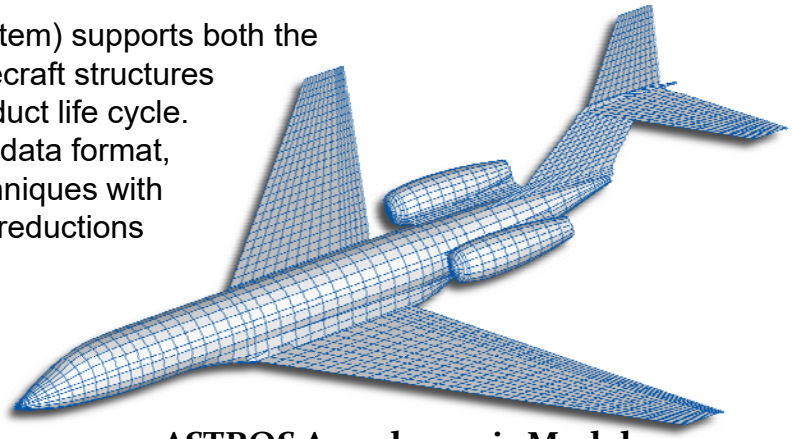
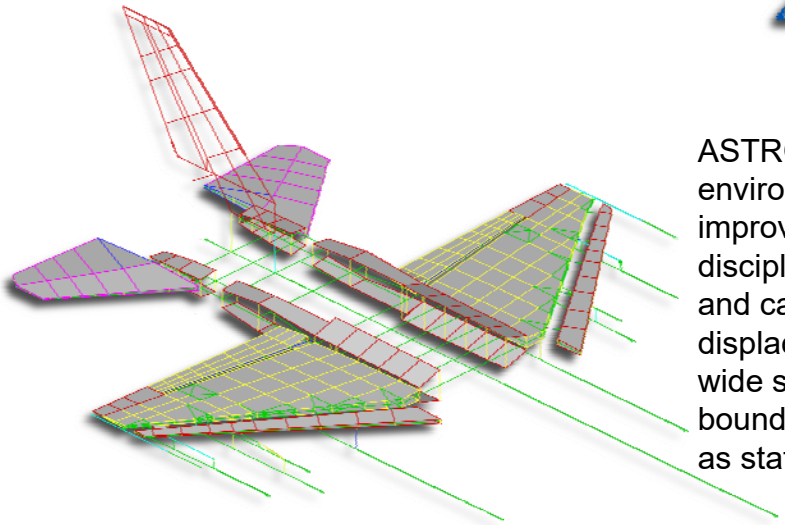
ASTROS

A Next Generation Aircraft Design System

ASTROS (Automated STRuctural Optimization System) supports both the preliminary design stages of new aircraft and spacecraft structures and design modifications that occur later in the product life cycle. ASTROS, based on the world-standard NASTRAN data format, combines finite element modeling and analysis techniques with efficient optimization solutions to deliver significant reductions in the time required to develop superior designs of aerospace structures.



ASTROS Aerodynamic Model

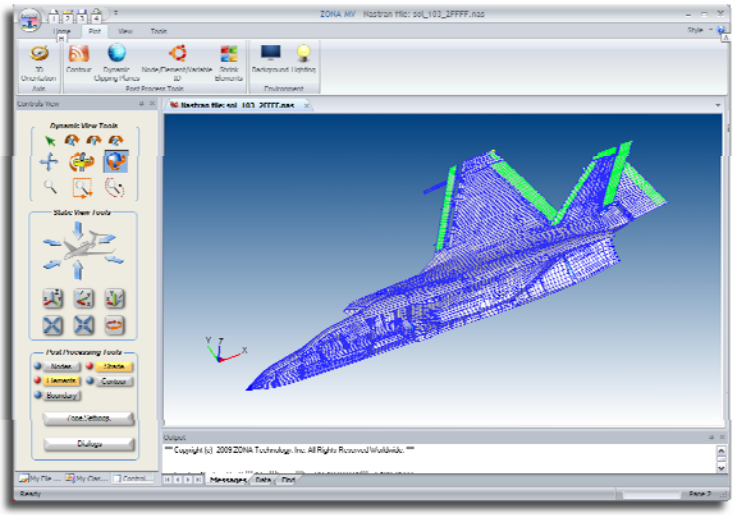


ASTROS Structural Model

ASTROS offers a single multidisciplinary automated environment to help reduce the time required to develop improved designs. ASTROS integrates all of the engineering disciplines that impact the preliminary structural design phase and can simultaneously design to strength, flutter, displacement, and other requirements. ASTROS considers a wide scope of conditions in a design task and treats multiple boundary conditions, each permitting a range of analysis such as statics, modes, and flutter.

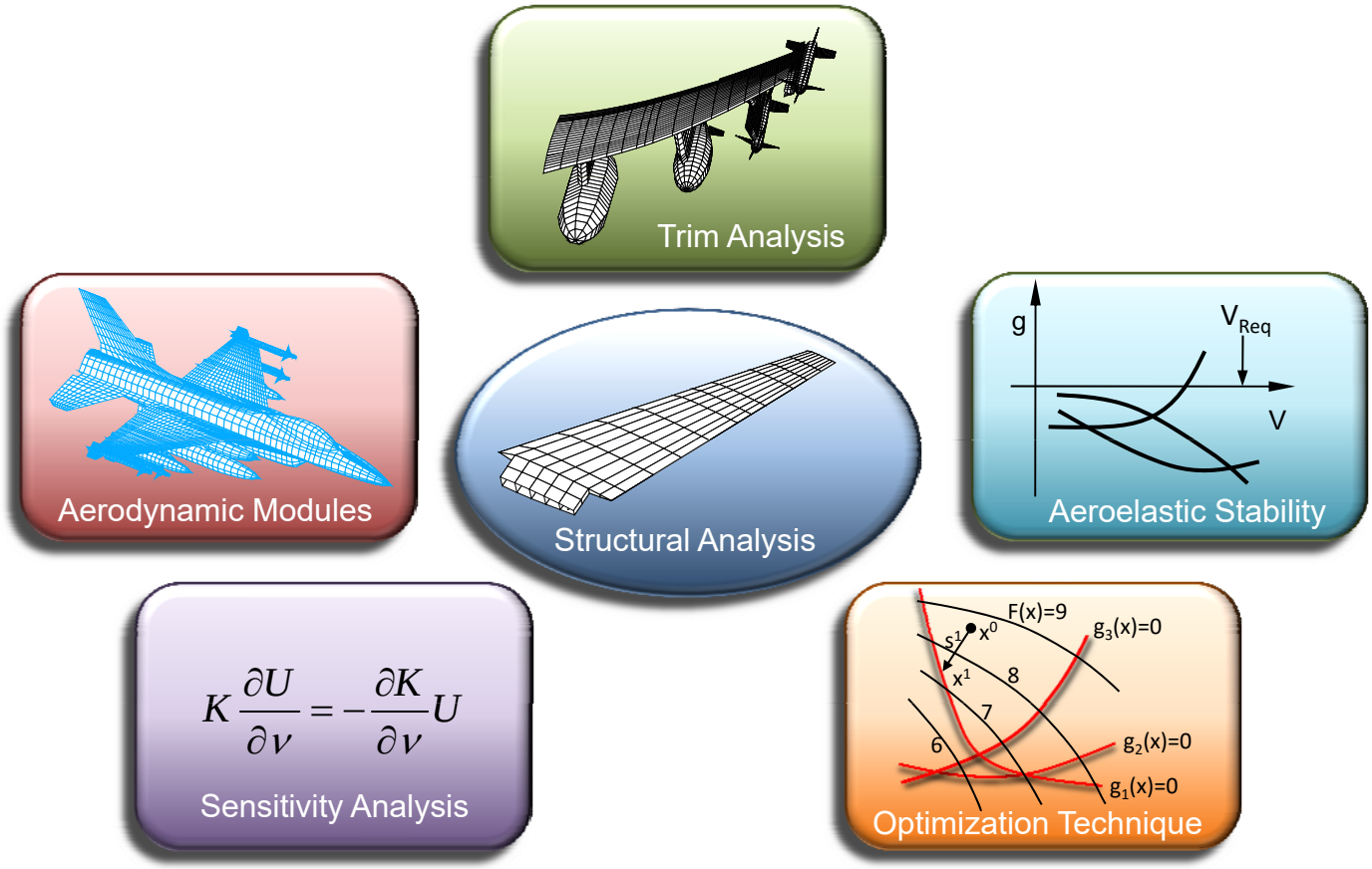
The ASTROS multidisciplinary design environment includes complimentary engineering analysis technologies from a comprehensive range of disciplines including:

- Structural Analysis
- Aerodynamic Loads
- Aeroelastic Stability
- Control System Interaction
- Multidisciplinary Design Optimization
- Sensitivity Analysis
- Engineering Data Management



ASTROS Post-Processor

ZONA TECHNOLOGY



ASTROS MDO Environment

LARGE MODELS, MULTIPLE CONSTRAINTS

With ASTROS there are no limits on problem size. ASTROS efficiently optimizes very large models with many constraints. The ability to simultaneously consider many constraints from each of several disciplines allows designers to develop non-intuitive solutions to the complex design problems resulting from conflicting multidisciplinary constraints placed on modern aerospace structures.

With the widespread use of composite materials, ASTROS' multidisciplinary optimization is becoming increasingly important in helping designers realize the benefits of customizing composite materials to provide acceptable strength and stiffness at minimal weight. ASTROS allows designers to balance the conflicting requirements of structural strength and stiffness while exploiting the benefits of anisotropic factors such as aeroelastic tailoring.

ASTROS simultaneously considers a range of flight conditions and disciplines, offering a significant improvement over systems that either consider these conditions sequentially or limit the disciplines they provide. The ASTROS unified environment improves communication among design team members, bringing better focus to their design tasks and greater insight into the entire design process.

OPEN ARCHITECTURE

Many engineering organizations have developed specialized software for particular design and engineering requirements. As they move forward, these organizations need to leverage their proprietary tools, integrating them with new commercial programs. ASTROS provides an open architecture to help users extend the system to cope with new design criteria and leverage their investments in software development.

For organizations that are continually improving their structural design and engineering process with improved integration and software tools, the ASTROS open architecture adds value, allowing them to add new data types, write new functions in either FORTRAN or C and access the ASTROS database with their specialized software.

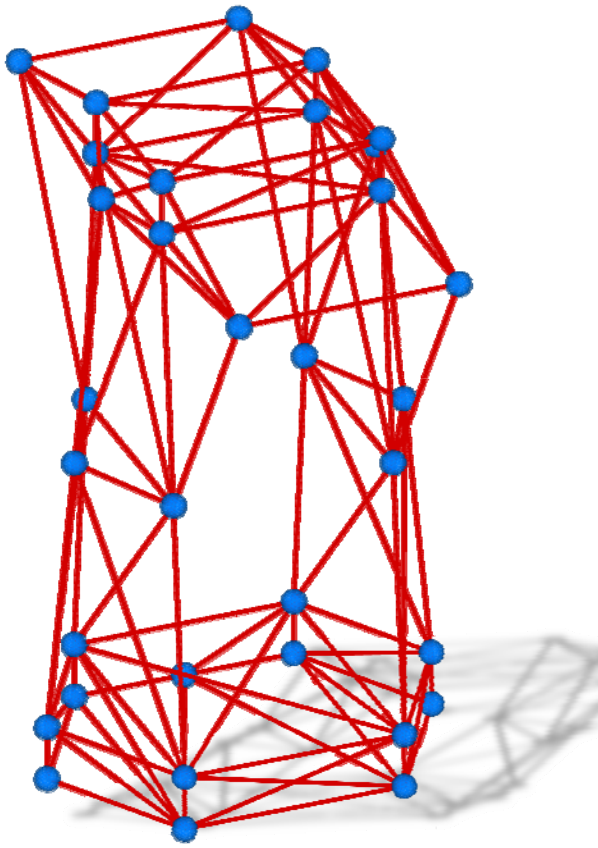
STRUCTURAL ANALYSIS

The core module of ASTROS is finite element-based structural analysis. This module determines structural response to applied mechanical, gravitational, aerodynamic loads. Response quantities include:

- Stresses
- Strains
- Displacements
- Strain Energies
- Natural Frequencies
- Mode Shapes

The structural analysis module incorporates commonly used finite elements such as rods, beams, membrane and bending plates, rigid, and solid elements. Plate and shell elements also support full composites material modeling.

ASTROS takes advantage of recent developments in sparse matrix solution technology to accelerate the analysis of very large problems. For determining eigenvalues of very large systems, ASTROS supports the Lanczos procedure which is fully integrated with sparse matrix technology for outstanding performance.



Space Structure Model - ACOSS

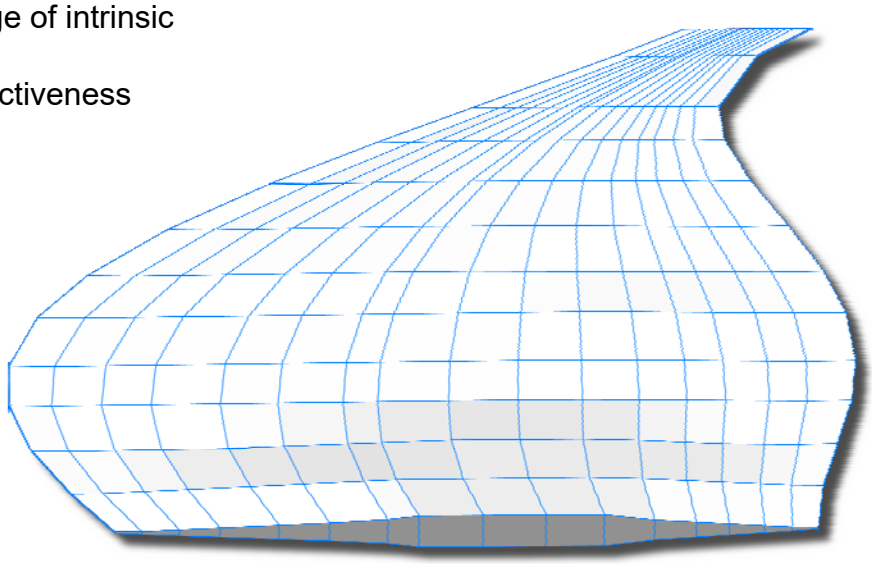
DESIGN OPTIMIZATION

ASTROS performs both design and analysis using mathematical optimization techniques to find the lightest weight design that meets given design criteria.

ASTROS employs the well-known Automated Design Synthesis (ADS) procedure and- optimality criteria methods to carry out the optimization once the problem is properly posed for efficient solution.

ASTROS provides a comprehensive range of intrinsic constraint functions including:

- Aeroelastic Lift and Control Effectiveness
- Panel and Beam Buckling
- Fiber/Transverse Strain
- Laminate Composition
- Tsai-Wu Stress Criteria
- Von-Mises Stress
- Stability Derivatives
- Deflection
- Principal Strain
- Flutter



AIM9-X ASTROS Structural Model

Using ASTROS, designers satisfy constraints while designing elements individually in groups or by using easily defined shape functions. ASTROS employs design variable linking to reduce the number of design variables and keep the design from specifying structural sizes that are unrealistic from a manufacturing standpoint.

In addition to intrinsic constraints, ASTROS allows users to easily define constraints based on any of 27 ASTROS response types that can be combined freely across multiple subcases and analysis disciplines. The ability to easily define user functions also serves as a powerful prototyping tool for developing new constraint formulations, such as for sine-wave spar buckling.

SENSITIVITY ANALYSIS

ASTROS calculates derivatives for the response functions - called sensitivity analysis - to drive the redesign of a structure. Sensitivity analysis is based on analytic derivatives. Both direct and adjoint variable methods are employed, as appropriate, to achieved the most efficient computations.

ASTROS has been streamlined to compute all invariant matrices once and store them for efficient access as needed.

AIR LOADS ANALYSIS

An advanced high order panel method based on proven procedures simulates the aerodynamic loads for all flight regimes. Using advanced aerodynamic modeling capabilities, ASTROS provides an efficient alternative to CFD and wind tunnel-based loads data.

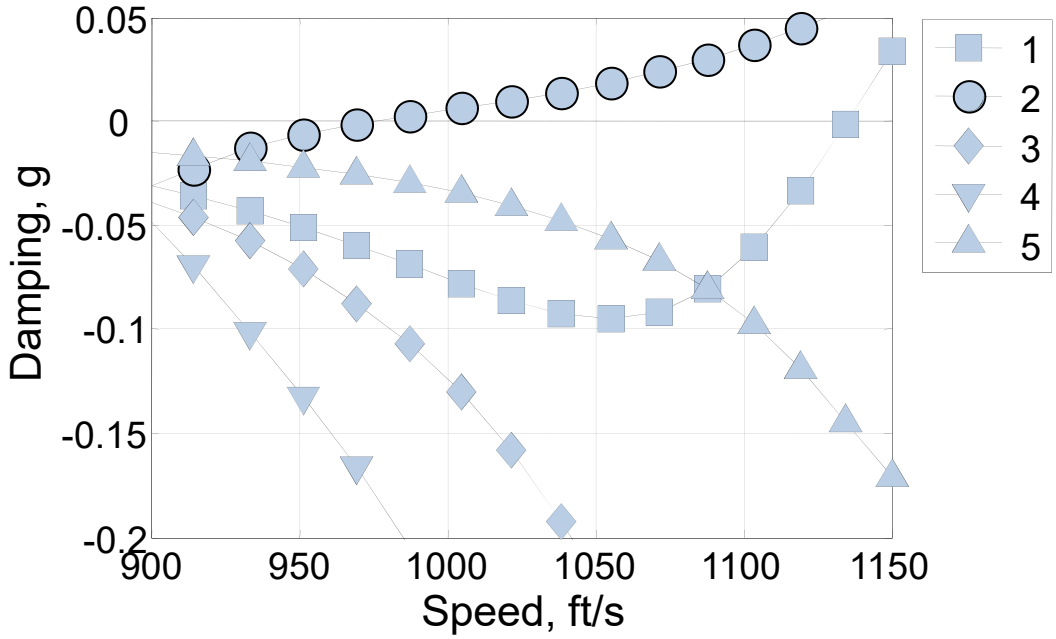
Advanced spline techniques couple aerodynamic loads to the structure. For defined flight environments ASTROS performs a trim analysis by imposing an unrestrained boundary condition that models an aircraft in steady flight. Invariant aerodynamic unit load vectors are applied to the structure and inertial effects are included to determine the control surface and angle of attack values that permit steady flight at prescribed flight conditions. The stresses or strains that result from this trimmed condition can be included in the design task along with displacement limits. ASTROS assesses wing divergence speed and control surface effectiveness.

UNSTEADY AERODYNAMIC AND AEROELASTIC ANALYSIS

Aircraft designers must ensure that their aircraft do not encounter flutter within the flight envelope. Flutter, a dynamic instability, occurs when structural stiffness and inertial properties couple unfavorably with unsteady aerodynamic forces.

Using ASTROS, designers calculate the unsteady aerodynamic forces and perform flutter analysis. Subsonic aerodynamics are calculated by the ZONA6 method. The ZONA7 method is used for supersonic regimes. A flutter analysis is performed using these aerodynamic forces and the structural properties obtained from the finite element model.

ASTROS provides a g-method flutter solver which performs intelligent internal root tracking to deliver convergence behavior that is superior to that of older solutions based on Muller's or standard PK methods. The outstanding convergence facilities provide reliability and better results options than earlier solutions. In addition to providing damping curves for a given set of velocities, ASTROS identifies and saves the flutter crossings in relational form in the database. Damping and frequency curve data also are available in relational form. Designers can define the input velocities in either true or equivalent speed units. ASTROS allows users to identify and filter out non-critical, lightly damped modes in the crossing summary.



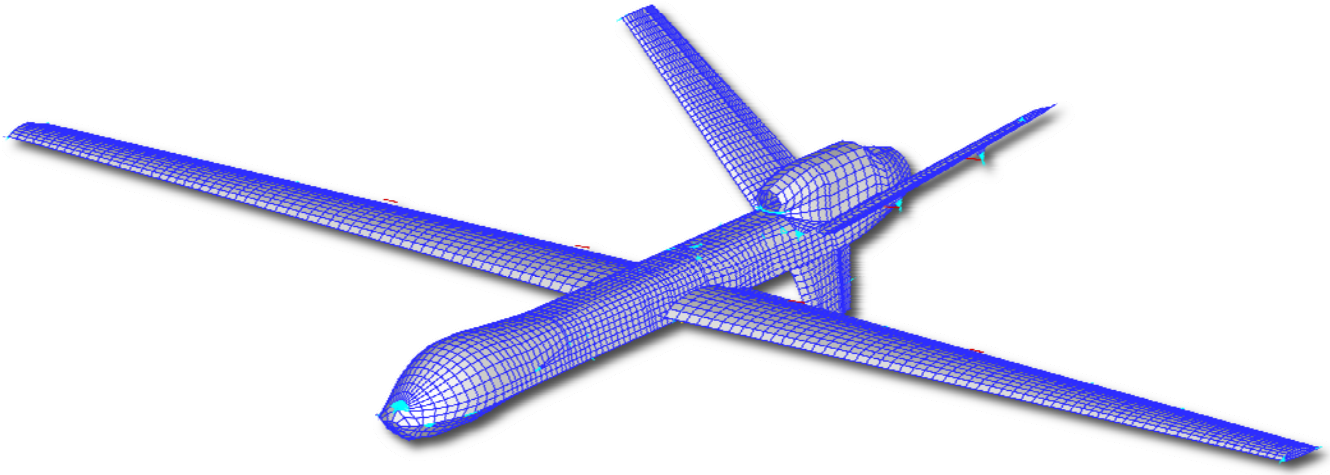
Flutter Analysis Result (V-g plot)

ZONA TECHNOLOGY

LOAD CONTROL AND TRIM OPTIMIZATION

To address complex air vehicle requirements, ASTROS provides a nonlinear trim solver to trim control configured vehicles with redundant control surface configurations.

The ASTROS optimization process provides trim solutions based on a specific set of constraints on structural loads or control surface hinge moments. In ASTROS structural loads are based on integrated shears, torques and bending moments, not on individual element stresses or forces. Users can define the reference axes about which ASTROS integrates the internal loads.



Predator ASTROS Structural Model