Creating and Capturing Value: Next Moves for Northrop Grumman in the Unmanned Aircraft System Domain

Team 10
Kristina Connelly
Luke Cropsey
Michael Johnston

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Northrop Grumman Pegasus Unmanned Combat Air Vehicle (UCAV) Concept Rendering

Picture Source: Northrop Grumman X-47B Web Site.
Introduction

This paper describes the actions that Northrop Grumman should take with respect to the position that it currently holds in the High Altitude, Long Endurance (HALE) unmanned aircraft system (UAS) market segment. The key technological innovation decisions facing Northrop Grumman will be examined in conjunction with the current and expected demand opportunity facing the UAS market overall, and the HALE UAS market in particular. The UAS business ecosystem will then be assessed and a strategy will be recommended for dealing with the critical issues of safety standards, modularity, and value creation and capture. The discussion will conclude with a description of the strategy Northrop Grumman should pursue with respect to positioning itself within the UAS ecosystem to create and capture the maximum value possible.

Technology Innovation: Where to Go from Here?

Northrop Grumman (NG) is at an interesting cross-road in the UAS technology domain. A key question before them is where to spend their valuable internal research and development (IRAD) budget to best position themselves in the intensely competitive aerospace ecosystem. Within the broader scope of the aerospace environment, the immediate context surrounds their UAS product line and the direction they should take technology development efforts. Should NG look to extend its position within the defense aerospace sector by focusing on the unmanned air combat vehicle (UCAV) development effort by the Navy? Or would it be more profitable to drive evolutionary developments by building on the success of the RQ-4 Global Hawk platform and their recent win of the Navy’s Broad Area Maritime Surveillance (BAMS) contract, leveraging their experience with the HALE mission? Alternatively, they could also bolster the efforts of the UAS industry as a whole in expanding the realm of UAS markets by aggressively pursuing and aiding in the development of the appropriate equipage standards to access larger government and civil markets with their technology. These scenarios, depicted in Figure 1, can be categorized generally as new defense aerospace markets (UCAV), consolidation and expansion of existing defense aerospace markets (HALE and MALE), and non-defense or civil markets.
To get to the bottom of these questions, the demand opportunity and the technology evolution and trajectory both need be assessed. First, it is critical that the demand environment be appropriately characterized for each of the three scenarios represented in the three questions raised in the above paragraph. The UCAV market segment is considered to be an area of future growth in the defense aerospace market segment, and one that many believe will ultimately replace the manned bomber mission as the technologies continue to mature. The largest uncertainty with the UCAV development effort is the long-term viability of the program itself. Without getting into the history of the effort, the current situation has pitted NG and Boeing against each other for what is sure to be a long, drawn-out acquisition program with the Navy for a carrier-based UCAV capability that provides long-range, high-endurance, and low observable intelligence, surveillance, and reconnaissance (ISR) capability to the fleet. Current estimates put the expected number of total systems at around the 70 aircraft mark. (1) NG was awarded one of the N-UCAS development contracts for a total of $637M, responding to a Navy RFP worth a total of $1.9B over the next 6-year technology demonstration program. (2) This of course assumes that Congress does not cancel the program altogether between now and then.
The UCAS effort is squarely within the early ferment stage of technological development (3) and NG would need to pursue an aggressive architectural or potentially radical innovation strategy to be successful in this effort against Boeing. (4) In contrast, the technological innovation required for improving on the existing RQ-4 and BAMS product line would shift the focus to an incremental or potentially modular innovation effort (See Figure 2). In addition, the higher degree of maturity in the Global Hawk technology puts the overall effort further along the trajectory evolution path, with the emphasis shifting from providing purely functional capabilities housed in highly integrative designs to a more incremental innovation approach that capitalizes on NG’s apparent dominant design with the RQ-4. (3)

![Diagram](Image)

**Figure 2. Types of Innovation Required with Respect to Various Market Segments.**

With the award of the BAMS contract, this also puts NG in a position to begin a “descent” into the Medium Altitude, Long Endurance (MALE) market segment dominated up to this point by General Atomics with the MQ-1 Predator and MQ-9 Reaper. In contrast to the UCAV market segment, the HALE market segment is currently exclusively dominated by NG, and at least in the immediate future, their position in this segment appears to be safe from any significant threat from one of the other major defense aerospace contractors (assuming that Lockheed Martin’s
The protest of the BAMS contract award is unsuccessful. The biggest question is what the demand opportunity is if NG stays in the HALE niche, even if it tries to expand into the upper end of the MALE segment. The BAMS contract is worth $1.6B over an 89-month contract period to take the program through system design and development (SDD). (5) Total expenditures for the full complement of 68 systems is budgeted for approximately $3B. (6)

The third market segment is the non-defense aerospace sector with an expansion into other governmental markets and beyond that into the commercial arena. This market segment is completely virgin territory and is unlikely to see any major penetration for some time to come. The size of this market is difficult to estimate given the lack of any good analogous information from anything other than the defense aerospace domain. Initial looks into various niches of this broader market suggest orders of magnitude size differential in this segment than those just cited for the defense sector (See Figure 3 for the methodology on understanding UAS markets within the civil airspace structure). For instance, in the small UAS segment, the law enforcement application market potential was estimated at $3.5B, and this represents just a single niche within one segment of UAS applications (NG also has highly successful UAS platforms in the small UAS market segment, including the Hunter and Fire Scout). (7)

![Figure 3. Targeting Civil Airspace Markets for UAS Applications.](image)

Given the access, the civil market potential is easily in the tens of billions of dollars with significant headroom to continue to grow as the technology drives down cost and brings performance up. The major hurdle to market penetration is the lack of FAA UAS type certification standards for commercial UAS use. Without type certification standards, UAS providers are limited to selling UAS platforms to self-certifying, public aircraft operators like the
DoD. Sales of UAS for civil and commercial applications cannot be done legally until the FAA establishes the appropriate type certification standards and then provides the needed certifications to requesting UAS manufacturers. Estimates on the publication of these standards range from 2015 to 2025 depending on the scenario used and assumptions made about the political and national security context within which the FAA operates the national airspace system (NAS). (9)

Clearly, the long-term payoff and market growth potential is within the commercial and civil applications sector. Access to this untouched market space will be an arduous process that will require a significant degree of insight into the broader UAS ecosystem and the value propositions each of the major stakeholders have in bringing this market into play. A bold, well-played move on the part of NG in this arena could pay dividends in the future that would make the UCAV and HALE/MALE defense sectors look insignificant in comparison. The remainder of this report focuses on the issues and strategy NG would need to implement in order to break into the civil market segment and capture significant value for their efforts.

**Building the Ecosystem**

First and foremost, NG must realize that it must take a long-term perspective on the growth potential in this market segment. The work done over the next 5 to 10 years will not show up in positive quarterly earnings statements for some time to come; however, the ground work that is laid for establishing a viable civil UAS ecosystem (10) will provide intangible benefits in the future that will be hard-to-impossible for competitors to match once the market finally opens up.

A key piece to building this ecosystem is to identify the other key players and a transition path out of the current defense sector ecosystem into the new one. The differences in these environments could scarcely be more diverse. In the DoD environment, performance is the name of the game, and a significant amount of budget and schedule will be traded away to get the last ounce of weight, speed, or range out of a design. Safety considerations, while important, take a back seat to mission capability and effectiveness. The civil environment is a different dynamic altogether. In fact, if the defense sector is likened to a heavily forested landscape with plenty of “cover” in which to continue pushing the technology, the civil environment is a veritable desert for the high degree
of exposure it leaves the inhabitant to the scrutiny and judgment of the existing civil airspace players.

The dominant presence on this civil landscape is the FAA. Their role as the regulator of civil airspace puts them in a unique and powerful position with respect to the strategy NG will need to pursue if they are to successfully penetrate this market. In addition to the FAA, the NG plan will also need to address a myriad of other players, including existing civil airspace user lobbying groups like the Air Line Pilots Association (ALPA) and the Aircraft Owners and Pilots Association (AOPA). The dearth of standards will also require active engagement with various standards writing bodies like the RTCA, the federal advisory committee to the FAA on proposed rule changes. NG will even need to build relationships with other UAS manufacturers and equipment providers that may on the surface appear to be direct competitors in this market space. This would include companies like General Atomics, Raytheon, Sierra Vista, and others that may have similar motivations for seeing the civil airspace opened up for commercial UAS use.

The one consistent element in the transition across this landscape from the defense sector to the commercial environment is the DoD. Surprisingly, perhaps, the DoD has a keen interest in seeing UAS flight capable in the NAS (See Figure 4 for historical and projected growth of DoD requests for UAS access to the NAS). This provides a strong alliance and a technology/funding bridge that NG may be able to leverage to their advantage in establishing themselves in this new ecosystem. Having the DoD in the mix is not to be underestimated in considering the challenges associated with trying to build a UAS presence in the civil airspace ecosystem. There is intense competition for resources within this arena (both in terms of air traffic services and access to airspace), and the UAS capability itself is seen by many incumbents as a system that will suck resources out of the system.
In addition, there are a whole host of market niches (See Figure 5) that see the UAS as a potential disruptive technology in their area of application because the UAS may be able to provide comparable or better performance at significantly lower costs. (11) A major component to a successful UAS transplant in the civil ecosystem will be a well-planned, symbiotic relationship with the DoD, and solid alignment with a targeted civil UAS application niche that provides a way to establish a foothold in the broader civil airspace.

Figure 4. Actual and Anticipated Requests by the DoD for UAS Access to the NAS.
The key considerations in light of these factors devolve primarily down two specific lines. The first set of issues deal primarily with how NG relates to the FAA and the DoD in attempting to build out the UAS civil ecosystem. The second pertains to the lateral and downward focused relationships needed with the rest of the ecosystem players for the effort to be successful. As might be imagined, these two arenas are highly coupled, and the constraints in the first set of considerations will drive to a significant degree the strategy that will be recommended in the second. These two sets of considerations can be thought of within the frameworks of creating value versus capturing value. (13)

Value Creation

Value creation occurs across the domains of demand opportunity, business ecosystems and technological infrastructure. (13) The primary consideration for NG in the area of value creation is how to go about delivering what is important to the decision makers holding the keys to civil airspace access for UAS, primarily the FAA. Prior work accomplished in the area of FAA value definition with respect to flying both military and civil UAS in the NAS very clearly established

Figure 5. Potential UAS Applications and Market Niches. (12)
the need for safe operations as the most critical factor in the FAA’s considerations. (14) (15) This value priority with the FAA is depicted in Figure 6.

![Figure 6. FAA Value Delivery and Importance in UAS Operations.](image)

The single largest barrier UAS face to the safety challenge is the ability to “see-and-avoid” other aircraft, as defined in Title 14 Code of Federal Regulations, Chapter 1, Part 91—General Operating and Flight Rules. Essentially, the FAA wants assurance that the UAS will have the ability to comply with this part of the regulations despite no longer having a pair of human eyes and the brain that accompanies it in the aircraft. There are significant technological and legal challenges intertwined in this topic, and both sets of issues must be resolved before the FAA’s value proposition will be sufficiently addressed to warrant opening the civil airspace up to commercial UAS use.
The technological piece required for the sense-and-avoid (SAA) capability is the ability to sense other aircraft on or in the proximity of the UAS flight path, determine the potential for a collision, and then take the appropriate evasive maneuver to ensure that a collision does not occur. This must be accomplished in all flight conditions for which the aircraft is certified, and it must be capable of performing its function even when command and control links may have been lost with the ground station, implying a level of autonomy in the flight control system that has heretofore never been required or tested—at least as flight critical hardware and software. Figure 7 provides the overall structure and considerations that must be addressed in the civil airspace environment.

Figure 7. Overview of Civil UAS Operational Requirements. (16)
The legal issues pertain to the development, implementation and “ownership” of the collision avoidance algorithm by which the UAS will determine which actions to take for the avoidance maneuver described above. Current collision avoidance systems aboard passenger aircraft employ a system that was developed, tested, and mandated by the FAA under Congressionally mandated requirements and at a cost of billions of dollars. These manned aircraft collision avoidance resolution advisories provide simple climb or descend instructions to the pilot who then determines whether the course of action prescribed by the system is appropriate. The FAA owns all of the liability associated with the proper functioning of these algorithms. In the UAS case, no such ownership currently exists, and the FAA has not been funded by Congress to move forward and develop an equivalent set of avoidance algorithms for UAS use.

Fortunately, developing solutions to these two very difficult challenges doesn’t have to be done by NG attempting to “go it alone.” In fact, if done correctly, NG should be able to leverage many of the previously mentioned contracts in place with the defense sector to underwrite significant portions of this work. The Air Force already has several million dollars in contract with NG to begin exploratory work on a true SAA capability for Global Hawk, and it has budgeted upward of $80M over the next four years to attempt a prototype implementation of an SAA system. In addition, the BAMS requirements documents put out by the Navy also includes as a key performance parameter the ability to do integrated airspace operations. Both of these venues give NG a significant leg up on the competition when it comes to a funding stream for sorting through the technology development challenges described above.
In addition, NG has also established strategic research and development efforts with the Air Force Research Laboratory (AFRL) to expand the current flight control algorithms to accept inputs from other feeds into the autopilot routines. An initial set of tests were conducted with the FAA’s participation back in the summer and fall of 2007 which tested the overall performance of an electro-optical sensor package running a proprietary detection algorithm and connected into the flight control algorithms used by Global Hawk. While the results of the testing demonstrated that a significant amount of work remained before this particular SAA architecture would be viable, enough progress was made to convince the Air Force to fund the more significant effort mentioned above. It also provided an opportunity for NG to interface with an SAA sensor provider to begin to understand a number of the processing and size, weight and power (SWaP) requirements for this kind of a system. Perhaps the most important conclusion to come out of this series of tests was the realization that a single sensor type would not be sufficiently robust to meet the FAA’s safety concerns. This pushed the technology pursuits further afield to address multisensory fusion techniques (For an example of this type of sensor suite, see Figure 8).

![Turret Unit and Electronics Unit](image)

**Figure 8. Example Sensor Package-Raytheon MTS-B Multispectral Targeting System. (17)**
Value creation is also possible for the sensor and algorithm subsystem providers. As additional capability is sought for increasing the SAA performance, NG continues to investigate other vendors’ capabilities for potential applications or solutions. Viable alternative technologies in the electro-optical, infrared, and radar arenas are actively being investigated and pursued. The implementation of a successful SAA capability would provide a path for several leading contenders in the sensor subsystem and algorithm processing fields to contribute to advancing UAS platforms into mainstream civil airspace use.

Value creation for NG, then, can be considered as the locus between the demand opportunity represented by the civil UAS airspace market, the on-going work NG is already on contract to perform for both the Air Force and Navy within the military UAS ecosystem, and the technology insights that have resulted from recent R&D efforts with AFRL and several sensor subsystem manufacturers. The final issue is to describe how NG brings that value creation to fruition and captures a significant amount of the profits as the fruit of its labors.

**Value Capture**

Achieving a significant capture of value in this endeavor will require NG to do a number of things that may be well outside of its comfort zone. Essentially, NG must deal with the issues of SAA design and architecture in a way that allows it to balance the competing demands of an integrated vs. modular architecture as it relates to a significant standards development effort. It should be clear from the previous discussion that no one wants to “own” the collision avoidance algorithms as a proprietary standard. In addition, NG needs to be very deliberate about how it creates the SAA architecture. As Christensen et al. indicate, NG needs to stay in the game where significant performance gains are still needed. Christensen makes the following statement with respect to anticipating where the profit is headed:

> “The power to capture attractive profits will shift in the value chain to those activities where the immediate customer is not yet satisfied with the functionality of available products. It is in these stages that complex, interdependent integration occurs—activities that create steeper economies of scale and greater opportunities for differentiation.” (11)
Within the current context, this means NG should focus its attention on those activities within the SAA technology arena that allow it to stay in the middle of the most difficult aspects of the problem—integration.

The implications of the above observations provide a clear path ahead for NG. First, the collision avoidance algorithm should be “open sourced” on the part of NG. They already have a significant position within the military UAS ecosystem with their flight control algorithms and the additional work they have accomplished with AFRL on preliminary collision avoidance algorithm integration. The smartest move they could make would be to offer up their control algorithms to the community as a point of departure for a more robust, community-wide set of algorithms that could eventually be transferred over to the FAA for safe keeping and configuration control. This would also provide them with leverage into the existing standards development organizations like the RTCA who are currently working on implementing SAA standards and are in desperate need of hard data with which to substantiate models and build confidence in various approaches to the problem. Ultimately the implementation of an NG-based algorithm works in their favor given their familiarity with the code and their understanding of the nuances required for stable interface designs.

Open sourcing the flight control algorithm opens additional resources up for NG to use in pursuing those aspects of the value chain they do want to own, primarily the know-how to integrate the entire system in a way that satisfies the FAA’s demand for safety performance. This is an area where the sum of the parts is almost always greater than the whole. The tacit knowledge NG gains in this area as it develops and deploys initial SAA capability on the Global Hawk will be both expensive and timely for other’s to attempt to replicate. This puts them in a position of inimitability and durability with respect to their end-to-end system integration capabilities and provides them with a distinctive competence that few, if any, others will be able to claim. (18) It also gives them potential first-mover advantages in the market, which, when coupled with what will likely be a high degree of tacit knowledge, makes it likely NG will be able to sustain this advantage for a considerable period of time (See Figure 9). The advantage they cultivate in the current “calm waters” market condition of the UAS civil segment, however, will have to be jealously guarded by continuing investments in the appropriate technology as the market opens up and the dynamic shifts to a “technology leads” market place.
Given their history in radar sensors, they may also consider the potential for developing an SAA targeted radar that is specifically designed to address the SWaP and performance needs of the SAA space. Current radar technology has been tuned for significantly greater ranges. There are currently no viable low-SWaP radars capable of doing the SAA mission. This would also meet Christiansen’s recommendation to focus on those areas that are currently lacking the required functionality.

In the end, the success of this approach will depend to a significant degree on how well NG can balance the performance needs of the SAA system with the advantages that a modular approach may provide to the broader ecosystem, and the resulting relationships that it needs to establish with other sensor providers. This should occur in a phased approach that allows NG to pursue fairly tightly integrated systems initially that then migrate to more modular architectures as the technology improves and additional vendors begin to enter the market. Once the FAA finally approves the standards, the gloves will come off and there will be a massive wave of new entrants into the market space at this point. If NG has not already transitioned to a modular approach for significant sensor providers, it will face the very real possibility of losing much of
the market share to faster moving, smaller companies. As a result, NG must establish and build the relationships that will help it preserve its unique market position as the ecosystem leader by providing the motivation and mechanisms by which other subsystem vendors can find niche markets and establish enduring relationships.

The final point to be made with respect to the modularity of the SAA architecture decision is the fact that the FAA evaluation approach will make doing highly integrated SAA systems a much more costly way of attempting development. Without a modular architecture, it will be difficult, if not impossible, to decouple major elements of the system in order to isolate the root cause of a problem. Beyond that, it will require the redesign of the entire system to fix a shortfall or deficiency with the product. A modular approach, while providing upfront performance challenges, provides for a relatively quick and cheap way to “plug-and-play” different components in the architecture should one fail, or another becomes available that is cheaper for does the job faster.

To provide the needed overall direction and strategy to the effort, NG should employ a simple rules strategy that focuses on a couple of critical processes and relies on a set of standard criteria against which to make design and implementation decisions. (20) This approach works well when there is a significant amount of uncertainty in the way in which the environment will develop, and it provides a good match with recommendations for how the FAA and the DoD themselves should consider addressing this issue. (15) By establishing a set of clear guiding criteria for making resource allocations and design decisions, NG will put itself in a place where others will begin using the same set of criteria, fostering a greater degree of unanimity in the approaches and implementation paths taken in the community. By instituting several critical processes with the FAA, DoD and other SAA subsystem providers, NG can stay on top of the coordination and R&D game between interested and concerned parties.

**Recommendations**

To take full advantage of its current position on the HALE UAS defense sector, NG should implement a pioneering approach to tackling the lack of FAA type certification standards. By stepping up to provide a catalyst in the UAS civil market arena, NG has the potential of seeing significant first mover advantages, as previously described. Specifically, NG should carefully
consider the move to putting its algorithm for flight control out in the open source community to help foster transparency and begin the process of building to an industry wide standard. They should leverage their existing work with the DoD to build their core expertise around the end-to-end integration of systems, and pursue the subsystem design for specific sensor technologies where it already has a strong presence, such as that for radars.
Works Cited


