The Skybus SB-400 Short Range Transport Aircraft

Members: Alex Barroso, Austin Klee, Chandler Palmer

Advisor: Prof. Adeel Khalid

ISYE 4900 – Aerospace Senior Design Project

Introduction

As air travel becomes more and more affordable and the world economy expands, so does the demand for flights. Major commercial airports and their infrastructure are struggling to keep up with this increased demand. The AIAA has identified this problem and has put out a Request for Proposal for a High-Capacity Short-Range Transport Aircraft that can carry 400 people in a two-class configuration up to 3,500 nautical miles but optimized for a 700 nautical mile flight (approx. ATL to NYC). The Skybus SB-400 is our clean slate design response to the AIAA's RFP.

Design Requirements

Table 1 – AIAA HDSRTA Requirements

General	
RBS	**Requirement**
1	Capable of taking off and landing from runways (ashphalt or concrete)
2	Capable of VFR and IFR flight with an autopilot
3	Capable of flight in known icing conditions
4	Meets applicabale certifcation rules in FAA 14 CFR Part 25
5	Engine/propulsion system assumptions documented with use of engine(s) in service by 2029
Mission	
RBS	**Requirement**
1	Crew: 2 pilots, 8 flight attendants
2	400 passengers in a dual class configuration
2.1	50 Business class passengers with 36" seat pitch, 21" seat width
2.2	350 Economy class passengers with 32" seat pitch, 18" seat width
3	5 cubic feet per passenger for baggage
4	Galleys, Lavatories, and Exits to meet 14 CFR Part 25
5	Number of aisles appropriate to the passenger layout
6	Passenger/pilot/attendant weight of 200 lb
6.1	Baggage weight per occupant of 30 lb
7	3,500 nmi design range mission with reserve energy to meet 14 CFR Part 25 requirements
8	Maximum takeoff length of 9,000' over a 35' obstacle to a runway with dry pavement (sea level ISA + 15 °C) at MTOW
9	Maximum Landing field length of 9,000' to a runway with dry pavement (sea level ISA + 15 °C) at the end of design range mission
10	Maximum Approach Speed of 145 KCAS at the end of design range mission
11	Cabin pressurized to 8,000 ft pressure altitude at maximum flight altitude

Methodology

The first step to designing an aircraft is to define the problem. Our problem was defined by AIAA as congestion of major commercial airports and simply stated, the solution we were to design was a high-capacity short-range transport aircraft. We understood that in order for this aircraft to be successful, our solution had to either match or beat current cost per passenger on a 700nm flight. With our problem and end goals defined, our first actionable step was to conduct research into existing high capacity airframes and determine why they were not optimized for short range flights. We determined that a few non-optimal factors were fuel requirements, baggage demands, dated technology, and inefficient use of space. In designing the aircraft, we first created our two classes of seats, tested multiple seat and aisle configurations, then built our fuselage around the necessary seat configuration. Once we had our fuselage, we estimated our weight and thrust requirements, tested engines and airfoils against those requirements and determined our optimal solutions.

Figure 1 – The Skybus SB-400

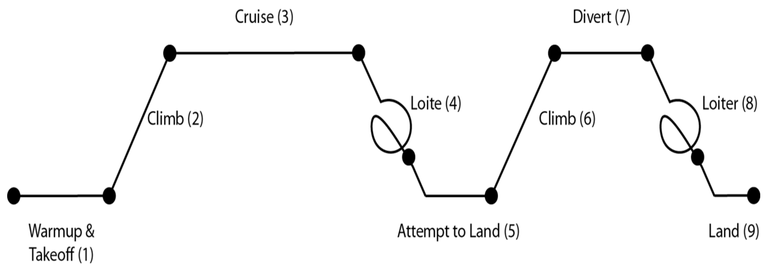


Figure 2 - Mission Profile

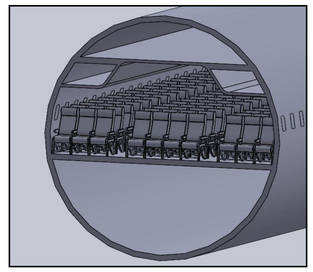


Figure 3 – Passenger Compartment Cross Section

Airfoil Selection

The selection of an airfoil for an aircraft is a critical design choice, especially for those that approach trans-sonic speeds. The Skybus SB-400 has a design cruise speed of Mach 0.85, requiring a sophisticated and modern airfoil. The Supercritical family of airfoils allow for efficient high subsonic cruise by reducing the critical Mach number, in other words, decreasing the magnitude of the shocks formed along the wing when nearing Mach 1. At the same time, these airfoils do not sacrifice performance at low speeds & high angles of attack for efficiency at cruise. They are also capable of maintaining a high coefficient of lift at those conditions.

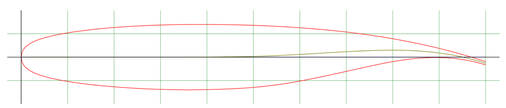


Figure 6 - NASA SC(2)-0714 Supercritical Airfoil

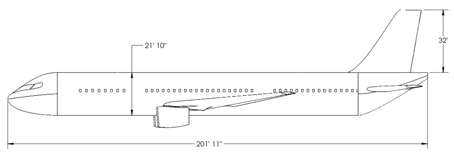


Figure 4 – Side View

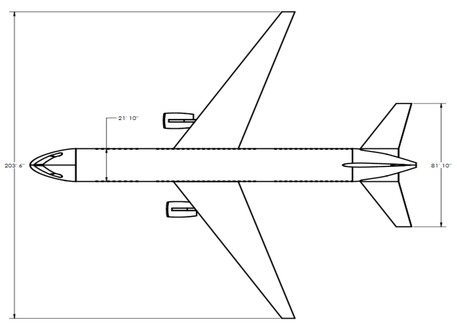
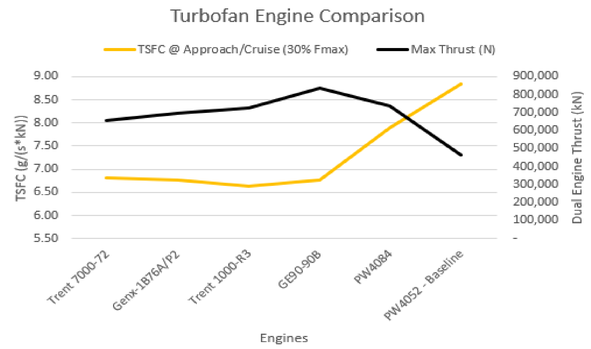


Figure 5 – Top View

Engine Selection

The selection of the engine was one of the most critical design choices due to its direct impact on the recurring cost of flight. The objective with the engine selection was to minimize the fuel consumption at cruise while maintaining adequate levels of thrust to transport 400 passengers, baggage and cargo. We determined our aircraft weight to be 106,786 kgs, and using a thrust to weight ratio of 0.252, we determined the thrust required to be 263,718 at a minimum, not counting fuel weight. In researching engines for similar sized aircraft, we found the 787-800 utilized engines with around 76,000 lbf (340kN) of thrust and had a maximum take off weight nearly double its empty weight. Taking into account the 70 additional passengers our plane would carry, along with their additional luggage, as well as the cargo hold additional capacity, we ultimately calculated the need for an engine with more than 600kN of thrust. We were looking for the smallest fuel burn and lowest thrust specific fuel consumption and ultimately decided on the Trent 7000-72. You can see comparisons of TSFC and max thrust below for various engines.



Conclusion

In conclusion, we were able to meet or exceed all minimum requirements while simultaneously reducing the current cost per passenger on a 700 nm flight. Our carbon fiber material choice prevents corrosion that can occur on aluminum aircraft, reducing maintenance, while also reducing weight. The SkyBus can carry 400 passengers burning 10,600 lbs/hr of fuel resulting in a fuel per passenger per hour rate of 26.6 lbs/hr. Compared to existing aircraft flying 700 nm flights and excluding cargo revenue, the results can be seen below.

	SkyBus	737-800	787-800
Capacity	400	162	330
Fuel Burn (lb/hr)	10,637	5,579	10,805
Fuel per Passenger per Hour (lbs)	26.59	34.44	32.74
Fuel cost per hour*	$7,978	$4,184	$8,103
Fuel Cost Per Passenger per hour	$20	$26	$25
Increased Cost over Skybus	-	23%	19%