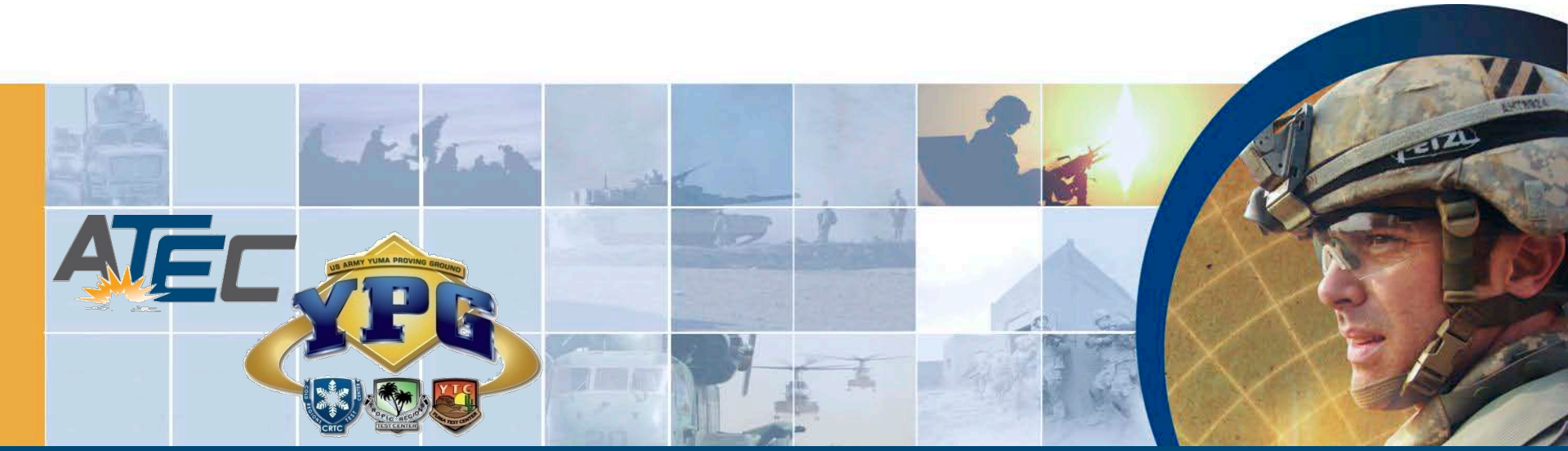

Science of Test at Yuma Proving Ground

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15 Aug 2012

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Agenda

- Objectives
- YPG – Overview with Unmanned System Emphasis
  - Yuma Proving Ground – Mission
  - Yuma Proving Ground – Test Centers
  - Unmanned Aircraft Systems
  - Unmanned Ground Systems
- The Science of Test
  - Some Definitions & Benefits
  - Fundamental Research
  - New Solutions, New Approaches for Unmanned Systems
  - Multi-Agent Systems
- On the Horizon
- Questions

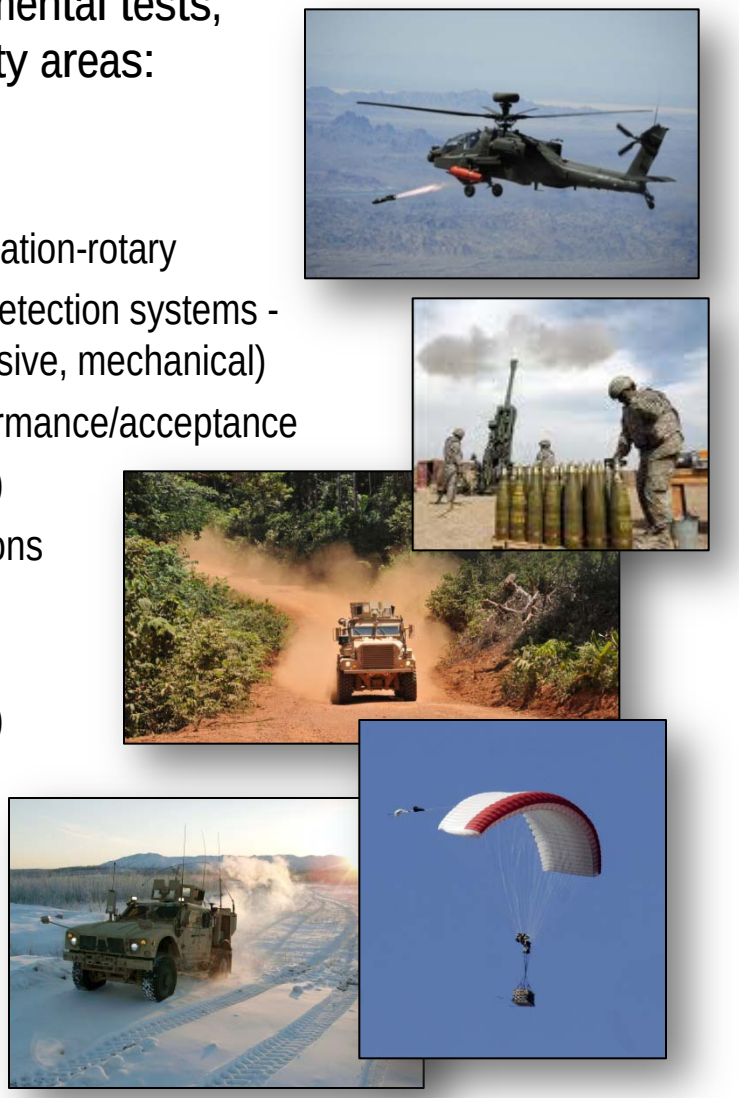
Objectives

- To generate discussion on the exploration of effective solutions to improve the conduct of test through fundamental and advanced research focused on the science of test.

- To foster relationships that tighten the links between the R&D, product development, and test & evaluation worlds to enable all players to better understand each role, ultimately to enhance the test community's ability to develop and implement effective, streamlined, and cost efficient testing approaches to support materiel development.

Yuma Proving Ground - Mission

- Plan, conduct, analyze, and report the results of developmental tests, production tests, and other tests in the following capability areas:
  - Combat vehicles and automotive systems
  - Air delivery systems/airdrop
  - Aircraft systems - aircraft armaments and armament systems integration-rotary
  - Engineering equipment (demolition, mine systems, countermines, detection systems - hand-held, vehicle mounted, airborne, and clearing systems - explosive, mechanical)
  - Direct-fire systems (non missile/rocket) - Direct-fire munitions performance/acceptance
  - Electronic Countermeasures - Improvised Explosive Device (C-IED)
  - Indirect-fire systems (mortars, indirect-fire weapon systems, munitions performance, Smoke/obscurants)
  - Ground and airborne sensors
  - Unmanned aircraft systems (performance and weapons integration)
  - Extreme natural environment (desert, cold, tropics)
- Provide test and test support services for authorized customers within the Department of Defense (DoD) and outside DoD, including domestic and foreign government and nongovernmental organizations



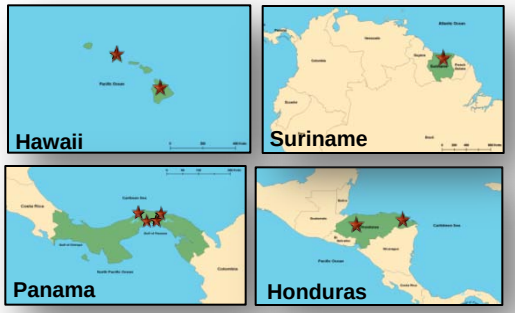
Yuma Proving Ground - Test Centers

COLD REGIONS TEST CENTER
Fort Wainwright and Fort Greely Alaska

Cold Regions Test Center

- 670,713 acres; 254,000 acres of impact area
- Airspace designated user and range priority
- DoD's only high speed closed circuit test track

TROPIC REGIONS TEST CENTER



Tropic Regions Test Center

- Access to ranges in three countries (Honduras, Panama, and Suriname) and the state of Hawaii
- Variety of microenvironments combining factors unable to reproduce simultaneously in a chamber
- Vehicle courses in Suriname and Panama, modifiable to meet customer test requirements

YUMA TEST CENTER
Yuma, Arizona

Yuma Test Center

- 838,000 acres; 1,300 square miles
- 8 Runways and 12 Air Delivery Drop Zones
- Execute an average of 100 active tests per day

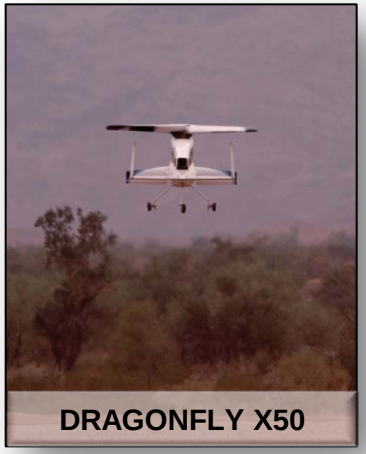
Unmanned Aircraft Systems

VARIOUS TEST OBJECTIVES

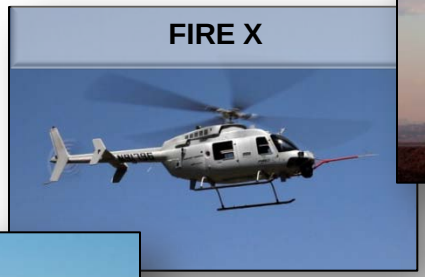
- Initial Flight
- Payload/Sensor
- Laser Designator
- Sensor & Target Acquisition Systems
- Cargo Delivery Systems
- Weapons Delivery
- Manned/Unmanned Teaming
- Endurance
- Air Vehicle Performance
- Operator Training
- High Altitude
- Long range


HUNTER VIPER STRIKE


KMAX CARGO UAS


DRAGONFLY X50


SNOWGOOSE


FIRE X

DIVERSE UNMANNED AIRCRAFT SYSTEMS

- Rotary Wing
- Fixed Wing
- Varied Launch and Recovery
  - Catapult
  - Vertical capture
  - Belly land
  - Runway
  - Hand thrown


SHADOW M


VIGILANTE


FIRE SCOUT WEAPONS


A-160 HUMMINGBIRD

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U.S. Army Yuma Proving Ground

Unmanned Aircraft Systems (cont.)

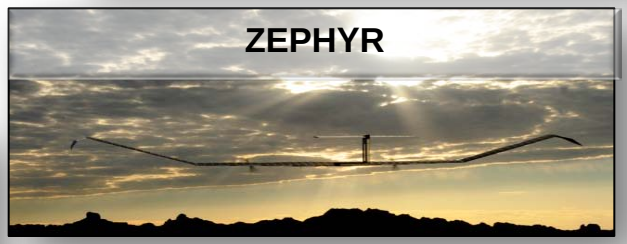
CHALLENGES

- Safety
- Risk Assessment
- RF Spectrum Approval
- Non-traditional Use Of Restricted Areas
- Training For UAS Support Personnel
- Support For Longer Range Flight Operations

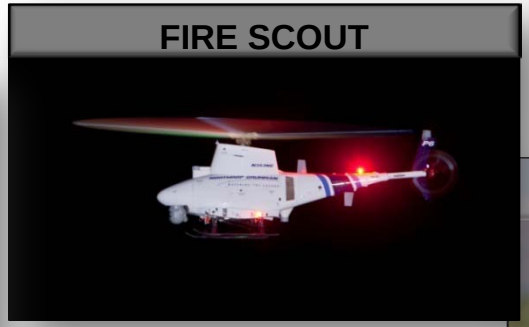

PTDS2

UNMANNED LITTLE BIRD

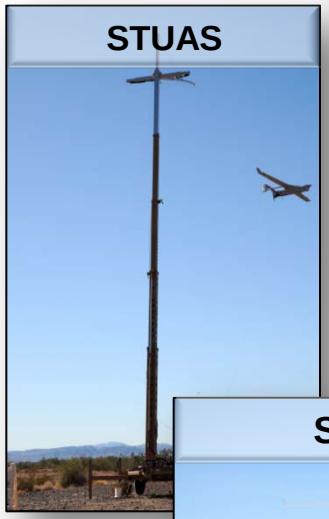
ZEPHYR



FIRE SCOUT



STUAS



COBRA WITH STM

KILLERBEE

STUAS


FCS CLASS I

BATCAM

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U.S. Army Yuma Proving Ground

Unmanned Ground Systems

TESTING OF

- Countermine
- Cargo
- Reconnaissance
- Remote Hazard
- Vehicle Reliability, Availability and Maintainability (RAM)
- System Safety Testing
- Environmental Performance

ABILITY TO TEST INTEGRATING UGVs

- Sensors
- Fire Control
- Weapons

CHALLENGES

- Reliability
- Mobility
- Perception
- Pathing

U.S. Army Yuma Proving Ground

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The Science of Test

Some Definitions & Benefits

The science of test is…

- Fundamental and advanced research related to overarching testing concepts that show promise to significantly enhance the ability to evaluate system performance and inform the developmental process.
- Developing or applying new technologies and methodologies to the test process in order to make it more efficient and effective.

Benefits can include…

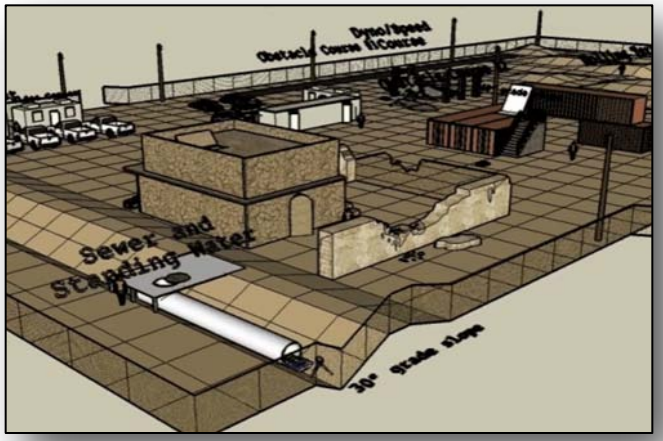
- Improved test quality
- Reduced test cost
- Shortened test schedules

Fundamental Research

The Science of Test in Action

- Test Facility Development
  - Questions…
    - How should we test the robots?
    - What should a robotic vehicle test facility look like?
  - Answer…
    - Start by producing a concept video to enable the lab, development, and test environments to envision and collaborate on development of a test facility that meets the full spectrum of requirements, from specialty experimental features to service facilities, and validated test & evaluation capabilities.

Collaborative Concepting



Click image for video

- Partnering with Industry and Academia to tackle Science of Test challenges
  - Examples
    - Antenna design for wireless IP deployment
    - Data mining within Testing Knowledge Database (TKD)
    - Testing networked multi-agent systems
    - Socializing the Science of Test

New Solutions, New Approaches for Unmanned Systems

Infrastructure

- Existing facilities and test areas were designed for testing *manned* tactical and combat vehicles

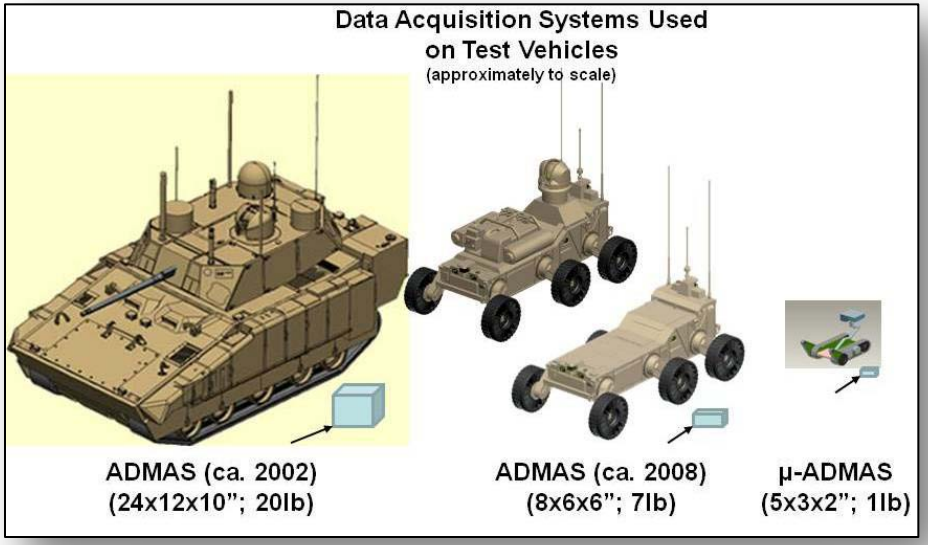
  Unmanned systems frequently have different requirements
  - Range space/safety fans
  - Airspace
  - Broad frequency spectrum demands (video)
  - Type/severity of courses
  - Instrumentation needs
  - Communication (wireless networks, long-range UAS capabilities may require geographically dispersed test support)

- Facilities are long-lead; need to anticipate requirements and solutions far in advance of actual need
  - Partner with Communities of Interest (COI) for development/specification + forecasting

New Solutions, New Approaches for Unmanned Systems (cont.)

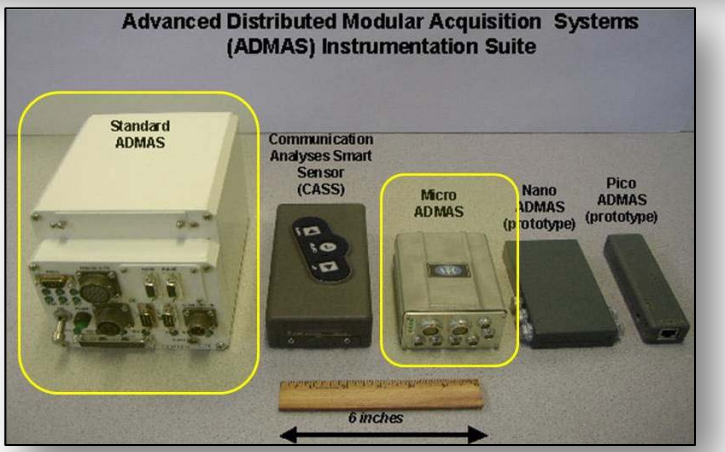
Instrumentation

- Limited volume and/or power to accommodate legacy data acquisition systems
  - — What is the “right size” ” for an instrumentation package to ensure System Under Test (SUT) performance isn’t adversely affected?
  - — How is instrumentation performance compromised by volume and/or power constraints? Is this acceptable?
- Required Data
  - — Time, Space, Position, and Information (TSPI)
  - — Controller & sensor inputs / outputs
  - — “Decision Process” data trails

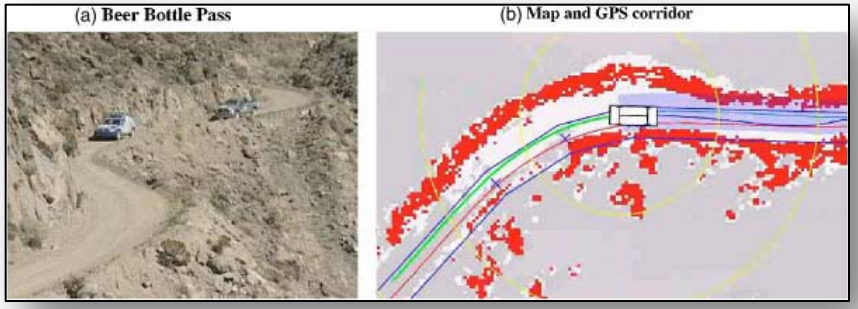


Data Collection & Management

- — Onboard, wireless, other
- — Related hardware and software
- — Data storage policy, scheme and provisions
- — Volumes of data being generated drives solution



New Solutions, New Approaches for Unmanned Systems (cont.)



System Safety

- Highly dynamic and emerging nature of UAS technologies makes assessing hazards uniquely challenging
- Armed vs. unarmed systems (require a tether for positive kill whenever possible?)
- Methodology of techniques used for loss of link recovery, gps denial, etc.
- FAA Air Worthiness definitions scarce/lacking; how to address?

Methodology, Processes and Procedures

- Existing paradigms of testing and evaluation may no longer apply
- RF spectrum management is a fundamental lynch pin for these systems – MUST have ironed out early
- Not just testing mechanical performance, but also software, and "soft criteria" such as perception and ability to "reason"
- How will the collected data be interpreted/analyzed?
- How to determine root cause (mechanical, software, system logic, system perf)? How to determine if failure is due to a combination of causes?

Multi-Agent Systems

- Complexity of testing increases exponentially as the number of individual agents increases
  - The complexity of individual agents' control systems can be tremendous; SoS (System of Systems) / intersystem control is higher order
  - If overall performance is interdependent, how do we evaluate a single platform or identify a root cause of failure?
  - How do you test overall behavior of a multi-agent system or swarm?
  - What data is relevant?

- Infrastructure and Resource Footprint Requirements
  - At least the sum of the constituents, likely more (additional resources required to support SoS activity)

- Data Collection & Management
  - Complexity grows exponentially with multiple agents (system-to-system commo alone is exponential)
  - How to manage?

- How do you "separate the wheat from the chaff?"
  - Potential for cognitive overload for both people and systems
  - How to manage?

On the Horizon

- Teal Group's 2012 market study estimates that *UAV spending alone* will almost double over the next decade from current worldwide UAV expenditures of $6.6 billion annually to $11.4 billion, totaling just over $89 billion in the next ten years. (source: http://www.tealgroup.com/, 25-Apr-2012)

- While the DoD engages autonomous system development and testing in full force, it will likely be Industry that is the primary driving force. The economic potential of autonomy is staggering (e.g., autonomous freight aircraft, autonomous human transports, etc.). Autonomous systems will become ubiquitous in our everyday lives.

- There is much work to be done in developing test and evaluation capabilities and methodologies that are sufficient to address the vast myriad of emerging product types. Scripted tests provide very limited system assessments, while exhaustive tests of all possible scenarios are not feasible or cost effective. Highly engineered, carefully balanced approaches must be developed. *So … let's get started!*

Questions?