Optimized design of Unmanned Combat Air Vehicle weighing 10,000 pounds

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***Abstract*— Ghost HS-1 is an unmanned combat aerial vehicle weighing about 10,000 lbs capable of carrying armament weighing up to 3000 lbs at seven hardpoints. The UCAV has a range of 900 nautical miles with a take-off and landing distances less than 1200 ft. The maximum Mach number that the aircraft can achieve is 0.45 and the maximum ceiling for the possible flight being 55,000 ft. the designed UCAV has an endurance of fourteen hours along with the gliding range of one-ninety nautical miles at a minimum angle of 2.37 degree. This feature helps in the scenario of powered off flight during any emergency as well as allows the UCAV to glide till the terrain clears enough for it land in case of low fuel warning. The designed UCAV is controlled by personnel sitting in the ground station.**

The designed UCAV can perform all the functions generally attributed to vehicles of such categories such as combat support (sometimes in swarms), reconnaissance, intelligence gathering, maritime patrol, Search and Rescue (SAR) support, playing decoy, Air-to-Ground and Air-to-Air Combat; without endangering the lives of military personnel.

The paper will focus on the optimization of different parameters for most desired output by the personnel operating the UCAV. Different capabilities can be optimized the UCAV pertaining to the specific use. Different parameters enhance different capabilities of the UCAV.

***Keywords*— UCAV, Optimization, Range, Endurance**

I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs) have been deployed by several armed forces since the 1960s, they have experienced a renaissance in the past 20 years. More recently, UAVs have evolved from a reconnaissance system (a combat-supporting system) to UCAVs (actual combat system).

The border between UAV and UCAV is a thin and grey one. An Unmanned Combat Aerial Vehicle (UCAV), or most commonly known as a combat drone, is a lethal type of a UAV that contains armaments such as firearms, explosives or missiles and is used to carry out lethal strike missions. The beauty about the UAVs is that they have no onboard human pilot. They are remotely-controlled or can fly autonomously based on pre-programmed flight plans or more complex dynamic 'self-thinking' systems. This means that these drones do not get tired or hungry and can work for hours. Still, most drones are usually under real-time human control and the equipment that is required for a human pilot such as the cockpit, armor, ejection seat, flight controls and environmental controls for pressure and oxygen are not needed since the operator runs the vehicle from a remote terminal, usually from a ground station, resulting in a lower weight and size than a manned aircraft. UAVs typically rely on a single propeller engine and are slower and less maneuverable than manned high performance aircraft.

The most common roles for UCAVs include:

- Combat Support (Sometimes in Swarms)
- Reconnaissance
- Radar, Optical and/or Electro-Optical Sensors
- Intelligence Gathering
- Maritime Patrol
- Search and Rescue (SAR) Support
- Survey and Mapping
- Non-Deadly Combat Role
- Electronic Countermeasures and Electronic Warfare (Mainly the Suppression of Enemy Air Defenses – SEAD)
- Decoy
- Air-to-Ground and Air-to-Air Combat

Generally, all UAVs are simple systems having an inherent combat capacity – one just has to replace a non-deadly payload with a deadly one. They need limited investments whereas the term UCAVs, is generally used for a high-performance vehicle, capable of high speed, long range and heavy weapon load and are therefore, exponentially more expensive and will, like other large systems such as combat aircrafts and air defense missiles, need significant investments.

II. LITERATURE REVIEW

The field of Unmanned Aircraft Systems (UAS) is very broad, covering myriad missions and system types. Those who are new to UASs may think of one particular system that embodies the essence of unmanned systems. It might be the Predator medium-altitude, long-endurance UAS that achieved fame in the recent conflicts in Afghanistan or Iraq. The system might be a hand-launched, man-portable system such as the Raven. Others may think of UASs as sophisticated versions of model aircraft or as simply aircraft without pilots. All of these perceptions are true to some extent, but these do not paint the full picture of UASs' diversity, complexity, and capabilities (Gundlach, 2012).

There are various categories of Unmanned Aerial Vehicles (UAVs). Some of them are mentioned below.

- Micro Air Vehicles (MAVs) – weigh less than 0.5 lb
- Small Unmanned Aerial Vehicle (SUAVs) – weigh between 1 – 55 lb
- Small Tactical Unmanned Aircraft Systems (STUASs) – weigh between 55 – 200 lb
- Tactical Unmanned Aircraft Systems (TUASs) – weigh between 55 – 1320 lb
- Medium Altitude Long Endurance (MALE) – weigh between 1000 – 10,000 lb
- High Altitude Long Endurance (HALE) – weigh above 5000 lb
- Ultra Long Endurance (ULE) – Endurance greater than up to 5 days

The purpose of selecting a reference aircraft is to estimate initial values and to compare the designed aircraft with existing aircrafts. Following three UAVs are selected for nomination of Reference Aircraft.

a) MQ-9 Reaper
b) BAE Systems Mantis
c) IAI Eitan

A. *Survey of Selected Aircrafts*

- MQ-9 Reaper or the Predator B is the first hunter-killer UAV designed for long-endurance, high-altitude surveillance capable of instant action and precise engagement.
- BAE Systems Mantis is a twin engine, turboprop-powered UCAV broadly comparable to the Predator B. Its endurance is about 30 hrs.
- IAI Eitan, also known as Heron TP is an unmanned reconnaissance aircraft developed in Israel and is considered to be of the MALE category having a long endurance time.

III. METHODOLOGY

On the basis of selected reference aircraft which in our case is MQ-9 Reaper, we designed our aircraft. The specifications are constrained by our desired objectives that are in form of the under designed UCAV capabilities. Once the UCAV has been designed we calculated the expected performance of our designed UCAV to measure its capabilities against the desired specifications. After which the designed aircraft was optimized for different trade-off analysis.

IV. RESULTS

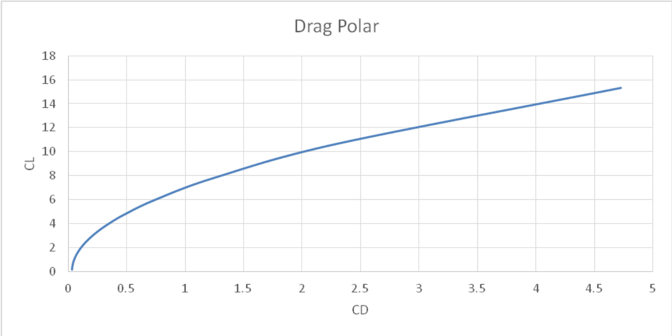

Fig. 1 Drag Polar

This graph shows how the value of CL varies with CD. It increases with increase in CD.

Fig. 2 Power Velocity Curve

1200 Hp is the power available to the UCAV. Power requirement changes with velocity.

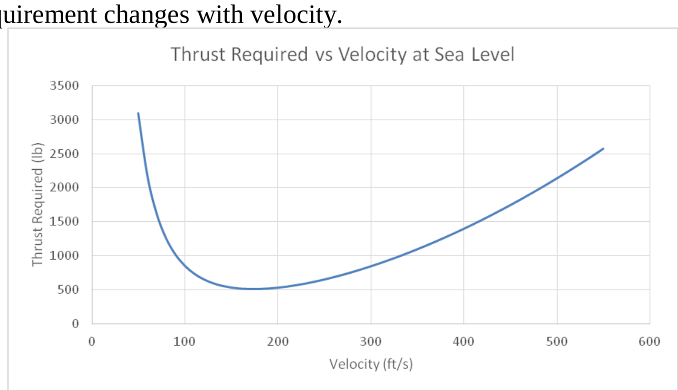

Fig. 3 Thrust Required

The thrust required is displayed with an inverted parabola.

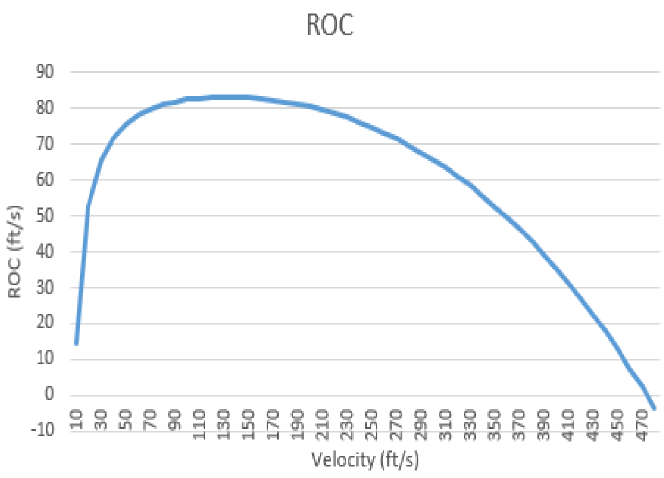

Fig. 4 Rate of Climb

Since we don't have a proper range equation for turboprop, "Aircraft Systems and Design by Jay Gundlach" assumes it to be between 50% - 80% of Range derived from the Jet propulsion Berquet Equation. Hence,

$$R = 0.8\left[\frac{2}{c_t}\sqrt{\frac{2}{\rho S}}\frac{C_L^{1/2}}{C_D}\left(W_0^{1/2} - W_1^{1/2}\right)\right] = 931.8\ nm$$

Since we don't have a proper endurance equation for turboprop, "Aircraft Systems and Design by Jay Gundlach" assumes it to be between 20% - 50% of Range derived from the Jet propulsion Berquet Equation.

$$E = 1.5\left[\frac{1}{c}\frac{L}{D}\ln\frac{W_0}{W_1}\right] = 15.44\ hrs$$

V. CONCLUSION

The UCAV can be optimized for different payloads, ranges and endurances.

Fig. 5 Payload Trade Off

Payload trade off shows the variation of gross takeoff weight with payload. Gross takeoff weight increases with increase in payload.

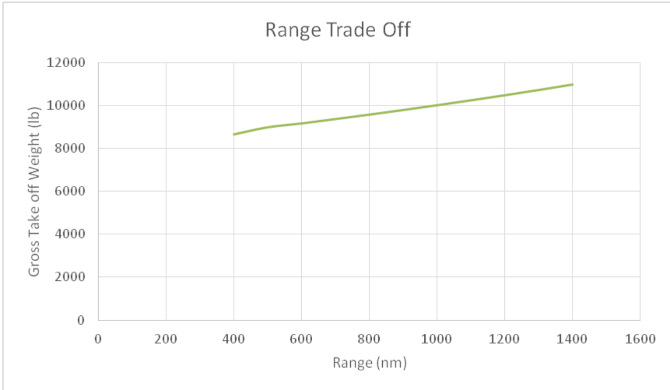

Fig. 6 Range Trade Off

Similarly for range trade off the gross takeoff weight increases with increase in range.

VI. FUTURE WORK

Future work regarding this UCAV can include designing of a more precise control and guidance system than that already developed.

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