Autonomy Test & Evaluation Verification & Validation (ATEVV) Challenge Area

Stuart Young, ARL
ATEVV Tri-Chair

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Outline

- ATEVV Perspective on Autonomy
- ATEVV Overview (goals, functions and milestones)
- ATEVV Activities Status
- Discussion

TEVV Perspective on Autonomy

"Unlike many other defense systems, the critical capabilities provided by autonomy are embedded in the ***system software***. However, the traditional acquisition milestones for unmanned systems, often along with the focus of the development contractor, are dominated by hardware considerations. Autonomy software is frequently treated as an afterthought or assumed to be a component that can be added to the platform at a later date—independent of sensors, processing power, communications and other elements that may limit computational intelligence."

"The Task Force recommends that the Military Services structure autonomous systems acquisition programs to separate the autonomy software from the vehicle platform."
– DSB Report on Autonomy 2012

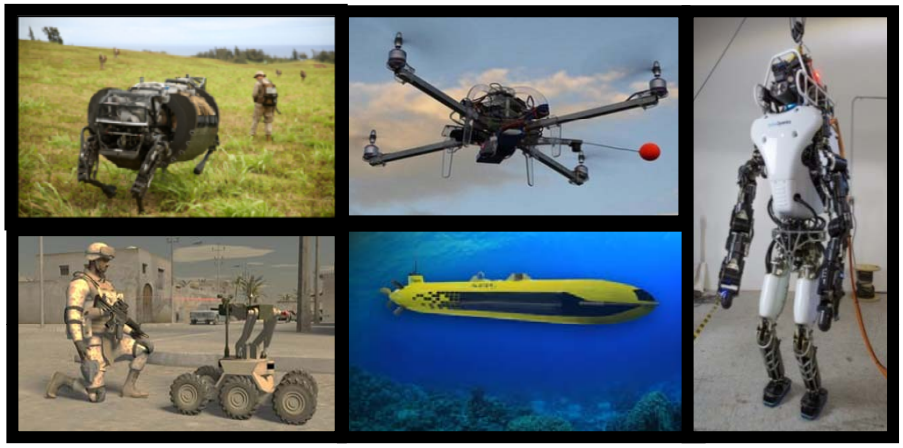
This might be hard to accomplish….

Principle Question:

How do we design in TEVV methods throughout the acquisition program to:

- **Gain better insight in the autonomous software**
- **Produce V&V evidence earlier in the lifecycle**
- **Argue risk more effectively?**

Autonomy Test & Evaluation Verification and Validation (ATEVV) Overview



Major Functions of the ATEVV WG

-Foster community collaboration
-Develop an S&T strategic roadmap
  -Assess current autonomy T&E and V&V standards, procedures, infrastructure and capabilities
  -Identify gaps where ATEVV capabilities, infrastructure, and policy are misaligned or deficient
-Coordinate with Major Range Test and Facility Base (MRTFB)
  -produce a database baseline of T&E infrastructure
-Support standards development unique to the V&V of autonomous systems

***Tri-Chairs Dr. Jeff DePriest DTRA, Matt Clark AFRL, Stuart Young ARL**

ATEVV Goals

Goal 1 – Methods & tools assisting in requirements development and analysis

Goal 2 – Evidence-based design and implementation

Goal 3 – Cumulative evidence through RD T&E, DT, & OT

Goal 4 – Run time behavior prediction and recovery

Goal 5 – Assurance arguments for autonomous systems

ATEVV Major Milestones

- ✓ **WG Established and Meeting Monthly/Quarterly Workshops**
- ✓ **Charter**
- ✓ **Technology Investment Strategy published in Jun 2015**
- ✓ **Develop Strategic Roadmap format and begin collaboration**
- ❑ **TRMC/GTRI Test & Evaluation Study (Initial Jan 2016)**
- ❑ **Pedigree Based Licensure Report findings (Mar 2016)**
- ❑ **Strategic Roadmap Complete (Jun 2016)**
- ❑ **Present Strategic Roadmap to OSD**

DoD must shift the TEVV paradigm for Autonomous capabilities, generating new evidence within design, in live and simulated environments - across all operational domains

OSD Autonomy COI
Test and Evaluation, Verification and Validation

2014 – Signed Charter TEVV charter

Autonomy COI TEVV Working Group Charter

Signature Page

The Autonomy Community of Interest (COI) Test & Evaluation and Verification & Validation (TEVV) Working Group (WG) Charter has been coordinated and reviewed by both Members and Stakeholders identified below and approved by the Autonomy COI Chair.

Morley O. Stone — 30 May 2014

MORLEY O. STONE, ST, PhD — Date

711th Human Performance Wing (711 HPW)

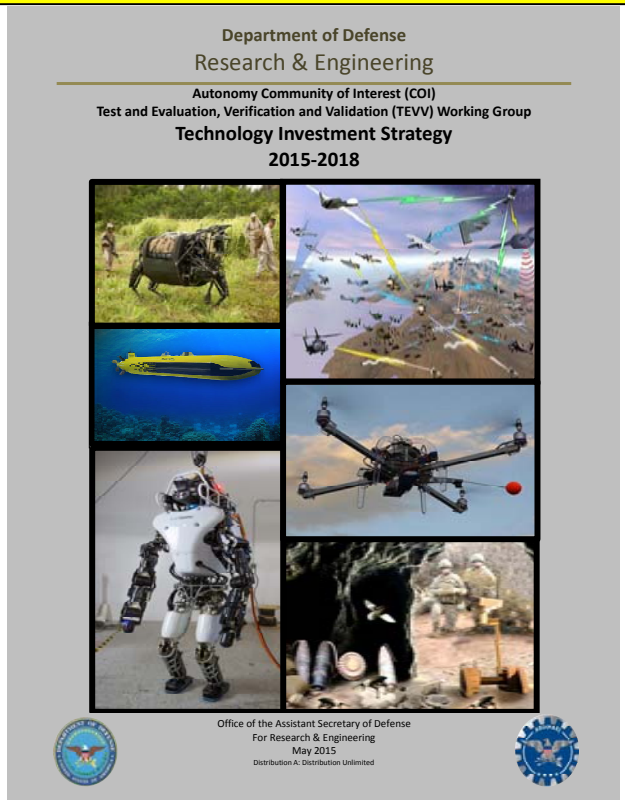
Initiate development of an S&T research roadmap to align DoD TEVV S&T efforts to fill capability gaps. This includes:

- Assess current ATEVV standards, procedures, infrastructure and capabilities along with related R&D activities
- Identify gaps where ATEVV capabilities, infrastructure, and policy are misaligned or deficient

Air Force Research Laboratory (AFRL)	
Constance Heitmeyer Naval Research Laboratory (NRL)	9 MAY 2014
Dr. Marc Steinberg Office of Naval Research (ONR)	9 MAY 2014

2015 – Signed TEVV Strategy

From algorithms to scalable teams of multiple agents – Developing new T&E, V&V technologies needed to enable the fielding of assured autonomous systems



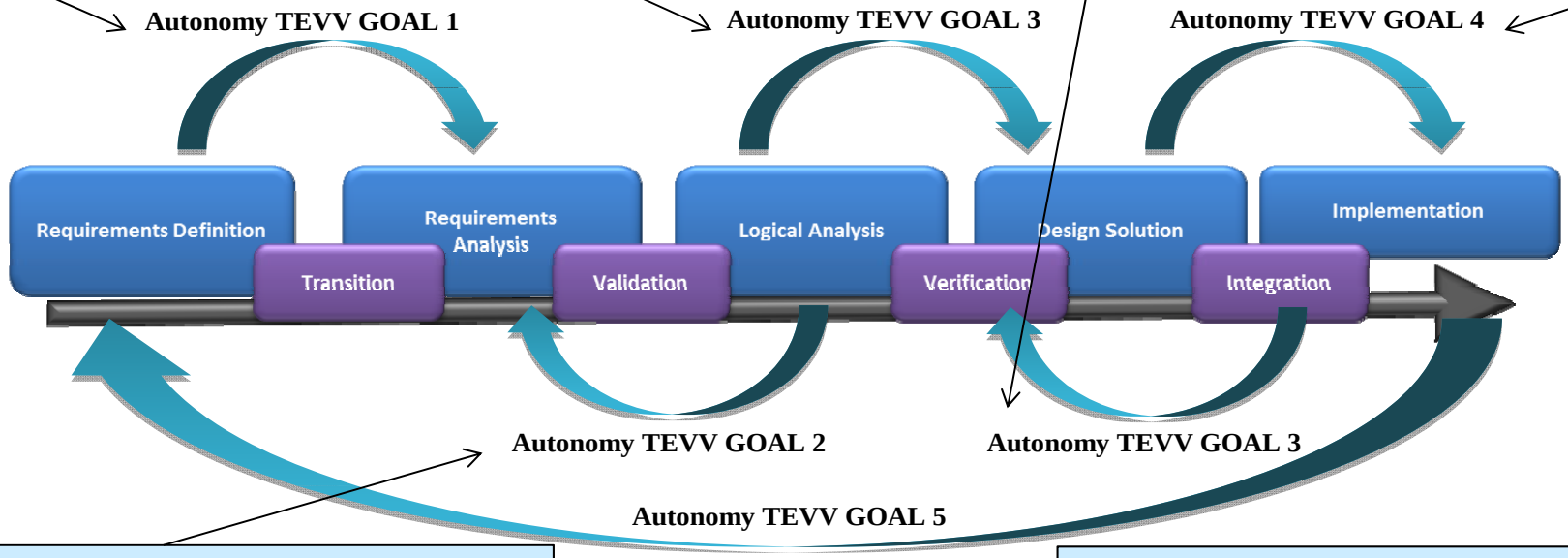
2016 – Cross Service Program Plan / Portfolio Supporting Strategy

ATEVV Process Model, Integrated with Systems Engineering "V"

ATEVV Goal 1: Methods & Tools Assisting in Requirements Development and Analysis:
Precise, structured standards to automate requirement evaluation for testability, traceability, and de-confliction

ATEVV Goal 3: Cumulative Evidence through RDT&E, DT, & OT
Progressive sequential modeling, simulation, test and evaluation

ATEVV Goal 4: Run Time Behavior Prediction and Recovery
Real time monitoring, just-in-time prediction and mitigation of undesired decisions and behaviors



ATEVV Goal 2: Evidence-Based Design and Implementation
Assurance of appropriate decisions with traceable evidence at every level of design to reduce the current T&E burden

ATEVV Goal 5: Assurance Arguments for Autonomous Systems
Reusable assurance case based on previous evidence "building blocks"

Current Working Group Activities

• ATEVV WG submitted seedling proposal **Methods & Tools Assisting in Requirements Development & Analysis** (Goal 1)

•Submitted **ONR MURI Project** Unifying Stochastic, Discrete, and Continuous Dynamics in Mathematically Rigorous Verification Frameworks for Intelligent and Autonomous Systems supporting ATEVV investment strategy (Goal 2)

•DASD (T&E) in cooperation with ASD/R&E drafting recommendations on changing T&E methods, tools, processes. Change culture to accommodate autonomy (AFIT) (Goal 3)

• TRMC contracted study (GTRI) on the **Impact of Autonomy on the DoD T&E Infrastructure**. (Goal 3)

• ATEVV WG leading study on alternative means of **autonomous agent licensure**, leveraging traditional certification for non-autonomous components. Seedling (IDA) (Goal 5)

• Drafting Autonomy COI TEVV (ATEVV) S&T Roadmap--addresses potential solutions to challenges identified in ATEVV Technology Investment (18 projects to date)

•ATEVV WG **collaborating with foreign partners** (India, Israel, UK and Singapore)

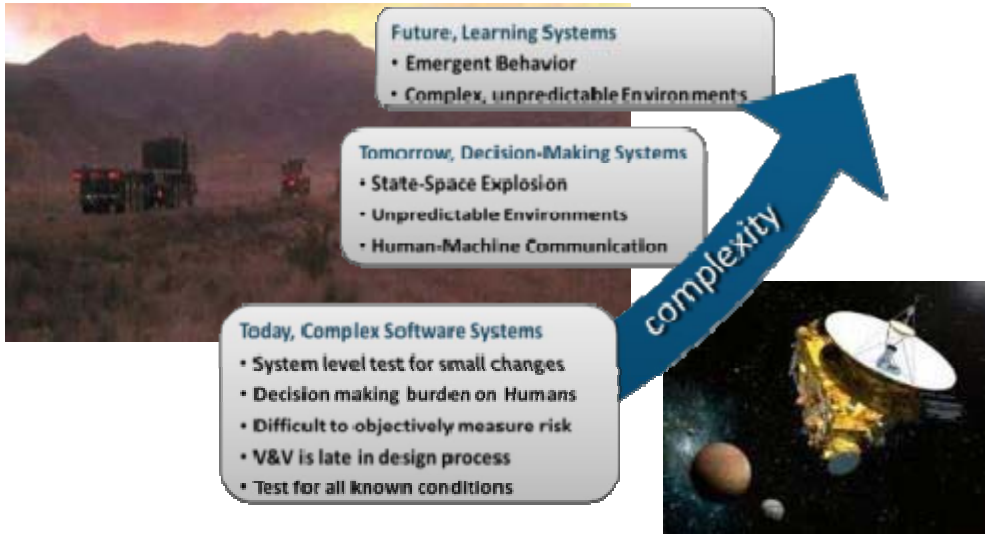
- •Current **engagement with NRL and India** CAIR center underway

- •**UK Ministry of Defense DSTL** (equivalent to ASD(R&E)) **adopted our Autonomy COI TEVV Technical Investment Strategy** as baseline for the 2015 “Initial findings on baseline engineering guidance for consideration of autonomous and supporting automatic functions in manned and unmanned military systems”

ASD/R&E funded study - TEVV: Pedigree-Based Training and Licensure

Objectives:

- Provide insight to DoD SMEs about the challenges associated with the autonomous systems training and licensure scheme
- Investigate current processes for training autonomous system operators, identifying requirements for documenting the "pedigree" of a learning algorithm as it relates to the "pedigree" or "competency" of a human operator
- Identify the technology gaps to be addressed should a certification approach be pursued w/i DoD



Operational Opportunities:

- Establishes a rigorous TEVV process for future autonomous systems
- Measures the ability of new technologies to operate in dynamic, complex, and/or contested environments
- Establishes a comprehensive strategy that addresses both the technical factors and current policy mandates

Technical Challenges:

- Provide critical information on the benefits and issues associated with pursuing a task-based licensure strategy for certifying autonomous technologies
- Guide future actions of the TEVV Working Group
- Share information with industry and academia to continue the dialog with key DoD technology development partners
- No plans to conduct further studies on this subject after this study is completed

Proposed Seedling

Methods & Tools Assisting in Requirements Development & Analysis (Goal 1)

Objective: This seedling effort seeks to initiate a joint DoD project to identify and develop science and technology directly focused on the current gap in Autonomy Requirements S&T.

Impact: Investigate, improve, and demonstrate S&T technologies that will reduce the current V&V burden for Autonomy at the Requirements generation and analysis phase. Three subtasks:

1. Generation of Generic Set of Testable Requirements for Autonomous Systems (ONI)
2. Available Requirements Analysis Tools (NRL)
3. Verification and Validation of Performance Metrics for Autonomy Requirements (ARL)

Discussion

- **Licensure Update**
- **ATEVV—Seedling (Requirements and Use Case)**
- **Collaboration with other Autonomy Challenge Areas**
- **Partner with other agencies (e.g. NRI/NITRD)**

BACKUPS

MURI Topic

Principles for Assuring Composability and Correctness for Nondeterministic Autonomous and Learning Systems that Interact with Unstructured Physical Environments

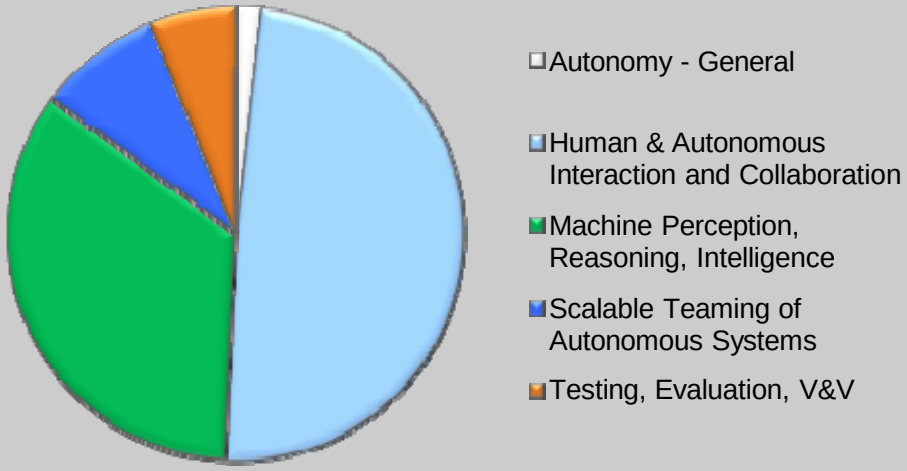
Objective: To develop new methods and principles to assure composability and correctness of nondeterministic autonomous and learning systems in unstructured and uncertain environments and rigorously balance design-time analysis under a subset of environmental conditions with real-time verification and bounding in broader, novel and unexpected situations.

Impact: New methods and principles from this effort could ultimately greatly reduce the cost of development of a wide range of future autonomous and intelligent systems from vehicles to wearable devices and improve their reliability.

The topic requires developing new composable frameworks, models/abstractions, and methods between the disciplines of control theory, robotics, machine learning, computational intelligence, and the computer science formal methods communities including spanning a range of formal methods.

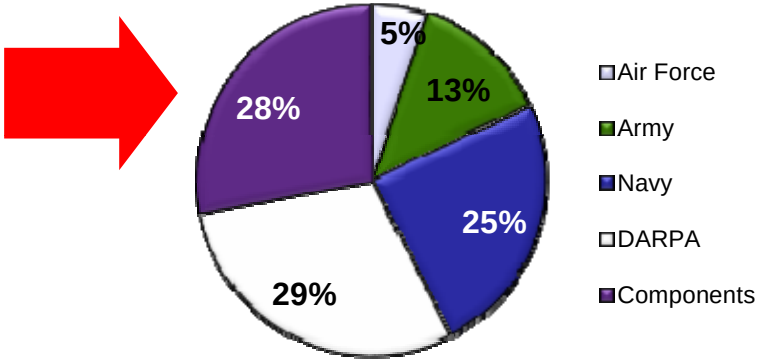
Autonomy S&T Funding Distributions

COI Sub-Areas



DoD PB15 FY 2015

By Component Investment



Only 6-9% of all Autonomy development is focused on new T&E, V&V methods