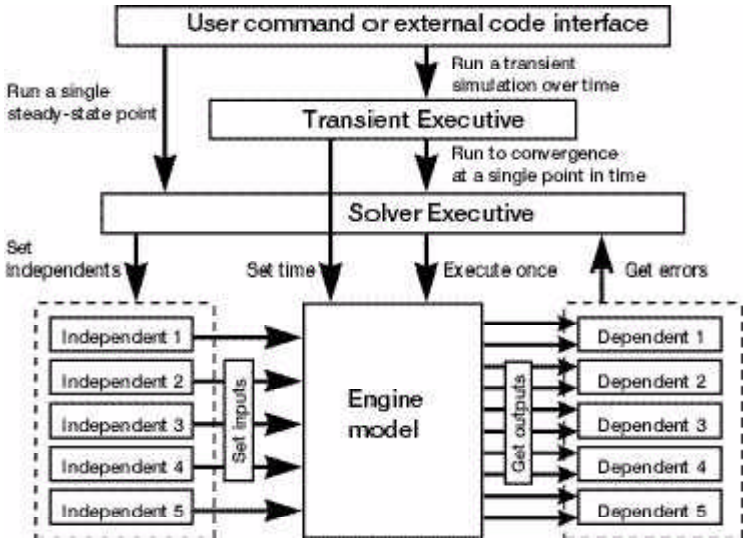
Numerical System Solver Developed for the National Cycle Program

As part of the National Cycle Program (NCP), a powerful new numerical solver has been developed to support the simulation of aeropropulsion systems. This software uses a hierarchical object-oriented design. It can provide steady-state and time-dependent solutions to nonlinear and even discontinuous problems typically encountered when aircraft and spacecraft propulsion systems are simulated. It also can handle constrained solutions, in which one or more factors may limit the behavior of the engine system. Time-dependent simulation capabilities include adaptive time-stepping and synchronization with digital control elements. The NCP solver is playing an important role in making the NCP a flexible, powerful, and reliable simulation package.

The NCP solver uses a modified Newton-Raphson method. For any given system model of interest, a set of independent and dependent parameters are defined, either by the user or automatically by the model elements. The solver characterizes the effects of each independent parameter on all dependent variables through direct perturbation of the model. It uses this information as a guide as it attempts to find the set of independent values that will render all dependent errors equal to zero (the solution). This is typically achieved through a number of successive iterations. The NCP solver employs a sophisticated set of algorithms to enhance the model's convergence toward the solution, and it has a number of attributes that allow expert users to fine tune the solution process.



NCP solver subsystem hierarchy.

The NCP solver has a flexible, object-oriented design that allows appropriate solver information to be embedded in the model, even though the solver itself is part of the NCP infrastructure and is not model specific. The functions of the solver are also hierarchical, as illustrated in the figure. The Transient Executive controls the overall performance of time-dependent simulations, which consist of one or more individual solutions to the model at different points in time. The Transient Executive sends messages to the Solver

Executive, requesting a solution at each individual point in time. The Solver Executive, in turn, sends messages to the independents and dependents to perform low-level functions as required (including integration with respect to time). This hierarchical approach provides a great deal of design flexibility and minimizes the need to keep multiple copies of data during execution.

The NCP solver was developed at the NASA Lewis Research Center in cooperation with experts at each of the industry partner companies. It includes the best practices of each partner company in a single package.

The original version of the solver included steady-state analysis capabilities only. In fiscal year 1998, time-dependent simulation capabilities were added, including support for simulation of the digital control elements. In fiscal year 1999, the NCP solver will be enhanced to include special handling for high-frequency, spatially distributed models (dynamics). A framework for optimization will also be incorporated in the solver in 1999.

Bibliography

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