Autonomy
S&T Priority Steering Council

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ONR/
Presentation to S&T EXCOM
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Two Human-Machine Relationships

Human is *Supported*

**Goal**
Minimize human control to defining mission

**Optimum Level**
System understands human intent

Human is *Supporting*

**Goal**
Minimize supporting humans

**Optimum Level**
Zero

(Images and text related to human-machine relationships, with descriptions of different levels of control and supervision.)
UxV and Autonomy

Now:
- Uninhabited UxVs are an intermediate step towards autonomy

Mid-Term:
- Current UxV systems are rule-based and can support relatively simple missions, but do not operate well in complex, uncertain dynamic environments

Long-Term:
- Level of reasoning capable of comprehending the battlespace
- Automated, coordinated, distributed, adaptive planning
Levels of Autonomy

Ability to Alter Actions
- Enhance World Model and Adapt
- Adapt to Achieve Goals
- No Adaptation

Ability to Reason
- Rational
- Deliberative
- Cognitive
- Reactive

World Model
- Platform Behavior
  - Vehicle control / Navigation / Sensor control / Group behavior / ...
- Mission Performance
  - Comprehend Commander’s intent / objectives
  - Perceive Battlespace
  - Assess Battlespace re: Commander’s intent / objectives
  - Dynamic replanning
  - Survivability
  - Appropriate human engagement for support / awareness; Understanding task / mission accomplishment or abort
  - Weapons release analysis
  - ...

Increasing Capability
- Path clear
- Path blocked; crash into obstacle
- Path blocked; note obstacle; take alternate route
- All paths blocked; explore uncharted territory and make new map

Physical / Cyber World
Operational and Tactical Pictures Development

- Operational and High-level Tactical (e.g., MOC)
- Non-Sensors-Based ISR
- Sensors-Based ISR
- Collection Tasking
- Analysis
- Decision Making (C2)
- Weapons Release / Countermeasures / Responsive Actions
- Tactical (e.g., Combat System, mission execution)
- Real-time Analysis
- Sensor Tasking
- Toward Non-Real-Time
- Toward Real-Time

Common, Distributed Information Storage (Data and Battlespace Context)

Objectives and Constraints
Autonomy Problem Statements

• **Problem:** **Insufficient manpower** to support command and control of persistent, pervasive surveillance assets across relevant battlespace
  • Desire for, at most, single operator control of unmanned teams
  • Increasing quantity and scope of ISR data pushing analysis “beyond human scale”
  • Expanding domains and time-criticality pushing decision-making “beyond human scale”

• **Problem:** Operators/decision-makers don’t have **appropriate level of trust** in autonomy, ie too low or too high.
  • Lack technologies for adaptive autonomous control of vehicle systems in the face of extremely harsh, unpredictable and mathematically intractable environments
  • Lack technologies to enable safe manned and unmanned operation in a mixed battlespace (civilian and military AORs)
  • V&V and C&A address only part of trust
    • Ramifications of over-reliance on autonomy in contested, complex battlespaces

• **Problem:** **Environments so harsh** as to not reasonably permit humans to enter and sustain activity
  • Examples include
    • High radiation, High biological, High chemical environments
  • Mission areas where one may not return
## Desired End States

<table>
<thead>
<tr>
<th>3 year (2016)</th>
<th>5 Year (2018)</th>
<th>7 Year and beyond (2020+)</th>
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<tbody>
<tr>
<td>• Develop highly flexible, interoperable environment for common control and computations</td>
<td>• No increase in supporting manpower requirements for C2 of 1,000 sq mile area</td>
<td>• Continue evolving technologies</td>
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<td>• 50% staff reduction for C2 for a notional 100 sq mile area</td>
<td>• Integrated wide area – classification / ID sensor resource for autonomous cooperation</td>
<td>• Complete Phase 2 advanced autonomous tech development</td>
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<td>• Autonomously update battlespace context using available sources</td>
<td>• Expand mixed manned/unmanned operations to non-cooperative, but not contested battlespace</td>
<td>• Initiate Phase 3 advanced autonomous tech development</td>
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<td>• Enable timely operational decision making based on commander’s intent</td>
<td>• Enhanced SIGINT input to include signal internals</td>
<td>Beyond</td>
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<tr>
<td>• Enable mixed manned/unmanned operations within common battlespace</td>
<td>• Continue 2nd generation prototyping</td>
<td>• Fully autonomous operations with periodic need for update</td>
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<td>• Complete Phase 1 advanced autonomous tech development</td>
<td>• Continue Phase 2 advanced autonomous tech development</td>
<td>• &gt;75% prob of success in contested battlespace</td>
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<td>– Tailored pattern recognition</td>
<td>– Tailored swarming tech-subterranean</td>
<td>• Training/experience (warfighter culture) support inclusion of autonomous capabilities</td>
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<td>– Decision making</td>
<td>– Coordinated multi-unit search</td>
<td>• Complete Phase 3 advanced autonomous tech development</td>
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<td>– Miniaturization of autonomous control sensors, power supplies, etc</td>
<td>– Obstacle negotiation, task restructure</td>
<td>• Complete 3rd generation prototype</td>
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<td>– Autonomous Protective system defeat</td>
<td>– Threat recognition &amp; adaptive response</td>
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Overview of Autonomy Roadmap *

- **Common / Interoperable Control / Computational Environment**
  - Evaluate Services' Approaches
  - Distributed, Networked Architecture
  - Integrated wide-area surveillance with classification / ID sensor resources

- **Operations in Mixed Environment**
  - Operations in a Mixed Battle Space with Manned and Unmanned Entities
    - Cooperative operations in battlespace
    - Non-cooperative operations in battlespace
    - Contested battlespace operations

- **Netted Platform Behavior Control**
  - Mission / Task Specific Resource Optimization (Priority, Time, Resource Readiness, etc)

**Activities**
- Regional (notional 100 Miles²) Persistent ISR
  - 2011
- Integrated Wide Area and High Resolution Surv. Regional
  - 2013
- FOB Area Protection
  - 2016
- Robust, Adaptive Autonomous Capability in Dynamic, Contested Battlespace
  - 2018
- > 2023

**Headers**
- Realistic Scenario Capabilities
- Netted Platform Behavior Control

*Comms and networking assumed available or adaptation*
Notional Autonomy Roadmap *

2011 2013 2016 2018 2020 > 2023

Semi-autonomous and Autonomous Analysis and Assessment

2011-2013: Identification of normal, new, and abnormal activity
2016-2018: Robust multi-platform tracking
2020-2023: Information integration and assessment in real-time and non-real-time

Broad Area Entity Tracking

2011-2013: Identification of normal, new, and abnormal activity
2016: Robust multi-platform tracking

Autonomous Image and Video Understanding / Comprehension and Assessment

2011-2013: Traditional analysis
2016-2018: Object classification and identification
2018-2020: Extraction of motions and actions in the context of the environment
2020-2023: Identification and assessment of activities

Bio-inspired Image and Video Analysis

SIGNET

Cultural / Behavior Algorithms and Social Network Analysis

Relationships and Pattern Recognition

* Comms and networking assumed available or adaptation