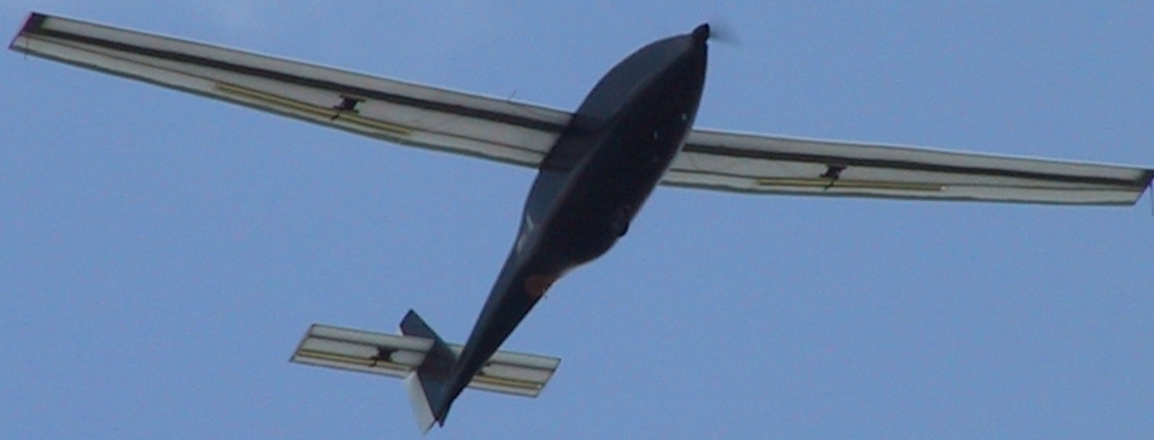
UAS's in S&T Aviation



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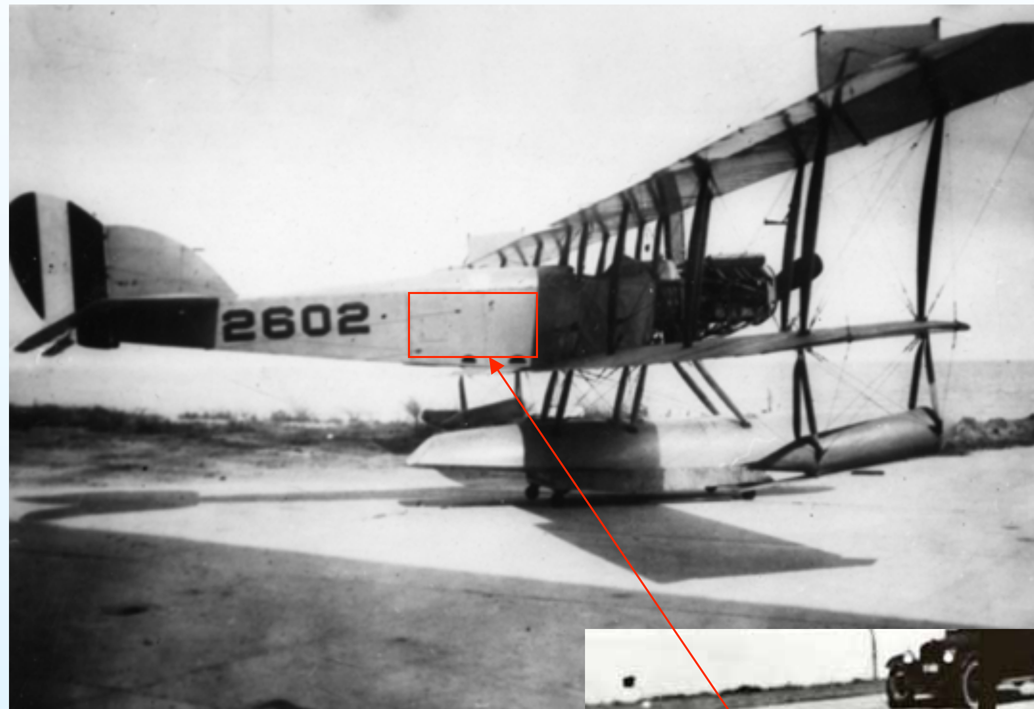
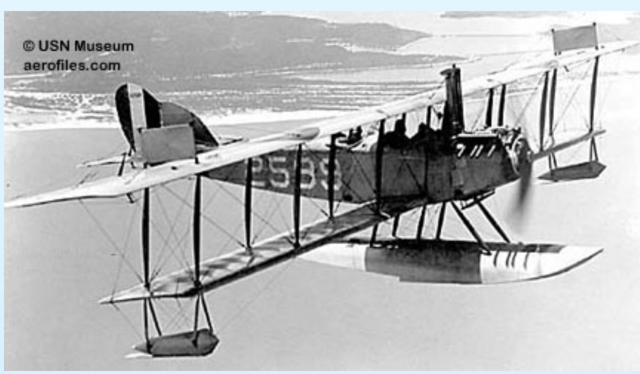
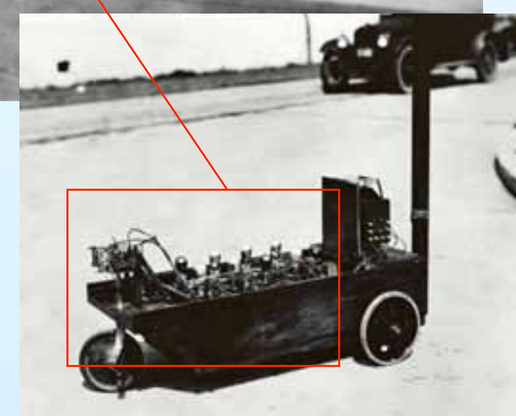
World's First Successful Remotely Piloted Aircraft By NRL - 86 Years Ago

- NRL's "Wild Goose", a WWI Navy Advanced Trainer, the Curtiss N-9H converted to a radio controlled drone
- Successfully flew on 15 Sep 1924 for 40 minutes executing 49 commands, but was damaged in landing and sank
- A piloted N-9H "chase plane" carried bricks to be thrown into the Wild Goose's propeller if its guidance system failed, an early version of "range safety"

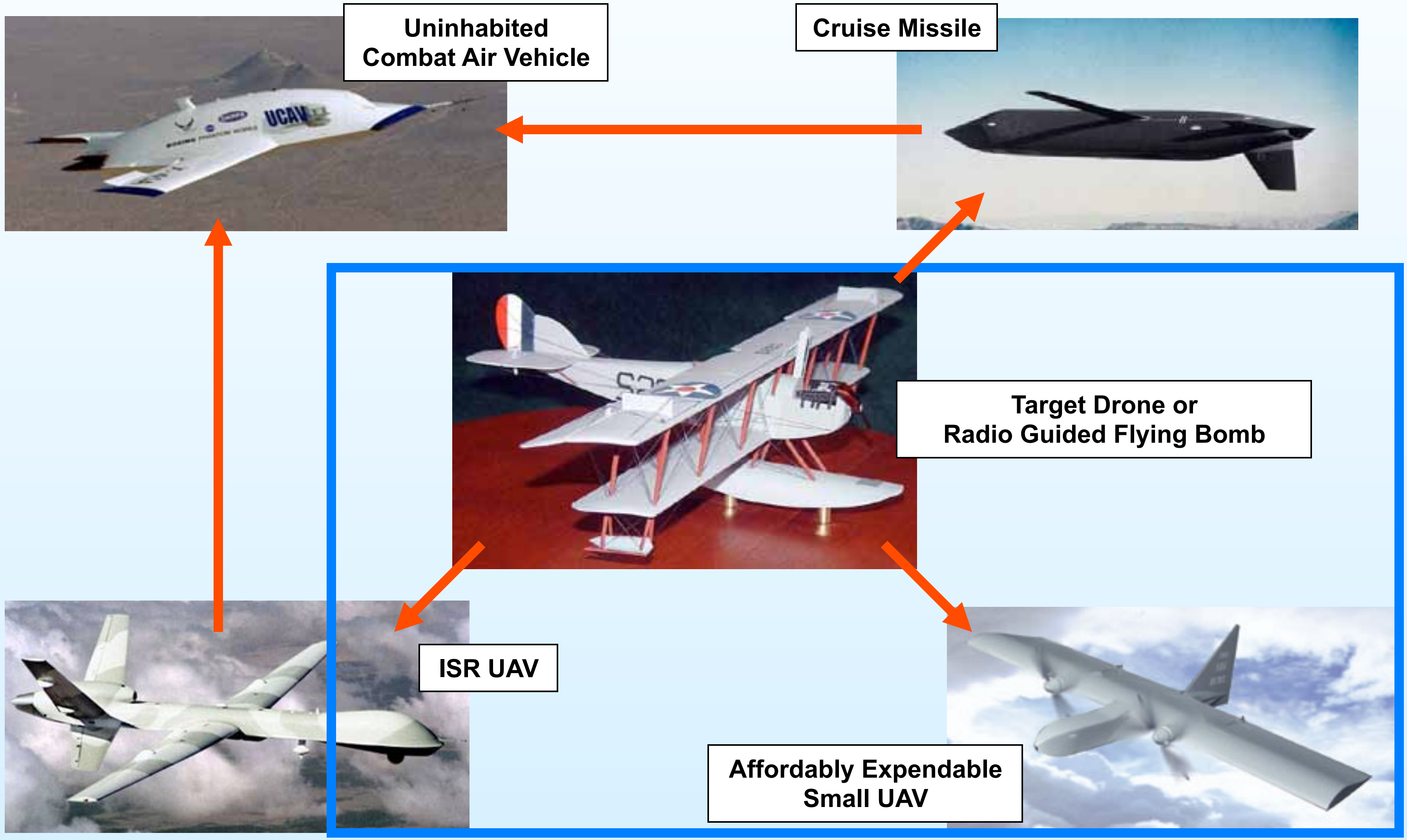




NRL's "Electric Dog" developed in 1923, featured the worlds first multi-function radio control system that formed the basis for the NRL system in the "Wild Goose"



UAS Categories



NRL UAS Payload S&T

- ISR: BAMS to MAV
  - Long to close range imaging
  - Geo-location & Mapping
- Detection & Recognition
  - Change
  - Biological Agent
  - Chemical Agent
- Electronic Warfare
  - Electronic Support
  - Electronic Attack
- Communications
  - Relay

EO/ IR Imagers

EO/ IR/ RF Sensors/Effectors

Navy UAS Missions

- ISR: BAMS to MAV
  - Moderate to close range imaging
  - Geo-location & Mapping
- Detection & Recognition
  - Change
  - Biological Agent
  - Chemical Agent
- Electronic Warfare
  - Electronic Support
  - Electronic Attack
- Communications
  - Relay

Ships at Sea
Shoreline & Land Installations
Large & Small Land Vehicles

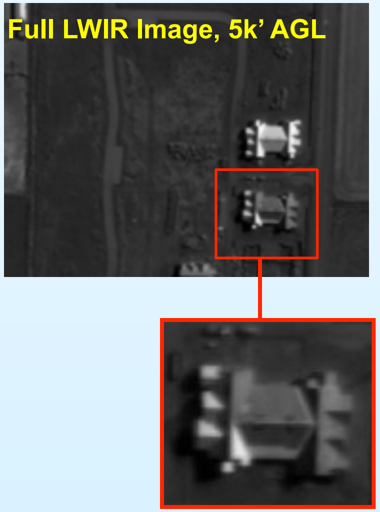
Face Recognition
Surfaces
Munitions

Stand-off
Direct sampling
Real-time Analysis

Close-in Collection
Onboard Data Storage
Antenna Integration

EyePod EO/IR Sensor

- Day/Night Survey & Inspection Sensor for TUAVs
  - LWIR (long-wave infrared) microbolometer array
  - VNIR (visible/near-IR) high resolution HDTV camera
- Small and lightweight : 9 in dia X 24 in, 25 lb
  - No mechanical cooling - low maintenance
- Embedded ground elevation data and GPS/INS for precise geo-location of imagery
- Ethernet connectivity for data downlinks/ command uplinks
  - Fully digital output with NITF 2.1 standard images
- Spiral Development:
  - "Phase 1" COTS optics flown since Fall'07
  - "Phase 3" full capabilities w/ custom optics, Fall'09
    - LWIR Narrow & NIR Narrow: from 5000' alt.

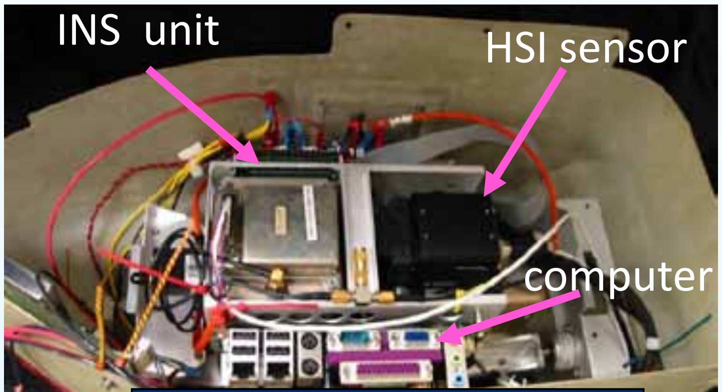


Full Res LWIR

Synthetic Aperture SAR (NuSAR)

- NRL-Developed
- Strip mode SAR, continuous operation
- L-Band or X-Band operation
  - 25 Watt transmitter; 475 MHz bandwidth
  - < 1 ft ground sample resolution in azimuth and range
- Designed for real-time SAR processing/ image formation
- Ethernet output in NITF image format or raw I&Q data
- Small and light-weight for Tier II (e.g., Shadow 200) UAVs
  - VME card design
  - Power: 160 W in, 25 W out (L-band); 240 W in, 30 W out (X-band)

Hyperspectral Imaging (HSI) TUAS Payload



HSI payload in Tern Pod

Pod on Tern-UAV

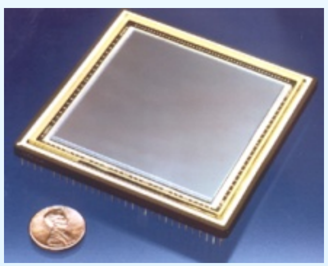
- NRL developed
- Initial Flight Tests 8/07 on a Manned Light Aircraft
- Tern-UAV flights 1/10

Day 1 | Day 2 | HSI CD

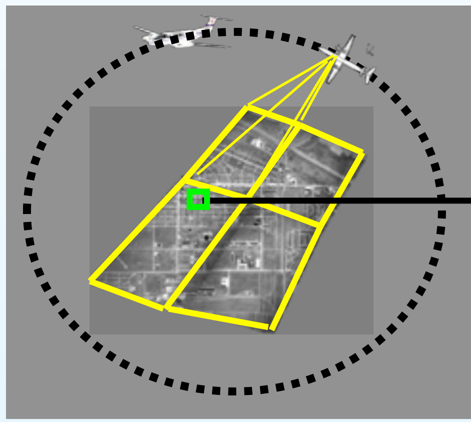
Imagery of Dillingham Airfield, HI. Geo-Registered RGB representation of HSI data and hyperspectral change detection results.

NRL Wide Area Day/Night Persistent Surveillance Sensors Pre and Post-Event ISR

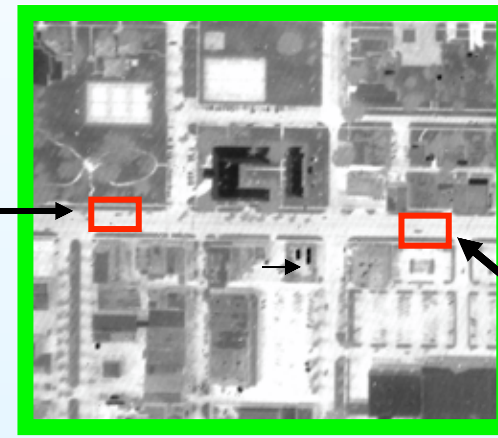
4,000² InSb focal plane



5,000² Silicon focal plane



Zoom-in



Car

- Vehicle Tracking
- Event Forensics

2005 OV-1 Mohawk
Mohawk Stare

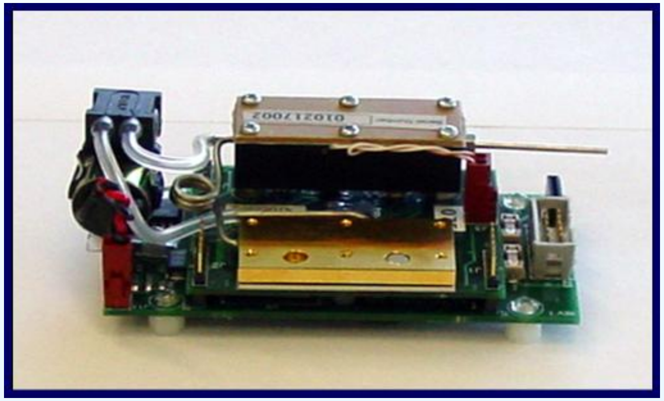
~ 42"long x 19" dia, 300 lb

2009 RC-12 KingAir
AngelFire/Blue Devil

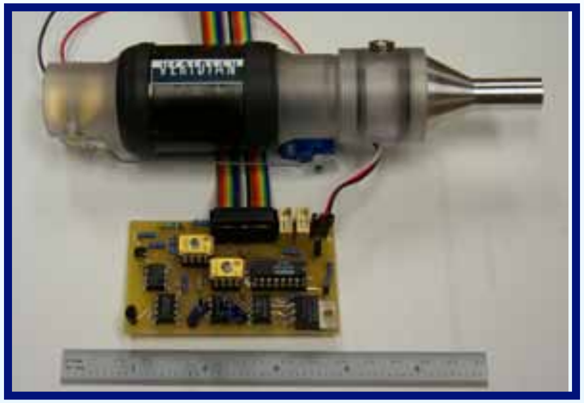
Future, ERMP, Shadow
Future UAS Sensor

1.5 cu ft.
50 lbs

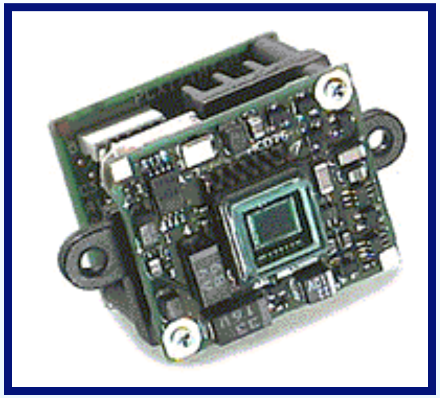
Advanced Tactical Recce Small UAV Payload



Chemical Agent Sensor



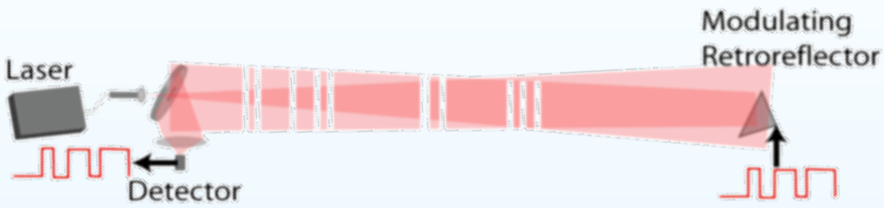
Biocollector



Video Camera

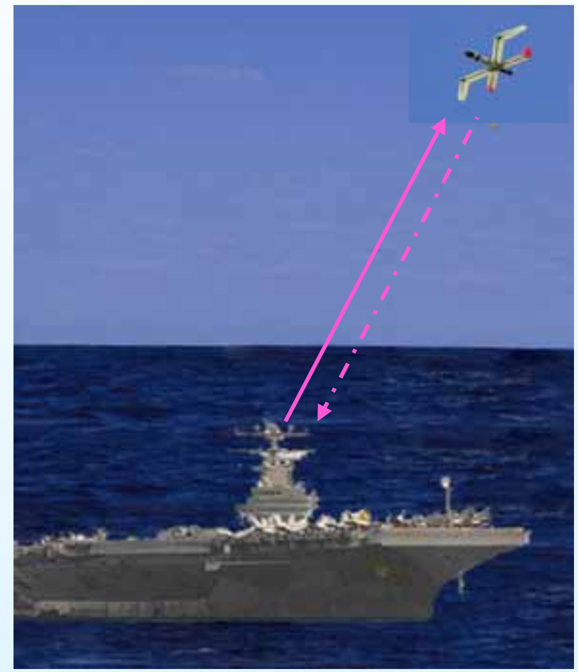
FEATURE	CHEM SENSOR DESCRIPTION	BIOCOLLECTOR DESCRIPTION	VIDEO CAMERA DESCRIPTION
Weight	4.1 oz	4.3 oz with anemometer/control circuit	0.79 oz - Side-Looking
Dimensions	3.7 in. Length X 2.0 in. Width X 1.62 in. Thickness	• Biocollector: 7.75 in. Length X 1.75 in. max. Diameter (cylindrical) • Control Circuit: 3.03 in. Length X 1.75 in. Width X 0.5 in. Thickness	0.86 in. Length X 1.02 in. Width X 0.63 Thickness
Power Supply Voltage	6.5V to 8.5V DC	15V to 24V DC	12V DC
Current @ Supplied Voltage	0.8 Amps	0.34 Amps with anemometer	0.08 Amps

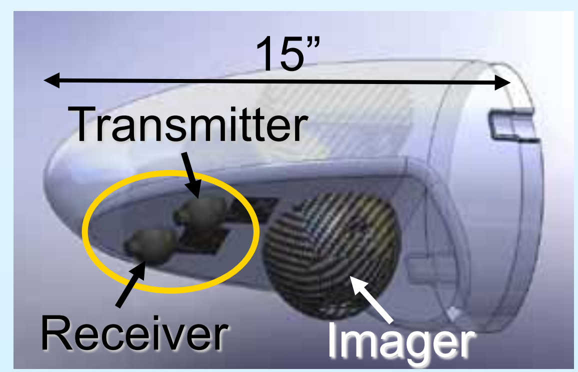
Lightweight Lasercom for Tactical UAVs



- For Tactical & Small UAVs
- Optical modulating retro-reflector (MRR) allows
  - Mbps bandwidth
  - Video downlink
  - LPI/LPD
  - Anti-jam, no frequency allocation issues
  - NO RF EMISSIONS
  - Very loose pointing on UAV (~15°)
- MRR Payload: Weight in Ounces
  - Power <1W

MRR





NRL UAS Payload Initiatives

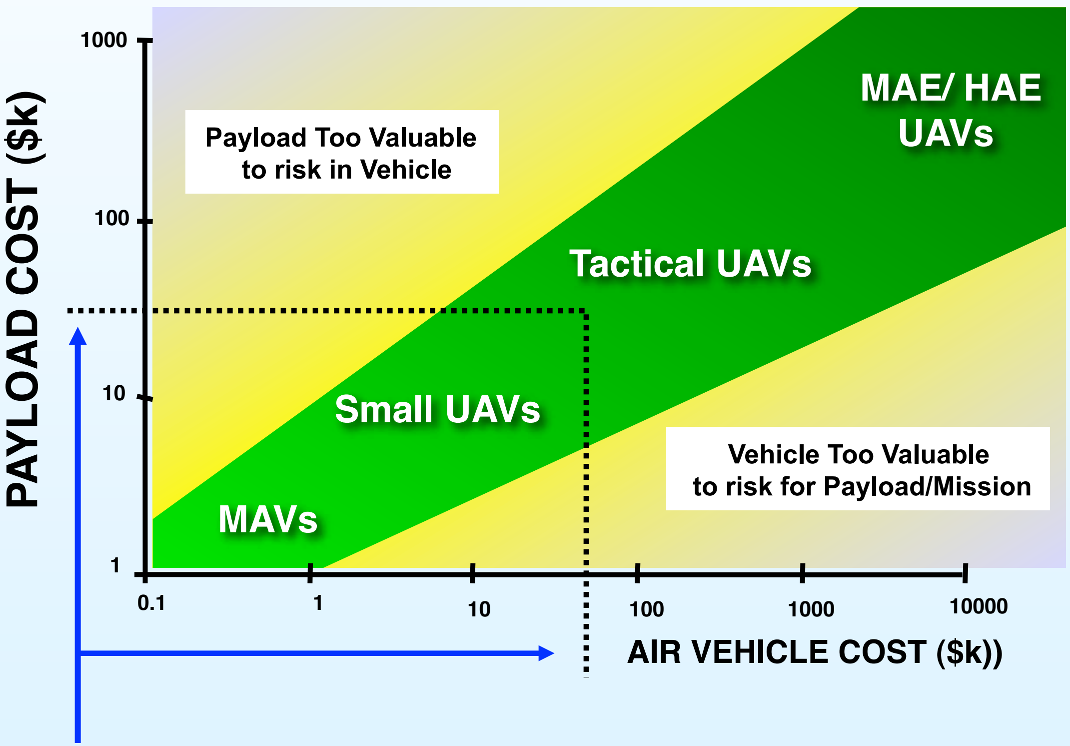
- Technology Advancement
  - Improve performance
  - Improve onboard processing
  - Data link optimization
  - Miniaturization
  - Reduce power and cooling requirements
  - Reduce production cost
  - Small vehicle/ payload Integration
  - Sensor fusion
  - Significant reduction in operational logistics and manpower

- Transition Technology to Industry

NRL UAS Payload Vision

- Technology Development which supports:
  - Multi tiered sensor integration (Subsurface to space)
  - Near real-time data dissemination to individual warfighters
  - Ability to perform missions too dull, dirty, dangerous or expensive with present day manned and unmanned assets
  - Evolving Fleet requirements
  - Affordably Expendable Tactical UASs
  - Long Endurance Tactical and Small UASs

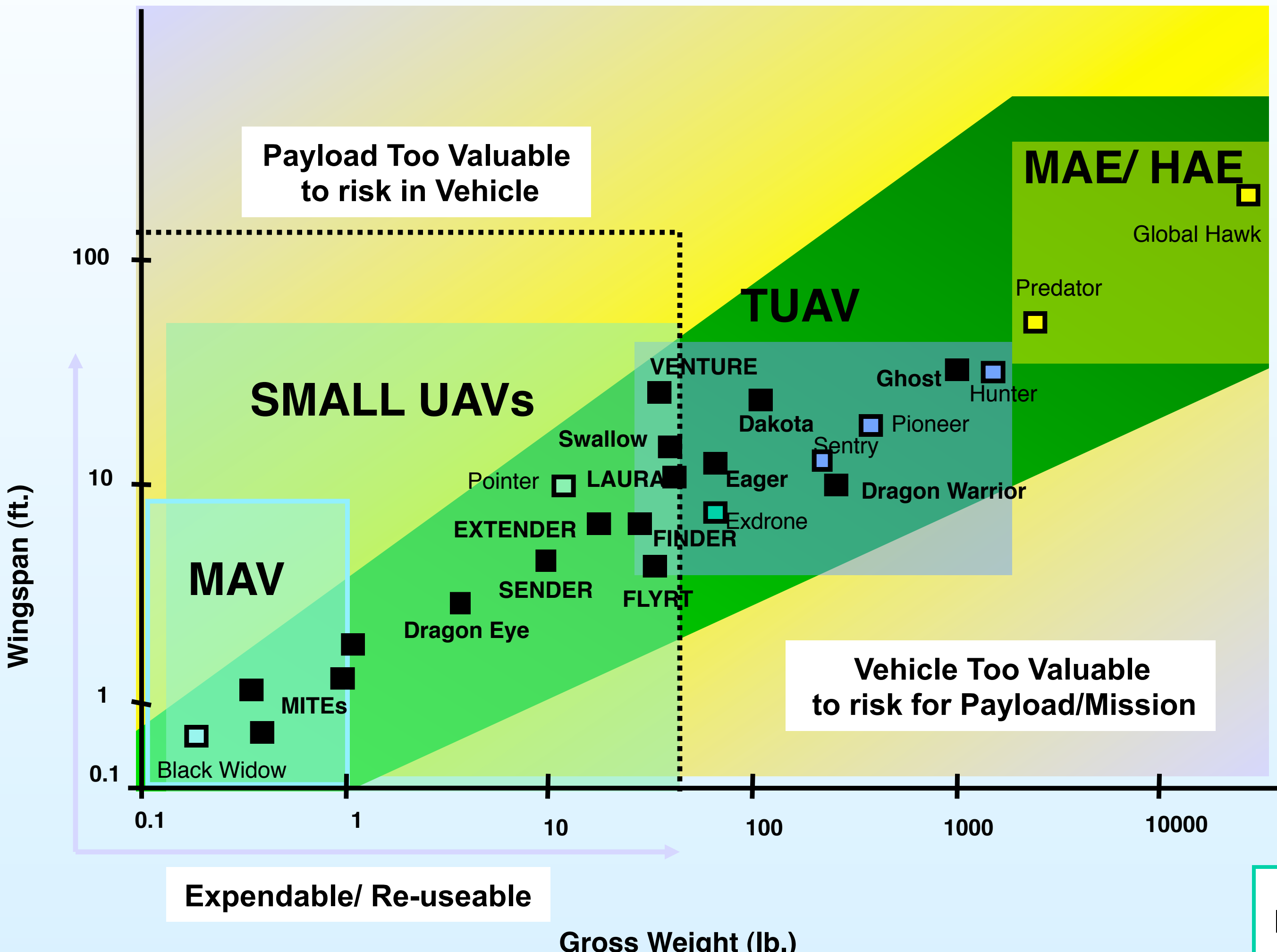
"Affordably Expendable" Design Philosophy



NRL's Affordably Expendable Air Vehicles

- Intrinsic value is its capability, not the system cost
- No/ minimal maintenance, i.e. use until failure, then discard
- Recover vehicle when convenient or necessary
- Expend vehicle when necessary
- Since the airframe is only the "carton" that holds the eggs, the airframe is easily upgraded or replaced in the spiral development acquisition cycle, enabling the system to incorporate the latest technologies

UAV Classes



■ NRL UAVs

Air Vehicle Technology Focus

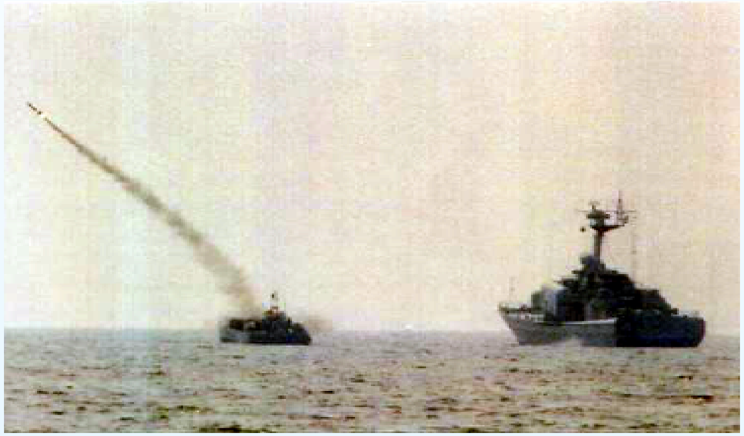
- 55 Major Projects
- 225+ Air vehicles

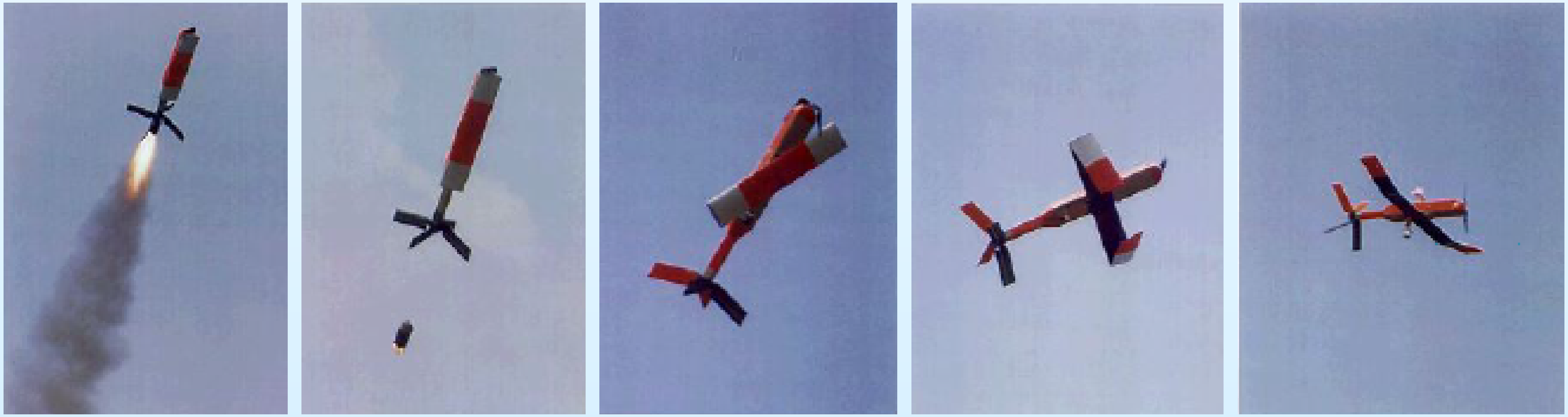
- Affordably Expendable
- Small Vehicles
  - Fixed Wing
  - Rotary Wing
- Autonomous Operation
  - Guidance, Navigation, & Control
  - Mission Planning
- Electric & Hybrid Propulsion
- Aerodynamic In-flight Wing / Multiple Deployment Techniques
- Payload Integration
- Airframe/Antenna Integration

FLYing Radar Target (FLYRT)
Advanced Technology Demonstration

Purpose:

- Demonstrate the capability to rapidly deploy from an unmodified MK-36 DLS launcher, a sophisticated electronic decoy for ships defense against advanced RF-guided anti-ship missiles.





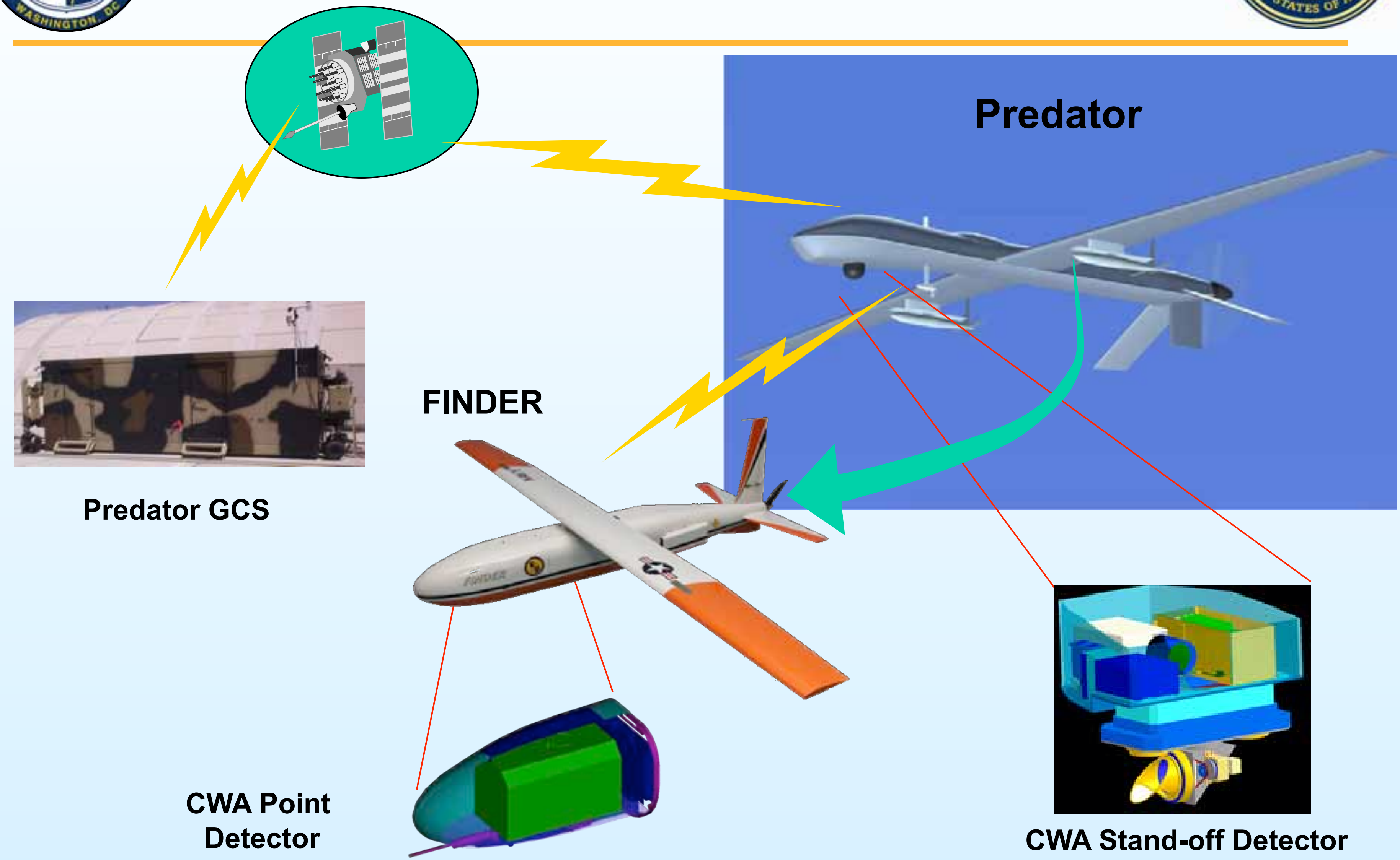
Flight Inserted Detector
Expendable for Reconnaissance

FINDER

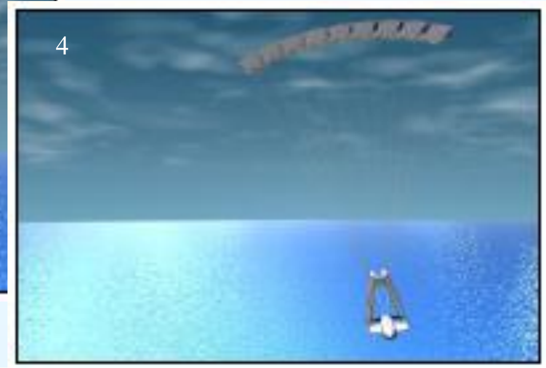
DTRA CP-2 ACTD

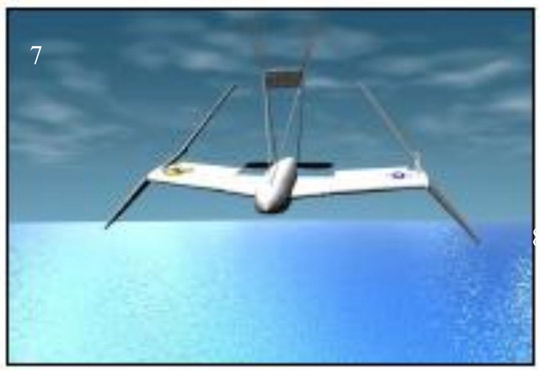
Post-strike chemical agent point sensor deployed from Predator UAV

FINDER System Architecture



U.S. NAVY P-3 DEPLOYMENT



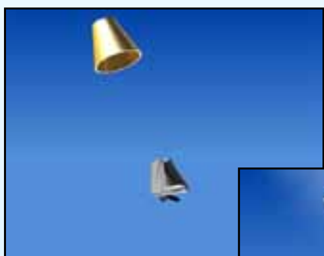


GROSS WHT. 30 LB W/ 5 LB SENSOR
FITS A 30 IN X 30 IN X 18 IN CONTAINER

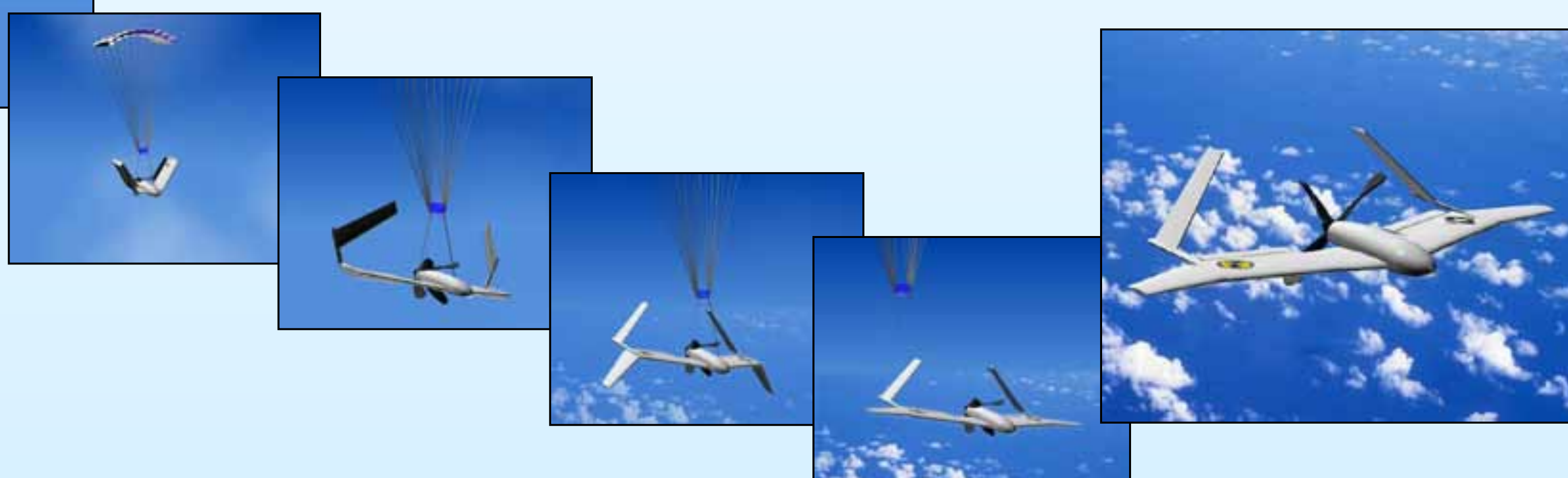
NRL UAS Technologies

One-Piece Unfolding Airframe

- Demonstrated on several research UAS’s, incl. ATD’s and ACTD’s
- Available since 1990 and fully matured for expendable & tactical systems
- No loose airframe components on-deck
- No tools required for pre-launch prep
- Short timeline from container to launch



- Enables development potential for autonomous and air-launch



Ghost

Custom designed and fabricated at NRL for a specific payload
All non-conductive airframe except engine, brakes and avionics box
Initial flight test through mission demonstration conducted by NRL team

Wingspan	30 feet
Length	22 feet
Cruise Speed	70 kts
Empty Weight	800 lbs.
Gross Weight	1200 lbs.
Payload	400 lbs.

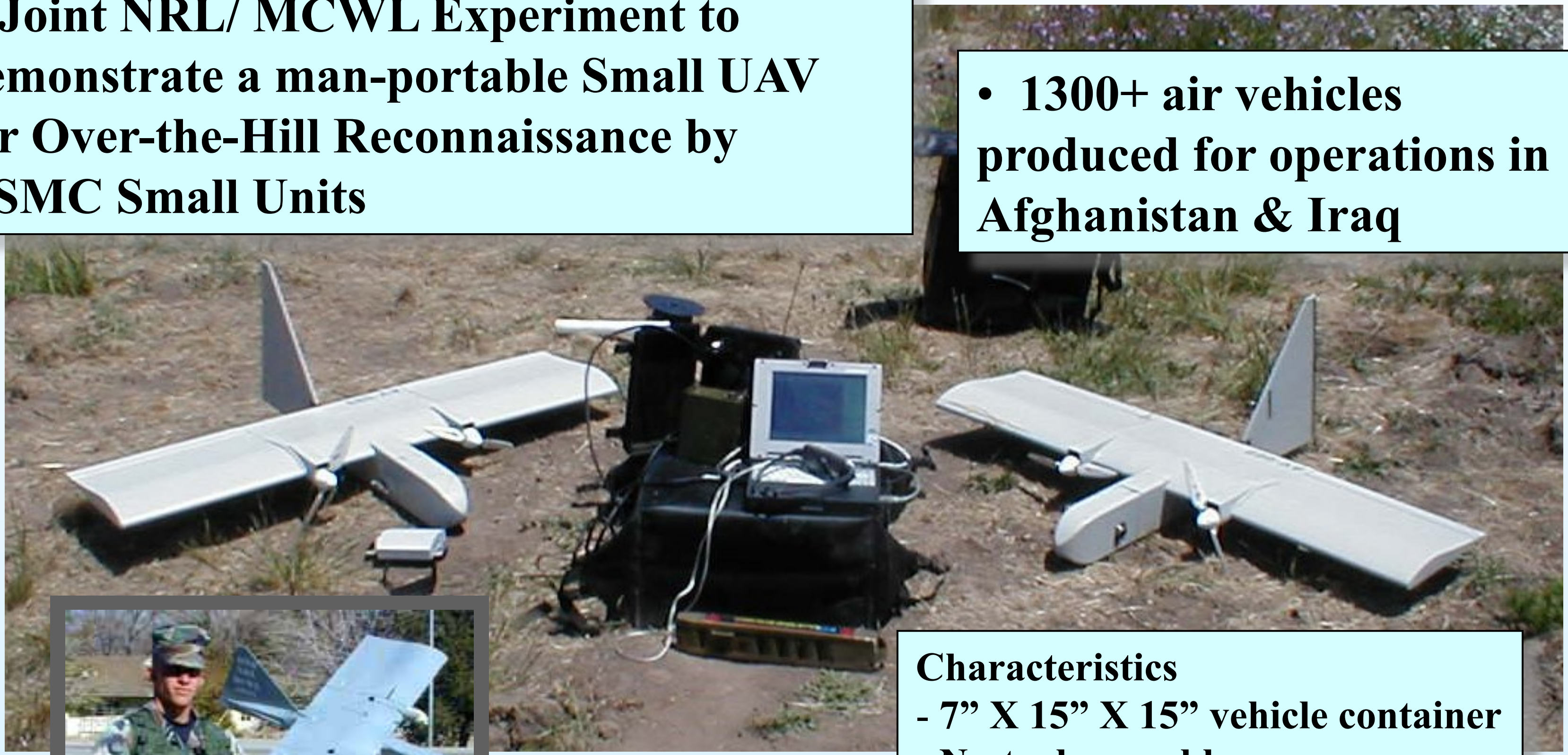
Small & Micro Vehicle Evolution

RQ-14A Dragon Eye

USMC Interim Small Unit Remote Surveillance System

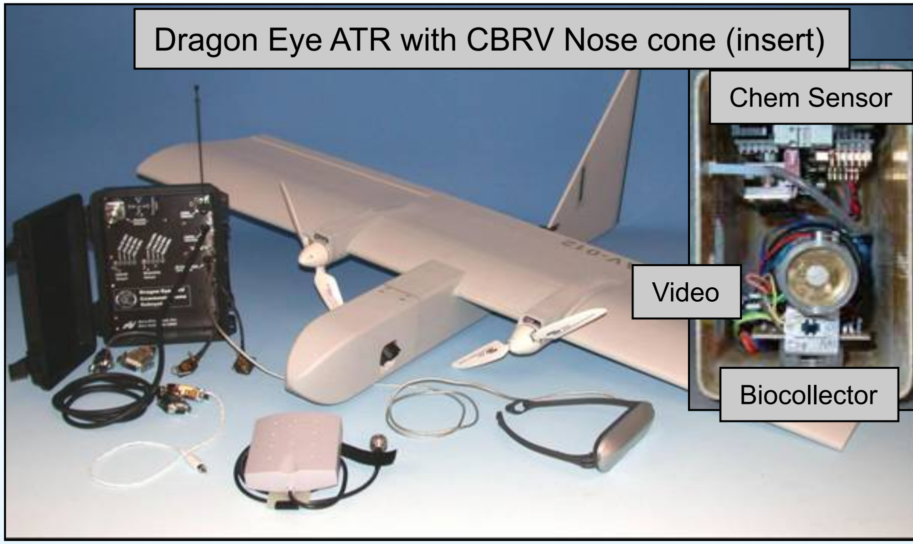
- Joint NRL/ MCWL Experiment to demonstrate a man-portable Small UAV for Over-the-Hill Reconnaissance by USMC Small Units

- 1300+ air vehicles produced for operations in Afghanistan & Iraq



Characteristics
- 7” X 15” X 15” vehicle container
- No-tool assembly
- Portable GCS
- Autonomous operation
- Daylight & IR imager
- 30 to 60 min at 40 mph

Dragon Eye ATR with CBV Sensor Payload



Capability Characteristics

- **Altitude:** 50-1000 ft AGL
- **Range:** ~50 min at 40 kt
- **Report Time (days, min, hrs):** Chem Detection (real-time); Bio Collect-then-Detect (30-45 min)
- **Multiple Sites per Mission:** Yes
- **Comms:** Ground Station
- **Military / Civilian Operators:** Military
- **# of systems required:** 1 per mission, reusable, multiple-type payloads
- **Confidence in Report:** High
- **Detect Single or Multiple Agents:** Multiple

Description

data

nin
or

Unclassified

SPIDER

Scientific Payload Insertion Device Electric Rotor

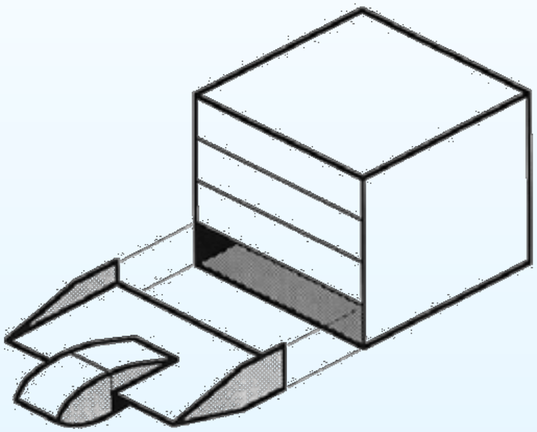
Features

- Electric propulsion
- NRL-developed flight control software implemented on Cloud Cap Technology hardware
- GPS aided INS
- Non-line-of-sight comms through Iridium network
- 4 lb. payload capacity
- 25 min mission endurance
- 38 mph cruise groundspeed
- 50 mph max airspeed

Objective

- Develop an easy to operate, easy to transport electric rotor craft to accurately deploy scientific sensors into hazardous environments

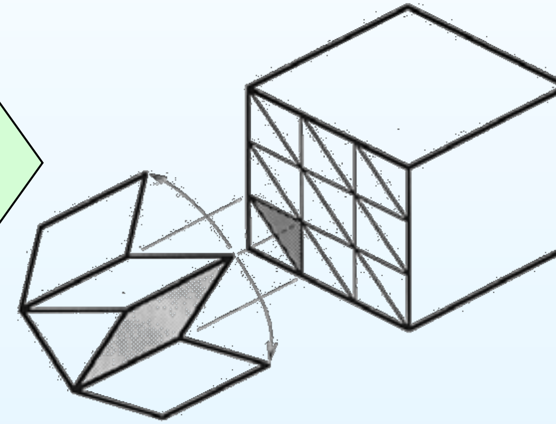
CICADA Concept



4 NRL or DARPA MAVs per 6” Cube

Proposed Effort

- Equiv. or better Aero Performance
- Equiv. Payload Capacity
- 450% Increase in Package Efficiency
- 1/10th Production Cost per Unit



18 CICADA MAVs per 6” Cube

<u>Objective</u>: Integrate current MAV autopilot and navigation technologies with the development of a deployment-optimized micro disposable air vehicle - CICADA. Demonstrate equivalent or improved flight performance with a substantial improvement in packaging and deployment efficiency, and a goal of a very low production cost (~ $0.1K/vehicle).

CICADA
Close-in Covert Autonomous Disposable Aircraft

Gliding Printed Circuit Board

Design Goals

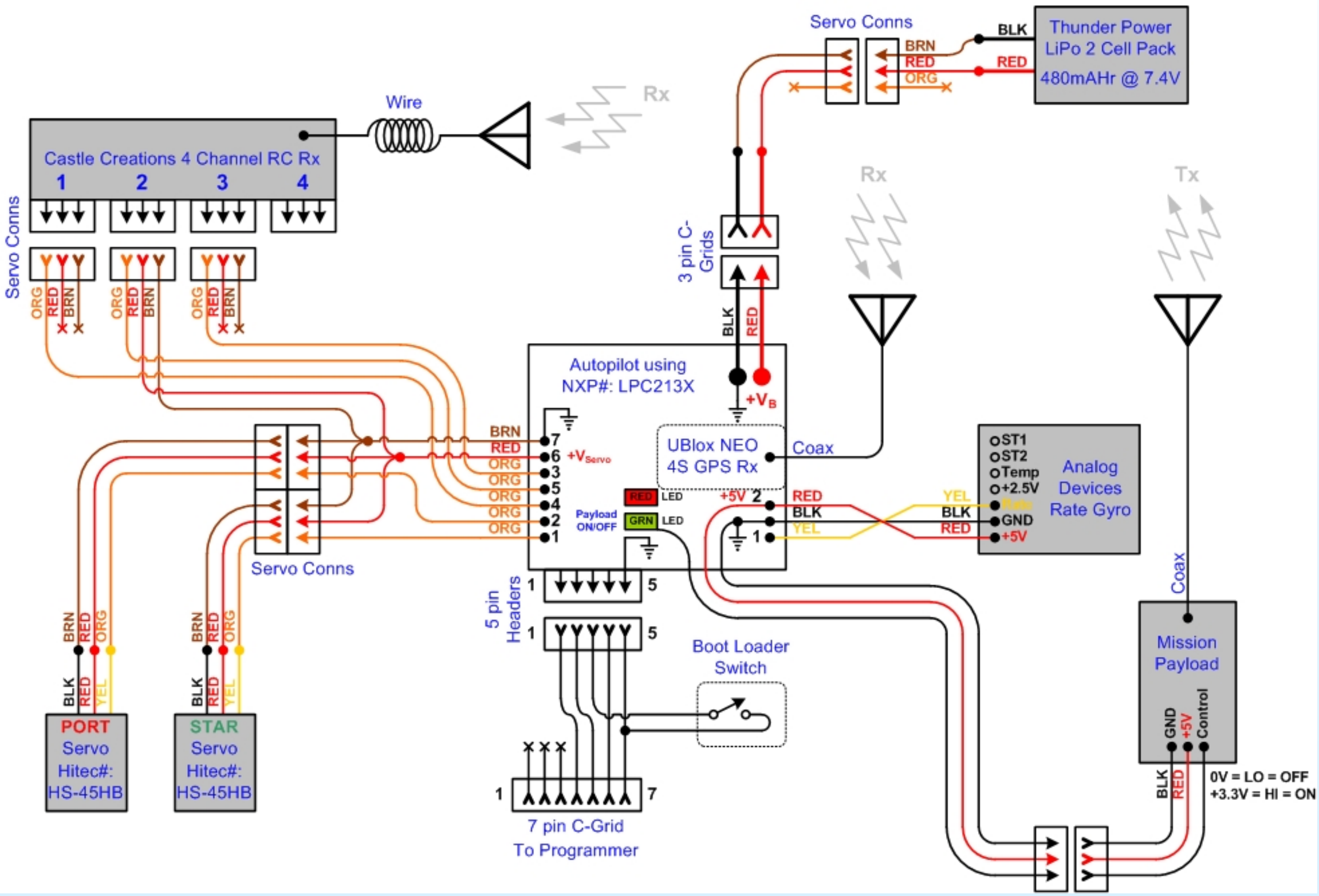
Cost:	$100 per aircraft
L/D Ratio:	3.5/ 1
Weight:	4 to 8 oz (MAV)
Range:	3.5 X Launch Alt
Navigation:	GPS
Control:	Yaw to Turn (inherently stable)

Mission

Air deploy a large number of micro payloads, each emplaced with GPS accuracy, to rapidly establish ad hoc sensor networks.

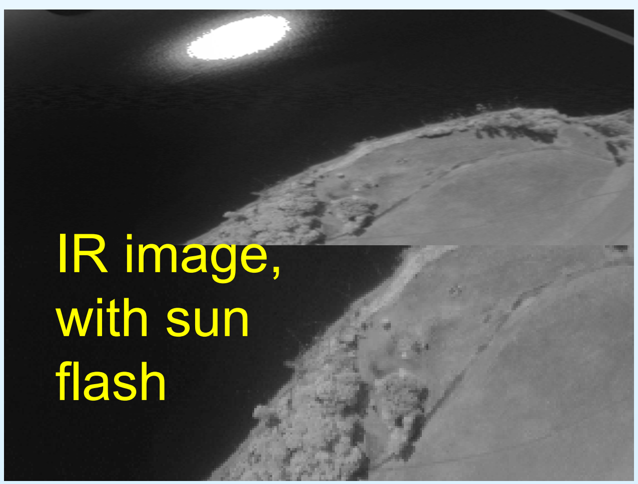
CICADA Avionics

CICADA Wiring Diagram V1 (CICADAWiringV1)(14AUG09)



Small Platform Navigation: Coast Watcher Shoreline-Following Machine Vision System

- For small UAVs in GPS denied area
- Optical discrimination of land/water
- Aircraft autonomously follows shore
- Successfully demonstrated Oct 2006
- Adaptable to following other features via hyperspectral imaging

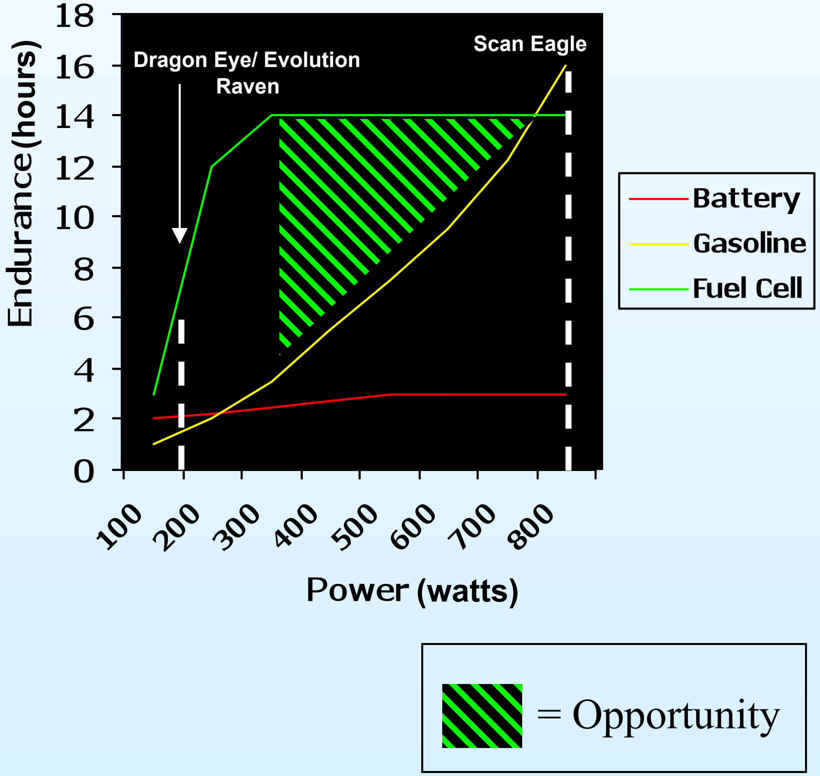


Hydrogen PEM Fuel Cell for Small Air Vehicles

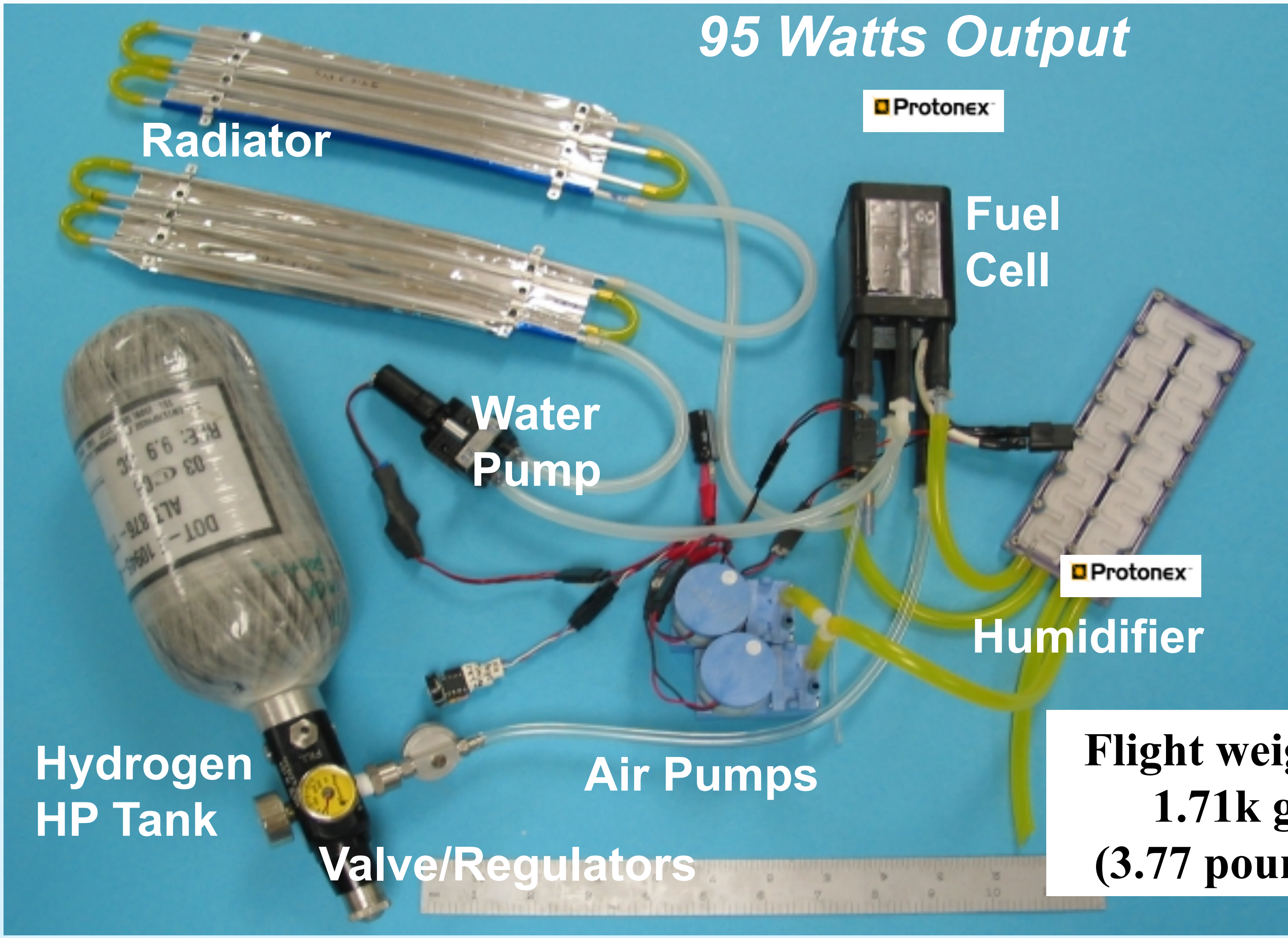
At power levels needed for man-portable Small UAVs (100 - 500 watts) the Hydrogen Gas PEM Fuel Cell is 45% efficient vs. the 7 – 12% of small IC engines

- This offers unprecedented potential for <u>long endurance</u> electric motor-powered Small UAVs

- Will enable <u>Persistence</u> for Reconnaissance, CB Agent Detection, and EW Missions to be performed by organic/ man-portable systems

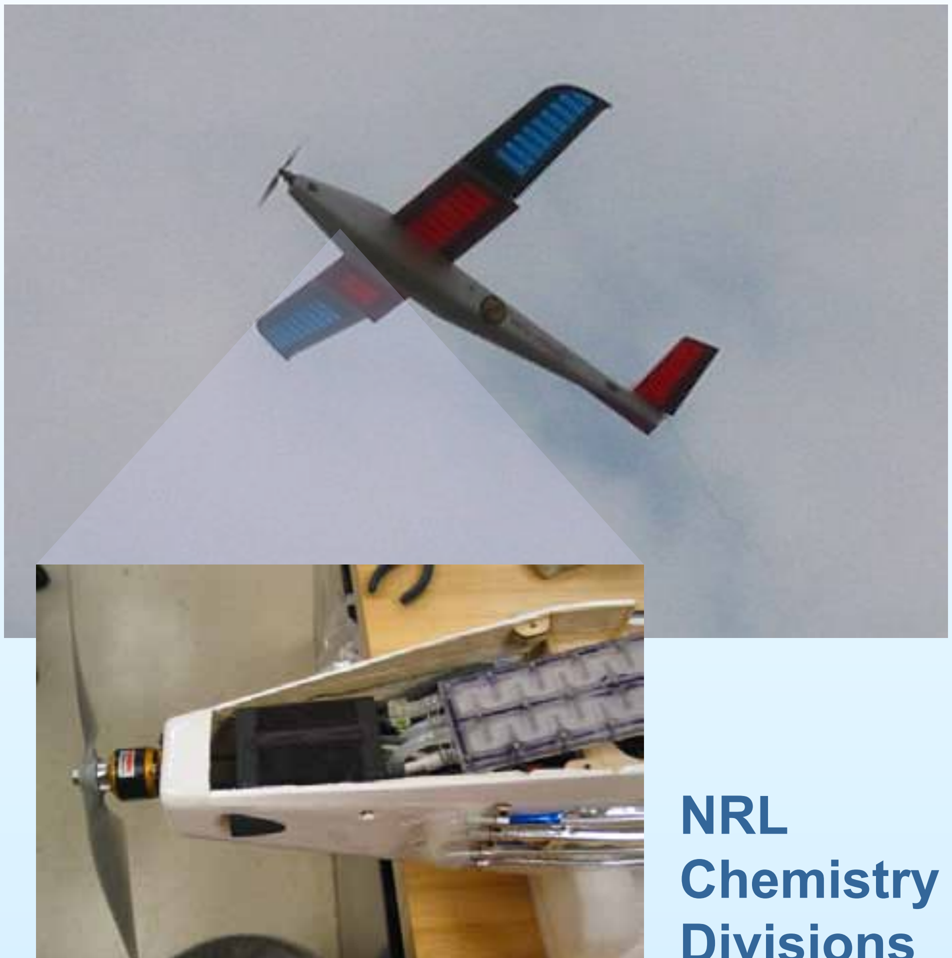


Spider Lion Fuel Cell Powerplant



Flight weight: 1.71k g (3.77 pounds)

Fuel Cell-Powered “Spider Lion” Small UAV - Endurance Test Flight



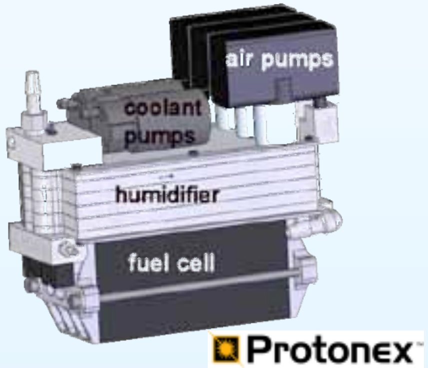
Flight Time: 3 hours, 19 minutes
9 Nov 2005, Ragged Island, MD

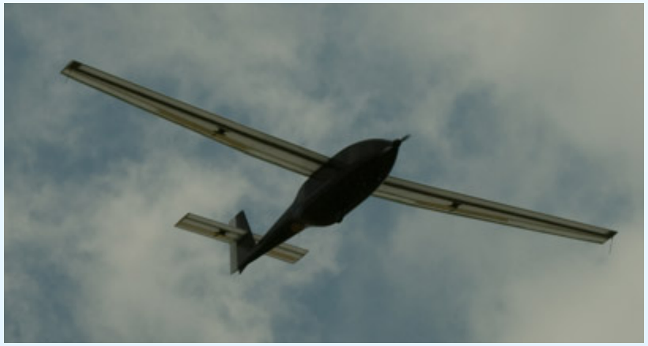
Consumed 15 g of H_2
(45 cu. in. @ 4500 psi)

NRL
Chemistry & Tactical Electronic Warfare Divisions

Ion Tiger Program

Demonstrate 24 hr flight of polymer fuel cell propulsion system capable of operating in relevant Naval environments

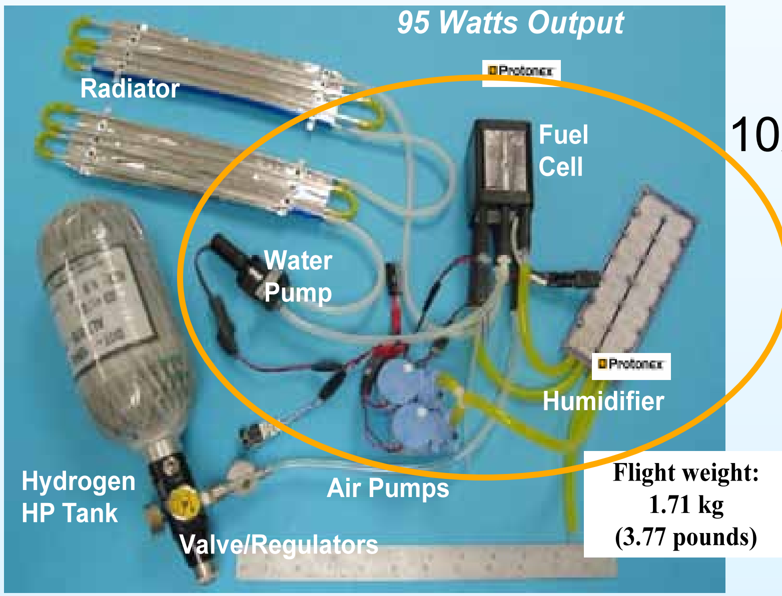




- 500-W/ 1-kg polymer fuel cell system
- 18-kg electric 24-h UAV with 2.5 kg payload
- High capacity storage of alternative fuels (hydrogen)
- Fuel cell contaminant and durability studies

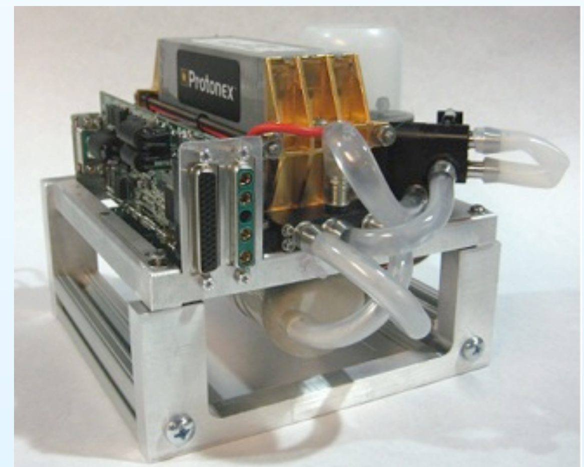
Fuel Cell Evolution 2005 to 2009

Spider Lion System



10x specific power
8x endurance

Protonex Ion Tiger Fuel Cell



- 1 kg fuel cell
- 6 kg system (fueled)*
- 550 W (max)
- Average 290 W for 24 hr flight

* Compared to a lithium battery:
5x endurance w/ compressed H2
15x endurance w/ liquid H2

Ion Tiger Flight Research

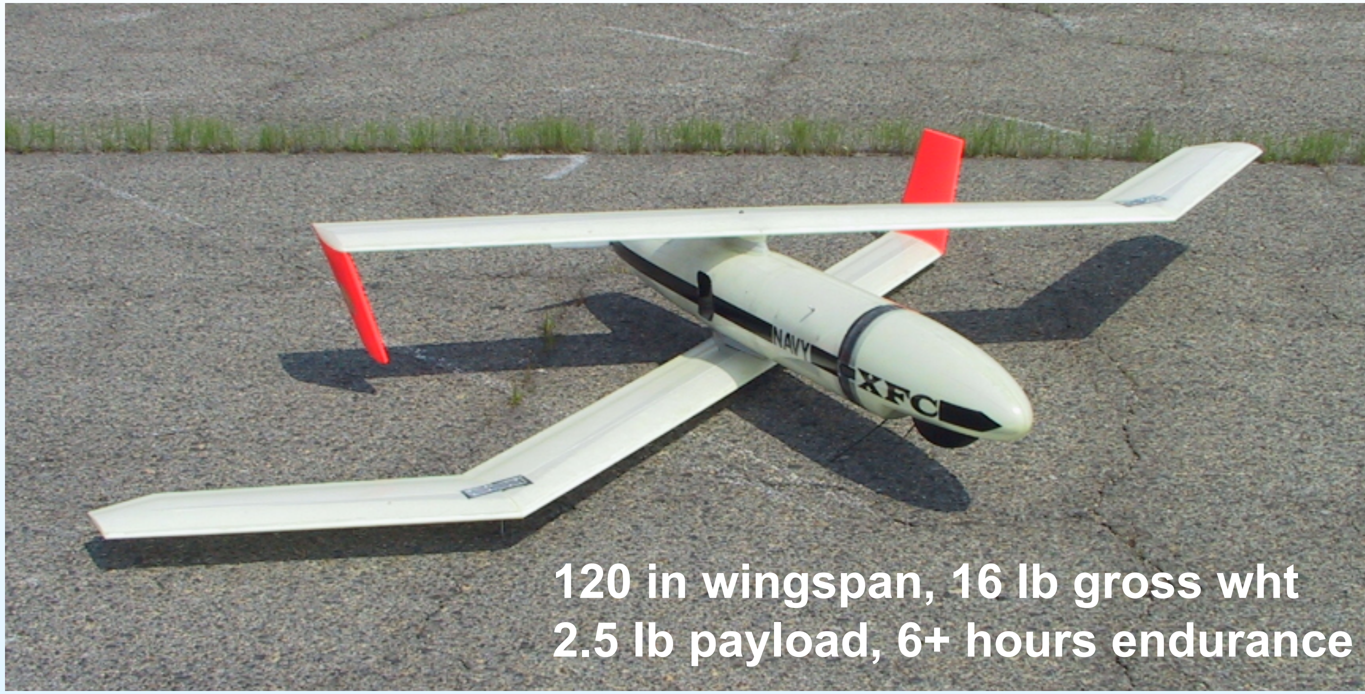
Ion Tiger – Hydrogen Fuel Cell, Electric UAV
Technology Demonstrator

23hr 17min Endurance
Demonstrated Under
Adverse Weather Conditions

26hr 1min Endurance
Demonstrated Under Average
Conditions
Landed with 1 Hour Fuel Reserve

XFC

Tube Launched, Long Endurance, Expendable Air Vehicle



Fits a 18 in diameter X 78 in length tube

Wings deploy by spring-driven rotation around one central pivot then hinged wing tip panel swing open by aerodynamic forces.
Patent pending on aircraft configuration and deployment method

XFC Flight Research