Design of the Blended-Wing-Body Subsonic Transport
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I. Background

It is appropriate to begin with a reference to the Wright Flyer itself, designed and first flown in 1903. A short 44 years later, the swept-wing Boeing B-47 took flight. Comparing these two airplanes shows a remarkable engineering accomplishment within a period of slightly more than four decades. Embodied in the B-47 are most of the fundamental design features of a modern subsonic jet transport: swept wing and empennage and podded engines hung on pylons beneath and forward of the wing. The Airbus A330, designed 44 years after the B-47, appears to be essentially equivalent, as shown in Figure 1.

Thus, in 1988, when NASA Langley’s Dennis Bushnell asked the question: “Is there a renaissance for the long-haul transport?” there was cause for reflection. In response, a brief preliminary design study was conducted at McDonnell Douglas to create and evaluate alternate configurations. A preliminary configuration concept, shown in Figure 2, was the result. Here, the pressurized passenger compartment consisted of adjacent parallel tubes – a lateral extension of the double-bubble concept. Comparison with a conventional configuration airplane sized for the same design mission indicated that the blended configuration was significantly lighter, had a higher lift to drag ratio and a substantially lower fuel burn.

This paper is intended to chronicle the technical development of the Blended-Wing-Body (BWB) concept. Development is broken into three somewhat distinct phases: formulation, initial development and feasibility, and finally a description of the current Boeing BWB baseline airplane. NASA Langley Research Center funded the first two phases.
II. Formulation of the BWB Concept

The performance potential implied by the blended configuration provided the incentive for NASA Langley to fund a small study at McDonnell Douglas to develop and compare advanced technology subsonic transports for the design mission of 800 passengers and a 7000 nautical mile range at a Mach number of 0.85. Composite structure and advanced technology turbofans were utilized. Defining the pressurized passenger cabin for a very large airplane offers two challenges. First, the square-cube law shows that the cabin surface area per passenger available for emergency egress decreases with increasing passenger count. Second, cabin pressure loads are most efficiently taken in hoop tension. Thus the early study began with an attempt to use circular cylinders for the fuselage pressure vessel as shown in Figure 3, along with the corresponding first-cut at the airplane geometry. The engines are buried in the wing root, and it was intended that passengers could egress from the sides of both the upper and lower levels. Clearly, the concept was headed back to a conventional tube and wing configuration. Therefore, it was decided to abandon the requirement for taking pressure loads in hoop tension, and assume that an alternate efficient structural concept could be developed. Removal of this constraint became pivotal for the development of the BWB.