping, etc), capable of calculating the steady actuations of liquid propellant rocket engines under design and analysis conditions (off-design).

The design models impose the design conditions as input data, based on which the components, such as the turbines and valves, are sized. Typical design conditions include: efficiencies, velocities, pressure drops in the turbines, pressure and mixture ratio in the combustor, pressure surges in valves, etc. This library also allows the user to completely size a motor if the requirements of a specific mission are imposed.

The analysis models of actuators (off-design) mainly impose the geometry and the nominal operating conditions of the motor, and in general use the actuation maps of the turbines in order to calculate the off-design solutions.

Despite the fact that these two models (design and off-design) require different input data, both can be simulated from the same schematic by making use of the design partition. EcosimPro's capacity to do this can transform data into unknown variables, and allows the design conditions to be added as new boundary conditions.

In addition, the STEADY\_EXAMPLES library contains a set of application examples that can be used by users to familiarize themselves with the use of the steady library, and as a standard for the construction of more complex models.

### New solid/hybrid and ramjet/scramjet combustor components

The solid/hybrid combustor component represents a non adiabatic combustion for combustion chambers for solid propellants, and allow the injection of a liquid oxidant. The range of fuels can be selected from a list of predefined fuels or it may be entered by the user via its composition and formation enthalpy.

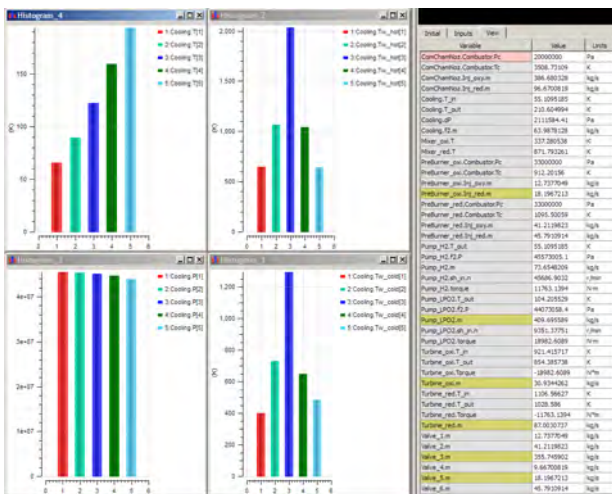
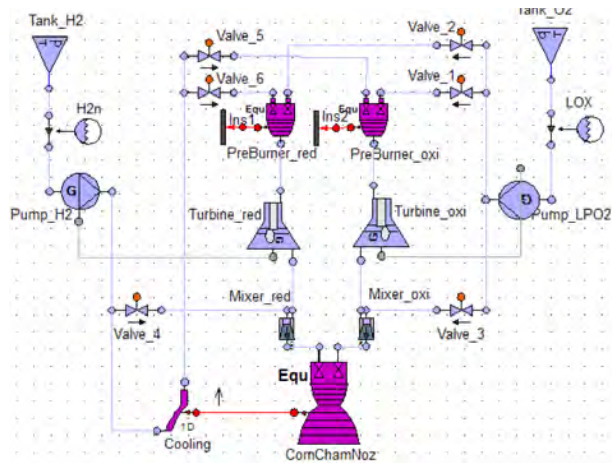


Figure 2.- Model of the SSME (in the STEADY\_EXAMPLES library)

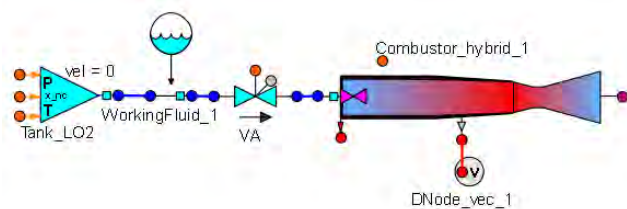


Figure 3.- Model of a hybrid motor

The ramjet/scramjet component represents a non adiabatic combustion for motors that take in air from the atmosphere, with subsonic or super-sonic combustion respectively. Influences like, for example, friction, geometry or fuel injection at any point of the chamber may be simulated.



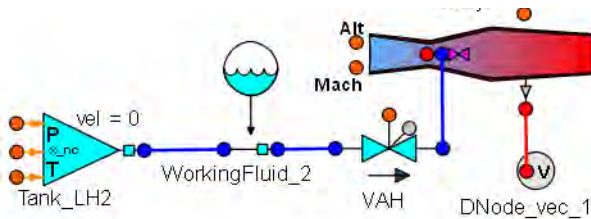
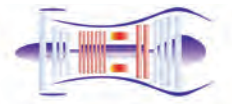


Figure 4.- Model of a ramjet motor

### New SATELLITE and EP libraries

These new libraries have been developed to cover the simulation needs in two important areas of space propulsion: the EP library allows transient simulation of electrical propulsion systems, while the SATELLITE library is used to simulate the behaviour of the components of a satellite and of their evolution and control (orbital transfers, orbit control, effects of the sun and moon, etc).

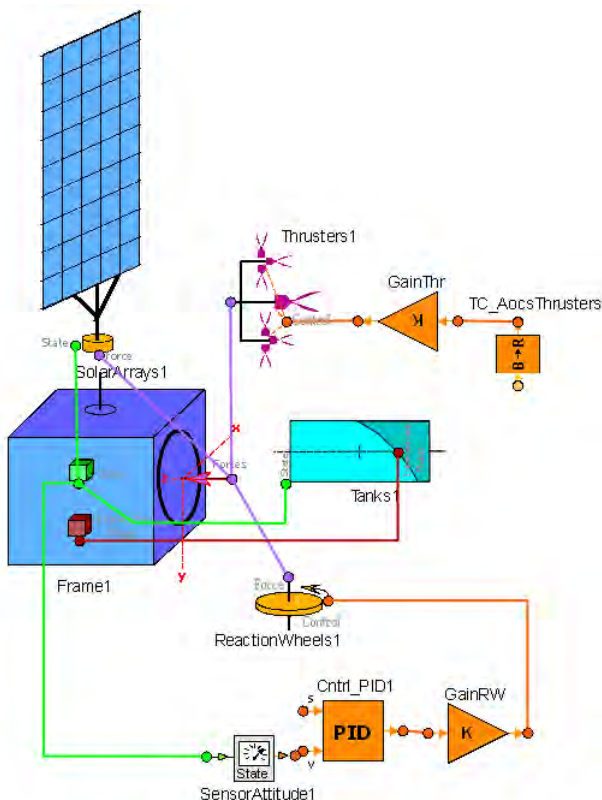


Figure 5.- Model of a satellite and of its control system

### Continuous improvement

Apart from the above novelties, much work has been done on updating the existing libraries, with a view to maintaining a process of continuous improvement and correction of errors: the initialization of state variables has been improved and simplified; the effects of absorption/desorption has been added for piping and tanks and for the transport of non-condensable gases; and Van der Waals property functions have been added for working fluids.

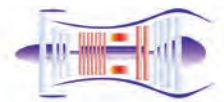
Most ESPSS components now have a new parameter called burnerGasesOption to choose if they work with a pure fluid or with a mixture of gases. Also, the combustors have new parameters to choose the model for the vaporization of the liquid propellant (GasLiqOption), the model for balance or delay in the reaction of the fuel (rateOption), and whether to take into account or not the quantity of liquid in the mixture that exits the chamber (liquidExitAllowed).

The new Version 3.0 of the ESPSS libraries is without doubt the most robust and complex to date, and it can be described as a tool that is ready for use with real industrial applications. Current and future developments aim to extend the application of these libraries to as wide a range of real phenomena as possible in the field of space propulsion.

## MODELLING OF THE AIRCRAFT ELECTRICAL SYSTEM WITH PROOSIS

By Victor Pordomingo. EcosimPro/PROOSIS Applications Team. EA Internacional. The creation of the ELECTRIC SYSTEMS library is the final step towards completing the capabilities of PROOSIS. It can now simulate the aircraft engine (TURBO library) and complete the simulation together with the electrical system. This document shows the modelling of the aircraft (B767) engine and the electrical system, and focuses on the most relevant elements and the results for the main actuations under analysis: generator startup at no load, simultaneous connection of all the loads to check the limitations required by standard MIL-STD-704F, study of several short-circuits and the protections against them.

Figure 1 shows that the aircraft electrical system normally receives the mechanical power required to move the electrical generators



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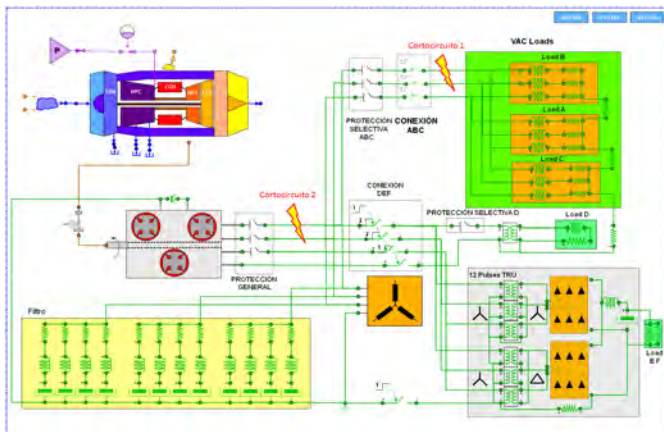


Figure 1. Aircraft Engine and Electric System PROOSIS model

from the engines propelling the aircraft themselves. This power is adapted to the needs of each load by means of electrical converters to supply the existing electrical loads in the system (DC, three-phase AC and single-phase AC).

In the aeronautical field, the electrical generators that are used are normally of synchronous type and will operate with a 200 V effective line connection at a frequency of 400 Hz. They will be Constant Speed Constant Frequency systems with a rotation speed of 12,000 rpm. These generators are normally of three-stage brushless type. They have been modelled in PROOSIS by means of the cascading of three common synchronous generators, as shown in figure 2.

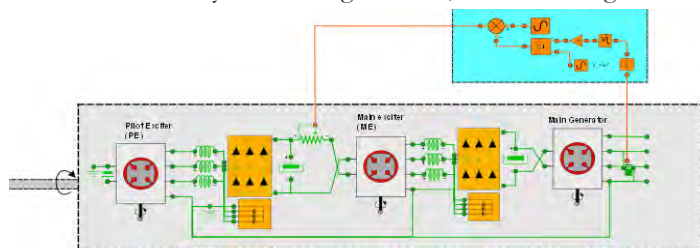


Figure 2. Three Stage Synchronous Brushless Generator

At the same time, a transformer-rectifier unit is used to supply the DC loads in the aircraft. These rectifiers can be of several types, but the '12 pulse'-type ones are the most common. Figure 3 shows the Proosis model of this unit. This type of converter has significant harmonic repercussions on the generated voltage. Their effects can be minimized by including a battery of tuned filters.

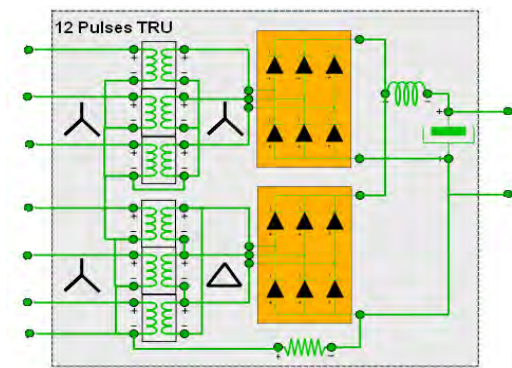


Figure 3. Pulse Transformer Rectifier Unit

The ELECTRIC SYSTEMS library also allows short-circuits and protection systems to be modelled. To do this, there is a set of protection switches that can selectively isolate short-circuits or any other type of fault. To guarantee correct selective system operation, the points where the short-circuits have occurred need to be adequately isolated, depending on the location of the system malfunction. Protection switches with the appropriate configuration will be used. The boards can be designed by means of different current-time curves based on the estimated consumption in each part of the facility.

The whole model mentioned above can be used to analyse the aircraft propulsion system, electrical system and the mutual influences between them simultaneously so as to guarantee the stability of the assembly under the worst case scenario. Figure 4 shows the evolution of the phase voltage during startup and how it is kept within the limits set by Standard MIL-STD-704F.

Figure 5 shows the evolution of the generated phase currents in

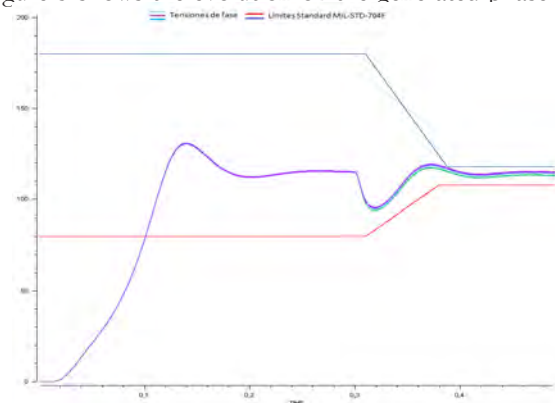
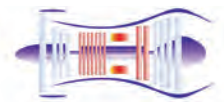


Figure 4. Phase voltages and limits in Standard MIL-STD-704F







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- Identification of the modified sections with respect to the open version.

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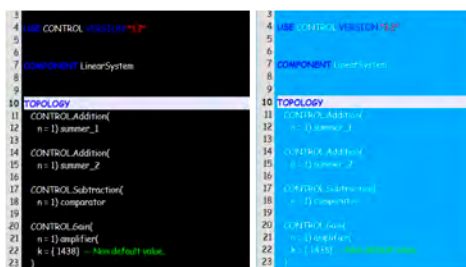
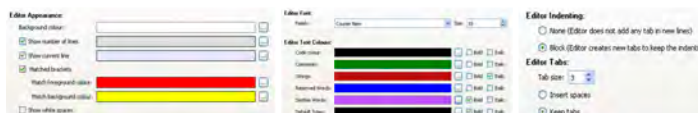
31
32 -- Event to detect stopping the simulation
33 -- Change introduced
34 WHEN (h < -.003) THEN
35   PRINT ("***** End of simulation: height < -0.003")
    
```

-Identification of the code by blocks by means of highlighting text and using the TAB and SHIFT+TAB keys to indent and de-indent.



The second point that has improved substantially in this new version is the final presentation of EL to let a user work under his own criteria of appearance and style, which makes it easier and more comfortable to use.

This has been achieved by including in EcosimPro a set of new set-up dialogs for completely personalizing the editor in terms of its appearance and defining properties such as: the font type, the font size, the color of the key words, display/hide the line number, change the type of indentation or spacing, etc.



As a result, the new text editor improves how EL code is created and used.

However, developments on this important part of our product do not stop here: we are already working on enhancements for the next version. We look forward to your suggestions for further improvements.

## NEW ECOSIMPRO ADDIN FOR MICROSOFT EXCEL

By Fernando Puech. EcosimPro/PROOSIS Applications Team. EA Internacional. EcosimPro 5.2 includes a new complement for Excel that also gives COM access to any model developed in EcosimPro. In other words, you can access an EcosimPro model from any software program written in VB, VBA, VB.NET, C#, C++, Python, etc. The new complement works with any EcosimPro-compatible compiler, from GCC to Microsoft Visual Studio 2010, which was not the case in previous versions. The compatibility does not end there, since the complement has been developed to work with Microsoft Excel 2003, 2007, 2010 and 2013 and on the Microsoft Windows XP, Windows Vista, Windows 7 and Windows 8 operating systems.

The aim when developing the new complement was to make it easier to use, install and set up. The user of the complement only has to install it once, and then choose which EcosimPro installation he wants to use. This step saves the user from having to modify environment variables, with the risks that entails. The speed of the complement has been greatly improved since the earlier versions.

The EcosimPro user interface in Windows 7 and with Microsoft Excel 2010 is as follows:

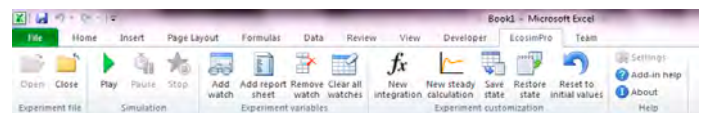


Figure 1 Toolbar in the EcosimPro complement for Excel

The above toolbar can be used to:

- Simulate the model exactly as defined in EcosimPro (Play button).
- Pause the simulation.
- Stop the simulation.
- Run a transient in the model in whatever time interval the user wants (“New integration”).

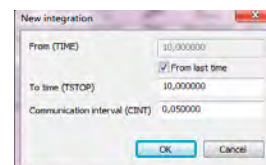
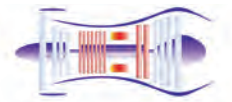


Figure 2 Creation of a custom integration



- Carry out a steady calculation for the current moment (“New steady state”).
- Save the simulation status, i.e., save the values of the variables in a file.
- Load the values of the variables using a file of a previously saved state.
- Reset the model to the initial situation.
- Associate cells to variables of the model (“watches”) to see how a variable evolves during the simulation and/or to modify values of some of the variables in the model. Values can only be modified when the simulation is paused or stopped; when restarted, the model will continue but using the new values of the variables.

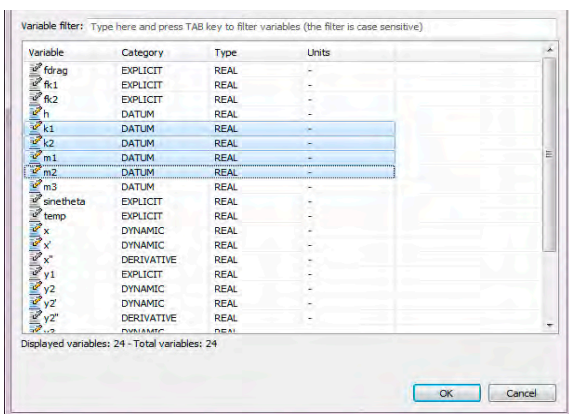


Figure 3 Dialogue to associate variables to cells in Excel

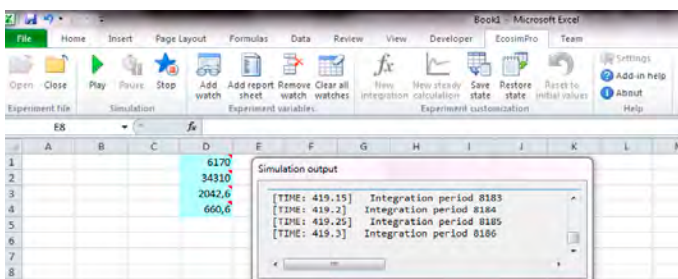


Figure 4 Associated cells

- Generate reports on variables that consist of Excel sheets containing the values of a set of variables for each moment in time in the simulation. The user can then use these reports to create graphs. The Figure 4 shows the dialog for choosing variables to produce a report, while Figure 5 shows the report produced.

Figure 6 Report created using the “Report” dialog. The results are refreshed every time the simulation is run and the model informs us that it has new data.

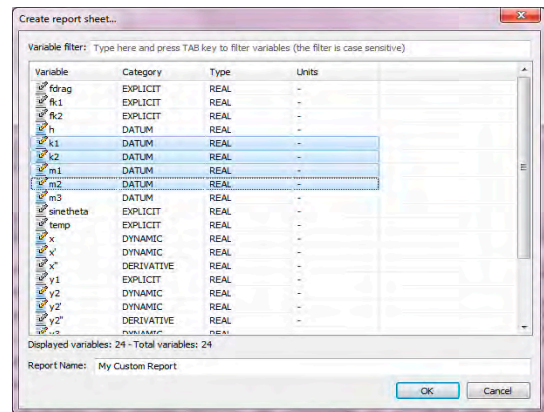


Figure 5 Dialog for creating reports

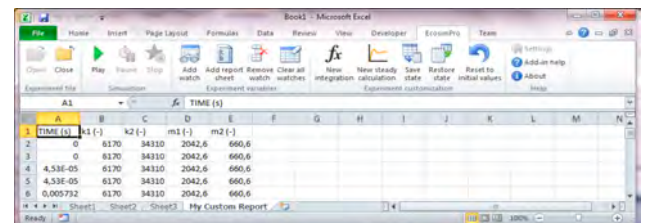
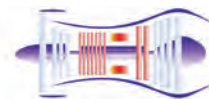


Figure 6 Report created using the “Report” dialog. The results are refreshed every time the simulation is run and the model informs us that it has new data

The functions of the EcosimPro complement for Excel are flexible enough to generate Excel books as complex as the user wishes. For example, the following figures show the result of a set of simulations. The model depicts a tungsten plate in contact with a gas and the Excel sheet shows the evolution of concentration, pressures and compositions of the gas and the plate. The Figure 6 shows the result of having used association of variables of the model to Excel cells (“watches”), the use of reports that will provide data for graphs and the simulation of the model as developed in EcosimPro. One of the main advantages of this complement for Excel is that it can be used to modify the variables in the model, and therefore make configuring the simulation as easy as associating a cell to a variable and modifying the value in the cell. When the simulation resumes, that variable will take the value stated by the user.

The power of the EcosimPro complement for Microsoft Excel is not confined to the toolbar, since it allows accessing the model





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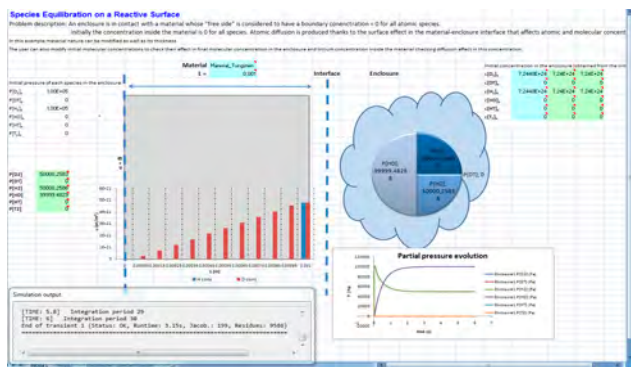


Figure 7 Simulation of the default case

via COM. In other words, the user may customize his spreadsheet using macros and basing it on the documentation of the functions of the COM interface, as well as the examples of the documentation from EcosimPro.

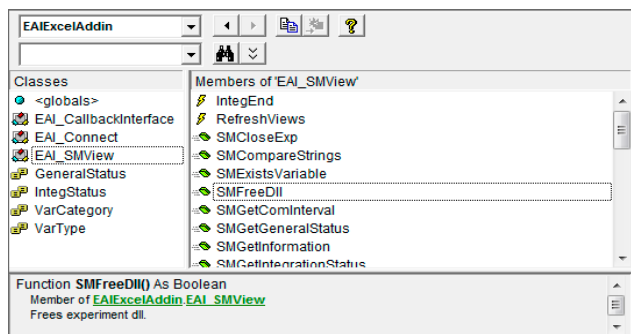


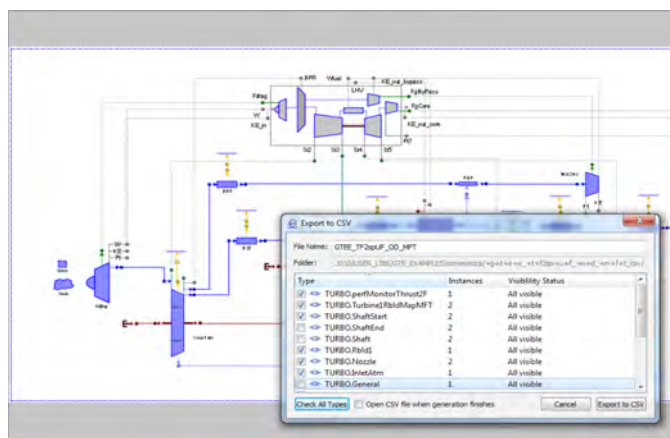
Figure 8 Documentation of the functions of the COM interface of the complement in Excel's Visual Basic editor

This article has given a brief description of the possibilities offered by the new EcosimPro toolbar for Microsoft Excel. As can be seen, the only limit is up to the user when developing a calculation book in Microsoft Excel that runs on information from a model developed in EcosimPro.

## EXPORT AND IMPORT DATA FROM THE SCHEMATIC

By *Diego García, EcosimPro/PROOSIS Development Team, EA Internacional*. On diagrams with a large number of complex components with multiple parameters and attributes it is not easy to

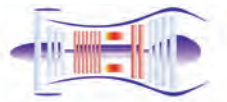
assess the current status of each component (i.e., the value of their parameters and attributes) at a glance. It can sometimes be tedious to identify a component with a wrong parameter or attribute that makes the results of the simulation not be what was expected.



This type of task can be simplified by using the export and import of diagram data. Exporting can be used to create tables in CSV (comma-separated values) files. This process gives these files a more legible format, in which for every component or port on the diagram, a table is generated where the rows list the different items and the columns give the value of the parameters and attributes. Thus, the value of the different parameters and attributes of each component and port can be examined.

	A	B	C	D	E	F	G	H	I	J	K	L	M
280	W_bld[2]	REAL	DATA	{ 0,005,0,01 }									
281	VarblDlaw	TABLE_ID	DATA	{ { 0,0,7,0,85,1,1 }, { 0,2,0,2,0,0 } }									
282	n_bld[2]	REAL	DATA	{ 0,1 }									
283													
284													
285	TYPE	Casing											
286	LIBRARY	TURBO											
287	INSTANCES												
288	VARIABLES	TYPE	CATEGORY	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE	VALUE
289	calcType	ENUM	TURB/PARAM	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc	steadyCalc
290	mCp	REAL	DATA	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
291	As	REAL	DATA	1	1	1	1	1	1	1	1	1	1
292	As	REAL	DATA	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
293	c	REAL	DATA	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
294	c	REAL	DATA	1	1	1	1	1	1	1	1	1	1
295	Qcustom	REAL	DATA	0	0	0	0	0	0	0	0	0	0
296													
297													
298	TYPE	Burner											
299	LIBRARY	TURBO											
300	INSTANCES												
301	VARIABLES	TYPE	CATEGORY	VALUE									
302	switchFuelPRNUM	TURB/PARAM		fromDATA									

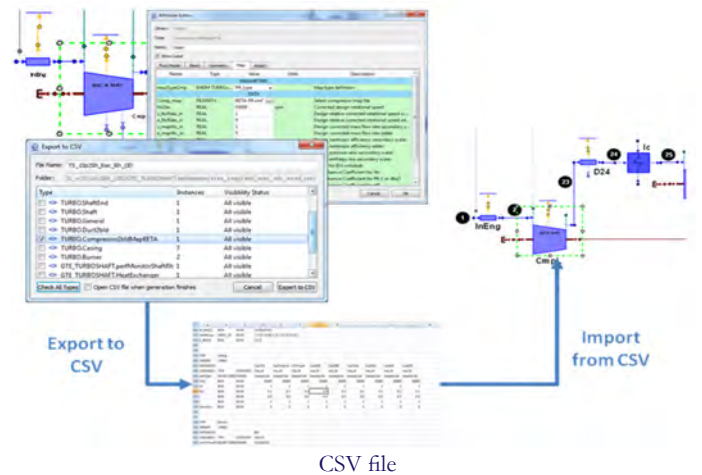
CSV files are compatible with most spreadsheets, where they are displayed in editable table format. This way makes it much easier to identify and correct an erroneous value of a parameter or attribute of a port or component. Having the values of the parameters and attributes in table format also makes it easier to compare



values for different items of the same component. Moreover, the value of the attributes and parameters can be edited together, for example by using macros, and new values can be imported to that same diagram or a different one.

It is also useful to import from a CSV file when there is a complex component with many different parameters and attributes in desired or optimum working order and you want to reproduce it in another diagram.

Instead of copying the values of the different parameters and attributes one by one, the diagram can be exported with the component with the desired status and then imported into the other diagram to give it exactly the same behaviour as the original.



Please feel free to send us any suggestions you may have for the EcosimPro newsletter, whether these have to do with content, articles or interviews that you would like to see published in coming issues to [info@ecosimpro.com](mailto:info@ecosimpro.com).

We look forward to receiving them. With your collaboration, we can continue to improve and expand the newsletter sections that are most relevant to you.

# SUGGESTIONS

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**EcosimPro**   
Modelling and Simulation Software

**PROOSIS**   
Propulsion Object Oriented Simulation Software

  
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