VIGILANT AEROSPACE SYSTEMS™

Integrated Multi-Sensor Automatic Detect and Avoid for BVLOS UAS Based on NASA Patents

FAA New and Emerging Aviation Technology
June 28, 2023

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Agenda

1. Overview of the Technology

2. Features

3. Functions

4. Technology History & Testing

5. Notable Projects

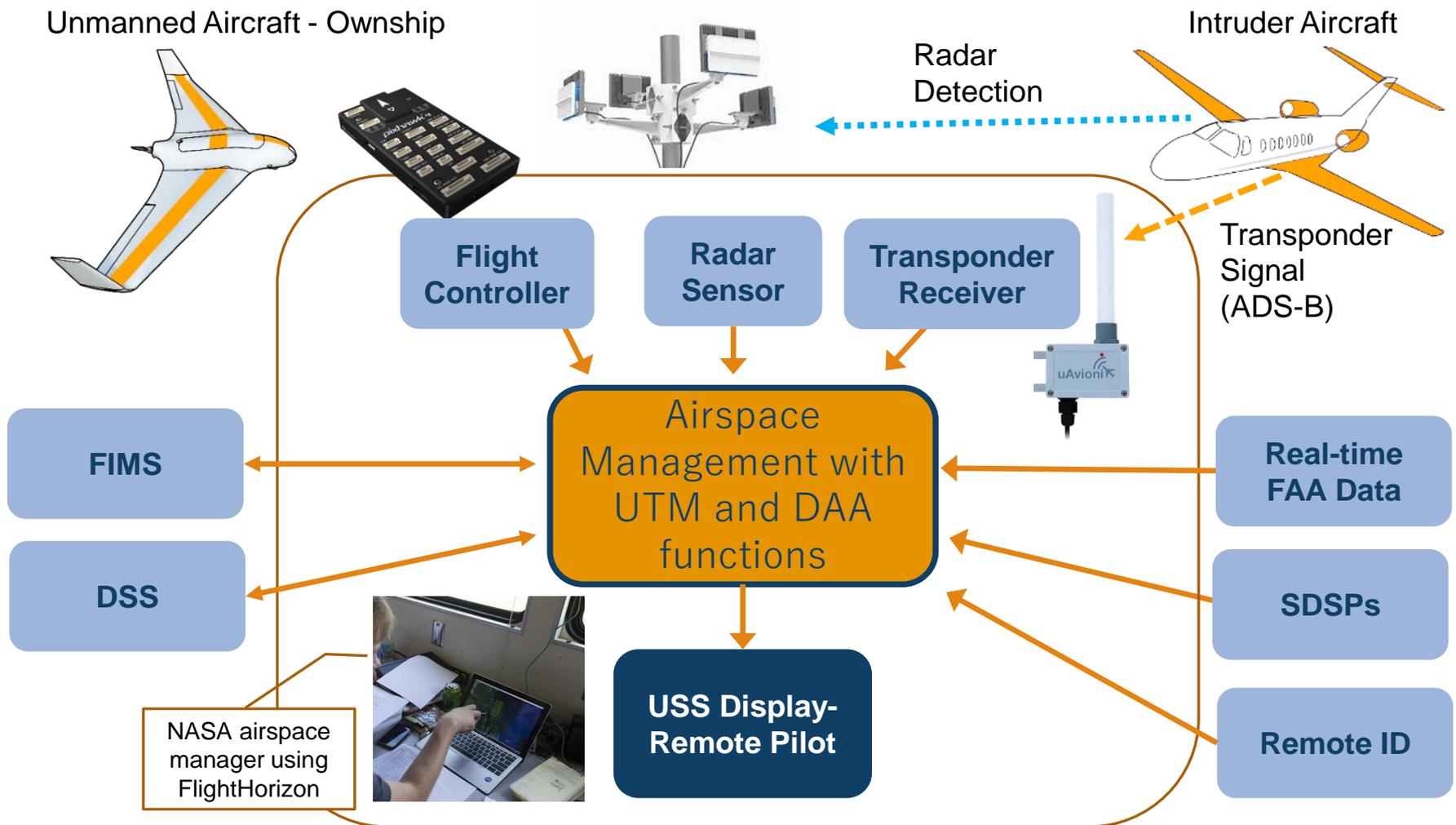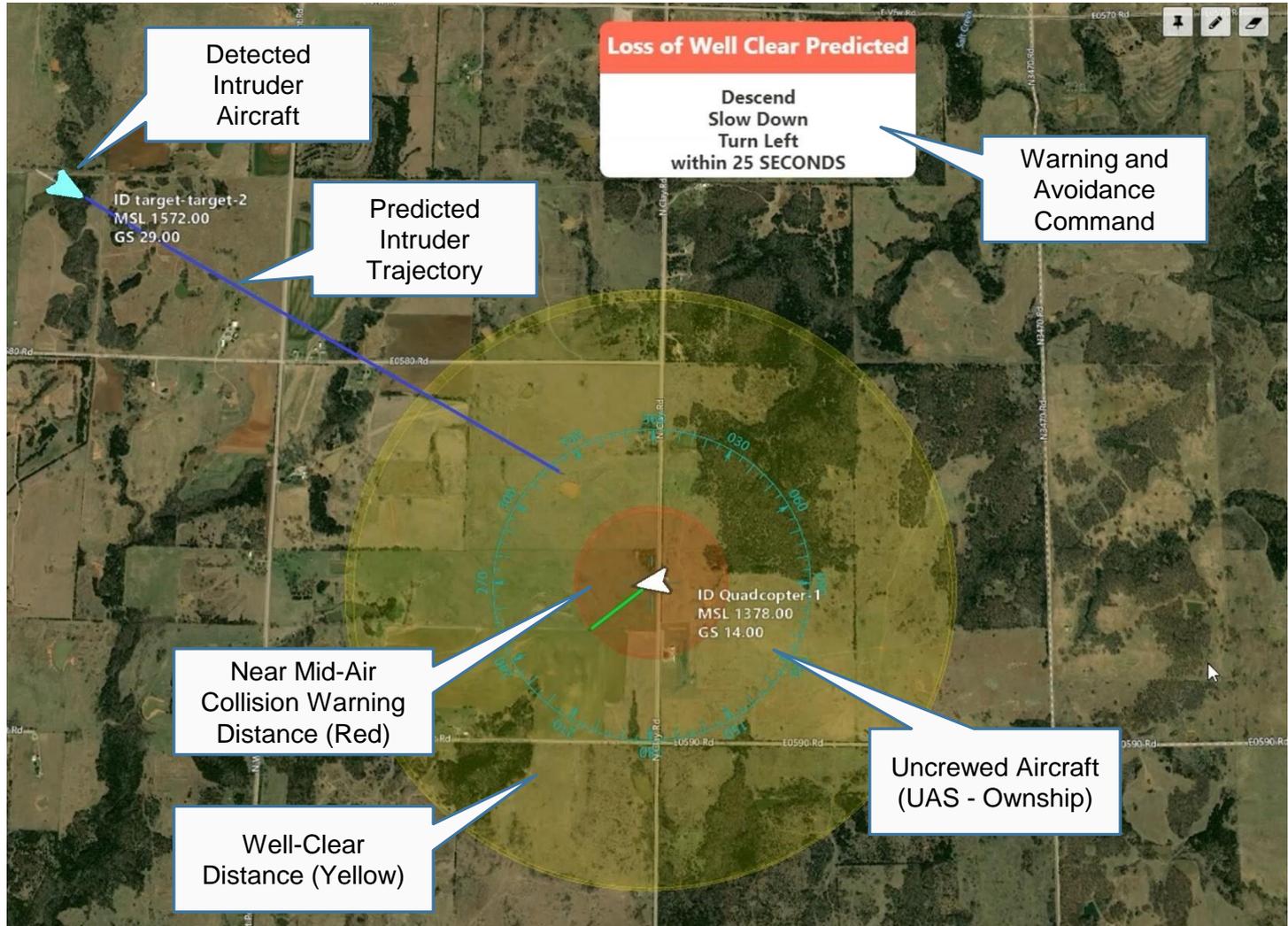6. Latest R&D Frontiers

7. Q&A

1. Overview

Overview

➢ Vigilant Aerospace Systems & FlightHorizon

➢ Focused on developing detect-and-avoid and airspace management systems

➢ FlightHorizon based on two NASA patents, projects with NASA, FAA, UAS test sites, and multiple USAF and civilian programs

➢ Fully-integrated multi-sensor systems for both ground and onboard use

➢ Use of both local sensors and online data sources and can be used online/offline
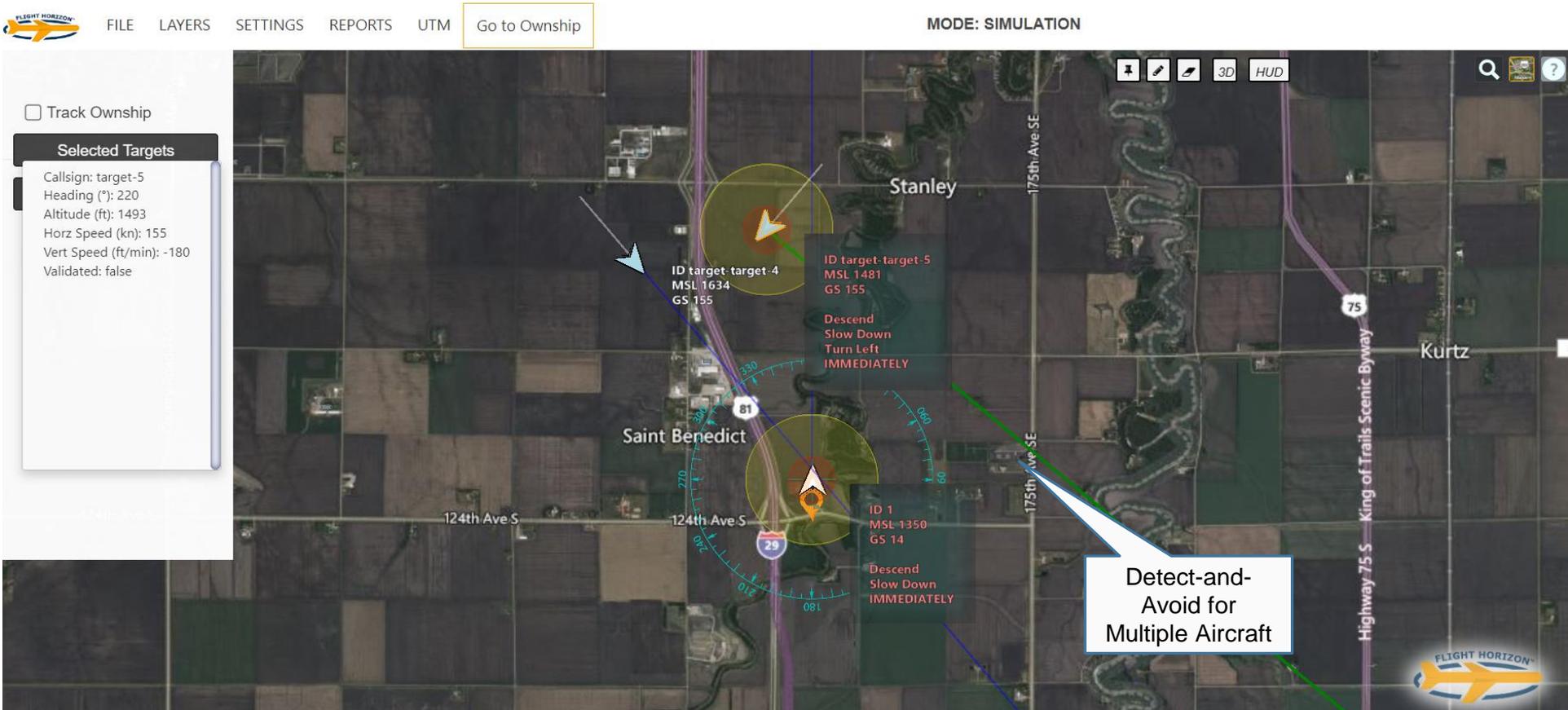
FlightHorizon System

Unmanned Aircraft - Ownship

Intruder Aircraft

Radar Detection

Transponder Signal (ADS-B)

Flight Controller

Radar Sensor

Transponder Receiver

FIMS

DSS

Airspace Management with UTM and DAA functions

Real-time FAA Data

SDSPs

Remote ID

NASA airspace manager using FlightHorizon

USS Display- Remote Pilot

Detect-and-Avoid User Interface

Detected Intruder Aircraft

ID target-target-2
MSL 1572.00
GS 29.00

Predicted Intruder Trajectory

Loss of Well Clear Predicted

Descend
Slow Down
Turn Left
within 25 SECONDS

Warning and Avoidance Command

Near Mid-Air Collision Warning Distance (Red)

ID Quadcopter-1
MSL 1378.00
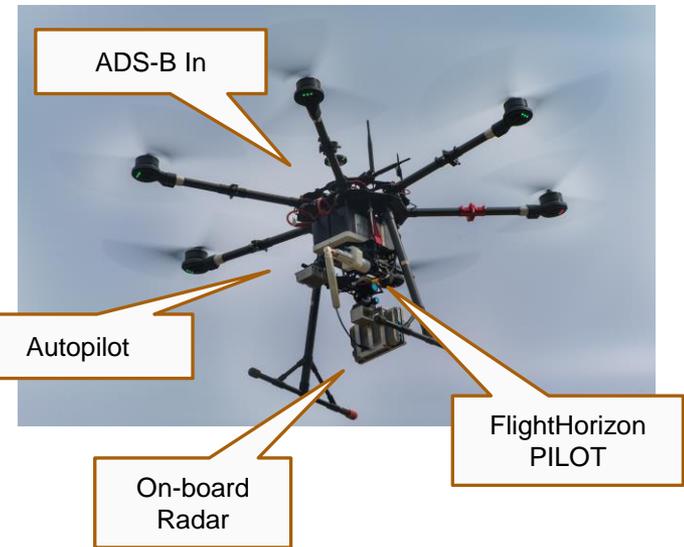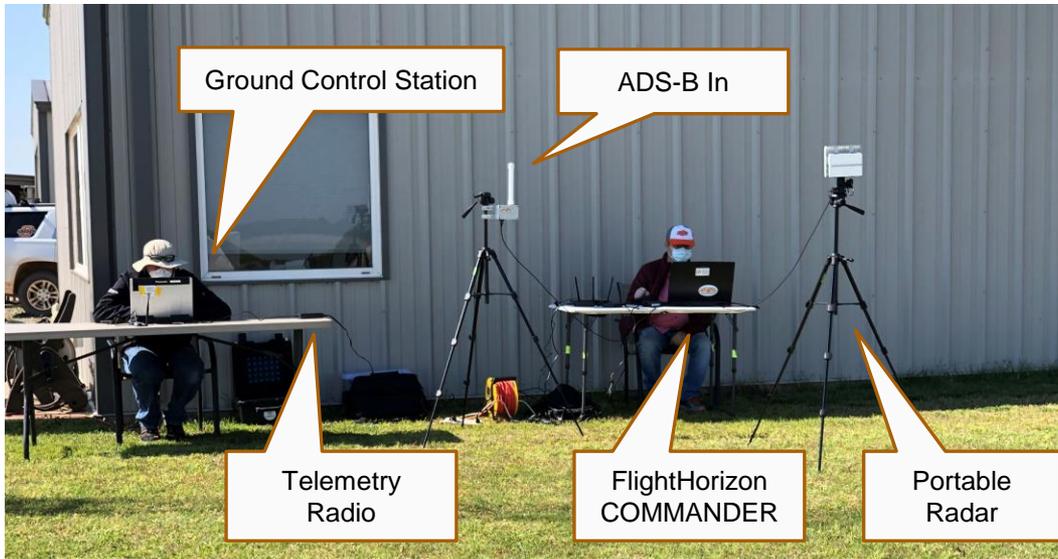GS 14.00

Uncrewed Aircraft (UAS - Ownship)

Well-Clear Distance (Yellow)

Multi-Aircraft Detect-and-Avoid

Multi-Aircraft Airspace Management with Collision Avoidance

Ground-Based or On-Board

Ground Control Station

ADS-B In

Telemetry Radio

FlightHorizon COMMANDER

Portable Radar

ADS-B In

Autopilot

On-board Radar

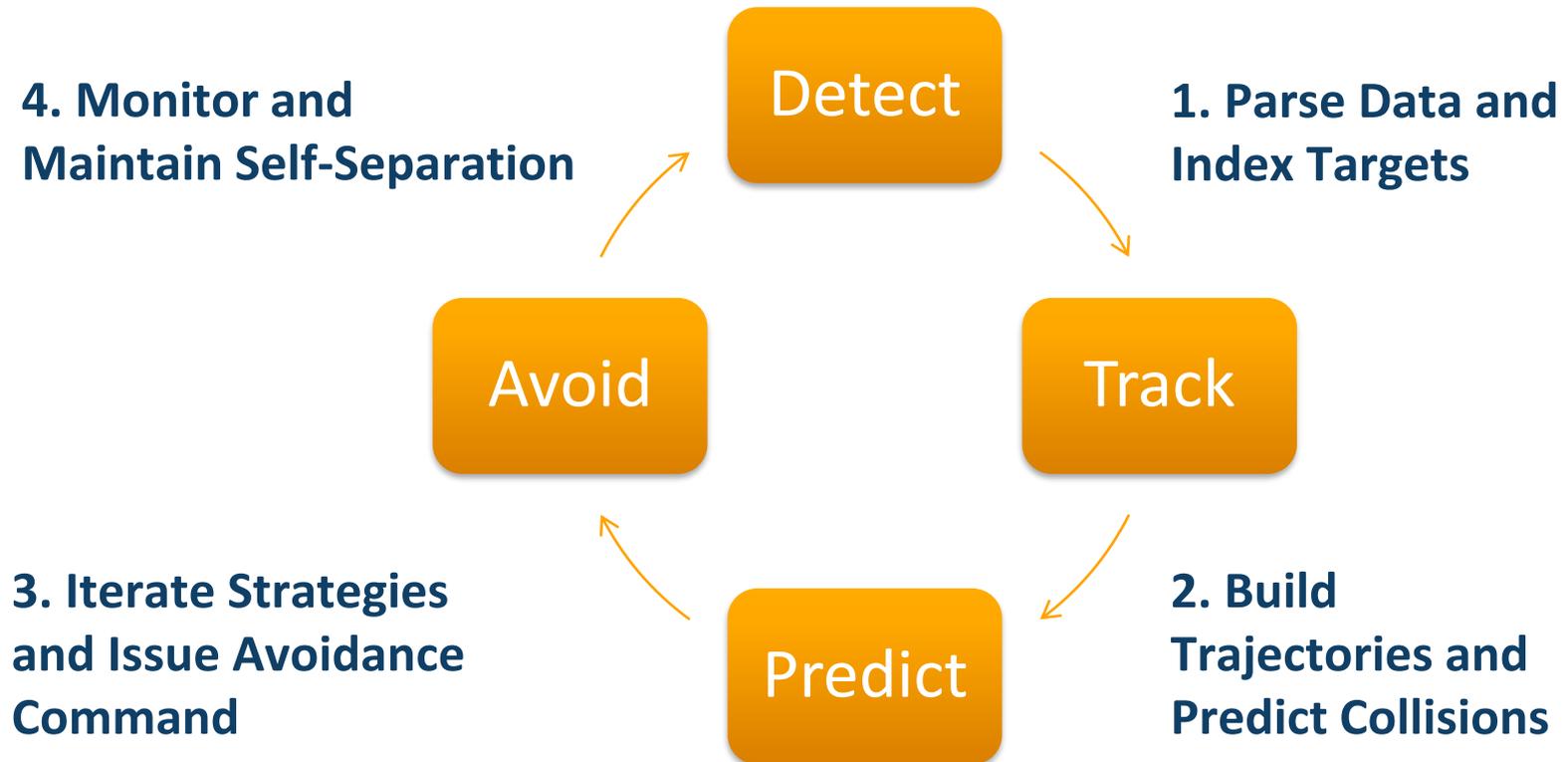FlightHorizon PILOT

2. Features

Product Features

- Prevents potential conflicts and collisions between aircraft by providing situational awareness and automatic **detect, track, warn and avoid** for UAS

- Provides plug-and-play integration with **aircraft transponder receivers** (ADS-B In), ground-based or onboard **radar**, UAS **autopilot** (MAVLink), **FAA online data**, **NWS weather data** and other sources

- **Laptop, server, cloud and on-board** versions are available and usable with **any aircraft** with rapid integration to **multiple sensors**

- Provides "**Safety-as-a-Service**" and **reduces complexity, integration costs and risk** for UAS operators, fleets, facilities and programs

- Provides built-in **concept of operations (ConOps)** and **safety case** for BVLOS waiver support and future FAA BVLOS rules

The FlightHorizon Detect and Avoid Process

4. Monitor and Maintain Self-Separation

Detect

1. Parse Data and Index Targets

Avoid

Track

3. Iterate Strategies and Issue Avoidance Command

Predict

2. Build Trajectories and Predict Collisions

FlightHorizon Versions

- **FlightHorizon COMMANDER**
  - Airspace management system; "Unmanned Traffic Management" or UTM
  - Designed for airfields, droneports, cities and states
  - Modular, scalable, extensible, modern software stack
  - On-site server or cloud-based installation
  - Fuses UAS telemetry, transponders, radars and online data to track air traffic, predict conflicts

- **FlightHorizon PILOT**
  - Onboard detect-and-avoid for single-board computer
  - Integration with on-board radar, transponder receivers, UAS autopilot and GPS

FlightHorizon PILOT

Technical Standards

➤ Why use standards?
  ➤ Consensus industry standards create agreement, certainty and technical targets
  ➤ Support investment and development
➤ Relevant Standards
  ➤ ASTM F3442/F3442M-20 – Detect and Avoid System
  ➤ RTCA DO-365b – ACAS sXu via NASA DAIDALUS II: Minimum Operational Performance Standards for Detect and Avoid Systems
  ➤ RTCA DO-366, others
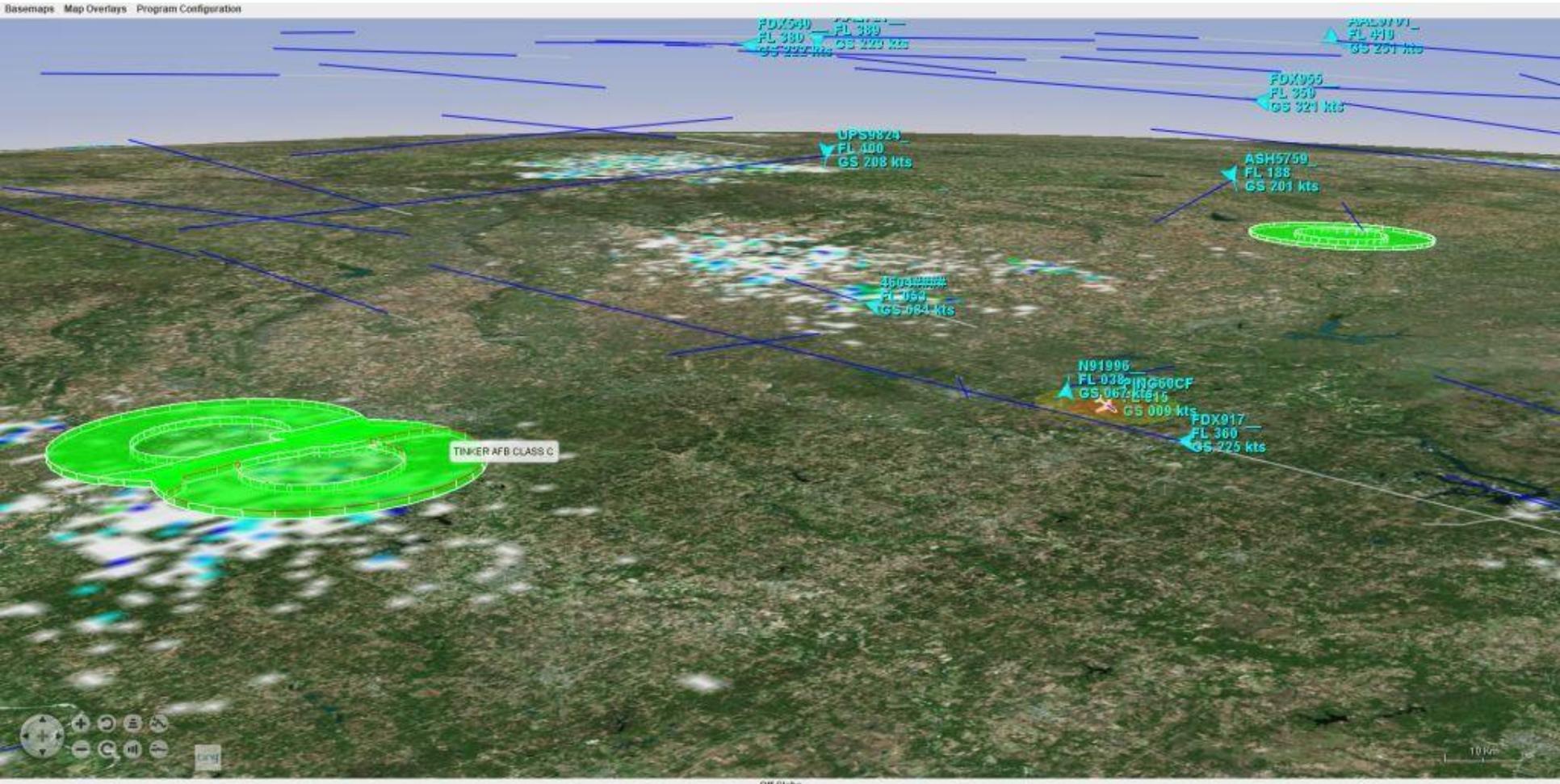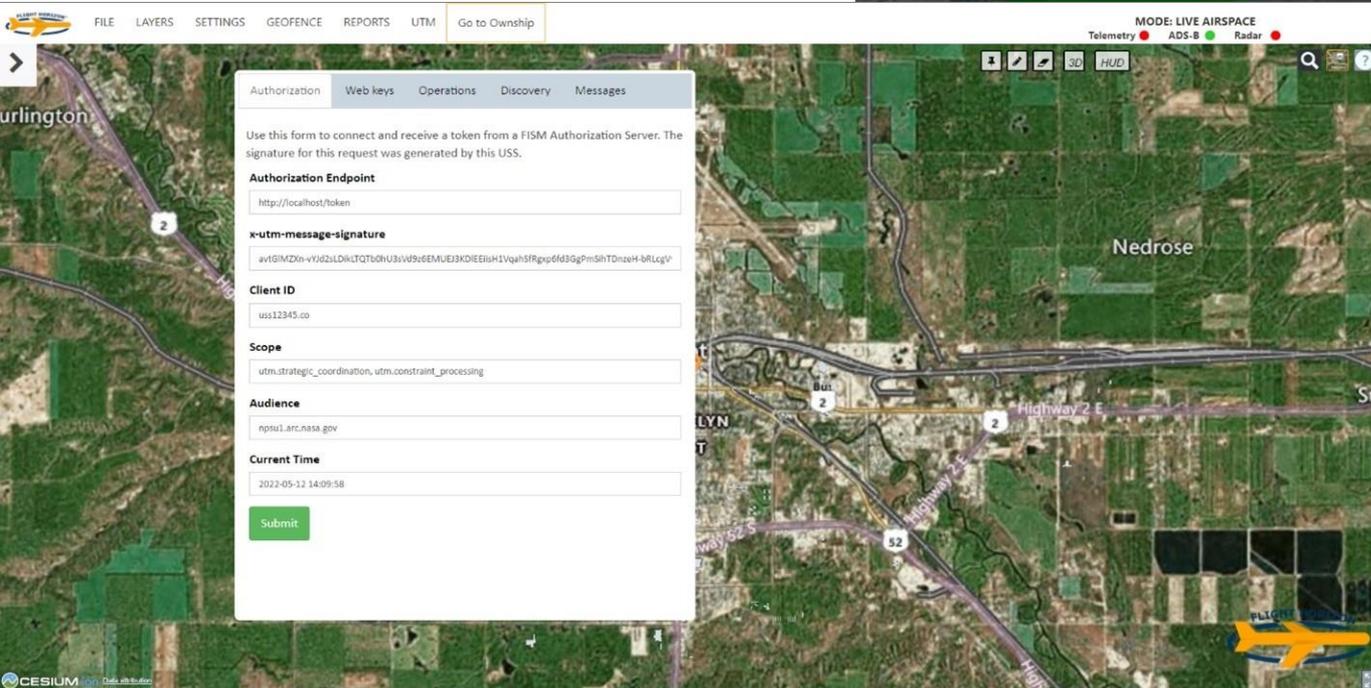 ➤ FAA AC 20-172b – ADS-B In Systems for UI

3. Functions
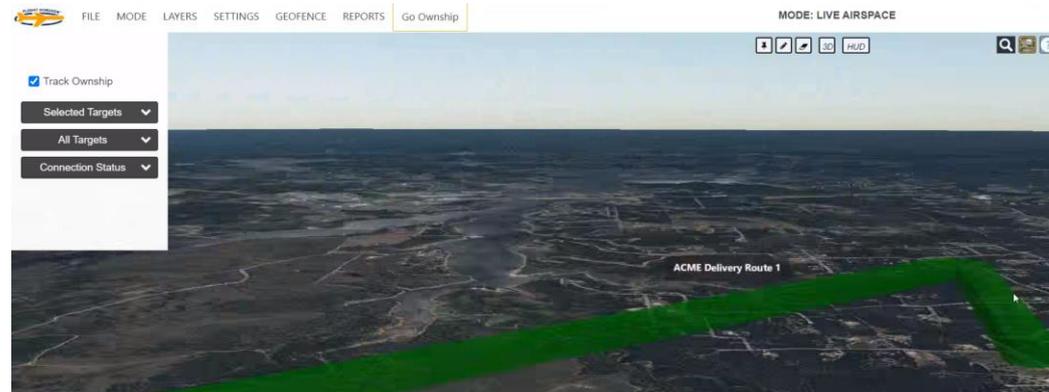
Real-time Airspace Visualization

UTM Functions

4. Technology History

Technology History

- 2013 – NASA testing, patent filing, AIAA paper publication
  - U.S. Patent No. 9,405,005
  - U.S. Patent No. 10,302,759

- 2015-2016 – Vigilant Aerospace Licensing

- 2016 – NASA BVLOS Testing, Space Act Agreement, AIAA paper

- 2017 – Commercialization, Hurricane Harvey disaster response support

- 2018 – Multiple flight campaigns, IPP program, AIAA paper with NASA on Group V

- 2020 – FAA Testing Project with ACUASI, OSU USRI radar integration, AIAA paper with OSU

- 2021 – FAA BEYOND Program, installations at Federal test sites, NASA weather hazards project, MAAP DAA testing

- 2022 – NASA IOY Award, Remote ID integration, US Army MFIX Demo

- 2023 – Multiple SBIR contract awards, commercial AAM projects
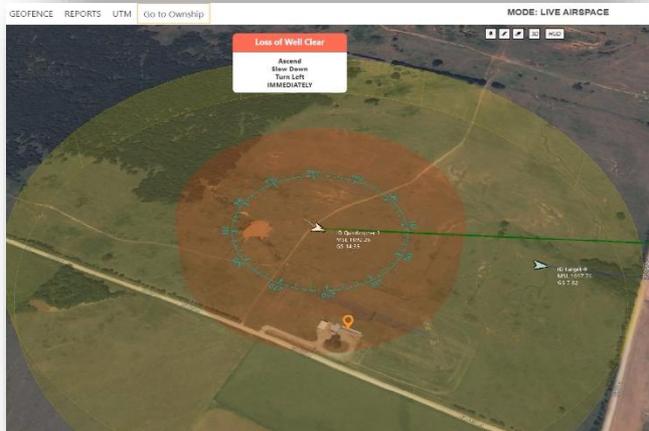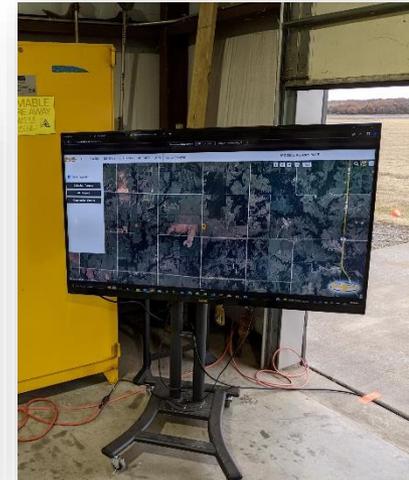
FlightHorizon for IPP Flights Over People - 2018

- FlightHorizon used to monitor FargoDome airspace during first IPP flights over people in Sept. 2018

- FAA waiver for flights over people

- Flights by CNN and Botlink

- Flights observed by FAA

- Provided validation for the "parachute standard" (ASTM)
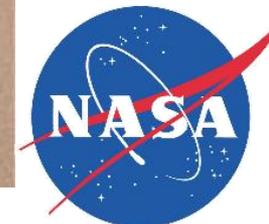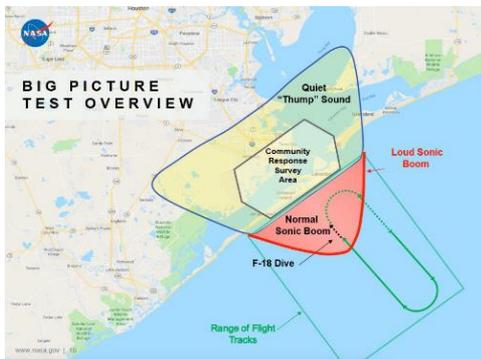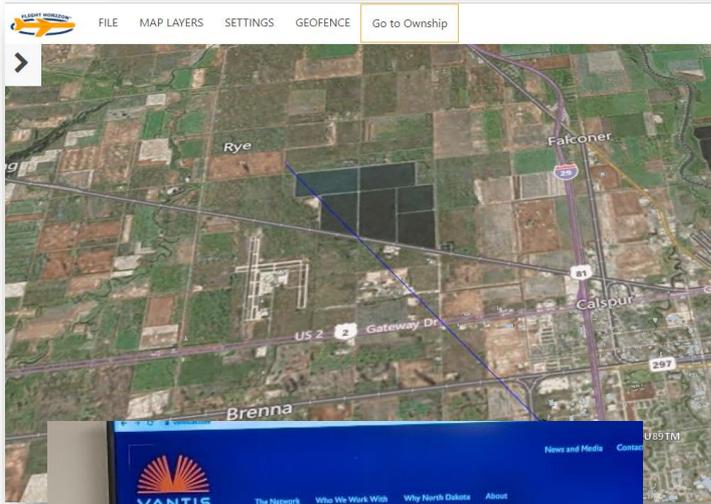
Small UAS Testing – 2017 - Present

NASA QSF18 - 2018

- NASA supersonic flights off the coast of Galveston

- FlightHorizon COMMANDER with Enhanced ADS-B for supersonic

- Airspace safety, monitoring and logging, onboard and at control center

- Detailed data collection

- AIAA publication – June 2019

Research Install of FlightHorizon at NPUASTS - 2021

- Installation of FlightHorizon COMMANDER for Northern Plains UAS Test Site (NPUASTS) in Grand Forks, North Dakota.

- NPUASTS is an FAA-designated UAS test site performing multiple R&D and demonstration programs.
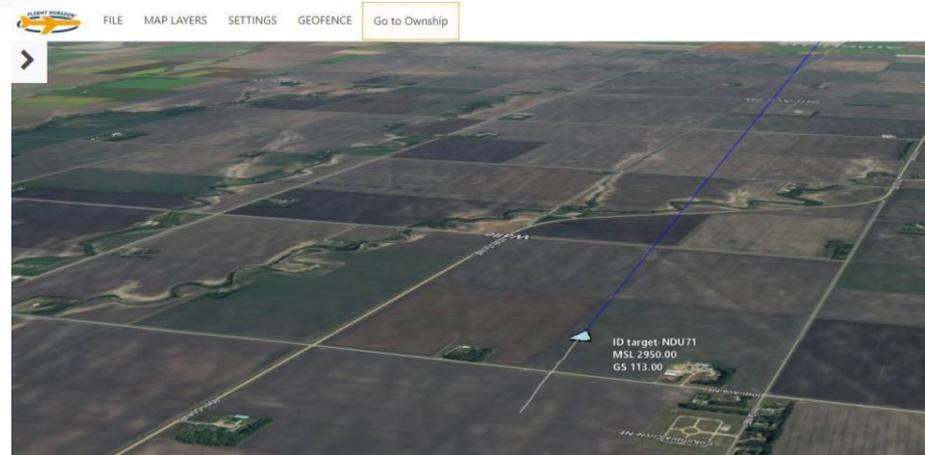
Virginia Tech MAAP National Detect-and-Avoid Trials

- November 2021 at Mid-Atlantic Aviation Partnership – Virginia Tech

- Trials with multiple companies, sensors, systems

- 80 small general aviation (Cessna) encounters over 2 days

- Used FlightHorizon COMMANDER with ADS-B In, Echodyne radar, drone telemetry

- Excellent testing results for detection, tracking, alerting and resolution advisories
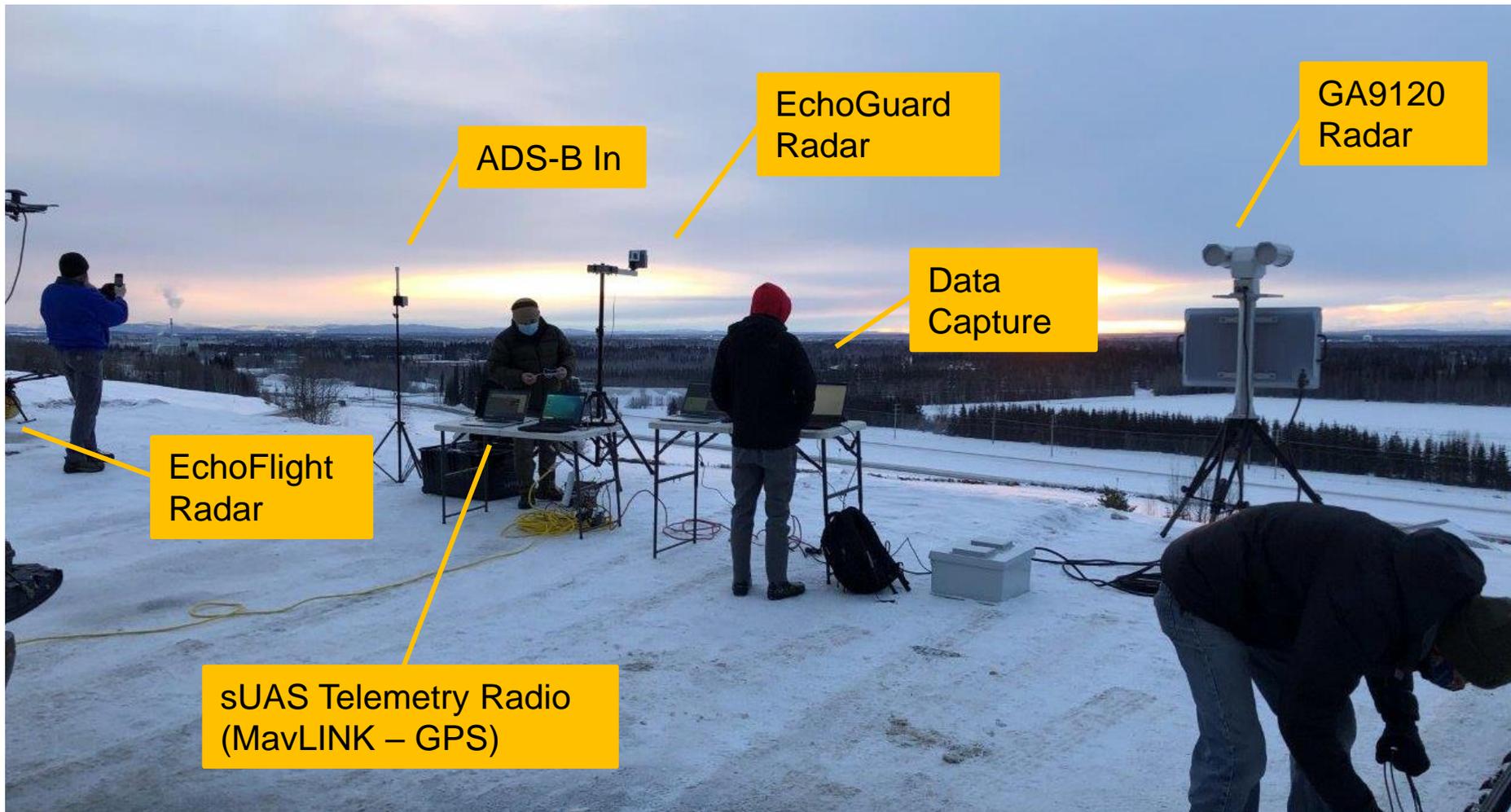
BVLOS Flights in Alaska

- FAA BAA contract for testing of multiple radars and detect-and-avoid functions – 2020-2021

- First flight of a multi-sensor onboard DAA system BVLOS on a sUAS in the US under a Part 107 commercial waiver

- Fully authorized beyond visual line-of-sight (BVLOS) flights in June 2021 with small UAS along the Trans-Alaska Pipeline

- Flown over multiple miles with no visual observers

- Had onboard radar, ADS-B In, autopilot integration, FlightHorizon computer

System Setup

GA9120 Radar

EchoGuard Radar

ADS-B In

Data Capture

EchoFlight Radar

sUAS Telemetry Radio (MavLINK – GPS)

FlightHorizon PILOT

EchoFlight Radar

Awards & Recognition

- BIS Research names Vigilant Aerospace a "Key Vendor" in its latest global sense and avoid market report, Global UAV Sense and Avoid Systems Market, Analysis & Forecast, 2017 – 2022

- Drone Industry Insights (DII) Lists Vigilant Aerospace as a market "disrupter" in its 2018 UAS technologies market map

- R&D 100 Award Finalist for 2017

- Winner of the FLC's National Excellence in Technology Transfer Award 2017

- Winner of the FLC's Far West Region Outstanding Commercialization Success Award 2016

- Federal Laboratory Consortium Far West Region - Outstanding Technology Development Award – 2014

NASA Commercial Invention of the Year Award 2021

NASA Armstrong Tech Wins NASA's Commercial IOY Award

URBAN AIR MOBILITY NEWS.COM

Detect and Avoid technology wins NASA's Commercial Invention of the Year 2021 award

📅 April 5, 2022   🏷 UAM infrastructure, UTM

NASA has announced this week that the technology licensed to Vigilant Aerospace and used in the company's FlightHorizon detect-and-avoid and airspace management product has won NASA's Commercial Invention of the Year 2021 award.

Transforming the UAS Market

The first embodiment of this technology was exclusively licensed by Vigilant Aerospace Systems in February 2016. The next is a patented DAA system that combines ADS-B and radar surveillance for detection of cooperative and non-cooperative aircraft. In June 2020, Vigilant signed a new license adding coverage for radar use in DAA and unmanned traffic management for drones. This non-exclusive license covers the use of miniaturized radar to extract target data for DAA systems on a UAS.

5. Notable Projects

US Air Force Pilot Project

- Tracking USAF MQ-9 Reaper training UAS for 49th Operations Group over New Mexico with situational awareness and traffic alerts using FAA and military data feeds
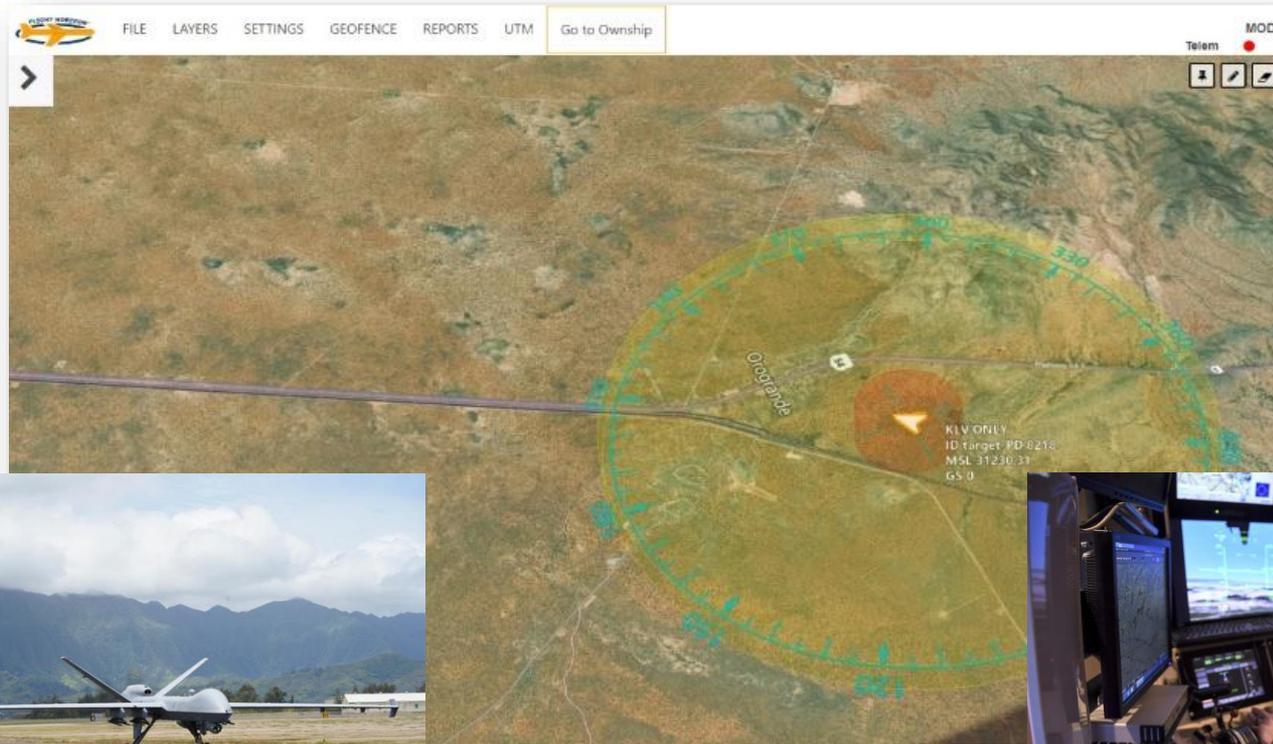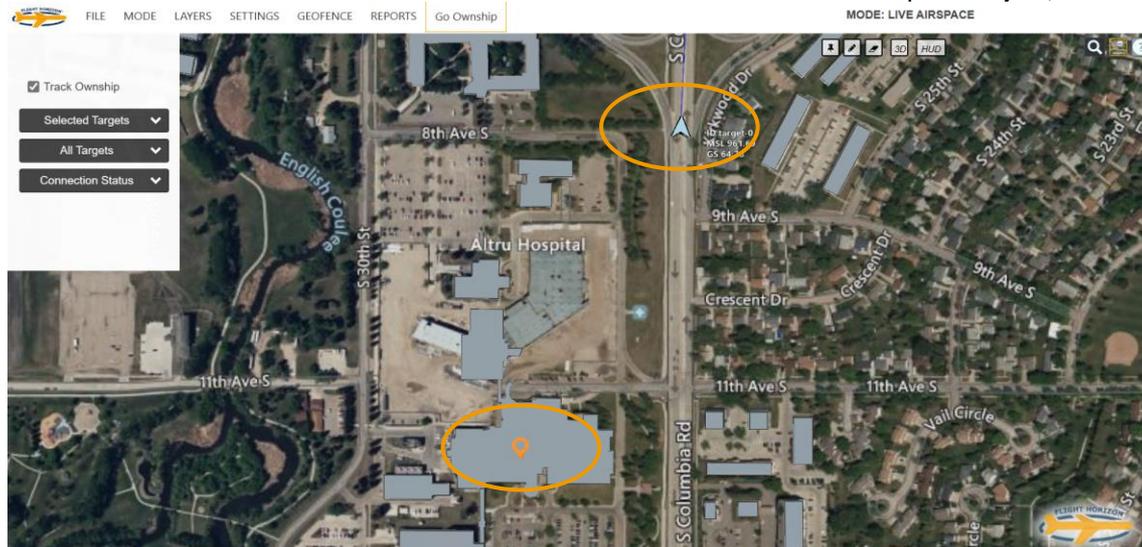
FlightHorizon at Altru Hospital for Delivery Drones

Install of FlightHorizon at Northern Plains UAS Test Site - 2021

Altru Hospital Project, 2023

OCAST Contract: FlightHorizon UTM

Project to develop large-scale, multi-radar version of FlightHorizon

New FlightHorizon USS Features – "Uncrewed Service Supplier" for UTM Integration
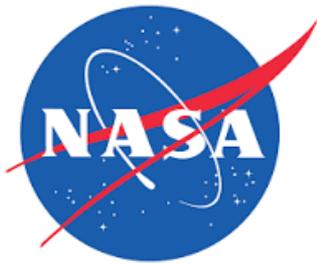
Improved multi-sensor integration and correlation

Stand-alone local/Regional UTM server in the cloud

Extensive flight-testing opportunities, corridor support

NASA ULI WindMap Project

- NASA-Funded University-Led Project

- Led by OSU - OAIRE

- Developing low-altitude weather observation, hazard avoidance, integration to ATC and UTM

- Vigilant Aerospace is the Commercial Partner for wind hazard avoidance in FlightHorizon

- Partners: National Center for Atmospheric Research, Oklahoma State University, University of Kentucky, University of Nebraska Lincoln, University of Oklahoma, Virginia Tech University

FlightHorizonX for Supersonic Flights - 2020-2026

- FlightHorizonX supersonic aircraft and spacecraft tracking

- Validating new FAA supersonic transponder standards

- Airspace situational awareness, real-time tracking, geofencing, data logging & analysis

- AIAA paper (June 2019)

USAF AFRL - DAA for Long-Endurance Platform

- SBIR Direct-to-Phase II awarded

- Must be a dual-use military-civilian product

"PHASE II: Integrate mature detect and avoid capability on an existing long-endurance, Group V UAS platform, and demonstrate the utility in several Air Force need areas for missions that are at different stages of conceptual maturity, including where conceptual development has not yet begun. Provide intermediate products to be assessed by planning teams, summarizing information that captures sensitivity of mission-level outcomes, including schedule, cost and risk, to key architecture and implementation decisions. Carry at least one flight test assessment of complete system integrated on UAS against manned aircraft intruder."

6. Latest R&D

Partnership with Pierce Aerospace for Remote ID

Pierce Aerospace has formed a partnership with Vigilant Aerospace Systems to integrate its Flight Portal Remote ID technologies into Vigilant's FlightHorizon airspace management and flight safety products.

Vigilant Aerospace has a proven track record as a provider of both Detect and Avoid (DAA) and airspace management systems for integration of Unmanned Aerial Systems (UAS) into the national airspace. The company's FlightHorizon product has been used in multiple NASA and Federal Aviation Administration (FAA) programs and is currently being deployed to support Beyond Visual Line-Of-Sight (BVLOS) flights of UAS for several corridors and droneports.

DeTect HARRIER Radar Integration
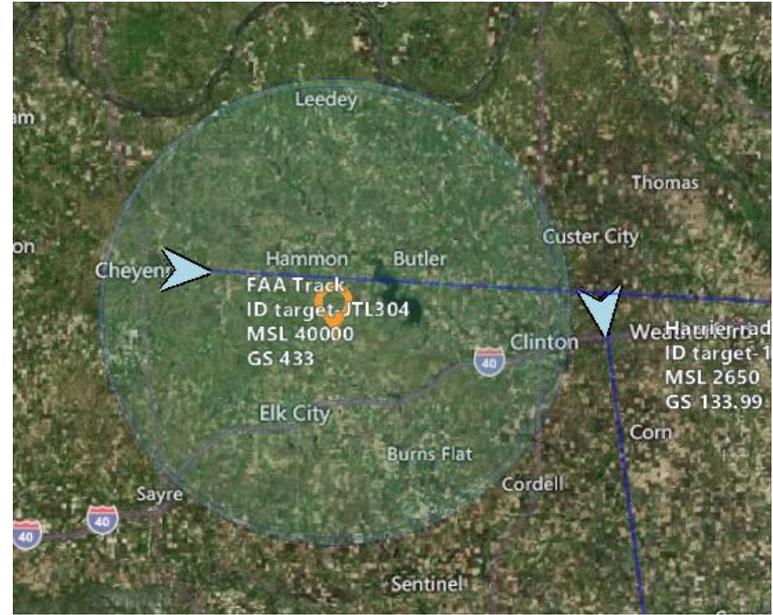
Model: S200 - BVLOS

Configuration: Fixed or Mobile

Field of View: 120° Azimuth, 12.5° Elevation

Operating Range: 360 coverage to 18nm

Features:

- ADS-B In for detecting cooperative aircraft
- Multi-functional for simultaneous detection of UAV, and crewed aircraft up to 20,000ft
- Remote access via cellular or hardwire
- Real-time display to wireless / cellular devices

Current R&D Frontiers

- ➤ Self-contained UTM platform
    - ➤ Associated Elements approach
    - ➤ SDSP standards compliance

- ➤ New sensor integrations

- ➤ New data sources, esp. weather

- ➤ Integrations to popular military and civilian GCS software

- ➤ FlightHorizonX for commercial spacecraft

Contact Us

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7. Q&A

THANK YOU!