Aircraft Static Stability Analysis using STARS

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ABSTRACT

Static stability and pressure coefficients of an aircraft will be determined computationally using STARS. A computational model of an aircraft will be created. Stability and pressure data will be plotted with reference to angle of attack and sideslip angle.

PROJECT DESCRIPTION

Computational methods will be used to determine the stability and pressure coefficients of an aircraft. The STARS fluid dynamics solver will be used. A computational model of the aircraft will be developed.

The design of aircraft requires the knowledge of stability and pressure due to the aircraft's geometry. Traditionally, stability analysis is performed by the superposition of simplified wing, fuselage and tail contributions to stability. This superposition method ignores the higher order contributions as well as interactions between aircraft surfaces. By using computational modeling, the stability and pressures coefficients of the total aircraft are found. This method is capable of determining the coefficients to within the precision allowed by the geometry definitions and fluid assumptions.

The STARS (STructural Analysis RoutineS) fluid dynamics solver is to be used. STARS is a 3D finite element solver developed by NASA that uses Euler's fluid equation. Euler's equation makes the solution valid for inviscid flow with variable density.

A computational model of the aircraft usable by STARS will be developed. The basis of the model will be the OSU Flight Factory's aircraft from the spring of 2000. Simplifications in the geometry are expected to keep the STARS geometry definitions relatively simple.

To assist in future use, the model will be made as geometrically changeable as possible. This will allows quick changes in geometry to be made which should assist in future optimizations. This will also allow investigations into surface interactions to be easily performed. It is hoped that the model will be capable of calculations otherwise relegated to wind tunnels.

PROJECT OBJECTIVES

The objective is to use an inviscid finite element fluid dynamics solver, STARS, to obtain static stability and aerodynamic coefficients for a model airplane. Pressure coefficients along the aircraft surface will be found. Stability coefficients in the longitudinal and lateral axes are to be determined from the aircraft's surface pressures.

Pressure along the aircraft's surface is output from STARS. The pressure coefficients for the entire aircraft surface will be plotted. Pressure will be integrated to determine the

static stability coefficients.

Aircraft stability coefficients for lift, drag and moment will be found. Changing the angle of attack of the computational model allows for the coefficients to plotted. The moments C_L, C_D and C_m will be plotted with respect to the angle of attack, α.

In the lateral axis, roll and yaw moments are to be determined. The model will be subjected to a sideslip angle which will result in the roll and yaw moments. The resulting moments C_l and C_n will be plotted with respect to the sideslip angle, β.

VALIDATION

The computational results will be validated with theoretical and experimental data. For the stability coefficients, a built-up method from linearized theory of stability will be used. Estimates of the wing using finite wing theory will be used to verify the computational data. Experimental data from wind tunnel tests of the airfoil used will be used to verify the computational output.

TIME SCHEDULE

Activity	*Time*	*Date*
Start of Project	-	Nov 17
Measure previous aircraft	1 hr	Nov 17
Create fuselage	5 hrs	Nov 17-18
Airfoil generator and rotator	5 hrs	Nov 19
Empennage	8 hrs	Nov 20-22
Wing	8 hrs	Nov 22-27
Computational Runs	30 hrs	Nov 22-Dec 01
Report/Presentation Due	-	Dec 12