Next Generation Carrier-Based Strike Fighter Aircraft, Ethereal

Logan Smith, Mika Nash, Ian McCurdy, Iris Kashirsky, Julio Bravo, Saya Kimura

Abstract

This project presents the conceptual design of our team, Ethereal's, design take on the next-generation carrier-based strike fighter developed in response to the 2025–2026 AIAA Undergraduate Aircraft Design Competition Request for Proposal. The objective is to design a replacement for the F/A-18E/F Super Hornet that improves combat performance while maintaining comparable acquisition cost and meeting carrier suitability requirements The Ethereal aircraft was designed to perform multiple naval aviation missions including air-to-air combat, strike operations, and electronic attack. Key design considerations included aerodynamic efficiency, structural feasibility, carrier compatibility, and mission performance. Wing and empennage sizing were performed using aerodynamic performance analysis to ensure sufficient lift generation, maneuverability, and stability across mission profiles. Airfoil selection and lifting surface sizing were optimized to balance lift generation, drag reduction, and stall characteristics. Performance analysis and design iterations were conducted to satisfy mission requirements such as combat radius, dash speed, payload capacity, and sustained turn rate. The final configuration integrates aerodynamic performance considerations with operational constraints for carrier launch and recovery. The resulting conceptual design demonstrates a feasible next-generation strike fighter capable of meeting the operational needs of future naval aviation missions.

Introduction

Modern naval aviation requires aircraft capable of operating in increasingly complex combat environments while maintaining affordability and operational compatibility with existing carrier infrastructure. The AIAA Undergraduate Aircraft Design Competition challenges teams to design a next-generation carrier-based strike fighter intended to replace the F/A-18E/F Super Hornet with improved combat capability at a comparable unit acquisition cost.

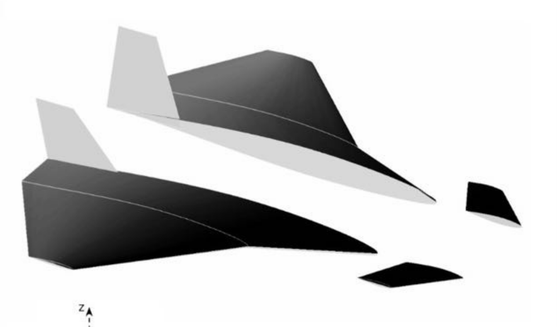
The proposed aircraft must perform multiple mission roles including air-to-air combat, strike missions, and electronic attack, while remaining compatible with existing U.S. Navy aircraft carriers such as the CVN-68 and CVN-78 classes. Carrier compatibility imposes several operational constraints including launch using catapult systems and recovery using arresting gear.

Key performance requirements outlined in the RFP include:

- A minimum combat radius of 700 nautical miles, with 1,000 nautical miles considered desirable.
- A Mach 1.6 dash speed at 30,000 ft for air-to-air missions.
- A minimum sustained turn rate of 8 deg/sec at 20,000 ft.
- External store carriage capability of at least 10,000 lb.
- Aircraft dimensions compatible with carrier storage, including wingspan, height, and deck handling constraints.

Additional requirements include the ability to operate in maritime environments for a 25-year service life, use currently available production engines and materials, and maintain compatibility with existing carrier operations.

Within these constraints, the Ethereal design focuses on maximizing aerodynamic efficiency, maneuverability, and mission capability while maintaining structural feasibility and operational practicality. Aerodynamic performance analysis and design optimization were used to determine wing sizing, airfoil selection, and stability characteristics required to meet the competition's mission and operational requirements.



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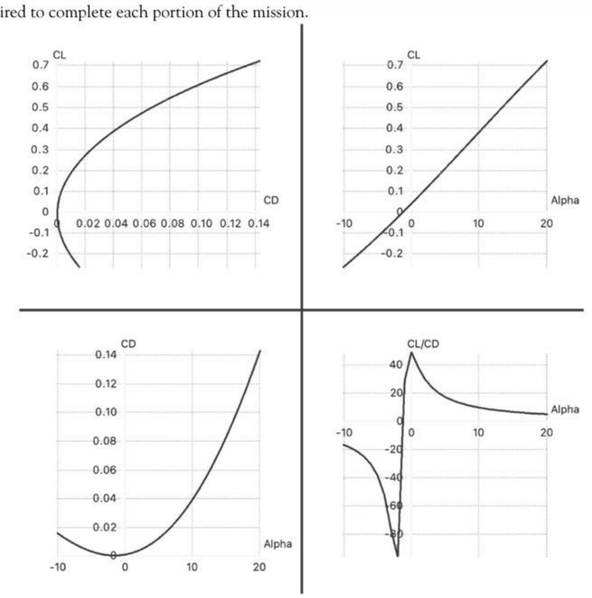
Project Design

WING SIZING

The aircraft wings were designed to produce enough lift to overcome the weight of fuel required to complete each portion of the mission.



EMPENNAGE ESTIMATE

The canards and tails stabilize the aircraft while allowing for maneuverability and control at high angles of attack. Since canards are located forward to the center of mass, they produce a negative moment, which allows for more controls. V-tails produce both longitudinal and directional stability. The horizontal and vertical projections were used to calculate how effective they are at counteracting pitch and yaw.

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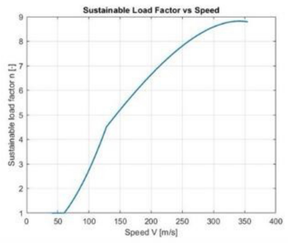
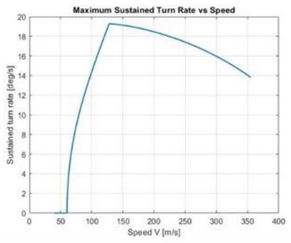
AIRFOIL

Specific airfoils were selected for each lifting surface. The wings reduce in camber along the span to generate lift and help prevent wing tip stall. The thickness ratio is largest at the root where most fuel is stored, and transitions to a thinner profile towards the tip. The airfoils on the canards and V-tails are symmetric so they deflecting in either direction produces the same result.

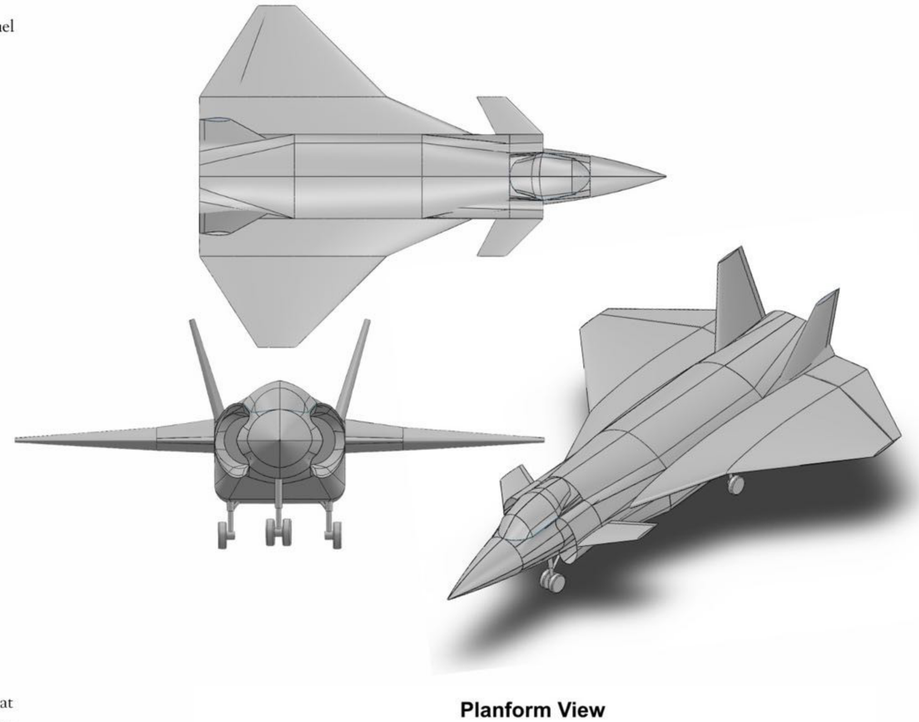
STABILITY AND CONTROL

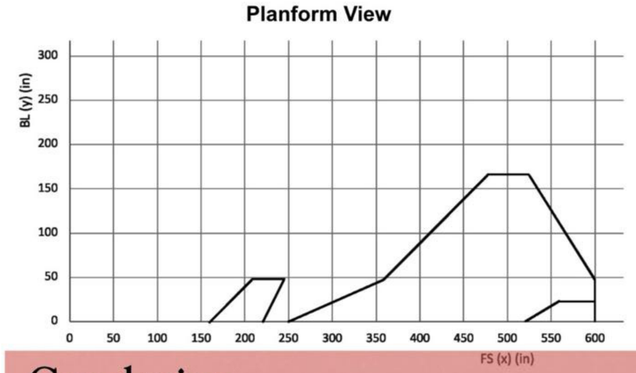
The jet was decided on using canards, one engine inoperative, static and dynamic stability, and aileron sizing. Our team went with canards to increase the aircraft maneuverability and increase the angle of attack before stall. This is useful for aircraft that need to land on short runways, like aircraft carriers, as it increases the lift before stall while reducing speed. The canards themselves are destabilizing on the aircraft. All control surfaces are sized to meet the AIAA RFP requirements. The rudder is designed to overcome a one engine inoperative failure event while maintaining trim drag less than 5% total drag. The ailerons / flaperons are sized to exceed the required sustained turn rate (at max thrust).





CAD





Conclusion

The Ethereal conceptual aircraft design demonstrates a feasible approach to meeting the operational and performance requirements defined in the AIAA carrier-based strike fighter design competition. Through aerodynamic analysis, lifting surface sizing, and stability evaluation, the final configuration provides sufficient lift generation, maneuverability, and control authority across mission conditions. Wing sizing and airfoil selection were optimized to balance aerodynamic efficiency with stall behavior and carrier operational requirements. Empennage sizing and control surface design ensured adequate longitudinal and directional stability while supporting maneuverability and control during critical flight conditions such as carrier launch and recovery. The resulting configuration satisfies key mission requirements including combat radius, maneuverability, and payload capability while remaining compatible with carrier operational constraints. This conceptual design highlights the importance of integrating aerodynamic performance, structural feasibility, and operational considerations when developing next-generation naval aircraft.

Overall, the Ethereal aircraft represents a viable conceptual solution for a future carrier-based strike fighter capable of supporting multi-role naval missions while maintaining performance, affordability, and carrier compatibility.

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