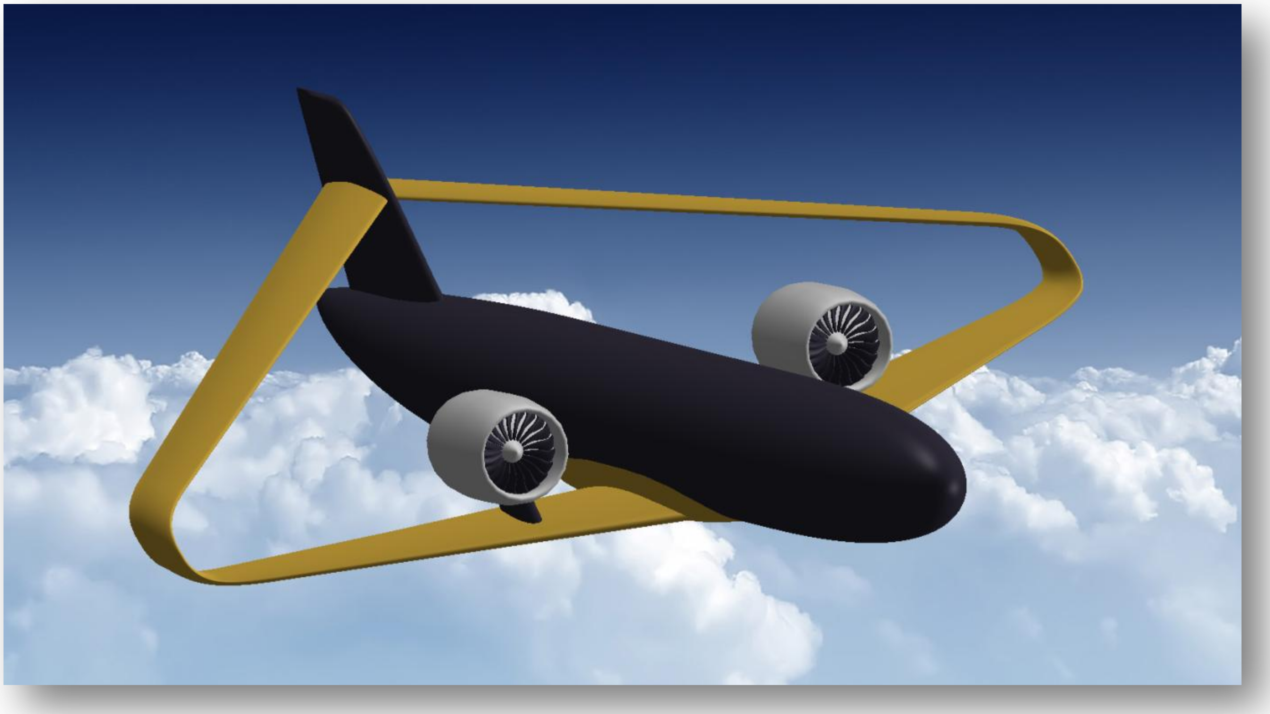
Aeolus Industries Presents: The Anemos-01



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Submitted: May 7th, 2012

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Abstract

Aeolus Industries has been presented with NASA's Environmentally Responsible Aircraft (ERA) and Unmanned Air Systems (UAS) goals as a request for the proposal of the development of a new, dedicated freighter aircraft capable of carrying a 100,000 lb payload 6,500 miles as efficiently as possible within the N+2 (2020) timeframe. After analyzing the global market for new cargo aircraft, it was determined that a freighter capable of carrying 220,000 lb of payload 4,500 nautical miles would better meet future demands. The overall goal of this new design is to meet these demands as well as adhere to the ERA and UAS goals. This report will walk through the design process and outline many major decisions made and tradeoffs considered to come to a final aircraft concept.

Our final design is a box wing, cylindrical fuselage layout. The box-wing's wing structure results in a significant weight reduction as well as a sizeable drop-off in induced drag. Our concept is inherently stable in pitch, roll, and yaw due to the box wing design that connects at the vertical stabilizer. The upper wing replaces the need for a horizontal stabilizer in addition to providing lift. The interior layout for the box-wing consists of two decks, a main deck and a lower deck consisting of a forward lobe and an aft lobe with three cargo doors to load cargo onto these decks. The cargo bay is designed to accommodate two rows of 125 inch by 96 inch pallets on the top deck and two rows of LD-3 containers in the lower deck. Removing pilots from the aircraft and instead having ground pilots oversee the flights from pilot command centers will advance unmanned technology pursuant to the UAS goals. Although this will raise costs and weights in some areas of the aircraft, it is believed that the benefits from implementing this technology will outweigh the disadvantages.

Many new technologies will be utilized to meet the ERA goals of reduction of noise, NO_x emissions, and fuel burn. Aerodynamic concepts such as hybrid laminar flow control, compliant control surfaces, and continuous mold line flaps all benefit the design through a reduction in drag and therefore a reduction in noise and fuel burn. Implementing composites into the aircraft design can reduce empty weight by as much as 28% over conventional alloys and virtually eliminate fatigue damage at just over 10% additional cost. Aluminum-lithium alloys can produce near 20% weight savings as a familiar alternative to composites, but are currently limited to simple structural elements and fuselage panels due to inadequate fracture toughness and low-cycle fatigue resistance. Electric taxi is an innovative solution to reducing fuel burn and minimizing engine wear. Adding electric taxi to a medium haul aircraft is estimated to lower block fuel burn by 1% and save almost $600,000 per aircraft, per year in cost of operations.

Propulsion is provided by two over wing mounted ultra-high bypass geared turbofan engines. This propulsion configuration allows the necessary thrust to cruise at the design Mach number of 0.85 while also drastically reducing the NO_x emissions as well as fuel burn due to the high efficiency bypass ratio. The over the wing layout helps reduce cumulative noise by deflecting engine noise up and away from the ground. The geared turbofan is also inherently less noisy due to the high bypass ratio. To further reduce cumulative noise levels, toboggan fairings will be added to the landing gear to smooth the flow over the gear on approach.

We used takeoff and landing distances at major cargo airports, second segment climb gradients, and a 2.5 maneuver load factor to develop carpet plots that gave us the appropriate values for wing loading, thrust to weight ratio and aspect ratio that gave the lowest gross takeoff weight. We developed a MATLAB based sizing code using a statistical group weights method that resulted in an aircraft with a 551,500 lb maximum takeoff weight capable of meeting our design goals. Finally, the acquisition cost of $226 million was found using the Development and Procurement Costs of Aircraft model, and the operating cost of $94,000/flight was found using the direct operating cost plus interest method.