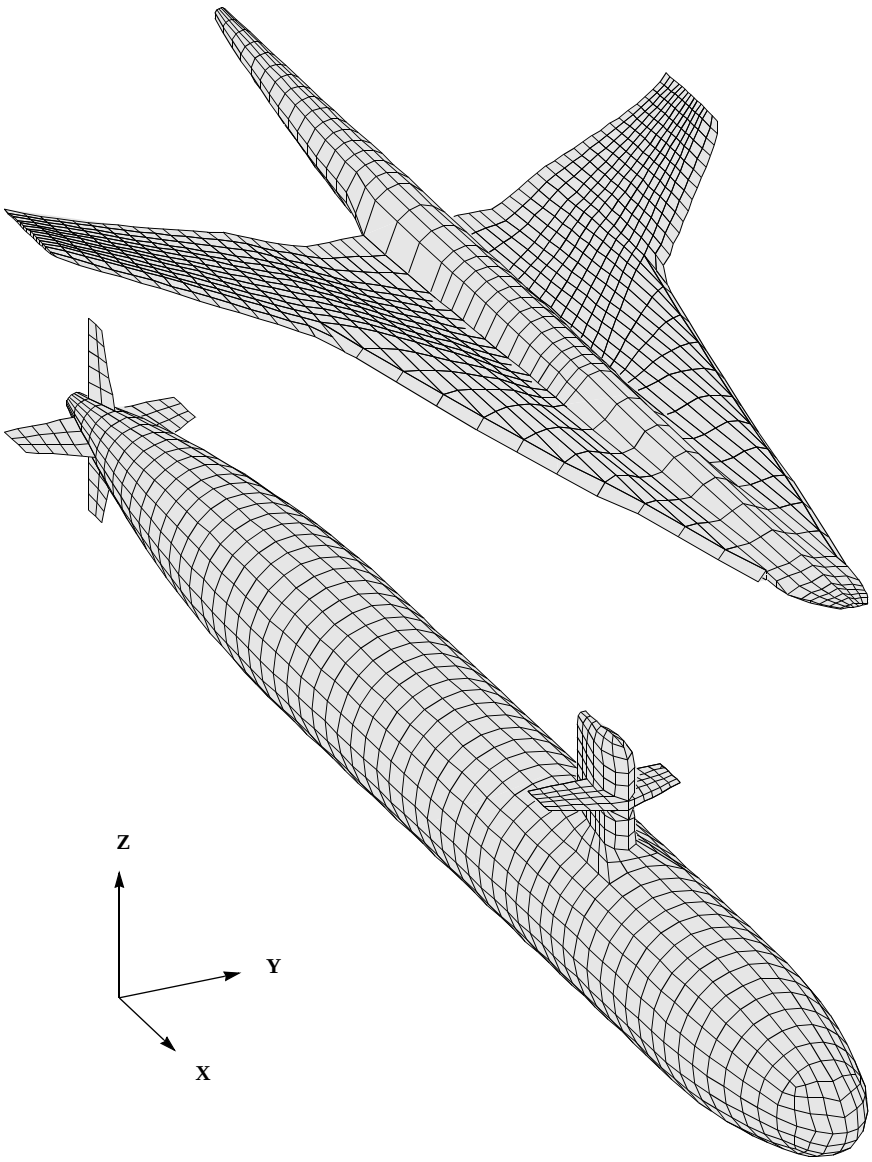
S T A G S

*ST*ructural *A*nalysis of *G*eneral *S*hells



Lockheed-Martin Advanced Technology Center

ANALYSIS OPTIONS

- **static**
  - geometrically linear or nonlinear
  - linear elasticity or plasticity
- **buckling**
  - bifurcation based upon either a linear or a nonlinear stress state
- **branch on bifurcation**
  - from a primary solution path to a secondary solution path
- **vibration**
  - based upon either a linear or a nonlinear stress state
- **transient**
  - geometrically linear or nonlinear
  - linear elasticity or plasticity

SOLUTION STRATEGIES

- **load/displacement control**
- **Riks arc-length technique**
  - traversal of limit points into post-buckling regimes
- **equivalence transformation**
  - switch from the primary solution path to a secondary solution path
- **restart**
  - from any previous solution
  - switch analysis option; e.g., from static to transient
  - change loads, boundary conditions

BOUNDARY CONDITIONS

- **standard B.C. types**
  - simple, (anti)symmetry, fixed, etc.
- **specified displacements**
- **displacement constraints**
  - SPC—single-point constraints
  - MPC—multi-point constraints; linear and nonlinear
  - Lagrange constraints—linear equations
- **initial conditions**
  - initial displ./velocity for transient analysis

ELEMENTS

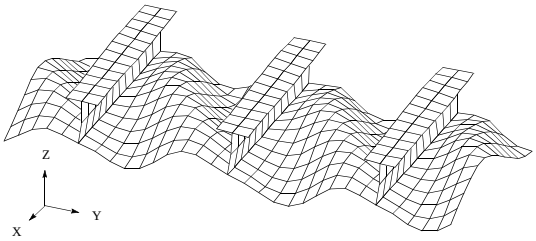
- **shells**
  - 3-node thin triangle
  - 4-node thin quadrilateral
  - 9-node thick quadrilateral
  - transition elements for mesh refinement
- **beams**
  - 2-node Timoshenko beam
- **nonlinear spring**
  - general, velocity-dependent, force-displacement behavior
- **special elements**
  - hyperelastic fastener element
  - moving-plane boundary
- **contact elements**
  - general point/surface contact
  - surface/surface pad contact
- **solid elements**

FABRICATION

- **shell walls**
  - laminate composite
  - corrugation-stiffened
  - general—stiffness matrix
  - smeared stiffeners
- **beam cross sections**
  - cross-section properties
  - sub-element properties
  - rectangular sub-elements
  - general—stiffness matrix
- **materials**
  - linear elastic
  - elastic/plastic with strain hardening
  - orthotropic properties
  - power-law creep

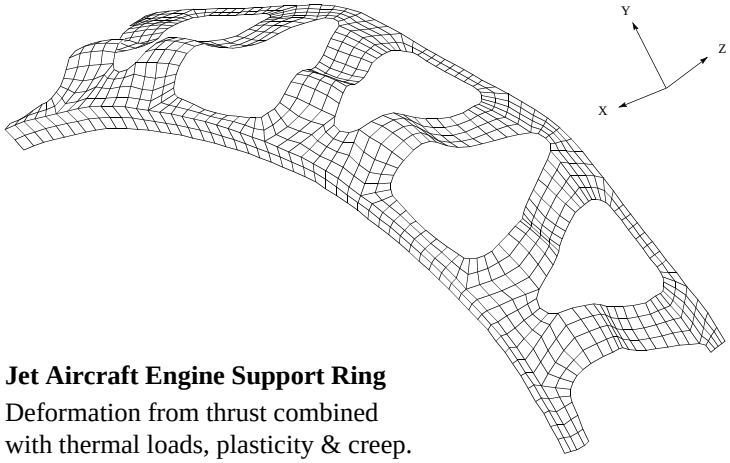
LOADS

- **mechanical loads**
  - point loads, line loads, surface traction
  - ‘live’ pressure—remains normal to the deformed surface
- **thermal loads**
  - arbitrary temperature distribution throughout structure



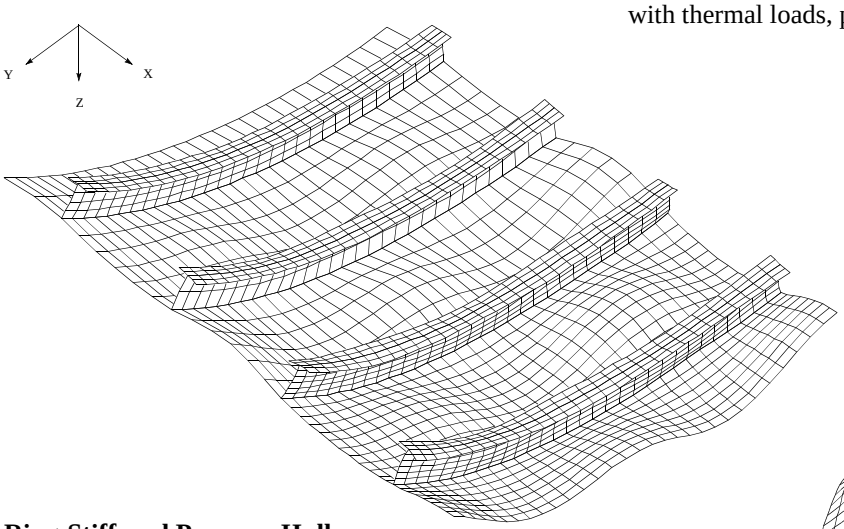
Tee-Stiffened Panel

Highly-stressed, post-buckled shape
produced by normal pressure and shear.



Jet Aircraft Engine Support Ring

Deformation from thrust combined
with thermal loads, plasticity & creep.

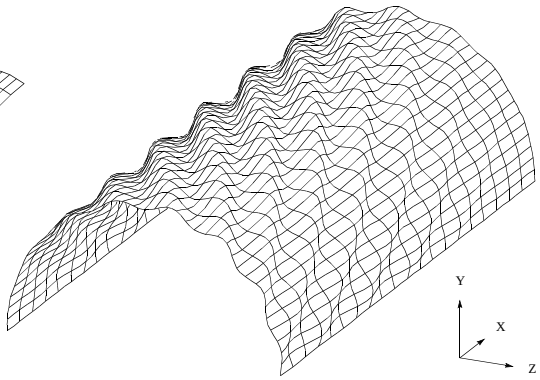


Ring-Stiffened Pressure Hull

Plastic collapse of imperfect cylinder.

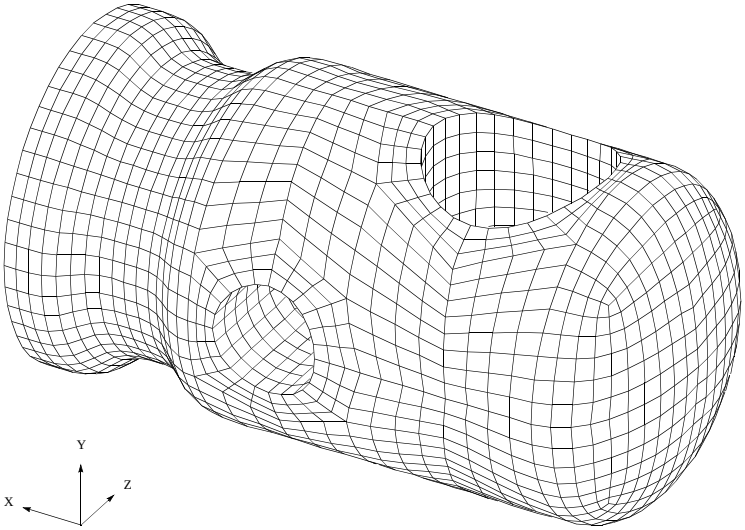
Composite Cylinder

Buckling of asymmetrical fabrication.



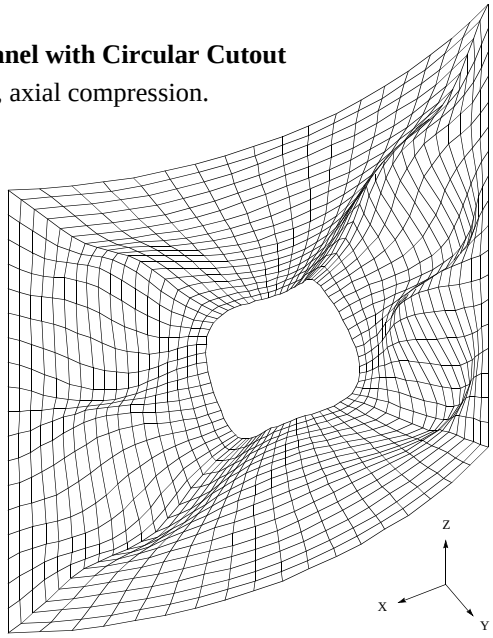
Complex Titanium Pressure Vessel

Intersecting cylinders, ellipsoidal end cap,
toroidal radius reduction.



Cylindrical Panel with Circular Cutout

Buckled shape, axial compression.



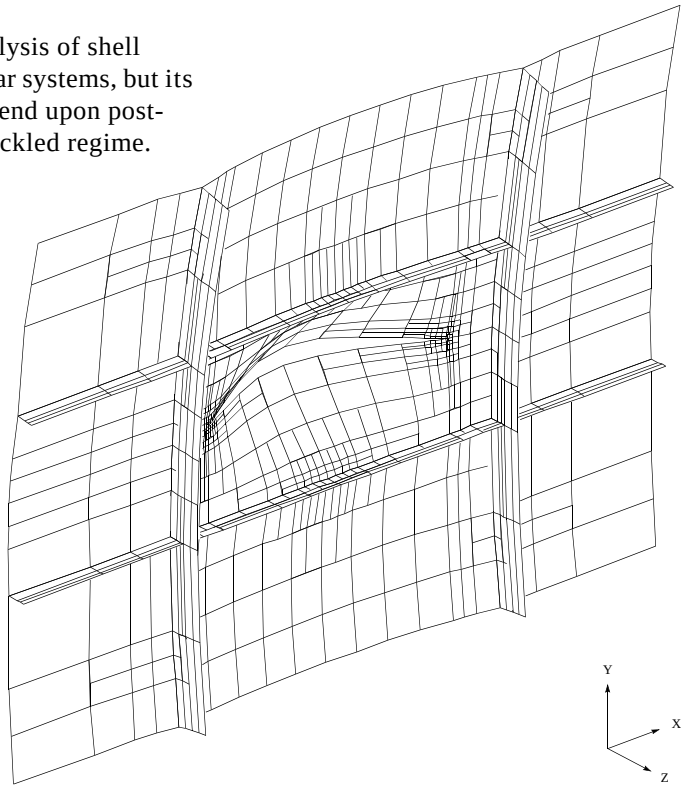
MODEL GENERATION & RESULTS PRESENTATION

- **shell units**
  - substructures defined using a large catalog of quadric surfaces
  - automatic generation, discretization, and assembly of substructures
  - complex models built with minimal user input
- **element units**
  - arbitrary assemblages of nodes and elements
  - most useful for inputting model data from a preprocessor
- ***STAPL***
  - ***ST****AGS* ***PLotting program***—post-processer for generating model plots and
  - plots showing displacement, stress and other results obtained by **STAGS**
- ***STAR***
  - ***ST****AGS* ***A****ccess* ***R****outines*—high-level read/write database access
  - facilitates user-development of translators
- **PATRAN**
  - forward & backward PATRAN translators (utilizing *STAR*) included

STAGS is a finite element program for general-purpose analysis of shell structures. *STAGS* can be applied efficiently to routine linear systems, but its forte is the analysis of complex, nonlinear systems that depend upon post-buckling strength and require analysis well into the post-buckled regime. *STAGS* is routinely used for pre- and post-test verification of complex systems — especially those that are sensitive to initial geometric imperfections, which can be defined in *STAGS* with ease and flexibility.

STAGS has been under continuous development since the 1960's by Lockheed's Research and Development Division and Lockheed-Martin's Advanced Technology Center, whose goals have always been to achieve the best shell-stability code available anywhere.

STAGS has a world-wide distribution and is used extensively throughout government, industry and academia. Current *STAGS* research topics include crack-growth simulation and adaptive mesh refinement, illustrated in the pressurizedaircraft fuselage model shown at the right.



MACHINES

UNIX Workstations	Sun
	DEC
	SGI
	IBM
	HP
Supercomputer	CRAY
PC, Macintosh—under development	

INFORMATION & ORDERS

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