Austere Field Light Attack Aircraft RFP

UF-7 Sabretooth

Design Requirements

The purpose of this project was to design a light attack aircraft that is capable of operating from austere fields and providing air support to ground forces. In terms of performance, the light attack aircraft had a series of requirements. Some of the general performance requirements are listed below:

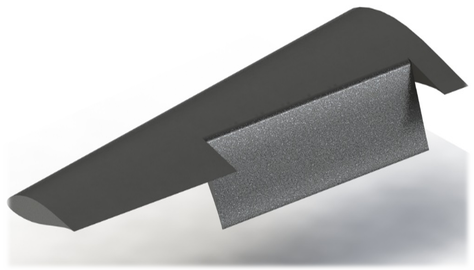
- Takeoff and land from austere fields with a 50-foot obstacle at altitudes up to 6,000 ft in under 4,000 ft.
- Carry a maximum payload of 3,000 lb. including missiles, rockets, bombs, and integrated guns.
- Maintain a service life of 15,000 hours over the course of 25 years.
- Operate with a service ceiling of at least 30,000 ft.
- Utilize a two-person crew, equipped with zero-zero ejection seats.

In the end, it was desired to produce a design that had a very strong performance to cost ratio. In other words, the Sabretooth was designed in order to maximize performance while minimizing the cost of the aircraft, when possible.

Wing Design

A NACA 63A415 airfoil was selected to be used on the UF-7 Sabretooth due to the high $C_{L_{max}}$ that it would provide and its use on similar aircraft. A plain flap is included to increase lift if necessary. A cut-off wing tip design is used for cost efficiency. A summary of the design values is provided:

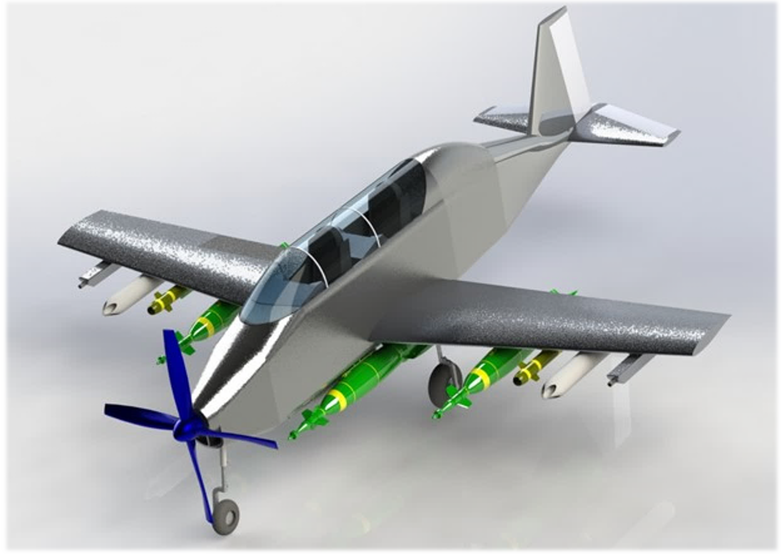
- Wing Span: 33 ft
- Wing Area: 156.9 ft^2
- Wing Sweep: 3°
- Taper Ratio: 0.55
- Chord at Root: 6.13 ft
- Chord at Tip: 3.37 ft
- Wing Twist: -3°
- Wing Dihedral: 5°



Propulsion

To select the engine for the aircraft, a trade study was performed that compared various engines used in other light attack aircraft. Factors such as cost, weight, and specific fuel consumption had the greatest impact when selecting an engine. After performing the trade study, the PT6A-68D was selected. Overall, this engine was superior to the other options in four of the seven factors that were considered. This engine is sure to provide sufficient power for our aircraft when needed as it can produce a maximum 1,600 SHP and 1,398 lb of thrust when the aircraft is at cruise. Additionally, to power the engine, the aircraft's fuel will be stored in bladder tanks located within the wing structure of the Sabretooth.

The Sabretooth will use a 4-blade propeller, as this provides a great balance between propeller thrust generation and diameter size, without a significant loss of efficiency due to the addition of more propeller blades.



Payload

The Sabretooth is intended to provide air support for troops on the ground. As such, the ideal payload for the aircraft is a total of 2,704.80 lb., and consists of bombs, missiles, and rockets. Four GBU-49, 500 lb., laser guided bombs are utilized to accurately neutralize heavily armored targets on the ground. Two, AGM-114 Hellfire missiles are used to neutralize powerful ground targets including armor or groups of people with pinpoint accuracy. Finally, fourteen GATR laser-guided rockets are used to eliminate lightly armored targets. Each of these weapons are useful in neutralizing various threats to troops on the ground.

In addition to the standard payload, three guns are mounted on the aircraft. A 20 mm NC621 nose canon is utilized, alongside two HMP-400 .50 caliber machine guns, one mounted under each wing. These weapons further diversify the support capability of the Sabretooth aircraft.

Stability and Control

The aircraft's longitudinal and lateral-directional static stability were analyzed. The longitudinal static stability analysis showed that the aircraft is stable, with an average coefficient of pitching moment with angle of attack, C_{m_α}, of -0.201.

The lateral-directional static stability analysis showed that the aircraft is statically stable in the lateral direction, with a coefficient of roll moment with respect to sideslip, C_{l_β}, of -0.138. The analysis also showed that the Sabretooth is slightly unstable in the directional axis, which is a result of the coefficient of yaw-moment with respect to sideslip. For the Sabretooth, this instability will be corrected with autopilot when necessary.

Performance Analysis

The final design of the Sabretooth surpasses all mission requirements. Some of the performance specifications are listed below:

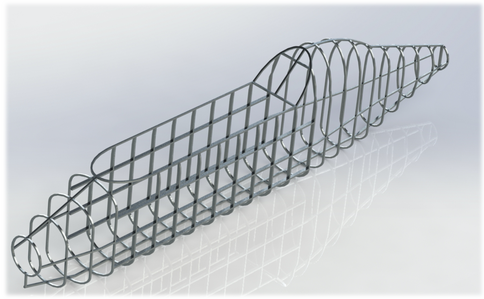
- Takeoff distance[A]: 2,869 ft
- Landing distance[A]: 3,790 ft
- Takeoff and landing velocity: 165 ft/s (112 mph)
- Empty weight: 7,873.5 pounds
- Gross takeoff weight: 10,959.8 pounds
- Cruising velocity: 359 ft/s (245 mph)
- Cruising altitude: 25,000 ft
- Range (at cruise): 3,137.6 nm
- Endurance (at cruise): 12.78 hours
- Service ceiling: 34,360 ft

[A]50 ft obstacle at ends of runway, altitude of 6,000 ft

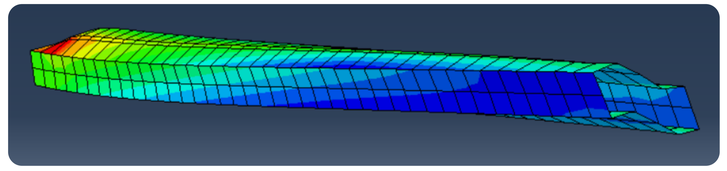
Structures

The Sabretooth was designed to handle the forces that are expected to be exhibited on the aircraft during flight. The bounds for the load factor range from -1.5 to 3.8. To support the loading, the low mounted wings of the Sabretooth will be attached to the fuselage via a wing box and a combination of ribs and spars along the inside of the wing. MATLAB and ABAQUS were used to analyze the wing box. The fuselage of the aircraft will be able to withstand the forces of compression and tension experienced during flight with the help of a semi-monocoque. The aircraft will be constructed of mostly metal alloys for easy repair between missions.

Aluminum 7075-T6 will be used for the wing box, the adjoining section between the wing and fuselage, and the frame for the fuselage. Aluminum 2024-T3 will be used for the skin due to its high fatigue resistance. Ti-6A1, due to its high temperature resistance, will be used to create the structure that holds the engine.



The propeller will be made of a carbon fiber composite that will save weight and reduce noise and vibrations curtesy of a foam core. A nickel-cobalt leading edge will act as an erosion shield for the propellers.



Cost

The costs for the Sabretooth were calculated on a yearly basis, assuming the aircraft completed 1,200 flight hours per year. A summary of the incurred costs is provided:

- RDT&E and Flyaway during design phase: $13,522,001.49
- Consumables (Oil, brakes, tires, etc.): $20,718.00
- Maintenance: $463,800.00
- Fuel: $493,606.19
- Salary per active crew member: $107,640.00

Summing the cost of consumables, maintenance, and fuel, it would take a total of $978,124.19 to properly maintain one Sabretooth aircraft throughout a service year.

Acknowledgements

Team UF-7 Sabretooth

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