NATURAL LAMINAR FLOW APPLICATION TO TRANSPORT AIRCRAFT

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by

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A major goal of NASA during the last 15 years has been the development of laminar flow technology for aircraft drag reduction. Of equal importance is achieving a state of readiness that will allow the successful application of this technology by industry to large, long-range aircraft. This effort gained impetus at a time when large fuel price increases and the foreseeable scarcity of petroleum products put great economic pressure on the aircraft industry and the airlines to reduce aircraft fuel consumption. Although the original focus was on subsonic aircraft, possible application to supersonic transports is now being emphasized.

Recent progress in achieving extensive laminar flow with limited suction on the Boeing 757 has raised the prospects for practical application of the hybrid laminar flow control (HLFC) concept to subsonic aircraft. Also, better understanding of phenomena affecting laminar flow stability and response to disturbances has encouraged consideration of natural laminar flow (NLF), obtained without suction or active mechanical means, for application to transport aircraft larger than previously thought feasible.

These ideas have inspired the current NASA/ASEE project with goals as follows:

1. Explore the feasibility of extensive NLF for aircraft at high Reynolds number under realistic flight conditions.
2. Determine the potential applications of NLF technology and the conditions under which they may be achieved.
3. Identify existing aircraft that could be adapted to carry out flight experiments to validate NLF technology application.

To achieve these objectives, the current study has focused on understanding the physical limits to natural laminar flow and possible ways to extend these limits. The primary factors involved are unit Reynolds number, Mach number, wing sweep, thickness and lift coefficient as well as surface pressure gradients and curvature. Based on previous and ongoing studies using laminar boundary layer stability theory, the interplay of the above factors and the corresponding transition limits have been postulated in the form shown in Figure 1.

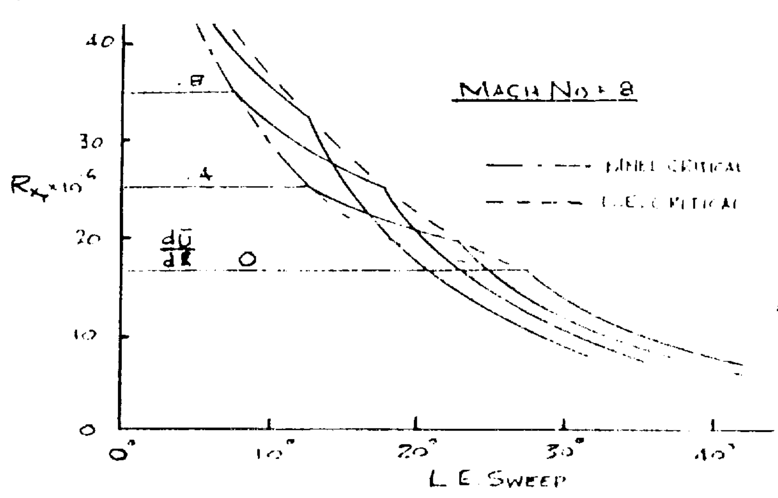

FIG. 2 TRANSITION CRITERIA FOR NLF

These relationships can be used as a provisional basis for identifying potential transport aircraft applications as well as to guide further theoretical studies to firmly establish NLF transition criteria. Using the above approach, several representative transport aircraft configurations have been identified as shown in Fig. 2. A comparison of lift-to-drag ratios for these types with values for comparable turbulent aircraft shows that the benefits of NLF, while diminishing with aircraft size, can still be significant for aircraft as large as the Boeing 747.

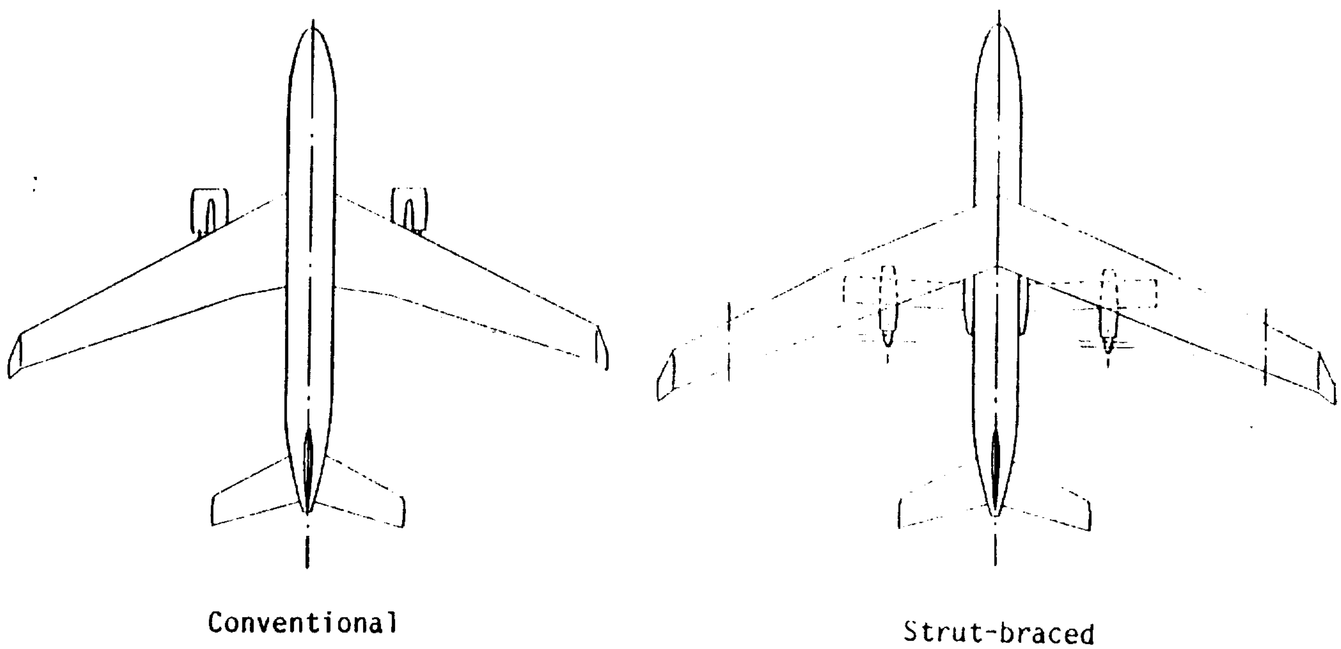

FIG. 2 NLF CONFIGURATIONS

Based on the encouraging results of the current study, a vigorous effort to expand the NLF transition limits so as to broaden the range of potential applications is recommended. Ultimately, a flight validation phase will be required to provide full-scale data under realistic operating conditions. A preliminary assessment of aircraft that could be adapted for this purpose has indicated the following to be worthy of serious consideration. Pertinent characteristics are shown below.

AIRCRAFT	CHORD R_e	MACH NO.	L.E. SWEEP	CONFIGURATION MOD.
Lockheed P-3	29×10^6	.67	0°	Glove/Remove O.B. Engine
Rockwell B-1B	27×10^6	.80	16°	Glove/Vary Sweep
Boeing 757-200	37×10^6	.80	23°	Glove (Reduced Sweep)
BAC-111	26×10^6	.68	20°	Glove (Reduced Sweep)

Further examination of these (and perhaps other) candidates, as well as preliminary hardware studies, are needed to establish costs, schedule, and overall suitability for the flight program.