SpeedFest VIII Orange Team: Ace of Diamonds

Low observable attack/sensor deployment UAV

Objectives

Evade:

Evade 34.7 GHz Doppler-based radar

Deploy:

Drop 2 payloads inside a 50 ft by 50 ft target

Recover:

Take off and Land in < 50 feet

Range:

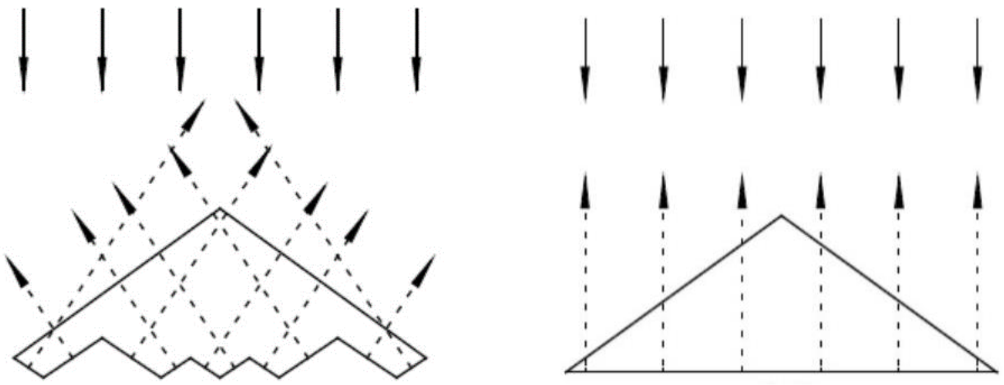
Travel at least 15 km in figure-8 laps

Speed:

Top speed between 120 and 173 kts

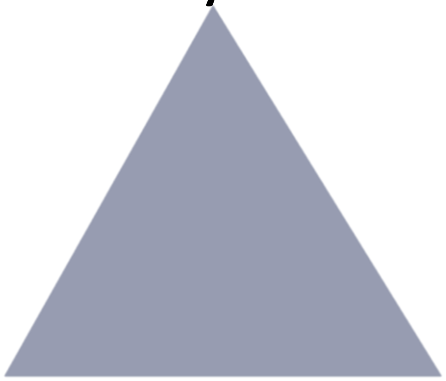
Early Stage Design—Low Radar Cross Section

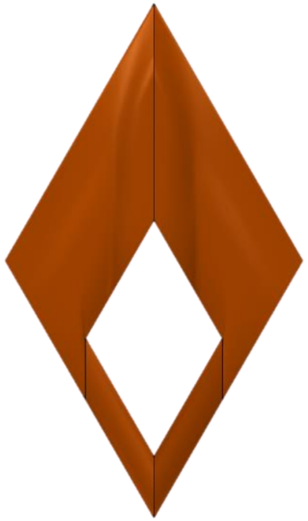
- Aerodynamic designs are not stealthy. Stealthy designs are not aerodynamic.
- Conclusion: It is easy to design something that flies, but difficult to design a stealth UAV. Therefore, design for stealth first.
- The main factor in Radar shaping is angle of the body relative to the radar. Examples are shown below.



Low Observability Design

- Three possible planforms which we looked at were the Delta wing (Left), Swept Delta (Middle) and the final Clipped Diamond design (Right).
- The clipped diamond planform has the fewest radar spikes of the possible planforms, and also permits more design choices for aerodynamics.

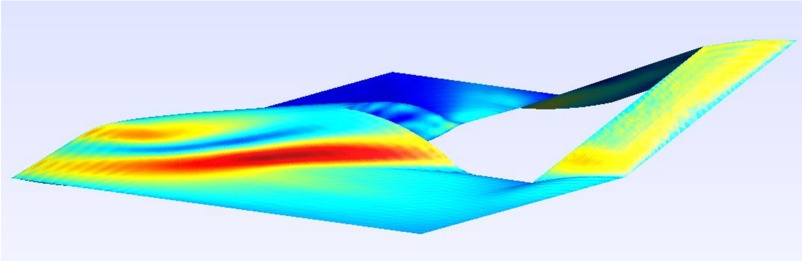




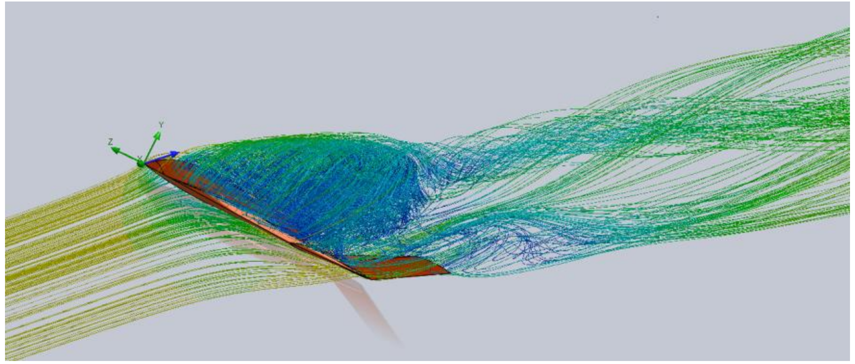
Aerodynamic Design

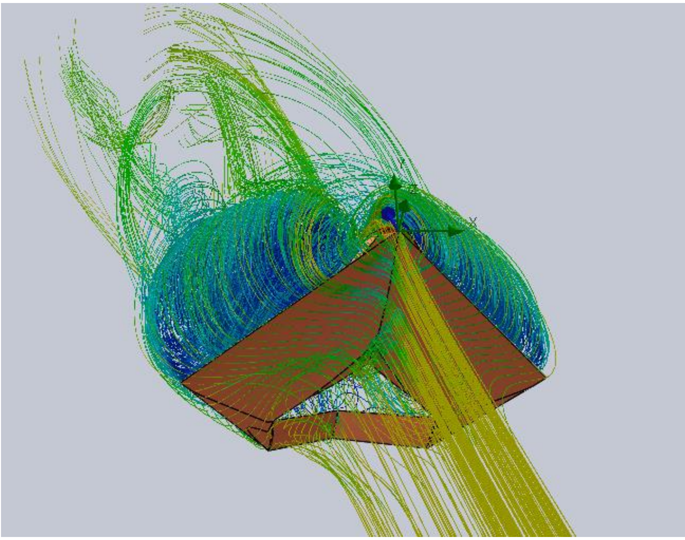
- Diamond and Delta-winged aircraft are much less aerodynamic than traditional tube and wing aircraft, and are also inherently unstable.
- Computational Fluid Dynamics (CFD) was performed in order to assist in making design choices about the aircraft.
- After CFD was performed, two foam models were made to get qualitative stability and handling data from the pilot.

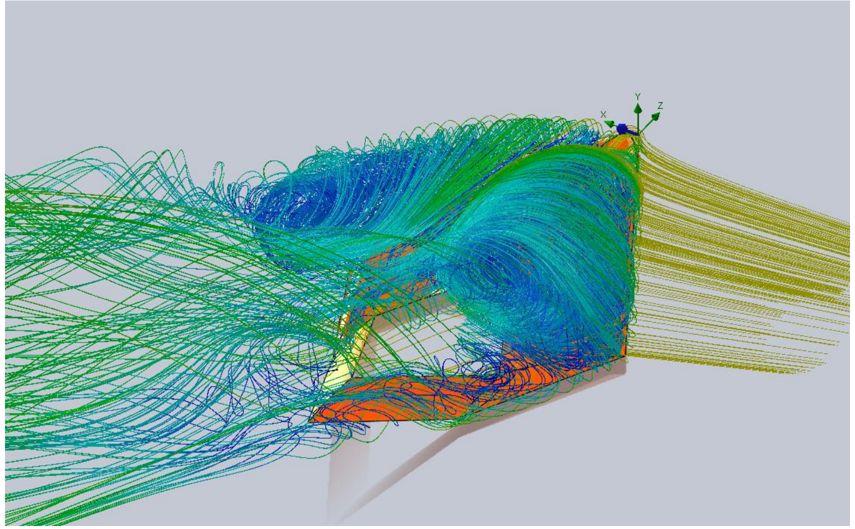
Computational Fluid Dynamics



- Initial CFD analysis was performed on a flat-plate model of the aircraft. This was simple, computationally efficient, and gave a good approximation of the stability characteristics of the aircraft.
- CFD was used to size the tail so that the aircraft would be statically stable in both the Roll and Yaw (turning) axis.

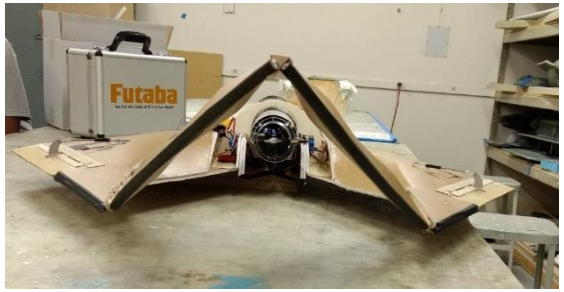


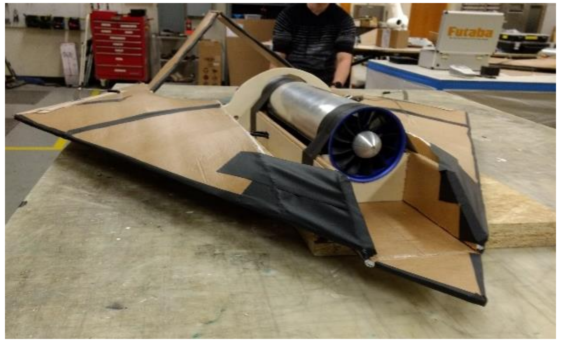




Foam Models

- Flight tests with the two foamies, Orange Magic and You Only Live Twice gave a lot of good qualitative flight data and allowed decisions to be made based on pilot opinion of the UAV.





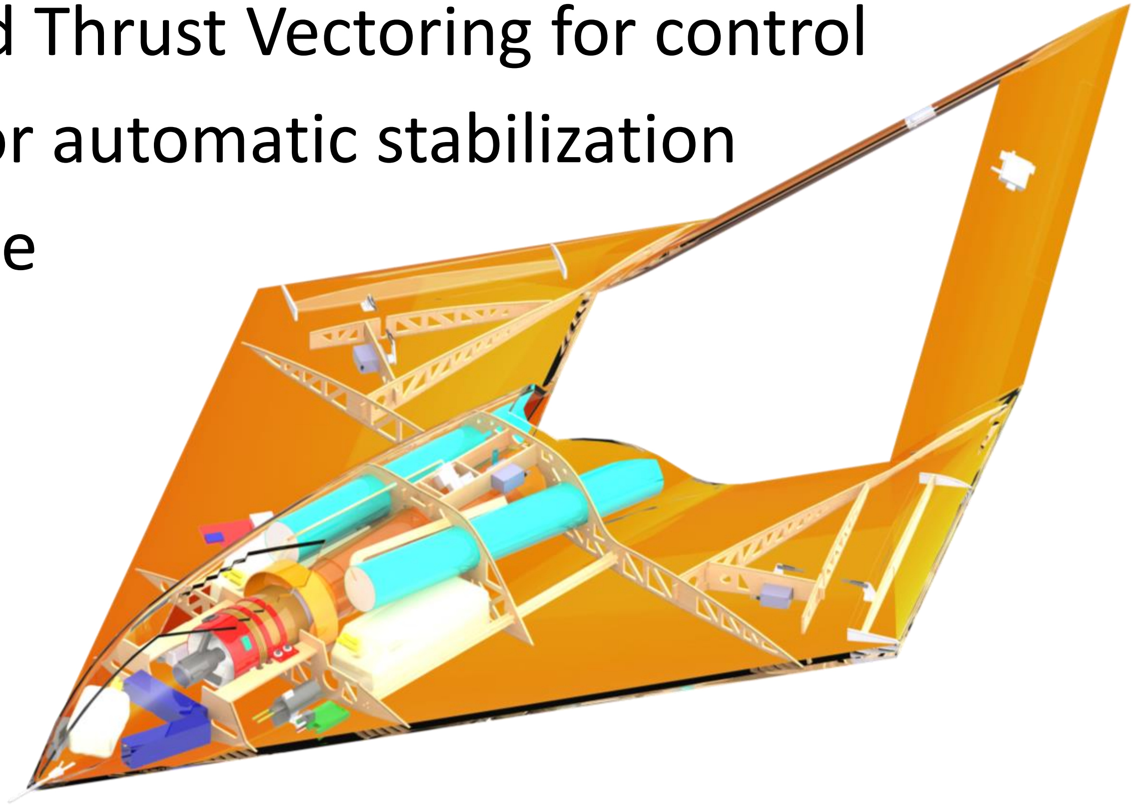
- Flight of the foamies validated the CFD data and showed that the aircraft was remarkably stable in yaw, had little to no wing rock, and was capable of spot landing.

Control Surfaces

- Three different control surface configurations were considered:
  - Elevon only: Control surfaces on the wingtips, control pitch and roll, but have no yaw input
  - Aileron and Ruddervater: Control surfaces on the wingtips control roll, tail controls pitch and yaw
  - Elevon and Ruddervater: Control surfaces on wingtips control roll and have pitch input, control surfaces on the tail control yaw and have pitch input as well
- Any of these three options could be augmented with thrust vectoring
- Final Decision: Dual Elevon and Ruddervater with Thrust Vector augmentation

Aircraft Final Design

- Clipped Diamond for RCS, with a Joined tail for increased stability.
- Elevons, Ruddervaters, and Thrust Vectoring for control
- Aura 8 acceleration gyro for automatic stabilization
- 15 lb-thrust turbojet engine



Aircraft Photos








Objectives Achieved

Evade:

Evade 34.7 GHz Doppler-based radar - Achieved

Deploy:

Drop 2 payloads inside a 50 ft by 50 ft target - Achieved

Recover:

Take off and Land in < 50 feet – Hand launch, land in <100 ft.

Land in < 50 ft with net assisted landing

Range:

Travel at least 15 km in figure-8 laps - Achieved

Speed:

Top speed between 120 and 173 kts – Achieved (top speed 135 kts)

Acknowledgements

- Special thanks to Dr. Arena, Dr. Kidd, Collin Boettcher, Speedfest TA’s, and all Orange Team Members.

Speedfest VIII Orange Team Promo Video

- https://www.youtube.com/watch?v=CtjwHngEhXk