

# CARINS : A versatile and flexible tool for engine transient prediction

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CARINS is a new versatile and flexible tool for simulation of liquid propellant rocket engine systems transients. Systems are composed by pneumatic, hydraulic, mechanical, thermal and combustion subsystems. This kind of numerical simulation can reduce drastically design development cost and checking capacities.

The main motivation of the project is to give to engineers and research teams a new powerful tool for reproducing time evolution of physical parameters which characterise the propulsion system behaviour for space launcher, or only part of it, during all the mission phases (start up and shutdown transients, chilldown phase, operating point modification, main stage,...). This project was initiated three years ago by CNES, in partnership with ONERA, and it involves several laboratories.

For this project, CNES included two extra items which make uniqueness of CARINS : first, the tool must be an open software where the users will be able to operate easily at the lowest level of programming for new models development, and second, the software must be free of licensed-tools, in order to control as much as possible the CARINS development and future upgrades, and to easily distribute the software to its partners, as research laboratories, if necessary. That is why we chose a symbolic manipulation offered by Computer Algebra System and numerical analysis for computing the response of a dynamical system. Moreover, the software structure must take into account complex physical phenomena involved in LPRE transients and in particular the characteristic times of components.

The general concept of CARINS combine useful Graphical User Interface with “black-box” and Computer Algebra System (CAS). This allows to manipulate not only numbers but formulas, equations, mathematical expressions and user expression. So the modelling task can be viewed as the CAS customisation to a specific engineering domain using the GUI. Coding of formulas provided by the user is also done by such software, as they can learn how to translate mathematical expression into numerical languages.

After the code generation and his link with numerical algorithms, we use another open source software : SCILAB. It manages and embeds the simulator for plotting and providing the sensitivity analysis of model outputs with respect to independent parameters. SCILAB is used as robot enables to rapid integration of these simulators and automates their execution to accelerate the evaluation of many more design alternatives. First applications are presented specially on ARIANE 5 stage pressurisation sub-systems, the stability of the VINCI hydrogen turbopump axial equilibrium system, VINCI and HM7 engine transient and VULCAIN combustion components.

CARINS is the dynamical module of a future complete and useful tool called CARMEN for modelling, simulating and analysing liquid propellant rocket engine systems.