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Information Summary

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Aerospace Careers: Structural Analysis Routines (STARS)

A group of engineers calling themselves the STARS team is an integral part of the aeronautical design, engineering and test process at NASA's Dryden Flight Research Center. STARS is the acronym for Structural Analysis Routines.

The STARS team takes conceptual designs for aircraft components — and entire aircraft — submitted by other engineering sections at Dryden and turns them into preliminary finite element models on a super computer. Then, it is the team's job to carefully analyze and test the models on the computer for structural soundness, efficiency and safety. Team findings are then presented to the originating engineers where the preliminary design is modified, if necessary, and the next steps in the review and approval process are carried out.

The most important job of the STARS team is to ensure that aircraft components are designed and developed safely.

What is STARS?

The STARS computer program is multidisciplinary software capable of evaluating a wide variety of engineering uncertainties and problems. STARS can identify and correct problems in structural analysis, heat transfer, computational fluid dynamics (CFD), aeroelasticity, aeroservoelasticity, flight controls and propulsion.

STARS is a finite element-based program that analyzes a reduced mathematical equivalent of an object. The object is broken down mathematically in the computer into several elements of different shapes. The more elements that make up the model, the more accurate it becomes. The STARS team, presented with the object divided into the several elements, can determine how much an object deforms under a specified load or test environment. Using the STARS program, the team can perform computer simulations on a variety of models undergoing analysis and tests, either in flight or on the ground.

The Work of the STARS Engineers

Flight safety is the most critical issue in NASA's flight research program and one of the key tasks of the STARS team is to determine if an aircraft, or a component, is flight ready. The component is subjected to close analysis and a variety of tests by the STARS program before a report is developed for the designing engineers.

The STARS tests include a look at all aeronautical and structural engineering issues related to the component to assure that it meets all flight safety standards.

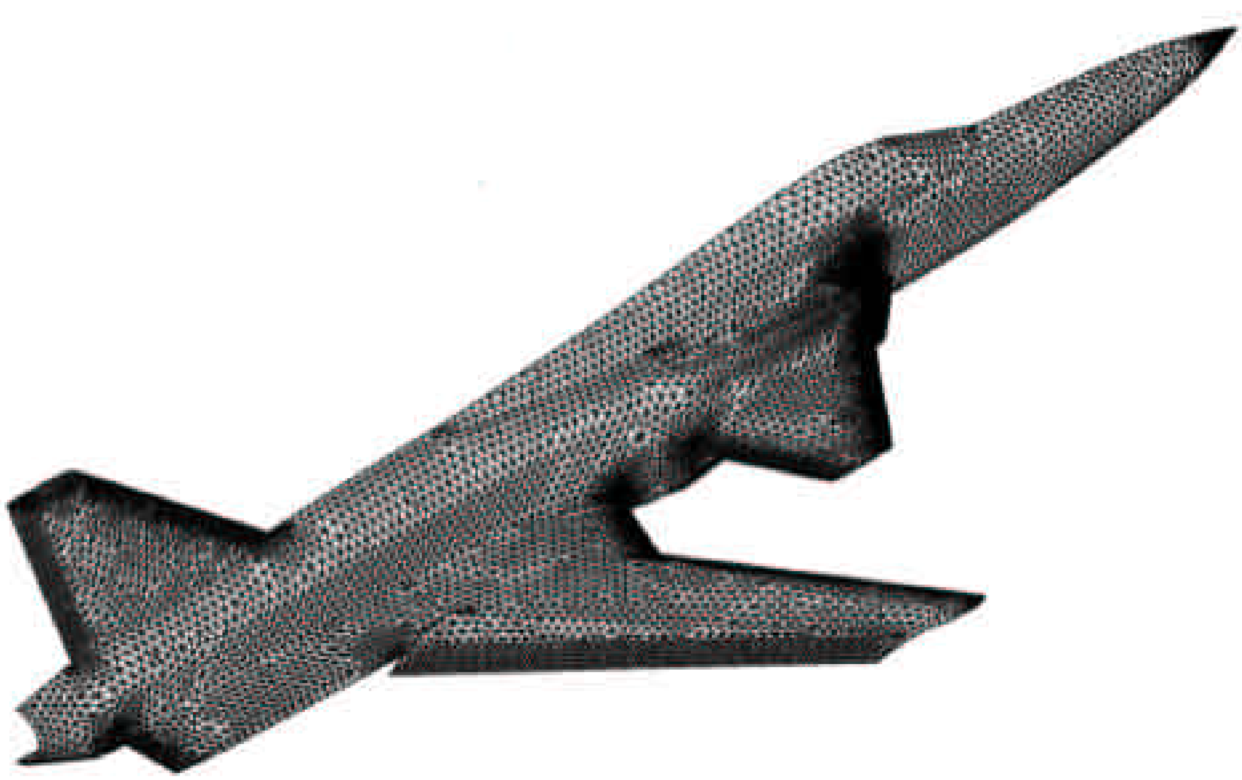
After the STARS team evaluates and tests the design model with its software program, the concept then must pass a battery of Dryden review and safety boards. Then, when approved, it is constructed and undergoes actual component testing in one or more of the Dryden test and evaluation laboratories for structural integrity and safety. During the testing process, if unexpected deficiencies or problems occur the STARS team goes back to its original design study to solve the problem. Suggested modifications are incorporated into the aircraft structure and the test process resumes until the component is deemed safe and flight ready.

The STARS computer simulations offer an indication of the flight conditions in which the research or test aircraft may become unstable and unsafe. An aircraft is considered unstable when any flight surface starts to vibrate uncontrollably — a condition known as flutter.

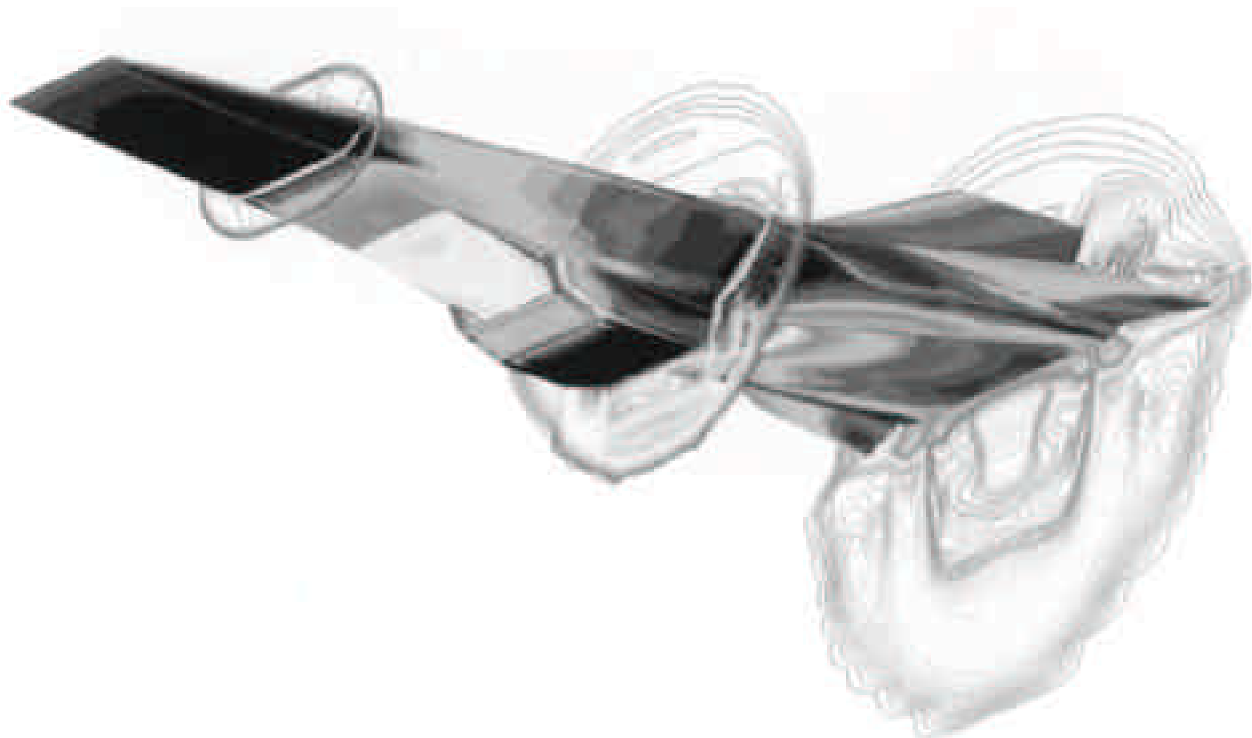
Flutter is a constant safety concern not only at Dryden but throughout the flight test community. It is caused by the flow of air across the surface of the structure — a combination of aerodynamic and structural elastic forces that result in a vibration. If the frequency of this vibration is near the resonant frequency of the component, breakage can occur within seconds and compromise the safety of the flight crew and the aircraft.

The STARS program can perform flutter analysis that allows the engineering team to see at what speed and at what altitude the aircraft will be flying when flutter occurs. The STARS program can also reveal at what frequency the airfoil is vibrating when flutter begins. These data are then used by project engineers to program the aircraft's flight control computers to prevent it from flying within the flutter environment.

One of the major projects of the STARS team is the future testing of flutter data that have been produced by the computer program itself. These tests will be conducted on an aeroelastic test wing constructed of composite materials.



The computational fluid dynamics unstructured surface grid of the X-29A.



This computational fluid dynamic image of the X-43A vehicle at the Mach 7 test condition with the engine operating. The image illustrates surface heat transfer on the vehicle and flow-field contours.

This scaled instrumented test wing will be attached to the Dryden F-15B Flight Test Fixture and, during flight, will be subjected to destructive flutter behavior that will be recorded on sensors. The data will be analyzed to validate the accuracy of the STARS computer program.

The STARS team also conducts CFD analysis to determine the aerodynamic load distribution on an aircraft or a flight surface. This is done by mathematically modeling the behavior of air around its surface. By studying the CFD models, the STARS team can determine, analytically and graphically, the distribution of the aerodynamic load and associated behavior of the air.

The CFD graphics also produce the density, velocity and direction of the air flowing over an aircraft, and when appropriate, display the behavior of a supersonic shock wave if the model has exceeded the speed of sound.

The use of CFD modeling with the STARS program is a less expensive way of studying aerodynamic phenomena than conventional prototype testing in wind and water tunnels. STARS has become a fast, convenient way for engineers today to study complicated aircraft structures.

The People and the Projects

Several projects on which the STARS team is working could have very significant impacts on the future of aeronautics and space flight.

Work by the STARS team is part of the research effort going into the Hyper-X multi-year hypersonic (five times the speed of sound) program, which will investigate supersonic jet (scramjet) engine technology at speeds up to 7,200 mph. Hyper-X is a 12 foot-long vehicle, designated X-43A, that will be mounted on the nose of a commercially developed Pegasus® booster rocket. The Pegasus® vehicle will be airlaunched from the wing pylon of NASA's B-52 carrier aircraft. At an altitude of about 100,000 feet, X-43A will separate from

Pegasus® for the scramjet engine tests. The STARS team is responsible for validating the initial design and engineering models of the Hyper-X vehicles. The team is also responsible for providing structural dynamics analysis of the B-52 wing pylon with the attached Pegasus®/Hyper-X vehicle to ensure a safe configuration. STARS work also includes a complete CFD analysis of the Hyper-X vehicle.

The Active Aeroelastic Wing project at Dryden will investigate the use of wing warping for roll control as a way of increasing aircraft performance and fuel efficiency. The concept will be tested on the modified wings of a NASA F-18, and the STARS team will provide structural analysis, including predictions of aerodynamic forces that will be incorporated into the flight control system.

The modified F-18 wing will be more flexible than before. New actuators will power the leading and trailing edge flaps to twist the wings for roll control. The original concept for wing warping was used by the Wright Brothers on their 1903 Wright Flyer, the first piloted aircraft to achieve controlled powered flight.

The STARS team has also studied NASA's X-33 design. The X-33 is a demonstrator for Reusable Launch Vehicle (RLV) technologies and could lead to the development of a successor to the space shuttle vehicles. STARS engineers are performing non-linear CFD-based stability and control research on the X-33 design.

Education and Experience

Members of the STARS team have a mixture of engineering disciplines and experience. Each has an undergraduate degree in aerospace or mechanical engineering, and the team is well represented by postgraduate degrees in engineering or computer science. Before their selection to the STARS team, members worked at other aeronautical engineering positions at Dryden.

Individuals interested in a NASA career involving computer simulation, computational fluid dynamics, structural analysis, and other forms of aerodynamic modeling should have a bachelor of science degree in aerospace, aeronautical or mechanical engineering. Studies should include, but not be limited to, aerodynamics, fluid mechanics, structure analysis, solid mechanics, mathematics, physics, computer science and finite element modeling.

All major aerospace companies have simulation departments where engineers are involved in computer analysis similar to STARS. Within the federal government, similar simulation engineering positions can be found in the Federal Aviation Administration and also in the flight test branches of the U.S. armed forces.

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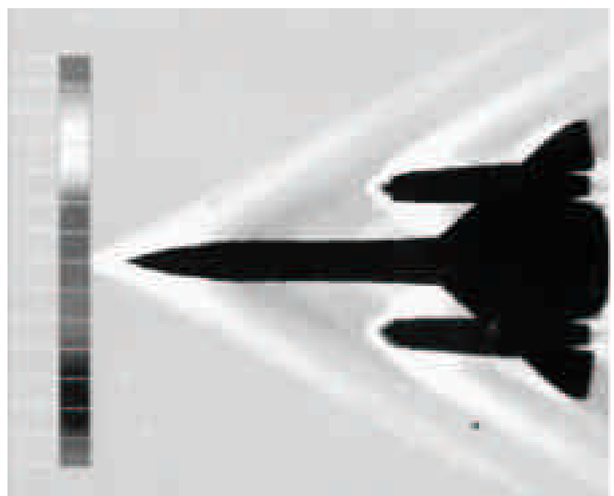

STARS simulation highlighting bow and nosecone shockwaves, and shockwave propagation of the SR-71 flying at Mach 2.1 at an altitude of 70,000 feet.