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Name: Kraettli L. Epperson

Title: Developing and Testing Real-World Beyond Visual Line-of-Sight Detect-and-Avoid for Unmanned Aircraft Systems

Company: Vigilant Aerospace Systems

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Agenda

- What is “Detect-and-Avoid”?
- Fundamental Requirements
- Components of a DAA System
- Discussion of Technologies
- Emerging Technical Standards and Regulations
- Projects and Testing
- Industry Next Steps

Distance and timing diagrams from the ASTM F38 Detect-and-Avoid Systems Standard

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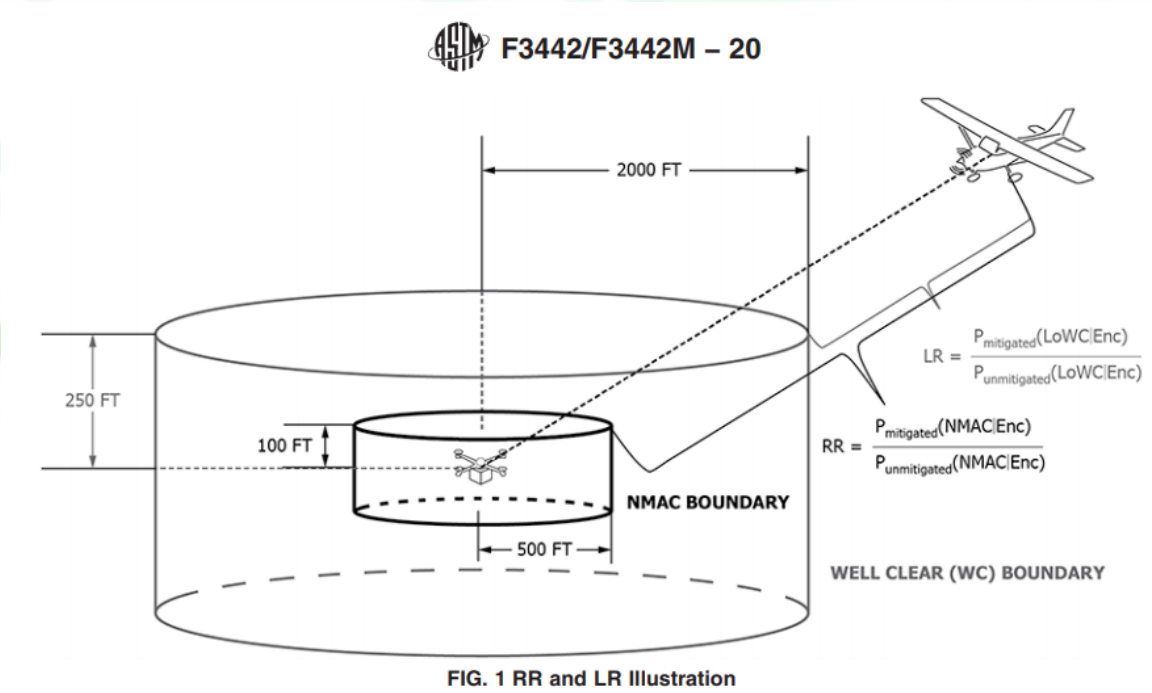
Detect-and-Avoid



Distance and timing diagrams from the ASTM F38 Detect-and-Avoid Systems Standard

- Allows unmanned aircraft to detect other aircraft when beyond visual line-of-sight
- Fundamental requirement for safety
- Remain “well-clear”
- Detection of cooperative and non-cooperative aircraft (no transponder)
- On-board DAA is required to make long-range BVLOS flights practical and economical
- Scalable solutions need automatic avoidance
- Systems must be trustworthy and well-tested

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Fundamental Requirements

- Detect non-cooperative aircraft
- Track targets, calculate LoWC, calculate avoidance
- Performance envelope
- Regain well-clear
- Avoid additional conflicts
- Return to planned flight

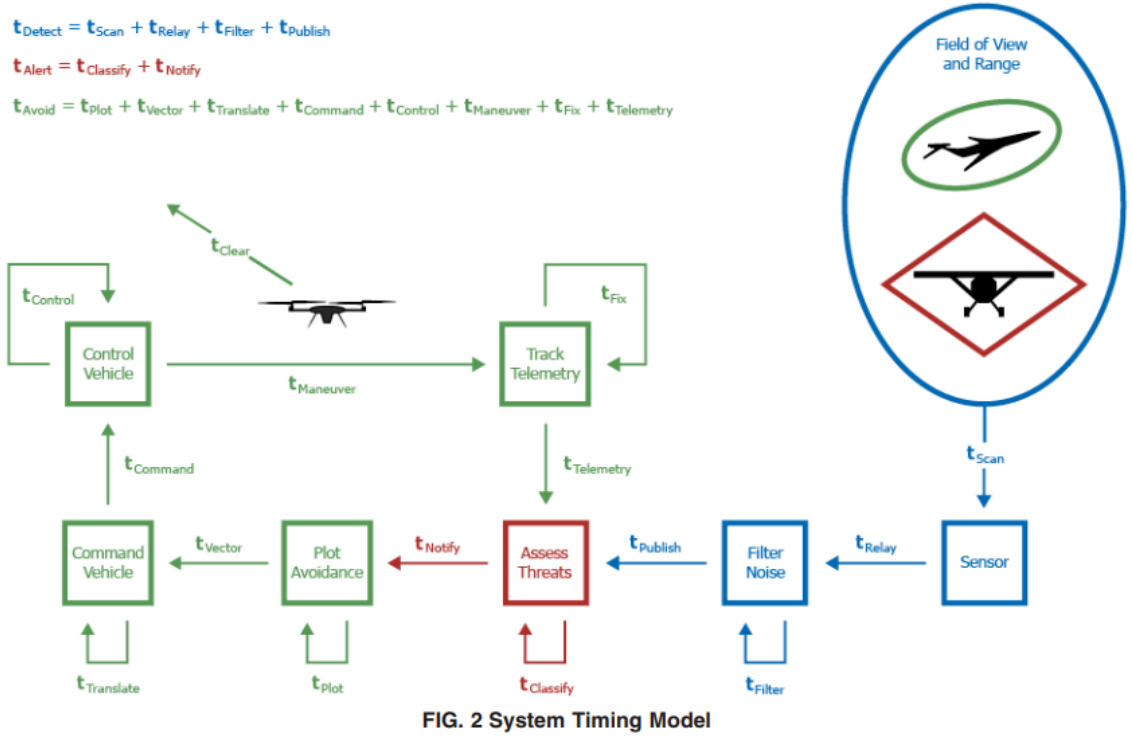

FIG. 2 System Timing Model

System Timing Model from the ASTM F38 Detect-and-Avoid Systems Standard

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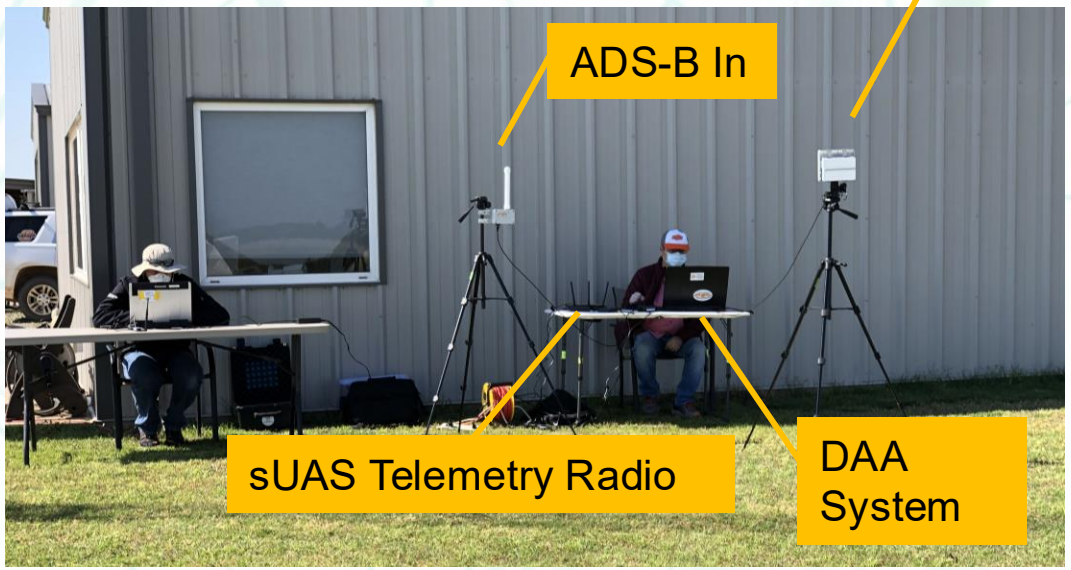
DAA System Components

- Sensors
  - Radar
  - EO/IR
  - Acoustic
  - Others
- Display and Human Factors
- Autonomous avoidance processes
  - Algorithms
- UTM, USS and Supplemental Data Service Providers
  - Ground-based, networked resources, services and processes



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Common Components

uAvionix PingStation

Echodyne EchoGuard

Pixhawk autopilot (MavLINK)

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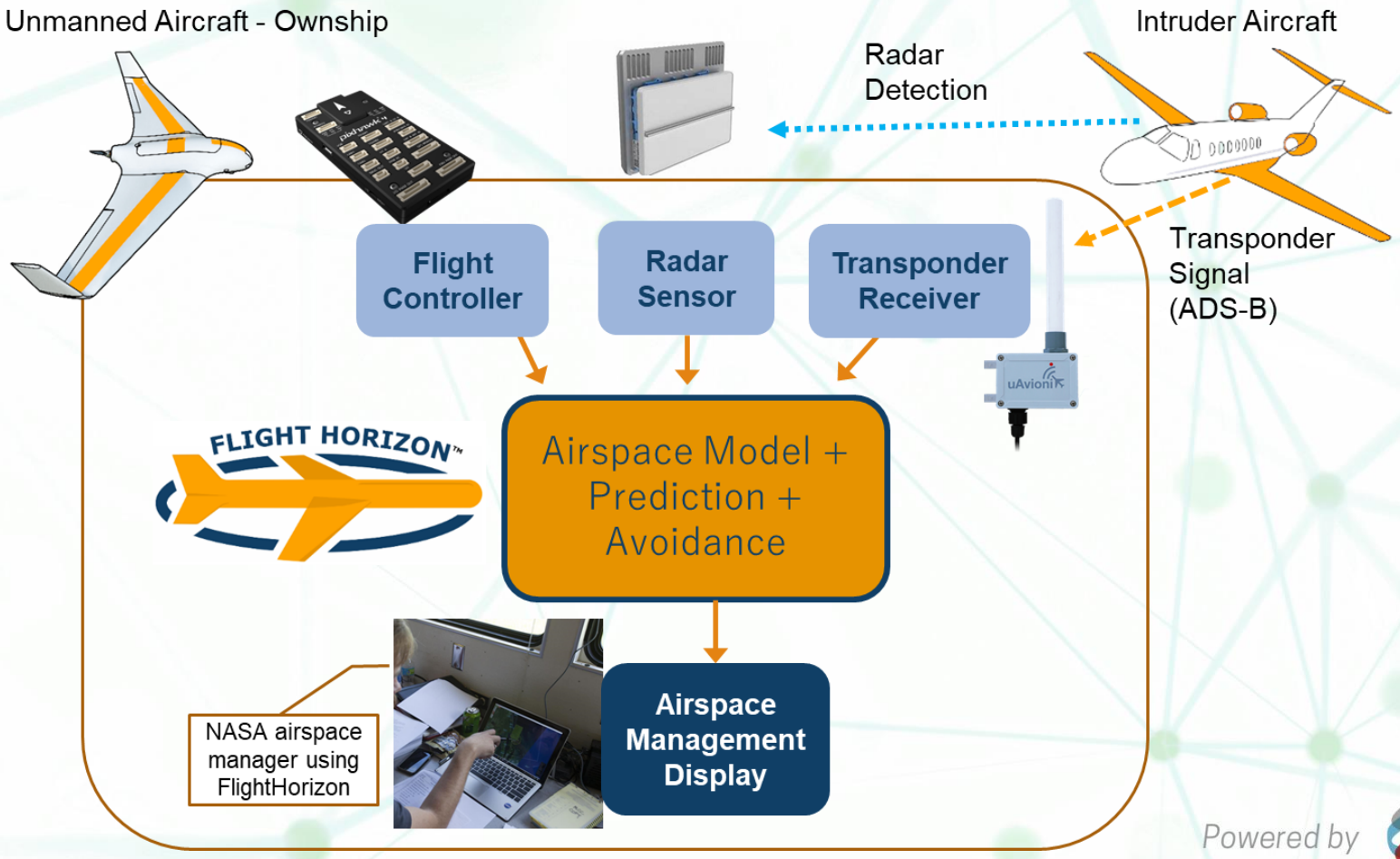
Components into a System



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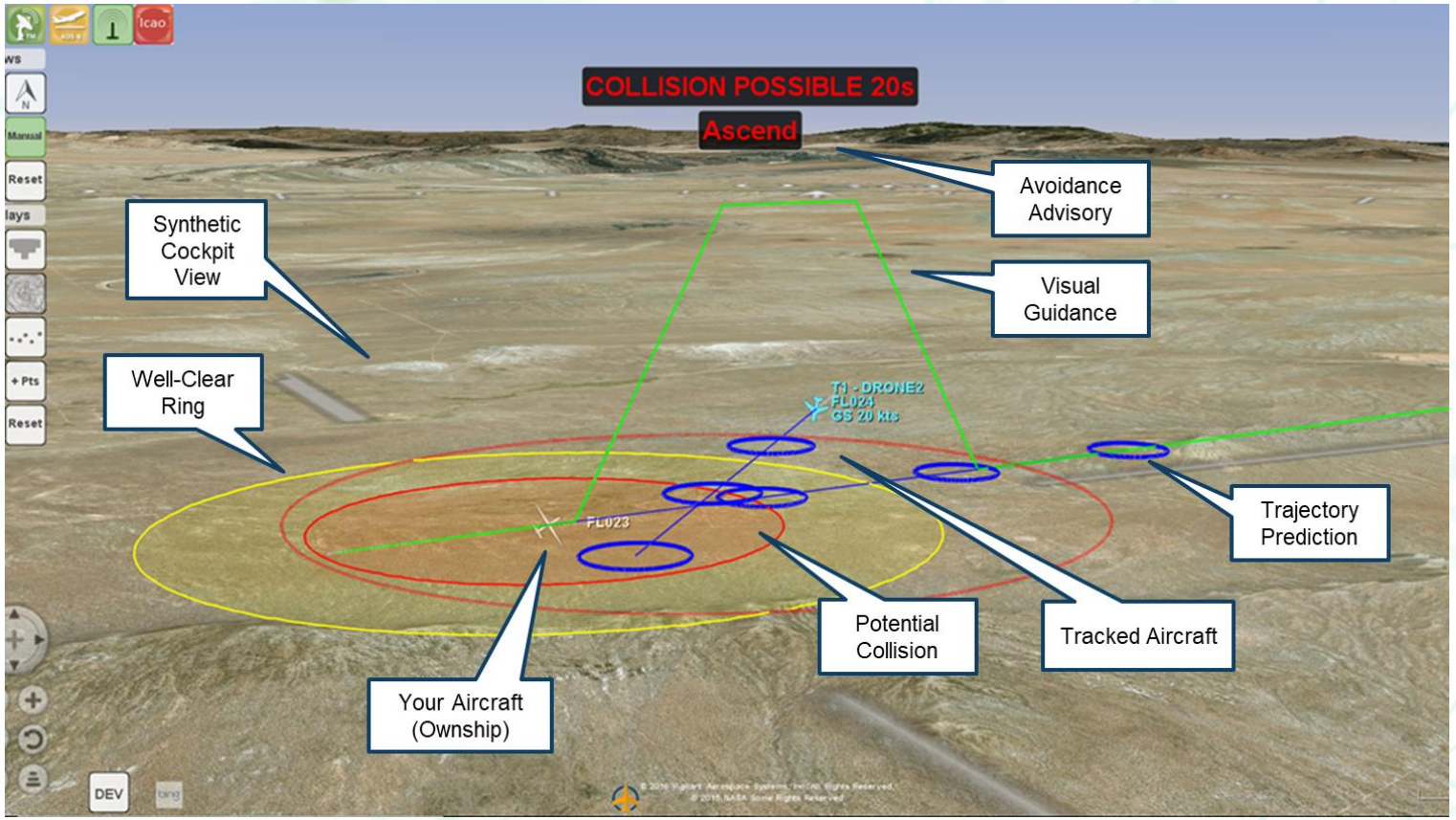
Detect-and-Avoid System: User Interface



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Algorthims

- Avoidance Algorithms
  - NASA Stratway & DAIDALUS
  - FAA ACAS X (ACAS sXu)

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Industry Technical Standards

- Technical Standards
  - ASTM
    - ASTM F3442– 20: Standard Specification for Detect and Avoid System Performance Requirements
    - ASTM F3201-16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems
    - ASTM WK69690: Specification for Surveillance UTM Supplemental Data Service Provider (SDSP) Performance
    - ASTM WK62669: Test Method for Detect and Avoid Systems
    - ASTM WK63418 UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability
  - RTCA
    - DO-365B – Minimum Operational Performance Standards for Detect and Avoid Systems
    - DO-366A – Minimum Operational Performance Standards for Air-to-Air Radar for Traffic Surveillance
    - SC-147 Pending - Minimum Operational Performance Standards for Traffic Alert & Collision Avoidance Systems (ACAS X)

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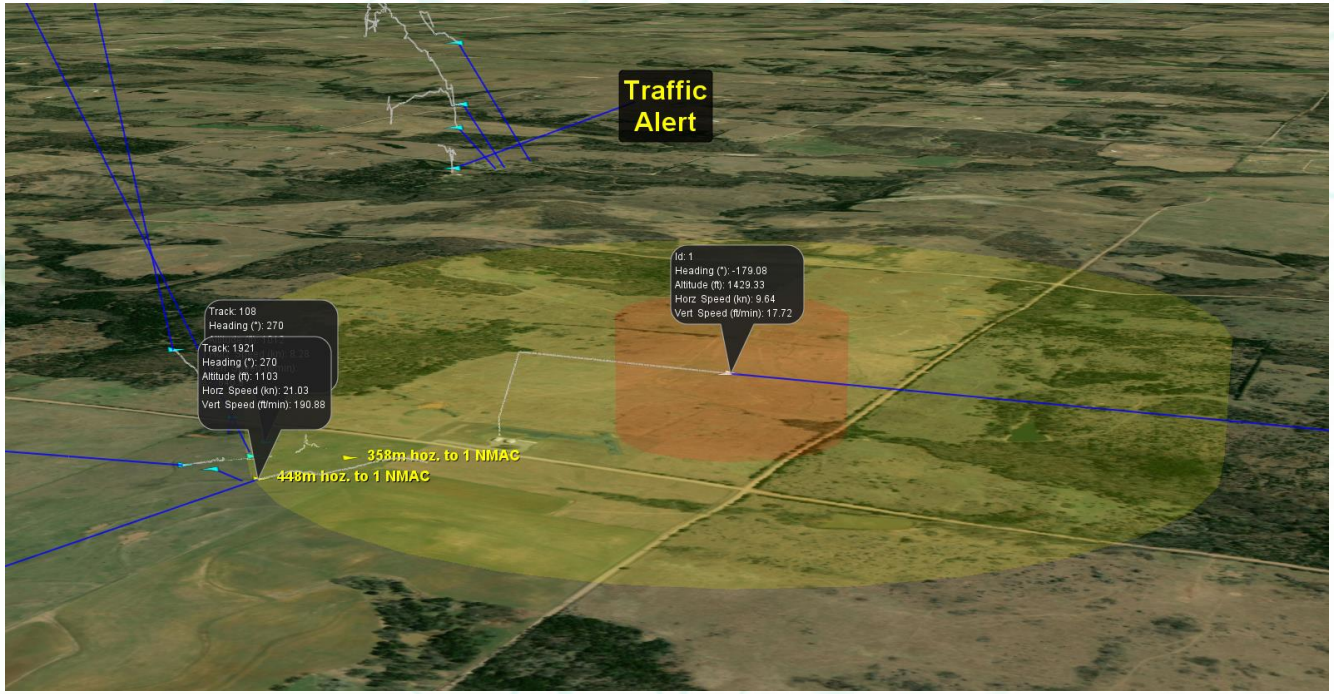
DAA Testing Types and Considerations

- Testing Types
  - Sensor performance testing
  - Encounter testing – multiple aircraft
- Sensors
  - Range
  - Accuracy
  - Clutter and Filtering
- Establish baseline system performance
- Simulations and encounter sets
- Develop specific safety cases



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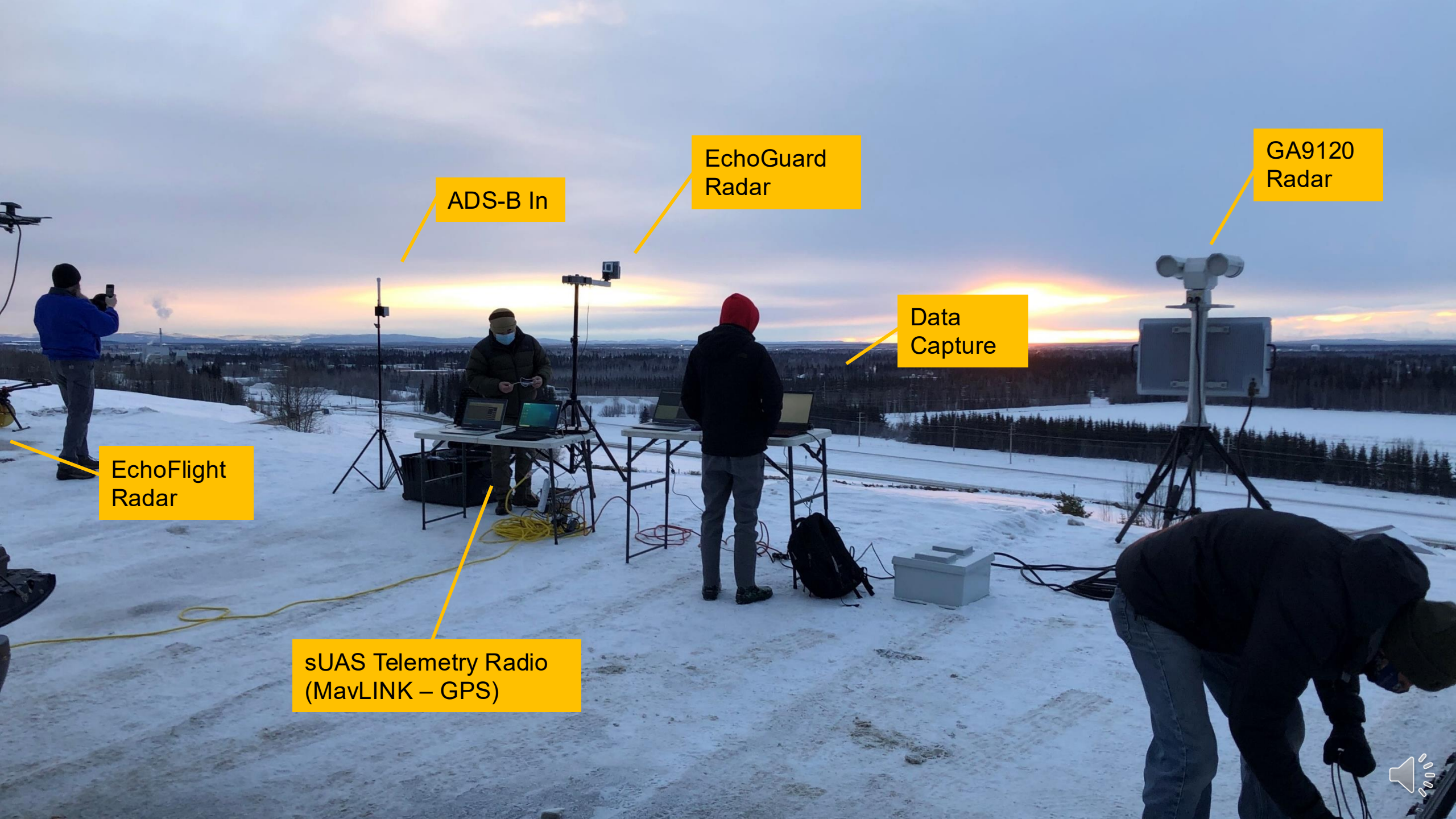
ADS-B In
EchoGuard Radar
GA9120 Radar
Data Capture
EchoFlight Radar
sUAS Telemetry Radio (MavLINK – GPS)


FlightHorizon
PILOT
EchoFlight
Radar

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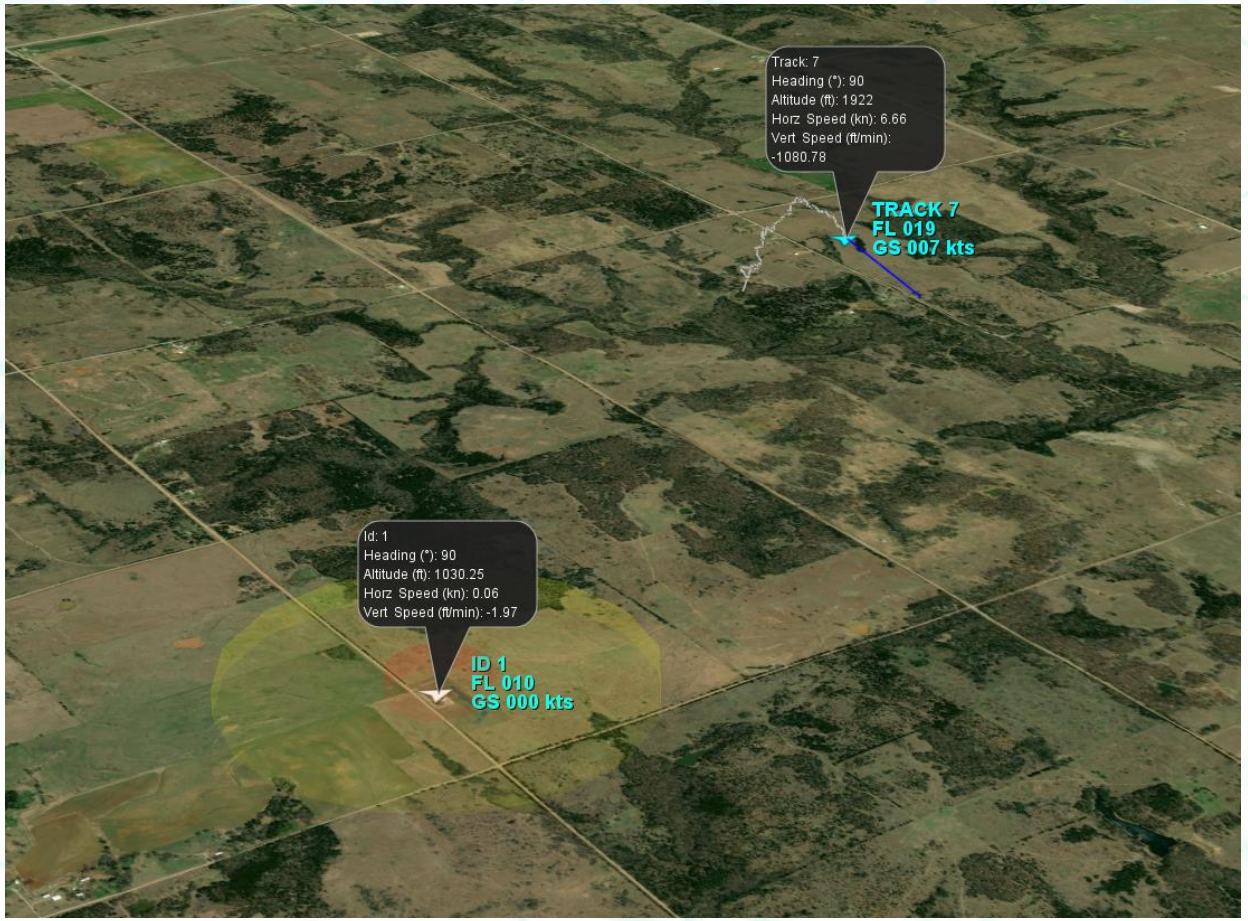
Recent Testing Projects



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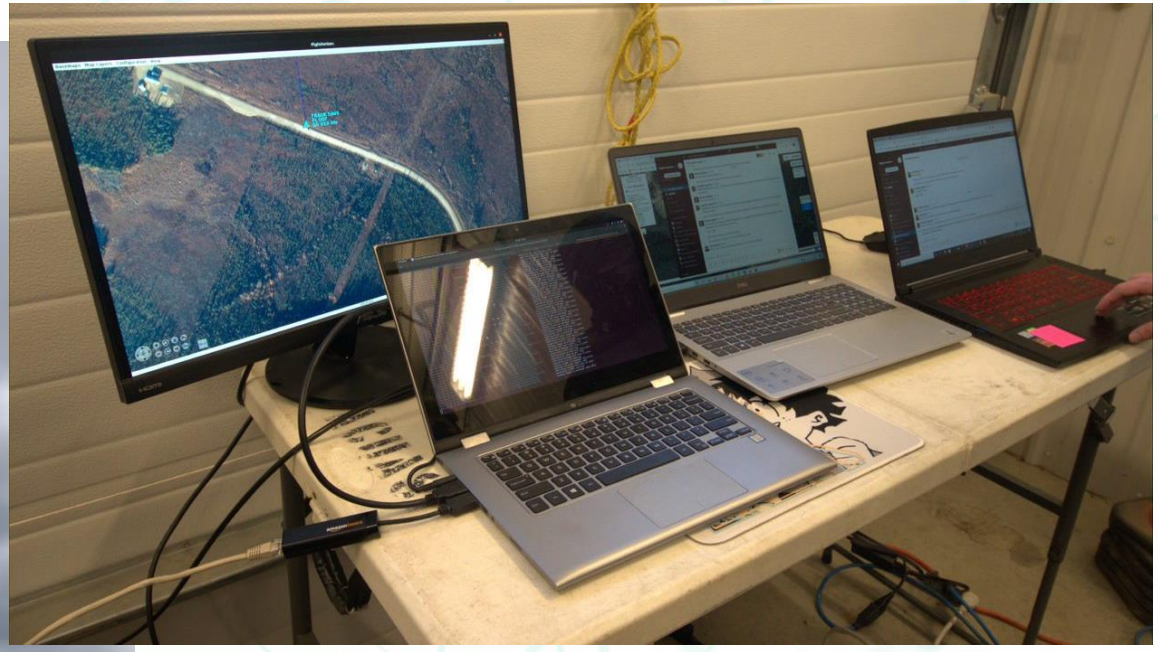
Field Testing



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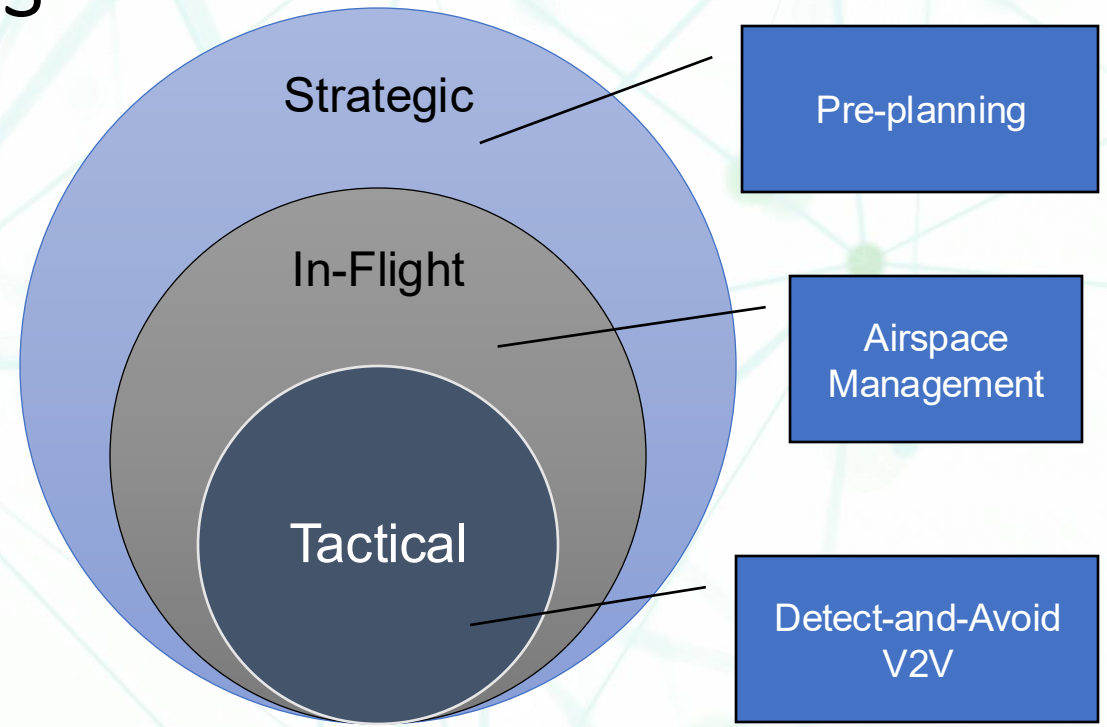
Industry & Regulatory Trends

- Current trends in DAA systems
  - Multiple sensors, data fusion, correlation and layered detection
  - Both cooperative & non-cooperative (no transponder) air traffic
  - Ability to meet a risk mitigation target for the airspace (risk ratio)
  - Airspace situational awareness
  - Autonomy & automatic avoidance
  - Networked coordination - UTM
- Solutions need to respond to new technology, standards and regulations



Portions of this section are derived from ICAO Doc. 9854, *Global Air Traffic Management Operational Concept*

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Industry Next Steps

- New FAA Aviation Rulemaking Committee (ARC) for BVLOS flight of unmanned aircraft
- Establish certification standards for components and platforms
- Establishing rules
- Establishing Risk Ratios based on testing
- Systems assurance process and trusted autonomy
- Impacts for AAM/UAM operations and delivery operations
- Integration of Remote ID and UTM

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Questions?

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