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Joint Unmanned Combat Air Systems: The Have Blue of the 21st Century

At DARPATech 2004, I introduced a new DARPA office and its linchpin program, Joint Unmanned Combat Air Systems (J-UCAS). It has been an exciting and precedent-setting time since then, with many events and activities unfolding as predicted, but not without a few surprises.

Over these past 17 months, we made significant strides in developing an unmanned air system that will change the nature of air combat. Our development efforts have been successful by many measures. We are on or ahead of our ambitious schedule for every major component of the program. We successfully introduced a novel architecture for this system-of-systems development, treating J-UCAS essentially as a network-based information system, with its air vehicles, sensors and weapons as plug-and-play peripherals, the nodes in the network. When the warfighter community asked for more flexible, diverse capabilities, we were able to provide them through this approach.

Our pace has been relentless. Our progress has been real and measurable. And the uniformed military has taken note. So has the rest of the world.

At the recent Paris Air Show, unmanned combat air vehicles and systems were the talk of the town, despite the lack of flying hardware. The day prior to the show, the French newspaper *Le Monde* featured only one aircraft on its cover: an American J-UCAS air vehicle. The French trotted out their Neuron, and the Italians showcased their Sky-X unmanned combat air vehicle (UCAV). Nearly every other country present was either a player or a "wannabe."

Popular Science brought J-UCAS to the general public by featuring the program on the cover of its July edition. The concept is even showcased in a major motion picture just released, "Stealth," which features an unmanned wingman that steals the show.

We have been so successful, in fact, that DoD has asked that we transition the program to the Services much sooner than expected. That transition is in process, and the new joint program is scheduled to be in place by the beginning of the upcoming fiscal year.

I can't speculate on the specifics of the program's future, but I want to talk about the impact and influence of the J-UCAS program in a larger context: the J-UCAS vision. In the process, I'd like to share some of our accomplishments as they relate to that vision.

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The J-UCAS vision is that a collection of unmanned, weaponized, high performance aircraft, equipped with the latest contemporary autonomous capabilities, fed by information from a variety of other battlefield sources, and operating as a coordinated team, could neutralize the most capable enemy air defenses and successfully defeat other threats while operating in the most dangerous, hostile airspace.

J-UCAS will operate globally. It will use land- or sea-based air vehicles that rely on space and other airborne assets to achieve worldwide connectivity and can be operated by remote crews from virtually any location.

The network-based Common Operating System (COS) is the "brain" of the system, the software that enables interoperability among its diverse platforms, sensors and subsystems. The COS will bring together the best-of-breed algorithms to enable unique functionality for multi-vehicle collaboration, high levels of autonomy, and flexible human intervention, well beyond today's state of the art for UAVs. I predict that J-UCAS, coupled with the enhanced situation awareness derived from shared information made available by its own and other platforms, will be able to dynamically reconfigure and adapt to the threat even as the battle unfolds.

Our goal then, as now, was to advance an unmanned capability that augments the manned force in the most difficult combat situations, to create operational synergy, and to provide the kind of leverage that can significantly amplify the effectiveness of our overall force.

Our vision for an affordable system of systems is one that leverages the COS and related system architecture, along with compatible, modular air vehicle families, to reduce acquisition and support costs.

Since that early introduction, we have accomplished much to bring that vision to reality.

Our air vehicle contractors, Boeing and Northrop Grumman, have come a long way in maturing their designs for the X-45C and X-47B, respectively. Both have passed major design reviews, have resolved serious design issues, and are on their way to producing flight hardware.

Boeing's first air vehicle has been in fabrication since early last summer and should be ready for rollout next year for a first flight in fiscal year 2007. Northrop Grumman is not far behind. The plan is to have each contractor build at least three experimental air vehicles, although the schedules for vehicles two and three have been affected by some significant cuts to near-term budgets.

While the larger vehicles have been on the drawing boards and in the early stages of development, Boeing's X-45A UCAV demonstrators have been an effective pathfinder for showcasing much of the basic functionality needed by the operationalized version of J-UCAS. Based out of Edwards Air Force Base with support from the folks at NASA-Dryden, the two X-45A platforms have been prolific in establishing a number of significant firsts for unmanned air systems.

In April 2004, the X-45A became the first UAV to successfully release a GPS-guided weapon, striking its aim point on the range near China Lake with uncanny precision. Flying at 35,000 feet at a speed of nearly Mach .8, the aircraft autonomously lined itself up with the prospective target coordinates and timed the release to achieve impact within less than a meter—all accomplished autonomously. The human crew provided the target coordinates and authorized the weapons release, leaving the rest of the job to the system.

Since June last year, the X-45As have been used together, with a T-33 UCAV surrogate, to explore and demonstrate capabilities needed for multi-vehicle operation, including multi-vehicle control by a single operator. Since that time, our demonstration system software has evolved to permit control handoff between our Edwards based station and a remote station in Seattle. We also conducted multi-vehicle attack planning and demonstrated in-flight distributed control. We recently completed a significant graduation exercise for this phase of the program, a complex, full-blown SEAD mission involving both aircraft working with a single operator to neutralize a group of known and surprise pop-up targets.

Perhaps the most significant demonstrations of our capability occurred in several instances of unplanned events, like the little heralded incident when an F-18 on approach experienced a technical problem, forcing the following X-45A to divert and do a go-around. The X-45 did so fully autonomously and without incident. Another example occurred when a faulty gear switch indicator told the onboard computer the landing gear was not locked in place. The aircraft decided, on its own, it wasn't safe to land despite being told to do so by an unknowing crew. After the problem was diagnosed and resolved, the aircraft landed without incident.

Our quest to create a COS to support our vision has also taken shape over the last 17 months. To develop this "brain" behind the J-UCAS, Boeing and Northrop Grumman successfully combined forces, with Johns Hopkins University's Applied Physics Laboratory, to create the J-UCAS Common Operating System Consortium.

This consortium is our nontraditional business vehicle for developing this aspect of our system. It is also the mechanism to access other technology contributors in our search for best-of-breed algorithms and functionality. Sporting a Government-owned, nonproprietary software infrastructure, the COS possesses the attributes that ensures a capability for growth and evolution over the long term.

The COS is the most misunderstood element of the program. The rationale behind our approach is manifold. The introduction of the COS as a separate system permits us to segregate its challenging software development from the various platform developments. This independence allows the different components to mature at their own pace, permitting an extra degree of freedom in addressing development or technology issues.

At the same time, this independence adds flexibility in addressing our military customers' needs. As the year has unfolded, uncertainties in threats and the impact of current conflicts have caused, not surprisingly, considerable turbulence in the requirements community. The platform-independent design of our operating system permits consideration of other air vehicles, having different performance and even addressing different missions, knowing that it doesn't mean an entirely whole new program or a new architecture.

This independence also allows for the versatility required to be effective in diverse combat environments, ranging from our fiercest conventional peer competitors to more asymmetric threats we face in Iraq and Afghanistan. In that regard, our current X-planes will serve as representative surrogates for a variety of military missions, in addition to being specialists at the missions for which they were designed.

The "common" aspect of the COS is powerful in concept. A common system that resides on every platform virtually guarantees interoperability. The machine-to-machine interoperability we envision for J-UCAS is necessary to reach the levels of synchronization and collaboration necessary to defeat the more capable integrated air defense threats we are likely to encounter in the foreseeable future. Like the raptors in "Jurassic Park," the real-time, collaborating J-UCAS platforms can find their targets faster, track them more assuredly, target them more precisely, and complete the kill chain more rapidly. Their collaboration can also help ensure their own survival through the use of mutual self-defense tactics.

The ability to shorten operational timelines is crucial to this nation's larger defense strategy. Our successful demonstration of these capabilities will help bolster the DoD's net-centric vision, and our underpinning technologies will become enablers for a host of other systems needing the same or similar capabilities. This is one of the reasons I often describe J-UCAS as an, "erector set for network-centric warfare."

In the end, it's not about hardware or software, but capability. Our opportunity to showcase our capabilities happens during a crucial endgame we call the operational assessment (OA). The OA is our proving ground. It not only gives us a venue for demonstrating capability, but affords an opportunity for operational experimentation, for discovering the art of the possible, for bringing the far side to the near side in a warfighting context.

We fully intend to bring the warfighter into the equation, first in interactive human-in-the-loop simulations and later with the actual full-blown system. Since our air vehicles will be delivered over a span of several years, we'll use surrogates, manned and unmanned, to fill in for the real thing until the fleet is complete. These warfighter participants have an important role to play in the development of the system and evolution of the J-UCAS concept. They will help us define the human-system interface and the interactions necessary to be effective.

The ideal crewing paradigm is still one of the major unknowns we face in developing our system of systems. Concepts of operation and tactics will be explored in an early state of development, allowing our engineers to develop the right software the first time around. Our warfighters will be co-opted by a new way to combat the enemy by this new way of doing business, one that fully exploits the advantages of net-centricity and the information age as we know it.

Numerous demonstrations for the OA are planned. As early as fiscal year 2007, J-UCAS air vehicles will engage in autonomous air refueling, land on a carrier deck, and perform all the operational functions needed in the execution of the most dangerous missions we have been assigned by our Service users.

Multiple platforms will passively detect emitting threats, compare notes, and decide which platform should take a snapshot using its synthetic aperture radar. The resulting imagery will be expeditiously passed to a control station with a minimum of bandwidth, and the operational crew will decide the target's fate. Once authorized, J-UCAS will collaboratively decide the best approach to achieve the desired effect. That could result in simple disruption of communications or a hard kill, depending on the circumstances. The human crew will always possess the ability to dictate the rules of engagement, maintaining the moral imperative for decisions having lethal consequences.

The OA will allow us to demonstrate our ability to achieve very predictable battlefield effects, while employing very unpredictable tactics for our adversaries to decipher.

The "O" in OA also stands for opportunity. J-UCAS will have the opportunity to make a statement for all its progeny and for the future of robotic systems.

Even as experimental vehicles, the X-45C and X-47B will set a new standard for range-payload performance that will be the envy of every combat aircraft ever built in their class. But the system is capable of doing so much more.

J-UCAS is positioned to be a pioneer for achieving routine access to civil air space. That role is important not just because of the J-UCAS mandate to be a global system, but because routine access opens the doors to commercialization of this class of system. Commercialization means lots of vehicles involved in many applications, a healthy and vibrant industry, and a lower cost for the technologies DoD will use.

J-UCAS will set a new standard for persistence. Because of the ability to be air refuelable, the vehicles' endurance will last many hours beyond their counterparts. With our current off-the-shelf engines, that's about 50 hours, more than enough time to circumnavigate the globe and, with some modifications, probably more than once.

J-UCAS can demonstrate our ability to fight the war wherever it is, from wherever we want to be. We could fight our mock war in the deserts of California and Nevada, but control the action from a console in downtown London the middle of the Pacific, or anywhere else. That possibility got ever closer with the creation earlier this year of a US-UK project arrangement for government-government collaboration on J-UCAS.

//8-minute video//

The battle is a complex chess game, and the adversary's defense system is tantamount to a 21st century fortress, as impregnable as technology can make it.

J-UCAS is the embodiment of a new form of air combat. More profoundly, it is the standard bearer for a more integrated defense in a larger sense. Our push toward command and control commonality and vehicle interoperability is an important visible step toward the defense vision, a vision for versatility and decisive victory unmatched in the annals of warfare.

More than 30 years ago, we changed the face of air combat with a DARPA program called "Have Blue," which brought the reality of stealth to the warfighter. J-UCAS can do the same on a much larger stage and for a much grander purpose.

J-UCAS is the Have Blue of the 21st century.

And it came to you from DARPA.