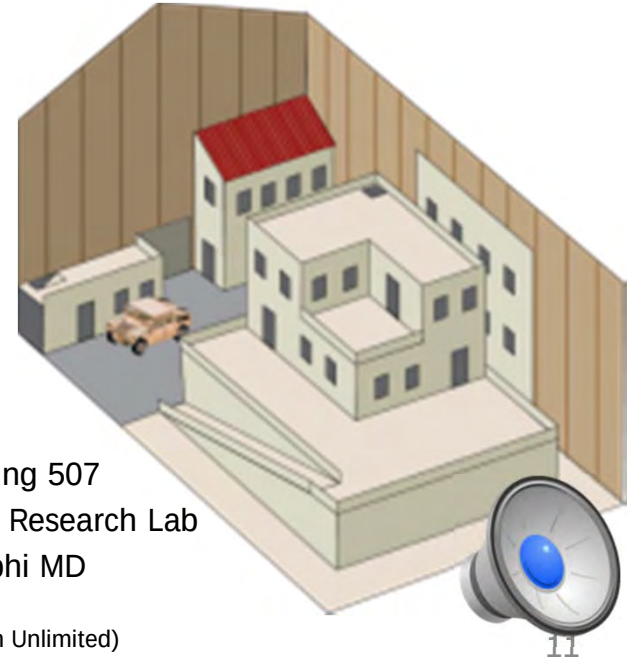
www.darpa.mil

Programmatic Approach

- Focus teams on autonomy by providing capable Government-Furnished Equipment
  - Enables quantitative comparison based exclusively on autonomy, not on mobility
  - Teams add own sensors, processors, software
  - Designed for unintended contact
- Test early and often in tactically relevant environments
  - Progressively denser obstacles
  - Provide spares to enable aggressive usage
- Transition
  - Enabling technology for a broad variety of missions inside and outside of DARPA
  - Applications with UAV, UGV, Maritime

GFE Platform
(seedling)



Building 507
Army Research Lab
Adelphi MD

Performance Beyond our Capabilities

What are we trying to do?

- Today, unmanned movement in unstructured environments requires:
  - extensive sensing and heavy computational processing to populate a 3D world model that is then used to plan movement
  - or, teleoperation by a human operator
- Both methods are too slow and limited for most military operations

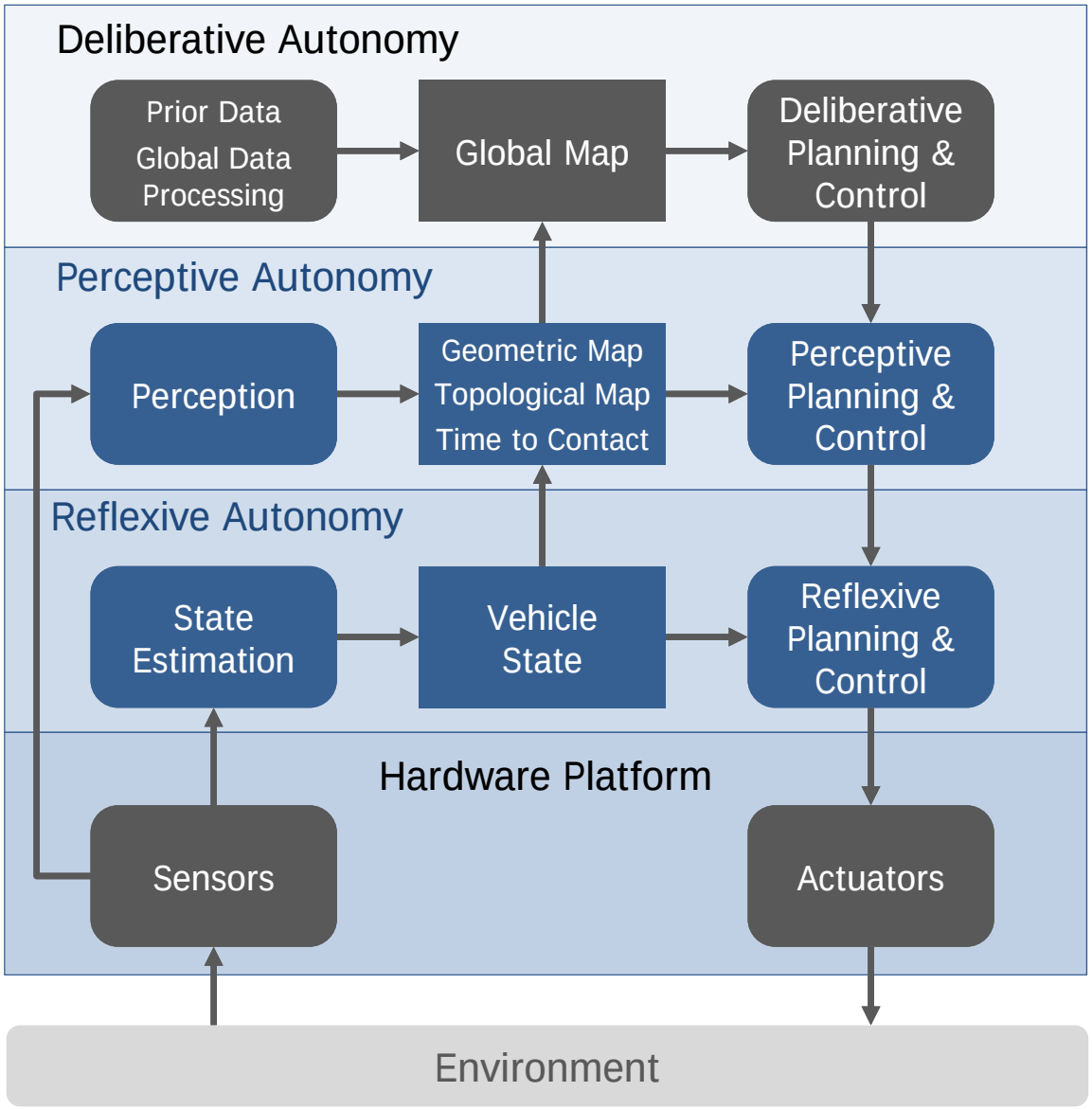
- Hypothesis: Advances in perception and reactive algorithms could enable a new, computationally light approach to autonomy:
  1. without teleoperation
  2. at speeds sufficient for tactical mission needs

- Approach:
  - Develop new perception and behaviors light enough to run on small, fast platforms
  - Use a common hardware base, to enable quantitative comparison of approaches

FLA Government Furnished Equipment

Goal: New class of algorithms enabling high-speed operation in cluttered environments

How is it done today?



Response time slow and computing power-hungry

Not required for selected FLA missions

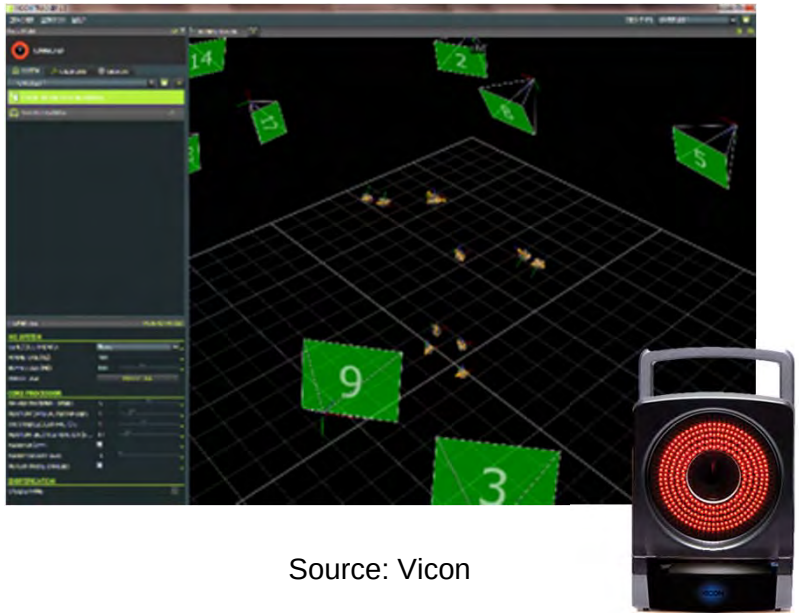
These layers provide fast reaction time and agility in unknown environments

FLA Program Focus

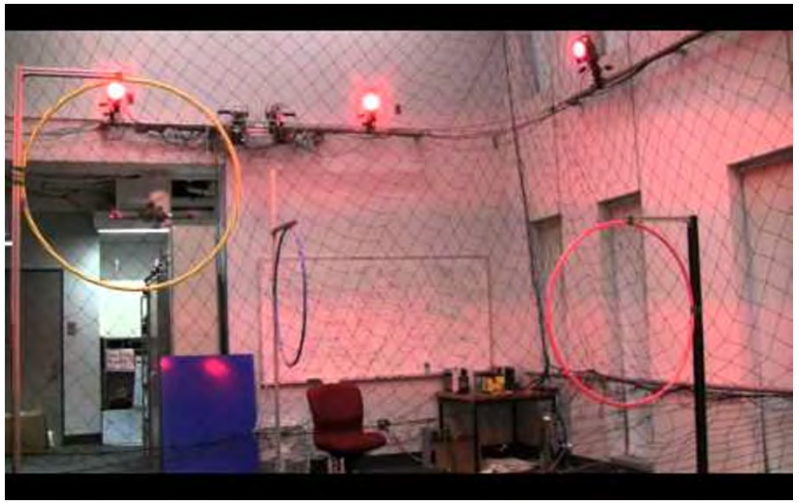
Active commercial development

FLA supplies as GFE

Limits of Current Practice



Source: Vicon



Source: UPenn

- The most compelling high-speed demonstrations require external motion tracking systems in laboratories and off board processing
- Supplies full pose to the UAV control system with millimeter accuracy at 500+ frames per second

Capability Gap: Algorithms able to maintain performance in mission-relevant environments without external sensors or computation

New Approaches and Outcomes

- **Behaviors** – Develop tightly coupled **control algorithms** for extreme maneuverability required to fly through windows, doors, confined spaces
- **Representation** – Explore time to contact and topological connectivity **knowledge representations** rather than volumetric grid of spatial layout
- **Perception** – Algorithms to **quickly recognize** previously visited areas using room features to answer "**have I been here before?**"
- Use only post-hoc analysis of data to reconstruct features, create maps, etc.

State of Art: High-speed absolute motion tracking

Challenge: Extreme maneuverability in unstructured and non-laboratory environments

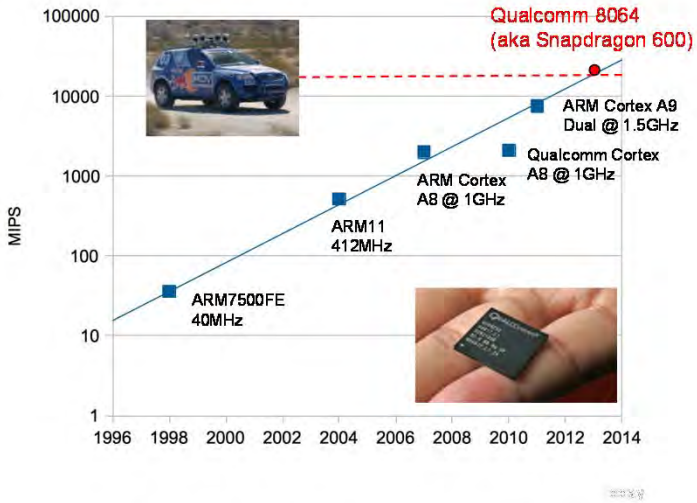
State of Art: "Been here before" local feature mapping at walking speeds

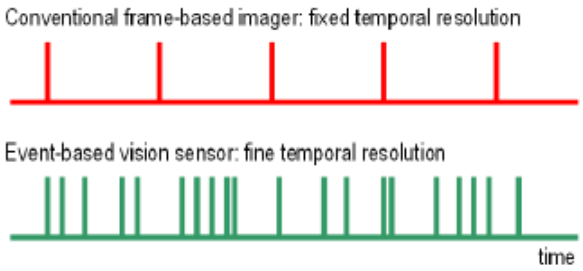
Challenge: High-speed UAV feature mapping

Why now?

- **Small UAVs** - Dramatic performance, form-factor, and capability improvements
- **Battery** - Power and energy with 50% efficiency for 2 minute discharge
- **Compute SWaP** - Commercially available
- **Sensing SWaP** - Ready (IMUs) or showing promise (kHz - MHz cameras)

(Estes Proto X, photo: gizmag.com)



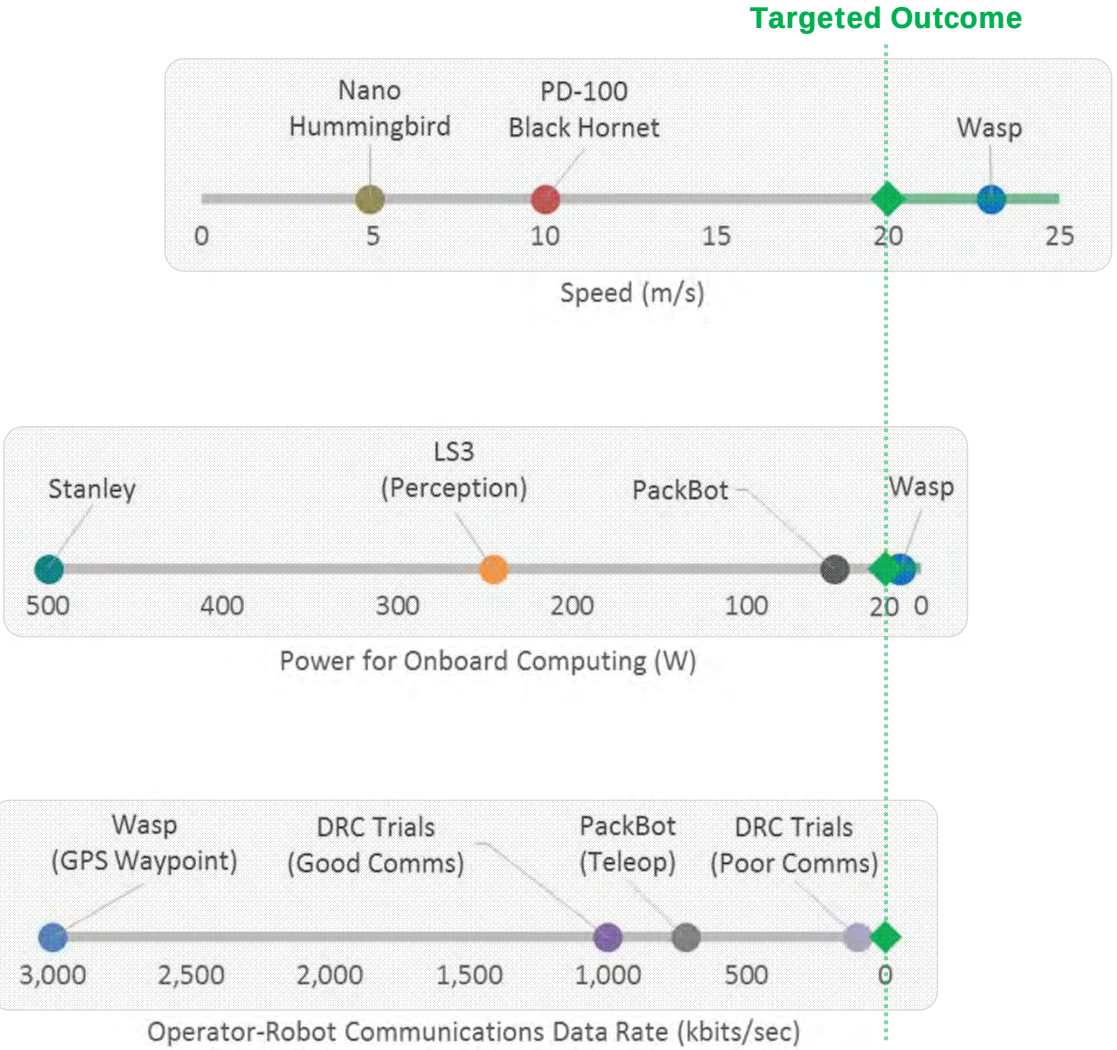


Spiking retina

Event-based, Time resolution 1 µs,
Dynamic range 120 dB *IniLabs*)

Open Problem: Representations/Algorithms to Couple Sensing, Actuation

Performance Targeted Outcomes



Nano Hummingbird

PD-100 Black Hornet

proxdynamics.com, @ProxDynamics

Wasp

Stanley

Legged Squad Support System (LS3)

Autonomous PackBot

DARPA Robotics Challenge Atlas

Program Objectives

Attribute	Objective
Speed	20 m/s (45 mph)
Autonomy Power	20 W computing + TBD sensing
Terrain	Complex, urban, cluttered
Prior Knowledge	Enough to indicate goals, but low-res and stale
Range	1 km
Duration	10 min
Comms	Zero
GPS	Denied
Demonstration	Prototype in realistic environment

Funding

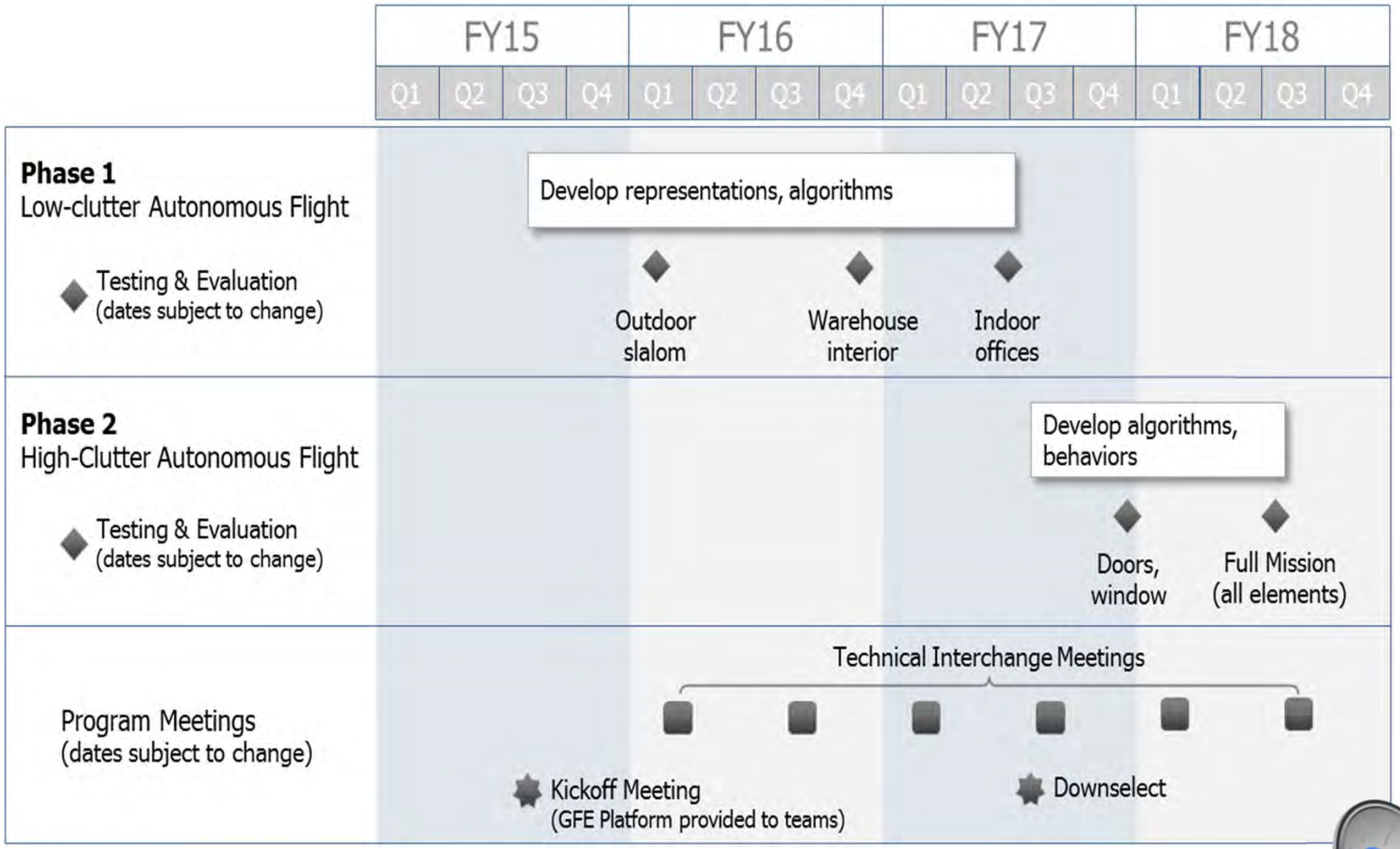
- DARPA anticipates that the FLA program will provide up to two (2) years of funding for Phase 1 efforts, and up to one (1) year of funding for Phase 2 efforts.

- Phase 1 element should be proposed as the Base effort and Phase 2 as an Option.

- Proposals must clearly allocate the statements of work, deliverables and costs to either the Base or the Optional effort.

- Although DARPA will consider proposals of any scale, team efforts are not envisioned to exceed $5.5M in total cost or three (3) years in duration.

Schedule


FY15
FY16
FY17
FY18
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4
Phase 1
Low-clutter Autonomous Flight
Testing & Evaluation
(dates subject to change)
Develop representations, algorithms
Outdoor slalom
Warehouse interior
Indoor offices
Phase 2
High-Clutter Autonomous Flight
Testing & Evaluation
(dates subject to change)
Develop algorithms, behaviors
Doors, window
Full Mission (all elements)
Program Meetings
(dates subject to change)
Technical Interchange Meetings
Kickoff Meeting
(GFE Platform provided to teams)
Downselect

Fast Lightweight Autonomy (FLA)

Dr. Mark Micire
Program Manager
Defense Sciences Office
DARPA

Virtual Proposers' Day

January 6, 2015