National Aeronautics and Space Administration

ICAO RPAS Symposium

NASA RPAS Operational and Research Activities

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UAS-NAS Project

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Subset of NASA Science-Related UAS Efforts

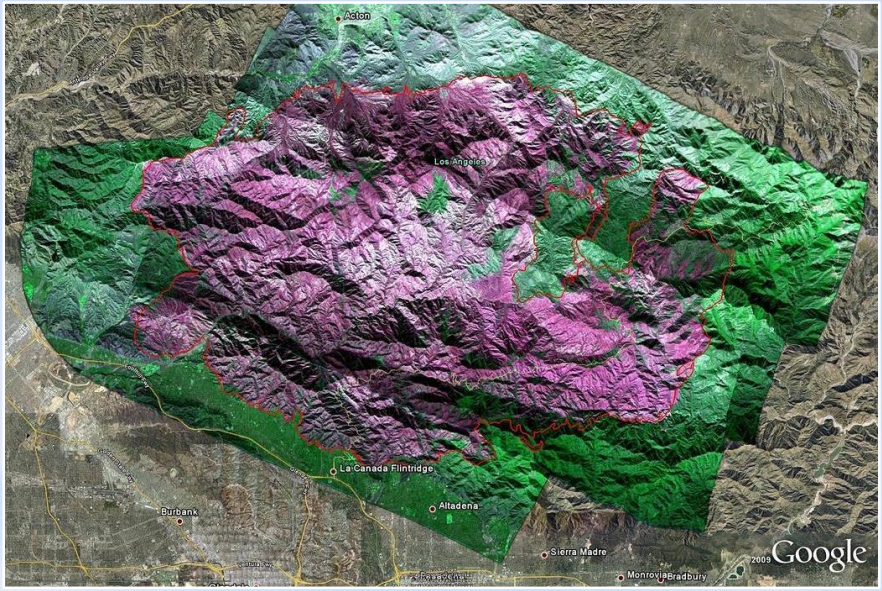
- **Science UAS Flight-Operations Focus:**
  - Conducting operations in collaboration with the FAA, NOAA, US Forestry, and other entities to provide data for advancing societal benefits
- **Demonstrated Societal Benefits**
  - NASA has collected and delivered infrared images of active fire hot spots in near real-time to fire fighters. This gives critical information directly to the front line to efficiently deploy fire-fighting assets.
  - NASA has collected imagery over time to measure the characteristics of sea ice. This provides data to assess the accuracy of satellite data, and refine models accordingly which enhances the ability to accurately determine climactic changes in the arctic.
  - NASA has collected imagery on hurricane storm formation, structure, and intensification. This provides data to assess the track and intensity of hurricanes as they approach populated areas.
- **NASA Science Approach:**
  - Define Science Mission Requirements
  - Select Vehicle/Platform that best meets the requirement
  - A UA is only used if it is the best fit

Ikhana Fire Missions

A collaborative effort between NASA and fire-fighting organizations including U.S., State, and local entities

Goal of Fire Missions:

- Image multiple fires while either lingering over key fire hot spots, or disparate regional fires areas
- Provide automated, on-board, terrain, and geo-rectified sensor imagery over horizon satellite communications (SATCOM) links to national fire personnel and incident commanders within 10 minutes of data acquisition

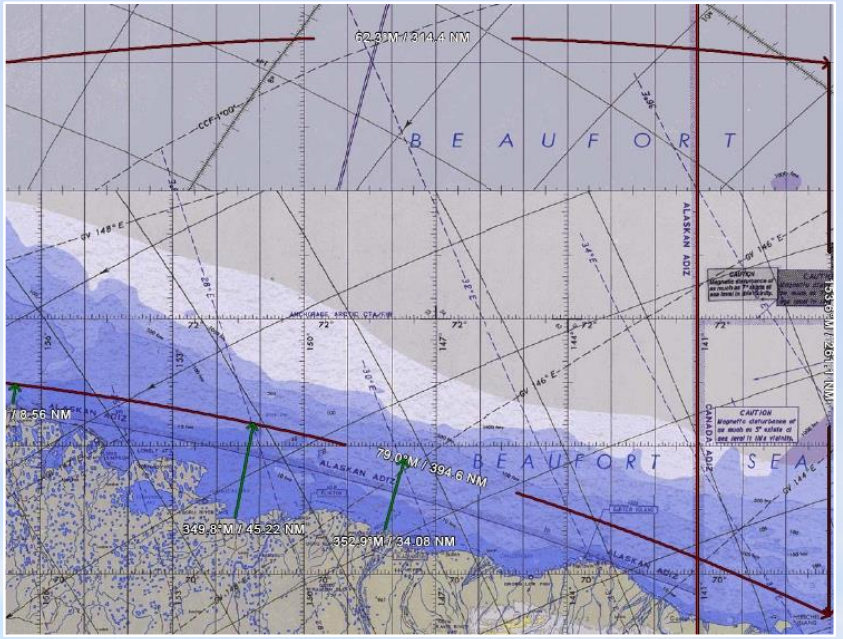


SIERRA MIZOPEX Mission

An interdisciplinary effort of oceanographers, cryospheric scientists, aeronautical engineers, UAS operators, and database/data systems experts

Goal of MIZOPEX:

- Determine how much is the warming of the marginal ice zone (MIZ) in the Arctic Ocean under or over estimated by satellite measurements
- Use updated models to better characterize sea ice survival rates in the transition zone between open ocean and permanent ice through improved data input to ice forecasting and climate models

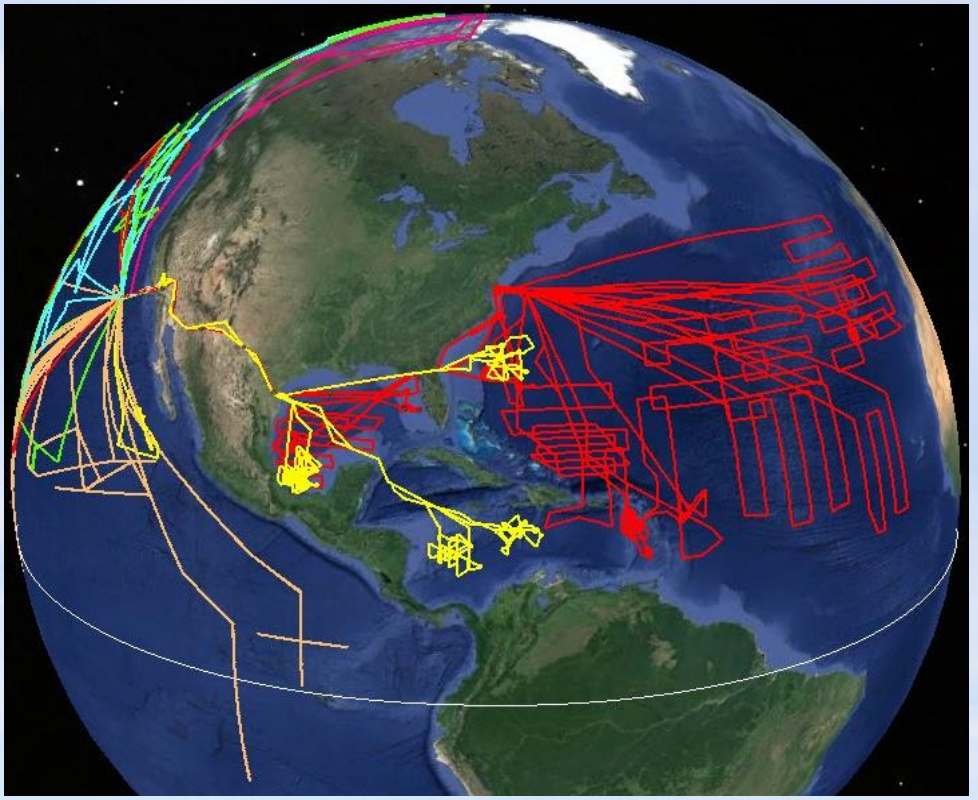


Global Hawk Hurricane Missions

A collaborative effort between NASA, NOAA, NWS, and other meteorological entities

Goal of Hurricane Missions:

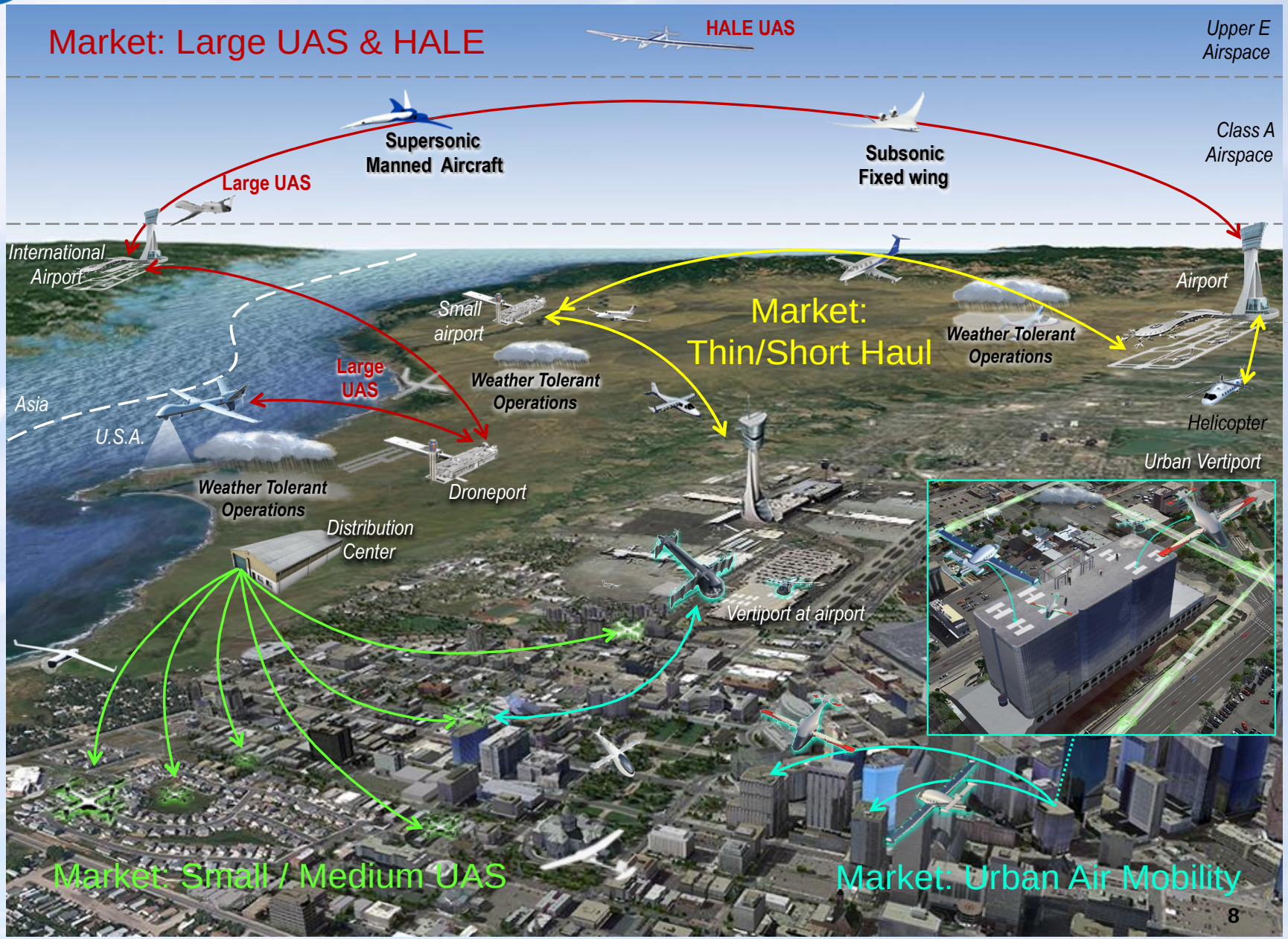
1. Conduct flights over hurricanes and severe storms, including the use of dropwindsonde weather instruments, to collect data on formation, structure, and intensity of hurricanes and other severe storms.
2. Disseminate high-definition pictures from the aircraft to meteorological entities and the general public in real time



Subset of NASA Aeronautics UAS Efforts

- **Aeronautics UAS Flight Research Focus:**
  - Developing research findings to enable performance-based access for all unmanned and autonomous systems
- **Expected Societal Benefits:**
  - Enabling emerging air markets for Large/HALE, Thin/Short Haul, Urban Air Mobility, and S/M UAS (Package delivery) will expand economic opportunities while significantly improving the quality of life for the general public.
- **NASA Aeronautics Approach:**
  - UAS Integration Pillars and Enablers
  - UAS-NAS Project
  - UTM Project
  - Small RPAS and Autonomy Activities

Emerging Aviation Markets



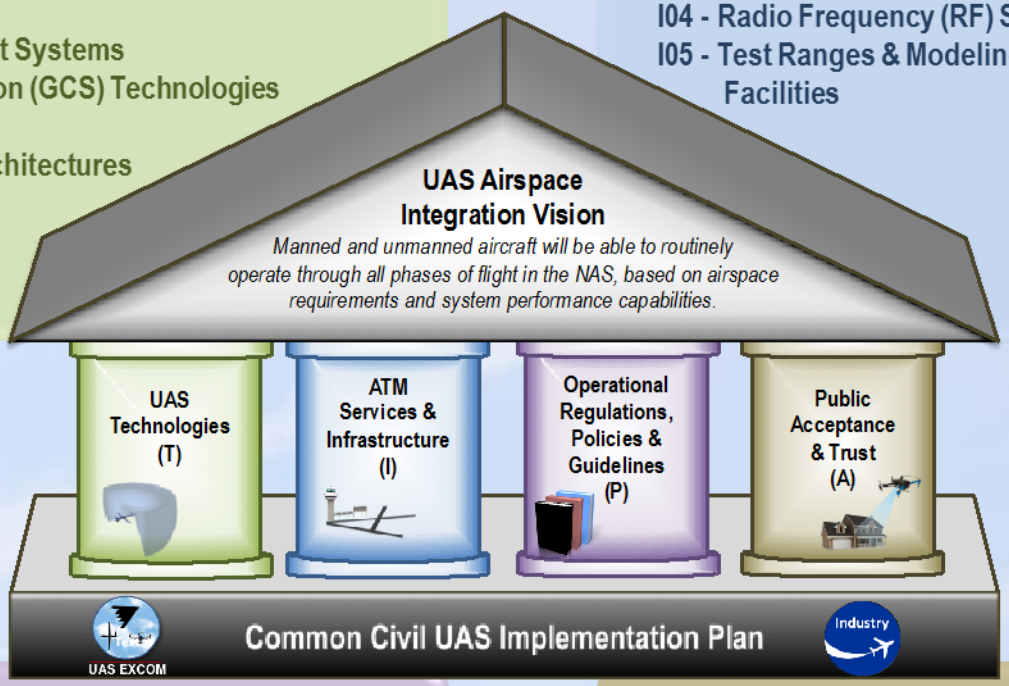
NASA UAS Integration Pillars and Enablers

UAS Technologies:

T01 - Airport Operations Technologies
T02 - Airworthiness Standards
T03 - Command, Control, Communications Technologies
T04 - Detect & Avoid (DAA)
T05 - Flight & Health Mngmt Systems
T06 - Ground Control Station (GCS) Technologies
T07 - Hazard Avoidance
T08 - Highly Automated Architectures
T09 - Navigation
T10 - Power & Propulsion
T11 - Weather Avoidance

ATM Services & Infrastructure:

I01 - Airport Infrastructure
I02 - Air Traffic Management (ATM) Infrastructure
I03 - Non-FAA Managed Airspace Infrastructure
I04 - Radio Frequency (RF) Spectrum Availability
I05 - Test Ranges & Modeling & Simulation (M&S) Facilities



Operational Regulations, Policies & Guidelines:

P01 - ATM Regulations / Policies / Procedures
P02 - Airworthiness Regulations / Policies / Guidelines
P03 - Operating Rules / Regulations / Procedures
P04 - Safety Risk Mngmt & Methods of Compliance

Public Acceptance & Trust:

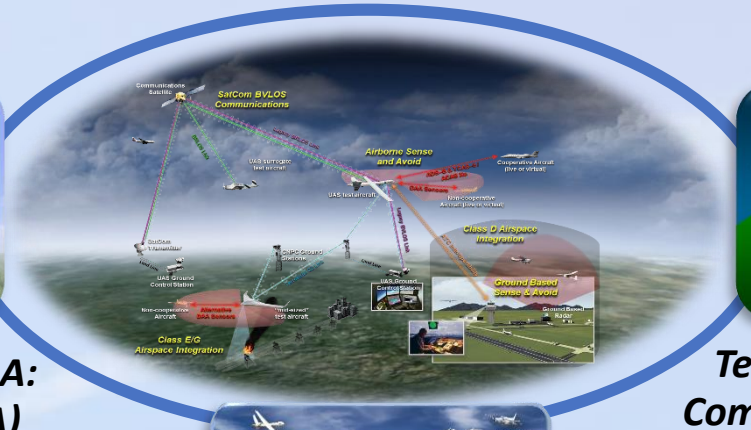
A01 - Cyber Security Criteria & Methods of Compliance
A02 - Legal & Privacy Rules / Guidelines
A03 - Noise Reductions
A04 - Physical Security Criteria & Methods of Compliance
A05 - Public Safety Confidence

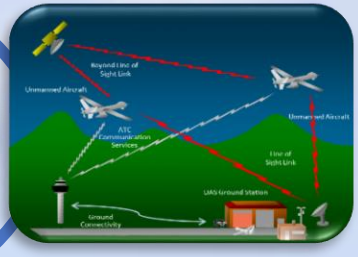
The UAS Airspace Integration Pillars enable achievement of the Vision

NASA UAS-NAS Project Goal

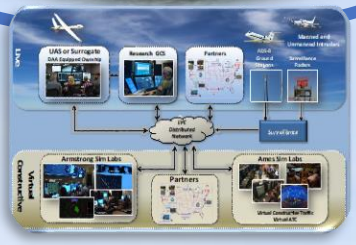
Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System

Technical Challenge-DAA: Detect and Avoid (DAA)





Technical Challenge-C2: Command and Control (C2)



SIO: System Integration and Operationalization for UAS (SIO)

NASA UTM Project Technical Capability Levels (TCLs)

Capability 1: Demonstrated How To Enable Multiple Operations Under Constraints

- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

Product: Overall concept of operations, architecture, and roles

Capability 2: Demonstrated How to Enable Expanded Multiple Operations

- Beyond visual line-of-sight
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the road”
- Longer range applications

Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes

Capability 3: Focuses on how to Enable Multiple Heterogeneous Operations

- Beyond visual line of sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking, V2V, V2UTM and internet connected

Product: Requirements for heterogeneous operations

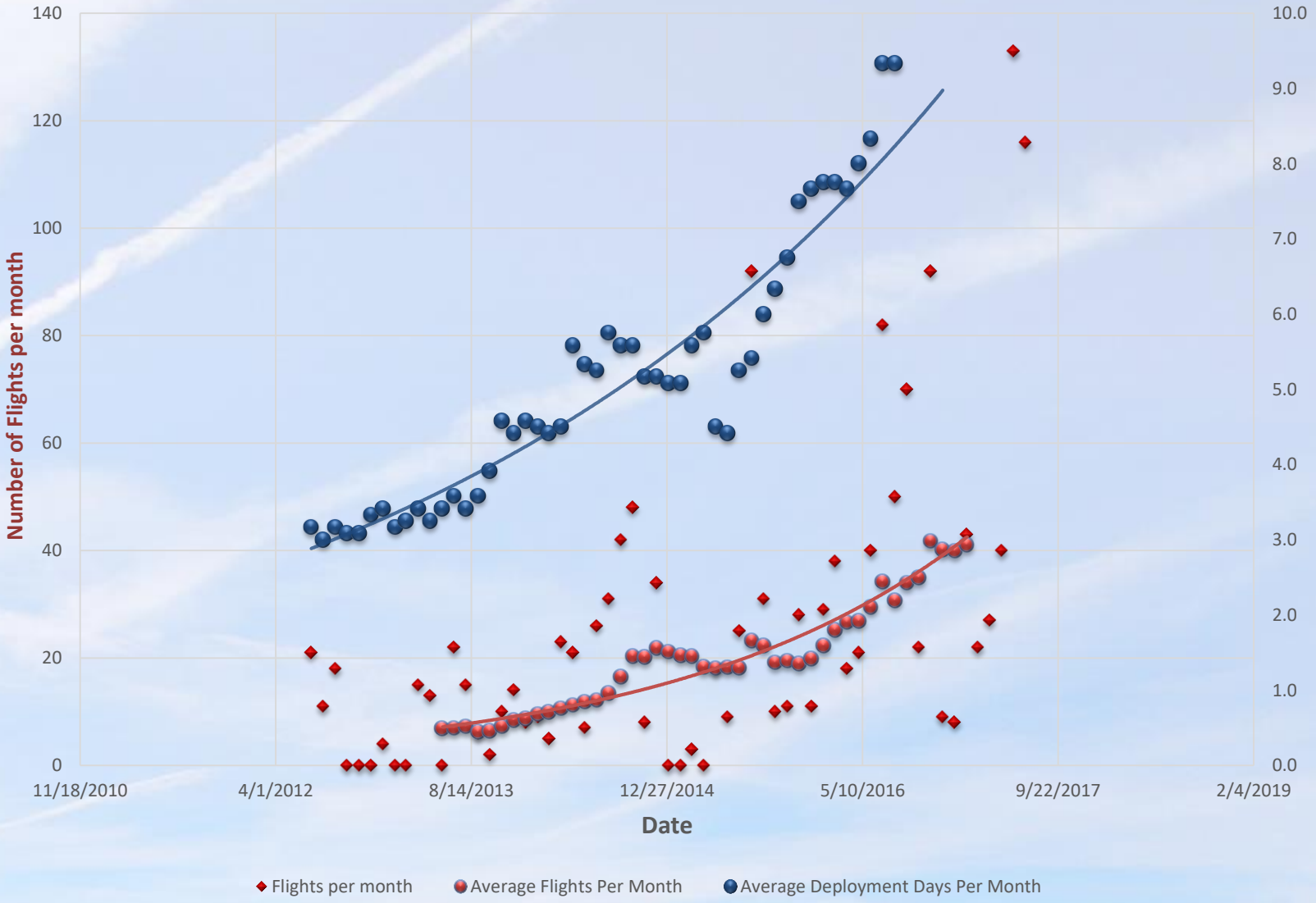
Capability 4: Focuses on Enabling Multiple Heterogeneous High Density Urban Operations

- Beyond visual line of sight
- Urban environments, higher density
- Autonomous V2V, internet connected
- Large-scale contingencies mitigation
- Urban use cases

Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations

Risk-based approach: depends on application and geography

Small UAS Operations at NASA Langley Research Center



Autonomy Testbed at NASA Armstrong Flight Research Center

- VTOL/Tilt-Rotor/Flying-Wing
- 5’ Wingspan
- <10 Pounds
- COTS <$2,500
- 20 – 45 min. Endurance
- 15 min. Turnaround
- 3 data-hours per flight-day
- Ops cost of $600 per data-hour

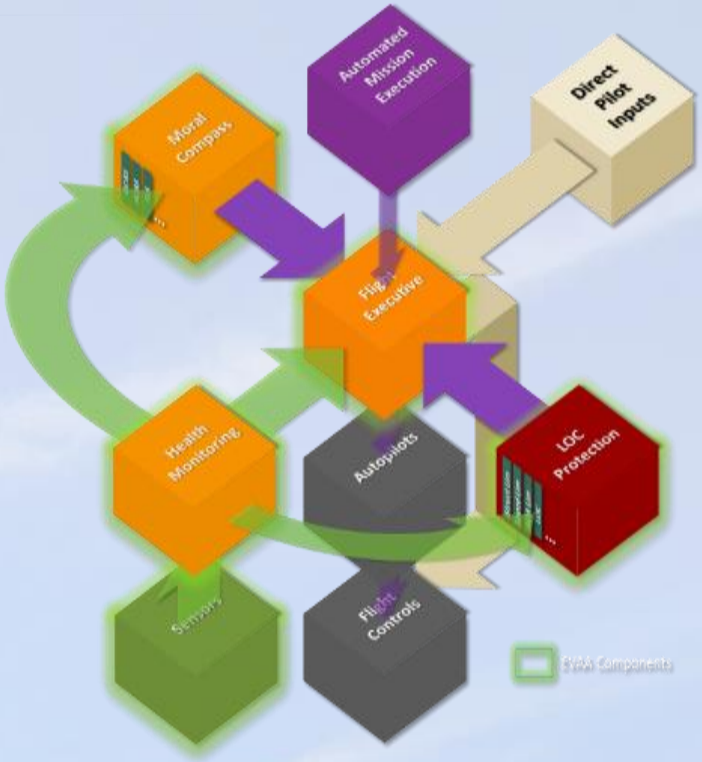
Multi Monitor Run Time Assurance (MM-RTA) Research

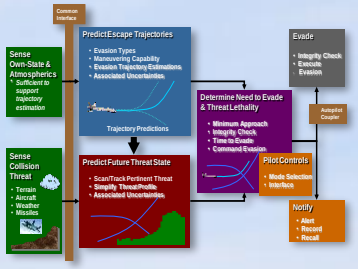
Research Goal: Develop a methodology for certifying unmanned and autonomous systems using software architecture testbeds

1. MM-RTA research findings using Low Altitude Small UAS Test Range (LASUTR) and Expandable Variable Autonomy Architecture (EVAA) realistic environment capabilities

2. Develop a methodology for generating the artifacts necessary to develop an airworthiness case for unmanned and autonomous systems

3. Use research findings to inform standards and best practices which will accelerate the certification of autonomous systems





Improved Ground Collision Avoidance System (*iGCAS*)

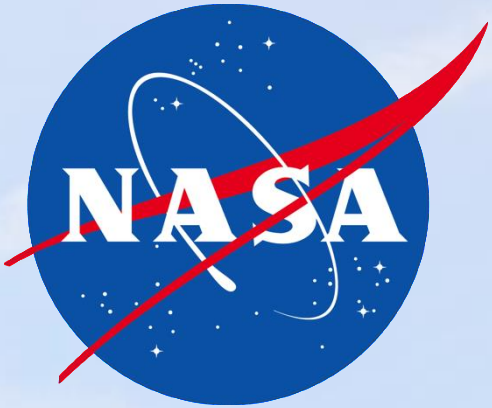
Engaging the Standards Community

NASA AFRC is collaborating with the FAA and industry through ASTM International by sharing research findings, techniques, best practices and lessons learned throughout the development of MM-RTA

Research findings are being vetted with ASTM International through Working Group 53403 (WK53403)

- WK53403 Goal: Develop a standard practice that safely bounds the flight behavior of autonomous UAS

https://www.astm.org/DATABASE.CART/WORKITEMS/WK53403.htm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