

NANOSAT/MICROSAT CONSTELLATIONS AND THE NEXT GENERATION UNMANNED SYSTEMS STRATEGY

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ABSTRACT

Our Nation has adopted integrated unmanned ground, air and maritime systems into nearly every facet of conventional and irregular warfare. Today’s warfighters are dependent on the Intelligence, Surveillance, Reconnaissance (ISR) and Communications provided by unmanned systems from the strategic level down to the tactical edge. Demand for these systems is quickly outpacing our capacity and despite the game changing capabilities provided by these systems, there are still gaps in our ability to utilize them in denied access areas, to rapidly deploy / task them to new and changing areas of interest, and provide cost effective, ubiquitous ISR and communications coverage.

Agile, reliable and cost effective nanosatellite/microsatellite constellations, integrated into the military services’ unmanned systems roadmaps, could fill their ISR and communications capability gaps, augment their existing architectures and enable Beyond Line of Sight (BLOS) exploitation of information for the tactical edge (i.e., conventional, clandestine and special operations forces).

Northrop Grumman is pursuing and conducting technology demonstrations to validate the concept of nanosatellite/microsatellite constellations providing actionable intelligence to the lowest tactical level and exploring innovative architectures enabling dynamically retaskable unmanned ground, air and space assets to ground units at or below the Brigade Combat Team (BCT) level. Soldiers could soon have unprecedented access to relevant, real-time ISR and communications regardless of geography, borders, weather or enemy tactics.

INTRODUCTION

In 2000, DOD had fewer than 50 unmanned aircraft in its inventory; within a decade, this number had grown to more than 6,800. The introduction, proliferation and subsequent demand for Unmanned Systems (UMS) fundamentally changed U.S. manned and, more recently, space strategies. Increasingly, traditional manned and/or space missions, such as ISR and C3 are transitioning to UMS missions. This fact has been recognized by the Services, OSD, Congress and industry.

“Ongoing operations in both Afghanistan and Iraq have dramatically accelerated UAS usage The majority of surveillance is already being conducted by unmanned platforms and will continue to increase...”
U.S Army Roadmap for UAS 2010-2035¹

“Unmanned aircraft systems (UAS) and the effects they provide have emerged as one of the most „in demand“ capabilities the USAF provides the Joint Force” United States Air Force Unmanned Aircraft Systems Flight Plan 2009 – 2047²

“The last six years have proven, without a doubt that unmanned systems operating in the air, on land, and in maritime domains have significantly contributed to accomplishing the Departments’ missions.” FY2009-2034 Unmanned Systems Integrated Roadmap , Office of Secretary of Defense.³

In under a decade UMS’s have fundamentally changed the way we conduct warfare. Demand for these systems is quickly outpacing our capacity. Additionally, despite the unprecedented capabilities these systems provide, there are still gaps in their ability to operate in the presence of environmental and/or deliberate adversarial actions, operate in bandwidth constrained environments or to provide cost-effective, theater-wide persistent coverage.

SMALL SAT EMERGENCE

Currently there are fewer than 50 Nano/Micro Satellites (small sats) in the DOD inventory. What will this industry look like in a decade? The trends are clear. Fueled by the explosion in consumer applications such as smartphones and tablet computers, electronics

continue to decrease in size and power while increasing in capability. The cubesat community is exploiting these advances and drawing in thousands of participants around the globe, not just industry but universities and amateurs also, each bringing a new way of looking at old problems. The small sizes of payload components are driving spacecraft designers to rethink other spacecraft technologies. The standardization of the cubesat form factor is one such example and innovative composite bus structures are another. Budget pressures are forcing decision makers to look for opportunities to get good-enough performance at much lower cost. And finally we are seeing emerging opportunities for lower cost launch, through rideshares such as the Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adaptor (ESPA) or innovative, small, low cost launcher proposals.

All of these forces pushing towards smaller size and lower cost change the mission design equation radically away from the paradigms that have ruled the space industry for decades. Nano and micro satellites are cheap enough that they can be built to inventory and launched on demand to respond to an immediate crisis, whether military or humanitarian, or as gap fillers. Being low cost, even when you include launch costs, they can be viewed as consumables, comparable to expending a few cruise missiles. This, by the way, removes the pressure to build in extreme reliability which triggers the vicious circle of cost increase. If the satellite or launch fails, it's cheaper just to launch another one. Low cost also changes the rationale for command and control of space assets, making it economically feasible for satellites to be "owned" directly by the warfighter in theater, and not having to compete with other users for access to the resource. Low cost and size also means that large proliferated constellations are practical. Constellations as large as 50 or more can be deployed for well under the price of national systems. This can provide global reach, persistence or very short latencies. A constellation in storage on the ground or in orbit would be a very cost effective insurance policy to protect against loss of national capabilities. And again, because of the low cost, the constellation could be continuously replenished with more advanced designs as the technology and operational experience mature. Small size adds a further benefit of survivability. The satellites are more difficult to detect and their replacement cost will likely be lower than the cost to an adversary of destroying them.

All of these trends suggest that small sats are at a tipping point where they will begin to fill current UMS Intelligence, Surveillance, Reconnaissance (ISR) and communications capability gaps, as well as augment

existing and future manned and unmanned ISR architectures.

MILITARY APPLICATIONS

There are countless military applications both current and emerging that could benefit from small sats. Two of the most urgent and prolific are disadvantaged user support beyond line of sight and Anti Access Area Denial operations.

BLOS Disadvantaged User Support

"In the rugged and remote terrain of Afghanistan, small unit dismounted operations, inserted and extracted by Air Assault and far from the support of combat vehicles are the norm, not the exception. We lack the dismounted Beyond Line of Sight (BLOS) Situational Awareness (SA) capability for soldiers” Operational Needs Statements (ONS) for 101st ABN DIV (AASLT), Situational Awareness capability for Dismounted and Mounted Soldiers⁴

UAS currently conduct BLOS communications relay in support of dismounted, disadvantaged users like the Special Operating Forces (SOF). However, due to bandwidth, coverage, signature and access limitations many disadvantaged users may never get access to reliable, persistent BLOS comms at the tactical edge.

U.S. Special Operations Command (USSOCOM) is tasked with conducting unconventional warfare, foreign internal defense, special reconnaissance and direct actions in support of U.S. national policy objectives. At any given time USSOCOM may have as many as 5,000 soldiers and civilians deployed around the world in more than 50 countries and that number is projected to double in size by 2017.

Demand for Special Operations Forces (SOF) has roughly quadrupled since 9-11 and is expected to continue growing along with the global war on terror. As demand for special operators rise and mission complexity increases, deployed SOF teams will increasingly operate in uncertain, inaccessible lawless areas with insufficient theater-based military or civil communications assets and networks. Our ability to support these forces with UMS communications and ISR is often contingent on complicated international over flight regulations, local logistical support and survivability limitations.

Affordable and agile small sat constellations equipped with software defined radios could soon provide SOCOM and other disadvantaged units with networked architectures providing global secure communications access and greatly extend communications windows and data rates for passing and tracking time-critical

information and fleeting targets. Small sat constellations will enable a disadvantaged unit in the field, under dynamic conditions, to reach out/up/back anytime conditions warrant and provide cost effective, persistent two-way secure communications regardless of geography, political borders, weather or enemy tactics.

Anti-Access Area- Denial

“Prospective adversaries are developing and fielding, or have ready access to, military capabilities that will place US forces operating from large, fixed forward bases, and in the littoral regions, at increasing risk. Consequently, the Pentagon faces new challenges to the operations of air and land forces from overseas bases, as well as how best to structure its maritime forces to operate in the littoral.” Meeting the Anti-Access and Area-Denial Challenge⁵

Put another way, Andrew Krepinevich, a West Point-educated officer and former senior Pentagon strategist describes one of China’s Anti-Access Area-Denial (A2AD) strategies as a powerful combination of traditional but sophisticated air defenses, ballistic and anti-ship missiles, and similar weapons to put at risk nearby U.S. forces and regional bases, together with anti-satellite and cyberwar weapons to disable U.S. reconnaissance and command-and-control (C2) networks.

UAS typically avoid anti-air threats in contested airspace and most often operate from regional bases. Commanders must provide direct support by other systems to employ tactics such as Suppression of Enemy Air Defense (SEAD), or Information Ops (IO) to mitigate this operational UAS risk. These tactics may not be suitable if the commander is conducting peace time operations, providing SA of ongoing adversary exercises, looking for indications of hostile intent, or simply does not have the required in-theater capabilities to execute SEAD missions.

The increasingly congested, contested and competitive space domain is revealing risks to our space based reconnaissance and command-and-control (C2) networks. Proliferation of anti-satellite ASAT weapons and sophisticated jamming systems endanger our ability reliably task National Technical Means in A2AD theaters.

In addition to kinetic threats, other A2AD issues include political borders and environmental conditions such as precipitation, high winds or sand storms that may degrade or even periodically eliminate the employment of both manned and unmanned air assets.

Small sat constellations, either launched on demand or established prior to an event, could provide adequate reconnaissance and C2 gap fillers to mitigate the risks in A2AD environments. Small sats would be survivable in even the most contested air-space, weather would have little effect on them and political boundaries do not yet reach low earth orbit. Additionally, the small sat low signature form factor and low cost make for both a very difficult kinetic/ non-kinetic target and a system-of-systems that can cost-effectively provide graceful degradation and high redundancy through on-orbit spares.

INTEGRATED ARCHITECTURES

The U.S Army Roadmap for UAS 2010-2035¹ describes the concept of manned-unmanned teaming as combining “the inherent strengths of manned platforms with the strengths of UAS, which produce synergy not seen in single platforms.” It goes on to say, “properly designed, Manned Unmanned (MUM) teaming extends sensor coverage in time and space, and provides additional capability to acquire and engage targets.”

With the emergence of small satellites, we see a similar evolution in which space capabilities will be teamed with UAS to produce new synergies. Perhaps more than any other service, the Army has the most to gain from space-unmanned teaming. Air-space integration could directly impact many of the Army’s key UAS strategy areas such as manpower and commonality.

Manpower

Soldiers are the backbone of the Army’s UAS strategy and manpower has always been a key factor for the Army. The Army can purchase more systems; it cannot purchase more soldiers. Air-Space integration could reduce the logistics footprint required to support combat troops in theater. Soldiers who previously focused on flying and maintaining UAS’s will be free to focus on the mission’s combat objectives. Required personnel for UAS force protection, maintenance and operators could be taken out of theater and/or reassigned.

Commonality

Another key area for the Army is commonality. The Army uses a “commonality” and an “open architecture systems” approach as the two fundamental foundations of the UAS strategy. Integrated Process Exploit Disseminate (PED) architectures for UAS’s have been slow to emerge and continue to evolve. Integration of disparate assets has been a challenge and the introduction of satellites to that architecture will be a similar challenge that needs to be addressed. Common ground stations that seamlessly integrate small sat

space, air and ground ISR could reduce the training required to operate multiple ground station types. Soldiers can be trained once and employed anywhere regardless of the ISR architectures supporting the mission. Ground commanders could access constellations, dynamically requesting mission specific ISR and communications via common ground control stations. Constellations of small sats, UAS and UGS could work seamlessly together to provide ground commanders persistent, ubiquitous theater/AOI communications and ISR coverage. To the warfighter on the ground, the source of his ISR data or the path taken by his communications would be transparent.

Challenges

Small sat architectures will not be without challenges as they proliferate into existing and future architectures. Scheduling and adjudication of tasking requests as satellites transition across AORs and possibly between theaters will present special challenges. Integrating the data links used by satellites, which may include direct in-theater downlink or remote ground stations or even store and forward to CONUS, with the existing architecture for UAS will be another technological challenge. Another equally complex issue will be centrally managing the health and operational configuration of satellites while reconciling the need to make the system responsive to a distributed set of users, each wanting to have a virtually dedicated asset.

CONCLUSION

“Inefficiencies are created by duplicative activities carried out for similar functions. The rapid pace of technology change, coupled with the demands of seeking ways to use technology to save both Warfighter and noncombatant lives as soon as possible and the non-robust coordination across current activities/domains has caused some duplication of functions across the domains. This has often kept stakeholders unaware of other’s efforts, thus creating some duplication.” FY2009-2034 Unmanned Systems Integrated Roadmap³

Small sats will change the way services develop, organize, and employ UMS across the full spectrum of operations and will need to be considered when developing the next generation unmanned systems strategy. They will face challenges along the way but as the technological and architectural milestones are met we will see a robust small sat presence in future missions. Small sats will augment or replace insufficient theater-based military or civil communications assets and networks and, as nation states advance their own UAS and counter-UAS capabilities, the services will rely more heavily on the

ISR and communications being supplied by small sats. Small sats will ensure a soldier’s ability to instantly push as well as pull time-critical information both vertically and horizontally in any terrain and across any border.

References

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