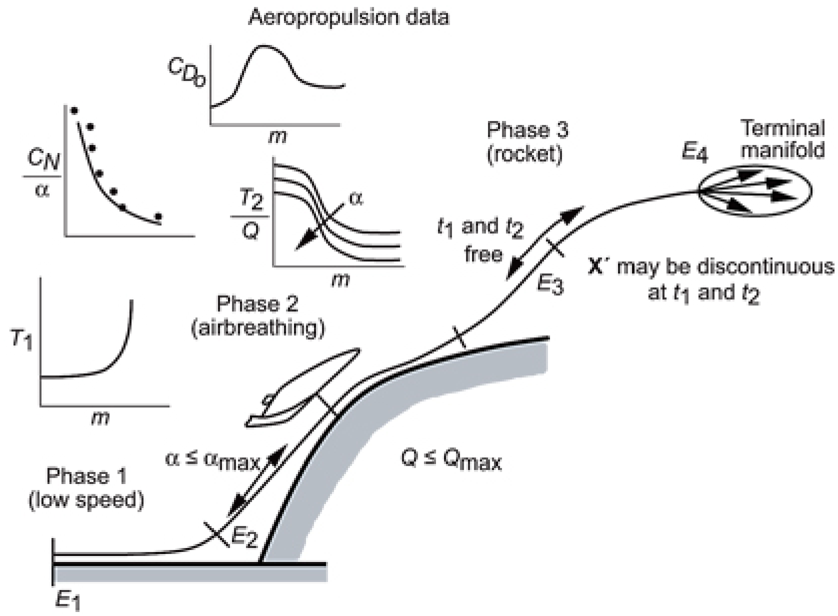
OTIS 3.2 Software Released

Trajectory, mission, and vehicle engineers concern themselves with finding the best way for an object to get from one place to another. These engineers rely upon special software to assist them in this. For a number of years, many engineers have used the OTIS program for this assistance. With OTIS, an engineer can fully optimize trajectories for airplanes, launch vehicles like the space shuttle, interplanetary spacecraft, and orbital transfer vehicles. OTIS provides four modes of operation, with each mode providing successively stronger optimization capability. The most powerful mode uses a mathematical method called implicit integration to solve what engineers and mathematicians call the optimal control problem. OTIS 3.2, which was developed at the NASA Glenn Research Center, is the latest release of this industry workhorse and features new capabilities for parameter optimization and mission design.

OTIS stands for Optimal Control by Implicit Simulation, and it is implicit integration that makes OTIS so powerful at solving trajectory optimization problems. Why is this so important? The optimization process not only determines how to get from point *A* to point *B*, but it can also determine how to do this with the least amount of propellant, with the lightest starting weight, or in the fastest time possible while avoiding certain obstacles along the way. There are numerous conditions that engineers can use to define optimal, or best. OTIS provides a framework for defining the starting and ending points of the trajectory (point *A* and point *B*), the constraints on the trajectory (requirements like "avoid these regions where obstacles occur"), and what is being optimized (e.g., minimize propellant). The implicit integration method can find solutions to very complicated problems when there is not a lot of information available about what the optimal trajectory might be. The method was first developed for solving two-point boundary value problems and was adapted for use in OTIS. Implicit integration usually allows OTIS to find solutions to problems much faster than programs that use explicit integration and parametric methods. Consequently, OTIS is best suited to solving very complicated and highly constrained problems.

Typical OTIS input includes a description of the objective function (the thing that is the measure of goodness) and a number of general specifications that describe what the program should output, and how these results should be formatted. Also, OTIS provides input items for modeling vehicles by the stage of operation. This is entirely analogous to the stages of a rocket, where first one stage operates and then another and another. It also has input items for describing phases of operation. Within each phase, the user specifies the stage that is operating, the current constraints on the operation of the vehicle, the initial and final conditions of the phase, the bounds on the problem, and the control parameters--such as steering angles and engine throttle parameters. See the diagram for a notional representation of the phases and stages.



Typical trajectory optimization problem. (Note: C_N, coefficient of normal force; α, angle of attack; C_{Do}, coefficient of base drag; m, mach number; T_1, T_2, temperature during phases 1 and 2; Q, dynamic pressure during phase 2; t_1, t_2, initial and final phase times; X'*; state vector dynamics; E_x, phase times in seconds.)*

Long description of figure. Diagram showing simple graphs of phase-1 temperature versus mach number, coefficient of normal force divided by angle of attack, coefficient of base drag versus mach number, phase-2 temperature divided by dynamic pressure during phase 2 versus mach number; and a diagram of phase times.

The Boeing Company wrote the first versions of OTIS for the U.S. Air Force in 1985. Since then, NASA has taken ownership of OTIS and has systematically improved and updated it. OTIS is written in Fortran 77 and uses the SNOPT nonlinear programming package. The OTIS program is restricted to users within the United States who are working for the Federal Government, its entities, contractors, and subcontractors. Eligible users can obtain OTIS from NASA Glenn's Technology Transfer and Partnership Office by following the links at http://otis.grc.nasa.gov/request.shtml.

Find out more about this research
OTIS at http://otis.grc.nasa.gov/
Space Propulsion and Mission Analysis Office at Glenn at http://trajectory.grc.nasa.gov/

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