DEVELOPMENT OF FLIGHT TESTING TECHNIQUES

FINAL REPORT

Principal Investigator

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Introduction

This is the final report for Grant #NCC 4-1, a graduate student program entitled Flight Analysis and Development sponsored by NASA/Ames and the Dryden Flight Research Facility. The grant was initiated October 1, 1979, and was terminated October 31, 1984. Several students worked at NASA and took classes at Cal Poly and were supported by this grant. The principal investigator was Dr. Doral R. Sandlin, a professor in the Aeronautical Engineering Department at Cal Poly.

List of Students and Abstracts

The following is a list of students, the title of their research project and abstracts of thesis reports.

(1) Dale Turley

LONGITUDINAL STABILITY AND CONTROL DERIVATIVES OBTAINED FROM FLIGHT DATA OF A PA-30 AIRCRAFT

This report presents the longitudinal stability and control derivatives obtained from flight data of a PA-30 aircraft by using a maximum likelihood estimator technique. Derivatives were obtained at zero flap conditions and to show flap and thrust effects. These derivatives are compared with previously obtained flight derivatives and wind tunnel estimates. The new flight estimates are

shown to be in much better agreement with the wind tunnel stability and control derivative estimates than those of the previous flight estimates. The moments of inertia (I_x, I_y, I_z) of the aircraft were determined for use in the derivative estimation analysis using the swing oscillation method.

(2) Randall Peterson

AERODYNAMIC DRAG REDUCTION TESTS ON A BOX-SHAPED VEHICLE

Coast-down tests have been performed on a box-shaped ground vehicle used to simulate the aerodynamic drag of high volume transports such as delivery vans, motor homes and trucks. The results of these tests define the reduction in aerodynamic drag that can be obtained by the addition of either a full boattail or a truncated boattail to an otherwise blunt-based vehicle.

Test velocities ranged up to 96.6 km/h (60mph) with Reynolds numbers to 1.3×10^7. The full boattail provided an average 32-percent reduction in drag at "highway speeds" whereas the truncated boattail provided an average 31 percent reduction in drag as compared to the configuration having the blunt base. These results are compared with one-tenth scale wind-tunnel model data.

(3) Dan Morrow

A MICROPROCESSOR BASED ANTI-ALIASING FILTER FOR A PCM SYSTEM

This project thesis describes the design and evaluation of a microprocessor based digital filter. The filter was designed to investigate the feasibility of a digital replacement for the analog pre-sampling filters used in telemetry systems at the NASA Dryden Flight Research Facility (DFRF). The digital filter will utilized an Intel 2920 Digital Signal Processor (PSF) chip. Testing includes measurements of (a) the filter frequency response and (b) the filter signal resolution. The evaluation of the digital filter was made on the basis of circuit size, projected environmental stability and filter resolution. The 2920 based digital filter was found to meet or exceed the pre-sampling filter specifications for limited signal resolution applications.

(4) Kevin Penning

FLUTTER PREDICTION OF A WING WITH ACTIVE AILERON CONTROL

A method of analyzing the vibrational stability of aircraft with active aileron flutter suppression systems is explained. A computer program was written using this analysis. A comparison between predictions and flight test data for the DAST ARW-1 flight test vehicle is shown. Results show the method presented closely predicts frequency and damping for aircraft with flutter

suppression systems.

(5) J. Blair Johnson

COMPARISON OF THEORETICAL AND FLIGHT-MEASURED LOCAL FLOW AERODYNAMICS FOR A LOW-ASPECT-RATIO FIN

Flight test and theoretical aerodynamic data were obtained for a flight text fixture mounted on the underside of an F-104G aircraft. The theoretical data were generated using two codes, a two-dimensional transonic code called Code H, and a three-dimensional subsonic and supersonic code called wing-body. Pressure distributions generated by the codes for the flight test fixture as well as boundary layer displacement thickness generated by the two-dimensional code were compared to the flight test data. The two-dimensional code pressure distributions compared well except at the minimum pressure point and the trailing edge. Shock locations compared well except at high transonic speeds. The three-dimensional code pressure distributions compared well except at the trailing edge of the flight test fixture. The two-dimensional code does not predict displacement thickness of the flight test fixture well.

(6) Ronald J. Ray

IN-FLIGHT THRUST DETERMINATION ON A REAL-TIME BASIS

A real-time computer program was implemented on a F-15 jet fighter to monitor in-flight engine performance of a

Digital Electronic Engine Controlled (DEEC) F-100 engine.

This thesis describes the application of two gas generator methods to calculate in-flight thrust real-time at the NASA/Dryden Flight Research Facility. A comparison was made between the actual results and those predicted by an engine model simulation. The percent difference between the two methods was compared to the predicted uncertainty based on instrumentation and model uncertainty and agreed closely with the results found during altitude facility testing. Data was obtained from acceleration runs of various altitudes at maximum power settings with and without afterburner.

Real-time in-flight thrust measurement was a advancement to flight test productivity and was accomplished with no loss in accuracy over previous post flight methods.

(7) Albion Bowers

A COMPARISON OF COMPUTER-GENERATED LIFT AND DRAG POLARS FOR A WORTMANN AIRFOIL TO FLIGHT AND WIND TUNNEL RESULTS

Computations of drag polars for a low-speed Wortmann sailplane airfoil are compared to both wind tunnel and flight results. Excellent correlation is shown to exist between computations and flight results except when separated flow regimes were encountered. Wind tunnel transition locations are shown to agree with computed

predictions. Smoothness of the input coordinates to the PROFILE airfoil analysis computer program was found to be essential to obtain accurate comparisons of drag polars or transition location to either the flight or wind tunnel results.

(8) Faramarz A. Mahdavi

DEEP STALL FLIGHT TESTING OF THE NASA SGS 1-36

Twenty successful, manned flight tests of the modified NASA SGS 1-36 Sailplane were conducted at angles-of-attack between -5 and 75 degrees. The aircraft exhibited good longitudinal and lateral-directional handling qualities in the normal flight regime and deep stall angles-of-attack range of 35 to 55 degrees. At angles-of-attack greater than 55 degrees, the vehicle displayed an unstable, apparent Dutch-roll oscillation, as well as lateral stick forces. The oscillations, and lateral stick forces appear to be a function of angle-of-attack. As the angle-of-attack increased above 55 degrees, so did the magnitude of the oscillations and the stick forces.

A complete set of flight determined aerodynamic stability and control derivatives was obtained using the Modified Maximum Likelihood Estimation program. The derivatives obtained from flight were compared to those obtained from the quarter scale wind tunnel model tests and the pre-

dicted rotary derivatives. Generally, the flight determined static derivatives compared well with the wind tunnel predicted data at low angles-of-attack, but at high angles-of-attack the correlation was not good. The dynamic derivatives obtained from flight did not compare well with those of the predicted in the deep stall region. The pitch, roll, and yaw control surface effectiveness, and the primary damping derivatives approached zero as the angle-of-attack was increased to 75 degrees. S-Plane root locus analysis of one of the flights at 65 degrees angle-of-attack indicated a stable, coupled, oscillatory roll-spiral mode as well as an unstable Dutch-roll mode. The flight determined lateral directional oscillation frequency for this flight was equal to the Dutch-roll frequency obtained from the root-locus analysis.

Final Comments

Copies of the final reports of each of the students are included.