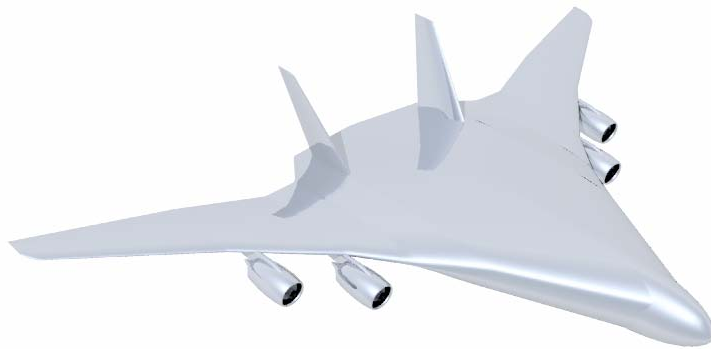# The VELA Project

In the frame of the VELA[1] project, lasting from October 2002 to October 2005, 17partners were working on problems associated with flying wing passenger aircraft.
The project was supported by the European Commission to stimulate research for innovative, efficient and environmental friendly concepts in air transport sector.

Airport congestion and increased passenger numbers are the primary drivers leading to the development of larger and larger aircraft. However as aircraft size increases, it becomes more and more difficult to achieve corresponding improvements in aircraft performance. It is believed that for large civil aircraft the "flying wing" design may offer improvements in aircraft performance that are significantly greater than those achievable by conventional aircraft.

There have been a number of successful flying wing aircraft designs developed for the military market, but no civil flying wing transports. This has been caused by the differing payload, mission and airworthiness requirements, which, in the past, have penalized the design of a civil "flying wing" aircraft. Modern conventional aircraft are "fly-by-wire" where the flight control computer produces an aircraft response to pilot control inputs that is tailored to give optimum handling characteristics. This alleviates the need to tailor the airframe shape to provide acceptable handling qualities, which may allow a more optimal aerodynamic solution. The VELA project was aimed at the development of skills, capabilities and methodologies suitable for the design and the optimization of civil flying wing aircraft.

The project was organized in six work packages as shown below.

| WP1	WP2	WP3	WP4	WP5	WP6
Configuration Set up	Aerodynamic Shape Optimization	Stability & Control	Structural Solutions	Payload Accommodation	Integration Assessment Exploitation
development of mission requirements, two realistic working configurations, one reference aircraft	aerodynamic shape optimization for cruise conditions, development of concept level methods	development of flight control systems, static and dynamic wind tunnel tests, assessment of handling qualities	development of structural concepts, finite element models, weight estimates	cabin design, evacuation analysis, fire and smoke propagation analysis	integration of results, development of final configuration

These work packages covered most relevant and critical topics of these types of aircraft. All work packages used two baseline configurations (VELA 1 and 2) produced in WP 1 to develop methods, tools and new solutions which were used in the final work package 6 to design an improved final flying wing configuration (VELA 3).

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[1] The acronym VELA stands for *Very Efficient Large Aircraft*.

The two baseline configurations shown below have been designed to establish two boundaries of the design space in placement and blending of the outboard wing (most forward, most rearward).
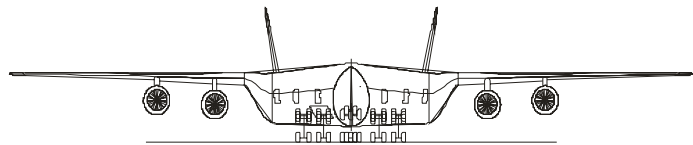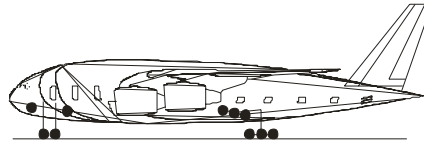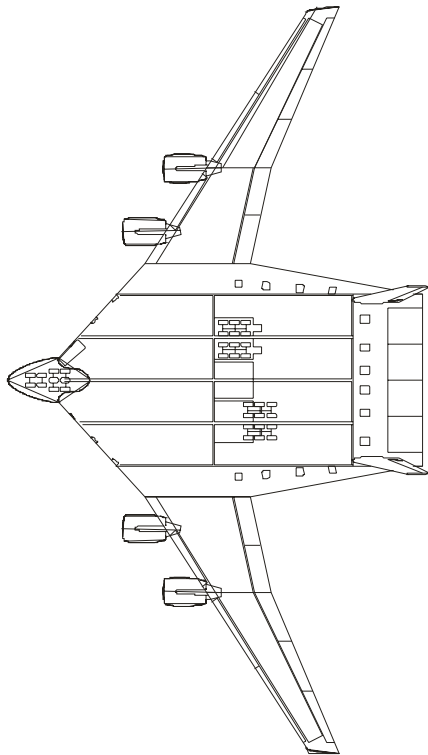
VELA 1 Baseline Configuration.
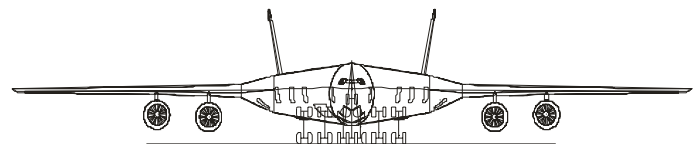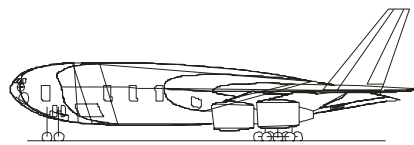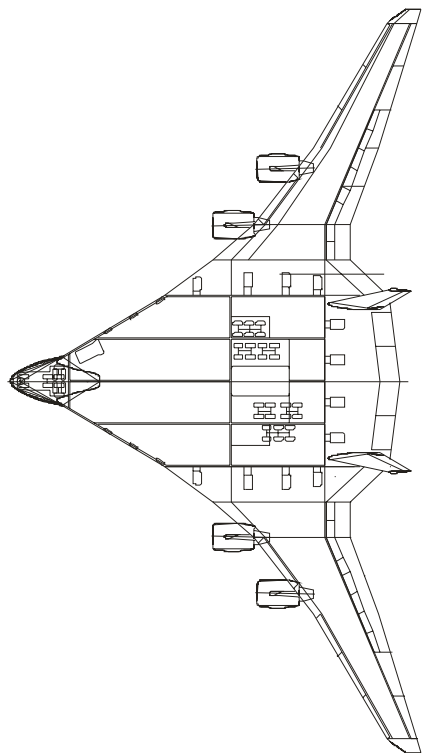
VELA 2 Baseline Configuration.

Contents of the Work Packages

WP 1: Configuration Setup

This work package provided a specification of targets and challenges for the work packages 2 to 5. Based on a prescribed mission, it produced two initial flying wing configurations and one conventional reference aircraft in form of specifications, CAD models and initial performance data. These models were then used in the following work packages.

WP 2: Aerodynamic Shape Optimization

A design space has been explored by applying different optimization methods. The target was to maximize Lift over Drag for a single prescribed mission point taking into account geometrical and stability constraints. For a variety of prescribed leading edge sweep angles, optimum shapes were developed to find the best aerodynamic performance. Different levels of numerical optimization as well as manual optimization techniques were applied. No multidisciplinary optimization has been performed. The results were used to develop an aerodynamic conceptual level method for application during the conceptual design phase.

WP 3: Stability and Control

The main task of the stability and control work package was to provide the means to design an unconventional aircraft by exploring the new features of these configurations. It covered analysis of stability and control requirements, assessment of handling qualities, development of flight control systems and low speed wind tunnel tests. In order to study the control characteristics of these unusual configurations, two wind tunnel models were built and tested under static and dynamic conditions.

### WP 4: Structural Solutions

Within this work package different structural solutions were studied. These included double shell concepts and single shell structures. Different concepts were compared in terms of weight and deformation. Finite element models were used for these structural studies.

WP 5: Payload Accommodation

The cabin of flying wing aircraft poses new challenges in terms of passenger activity and evacuation. Different cabin layouts have been developed according to standard comfort levels. Existing tools for the simulation of evacuation behavior and evacuation times have been adapted to accommodate flying wing concepts. Questions of passenger acceptability and certification aspects have been studied.

WP 6: Integration and Assessment

This work package defined additional requirements and exploited the results produced in work packages 2 to 5. Using these results, the initial configurations were refined and improved to produce a new final configuration. This configuration had been developed using the knowledge gained within the VELA project. It has also been assessed by comparison with the conventional reference configuration.
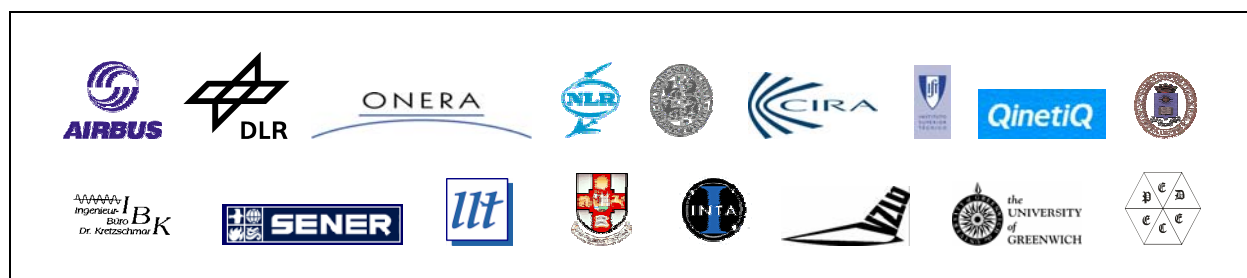
Partners in VELA

◄ Wind Tunnel Test

For radically different configurations like the flying wing aircraft, validation data was needed.

Low speed wind tunnel tests have been performed to measure static and dynamic derivatives. These test results have been compared with the predictions made in advance using preliminary design tools.

Aerodynamic derivatives are used to develop flight control systems. They describe the effect of the static deflection of control surfaces and the dynamic damping characteristics of an aircraft configuration.
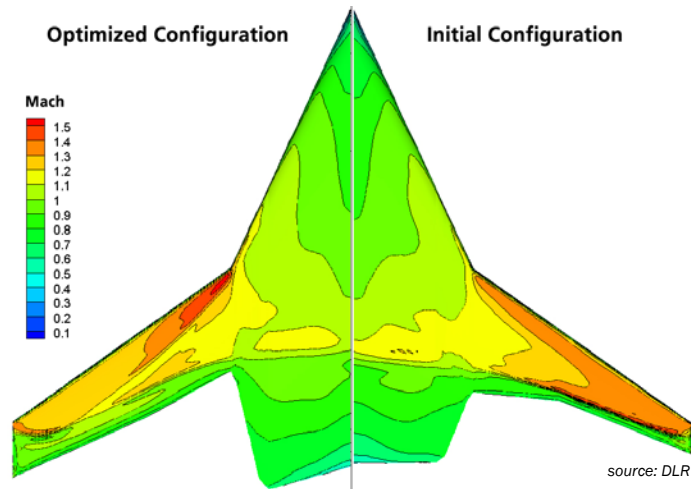
source: DLR

Aerodynamic Optimization ►

Various optimization techniques have been enhanced and applied to maximize the efficiency of flying wing configurations. Parameters like chord length, twist angle and airfoil section shape were varied.
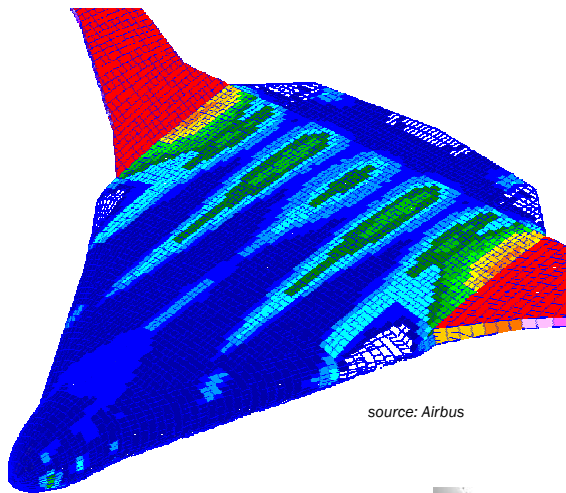
To achieve realistic results, constraints like cabin dimensions and floor angle as well as longitudinal stability have been taken into account.

Optimized Configuration **Initial Configuration**

Mach
1.5
1.4
1.3
1.2
1.1
1
0.9
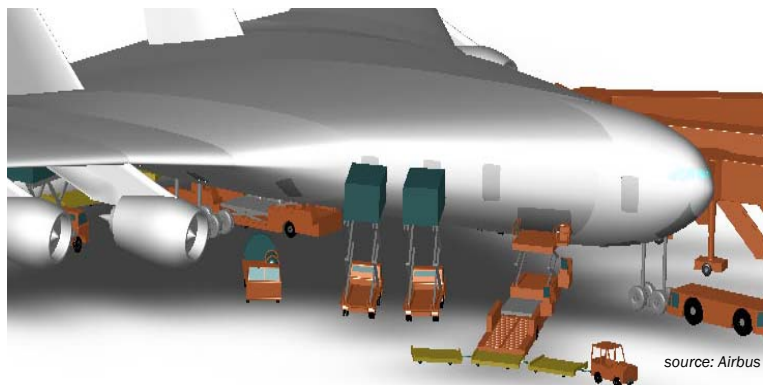0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

source: DLR

◄ Structural Concepts

Alternative solutions for the flat pressure cabin have been developed and assessed with Finite Element models.

These models were then used to derive more accurate estimates of the structural mass of the configurations.

source: Airbus

Airport Integration ►

Issues of airport integration as well as ditching and passenger evacuation have been addressed by new simulation techniques.

source: Airbus