Desna: Pathfinder VI Experimental Payload

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Abstract

The objective of this project is to design, fabricate and test a fixed wing unmanned aerial vehicle (UAV) that is to be carried in, and deployed from the Pathfinder VI rocket. The UAV, known as Desna, is tasked with being able to carry a Tamarisk 640 75mm thermal imaging camera, and transmit live video footage to a ground station from 8500 feet AGL. Desna must also fit inside Pathfinder VI's 7.5" diameter, 35" long cargo bay. To accomplish this, Desna's wing configuration, determined through description matrices and light prototype testing, will consist of a 35" wing that rotates about its center with 11" folding winglets to increase lift and stability. Desna will be constructed from blue high-density foam to allow for cheap, rapid prototyping as well as being light as possible while still being able to survive the G loadings during assent. Desna will fly in Pathfinder VI this June in the Intercollegiate Rocket Engineering Competition as an experimental payload.

Mission Objectives

- Desna must fit within the the allocated payload bay space of a cylinder 7" in diameter and 35" in length.
- Desna must carry a DRS Tamarisk 640, 75mm thermal imaging camera.
- Desna is to be able to be launched inside of the Pathfinder VI rocket to an altitude of 10,000 feet above ground level (AGL).
- Desna must cruise at an altitude of 8500 feet AGL.
- Desna must transmit live telemetry and video data to a ground station.

Aircraft Design

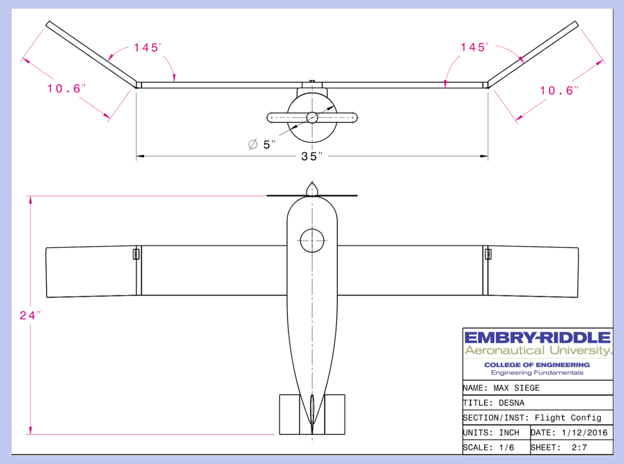


Fig 1: Desna: Flight Configuration

Desna was designed with a 35" main wing section, and 11" outboard winglets. The winglets were given 35° of dihedral to increase the roll stability. Desna's fuselage was designed to be a 5" diameter, 24" long solid of revolution to reduce drag while still being able to accommodate the size of the camera. Both the rudder and elevator are full flying stabilizers to maximize control authority while still fitting within the size restrictions of the payload bay.

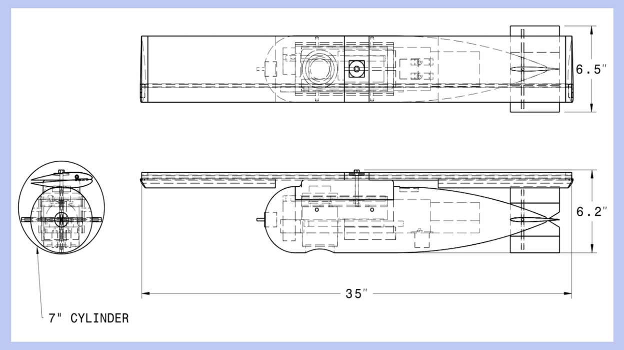
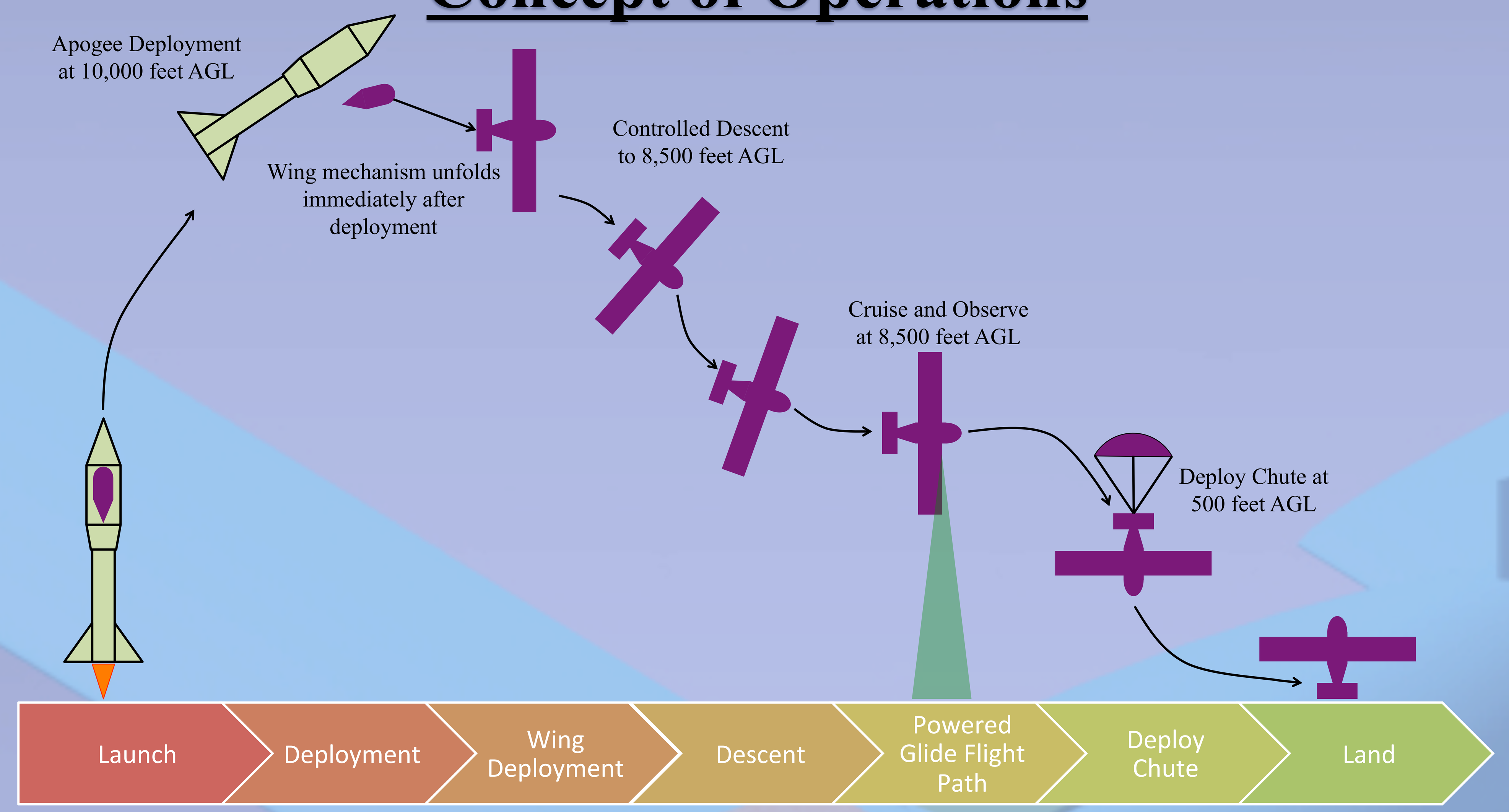


Fig 2: Desna: Launch Configuration

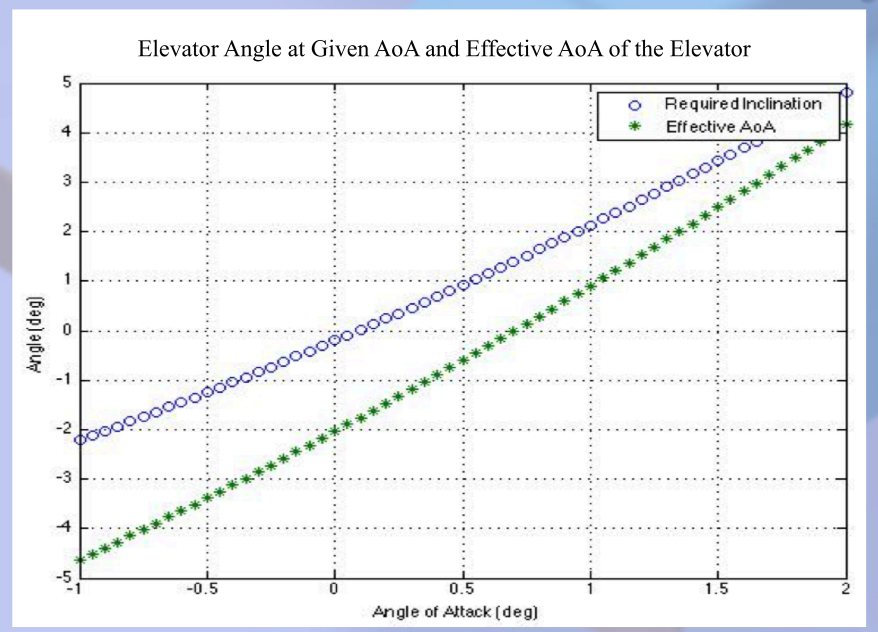
Desna was designed with a centrally rotating wing mechanism, allowing it to fold and fit into a cylinder 7" in diameter and 35" long. The mechanism folds the 11" winglets under the 35" main wing section, and then rotates the wing about a bolt in Desna's payload access hatch.

Concept of Operations

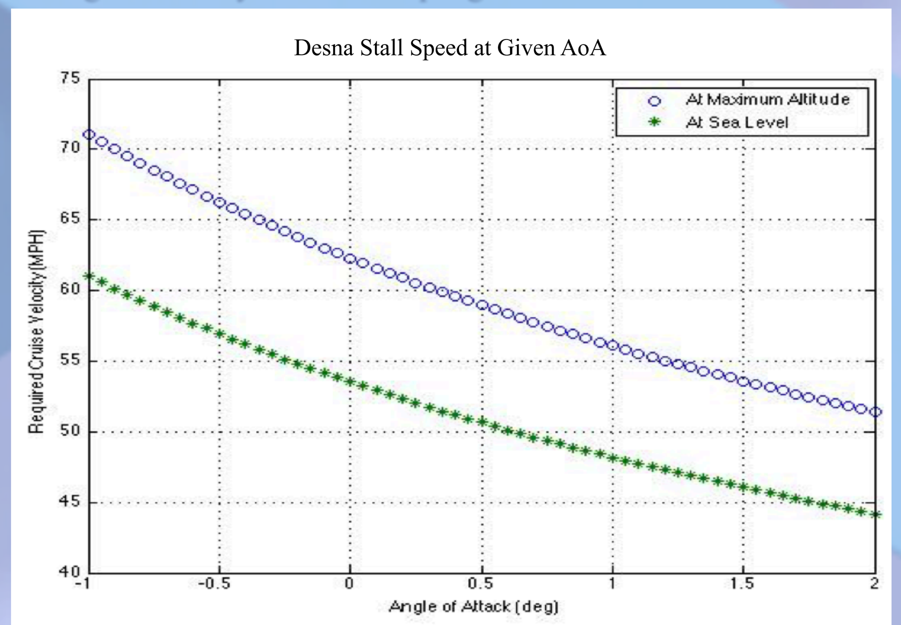


Flight Performance Calculations

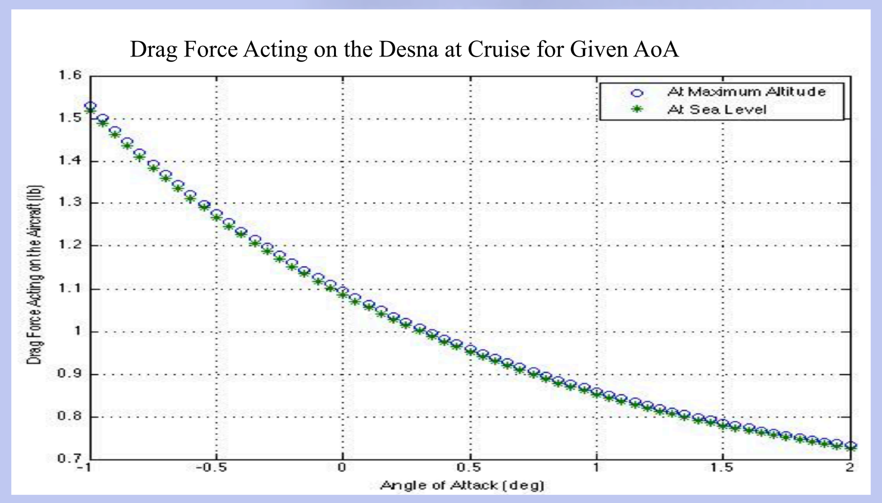
All calculations were done using a custom flight stability MATLAB program.



Graph 1: This graph displays the relationship of the angle of Desna's elevator, to Desna's cruising angle of attack. The graph also displays the elevators effective angle of attack at these giver angles.



Graph 2: This graph displays Desna's cruise velocity at given angles of attack at both it's maximum altitude of 10,000 ft (AGL) and at Sea Level.

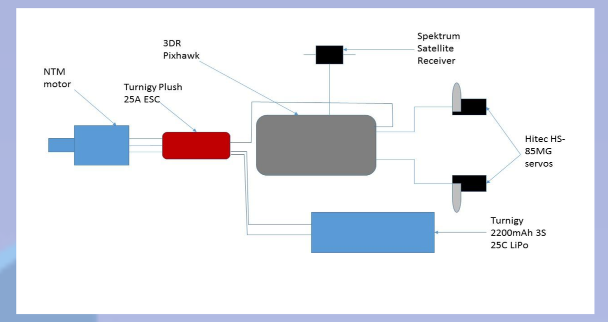


Graph 4: This graph displays the drag force at cruise speed acting of Desna at given angles of attack at both it's maximum altitude of 10,000 ft (AGL) and at Sea Level.

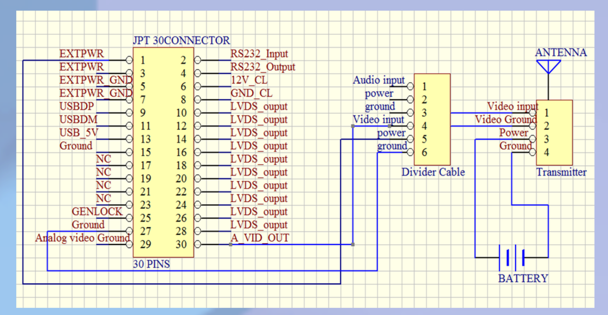
Graph 4: This graph displays Desna's glide slope at given angles of attack at both it's maximum altitude of 10,000 ft (AGL) and at Sea Level.

System Configuration

Desna's electrical systems are split into two sections, the propulsion and flight control system, and the video transition system. Each system is powered by a three cell lithium polymer battery. The wiring setup for both systems is displayed bellow.



Propulsion and Flight Control System:
Desna's telemetry system utilizes a Pixhawk flight computer for autonomous control and the software MissionPlanner to receive telemetry and transmit instructions from the ground station using a 915 MHz transmitter. Desna uses two servos (one for each control surface) and an NTM motor for flight.



Video Transition System:
The video downlink will be a Ready-Made RC 900MHz FPV system. The transmitter will be connected to the camera and has an output of 800 mW. The theoretical average range is 4.903 miles (with a maximum of 9.388 miles) as calculated by Lingxiao Wang but this has yet to be tested.

Conclusion

Desna is currently in the final stages of development. Desna has passed both it's Preliminary Design Review and Critical Design Review, and the Desna team has begun manufacturing of both a prototype for flight testing and the final iteration. The prototype of Desna will be flown aboard the maiden flight of Pathfinder VI on Saturday, April 18th at the Spaceport Rocketry Association. The final iteration of Desna will be flight tested upon completion, and will fly aboard Pathfinder VI in the Intercollegiate Rocket Engineering Competition (IREC) in Green River Utah this June. In the future, Desna can be used by the Coast Guard for search and rescue missions, or by the military for rapid reconnaissance in the field.

Acknowledgments

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