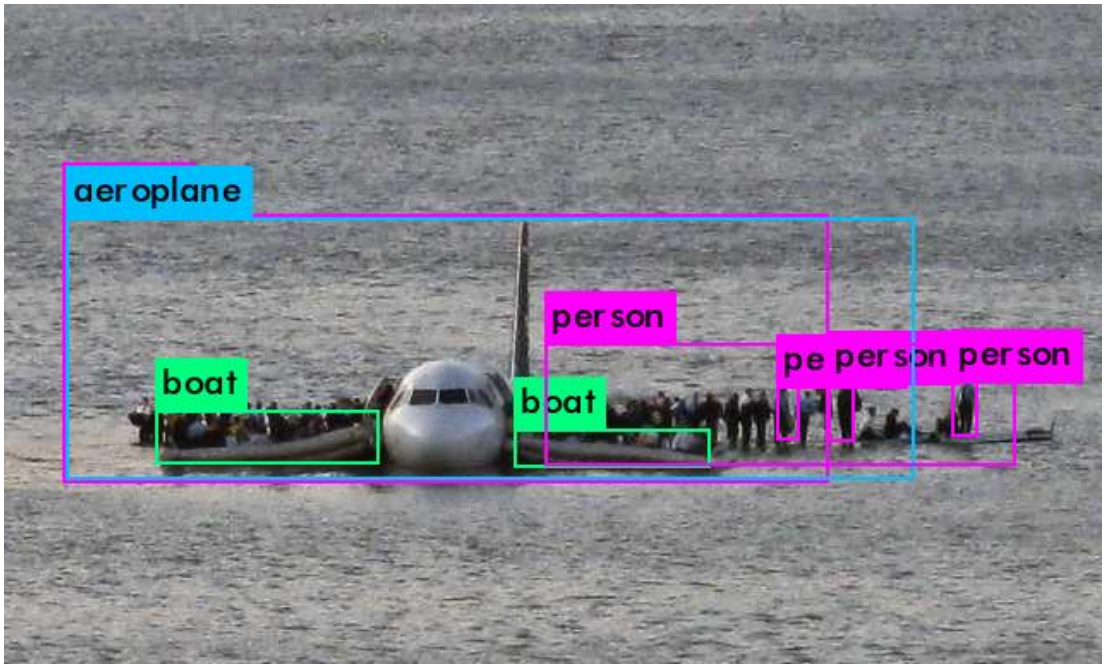
The National Academies of SCIENCES ENGINEERING MEDICINE

AI Enabled Technologies



AI Workshop Sept 26, 2019

Neil A. Armstrong Flight Research Center

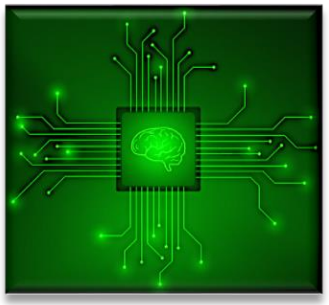
Ricardo A. Arteaga

Overview

Mission Objectives: Explore use of a sUAS capability at an aircraft crash scene to:

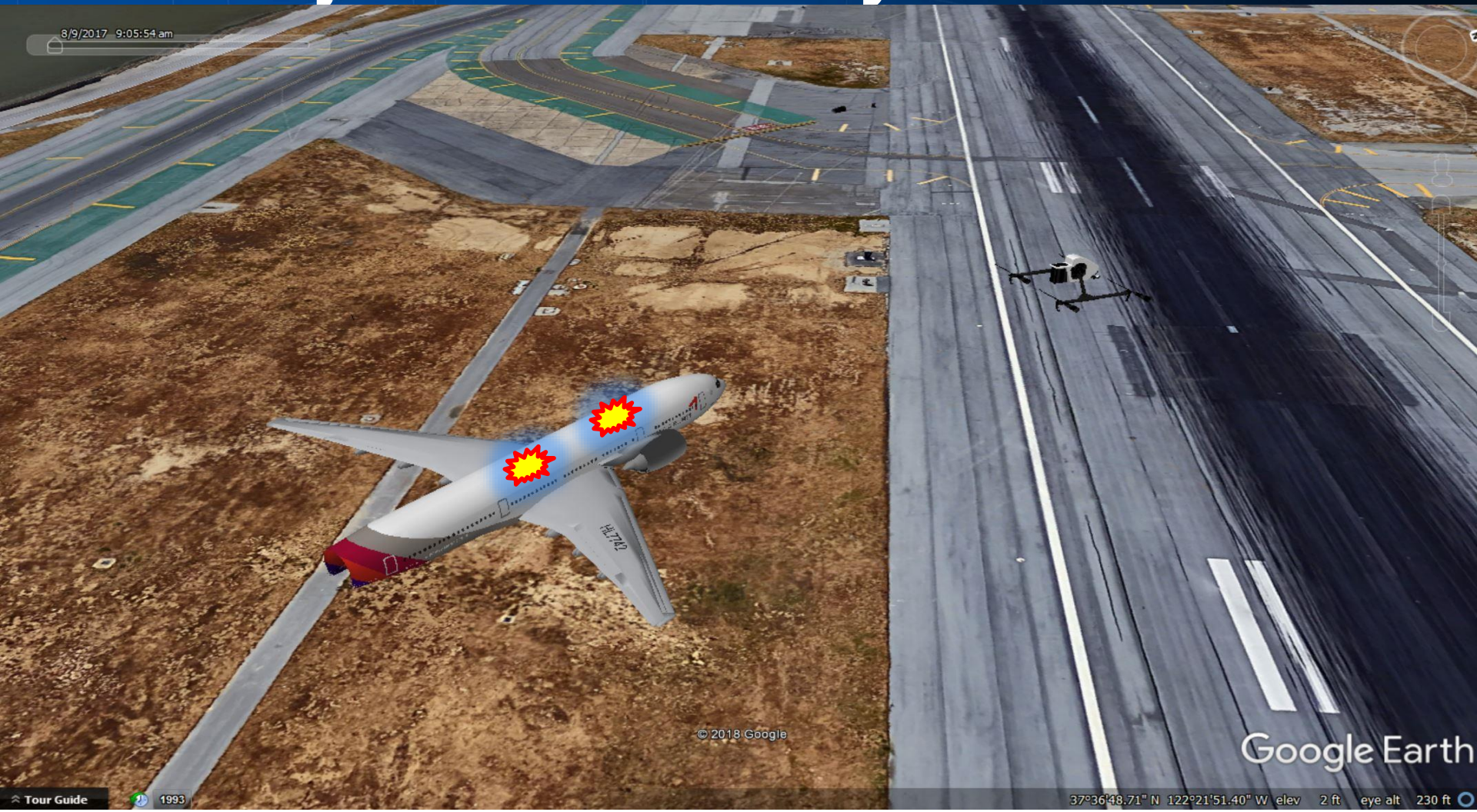
- ❑ Assist Crash and Rescue Efforts
  - ❑ Define Crash Area –security and public safety
  - ❑ Assess hazards before entry
  - ❑ Locate personnel
- ❑ Video document the site
  - ❑ Identify/locate objects
  - ❑ GPS tag/inventory individual objects
  - ❑ Enable management and EOC efforts
  - ❑ Detect/Classify the Black Box
- ❑ Stream video to AFRC Edwards location

20 Megapixel Camera



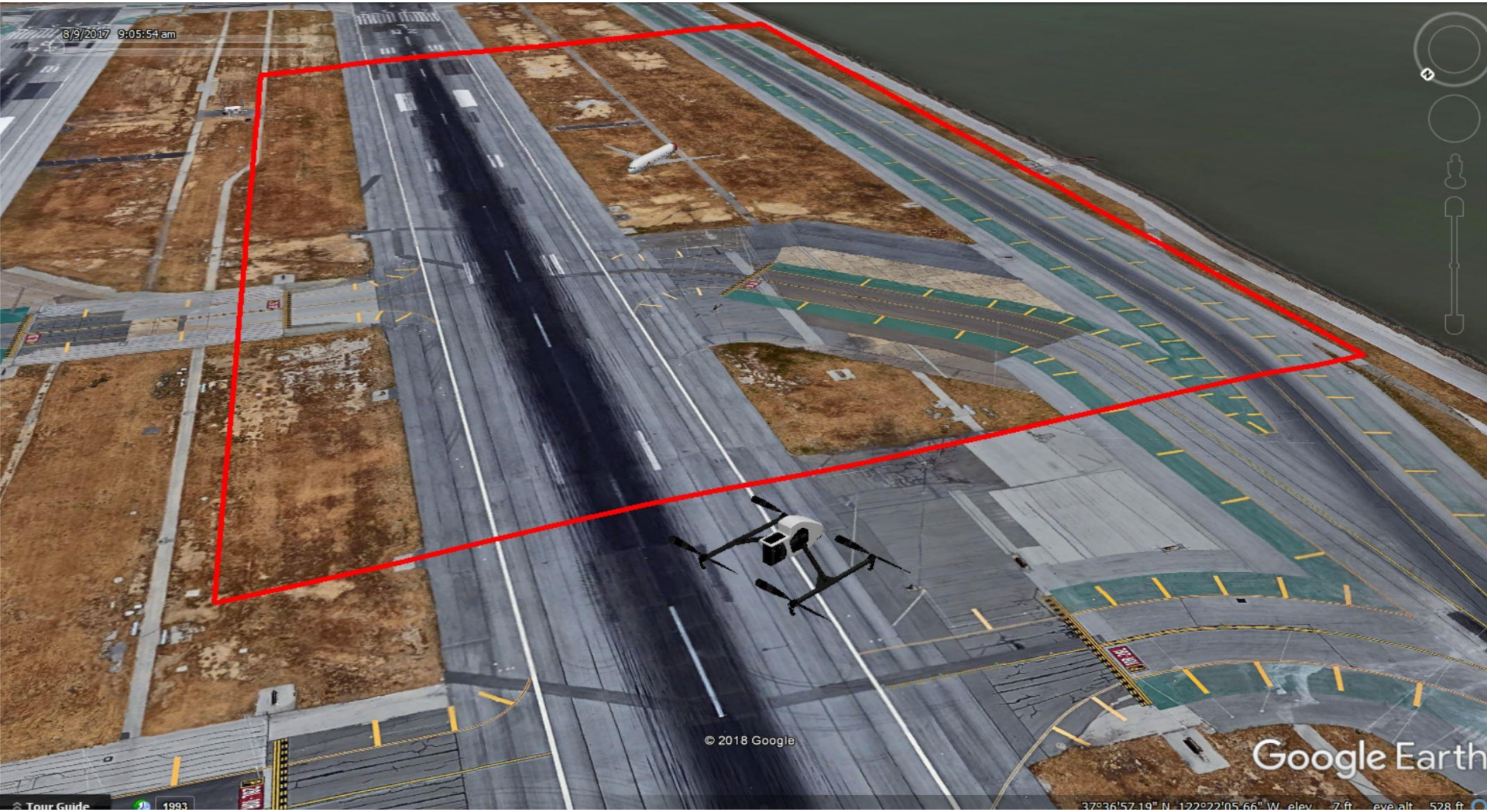
Artificial Intelligence

Mishap Demonstration
Objective 1: Survey the scene



- **Method: 4K Video and Camera imagery (20.8 MP). Concurrent with initial firefighting operations, the IRT will launch a sUAS that provides a live video feed to provide additional situational awareness for the incident commander.**

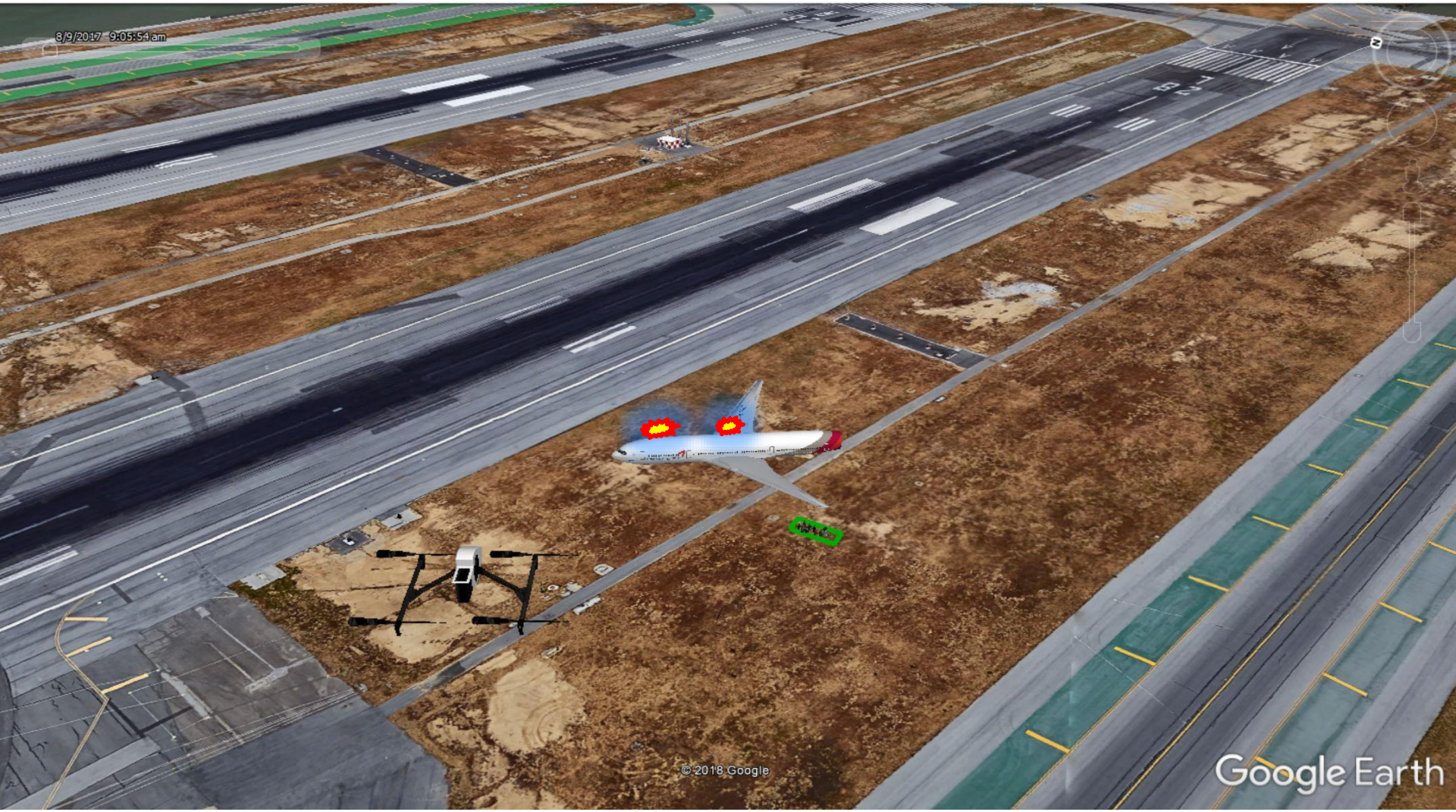
Objective 2: Secure the scene



- ❑ **Method: 4K Video and Camera imagery (20.8 MP)**

sUAS flies to altitude and provide a live video feed to outline secure boundaries for the IRT

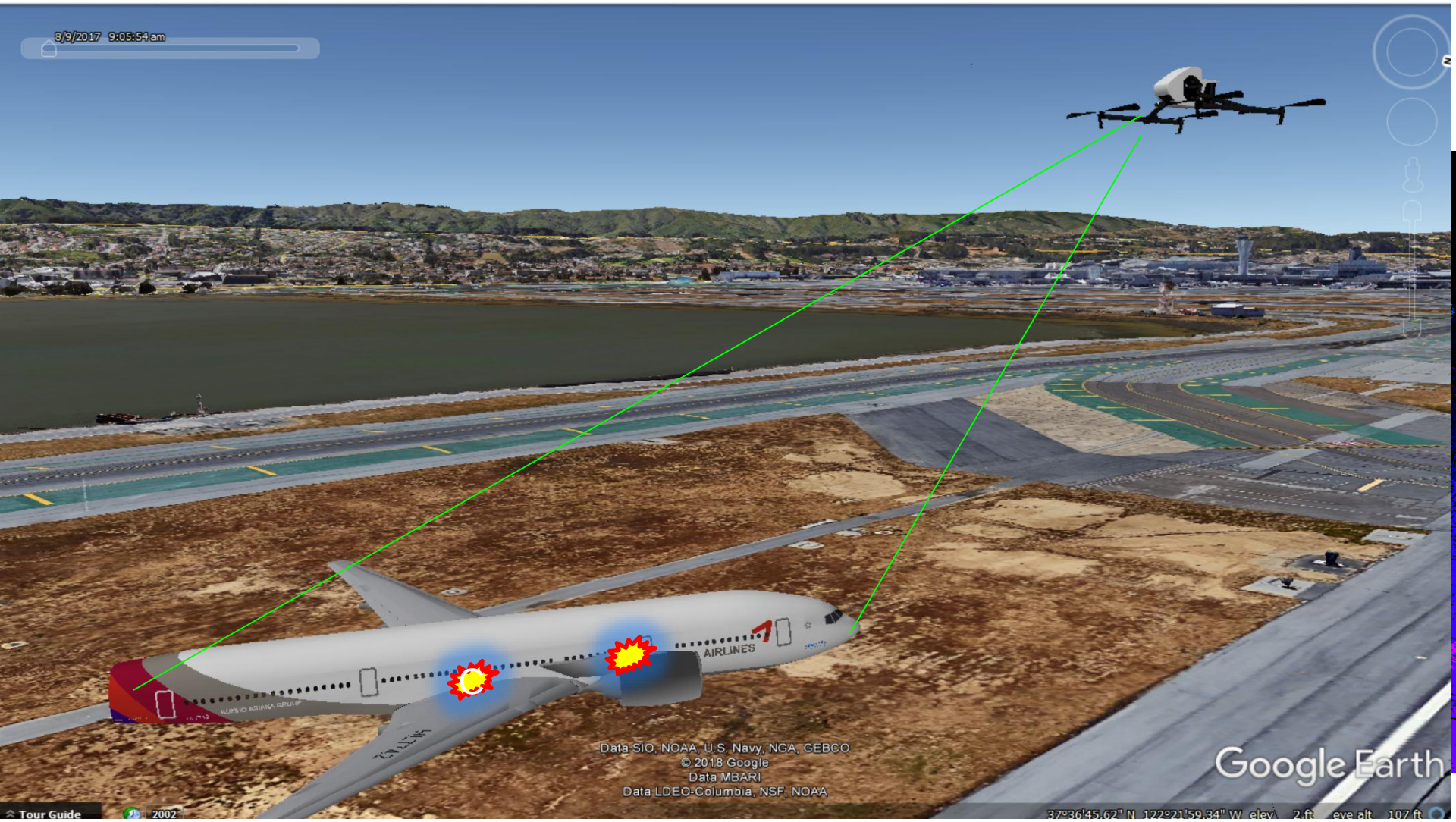
Objective 3: Identify/locate the injured



- **Method: 4K Video and Artificial Intelligence detect and classify objects in real time**

The sUAS will expedite the search for aircraft victims and explosive hazards

Objective 4: Collect evidence



❑ **Method: Using 4K Video and Camera for Debris Footprint Find the "Black Box"**

sUAS flies pre-programmed patterns and provides a live video feed to collect evidence for the mishap team.

Artificial Intelligence Algorithm

Research in Machine Vision uses a robust real-time system based on the YOLO object detection Convolutional Neural Networks (CNNs)

- Major focus is on training data and HW development
  - Iterative Process
  - Label small dataset
  - Train CNN network on small dataset
  - Use trained network to classify many images
  - Manually review and correct results
  - Incorporate new images into dataset
  - Repeat (may take up to a week)

- Neural Networks trained for detecting aircraft debris, people, vehicles another for detecting the “Black-Box”

AI CNN Detection Results

- Neural Networks for Object Detection and Tracking (speed, accuracy, and efficiency)

- Results: YOLOv2 predicts (96%) bounding box on 1080P resolution at 30 FPS video at low altitudes

Aircraft Crash Mishap Exercise

- Mission Economics based on the hazardous conditions and limited time

- Results: Video Uploaded 2.5 Mbps at 30 FPS ~ 3 second lag on Live Stream Video on MiFi

AI Enabled UAVs for Search & Rescue

- Mission Economics based on the limited mission resources and limited time

- Results: YOLOv2 predicts multiple bounding boxes on 1080P resolution at 30 FPS video.

ENHANCED ADS-B SUPERSONIC

National Aeronautics and Space Administration

NASA

NASA

ADS-B

Commercial Supersonic Technology

Introduction to ADS-B

Automatic Dependent Surveillance Broadcast

- Replacing radar for tracking aircraft worldwide
  - Prevent collisions
- Sharing position, altitude, velocity, etc. with air traffic control and other aircraft
  - ADS-B Out = Transmit
  - ADS-B In = Receive
- **FAA-mandate**
  by Jan. 1, 2020

Concept of Operations

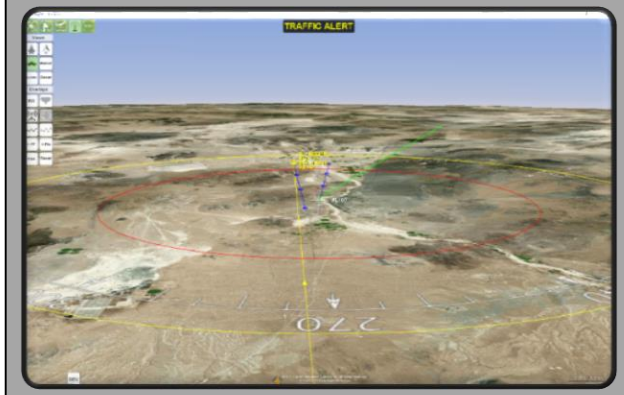
Supersonic F-18 Aircraft

ADS-B Out 1090 MHz

ADS-B Out 1090 MHz

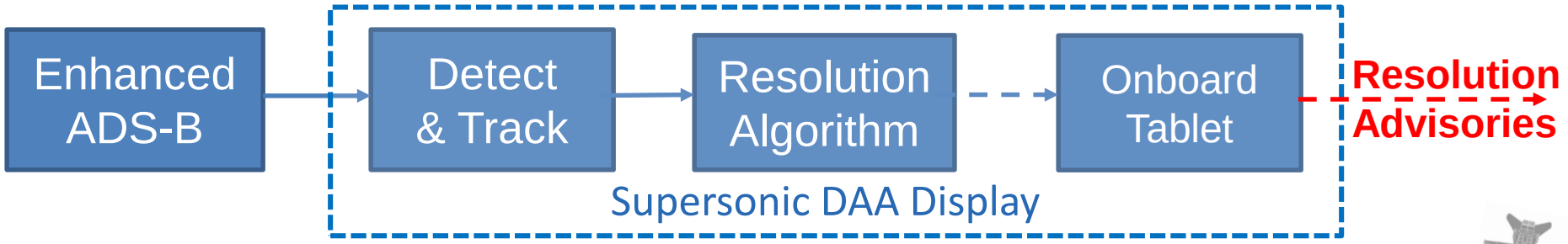
FAA ADS-B Ground Station

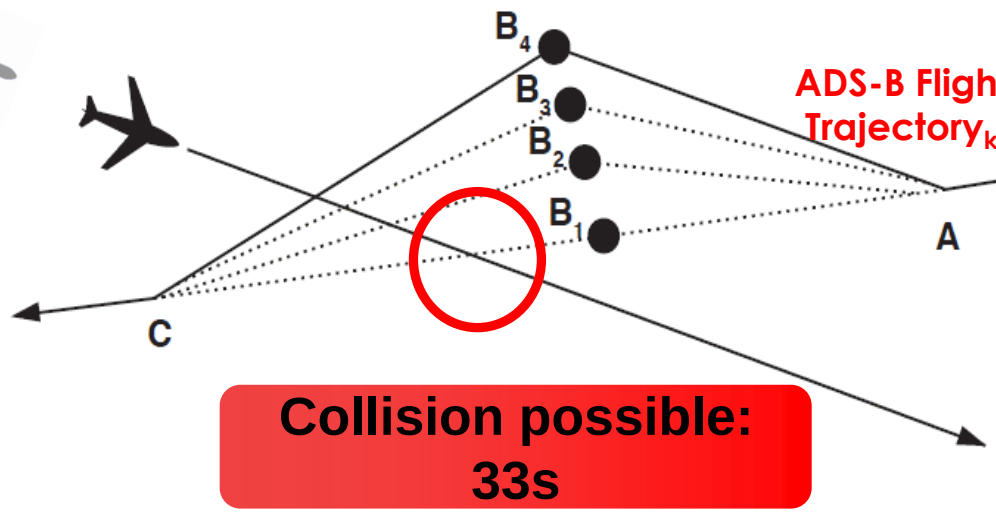
ADS-B In Ground Control Station

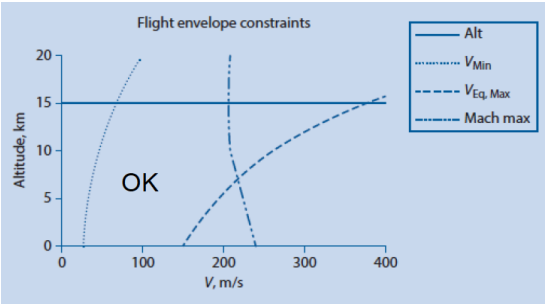


Collision Avoidance
Neural-Network Trajectory Predictions

Stratway+ Conflict Resolution Algorithm





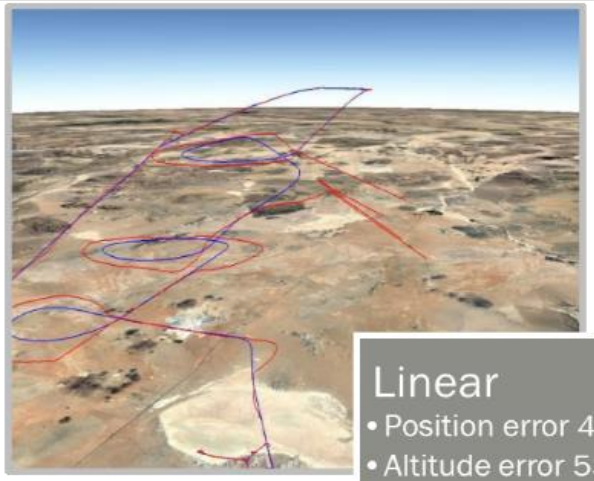


Stratway – strategies are iterated.

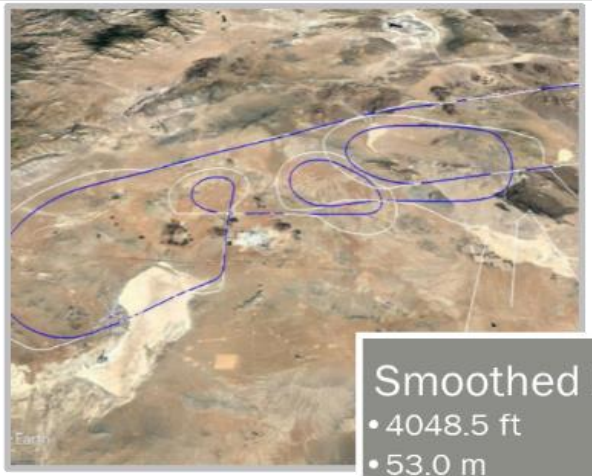
AI-Trained Neural Network
F-18 Flight Trajectory Prediction

- 10 Super-Sonic flights, 8 used for AI supervised learning, 2 used for testing

Baseline Prediction

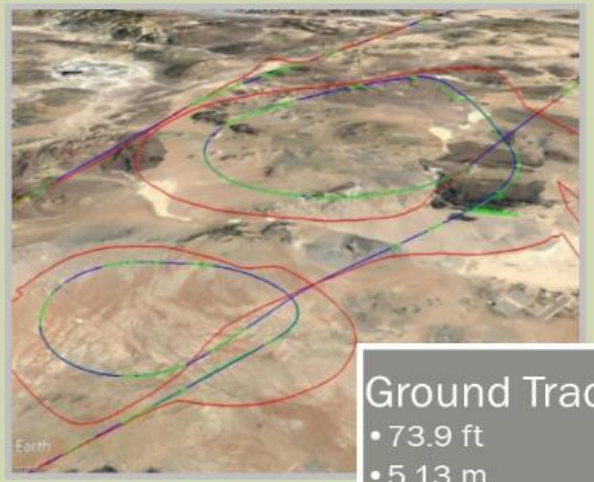


Linear
- Position error 4052.9 ft
- Altitude error 53.5 m

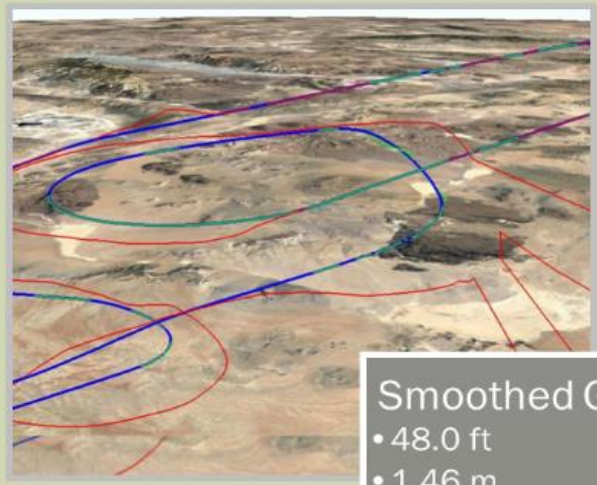


Smoothed Linear
- 4048.5 ft
- 53.0 m

Neural Net Prediction



Ground Track Angle
- 73.9 ft
- 5.13 m



Smoothed GTA
- 48.0 ft
- 1.46 m

- Trained Neural Network is required to reduced errors in ADS-B flight trajectory predictions during dynamic supersonic maneuvers for a more accurate conflict detection.

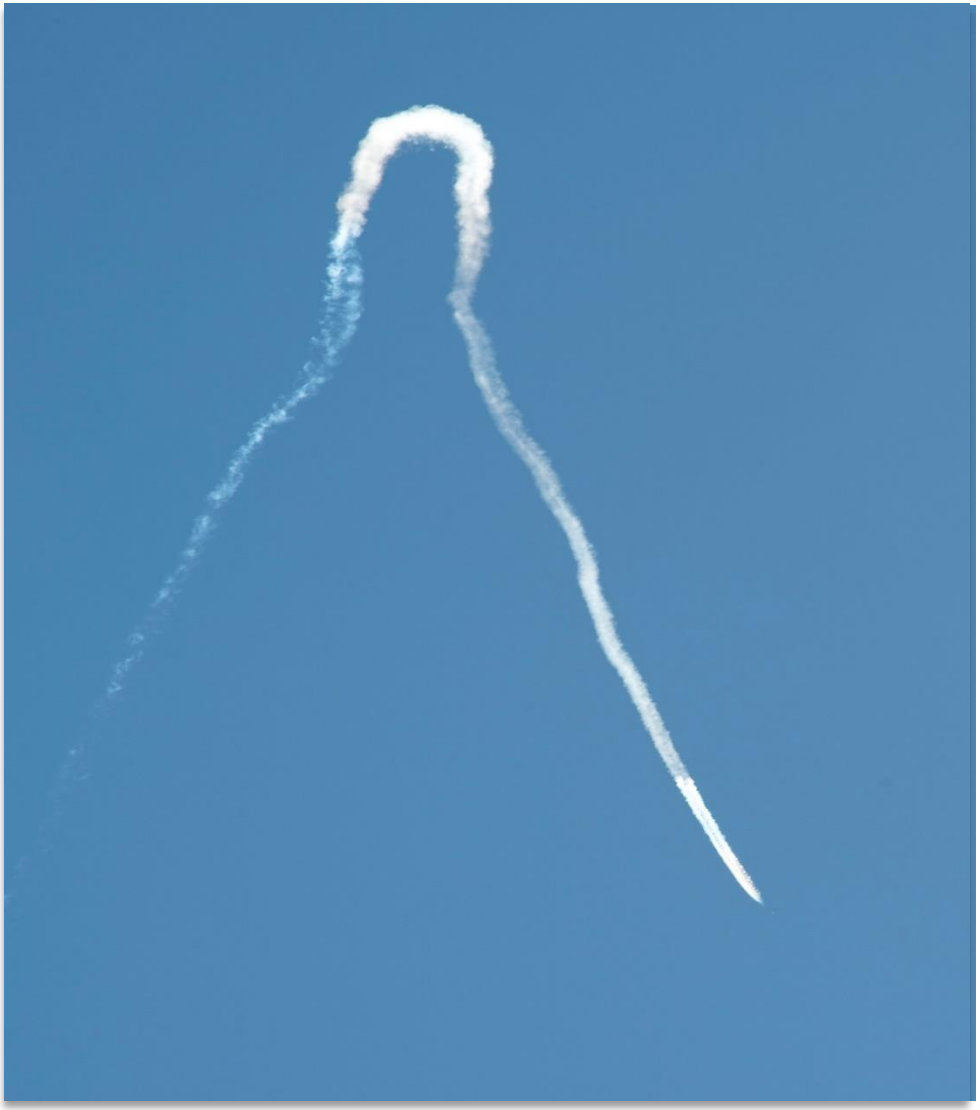
Flight Tests

ADS-B Supersonic Flight #1

First Flight of NASA 846 equipped with an enhanced ADS-B device - Sept 24th 2018.

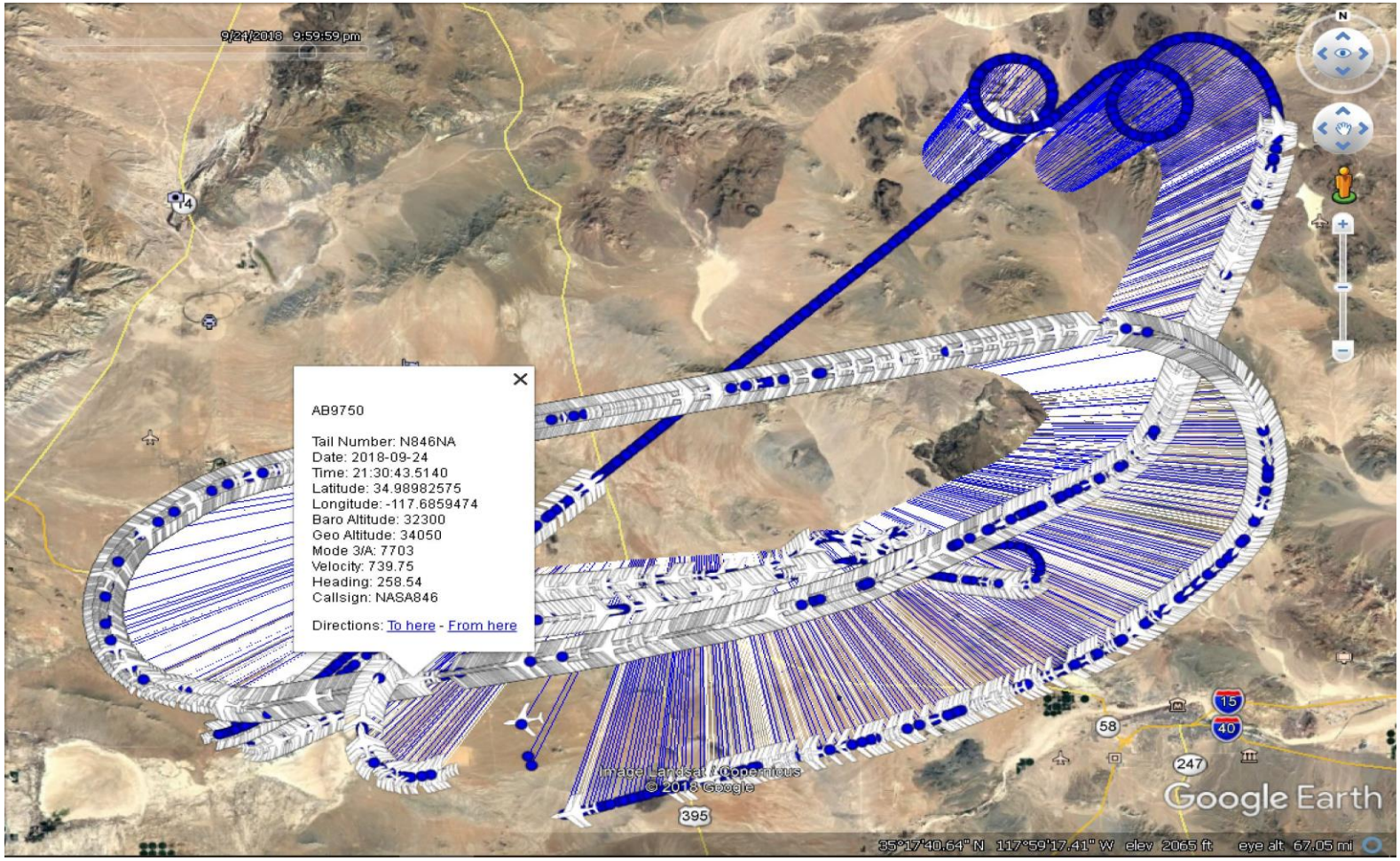
Flight Tests

NASA 846 low-boom dive flight-trajectory



Flight Test #1

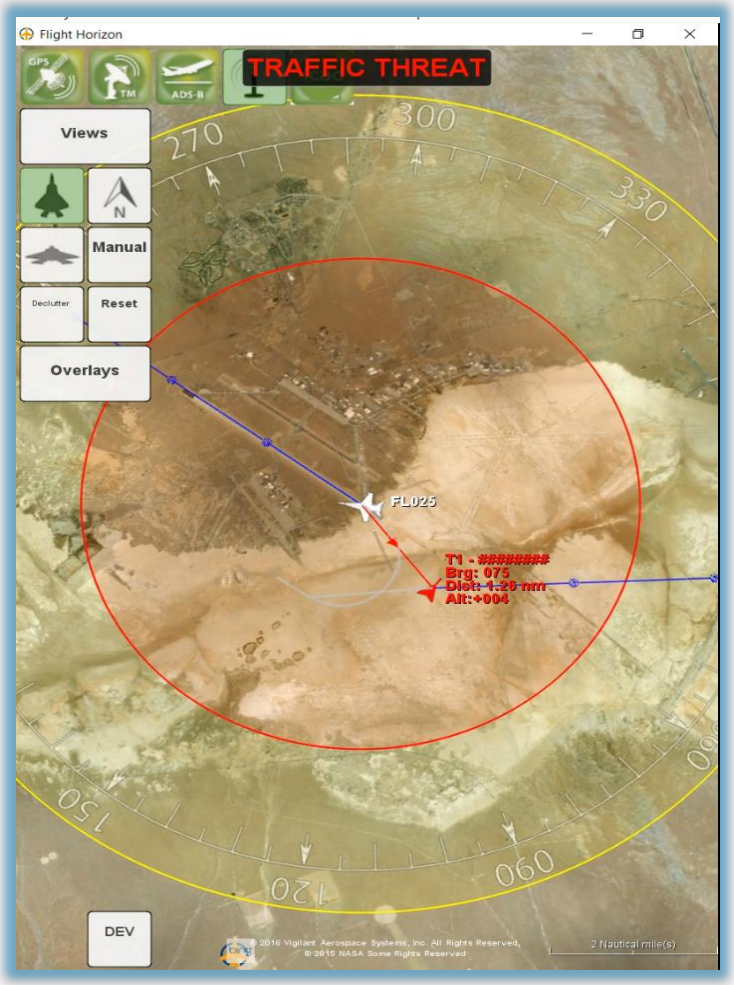
ADS-B Trajectory Profile M=1.4 FL49

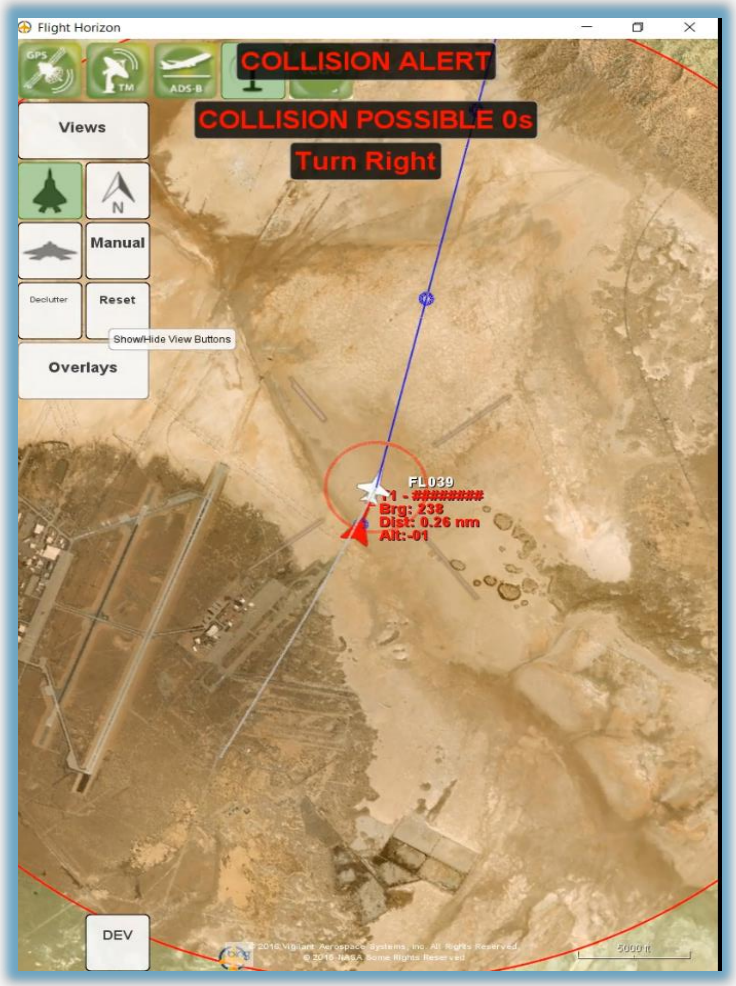


Enhanced ADS-B Flight 1- FAA NAS GBT data (blue) vs FAA local recorder (white)

Enhanced Vision Display

On board Tablet ADS-B Traffic Alerts





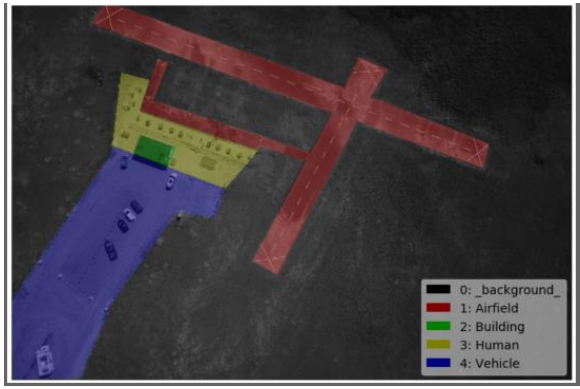
ADS-B Flight #3 - Sept 25th 2018 PM: Commands maneuver to avoid the collision

AI Challenges & Regulations

- When an AI system fails at its assigned tasks, who takes the blame?
  - Programmers
  - End Users, UAV operators
  - Blame AI for any decision with negative outcome

'HERMAL CAMERA

- Autonomous Crash Landing site selection -do no harm heuristics:
  - Avoid people
  - Avoid vehicles
  - Avoid buildings or structures
  - Avoid terrain obstacles



- Safety and ethical considerations with AI operations in specific domains.

- AI needs “Black-Box” for explaining decisions “Sully Factor”

VIDEO: Artificial Intelligence enabled UAVs for Mishap investigations

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sUAS the future of emergency response

Does not put accident investigators in harms way