BEYOND VISUAL LINE OF SIGHT (BVLOS) OPERATIONS FOR CIVIL UAS

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WHAT YOU NEED TO FLY BEYOND VISUAL LINE OF SIGHT (BVLOS) FOR UAS

1. **Permission**: COA, UAS with N#, Rules and Regulations

2. **Ability**: Commercial Pilot License with 3rd Class Medical Certificate

3. **Communication**: FAA-certified mode A/C/S transponder, NOTAMs, ATC contact

4. **See and Avoid Requirement**: A manned chase plane following UAS
WE FOCUS ON AIRCRAFT AGNOSTIC TECHNOLOGY NEEDED FOR SAFE AND ROUTINE FLIGHT OPERATIONS

Apollo UAT
Cooperative System. Automatic Dependent Surveillance - Broadcast 978 MHz in/out, Universal Access Transceiver (UAT) with Mode S transponder, on board processor

Zeus Radar
Non-Cooperative Collision Avoidance System

Hermes Link
Secure BLOS data link
TWO TYPES OF AIRCRAFT

• Cooperative – aircraft that are electronically identifying their position (>90%)
  – These aircraft are 130-150% less likely to be involved in a mid-air collision
  – Ads-B/Mode S equipped

• Non-Cooperative – aircraft that are limited to visual identification (<10%)
  – These aircraft are the #1 threat to avoidable mid-air collisions
  – Legacy/small UAS
Zeus Coherent Radar
- Operates at X-band and is both fully solid state and coherent
- Detects a single-engine aircraft at ranges exceeding 6 nautical miles (11 km)
- Supports air and surface target detection as well as field weather detection

Apollo ADS-B Transceiver
(Automatic Dependent Surveillance-Broadcast)
- Small, light weight, low power, and low cost
- Built-in self-separation and collision-avoidance algorithms
- 1090 MHz in & 978 MHz in/out dual frequency operation
- Capable of autonomous collision-avoidance operation under loss of link

Hermes Tracking PTU
(Pan and Tilt Unit)
- Tracking antenna system seamlessly interfaces with unmanned aircraft telemetry, FAA NextGen ADS-B transceivers and the ground radar system
- Tracking antenna and camera increase mid-air situational awareness of unmanned aircraft operator
APOLLO PROJECT SUMMARY

• If I know where you are, I can avoid you

• UASs may not be able to “see”; but they can “detect and avoid”

• By 2020, all aircraft operating in class A, B, C and some E will broadcast their ADS-B position message.

• With ADS-B In/Out, UAS’s can “detect and avoid” all cooperative aircraft in the NAS

• Work on “low hanging fruit, “ progress towards added complexity
APOLLO HIGHLIGHTS

Cost < $2.5 K (target $50)
Weighs < 1 pound  (3.5 oz for 2nd gen)
Open Architecture  Any algorithm, autopilot, display or sensor
Receives  ADS-B radio transmissions on both frequencies
Receives  FAA re-transmitted information for traffic, weather, etc.
Receives  ported non-cooperative sensor inputs: radar, EO/IR, acoustic, etc.
Transmits  self ADS-B position on 978 MHz (2nd gen sends 1030MHz if no 1090 MHz present)
Stores  available database information (e.g. - terrain, obstacles, and no-fly zones)
Analyzes, processes and smartly communicates real time assured separation or collision avoidance guidance to GCS or auto-pilot. Operates under lost link conditions.
OUTFITTING THE TIGER SHARK UASs

- Easy installation (minimal SWaP)
- COTS antennae

Apollo SS/CA

ADS-B Antenna

Autopilot Interface

GPS Antenna

II. Yuma Proving Ground
II. Yuma Proving Ground
OVERALL TESTING TRACKS DAY 5

Red – Intruder
Tiger Shark UAS with Apollo

Green – Avoider
Tiger Shark UASs with Apollo and autopilot control
Complete Situational Awareness

Purple - high flying commercial traffic (1090ES)

Yellow - UAT traffic below FL180 (978 MHz)

Cyan - TIS-B traffic transmitted on 978 MHz by FAA.

Red and Green – TigerShark UASs with AWSAS
YPG ACCOMPLISHMENTS

• **First** ADS-B *autonomous* collision avoidance in CONUS with UAS
• **First** *autonomous* dynamic modification to UAS flight plan
• UAS pilots demonstrated over-ride capability of the SS/CA
• ADS-B based Self Separation and Collision Avoidance (SS/CA) effective, reliable, and repeatable
• UAS pilots improved Situational Awareness using ADS-B
• 40+ encounters executed (single aircraft Intruder – multiple aircraft tracked)
DJI Phantom II with Apollo
SITUATIONAL AWARENESS BEYOND 50 MILES!
**Non-Cooperative Detect and Avoid**

- Will be a requirement for UAS due to ADS-B equipage laws.

- The crux of the detect and avoid conundrum for UAS. Avoid the “unknown and invisible”

- Orders of Magnitude *less safe* and *more expensive* than all-Cooperative solution.
  - Air-Based
  - Ground Based
ZEUS RADAR – LOWEST COST, HIGH PERFORMANCE SYSTEM

• All Solid state, programmable, coherent radar system
• Capable of Moving Target, Doppler, Synthetic Aperture, Inverse Synthetic Aperture and Weather detection
• Well suited to GBSAA and ABSAA
• Smaller, silent, electric vehicles or small manned aircraft are also potential platforms.

Under contract to test UAS nosecone radar with Zeus for Airforce ABSAA effort.

Zeus suitable for installation on Tiger Shark UAS.
ZEUS RADAR DETECTION OF AIRCRAFT, UAS AND SMALL UAS

Raw radar return data for the RS20 UAS and Cessna 152 (left image) and DJI Phantom 3 (right image) as seen by the Zeus Radar.
GUARDIAN EYE: A RANGE-READY BLOS SAFETY MANAGEMENT SYSTEM

• Complete package used for routine BLOS UAS operations in Canada

• Cooperative/Non-cooperative self separation and collision avoidance technologies

• Flip mounted avionics minimize set-up time, remain secured inside during hauling/storage

• Toilet
THANK YOU FOR YOUR TIME!