Traveler

TRUSTWORTHY AUTONOMY

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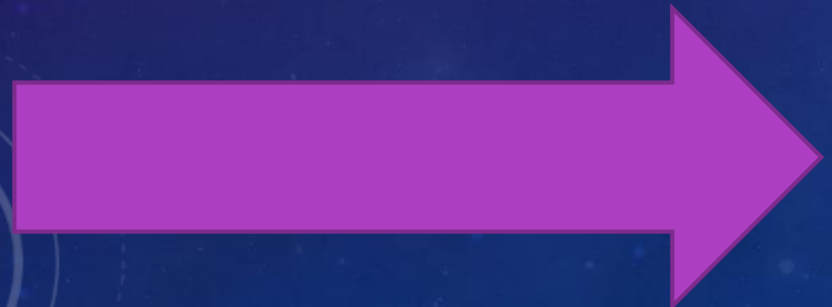

Safe, Efficient Growth in Global Operations

- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft

- Achieve a low-boom standard

Ultra-Efficient Commercial Vehicles

- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion

- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance

- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation

- Develop high impact aviation autonomy applications

Autonomy

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Autonomy

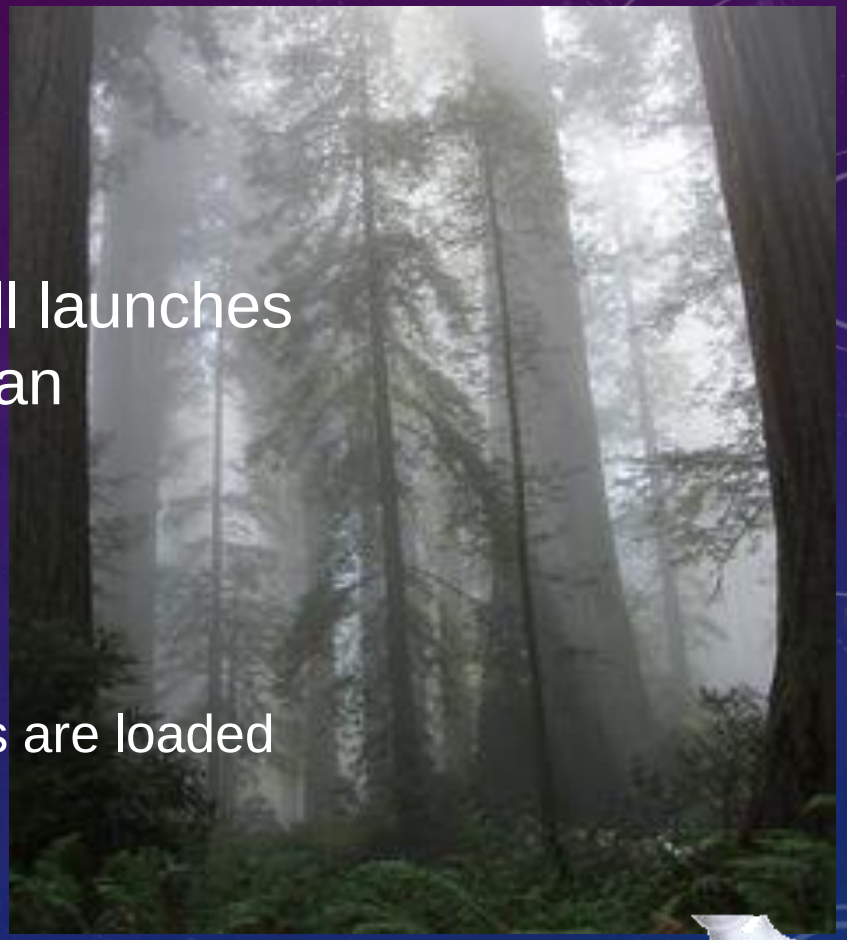
1. Self-directing freedom and especially moral independence. - *Websters*
2. Independence from the organism as a whole in the capacity of a part for growth, reactivity, or responsiveness. – *Medical Reference*

- **Self-Directing Freedom**
  - **Independence from the organism as a whole**
- **Moral Independence**
  - **Reactivity**
  - **Responsiveness**

Vision

Imagine a day when a 911 emergency medical call launches a vehicle to the aid of an injured victim trapped in an inaccessible location in the wilderness.
The vehicle:

- Self-Plans
- Self-Files
- Self-Launches once needed medical supplies are loaded
- Travels Safely
- Coordinates its own refueling
- Finds the injured victim
- Lands delivering the supplies
- Launches and establishes communication between the victim and trained medical personnel



The Challenge

- **Verification & Certification of a Complex System**
- **A Possible Solution – Run-Time Assurance (RTA)**

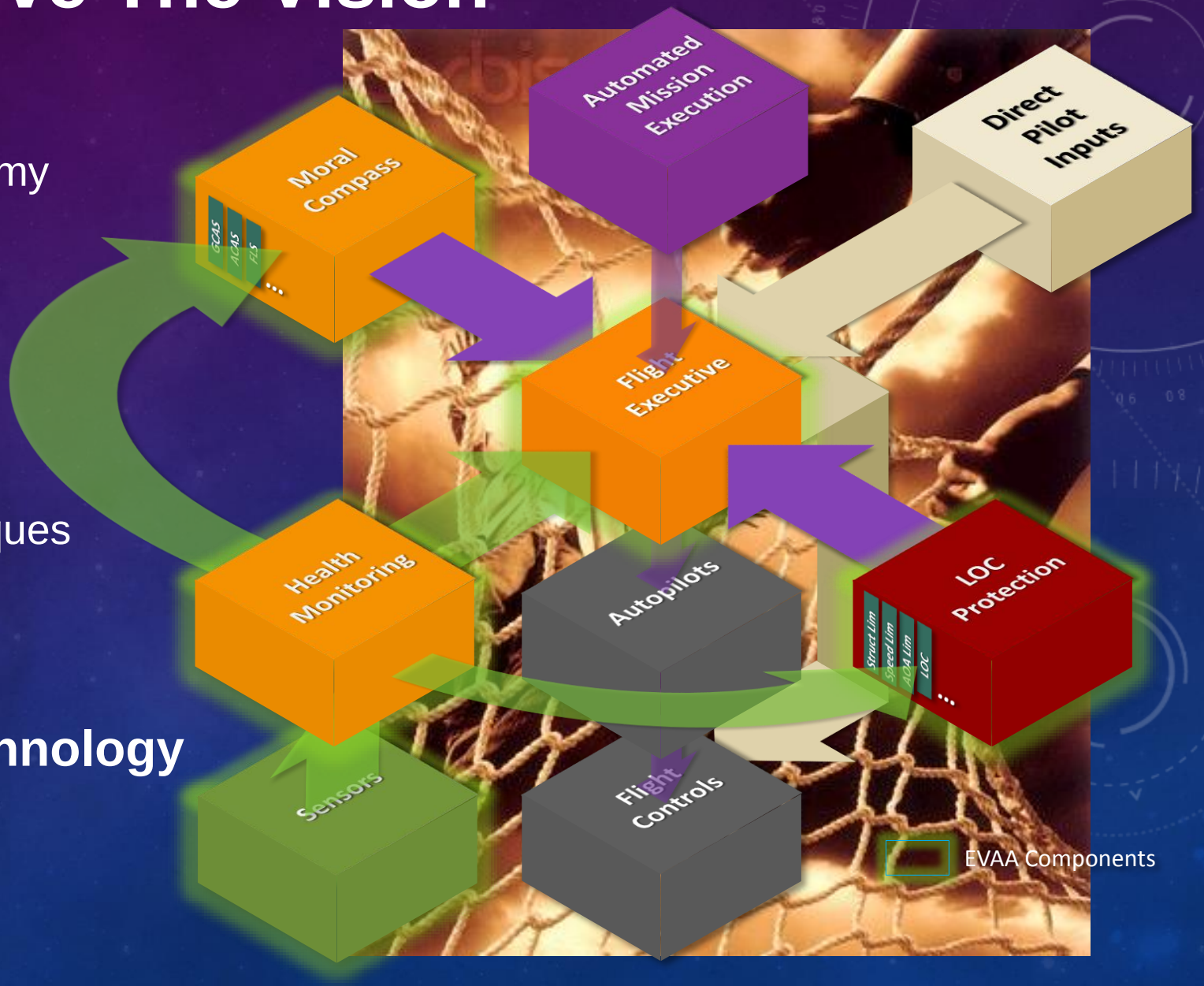
Our Goals

Project Goals, Research Themes & Technical Challenges

- **Project Goals**
  1. **Fly an Autonomous System Outside of Restricted Airspace**
     - **Make an airworthiness case (to NASA & FAA) for a COA**
     - **Utilize appropriate test safety mitigations (Safety Pilot in Line-of-Sight)**
  2. **Fly a Portion of an Autonomous Mission without a Link or Safety Pilot for Mitigation**
     - **Make an airworthiness case based on human equivalency**
- **Develop and Verify a Highly Autonomous System**
  - 2 Themes
    1. **System-of-Systems Development & Integration for Comprehensive Flight Safety**
    2. **Expand the Paradigm of Run-Time Assurance**
  - Technology Maturation – TRL 3 to 5
  - Challenge: Certification & Airworthiness of Autonomy

How We Will Achieve The Vision

- **A Software Framework**
  - Expandable Variable-Autonomy Architecture (***EVAA***)
  - A Federated Architecture
    - **Safety Systems**
      - 1
      - 2
      - 3…
    - **Flight Executive**
  - Software Structure & Techniques
- **Classical & Non-Classical Verification Methods**
- **Demonstration of the Technology**
  - Flight Demonstrations
  - Social Interaction



Automatic Collision Avoidance Development Background

1980 2000 2010 2015

AFTI/F-16
Advanced Fighter Technology Integration

ACAT/F-16
Automated Collision Avoidance Technology

ACAT/SUAV
Small Unmanned Air Vehicle

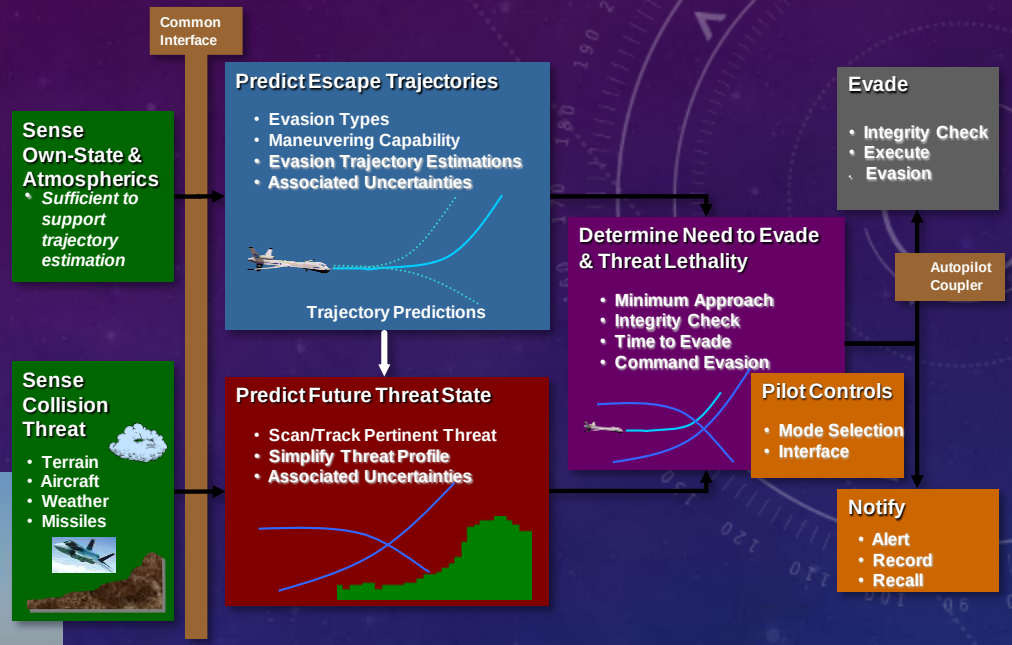
iGCAS/SR22
Improved Collision Avoidance System

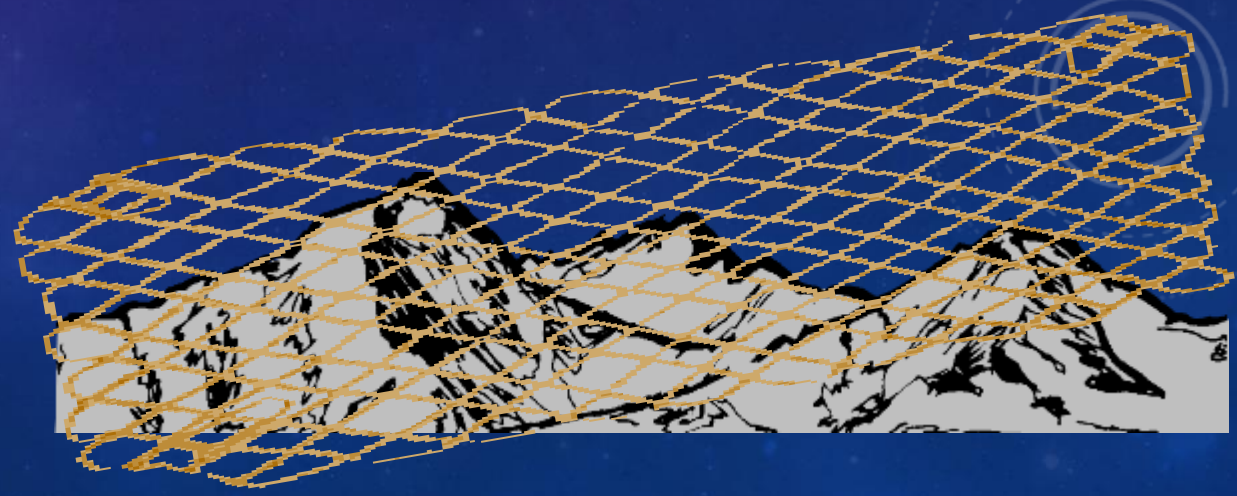
Ground Collision Avoidance


Nuisance Free

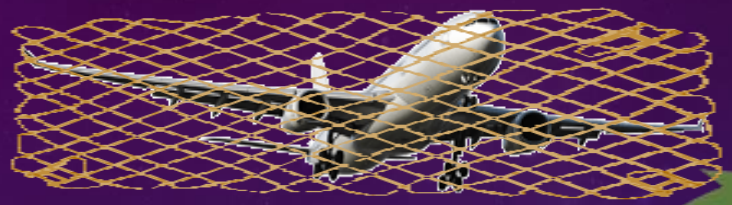
Automatic Ground Collision Avoidance

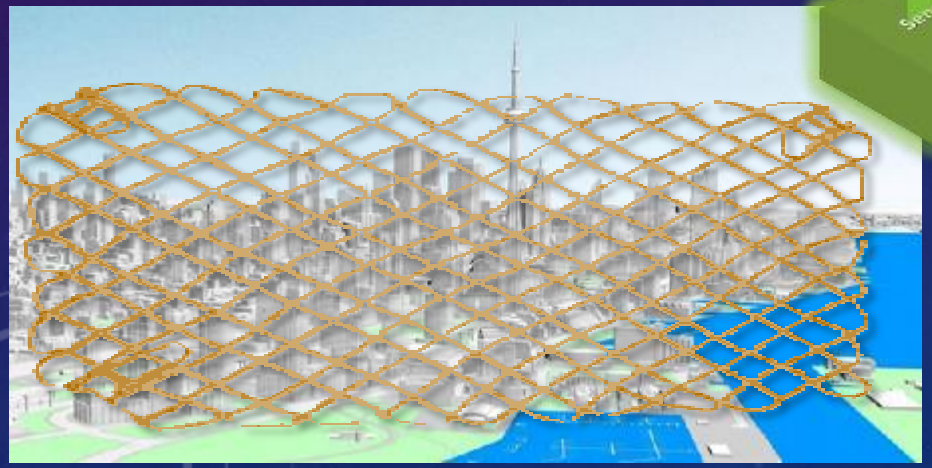
Safety Systems

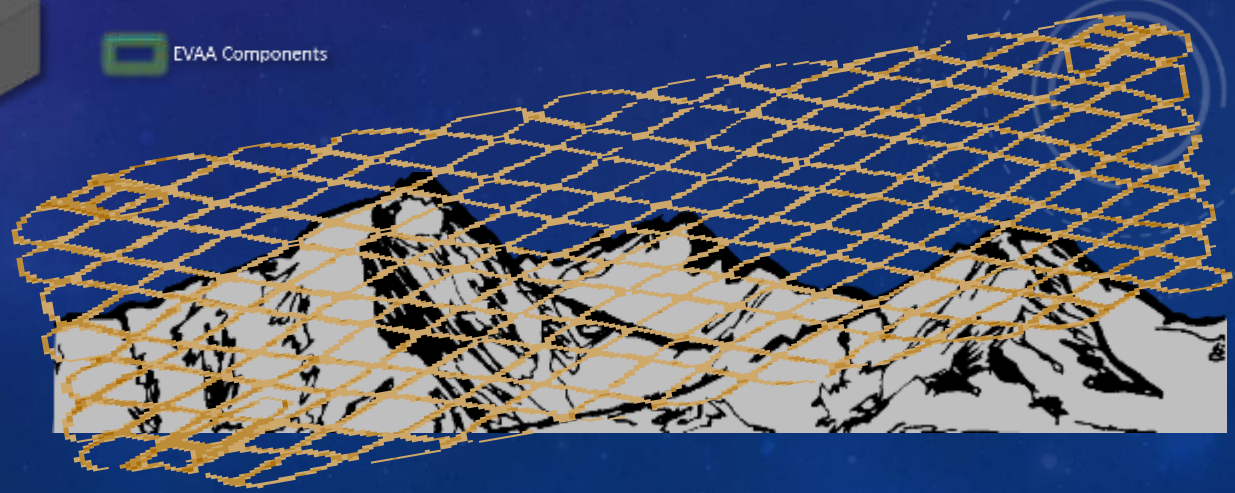




Safety Systems

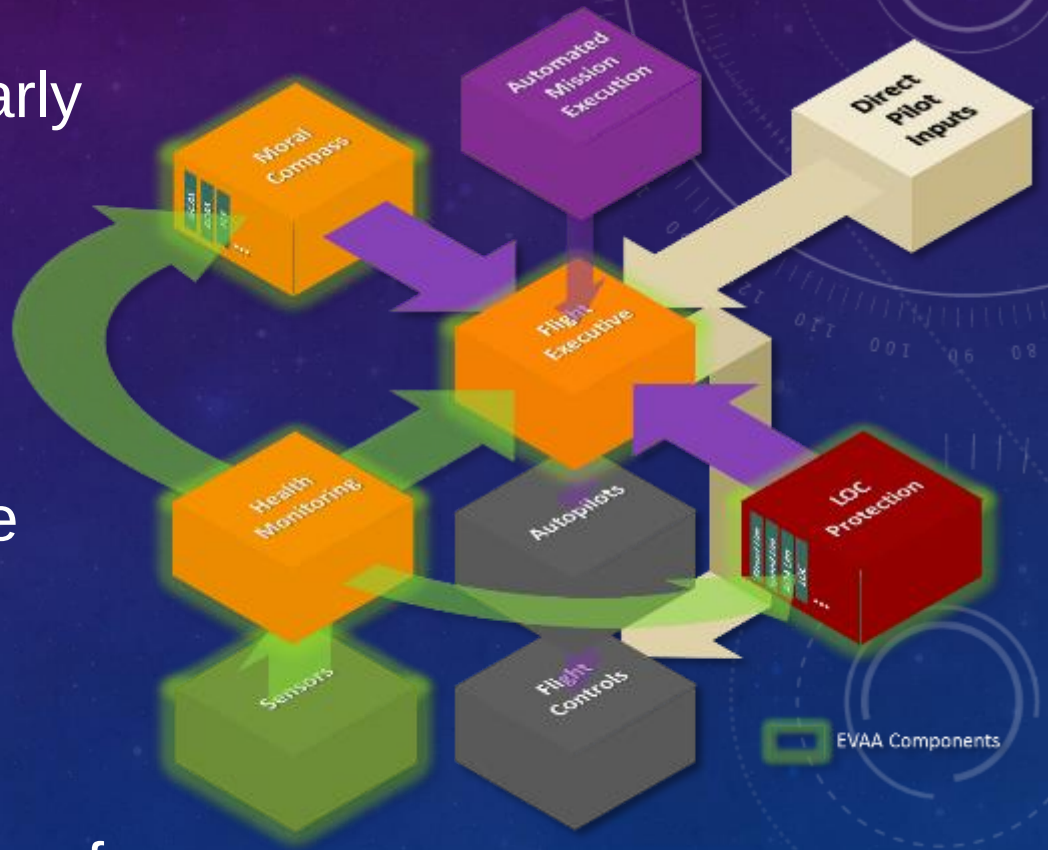






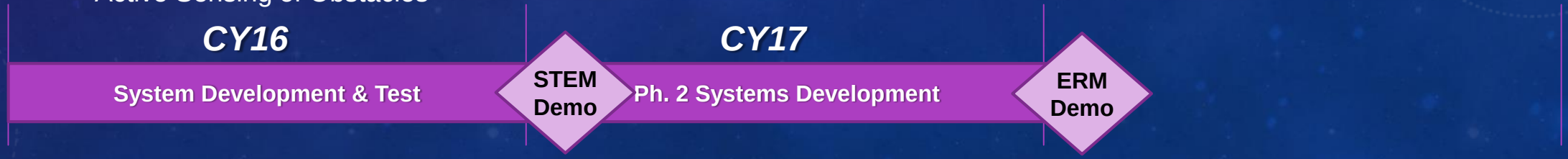
EVAA Core Principles

1. **Modular Software Architecture**
   - Top down architecture hierarchy with clearly specified interfaces
2. **Functionally Partitioned Modules**
   - Each module limited to a single safety function
   - Software isolation of Vehicle performance modeling
3. **Computational Agility**
   - Rapid assessment of vehicle situational hazards with quick and decisive mitigation of those hazards



Demonstration of Technology

- **Autonomous Missions**
  - **STEM Demo - early 2017**
    - *Science Technology Engineering & Math (STEM)*
    - **Goal**
      - Flight Outside of Restricted Airspace
    - **System Requirements**
      - Flight Executive
      - Geo-Fence (a priori data)
      - Ground & Obstacle Avoidance (a priori data)
      - Forced Landing System (a priori data)
      - Basic Mission Planner
      - Test Safety Monitor
  - **ERM Demo - early 2018**
    - *Emergency Response Mission (ERM)*
    - **Goal**
      - Fly a Portion of the Autonomous Mission without a Link or Safety Pilot
    - **Additional System Requirements**
      - Separation Assurance & Air Collision Avoidance
      - Active Sensing of Obstacles



Weather Avoidance

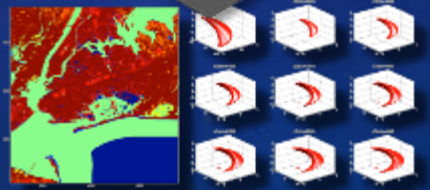
Aircraft Avoidance

DISCUSSION

Terrain Avoidance

Obstacle Avoidance

Health & Integrity Monitoring



Forced Landing System

Geo-Fence