TO: Associate Director

FROM: Technical Assistant, Group 3

SUBJECT: C-5A Aerodynamic Conference at Marietta, Georgia, December 13 to 15, 1966


Dr. Richard T. Whitcomb, Mr. A. Gerald Rainey, Mr. John W. Paulson, and the writer attended the subject conference in response to the invitation in reference. The meeting began with a tour of the C-5A mock-up, the master production models, and the low-speed wind tunnel which is under construction. Following the tour, presentations were made by Lockheed personnel on the development of the C-5A cruise configuration, the history of the cruise performance, the development of the take-off and landing configurations, the history of the take-off and landing performance, the flying qualities, the flutter characteristics, and the past and future wind-tunnel programs. Information presented at the meeting on most of these subjects, as well as the agenda and attendees, is contained in the enclosure.

In brief, a variety of configuration changes has resulted in an aerodynamic design which is expected to achieve the target values of high-speed drag. These changes included rework of the fuselage nose, fuselage aft end, and landing gear pods. The design of the air inlets and exits for the air conditioning system is a current problem and Dr. Whitcomb was concerned that the exit design presently being considered would produce an excessive drag increment.

In regard to the take-off and landing configurations, the originally proposed double slotted, simple hinged, trailing edge flaps has given way to single slotted, Fowler trailing edge flaps. This change was made after considerable study involving many designs which included triple slotted flaps. The main reasons for the change was higher L/D important in the take-off distance, less weight, and greater reliability.

The Krueger leading edge flaps, proposed in early designs, has been replaced by 1½ percent chord, full span, leading edge slats. The slat is sealed inboard and forms a slot only on the outboard sections to provide better flow over the ailerons. The main reasons for this change was higher L/D, more wing volume for fuel, and less complexity.
Lateral control at all speeds is by ailerons and spoilers. The spoilers will eliminate the aileron reversal tendency which was a problem on the C-141. Deflection of the spoilers allows air to flow from the bottom of the wing over the top of the ailerons; this feature reduces the aileron hinge moments. A vortex generator is installed on each flap. Oil flow pictures showed poor flow on the ailerons and Dr. Whitcomb strongly recommended that vortex generators be tried there too.

The take-off and the landing distances appear to be 200 or 300 feet longer than the guaranteed values of 7,500 and 4,000 feet, respectively. In an effort to shorten the landing distance, Lockheed proposed automatic actuation of the thrust reversers at touchdown, rather than manual operation which usually occurs about 3 seconds after touchdown. The Air Force attendees did not support the proposal.

It was apparent throughout the presentations that the similarity of the C-5A configuration to that of the C-141 has simplified the C-5A development. However, two significant differences are the 15 percent lower thrust-weight ratio and 20 percent greater wing loading for the C-5A.

Much of the flying qualities information has been obtained from a simulator at North American in Los Angeles. The simulator includes both visual and motion cues. The results illustrated the need for a great deal of automatic stabilization.

In the presentation on flutter it was revealed that an effort is being made to analyze the fan engine for propeller whirl flutter, since the enormous fan comprises in a sense a ducted propeller. Mr. Rainey's branch has applicable work under way and arrangements for transfer of information was made.

Flutter considerations increased the nacelle pylon thickness from about 16 inches to 27 inches and added 307 pounds to the wing structure between the pylons. However, Mr. Leon Tolve said the C-5A airplane required less weight of material, in percent of gross weight, to be added to increase stiffness than did the C-141. He attributed this circumstance primarily to the contour flying required for the C-5A which results in increased strength for the more severe maneuver and gust loads which will be encountered and to the 15 percent flutter margin permitted for the C-5A as contrasted to the 20 percent margin required for the FAA certificated C-141. In a separate discussion Mr. Rainey and the writer discussed the gust loads design procedure with Mr. Tolve and his coworkers.

Mr. Robert Ormsby told the writer he considered the greatest concerns for the airplane at the present time to be weight control (possibly 5,000 to 10,000 pounds overweight at this time), scheduling (however,
the guaranteed roll out in February 1968 and first flight in June 1968 still appear possible if the present schedule can be maintained), landing and take-off distances (very difficult to meet the guaranteed distances), and cruise drag uncertainties (although not any more so than for any other airplane). He also said that about 9,000 pounds of titanium would be used in the airplane. Weight savings still occur for greater usage of titanium, at least up to 60,000 pounds; however, cost effectiveness peaks at about 9,000 pounds. He said much of the titanium is being used in screw fasteners where the increased strength of titanium permits greater preload and, consequently, greater fatigue life.

Messrs. Frank Wilson and J. Cahill discussed with Dr. Whitcomb, Mr. Verlon Reed of Ames, and the writer Lockheed's considerations on the necessity for a subsonic-transonic wind tunnel with a greater Reynolds number capability than any now operating. Difficulties have been encountered in predicting wing pressure distributions at cruise conditions for both the C-141 and C-5A. The problem has involved the shock location as influenced by the boundary layer. Lockheed considers that a high Reynolds number facility is urgently needed for this problem as well as others on the horizon. They would like to see NASA build such a facility. Dr. Whitcomb and the writer had some reservations on the urgent need for the facility. Mr. Cahill will visit Langley on January 12, 1967, to discuss the matter further.

Mr. Wilson volunteered to have one of his men come to Langley, perhaps in February, to make a presentation for the information of the Langley staff. The presentation would be based on Lockheed experience and would be a discussion of the aerodynamic and other compromises required in the design of a modern transport. The writer said Langley would have great interest in such a presentation.

Robert W. Boswinkle, Jr.

Robert W. Boswinkle, Jr.