EXECUTIVE SUMMARY

Context

The Global War on Terror (GWOT) shifted the military emphasis from traditional warfare to irregular warfare. Traditional warfare focused primarily on having the force structure needed to destroy the enemy. In the GWOT context, the emphasis is now on finding small, maneuverable, highly asymmetric threats [1, 2]. The result is a rapidly increasing demand for additional Intelligence, Surveillance, and Reconnaissance (ISR) capabilities provided to the Combatant Commander.

Unmanned Aircraft Systems (UAS) provide a significant ISR capability to meet this growing demand [3], providing additional capability at significantly lower cost than would otherwise be expended for additional manned aircraft. This is a significant factor to the Air Force, operating with the oldest flying airframes in its history and attempting to recapitalize its force structure [4]. The impact of these factors is an exponential growth in the numbers of UAS platforms procured over the past 5 years.

The rising numbers and growing importance of UAS missions creates a burgeoning need for UAS airspace that challenges existing DoD restricted airspace capacity. This is increasing the pressure to see UAS more fully integrated into the U.S. national airspace system (NAS) for operations and training from home garrison bases. This further complicates an already dense air traffic picture the Federal Aviation Administration (FAA) is attempting to manage while also ensuring the safety of the airspace.

Several organizations responded to the need to better integrate UAS operations in the NAS. These included an effort by the National Aeronautics and Space Administration (NASA) called Access 5 that incorporated representation from across industry and government; the creation of an UAS Program Office within the FAA; the stand-up of a sense-and-avoid standards body by the FAA federal advisory committee RTCA; the establishment of a Joint Integrated Product Team by the Military Services' UAS program managers; the initiation of an UAS Task Force by the Air Force; and the creation of an unmanned warfare office with an air component under the

Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). All of these efforts engaged at some level on increasing the degree to which UAS operations and training integrate into the NAS, and several of them are on-going initiatives. To date, none of these efforts successfully increased the degree of airspace integration beyond the existing baseline established by the FAA's Certificate of Authorization/Waiver (COA) process.

Purpose and Scope

The purpose of this research is to investigate, develop, and implement a value-focused methodology compatible with the existing DoD Capability-Based Assessment (CBA) process to provide an avenue for assessing the issues associated with defining an UAS airspace integration (AI) enterprise, and the required value delivery needed to move the activity forward within the previously described context. The scope of this research is limited to Level 3-5 UAS flown by the Air Force (i.e. MQ-1, MQ-9, and RQ-4 platforms) at medium to high altitudes. In every other regard, this research addresses the value definitions across the entire spectrum of UAS AI enterprise decision makers (ACC, FAA, and Air Force acquisitions) needed to move UAS AI forward.

Methodology

The methodology implements frameworks from several different disciplines and research. An overarching value-focused approach provides the framework for the analysis, drawing heavily upon work by Keeney [5] and Murman et al. [6]. The unifying approach is the three-phase, value-creation model by Murman et al. The three stages to value-creation are value identification, value proposition, and value delivery.

Value identification focuses on defining the enterprise purpose and the most important stakeholders in the enterprise, called enterprise decision makers. In this research, an enterprise is an integrated entity that efficiently creates value for its multiple stakeholders (e.g. the UAS AI enterprise comprised of the user, the developer, and the regulator acting in concert to restore maneuver). An "extended enterprise" consists of the enterprise under investigation as well as the additional organizations laterally or above the focus enterprise contributing or constraining on-going activities. An example is the Global Strike Task Force (GSTF) extended enterprise composed of not only the UAS AI enterprise, but also other organizations contributing to Global Strike like fighter aircraft enterprises, higher headquarters, and senior leadership). Vertical value alignment between enterprise and extended enterprise is accomplished using a structured enterprise purpose statement framework developed by Crawley [7]. Enterprise stakeholder's are identified and ranked using a modified stakeholder saliency approach described by Grossi [8] and implemented using the decision maker model put forward by Ross [9]. Horizontal value alignment implements a modified X-matrix approach based on the work of Stanke and Nightingale [10].

Value propositions use the enterprise architecting method advanced by Nightingale and Rhodes [11] to generate alternative means of delivering value. This approach is a full-dimensional analysis across eight different aspects of an enterprise with the focus of creating a lean, value-delivering enterprise. Analytical rigor is enforced through the use of QFD analysis and Object Process Methodology first put forward by Dori [12] and modified for system architecting use by Crawley [13]. Alternative architecture evaluations use the Software Engineering Institute's Architecture Tradeoff Analysis Method (ATAM) [14], supplemented with additional criteria from Crawley [7] and Wagenhals et al. [15].

Value delivery is the final stage in the value creation framework. The approach in this thesis implements the Enterprise Transformation Roadmap model described in Nightingale and Srinivasan [16]. The ATAM method provides additional insights into sensitivity and tradeoff points in the architectural design that provide high-leverage activities for architectural change at the enterprise level. Specific, concrete action for a transition plan results through the definition of the desire future state of the enterprise during the value proposition stage and implementation considerations provided by the Enterprise Transformation Roadmap framework.

Application

Data collected from various organizations across the Air Force, DoD, and FAA provided insight into UAS AI enterprise needs and challenges. UAS AI enterprise organizations interviewed included representation from the UAS user community, the UAS acquisition (engineering and budget) community, the relevant policy offices within Headquarters Air Force and the Office of the Secretary of Defense, and the appropriate offices within the FAA operations and safety divisions.

Value identification used the enterprise purpose statement and stakeholder saliency frameworks described in the previous section. Vertical value alignment results from a restatement of the UAS AI enterprise purpose statement to focus on restoring the principle of maneuver to UAS platforms with the stated goal of enabling global strike at the Global Strike Task Force (GSTF) extended enterprise level. The three primary groups of UAS AI enterprise decision makers are ACC, the FAA, and the Air Force acquisition community. The X-matrix provides horizontal value alignment with significant insights on enterprise performance, behavioral characteristics, and metrics. The enterprise value definitions require not only specific performance attributes, but also a defined process in which to deliver those performance attributes (i.e. enterprise behavior).

Three primary alternative enterprise architectures emerged from the value proposition stage. The first architecture focused on process-centric activities, the second architecture on product-centric efforts, and the third architecture combined strong points from the first two architectures. The third architecture proved to provide the best all-around value delivery assessment by integrating the need for a strong criteria-driven governance structure (i.e. a process or rule-based decision method) with the funding benefits that accrue with focusing on specific platform implementations.

The value delivery activity demonstrated a clear need to create a 2-year, budget-driven plan that focuses on time-certain delivery of incremental UAS maneuver gains. The UAS AI enterprise and the GSTF extended enterprise assess the incremental value delivery of the effort. Explicit recommendations detailed in the next section describe specific steps drawn from this research for delivering value.

Consolidated List of Research Findings and Near-Term Recommendations

A list of the “Top 5” research findings and near-term recommended actions resulting from this effort summarizes the hardest hitting results of this research. The research findings provide the context for implementing the near-term “tactical” recommendations that follow.

Research Findings

This summary of the research findings provides a succinct statement of the insights the methodology developed in this thesis provided in the analysis of the UAS AI effort. No ubiquitous claims to validation or extensibility result from this research; however, the methodology did prove useful in the following ways:

1. **The deployed methodology provides a clean interface to the existing DoD Capability-Based Assessment (CBA) process.** The results and implementation recommendations appear to align well with Air Force and DoD organizational structures and responsibilities. In addition, the recognition of CBA as a value-based approach resulted in significant insights and extensions to the current CBA processes based on the broader value-focused literature and theory.
2. **The enterprise purpose framework and the X-matrix analysis yield well aligned value structures both vertically and horizontally across the Global Strike Task Force (GSTF) extended enterprise and the UAS AI enterprise, respectively.** Disconnects between the UAS AI enterprise and the broader GSTF extended enterprise were highlighted. Using the X-matrix to assess the internal UAS AI enterprise provided key insights into needed development of specific attributes and metrics to align disparate decision maker perspectives within the enterprise. The coherency established by the value alignment in both dimensions provided a basis for accomplishing the more detailed analysis for the enterprise architecting effort.
3. **Unarticulated assumptions come to the forefront of the analysis, and several doctrine-to-activity disconnects were highlighted.** The combined insights resulting from the value alignment activities described above, coupled with the more detailed and rigorous analysis using the Object Process Methodology (OPM), served to highlight the interactions that were present (or lacking) between various elements of the enterprise. By requiring a clear articulation of what these interactions actually look like, as opposed to what people often mistakenly took for granted, disconnects between the doctrinal elements related to flying UAS (what was said) could be contrasted with the activities that were actually implemented (what was done). These insights provided a rich source of information for where barriers might exist to moving the UAS AI effort forward.

4. **The need for a consolidated position at the GSTF extended enterprise level on the constraints under which the UAS AI activity should operate surfaced as a major hurdle to creating value.** This insight resulted from the enterprise purpose statement analysis and an assessment of the vertical alignment in the value structure. This information, coupled with the explicit interactions described by the architecture OPM, highlighted the following: the current move to push additional capability onto UAS platforms is occurring without a clear trade having been conducted on the impact those platforms' capabilities bring (or don't) to the global strike capability of the larger Air Force force structure. The research methodology provided clear insights into the need for this discussion at the GSTF extended enterprise level to specify the resource expenditures for restoring maneuver to UAS.
5. **Rigorous implementation of the methodology provides strong and clear linkage between the delivery of the GSTF extended enterprise value definition (i.e. global strike) and the specific, concrete actions the UAS airspace integration enterprise must accomplish to realize the desired level of maneuverability.** The Enterprise Transformation Roadmap provided a robust approach for translating the GSTF Extended enterprise values driving the UAS AI enterprise into a concrete, time-phased roadmap grounded in details and practical implementation considerations. It is through the Enterprise Transformation Roadmap the transition is made from subjective (but needed) expressions of value definitions (i.e. restore maneuver) to concrete, specific, and actionable plans that can be implemented, assessed, and modified to take into account the relative success of a set of activities (i.e. implement joint-led teams).

In summary, the methodology as implemented in this research provides a natural interface to the existing DoD CBA process, yields vertically and horizontally aligned activities, pushes assumptions and interactions to the forefront of the discussion, establishes the strategic issue(s) that must be addressed to flow value, and connects subjective values directly to specific, actionable effort needed to deliver the desired value.

Near-Term Recommendations

With the previous research findings as context, the following "Top 5" describes the near-term, "tactical" activities needed to move the UAS AI activity in the right direction for realizing the desired value of both the UAS AI enterprise (restore maneuver) and the GSTF extended enterprise (enable global strike). The list is in roughly the order of highest-to-lowest priority.

1. **The UAS airspace integration purpose statement must clearly link military capabilities (i.e. global strike), where the principal shortfall is maneuver, and the need to integrate UAS into the airspace.** **S**olutions will be more difficult to resource if there is a perception that UAS airspace integration is the end goal as opposed to enabling the relevant mission area. Unmanned aircraft are national security programs tied directly to projected military capability, and framing the airspace integration issue in the same light is important to elevating the discussion to the appropriate level. A proposed UAS AI purpose statement connecting the desired military capability with airspace integration is provided as follows:

   The purpose of the airspace integration enterprise is to restore the principle of maneuver to operations by integrating UAS into civil airspace using a full spectrum approach of policy, procedures and materiel system equipage while enabling needed UAS training and operational missions and meeting the contextual constraints (political, cultural, organizational, resource, etc) necessary to successfully deliver incrementally meaningful levels of value.

2. **Implement a senior leadership engagement plan to specify the constraints** the Air Force and DoD have on the effort to restore the principle of maneuver to UAS platforms (i.e. Non-Recurring Engineering costs, production numbers, limited or niche mission areas assigned to UAS, the maneuver of the overall force, etc). Elucidating these constraints within the broader context of "enabling global strike" puts a handle on the strategic issues for senior leadership to engage on. Communicating the value of restoring the principle of maneuver will be most effective through an analysis of Air Force capability delivery and the ramifications of current UAS policy and practices on the Air Force's ability to deliver "global strike" to the Combatant Commander. Once the constraints are clearly established, they should be implemented in concert with a "Simple Rules" strategy of a few key processes and a couple of critical criteria (i.e. decision rules or processes—see Recommendation #4) to govern the overall enterprise effort across Air Force, DoD, and FAA decision makers.

3. **The enterprise must produce a resource-constrained approach** providing an incremental product delivery the decision makers within the UAS AI enterprise, and the GSTF extended enterprise will consider worthy of investment, while also meeting the intent of the limitations brought out in Recommendation #2. This means active engagement with all of the enterprise decision makers to ensure the development of a properly scoped, "revolving" two-year plan, providing an increase in value from the end user's perspective (i.e. how has global strike capability increased because of these expenditures of resource?).
4. **The absence of clear end-state, performance objectives requires the establishment of decision criteria and processes to effectively direct UAS AI enterprise activities**. Recommendation #4 expands on the need for enterprise governance decision criteria in the face of unspecified, final objectives or outcomes (the current condition in which UAS AI efforts are operating). Day-to-day activities needed for UAS AI enterprise unity of effort depend on clearly established governance criteria for teams or activities facing unspecified performance objectives or requirements [17]. More complex systems or activities require simpler (and fewer) rules for effective decision-making (see reference [18] for further expansion of this topic). As decisions arise, the only meaningful way to make consistent progress is to have a consensed set of priorities or criteria against which the enterprise has agreed to make resource and materiel related decisions. While seemingly straight forward, this approach is largely absent from past and present efforts.
5. **Limit the number of active decision makers on any one given enterprise effort** to less than 10, and preferably no more than six or seven, by segmenting the scope of activities into specific subsets of the problem the enterprise can work in parallel. Additional analysis shows the rapid decrease in activity effectiveness with an increase in the number of decision makers beyond the prescribed six or seven recommended for this effort [19]. One approach to implementing this recommendation would be to have the Air Force work all of the early operational aspects for the Level 3-5 UAS, have the Army work all of the early operational aspects for the Level 0-2 UAS, and have the Navy work all of the broader systems engineering aspects to the problem. These would be accomplished as largely independent efforts (and consequently involve fewer decision makers), but lessons learned and process related information would be communicated back out at the

full UAS AI enterprise level. This would also allow each service to conduct activities within the constraints established by their respective services while still contributing to the UAS AI enterprise effort.

In summary, implementation of near-term actions include redefining the UAS AI enterprise purpose, engaging senior leadership to clearly specify constraints, initiating a cyclical, 2-year plan to operate under these constraints, establishing the appropriate governance decision criteria, and limiting the total number of decision makers on any one given effort.

Wrap-Up and Future Work

Application of the methodology developed in this research extends beyond the current application of UAS airspace integration to the DoD CBA process itself. A discussion with respect to specific recommendations for implementing a rigorous approach to CBA examines the feasibility of extending the current methodology for use in the CBA process. Additional discussion is devoted to the challenges of creating an executable model of the framework developed in this methodology to extend into early conceptual and detailed product design activities. Emphasis on iterating with the UAS airspace integration enterprise decision makers to validate the value structures developed in this analysis and to provide a sanity check on implementation recommendations is foundational to the approach outlined in this research. This is the next step in putting the results of this analysis to practical use.