Test & Evaluation/Science & Technology Program

ITEA Test and Evaluation Conference 2017

Unmanned and Autonomous Systems Test (UAST)

Technology Area

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Unclassified

Mission

Develop technologies that significantly advance the science of testing autonomous systems

These technologies improve the safety and user trust in autonomous system tests and operations

Autonomous Cargo Transport

Autonomous Troop Transport

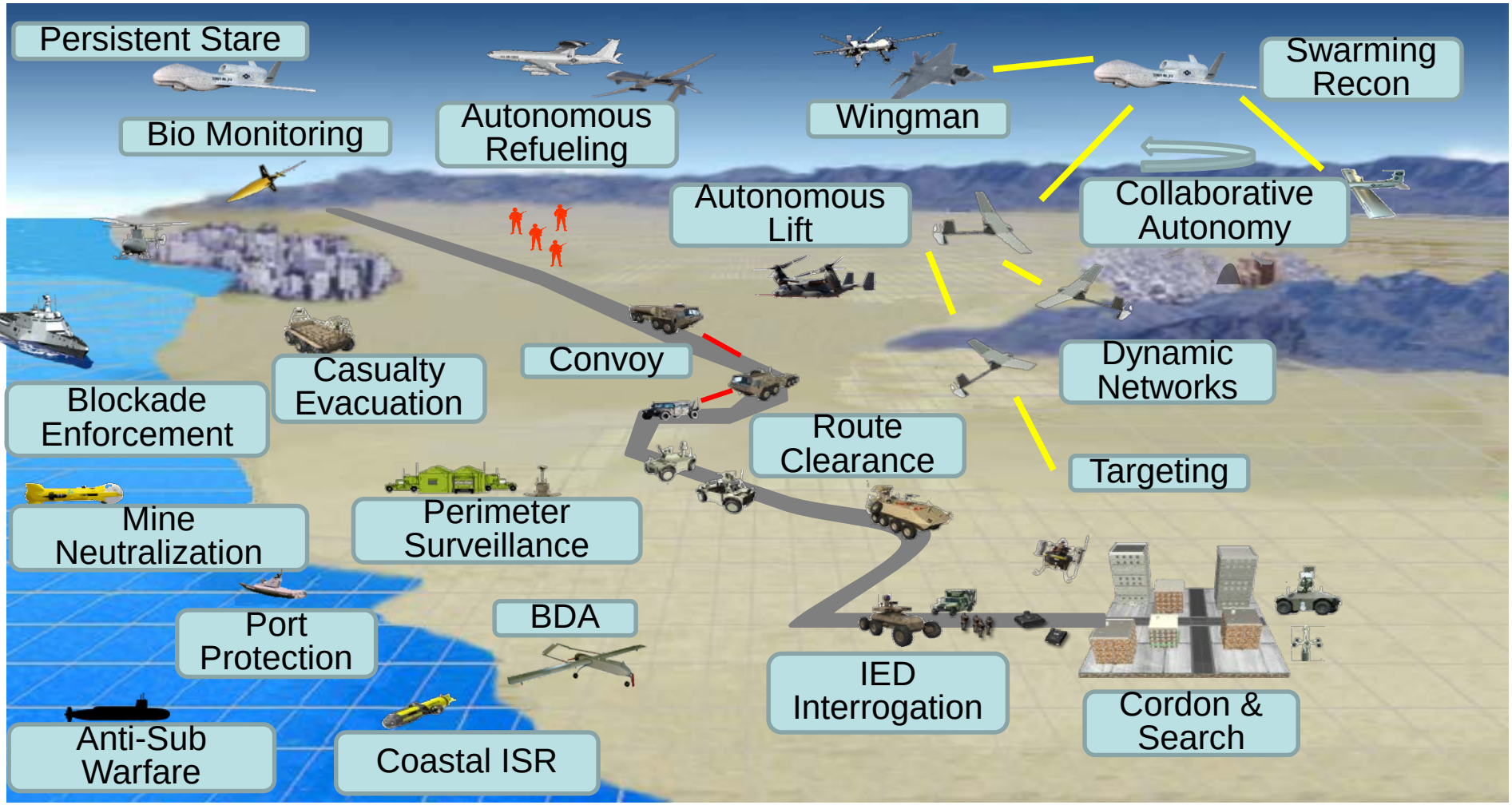
Autonomous Aerial Refueling

Autonomous Aerial Transport

Autonomous Undersea Survey

Autonomous Port Protection

Unmanned and Autonomous Systems Test Operational Scenarios



Better Testing of Autonomous Systems leads to greater Warfighter Trust in their mission performance

Autonomy Priorities

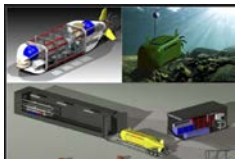
150+ Active Autonomy Programs

- Over 150 active programs employing a spectrum of autonomy
- Services have identified 23 programs as high priority

Service Priorities

XLUUV

CCS

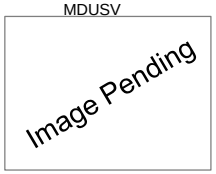

LDUUV

MDUSV

MQ25A

Tern

LOCUST



HCUS

SHARC

AACUS

FDECO

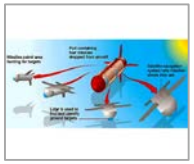
USVS

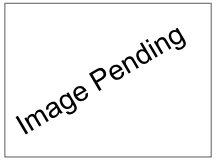
Leader Follower

RCIS

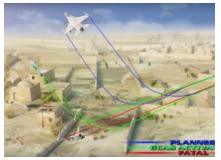
ACO

S-MET


GrayWolf



ICE-T


Aito ICAS

Tactical Offboard Sensing

Sense and Avoid

ART2

LCASD

Autonomy Testing Challenges

The testers are asking hard questions, like these:

- How do I measure human-machine interaction effectiveness?
- How do I design tests for manned-unmanned team coordination?
- How do I develop tests for evoking emergent behavior?
- How do I assess the decision process and cognition, especially with a learning system?
- How do I design tests for distributed teams and swarms interaction?
- How do I develop tests that fully exercise rule coverage?
- How do I create sufficiently smart actors for an immersive environment?
- How do I identify the most salient tests based on SUT parameters and mission?
- How do I measure adaptivity and emergence?
- How do I assess maturity of learning systems?
- Can I test it safely?
- Can I test it in budget / on time?

UAST Wants These Questions Answered

Eras and Testing Challenges

Automated Era…

- **Preprogrammed commands** with explicit tasks
- Deterministic behavior
- Dependence on reliable communications

Testers need to…

- **Verify action**
- Measure physical properties such as position, path, speed, separation distance, completion of event

Autonomous Era…

- Explicit tasks
- Decisions made based on environmental and contextual conditions
- Behaviors are preprogrammed
- **Structured independence,** locally aware

Testers need to…

- **Verify reasoning process**, not just action
- Verify that SUT perceived situation correctly and meant to act the way it did

Intelligent Era…

- **Independent reasoning**
- Experience driven
- Adaptive
- High decision complexity
- UAS-to-UAS cooperation
- Adversary interaction
- Unstructured independence
- Distributed understanding

Testers need to…

- **Verify cognition**
- Recognize that knowledge and decision ability are a function of time and experience
- Need to verify SUT had sufficient knowledge of a situation to form correct intent
- Need to verify combination of multiple mission goals

Near → Mid → Far

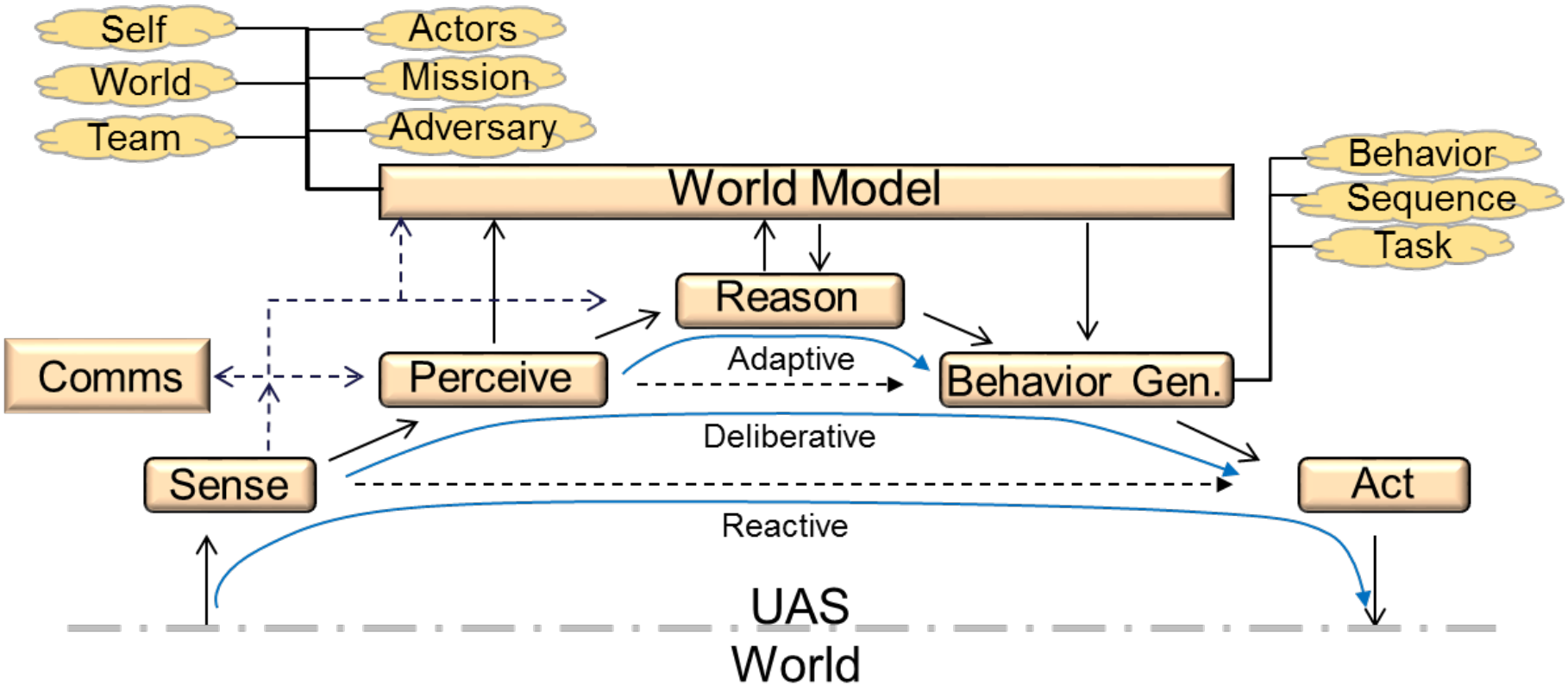
Time

Our Focus is on Testing *Autonomy*

SUT= System Under Test

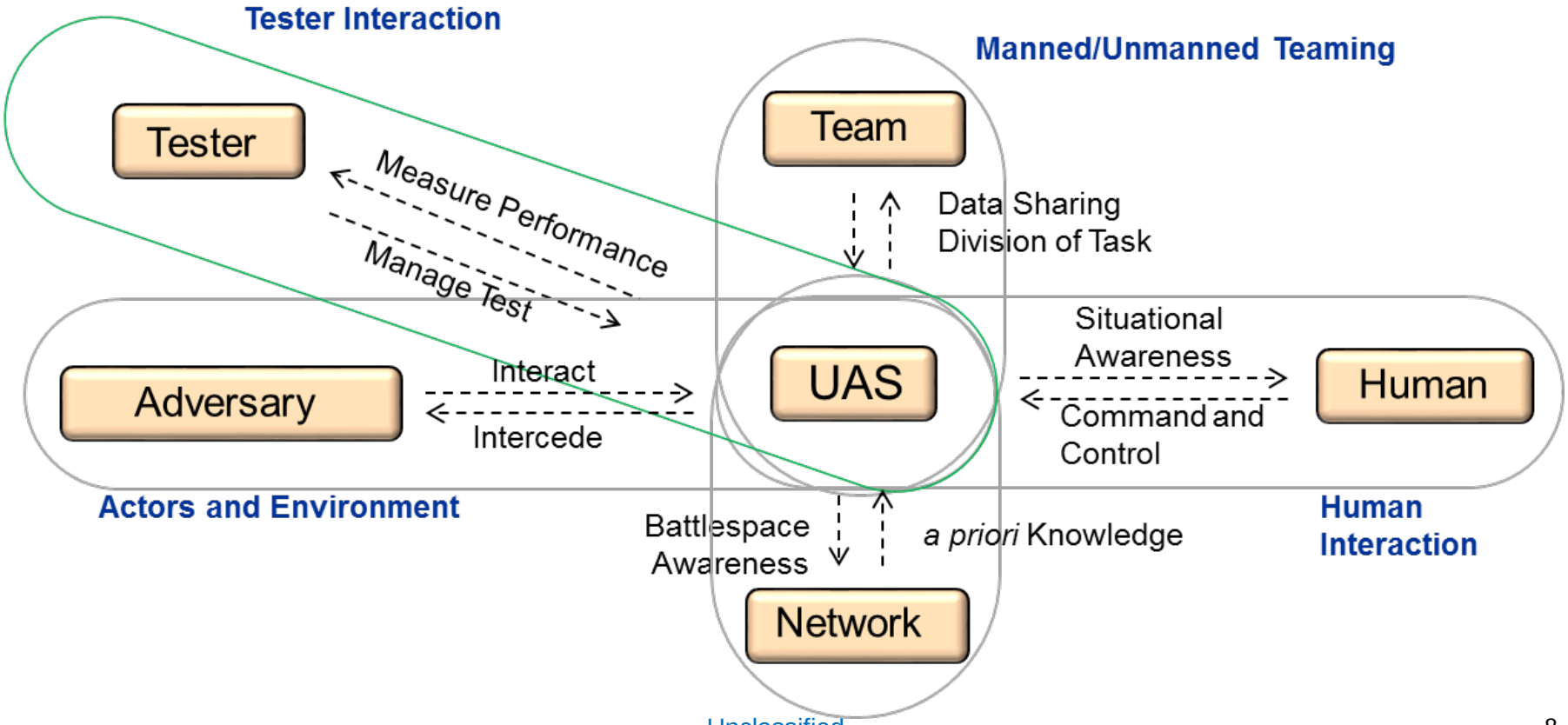
Unmanned & Autonomous Systems (UAS) Overview

Test Technologies are needed to measure and assess the **INTERNAL FUNCTIONS** of the autonomy



Unmanned & Autonomous Systems (UAS) Overview

Test Technologies are needed to measure and assess the **EXTERNAL INTERACTIONS** of the autonomy



Unmanned & Autonomous Systems (UAS) Overview

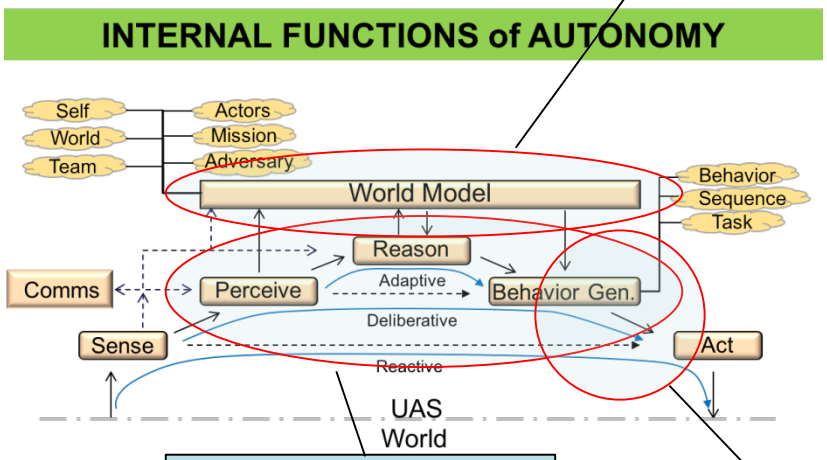
Common architectures, M&S environments & test tools enabling "designed-in" test interfaces, and tester data/knowledge sharing

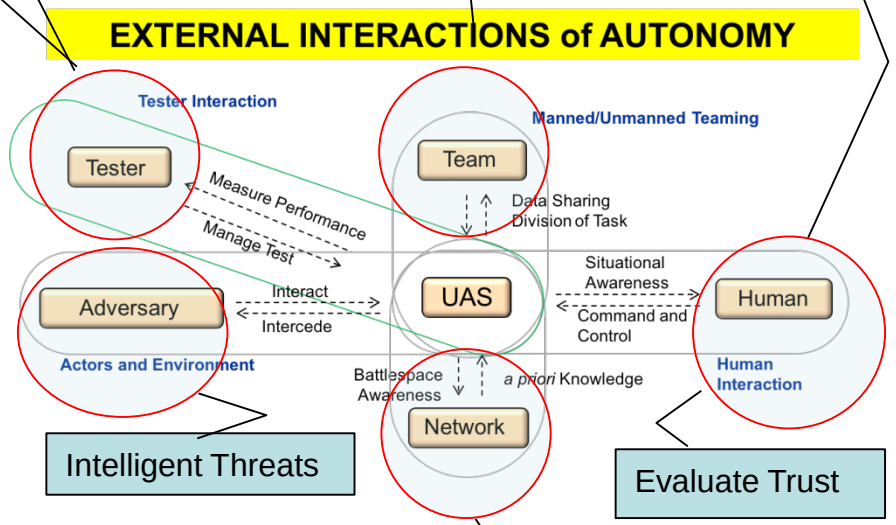
Evaluate Swarm Performance & Behavior

Intelligent Test Planning to Bound Performance & Test Space

Agile & Adaptive Test Ranges

Optimize Human Machine Relationship





Evaluate Internal Autonomy Functions in LVC Environment

Quantify Learning Ability

Intelligent Threats

Evaluate Trust

Emulate & Connect to Cloud

Common test cases, policy, metrics and methods enabling consistency/continuity/reciprocity across DoD as well as other federal and state regulatory bodies in licensing/certification/VV&A

UAST Roadmap Process

1

Evaluate and assess state of autonomy and identify any new and emerging capabilities that will lead to need for new testing

Service Roadmaps

EVAL FUTURE

2

Mission Use Case Formulation: identify and describe representative missions from the operational perspective (context)

17 Use Cases

BUILD USE

3

Task and Function Decomposition: decompose missions into key autonomy tasks and functions

Task and Function Decomposition

DECOMP USE

4

Function Era Assessment: scope to expected capability within 5-10yrs

UAST ERAs

BOUND ERA

5

UAS Considerations: Cross correlation with autonomy test issues from range personnel perspective

UAS Test Considerations

UAS CONSIDER

6

Test Resource Impact: for each function, identify assess gaps against each of the test resources (DMS, IL, HWIL, ISTF, OAR)

Test Resources Impact Assessments

RESOURCE IMPACT

7

Aggregate Gap Assessment: role up gaps and needs common to multiple functions/use cases

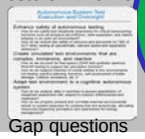
Gap Aggregation Matrix

AGGREGATE GAPS

8

Technology Identification: identify autonomy test technology needs from gaps and questions to seed BAA process

Testers Timeline

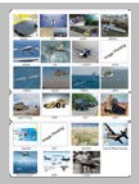


Gap questions

IDENTIFY NEEDS

9

Evaluate and assess priorities based on warfighter demands coupled with urgency and likelihood of fielding



SAE Program Mapping and Range Gap

PRIORITIZE GAPS

10

Develop and propose domains and topics to potential offers in the form of in cycle and out of cycle BAAs

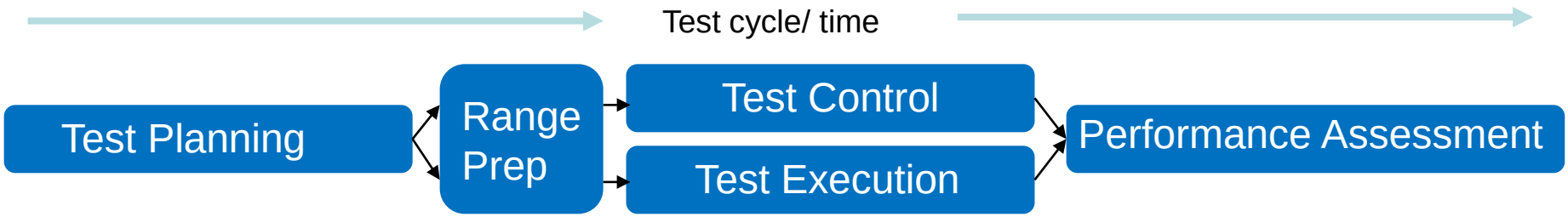
Broad Area Announcement

DEVELOP BAA

Current DOD Autonomy Projects

DoD Autonomy Program Survey and Assessment

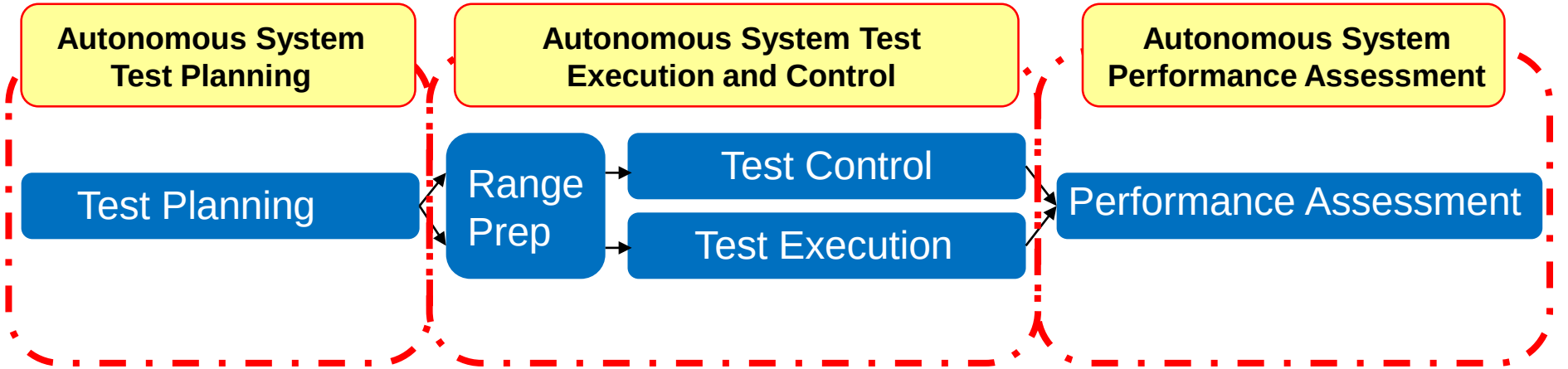
UAST Tester Timeline



- **Test Planning** – long lead time, SUT design and/or program not necessarily set
- **Range Prep** – SUT and/or SUT models identified, short lead time
- **Test Control** – SUT present, focus on safety of range/personnel/SUT
- **Test Execution** – SUT present, focus on efficient test, proper stimulus, data collection
- **Performance Assessment** – SUT and/or test environment no longer available, focus on data, feedback to next test cycles

Different perspectives/technologies needed across the test cycle

UAST Domain Partitions



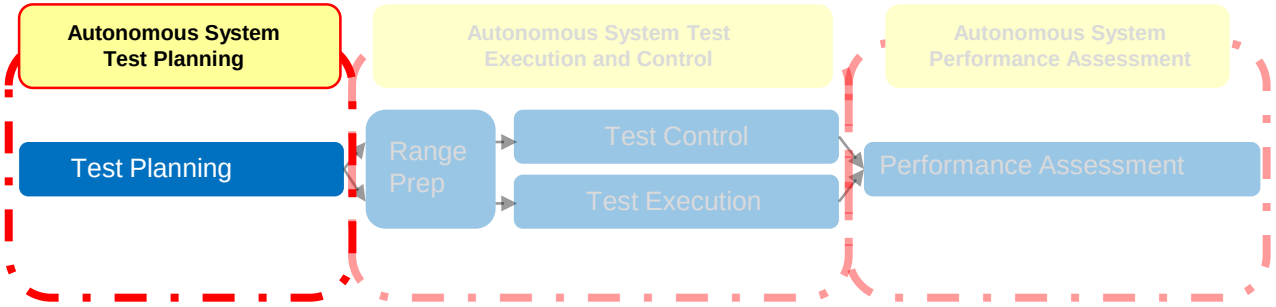
- **Tester Timeline perspective drives UAST domain partitions**
  - Autonomous System Test Planning
  - Autonomous System Test Execution and Control
  - Autonomous System Performance Assessment

Test Innovations Needed to Identify Limitations, Compress the Timeline and Expedite Soldier Acquisition

Autonomous System Test Planning Topics and Selected Needs

1. Design Timely and Cost-Effective Test Plans

- A design concept is needed to design tests that encourage reuse of strategies and data across test resources of varying fidelity (Modeling and Simulation, Integration Lab, Installed System Test Facility, Open Air Range, etc.)
- Technologies are required to dynamically adjust fidelity of testing environments (Modeling and Simulation, Integration Lab, Installed System Test Facility, Open Air Range, etc.) that just meet the requirements of the SUT

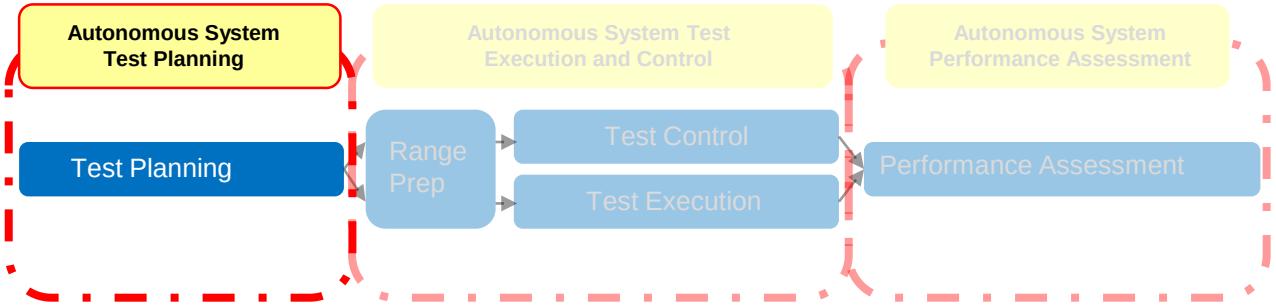


* Official topics will be presented in the BAA when it is released

Autonomous System Test Planning Topics and Selected Needs

2. Predict Autonomous Systems Behavior for Testing

- Technologies are required to predict performance envelopes and identify salient tests by exercising autonomy models and cognitive processes of the SUT across multiple scenarios and environmental conditions
- A design concept is needed to dynamically stimulate or simulate a system under test to effectively use time available for test and ensure that the SUT does not violate hard constraints



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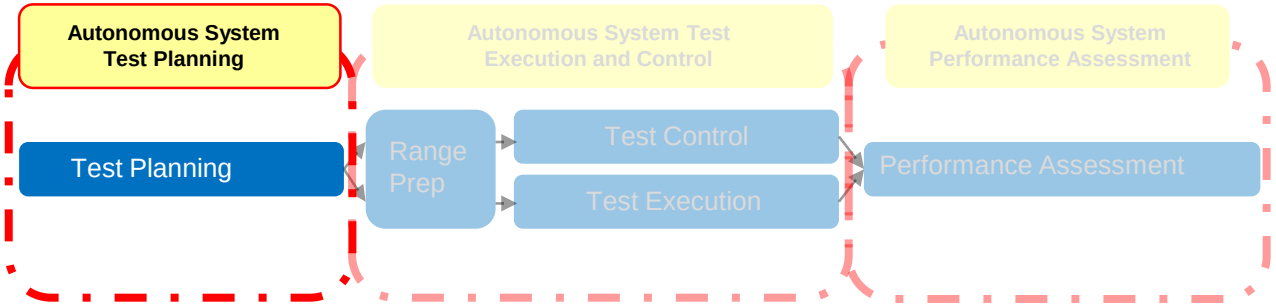
Autonomous System Test Planning Topics and Selected Needs

3. Assure a Sufficient Test

- Technologies are required to determine the level of fidelity required to simulate/stimulate identified sensors and cognitive logic of a SUT to provide measures of coverage and completeness of a given test plan



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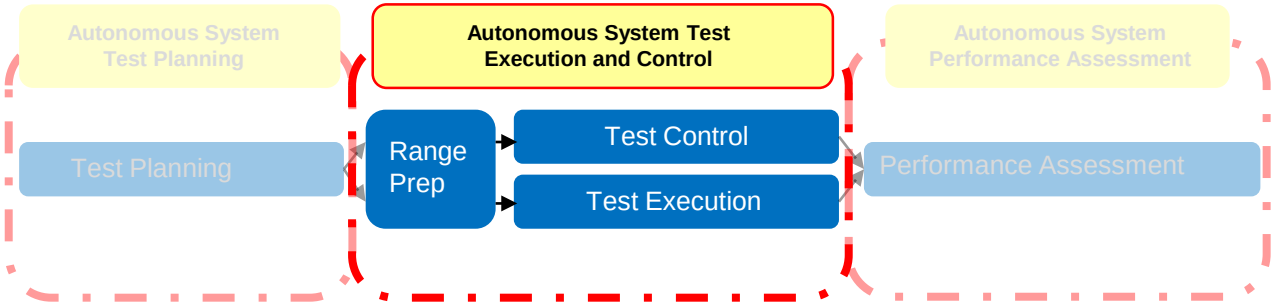
Autonomous Test Execution and Control Topics and Selected Needs

1. Enhance Safety of Autonomous System Testing

- Technologies are required to assure the safety of resources and personnel for T&E of SUT when testing at operationally relevant speed and separation distances
- Technologies are required to provide test range personnel critical situational awareness that systems are behaving safely during critical maneuvering functions such as airspace de-confliction, safe separation, and station keeping in an open air environment



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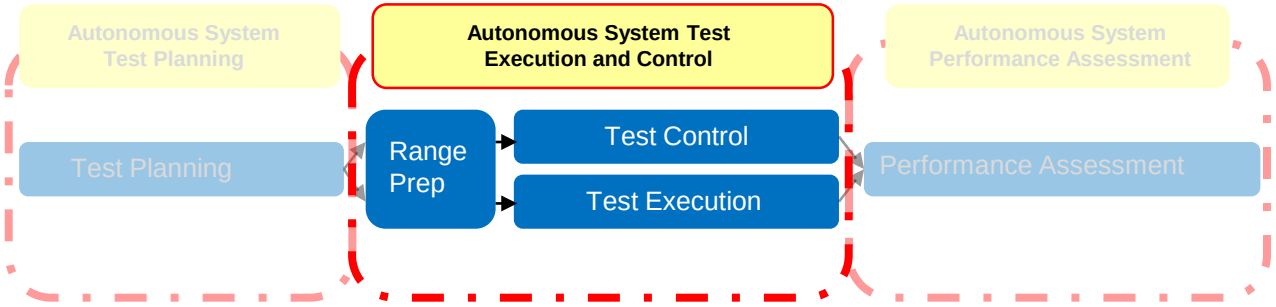
Autonomous Test Execution and Control Topics and Selected Needs

2. Create Immersion Technologies

- Technologies are required to extract and record internal states of reasoning, world model, behavior (decision matrices), and cognition functions, in real time, then correlate them with SUT actions to evaluate the effectiveness of cognition logic, support data fusion, and analysis of reasoning and behavior across a wide range of scenarios
- Technologies are required to insert virtual entities into a SUT in live environments to support testing of reactive planning functions, collision avoidance and high speed maneuvers



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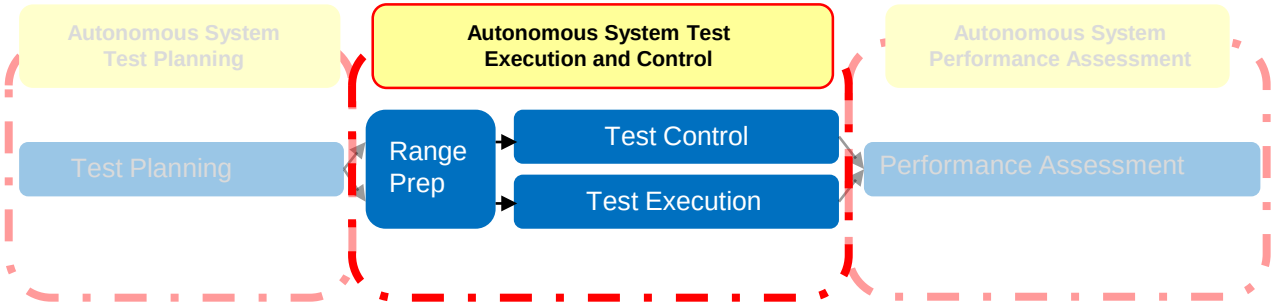
Autonomous Test Execution and Control Topics and Selected Needs

3. Adapt the Test Environment to a Cognitive Autonomous System

- Technologies are required to analyze data in real-time to assess degradation of situational awareness with respect to mission effectiveness and readiness
- Technologies are required to extract reasoning and behavior data from the SUT to support understanding of the decision processes
- Technologies are required to develop appropriate interaction models between SUT kinematic models and terrain



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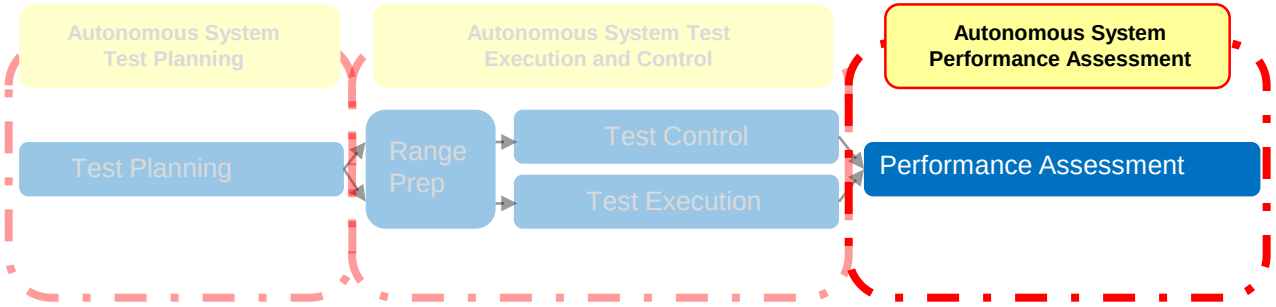
Autonomous Performance Assessment Topics and Selected Needs

1. Testing of Autonomy Functional Components

- Technologies are required to assess sensitivity of cognition/perception logic to variations in sensory inputs and calculate predicted versus actual behavior
- Technologies are required to analyze a System of Systems (SoS) with interactive/collaborative capability in an operationally relevant environment
- Technologies are required to support multi-variable analysis of perception and decision associated with network optimization logic in real time and post processing



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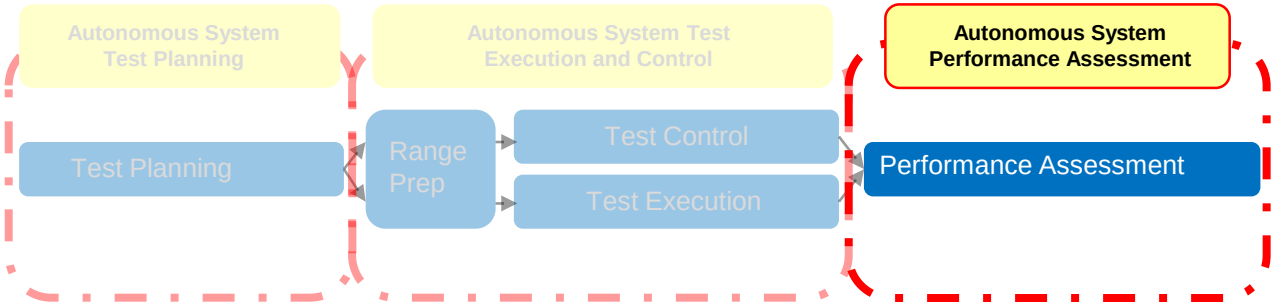
Autonomous Performance Assessment Topics and Selected Needs

2. Measure Human-Autonomous System Interaction

- Technologies are required to test cognition and perception sensitivity to variations (accents, pronunciation, etc.) in voice and or gesture based commands in both virtual and virtualized environments
- Technologies are required to assess the sensitivity/effectiveness of human machine interaction between ground coordination functions and collision avoidance routines when possible overrides are required (human mistake/SUT override, SUT mistake/human override)



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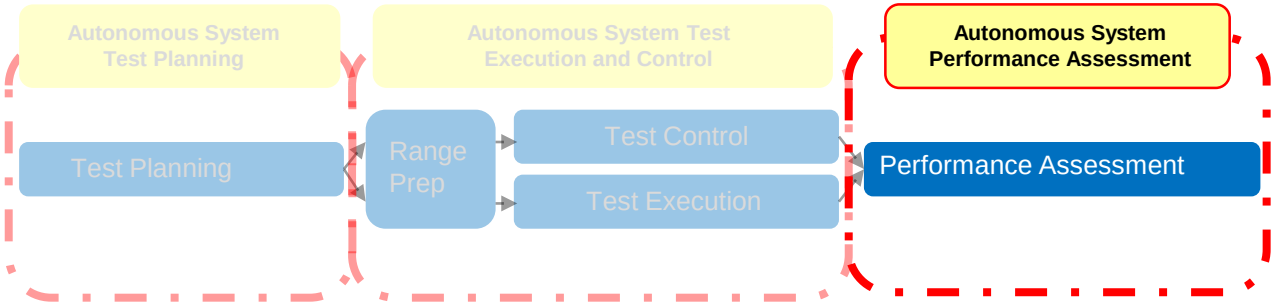
Autonomous Performance Assessment Topics and Selected Needs

3. Measure Autonomous System Reliability and Performance

- Technologies are required to assess effectiveness and performance of cognition and perception with comparisons between predicted and actual behavior
- Technologies are required to evaluate system maturity, for safe operations, as well as mission/capability based performance over a broad range of scenarios such as collision avoidance, refueling termination, safe separation, dynamic route re-planning, station keeping, etc.
- Technologies are required to provide an analysis of alternatives to support assessment of basic cognitive planning and perception algorithms in a wide variety of scenarios and environments for both individual systems and teams



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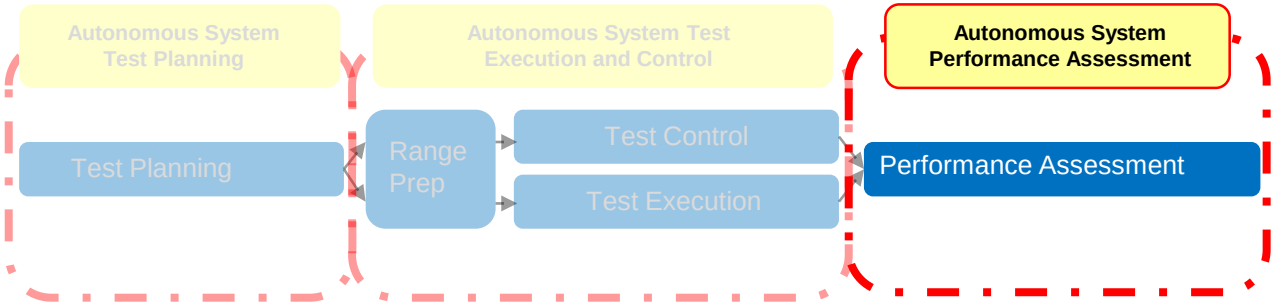
Autonomous Performance Assessment Topics and Selected Needs

4. Assess Vulnerabilities of Autonomous Systems

- Technologies are required analyze the vulnerability of autonomous systems to cyber, electronic attack and/or spoofing on decisions and actions of the system
- Technologies are required to measure software maturity of adaptive and learning systems and identify aberrant behavior development over a broad range of scenarios



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