(A). LAMINAR FLOW

The **Bellanca 19-25 Skyrocket II** is a prototype light plane built in 1975 by Payne Engineering Company[1]. Despite its advanced design and exceptionally good performance, it never achieved certification or entered production. The aircraft design was the result of Giuseppe Bellanca's son, **August** attempting to revive the original Bellanca company with an all-new design to prove that proper composite design could take advantage of a 1940's NACA laminar flow airfoil. The Skyrocket II is a six-seat, low-wing cantilever monoplane of conventional configuration with retractable tricycle undercarriage. It is constructed of composite materials, an advanced feature for its time, and test flying proved it to be extremely fast in the air. The test pilot for this new prototype was John P. Harris. Within months of its first flight, the prototype claimed five FAI world airspeed records for an aircraft in its class, all of which still stand in 2007. The aircraft attracted the attention of NASA[2], which conducted an aerodynamic analysis of the design, in order to investigate **natural laminar flow** as a factor of its high performance.

Photo #L-82-3004 from NASA Technical Paper #2256

Sublimating chemicals on right wing of Bellanca Skyrocket indicating large extent of natural laminar flow during Langley flight tests

1. SAE report #760473 April 1976 "**Laminar Flow Rethink – Using Composite Structure**." Given by Henry E Payne at the 1976 SAE General Aviation Meeting in Wichita, Kansas

2. NASA Technical Paper #2256, June 1984 "**Natural Laminar Flow Experiments on Modern Airplane Surfaces.**"

The following is an excerpt from the NASA Technical Paper #2256;

Natural Laminar Flow Airfoils

The initial emphasis in the Langley Advanced Airfoil Research Program for low-speed and medium-speed airfoils was to develop a series of airfoils that could achieve higher maximum lift coefficients than those produced by airfoils used on general aviation airplanes at that time. The assumption was that the flow over the entire airfoil would be turbulent because of the riveted sheet metal construction techniques used by the industry. Although the new low-speed airfoils did achieve higher maximum lift, the cruise drag was no lower than the earlier NACA airfoils used by the industry. The emphasis in the Langley program therefore shifted toward natural laminar flow (NLF) airfoils in an attempt to obtain lower cruise drag while retaining the maximum lift of the low-speed airfoils.

Research on natural laminar flow airfoils at Langley dates back to the 1930s when a team under Eastman N. Jacobs conducted its famous research for the NACA, which culminated in the development of the 6-series airfoils that were applied to many of the famous U.S. military aircraft of World War II, including the P-51 Mustang. The 6-series airfoils were not as operationally successful as low-drag airfoils because the riveted construction techniques employed at the time introduced physical disturbances that disrupted laminar flow.

In the mid-1970s, the emergence of smooth, composite structures led to a resurgence in interest in NLF research. For decades, the NLF interest resided in the sailplane community, but the advent of relatively lightweight composite structures for powered general aviation aircraft such as the Bellanca Skyrocket II, Elbert “Burt” Rutan’s family of aircraft, and the Windecker Eagle stimulated aerodynamicists to reexamine the feasibility of NLF airfoils. The Langley research efforts were pursued with airfoil research as well as substantiating flight test evaluation and validation.

The Skyrocket II had demonstrated exceptional performance in flight tests by Bellanca and had achieved an exceptionally low level of cruise drag that suggested some amount of laminar flow was being achieved by the wing. The aircraft had been designed to use an NACA 6-series airfoil similar to those developed by Jacobs in the NACA program. Under a cooperative program stimulated by Langley’s Joseph Stickle, special flight tests of the all-composite Skyrocket were conducted at Langley, under the direction of Bruce Holmes, to determine the extent of laminar flow on the aircraft.

The disappointment that had been experienced in the application of natural laminar flow airfoils in World War II carried over into the 1970s, and many critics in the engineering community doubted that the Skyrocket would exhibit any significant laminar flow—even with the smooth composite wing structure. Holmes and his assistant, Clifford J. Obara, utilized a spray-on sublimating chemical technique to visually identify the presence of laminar flow on the Skyrocket at cruise conditions. In flight, a gray-white area (aft of the front spar) covered by the sublimating chemical would indicate laminar flow; the presence of high surface shear turbulent flow would cause the gray-white sublimating coating to disappear. The results of the Skyrocket flight test vividly demonstrated the presence of laminar flow on the wing to the point of maximum wing thickness. This research activity represented a significant milestone because aerodynamic wing design for future low- and medium-speed general aviation composite aircraft could now consider laminar flow as an achievable goal.