Autonomy for Unmanned Systems
How Far is Enough and How Far is Too Much?

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“Tell me about your relationship with the Naval Postgraduate School.”
Admiral Michael Mullen, Chief of Naval Operations
Visit to Space and Naval Warfare Systems Center Pacific
October 4, 2005
Discussion Points for Today

▼ What is Driving the Need for Autonomy in Unmanned Systems?

▼ What are the Prospects for Enhanced Autonomy in Unmanned Systems?

▼ How Much Autonomy is Enough and How Much is Too Much – and How do We Achieve the “Goldilocks Solution?”
What is Driving the Need for Autonomy in Unmanned Systems?
“Today’s unmanned systems require significant human interaction to operate. As these systems continue to demonstrate their military utility and are fielded in greater numbers, the manpower burden will continue to grow … [this] is occurring at a time when constrained budgets are limiting growth in Service manpower authorizations.”

FY 2011-2036 Unmanned Systems Integrated Roadmap
Manpower Costs Have Reached An All-Time High

Military Personnel Expenditures (in billions of current dollars)

Data from: Office of Management and Budget, Budget of the U.S. Government, FY 2012, Historical Tables

05 SEP 2013
The Air Force has estimated that the MQ-1 Predator requires a crew of about 168 personnel, while the MQ-9 Reaper requires a crew of 180 and the RQ-4 Global Hawk relies on 300 people to operate it.

“The number one manning problem in our Air Force is manning our unmanned platforms” – General Philip Breedlove, Vice Chief of Staff of the Air Force

Overall military manpower costs are the fastest growing accounts, even as the total number of military men and women decrease.

CSBA Study: “Over the past decade, the cost per person in the active duty force increased by 46 percent, excluding war funding and adjusting for inflation. **If personnel costs continue growing at that rate and the overall defense budget remains flat with inflation, military personnel costs will consume the entire defense budget by 2039.”**
What are the Prospects for Enhanced Autonomy in Unmanned Systems?
“We will win – or lose – the next series of wars in our nation’s laboratories.”

Admiral James Stavridis
“Deconstructing War”
_U.S. Naval Institute Proceedings_  
December 2005
Making UxS Smarter – and Reducing TOC Brains Over Brawn

- Distributed Control of Unmanned Systems Using Widgets
- Intelligence Carry On Program (ICOP)
- **UV-Sentry**: The “UV-Sentry” project is a joint developmental effort between the ONR and the MCWL
- The Joint Unmanned Aircraft Systems Digital Information Exchange (JUDIE)
- Unmanned Combat Air System-Demonstrator (UCAS-D)
- The Multi-Robot Operator Control Unit (MOCU)
How Much Autonomy is Enough and How Much is Too Much – and How do We Achieve the “Goldilocks Solution?”
“If you find the use of remotely piloted warrior drones troubling, imagine that the decision to kill a suspected enemy is not made by an operator in a distant control room, but by the machine itself... While Americans are debating the president's power to order assassination by drone, powerful momentum – scientific, military and commercial – is propelling us toward the day when we cede the same lethal authority to software.

Bill Keller
Op-ed, “Smart Drones,”
The New York Times in March 2013
A large part of this autonomy for unmanned systems resides in their ability to “sense and adapt.”

This will enable unmanned systems to achieve much greater speed in decision making than is currently possible, and allow “blue forces” to act within an adversary’s OODA (Observe, Orient, Decide, and Act) loop.

Thus, as the environment and/or mission changes in unpredictable ways, the ability to sense and adapt will allow unmanned systems to find the optimal solution for achieving their mission, **without the need to rely on constant human operator oversight, input and decision-making**.

But are we ready for unmanned systems to operate without our decision-making, **to operate inside our OODA loops**?
“Contrary to what some critics of autonomous weapons claim, there won't be an abrupt shift from human control to machine control in the coming years. Rather, the change will be incremental: Detecting, analyzing and firing on targets will become increasingly automated, and the contexts of when such force is used will expand. As the machines become increasingly adept, the role of humans will gradually shift from full command, to partial command, to oversight and so on.”

Kenneth Anderson and Matthew Waxman
“Killer Robots and the Laws of War”
*The Wall Street Journal*
November 4, 2013
Designing in the Right Degree of Autonomy

▼ Instead of viewing autonomy as an intrinsic property of unmanned systems in isolation, the design and operation of unmanned systems needs to be considered in terms of human-systems collaboration.

▼ A key challenge facing unmanned systems developers is the move from a hardware-oriented, vehicle-centric development and acquisition process to one that emphasizes the primacy of software in creating autonomy.

▼ The manned F-35 Lightning has ten billion lines of computer code – and counting – and there is human supervision by the pilot! How many lines of code will need to be built into an unmanned system to get the balance of autonomy and human interaction “just right?”

▼ Back to the future: Isn’t this a lot like the Composite Warfare Commander Concept the Navy instantiated a generation ago?
If This Briefing Has Been of Any Value

We at SSC Pacific have growing equities with UxS and welcome the opportunity to partner with NPS and others in the CRUSER COI.

We’re happy to serve as a conduit for visits to SSC Pacific by those interested in partnering and/or learning more about SSC Pacific.

This is likely a propitious time to undertake research in reducing UxS TOC, and achieving the right degree of UxS autonomy

We’re leaving with Lisa digits copies of resource material:

- “Where is Increased Autonomy for Military Unmanned Systems Leading?” *Defense 2013 in Review*, Fall 2013
- Unmanned Systems “Foundation Manuscript”
“The year after his defeat by Deep Blue, Gary Kasparov set out to see what would happen if he paired a machine and a human chess player in a collaboration. Life a centaur, the hybrid would have the strength of each of its components: the processing power of a large logic circuit and the intuition of a human brain’s wetware. The result: human-machine teams, even when they didn’t include the best grandmasters or most powerful computers, consistently beat teams composed solely of human grandmasters or superfast machines.”

“Brain Gain” by Walter Isaacson
Book Review of Smarter Than You Think
Discussion
Backups
“The Department of Defense’s vision for unmanned systems is the seamless integration of diverse unmanned capabilities … DoD envisions unmanned systems seamlessly operating with manned systems while gradually reducing the degree of human control and decision making required.”

FY 2011-2036 Unmanned Systems Integrated Roadmap
“The DoD expects its inventory of aircraft, both conventionally manned as well as unmanned, to grow to 27,000 vehicles by 2035, including 8,000 traditional aircraft, **14,000 UAS of all sizes and types**, and 5,000 new aircraft with UAS technologies for pilot augmentation or optional pilot replacement.

*Unmanned Aircraft System (UAS)*

*Service Demand 2015 - 2035*

*Technical Report August 2013*

*DOT-VNTSC-DoD-13-01*
Astronauts David Bowman and Frank Poole consider disconnecting HAL's (Heuristically programmed Algorithmic computer) cognitive circuits when he appears to be mistaken in reporting the presence of a fault in the spacecraft's communications antenna. They attempt to conceal what they are saying, but are unaware that HAL can read their lips. Faced with the prospect of disconnection, HAL decides to kill the astronauts in order to protect and continue its programmed directives.

From Stanley Kubrick’s 2001: A Space Odyssey
“Goldilocks went for a walk in the forest. Pretty soon, she came upon a house. She knocked and, when no one answered, she walked right in. At the table in the kitchen, there were three bowls of porridge. Goldilocks was hungry. She tasted the porridge from the first bowl. "This porridge is too hot!" she exclaimed. So, she tasted the porridge from the second bowl." This porridge is too cold," she said. So, she tasted the last bowl of porridge. "Ahhh, this porridge is just right," she said happily and she ate it all up.

From *Goldilocks and the Three Bears*

By Robert Southey
“As they become smarter and more widespread, autonomous machines are bound to end up making life-or-death decisions in unpredictable situations, thus assuming—or at least appearing to assume—moral agency. Weapons systems currently have human operators “in the loop”, but as they grow more sophisticated, it will be possible to shift to “on the loop” operation, with machines carrying out orders autonomously. As that happens, they will be presented with ethical dilemmas...More collaboration is required between engineers, ethicists, lawyers and policymakers, all of whom would draw up very different types of rules if they were left to their own devices.

“Morals and the Machine”

*The Economist*
Multi-Robot Operator Control Unit (MOCU)

MOCU is a flexible software framework capable of monitoring and controlling unmanned systems across multiple domains.

- Modular, open architecture
- Government developed and owned
- Widely adopted
MOCU in Action: Flying the Raven

Stock GCS

MOCU
MOCU in Action: User Interface

Stock GCS

MOCU
“My view is that technology sets the parameters of the possible; it creates the potential for a military revolution.”

Max Boot

War Made New