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6. AUTHOR(S)
Capt. Christian Elenbaum (USAF)
Larry Harjes
Joshua T. Hu
John Lang
Brian Martinez

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Air Force Flight Test Center
418th Flight Test Squadron
300 North Wolfe Ave.
Edwards AFB, CA 93524-6001

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14. ABSTRACT
This article presents the accomplishments of the flight testing of C-130H air and ground minimum control speeds (Vmca/Vmcg). Testing was requested by Air Mobility Command and the C-130 System Program Office (SPO). Testing was conducted in accordance with test plan AFFTC-03—39, *C-130H GROUND- AND AIR-MINIMUM CONTROL SPEED AND AIRCRAFT AERODYNAMIC MODELING DETERMINATION TESTING*, on C-130H aircraft, USAF serial number 96-7322, from 12 January to 9 April 2004 and was comprised of 11 ground tests, 30 flights, and 71 flight test hours. The responsible test organization was the 412th Test Wing of the Air Force Flight Test Center, Edwards AFB, California. The test execution organization was the Global Reach Combined Test Force, Edwards AFB. The overall test objective was to determine the ground and air minimum control speeds for the C-130H aircraft. Test objective was met ahead of schedule using innovative fight testing techniques.

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Flight Testing of C-130H Velocity Minimum Control Airspeed/Groundspeed (Vmca/Vmcg)

Article Contributors:
Captain Christian Elenbaum (USAF), Larry Harjes, Joshua T. Hu, John Lang, and Brian Martinez

Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the United States Air Force.

Edwards AFB, California--The 418th Flight Test Squadron out of Edwards Air Force Base recently completed flight tests for the C-130 minimum control speed project. The Vmca/Vmcg combined test team accomplished an extremely aggressive test plan, test execution, and test reporting cycle by quickly responding to a short notice request from Air Mobility Command and the C-130 System Program Office (SPO) to investigate the engine-out performance of the C-130H Hercules aircraft. The team authored an affordable test plan, led the modification and instrumentation efforts of the test aircraft, conducted the test, and submitted the report, all under cost and ahead of schedule. It logged in a total of 11 ground tests, 30 flights, and 71 flight test hours within 60 days.

The Vmca /Vmcg test team addressed the technical hurdles of this test program by developing a number of novel test techniques and approaches to the overall execution. Due to minimum altitude restrictions and ambient air temperatures, the maximum one-engine-out thrust asymmetry achievable in flight was 8,000 pounds. In order to extrapolate to a higher thrust asymmetry of 10,000 pounds, the test team employed an innovative test technique that augmented thrust asymmetry by using engine number three. Additional thrust from engine number three was equated to the number four engine by the ratio of their distances from the aircraft centerlines, which were 196 and 400 inches, respectively.

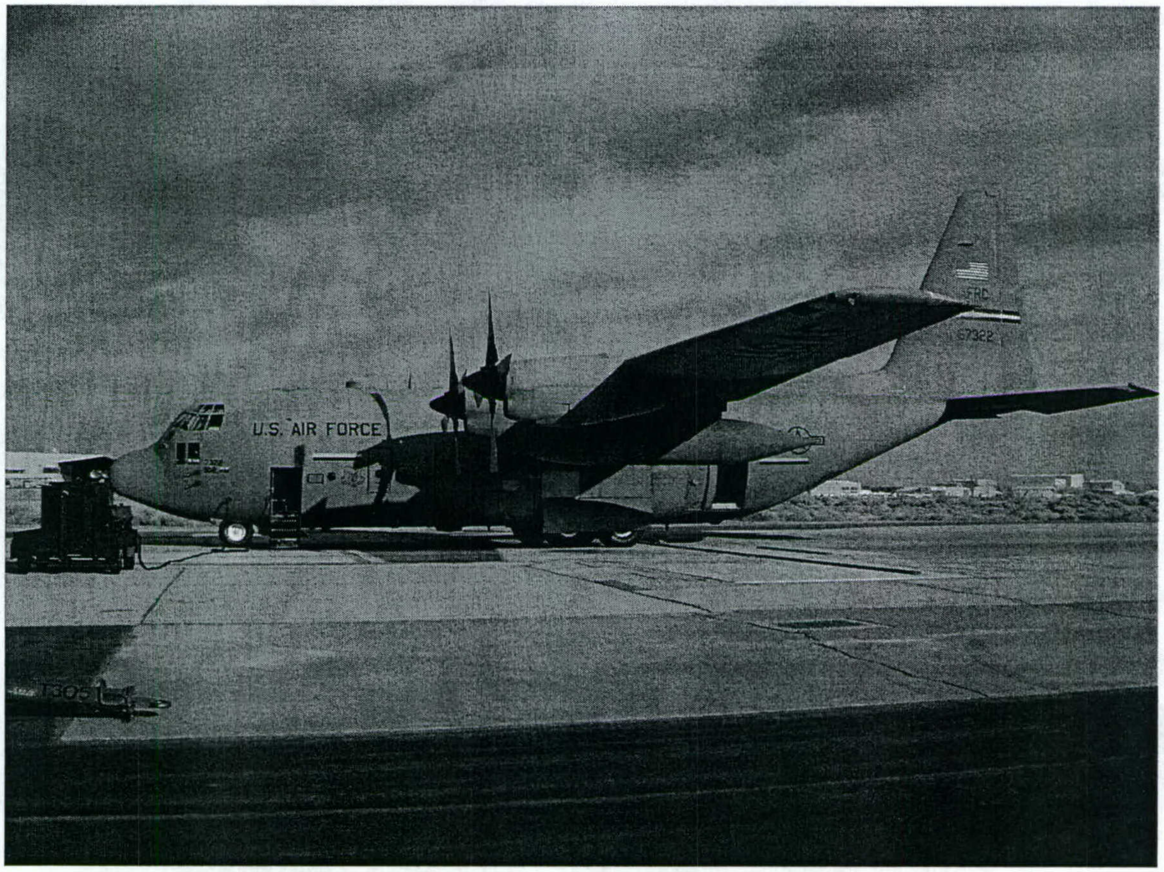
In order to successfully achieve the execution schedule and reduce the probability of test point rework, the team developed procedures to determine the validity of a test point real-time, through the use of a laptop computer. Flight test data were downloaded and immediately processed on the aircraft for assurance of test point validity. The team was able to quickly determine whether the data followed predictable trend behavior for Vmc speed characteristics and subsequently proceeded to the next test condition(s). This approach effectively circumvented the traditional approach bottleneck of testing followed by lengthy data reduction and analysis on the ground. It also allowed for a safe and confident build-up progression to new test points without the associated burden of accumulating and then repeating invalid test points. As a means of reducing the time and risk associated with final data analysis for reporting, the test team also updated the Air Force Flight Test Center (AFFTC) data analysis software for use on this C-130 program.

A three-engine simulation of two-engine-out Vmca was designed to reduce the risks of performing Vmca testing at low altitudes with two-engines shut down on the same wing. The test team used trim points to create a model of feathered and wind milling engine drag and established equivalent power-on torque settings. The technique was successfully validated by performing actual two-engine-out test points. The new techniques lowered the test risk level from medium to low and avoided the extensive risks associated with two-engine out operations. These techniques also produced 100% first pass data collection of the low-altitude, high thrust asymmetry test points.

A new test technique was developed using inboard engines set at power for level flight. Traditional Vmca test points were performed with all remaining engines set for full power. This required a very dynamic climbing test point to collect data at a specific speed and altitude, and often resulted in low precision test points. Specially designed tests validated that level flight conditions, at altitudes that resulted in the desired thrust asymmetry, produced the same results. All subsequent Vmca test points were performed using the level flight technique and resulted in a 98% first pass success rate, saving over 8 hours of flight test. Major Clifton Janney (USAF), project test pilot, confirmed, "I felt the innovative test technique used was instrumental in the quick completion of the flight tests and produced higher quality data than previous tests."

As a direct result of this test effort, the test team improved safety and lowered risk for operational C-130 aircrews deployed throughout the world. The team demonstrated that nosewheel steering was effective in reducing Vmcg speeds but required the pilot to closely monitor the tiller at rotation speed. Modifying takeoff procedures to account for nosewheel steering in takeoff planning could reduce Vmcg below the critical engine failure speed according to a balanced critical field length for dry hard surfaced runways. The team also concluded that if an engine failure occurred prior to reaching rotation speed, continuing takeoff was a safer course of action than aborting while still on the runway.

The data obtained by the team proved that minimum control speeds can be reduced. The test team demonstrated that Vmca with one engine inoperative and Vmcg using aero controls were both lower than those charted in the current USAF flight manuals. The C-130 SPO and Lockheed will use the flight test data to update the USAF flight manuals and the C-130 SPO will provide the data to all DoD C-130 operators. As a direct result of this test effort, USAF C-130 aircrews will be able to operate into and out of short, austere airfields with larger payloads. This capability translates into a sizeable increase in cargo hauling capability, consisting of both manpower and materiel. Virtually no airfield anywhere in the world today is off limits to a C-130, the workhorse of the United States Military's tactical airlift fleet. When asked about the test team's accomplishments, Major Janney replied, "It is a real figure of merit for the type of engineering that goes on at Edwards AFB." As for the flight test results, he said, "I am very excited about the increased capabilities for the C-130 operators out in the field."



C-130H taking a break from thrust stand run at Edwards AFB.

Another shot of C-130H on the static thrust stand at Edwards AFB.

Front view of C-130H on the static thrust stand at Edwards AFB.

Early morning picture of C-130H on the static thrust stand at Edwards AFB.