Sense and Avoid for Small Unmanned Aircraft

David Maroney

703-983-7917 • dmaroney@mitre.org

Robert Bolling

703-983-6471 • rbolling@mitre.org

MITRE Technology Program

MITRE Sponsored Research

Problem

- ***Can small autonomous craft <u>reliably</u> <u>detect</u> and <u>avoid</u> <u>collision</u> with <u>objects</u> in its path of interest, both <u>stationary</u> and <u>moving</u>, that <u>do not announce</u> their position?***
  - **Many research efforts focus on one or more components of the research question – but few broadly address the <u>combination</u>**

<u>“Sense and Avoid” Scope</u>

- **Small UAS missions as driver (remote sensing)**
- **Small payload limitation**
- **Uncontrolled VFR airspace operation, mixed with manned aircraft, without transponders**
- **Reactive timeframe for sensing and avoiding**
- **Fixed, moving, and virtual obstacles**

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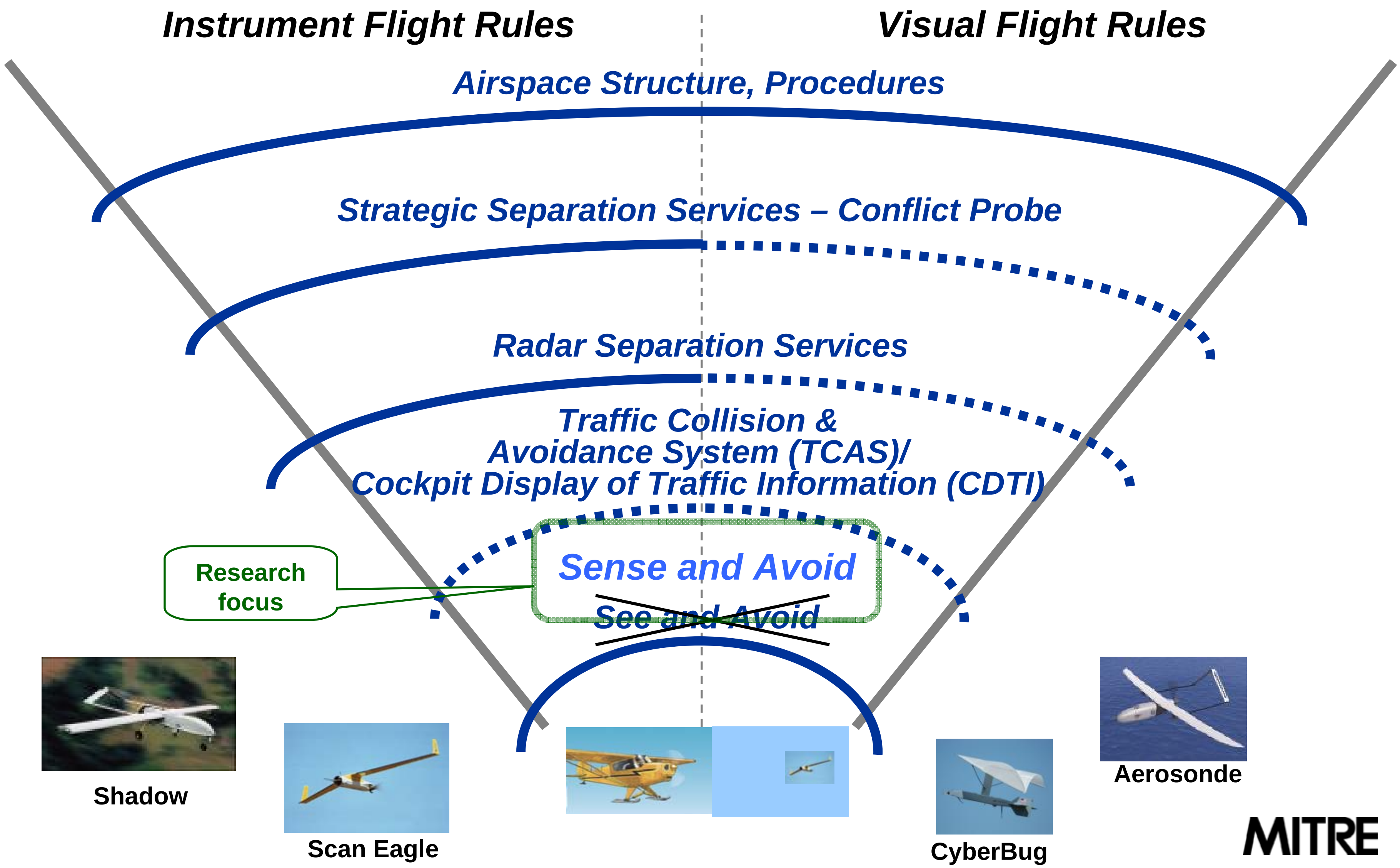
Background


Instrument Flight Rules
Visual Flight Rules
Airspace Structure, Procedures
Strategic Separation Services – Conflict Probe
Radar Separation Services
Traffic Collision &
Avoidance System (TCAS)/
Cockpit Display of Traffic Information (CDTI)
Research focus
Sense and Avoid
See and Avoid
Shadow
Scan Eagle
CyberBug
Aerosonde

Objective

- Discover and refine the ***requirements*** for small UAS sense and avoid
- Map the ***breadth*** of sense, detect, and avoid concepts and technology, and scope what is appropriate for small UAS
- Probe the ***depth***, by building, testing, and flying selected, promising combinations

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Activities

Sensor Research

- "Sense and Avoid" needs driven by multiple attributes:

ENVIRONMENT	OBSTACLE		UAS
Dark ↑ Light; Foggy Rainy ↑ Clear	**Object Movement**	**Object Size**	Size
	Fixed	pole ------------ building	Maneuverability
	Moving Predictably	UAS ------------ Cessna	(turn, climb rates)
	Moving Unpredictably	bird ------------- ???	SWP constraints

Sensor mode and type determines when object is sensed (and can be detected), DEPENDING on:
- Environmental conditions
- Obstacle type

UAS agility determines time needed to avoid, which in turn drives how much time the sensor needs to provide

- Developing a multi-dimensional sensor applicability space, defined by attributes shown above
- Mapping available sensors to space
- Using space to select sensors to test

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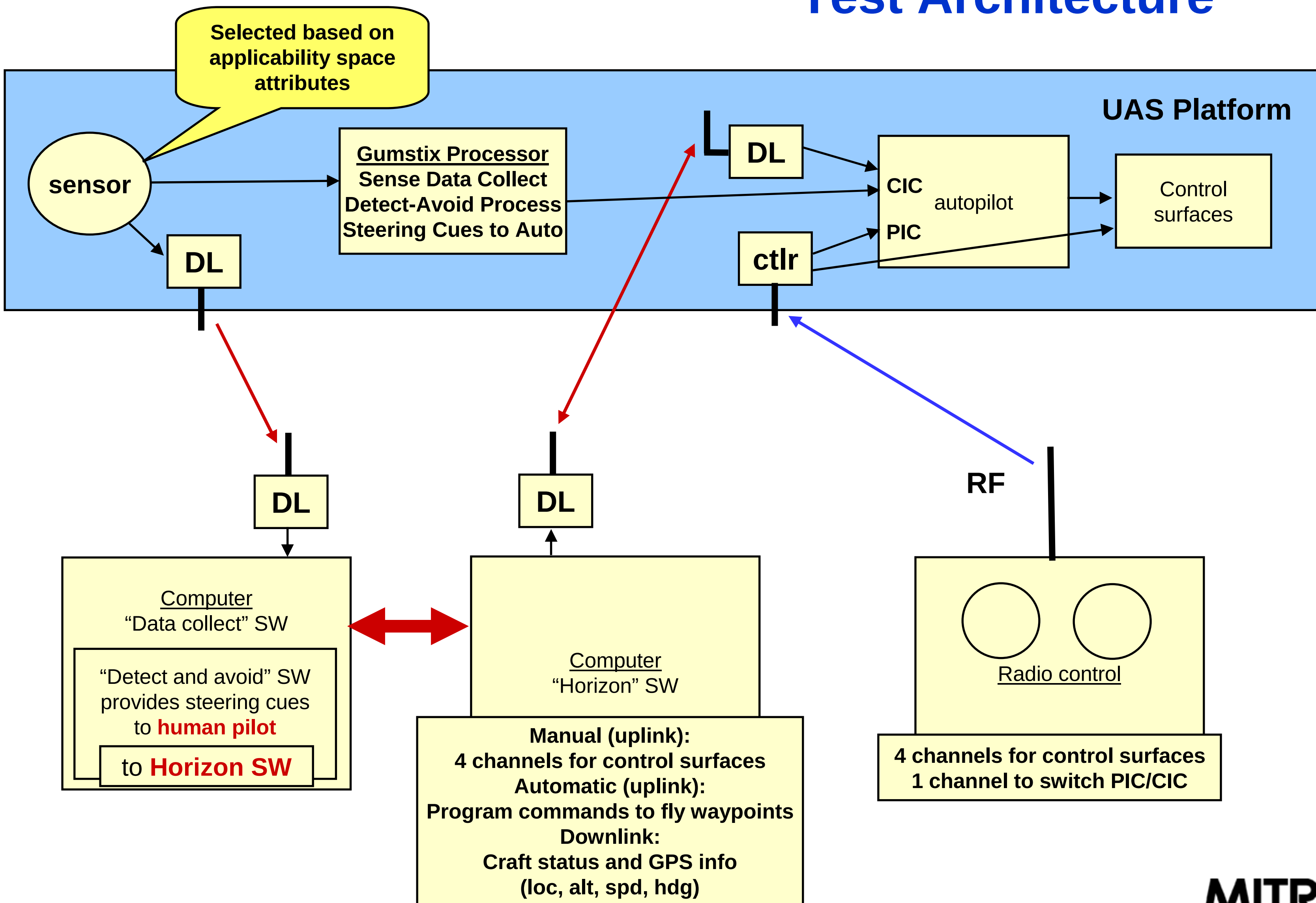
Highlight

Test Architecture



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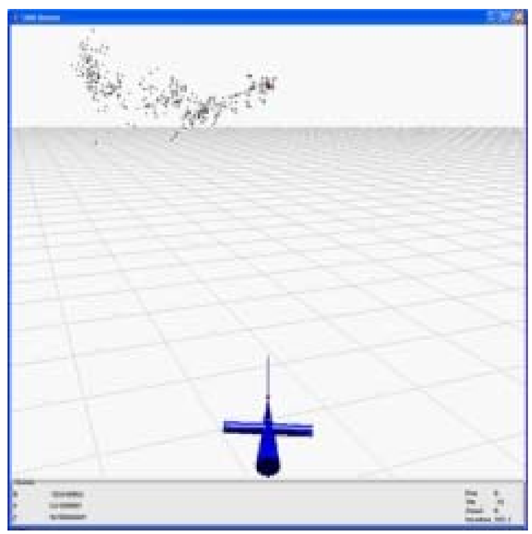
Demonstration

Field Testing

Fixed- and rotary-wing UAS flight tests

Field Analysis

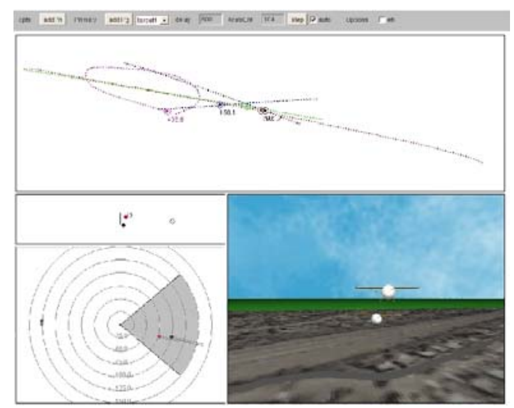
Downlink of on-board video



Real-time data visualization and analysis tools

Offline Analysis

3D data analysis



Simulation and data replay

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Impacts

- **Enable UAS access to airspace, by developing the capability for safe interaction of manned and unmanned aircraft**
- **Build corporate expertise with innovative UAS research and applied technology**
- **Directly leverage MITRE robotics experience and investment**

Future Plans

FY06	FY07	FY08
✓ Study aviation (TCAS, etc.) algorithms for CD and CA ✓ Evaluate sensor modalities, including visual, thermal, laser, sonar, and radar ✓ Complete construction of fleet of RC planes and autopilots ✓ Perform initial field trials (fixed) ✓ Build simulation support for algorithm development	• Acquire and test new sensors (iterate) • Integrate new sensor combinations into platforms • Develop onboard processing • Formulate system design • Extensive field tests; expand from fixed to moving targets • Continue simulation work to refine CA algorithms	• Complete sensor testing (current state-of-the-art) • Integrate good sensor combinations with onboard processing/algorithms • Reliability testing and refinement end-to-end • Refine system design • Document and report results; influence requirements/policy

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