https://ntrs.nasa.gov/search.jsp?R=20160007807 2019-08-31T02:22:56+00:00Z

UAV Research at NASA Langley:

Towards Safe, Reliable, and Autonomous Operations

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NASA Langley Research Center, USA

Aviation, Engineering on a High Level

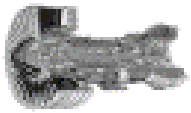
Simon Stevin Symposium

Eindhoven, 16 October 2016

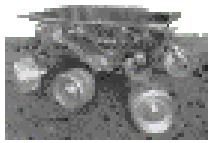
Location of NASA Centers

NASA Headquarters
Washington, DC.

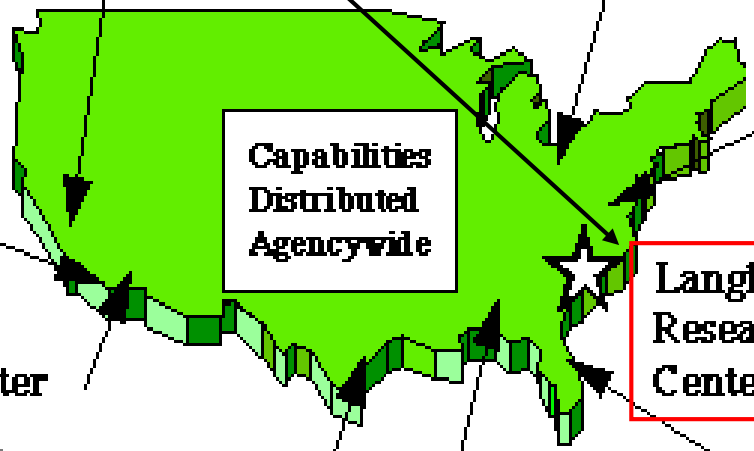
Ames Research Center



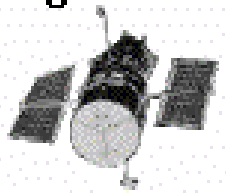
Lewis Research Center



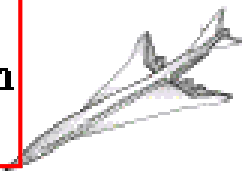
Jet
Propulsion
Laboratory



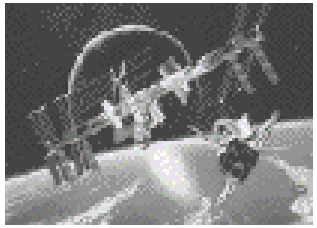
Goddard Space Flight Center



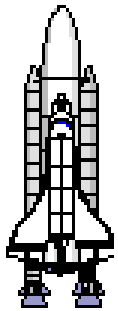
Langley
Research
Center



Dryden Flight Research Center



Kennedy Space Center



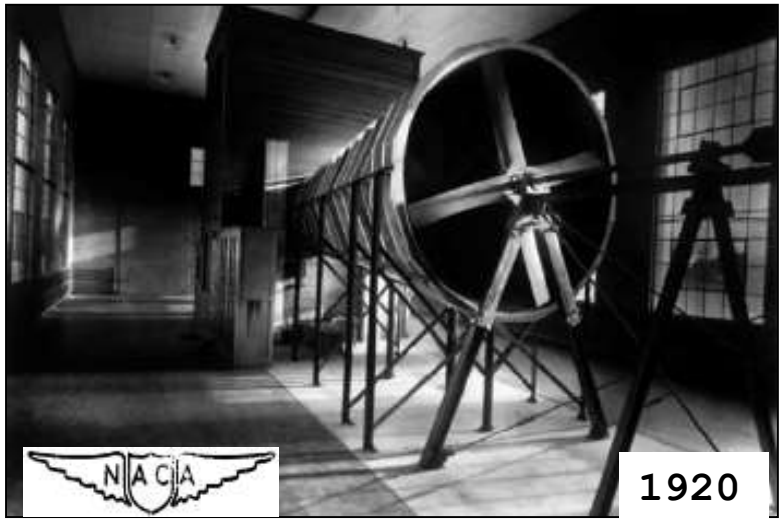
Marshall
Space
Flight
Center

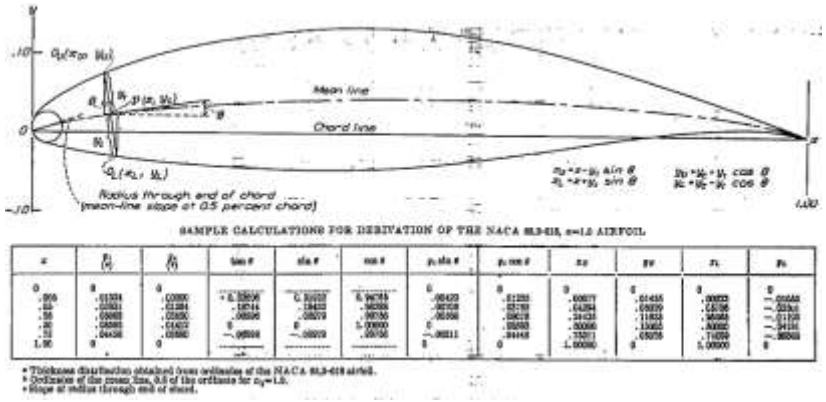
Johnson Space Center


INTELLIGENCE
AGENCY
Langley, Virginia
October 29, 2015
10 AM

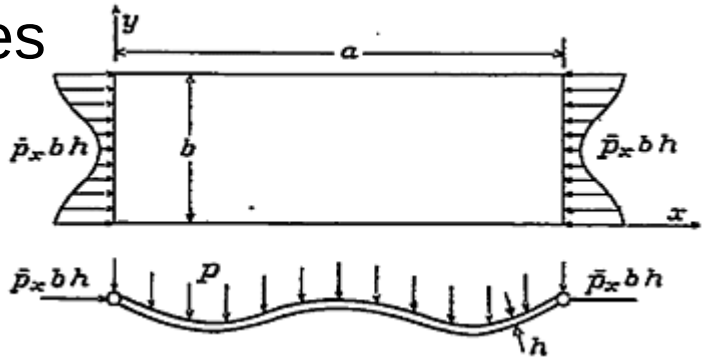
NASA Langley Research Center

Aerodynamics





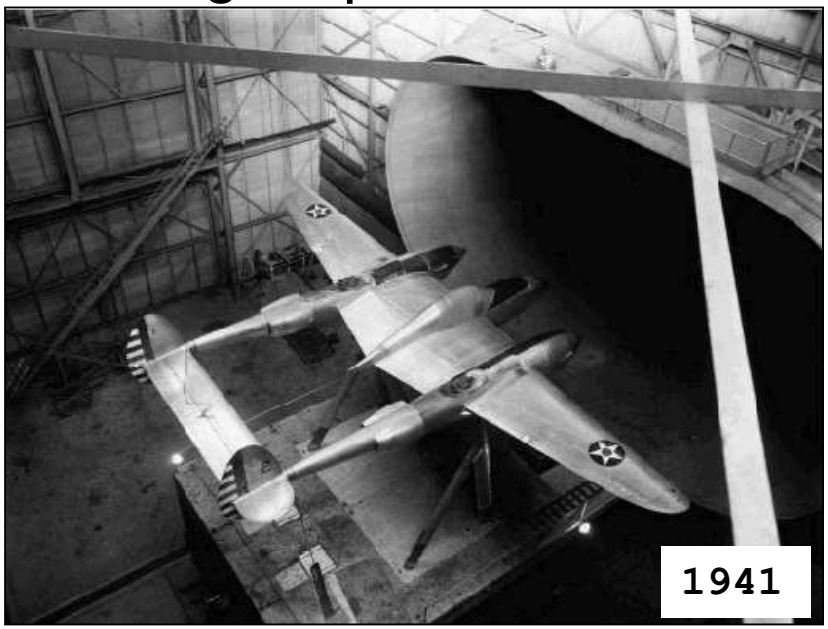
Structures



$$\epsilon_x' = \frac{1}{E}\left(\frac{\partial^2 F}{\partial y^2} - \mu \frac{\partial^2 F}{\partial x^2}\right)$$

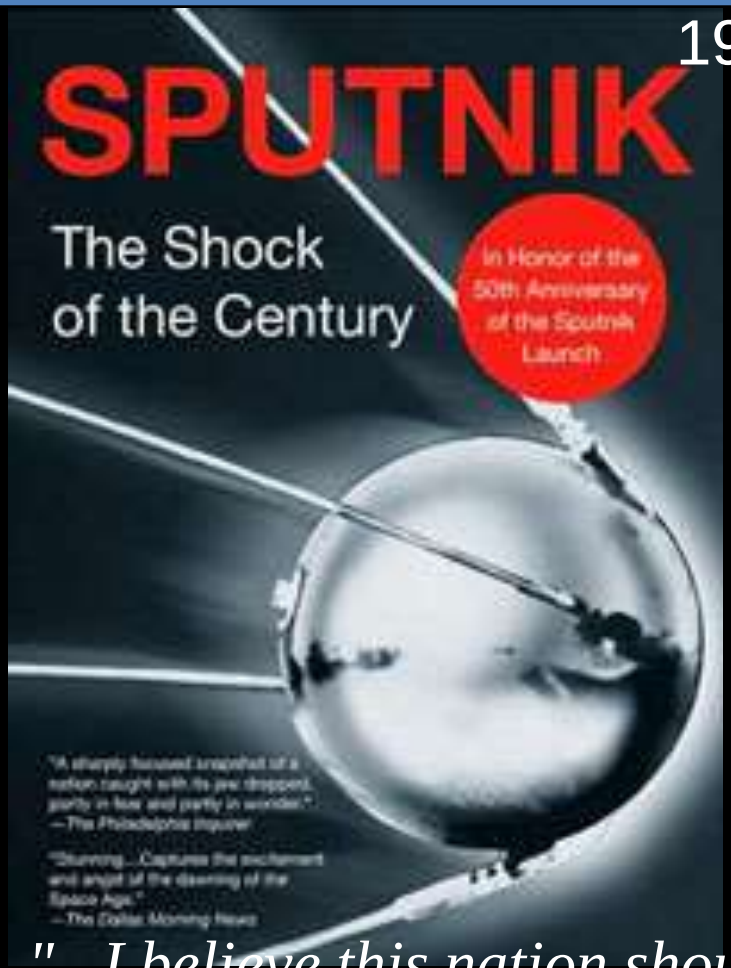
$$\epsilon_y' = \frac{1}{E}\left(\frac{\partial^2 F}{\partial x^2} - \mu \frac{\partial^2 F}{\partial y^2}\right)$$

Flutter, engine performance



NACA to NASA

1957



1961

"...I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth."

J.F. Kennedy, May 25, 1961

NASA Langley Research Center

Founded in 1917

- First civil aeronautical research laboratory

Programs

- ~$760 M total annual budget

Facilities

- ~800 acres, ~150 Buildings
- $2 billion replacement value

Programs

- ~3,700 employees

NASA Langley Research Center

Neil Armstrong At The Lunar Landing Research Facility
NASA Langley Research Center 1/28/1970 Image # EL-1996-00192

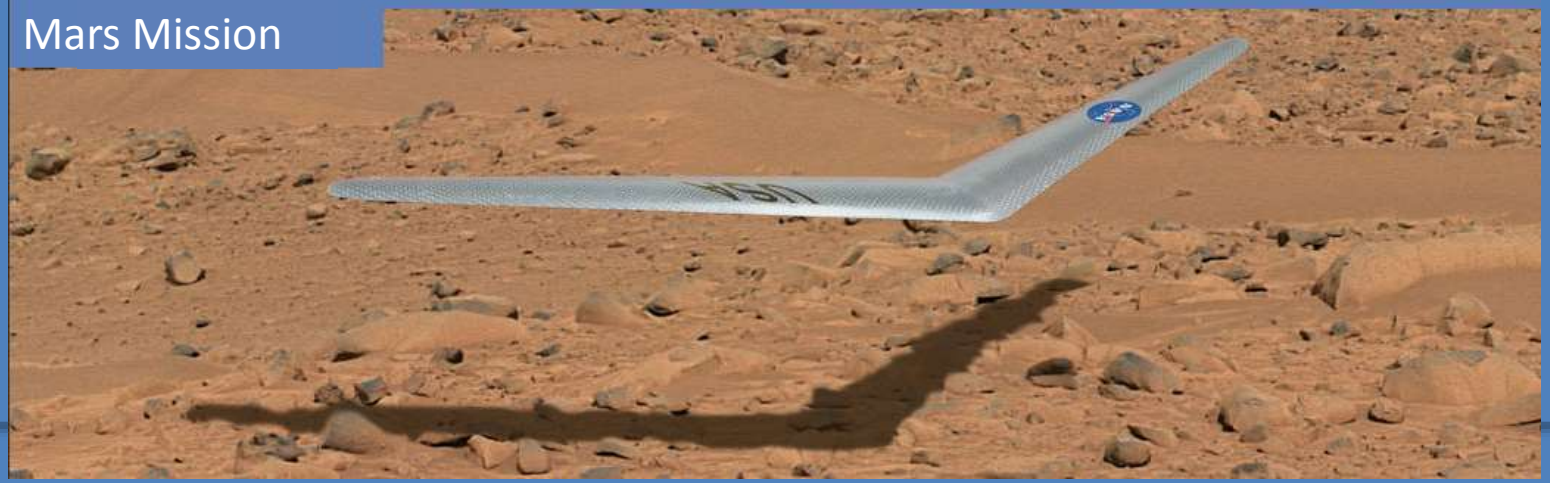
Landing and Impact Dynamics Facility

Drones @ LaRC

Future Aircraft

Flight Dynamics

Mars Mission



March 2016

UAS Research at Langley

Unmanned Air Vehicle (UAV) - Unmanned Aerial System (UAS)

- ***Vehicle Centric***
  - Autonomous Operations
  - Health Monitoring and Prognostics
  - Mission (Capability) Driven Airframe Design
  - Flight Dynamics and Controls
- ***Airspace Integration***
  - UAS in the NAS / Traffic Management
  - Sense and Avoid
  - Contingency Operations
  - Certification
- ***Research Payload Platform***
  - Atmospheric Science
  - Wildfire Detection
  - Acoustic Signatures

Future Aircraft Concepts

AirSTAR Project

NASA Aviation Safety Program

Research Goal: The goal of the project was to develop a dynamically-scaled, **subscale testbed** with remote pilot-in-the loop capability to conduct flight dynamics and control experiments

Status: Phase IV operations were wrapped up in 2013 with a total of 50+ research flights successfully completed. A flight demonstration of Beyon Visual Range capability (4000 ft AGL and 6 nm) along with several research experiments was completed.

AirSTAR Post Stall Parameter Estimation

Mars Plane


Straightforward Mission that Maximizes Use of Proven Technologies and Existing Infrastructure

Intelligence and Autonomy

Automation vs. Autonomy

"There is a paradigm shift from automated to autonomous: **automation is relegation; autonomy is delegation**…"

"… safe and trusted systems than can perceive their environment for situational awareness and assessment, make decisions on uncertain and inaccurate information, act appropriately, learn from experience and adapt their behavior…"

"…[certification] is about behavior and probability… we will need new methods of verification and validation."

Autonomy Incubator: Three Goals

1. Build a Multi-Disciplinary Team

- Mechanics/Electronics/Controls
- Computer Science/Programming
- Psychology/Machine Learning
- Signal Processing/Computer Vision

2. Enable new missions in

- Space
- Aeronautics
- Science

3. Create a Testbed for Autonomous Systems

- Open Software Architecture (AEON)
- Test range: CERTAIN

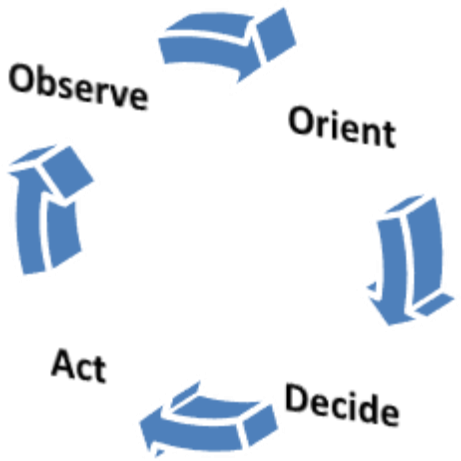
Autonomy Challenges

- **Human-Machine Interaction**
- **Data-rich/degraded/deprived environments**
- Size, Weight And Power (SWAP)
- Sensor Fusion
- Adaptive Control
- Geo-containment
- **Sense/Detect and Avoid (DAA)**
- **Precision navigation**
- **Localization**
- **Adaptation and Learning**
- Performance Standards
- Verification and Validation (V&V)
- Certification/Trust
- **Test and Evaluation (T&E)**

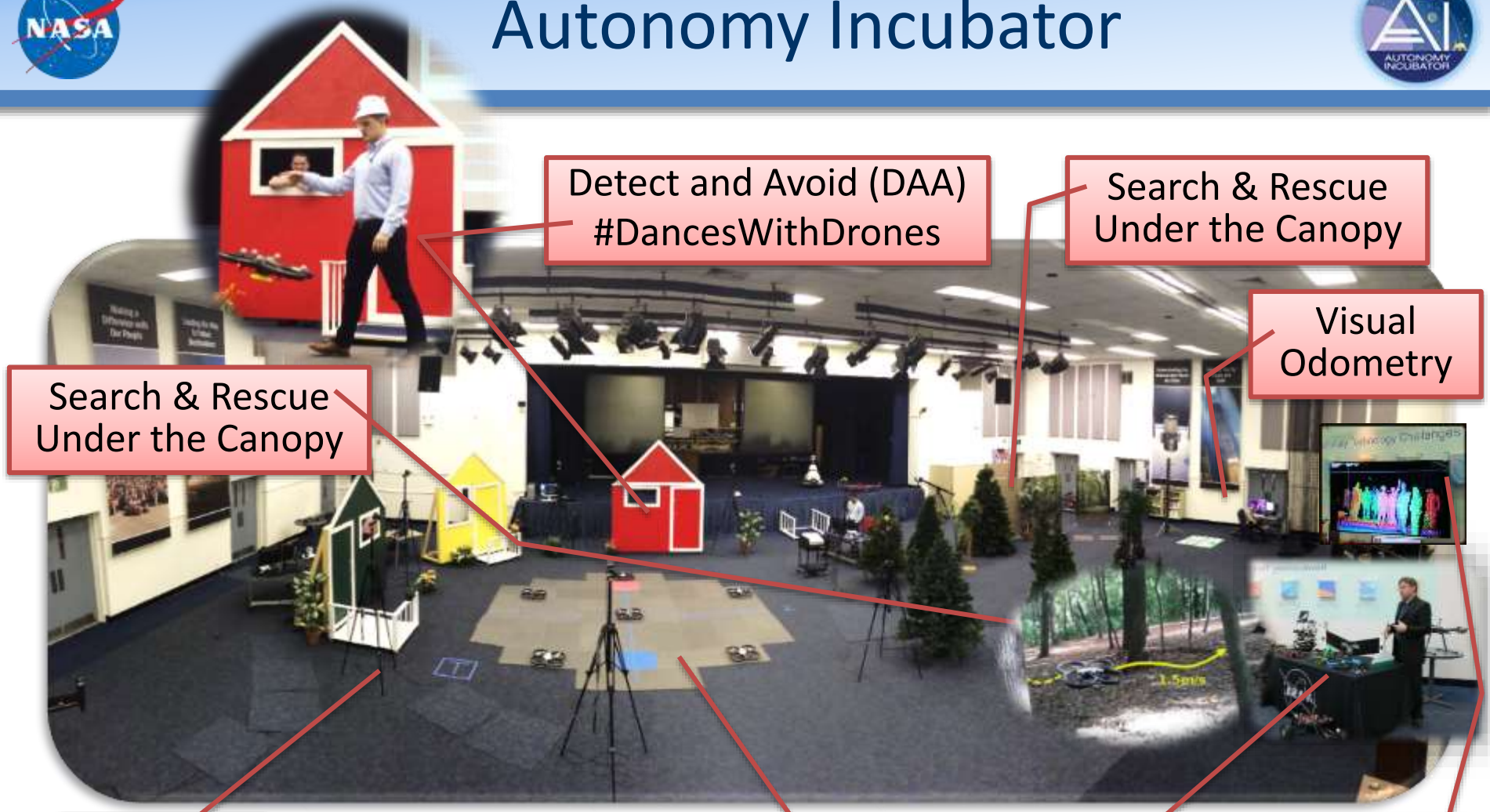
NASA's Missions and Autonomy

- **Human intelligence** applied to supervision, control, and intervention of operations will **no longer** be **viable** due to system/mission complexity, short reaction/decision time, communication delays, distance, or hostile environments.

- Systems with **machine intelligence:** capable of responding to expected and unexpected situations:
  - trusted and certified-safe systems capable of
  - sensing and perception
  - situation assessment/awareness
  - decision-making
  - taking action
  - and knowledge acquisition (learning)
  - **teaming with humans**

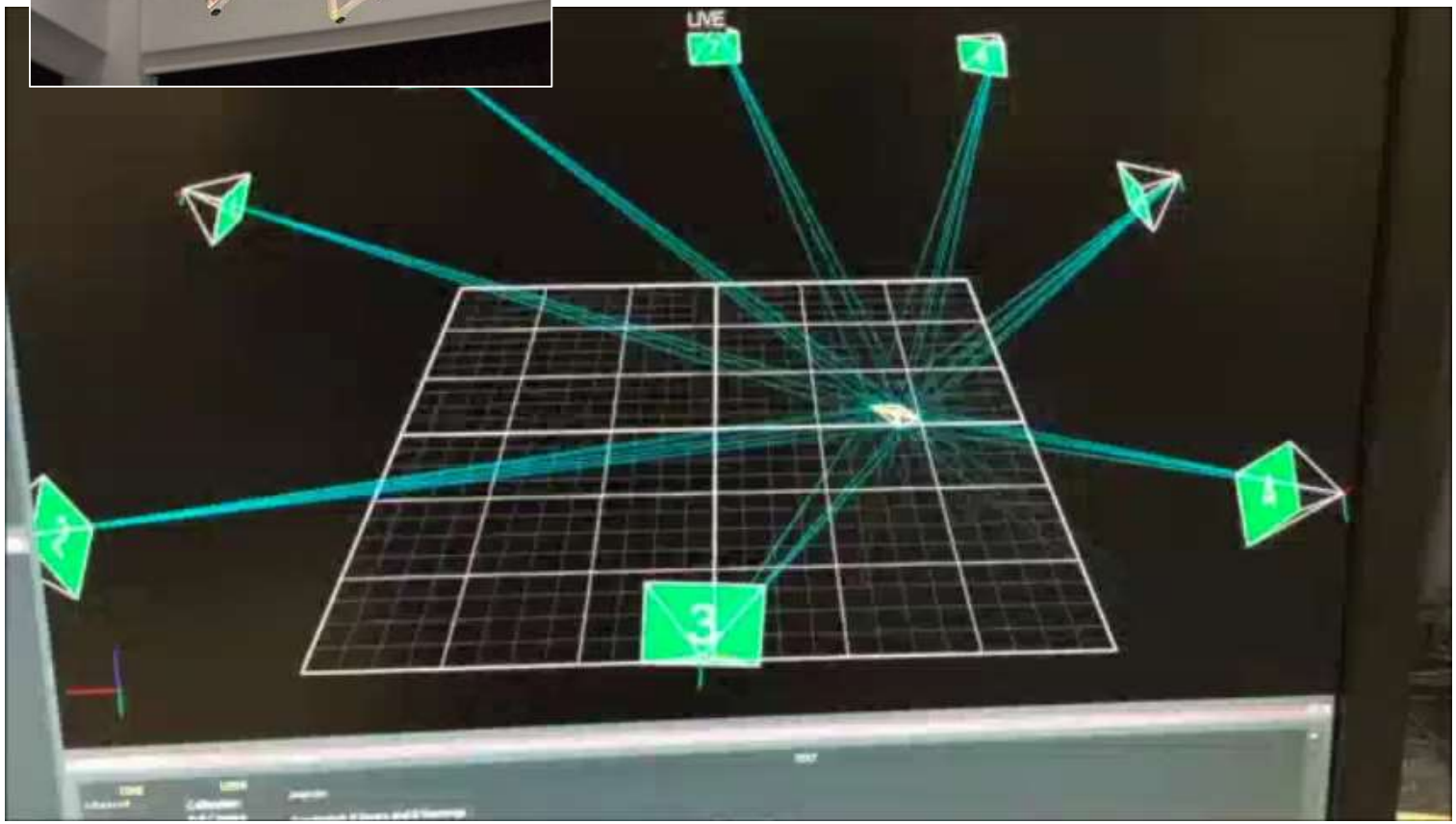


Autonomy Incubator

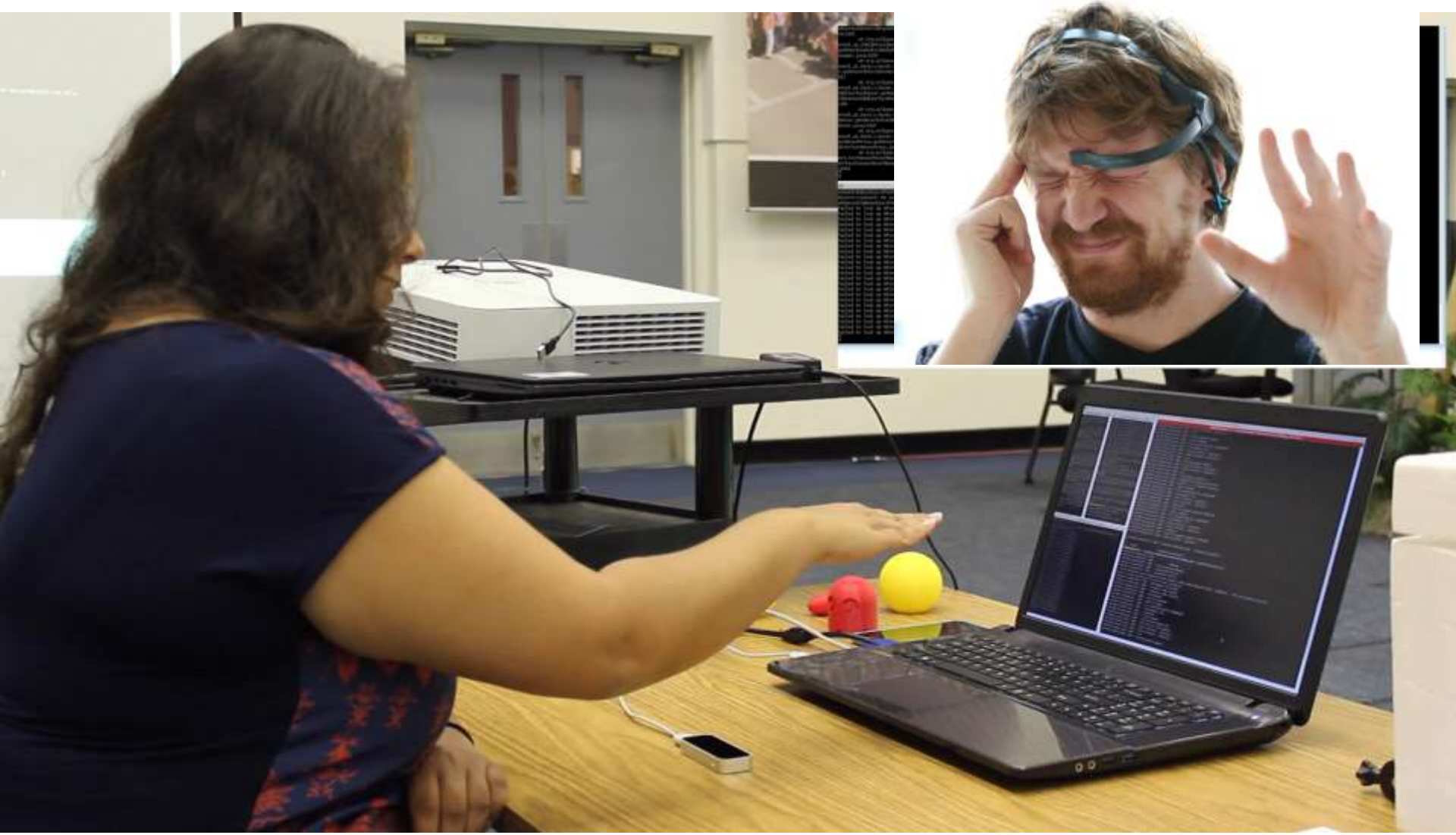


Telemetry – Motion Capture

Vicon camera system



Human Machine Teaming



Earth Science Mission

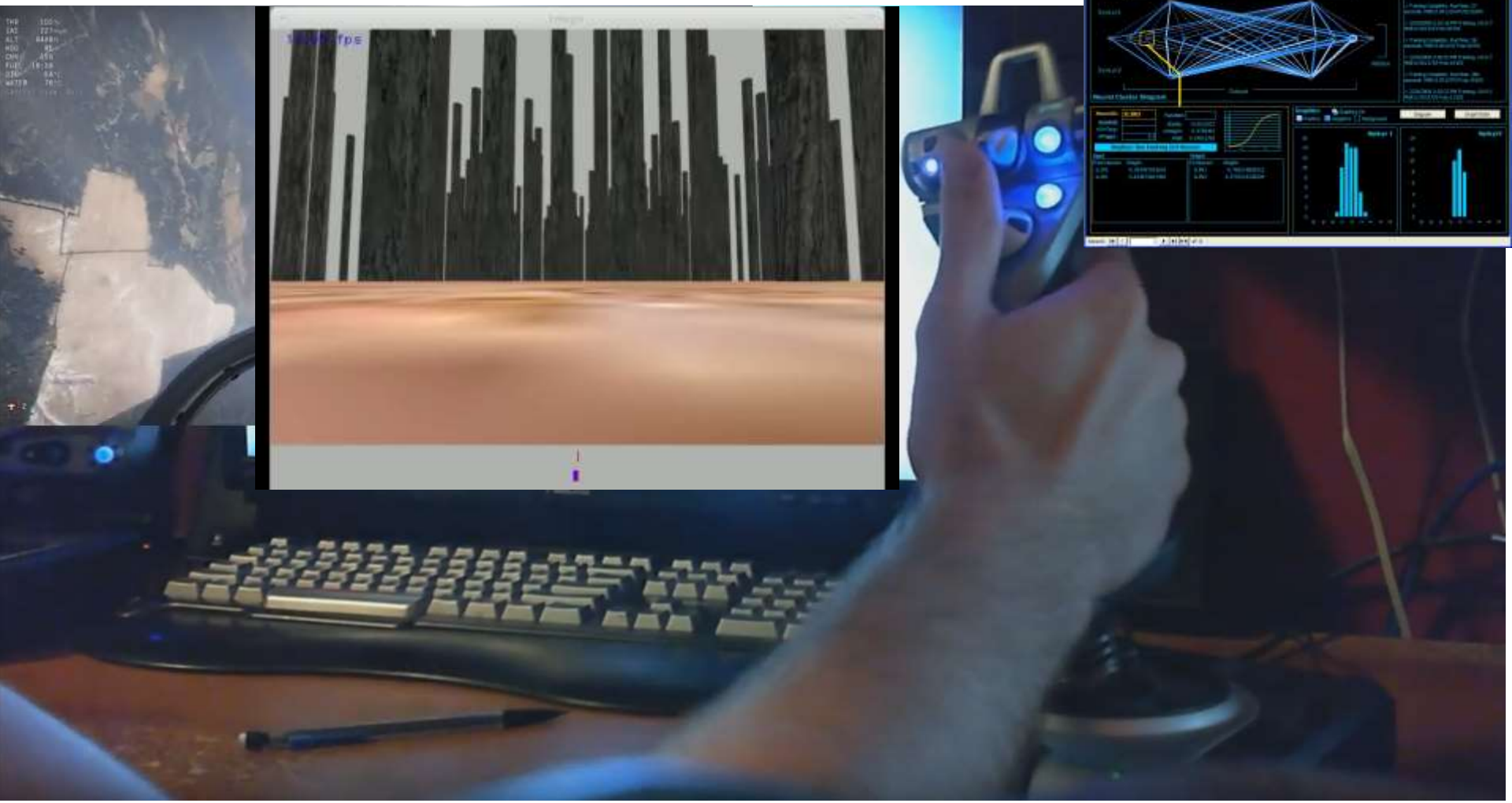
Air Quality Monitoring Sensors

- Multi-vehicle
- Data-denied
- Measurements

Detect and Avoid
(#TreeDodging)

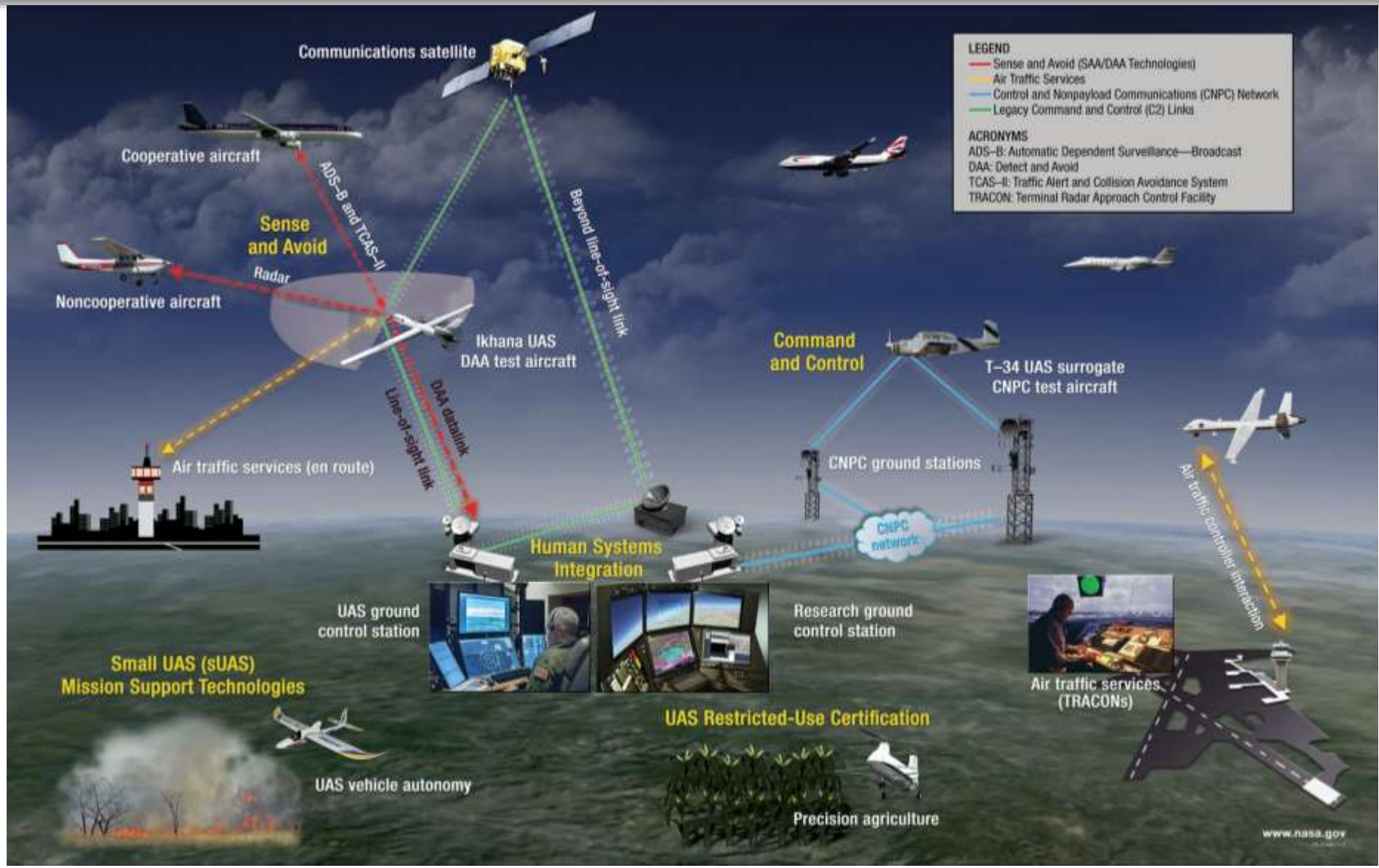
Machine Learning

Pilot trains UAV's neural network



Detect and Avoid
(#DancesWithDrones)

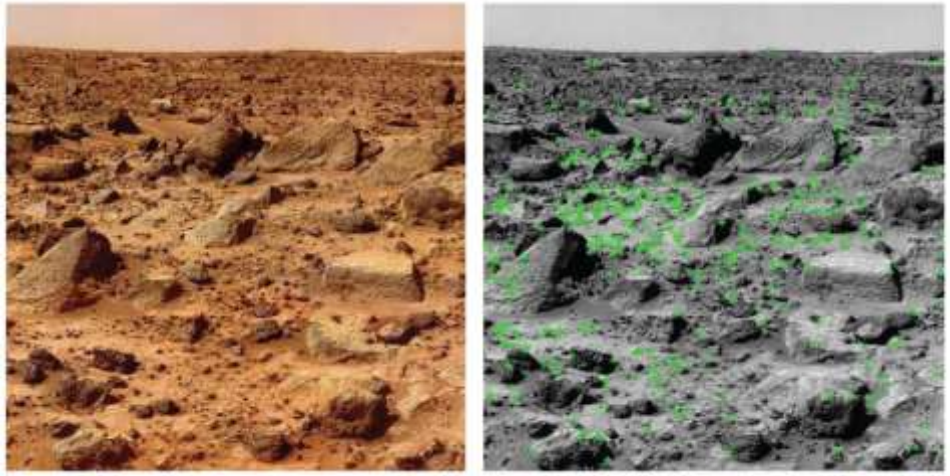
UAS Integration in the National Airspace

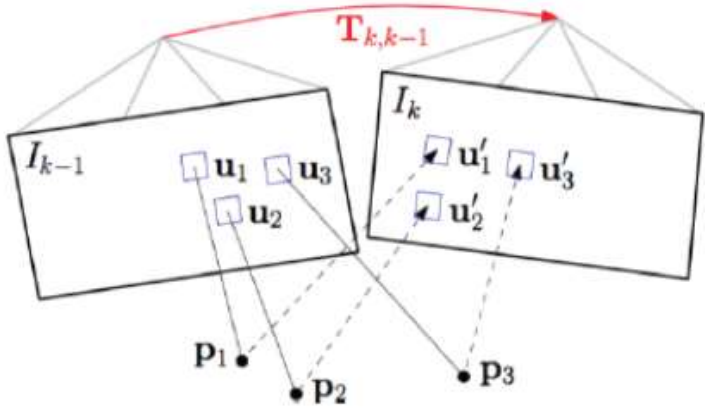


Precision Navigation and Interaction

Navigation in Data-Deprived Environments

Visual Odometry: process of determining the position and orientation of a robot by analyzing the associated camera images

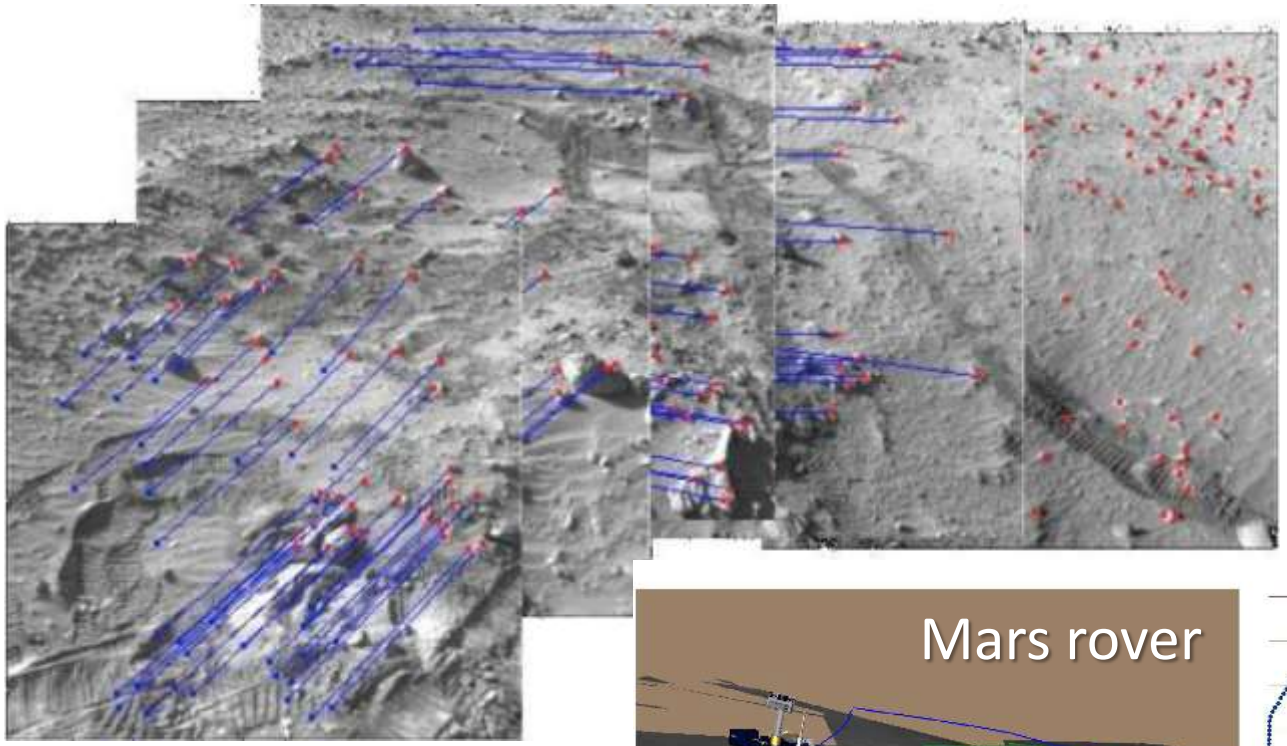


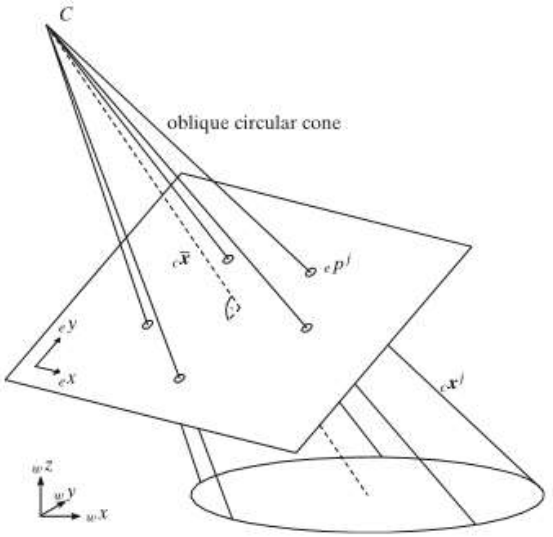


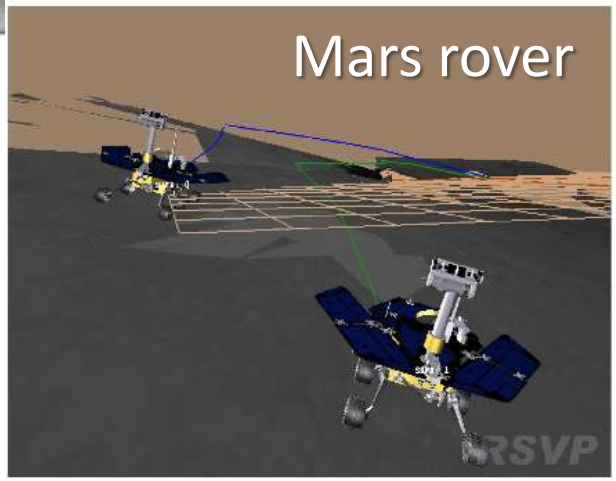
Features on the left video frame are matched with their corresponding features on the right video frame. Parallel lines indicate correct matches. Intersecting lines indicate mistaken matches.

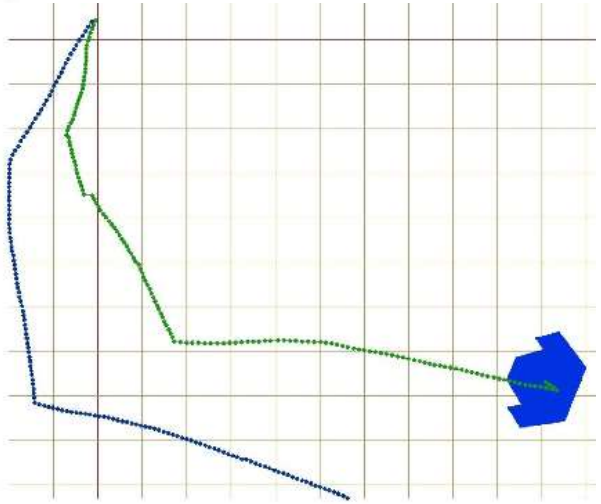
Navigation by Visual Odometry

Fast Semi-Direct Monocular Visual Odometry







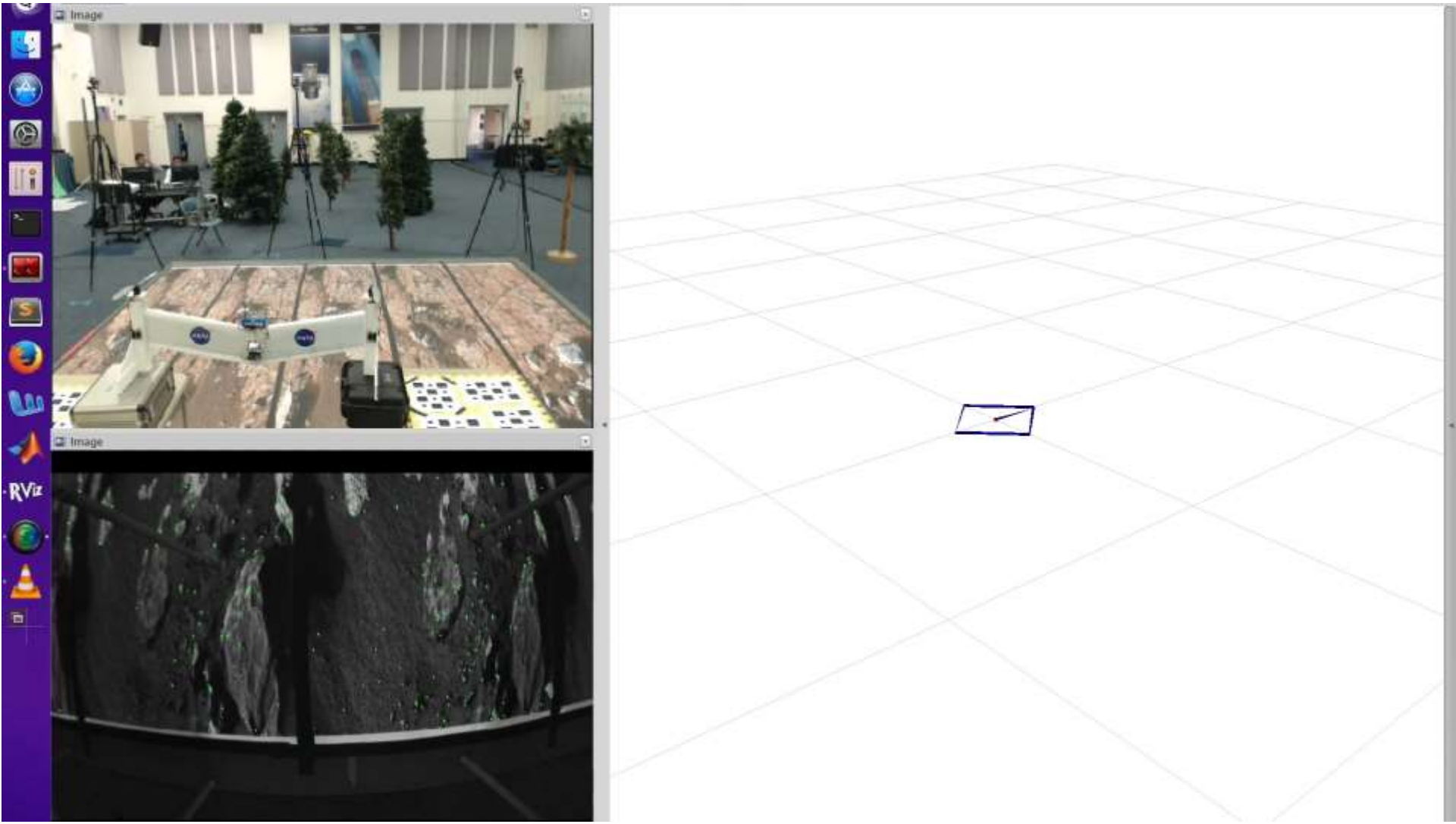


Dual function of VO:

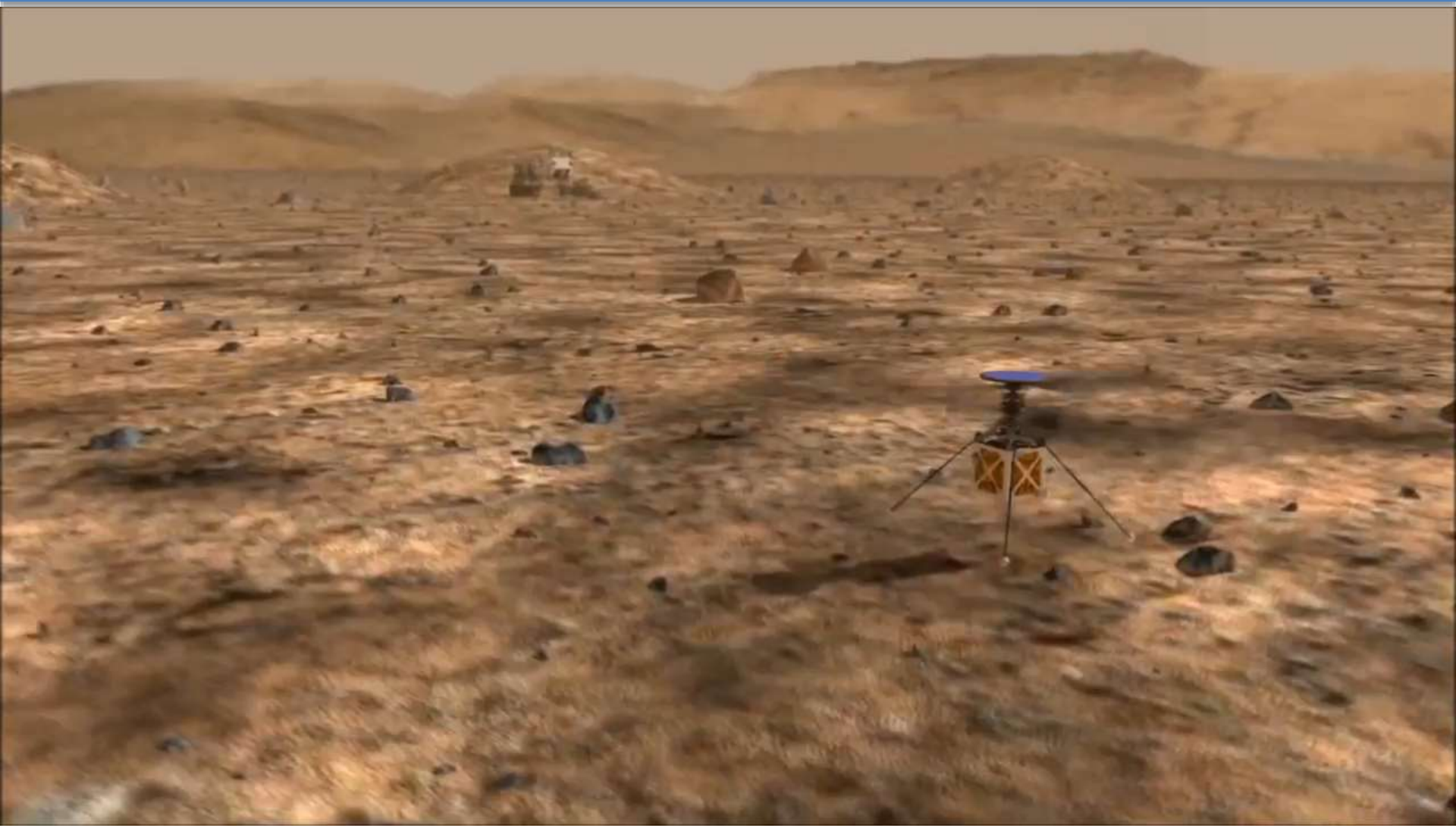
- Navigation
- Simultaneous mapping

Navigation by Visual Odometry

Simulation of Mars exploration using visual odometry

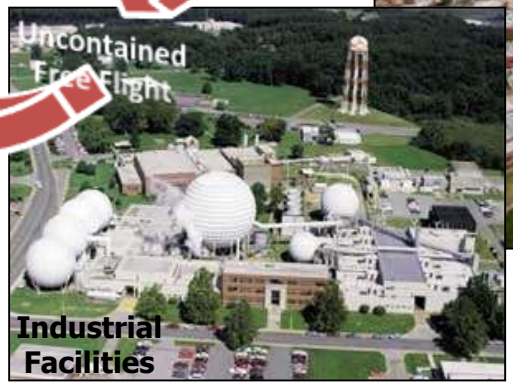


Mars Helicopter



Test and Evaluation

CERTAIN - City Environment for Range Testing of Autonomous Integrated Navigation



CERTAIN Test Range

Test: Search and Rescue Mission

In Conclusion…

- UAS related research, development and operations are a dynamic environment both in Technology and Regulation
  - Technology is increasing in capability and decreasing in cost
  - Rules and regulations are hard pressed to keep up with technology
- UAS are being utilized at Langley in a variety of research areas:
  - Technology testbed
  - Platform for sensors
  - Safe integration into the National Airspace
- Safe operation of UAS is:
  - Dependent on the organization
  - Necessary as we march toward integration into our everyday lives