# Defense Innovation

**Eric D. Evans**
**Director**

**28 August 2018**

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

# MIT Lincoln Laboratory

## DoD Federally Funded Research and Development Center

*Massachusetts Institute of Technology*

*MIT Lincoln Laboratory, Lexington, Massachusetts*

**Mission:** Technology in Support of National Security

**Key Roles:** System architecture engineering
Long-term technology development
System prototyping and demonstration

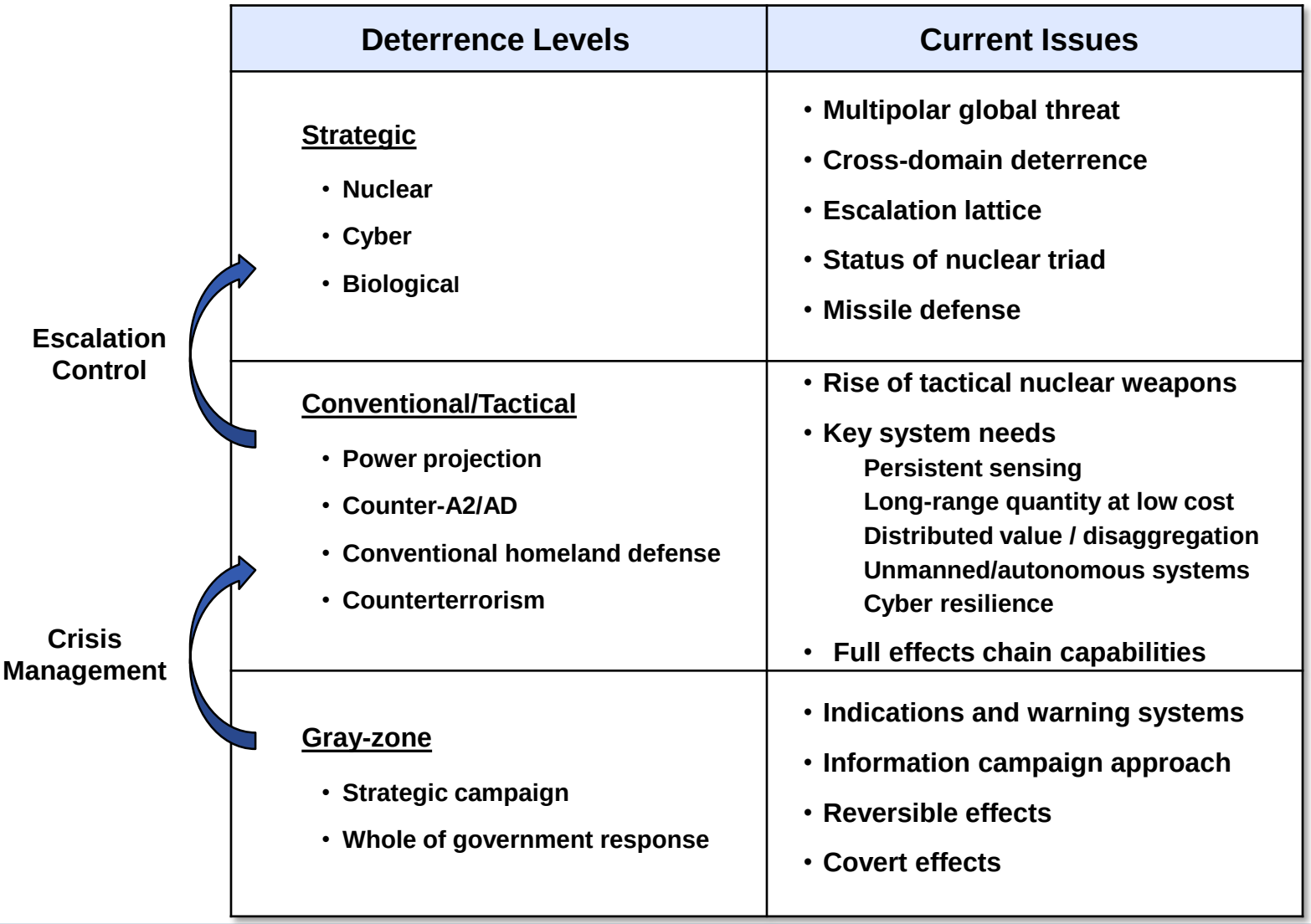
**Mission Areas:**

- Air, Missile, and Maritime Defense Technology
- Homeland Protection
- Air Traffic Control
- Communication Systems
- Cyber Security
- Advanced Technology
- Space Systems and Technology
- ISR Systems and Technology
- Tactical Systems
- Engineering

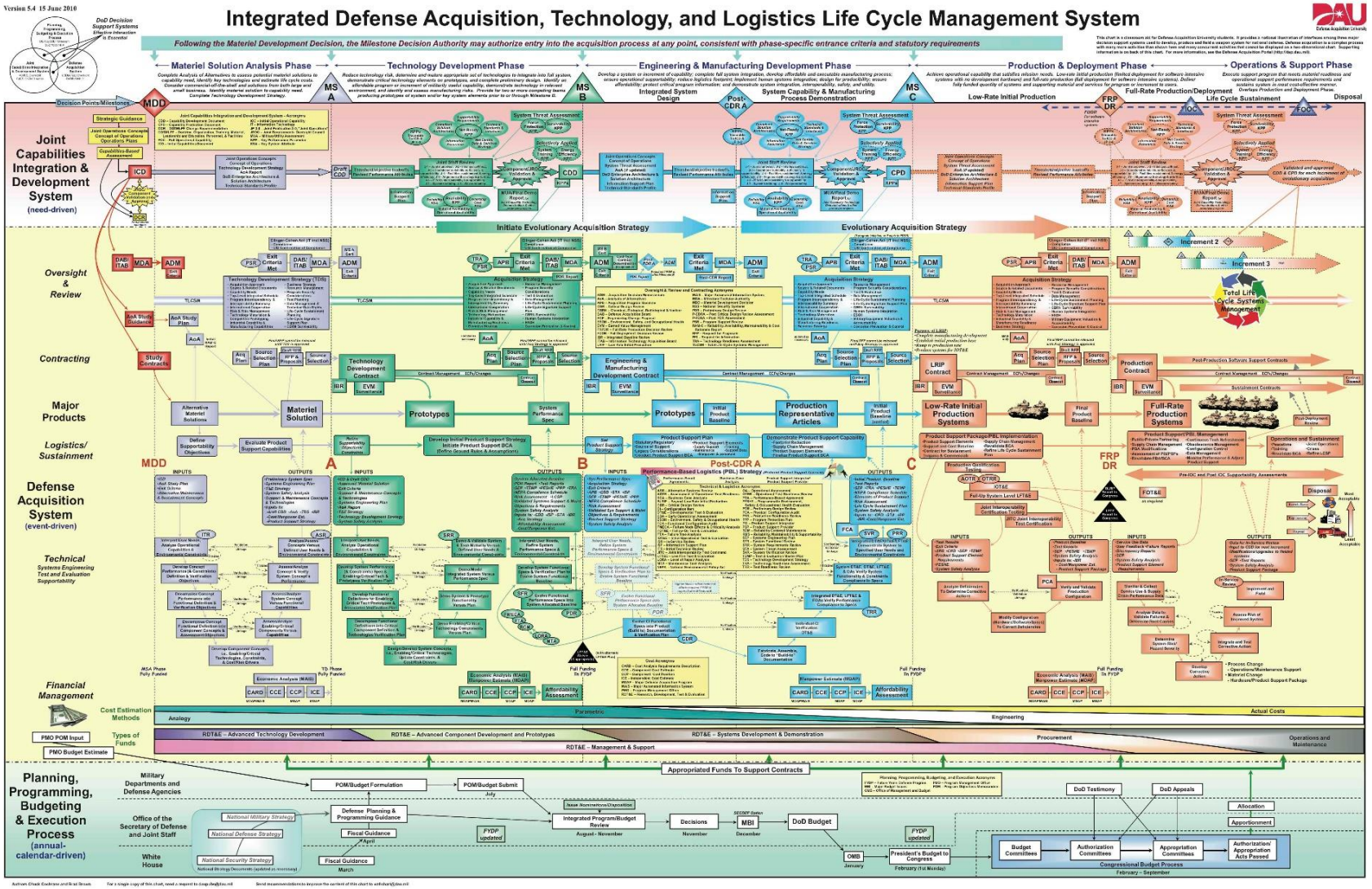
**FY18 Funding:** $1.05B

**Number of Employees:** 3995

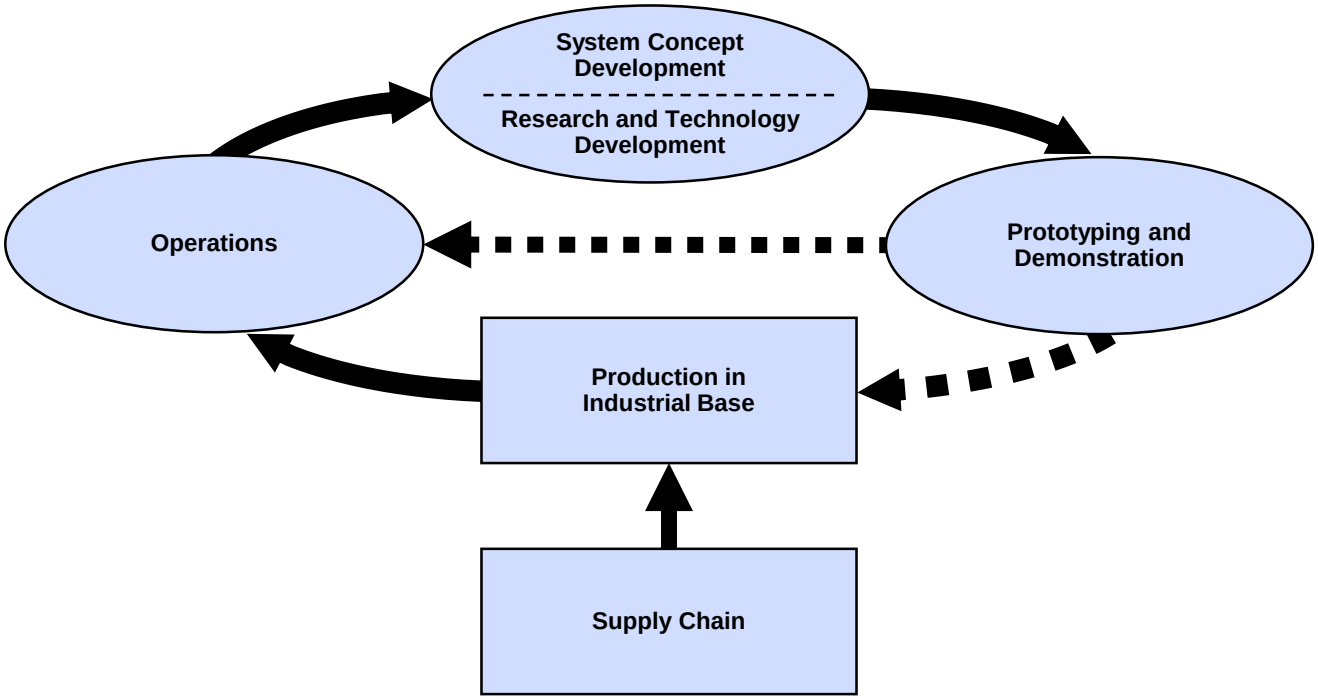
# National Security Landscape
## Deterrence Perspective



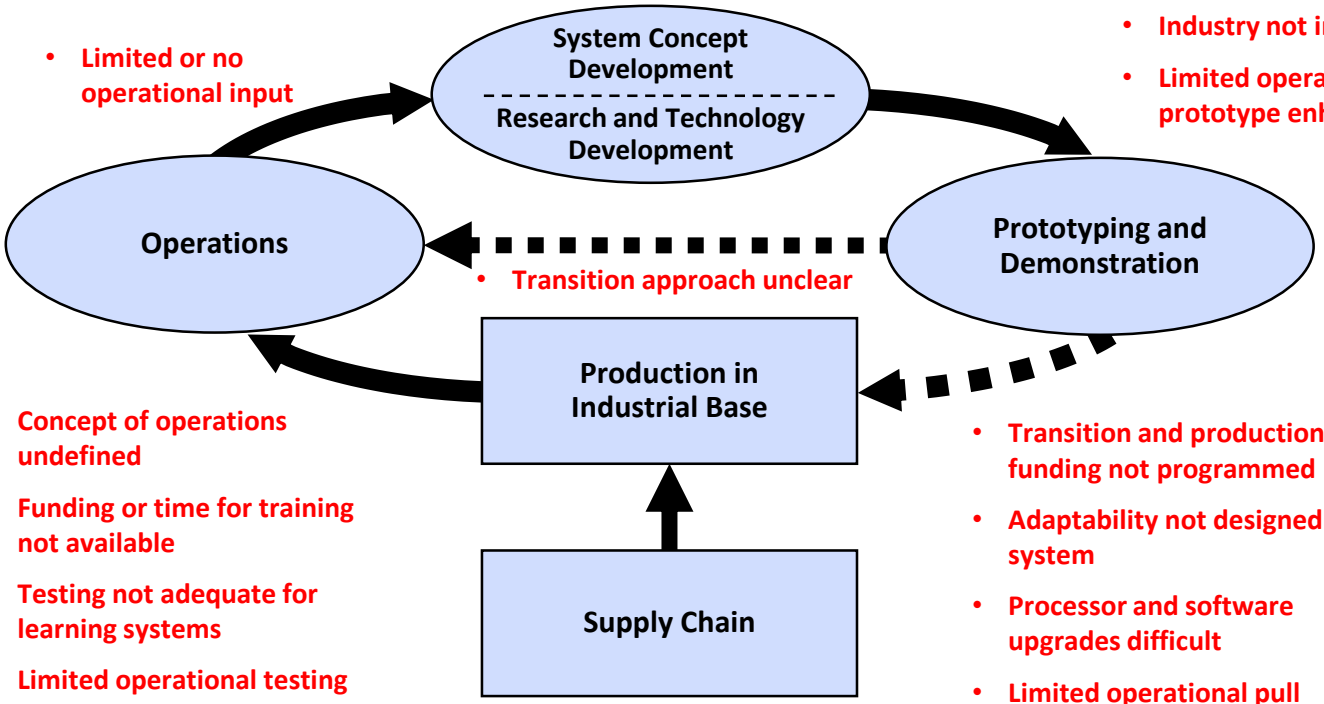
# DoD 5000 Acquisition Approach



# High-level Industrial Base Model

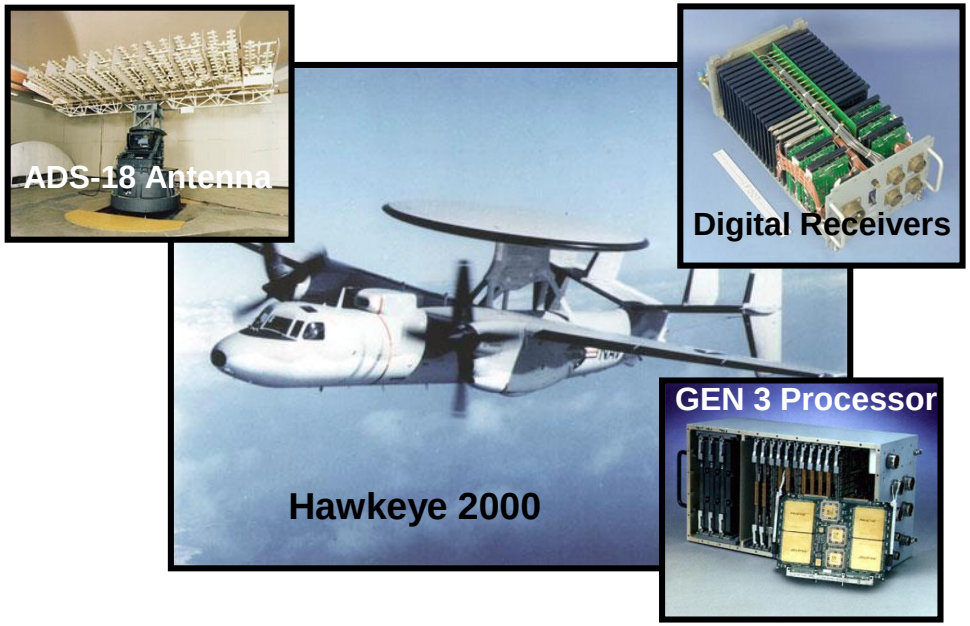


# High-level Industrial Base Model




- System concept extension of known conventional approaches
- Technology not mature
- Prototype does not adequately reduce risk
- Industry not included early
- Limited operational input for prototype enhancement
- Limited or no operational input
- Transition approach unclear
- Concept of operations undefined
- Funding or time for training not available
- Testing not adequate for learning systems
- Limited operational testing under degraded conditions
- Readiness and sustainment funding not available
- Transition and production funding not programmed
- Adaptability not designed into system
- Processor and software upgrades difficult
- Limited operational pull
- Limited visibility into vulnerabilities and scalability
- Some commercial companies unwilling to participate
- Some aspects of chain under attack

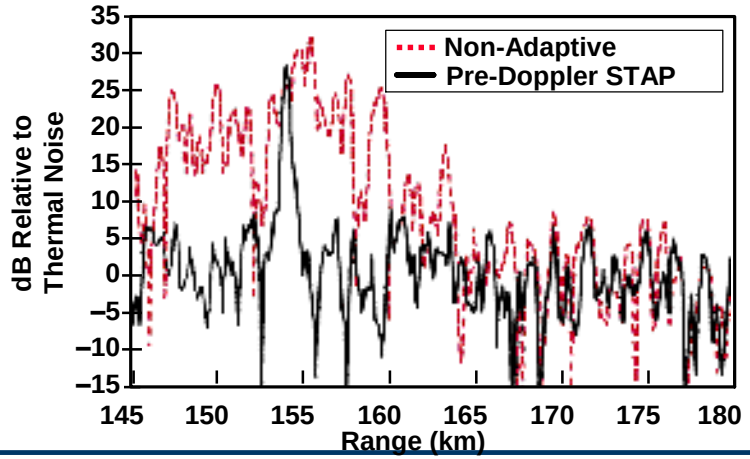
# E-2C Radar Modernization
## Lincoln Laboratory Roles




**Mountaintop Test Site**

- Technology prototype development
- System test beds and measurements
- STAP algorithm development
- Technology transfer to industry

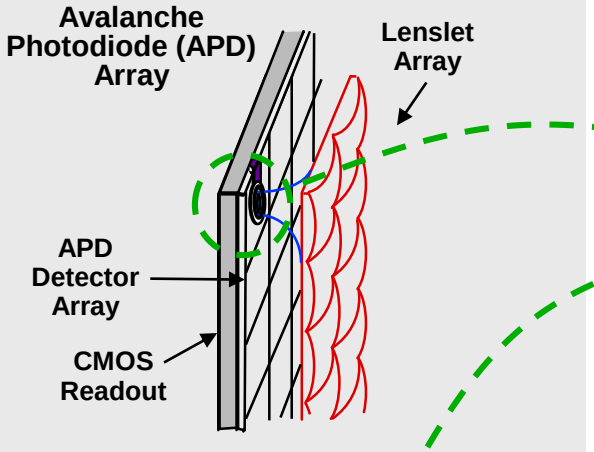
**STAP Performance Verification**

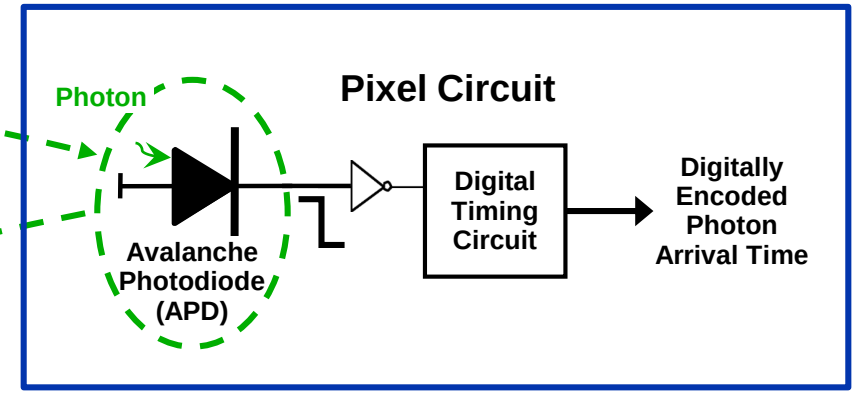


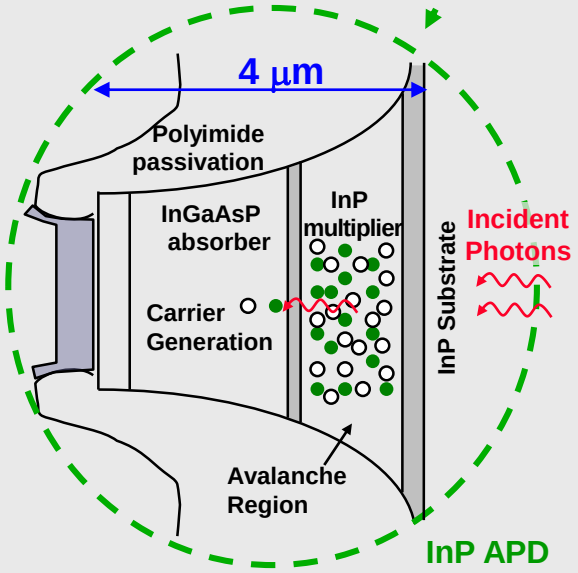
# “Low-Flying” Test Target

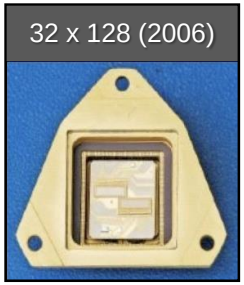
# Key Enabling Technology

## Geiger-mode Imager: Photon-to-Digital Conversion



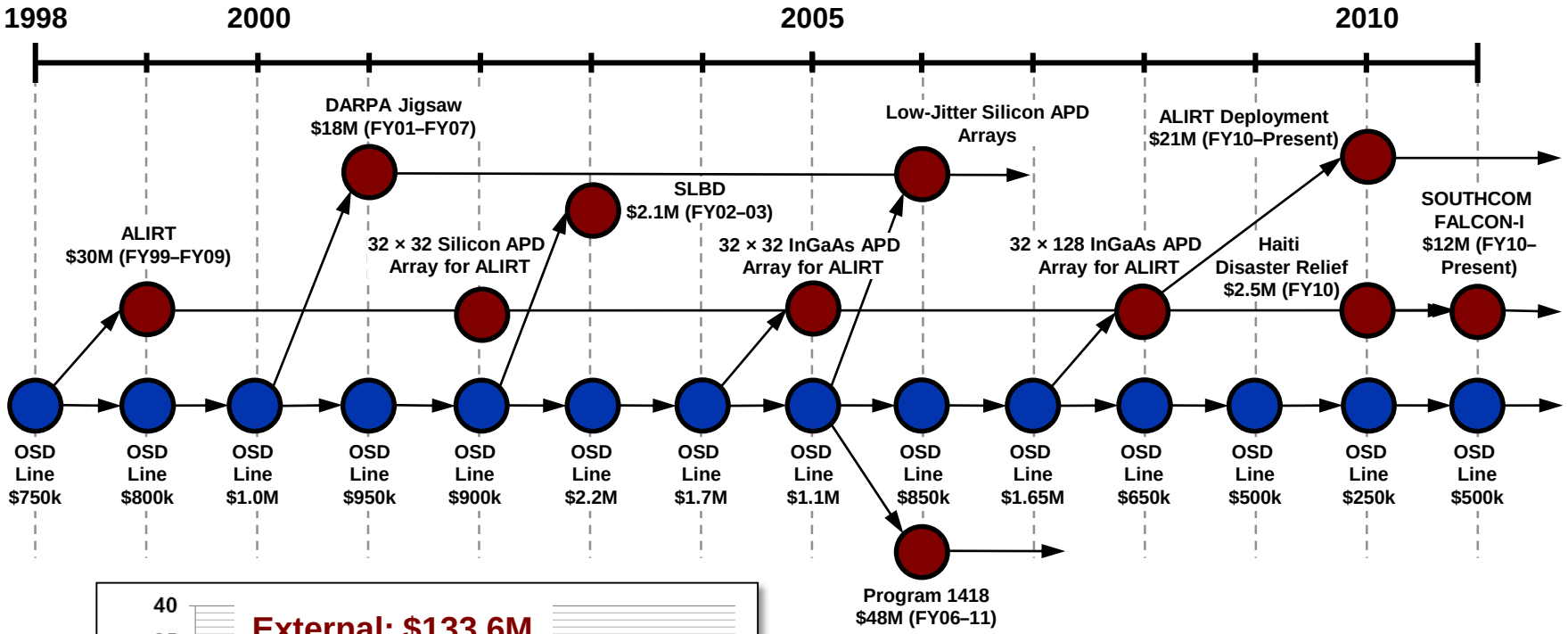
- Single-photon sensitivity
- Large format arrays
- High frame rate
- Sub-ns timing
- Noiseless readout

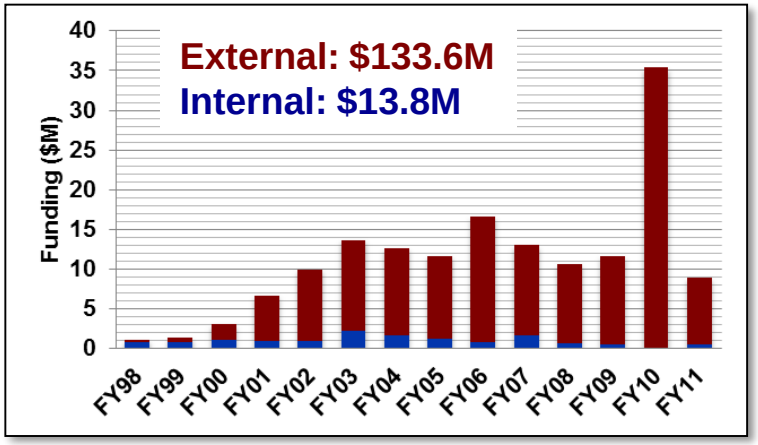
**Geiger-mode imagers enable revolutionary ladar capability**

- High altitude operation
- High area coverage rate

# Geiger-Mode Avalanche Photodiode Arrays

## *Program Genealogy*



# MACHETE: Advanced FOPEN Ladar System for USSOUTHCOM

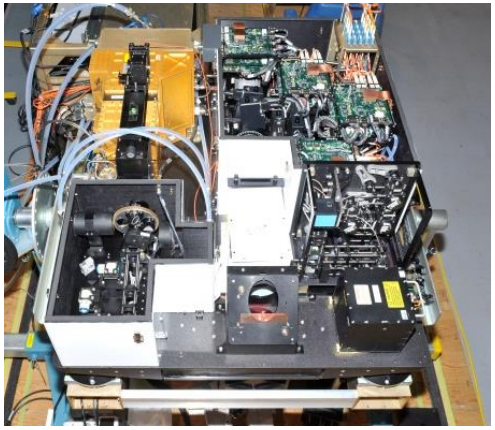
## DHC-8-202 Turboprop Platform

## MACHETE Onboard Processing Station

- Near real time products
- Handles 1 GB/s data rates
- SWaP constrained
- 2.5x real time

## MACHETE Sensor

- E/O-like resolution
- 3D imagery
- Laser: 15W, 400ps, 20kHz
- Detectors: 64×256 array (dual)

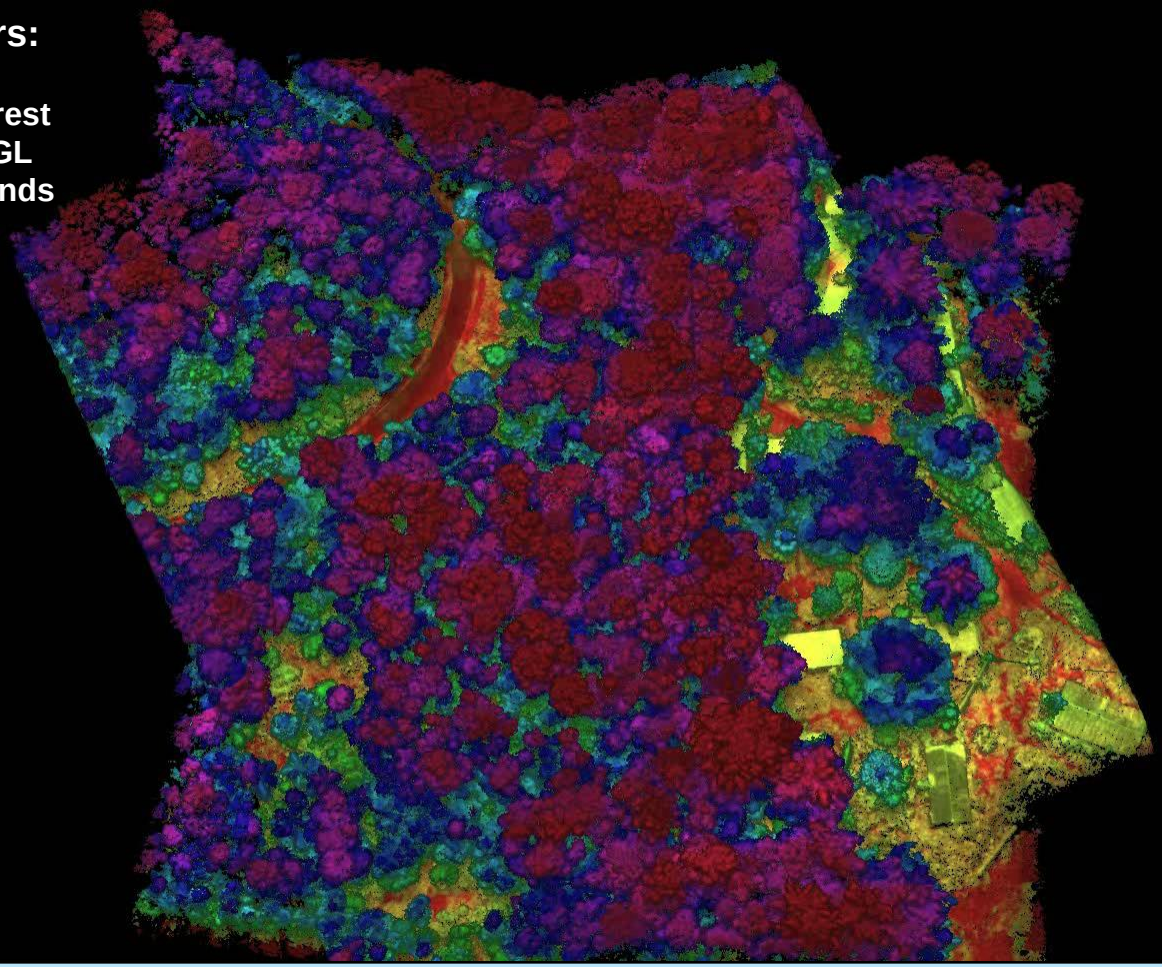


## MACHETE Ground Processing Station

- Scalable, multi-INT
- Advanced algorithms
- Transportable

# Rain Forest FOPEN Imagery Example:
## El Yunque National Forest

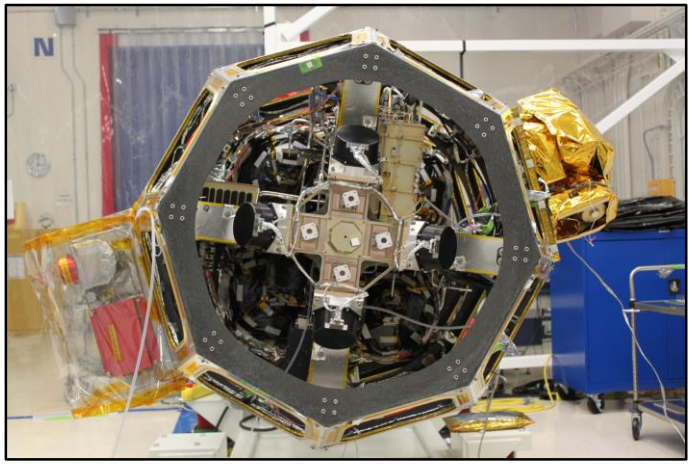
**Collection parameters:**
**Sensor: ALIRT**
**Location: El Yunque Forest**
**Flight altitude: 7.5 kft AGL**
**Imaging time: ~ 30 seconds**
**Box size: $(200\ m)^2$**



**ALIRT Puerto Rico campaign success resulted in USSOUTHCOM tasking Lincoln to develop FOPEN-optimized, next generation ladar sensor**

# NASA Lunar Laser Communication Demonstration (LLCD)

**LLCD Space Terminal Integrated with LADEE Spacecraft**

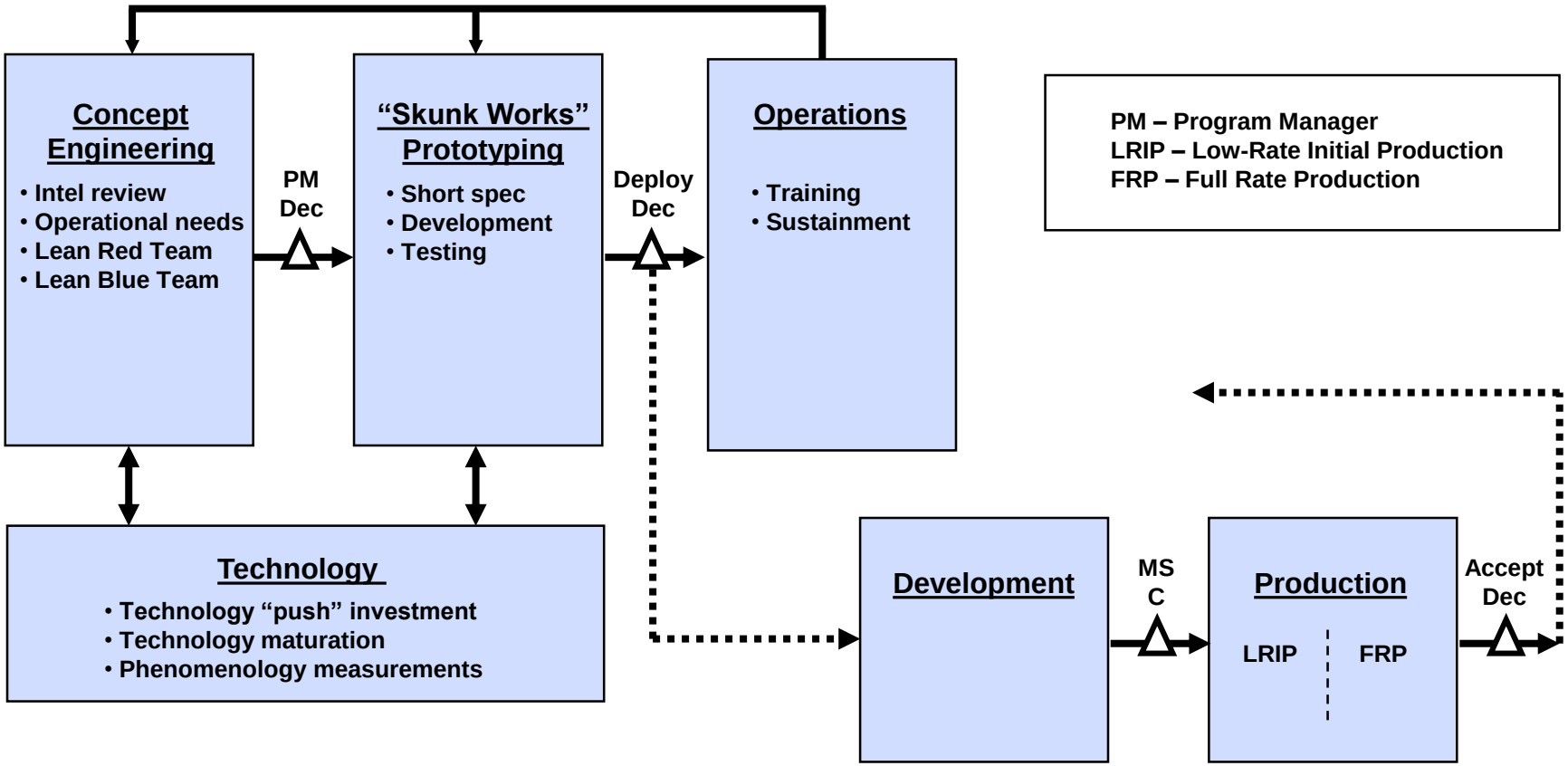


**LLCD Ground Terminal**

**LLCD on Lunar Atmosphere and Dust Environment Explorer (LADEE)**

- **Demonstrate high-rate optical trunk from lunar orbit (385,000 km)**
  - **622 Mbps downlink**
  - **20 Mbps uplink**
  - **Sub-cm ranging**
- **Laboratory roles**
  - **Lasercom architecture and system engineering**
  - **Build space terminal**
  - **Build portable ground terminal**
  - **Build lasercom operations center**
  - **Operate lasercom system and perform experiments**
  - **Develop superconducting nanowire detectors for ground terminal**

# Rapid Capability Development Approach



# Examples of Systems Developed through Rapid Development Approach

**Constant Hawk Camera Upgrades and Ground Processing**

**Radiant Falcon Counter IED Sensing Platform**

**JCREW Jammers**

**Advanced Air Force Jamming**

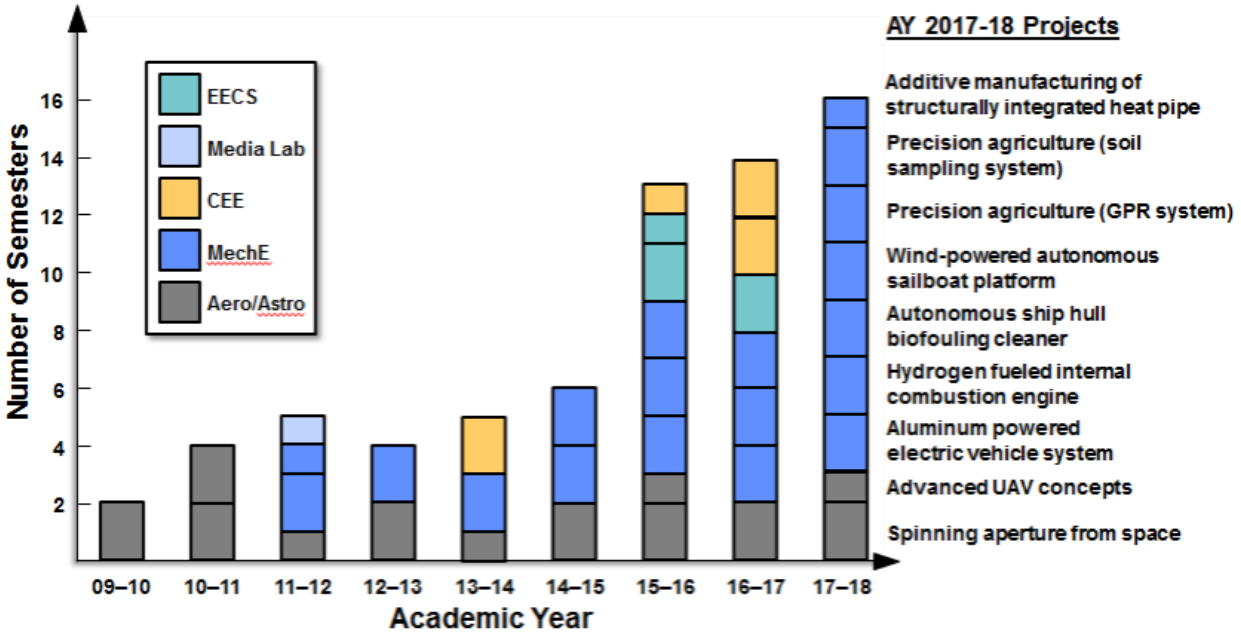
# MIT Lincoln Laboratory Beaver Works

## Joint Center with MIT School of Engineering

**Assistive Technology Hackathon (Feb 2015, Feb 2016, March 2017)**

**Lincoln IAP Courses (2014, 2015, 2016, 2017)**

### Beaver Works Capstone Projects




**Continuing to scale up Beaver Works opportunities to impact "Service to the Nation and World"**

- **Providing exceptional high-impact project-based learning opportunities and significant sponsor value**
- **LL - Aero/Astro Beaver Works extension completed (Building 31, ~4,000 sqft, Summer 2018 opening)**

# Air Launched Micro UAV

## "Perdix" Micro UAV System

11.75" deployed wingspan, 270 grams

Autonomous flight systems

## Key Operating Parameters

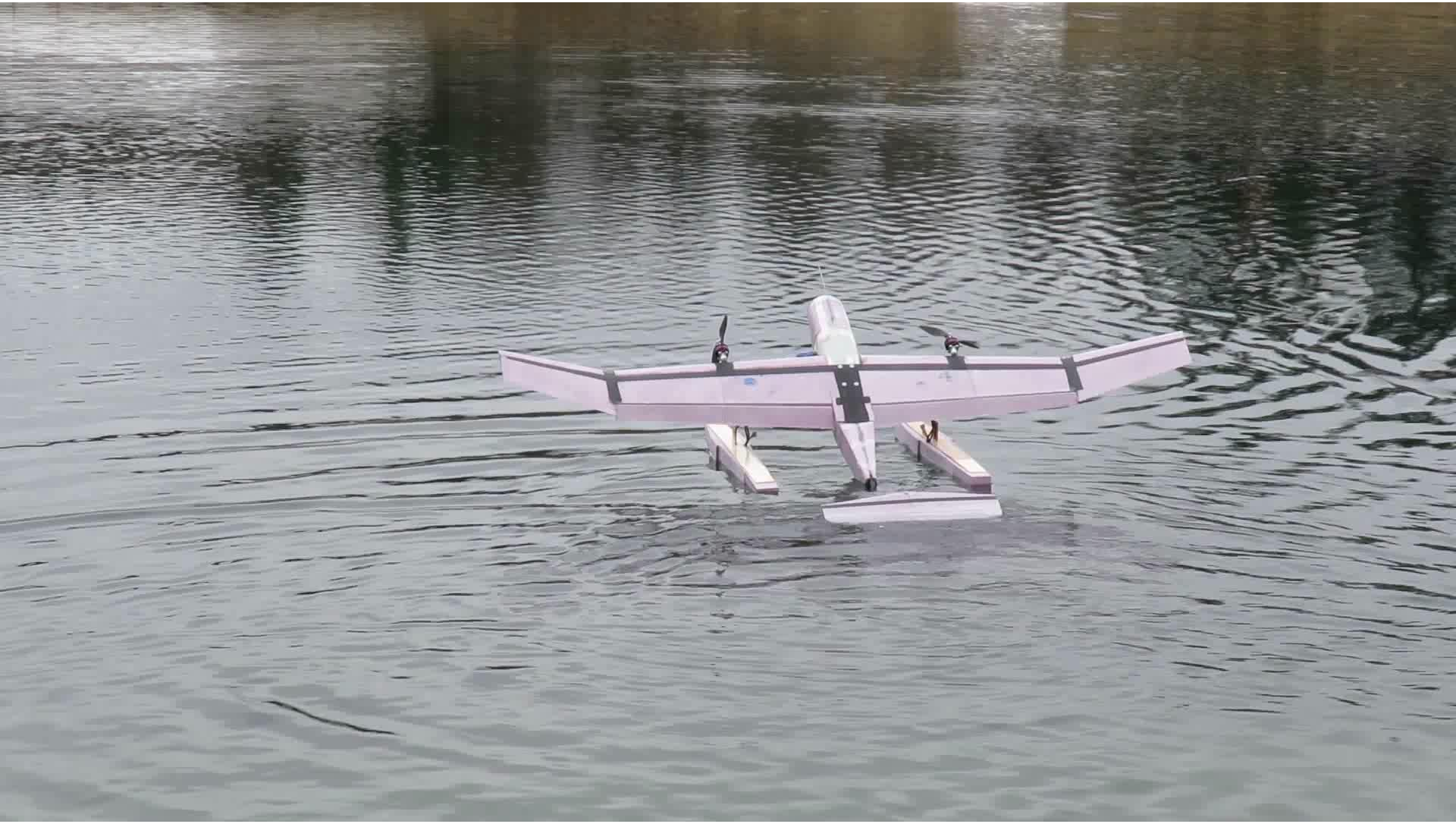
- Deployed at 30,000 ft
  - Standard chaff / flare canister
- ~30 min powered flight
  - 25 to 35 m/s speed
- Custom avionics board
  - Integrated GPS / INS
  - Multi-band communications
- Open architecture payloads

## Development and Flight Test

- Initial design as Beaver Works Capstone (Course 16.82 in 2010/2011)
- Continued collaborative development with Beaver Works and MIT Aero/Astro Dept.

- Collaborative development of novel miniature air launched UAV system
  - High altitude / high speed platform with ~30 min endurance

# Water-based Unmanned Air Vehicle



# Lincoln Laboratory
# Military Fellows Program

## Objectives

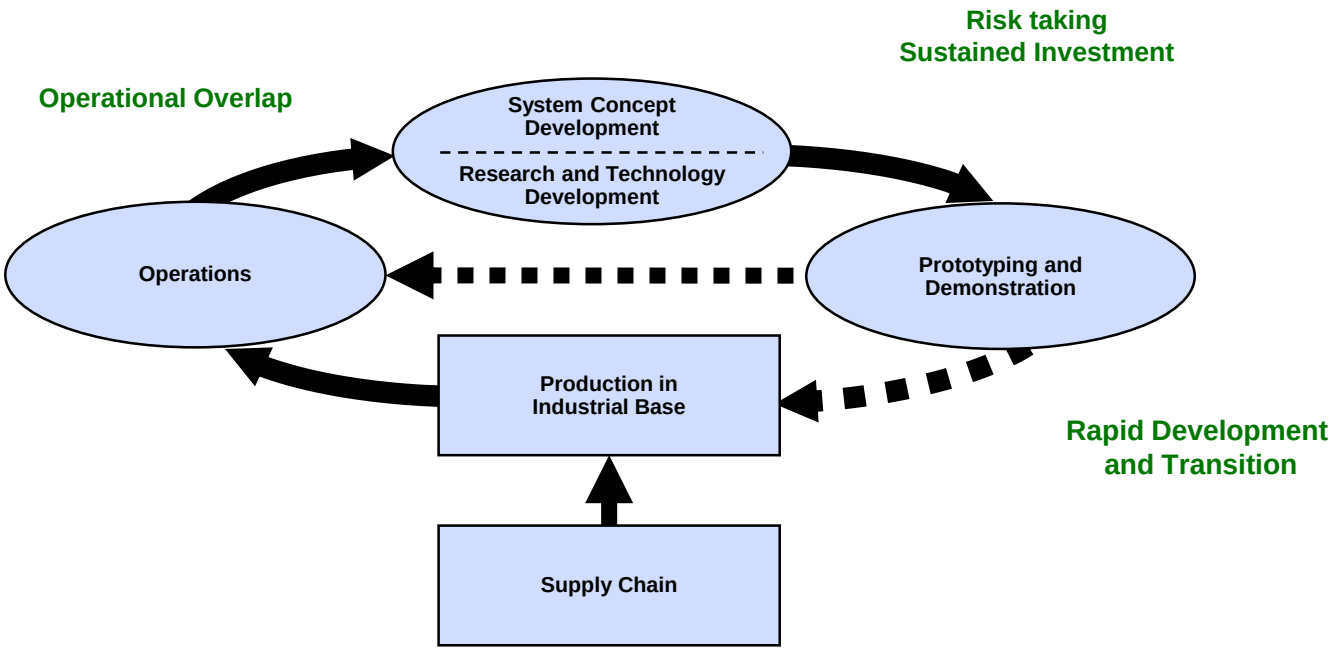
- Have "Warfighter" input early in the development process
- Educate active duty officers on Lincoln Laboratory and its capabilities
- Expose Lincoln Staff to active duty officers
- Educate the next generation of senior and junior military officers
- Expose Service Academy Midshipmen/Cadets to world class research

**Active Duty**
**Military Fellows (42) for 2017 - 2018**

**Service Academy Interns (76)**
**Summer of 2018**

# High-level Industrial Base Model

- **Much innovation and new technology needed to sustain U.S. defense advantages**




- **Stronger operational involvement needed in all areas**