Preliminary Sizing Completed for Single-Stage-To-Orbit Launch Vehicles Powered By Rocket-Based Combined Cycle Technology

Single-stage-to-orbit (SSTO) propulsion remains an elusive goal for launch vehicles. The physics of the problem is leading developers to a search for higher propulsion performance than is available with all-rocket power. Rocket-based combined cycle (RBCC) technology provides additional propulsion performance that may enable SSTO flight.

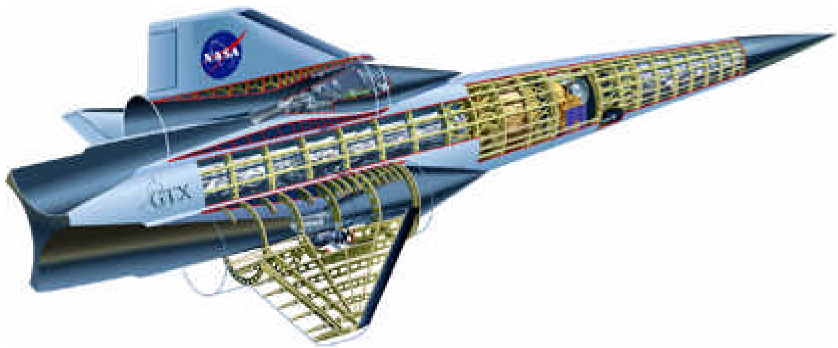
Structural efficiency is also a major driving force in enabling SSTO flight. Increases in performance with RBCC propulsion are offset with the added size of the propulsion system. Geometrical considerations must be exploited to minimize the weight.

Integration of the propulsion system with the vehicle must be carefully planned such that aeroperformance is not degraded and the air-breathing performance is enhanced. Consequently, the vehicle's structural architecture becomes one with the propulsion system architecture. Geometrical considerations applied to the integrated vehicle lead to low drag and high structural and volumetric efficiency.

Sizing of the SSTO launch vehicle (GTX) is itself an elusive task. The weight of the vehicle depends strongly on the propellant required to meet the mission requirements. Changes in propellant requirements result in changes in the size of the vehicle, which in turn, affect the weight of the vehicle and change the propellant requirements. An iterative approach is necessary to size the vehicle to meet the flight requirements.

GTXSizer was developed to do exactly this. The governing geometry was built into a spreadsheet model along with scaling relationships. The scaling laws attempt to maintain structural integrity as the vehicle size is changed. Key aerodynamic relationships are maintained as the vehicle size is changed. The closed weight and center of gravity are displayed graphically on a plot of the synthesized vehicle. In addition, comprehensive tabular data of the subsystem weights and centers of gravity are generated.

The model has been verified for accuracy with finite element analysis. The final trajectory was rerun using OTIS (Boeing Corporation's trajectory optimization software package), and the sizing output was incorporated into a solid model of the vehicle using PRO/Engineer computer-aided design software (Parametric Technology Corporation, Waltham, MA).



GTX reference vehicle.
Artist's conception of the GTX reference vehicle, a highly streamlined aerodynamic vehicle resembling a hybrid of a supersonic jet airplane and a rocket. Also shown as part of the figure is a cutaway view of the "airframe" with stringers, rigs, and longerons.

Glenn contact: Joseph M. Roche, 216-433-2575, Joseph.M.Roche@grc.nasa.gov
Author: Joseph M. Roche
Headquarters program office: OAT
Programs/Projects: Gen Three, hypersonics