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Emerging Patterns in the Global Defense Industry

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by

BGen (Ret.) Raymond E. Franck, Senior Lecturer
Dr. Ira Lewis, Associate Professor
Col (Ret.) David Matthews, Senior Lecturer
Dr. Bernard Udis, Visiting Research Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

Prepared for: Naval Postgraduate School, Monterey, California 93943

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Abstract

We continue our ongoing research into the global defense industrial base—with a view to better understanding its increasingly complex nature. Our aim has been to understand defense industrial developments, place those developments in context, and find explanatory paradigms suitable for better explanation of ongoing trends.

In this report we consider the ongoing travails of the KC-X program, the C-27, and the rise of unmanned aerial combat systems (UAVs, UCAVs, UASs). The KC-X has been an excellent example of the complicated influences that shape the U.S. defense acquisition system—bureaucratic, legalistic, and political. It has also illustrated (to this point) the capability of those influences to impose significant delays on even relatively simple projects. The C-27 is an excellent example of the increasingly globalized nature of aerospace industries—and their complex relationships with defense customers.

The rise of UAVs has been a significant event for military affairs, defense industrial firms, and military organizations. In this report, we discuss UAVs in the context of the ongoing competition between the U.S.and its allies against terrorist-insurgent opponents. We also discuss the organizational issues associated with UAVs—through the Raven UAV and its integration with the U.S. Army's support structure.

Keywords: Global defense industrial base, defense industrial developments, KC-X program, C-27, UAVs, ongoing competition, organizational issues, integration

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About the Authors

Raymond (Chip) Franck, PhD, is a Senior Lecturer, Graduate School of Business & Public Policy, Naval Postgraduate School, retired from the Air Force in 2000 in the grade of Brigadier General after 33 years commissioned service. He served in a number of operational tours as a bomber pilot; staff positions, including the Office of Secretary of Defense and Headquarters, Strategic Air Command; and served as Professor and Head, Department of Economics and Geography at the US Air Force Academy. His institutional responsibilities at NPS have included the interim chairmanship of the newly formed Systems Engineering Department (July 2002 to September 2004), serving as Associate Dean for Academic Operations (December 2007 to present), teaching a variety of economics courses, and serving on a number of committees to revise curricula for both the Management and Systems Engineering disciplines. His research agenda focuses on defense acquisition practices and military innovation.

Raymond (Chip) Franck
Senior Lecturer
Graduate School of Business & Public Policy
Naval Postgraduate School
Monterey, CA 93943
Phone: (831) 656-3614
E-mail: refranck@nps.edu

Ira Lewis, PhD, is Associate Professor of Logistics, Graduate School of Business and Public Policy, Naval Postgraduate School, Monterey, CA. His interests include transportation, public policy, and the international defense industry.

Ira A. Lewis
Associate Professor
Graduate School of Business & Public Policy
Naval Postgraduate School
Monterey, CA 93943
Phone: (831) 656-2464
E-mail: ialewis@nps.edu

David F. Matthews is a Senior Lecturer in the Graduate School of Business and Public Policy at the Naval Postgraduate School and served as a colonel in the U.S. Army (Ret.). He received his BA in 1966 and his MA in 1974. COL Matthews is also a graduate of the U.S. Army Command and General Staff College, the U.S. Army War College, and the Defense Systems Management College. His master's thesis was *Public Opinion and Political Impotence, a Twentieth Century Case Study—The Treaty of Versailles*.

An Ordnance Corps logistician for the first two decades of his career, he served successively in the office of the Deputy Chief of Staff for Logistics, HQ, Department of the Army; as Chief of the Logistics Division, Multiple Launch Rocket System Project Management Office; Commander of the U.S. Army Logistics and Materiel Acquisition organization, assisting in the modernization of the Royal Saudi Land Forces; and finally, as Project Manager, Army Tactical Missile System from 1990-1994. During the latter assignment, he was selected to receive the Secretary of the Army's 1991 Project Manager of the Year Award. In June 2003, December 2004, September 2007, and again in June 2009, he was selected to receive the Meyer Award for Teaching Excellence in Systems Engineering. He has served for the past 16 years as a Senior Lecturer at the Naval Postgraduate School, teaching project management, acquisition logistics, and defense systems acquisition.

David F. Matthews
Senior Lecturer
Graduate School of Business and Public Policy
Monterey, CA 93943
Phone: 831-656-2360
E-mail: dmatthews@nps.edu

Bernard Udis, PhD, is a Professor Emeritus of Economics at the University of Colorado at Boulder and Visiting Research Professor at the US Naval Postgraduate School. He has also served as Distinguished Visiting Professor of Economics at the US Air Force Academy and as a William C. Foster Fellow at the U.S. Arms Control & Disarmament Agency. His NATO research fellowship examined the costs and benefits of offsets in defense trade.

Professor Udis' published work includes three books: *The Economic Consequences of Reduced Military Spending* (editor, 1973), *From Guns to Butter: Technology Organizations and Reduced Military Spending in Western Europe* (1978), and *The Challenge to European Industrial Policy: Impacts of Redirected Military Spending* (1987). In addition, he has published numerous articles in scholarly journals on defense industries and military power. These include "Offsets as Industrial Policy: Lessons From Aerospace" (with Keith Maskus, 1992), and "New Challenges to Arms Export Control: Whither Wassenaar?" (with Ron Smith, 2001). A number of his works are considered classics in defense economics and have been reprinted in collections such as *The Economics of Defence* (2001) and *Arms Trade, Security and Conflict* (2003).

Professor Udis' current research focuses on competition and cooperation in the aerospace industries of the U.S. and the EU.

Bernard Udis
Professor Emeritus, University of Colorado
13 Camino Real
Sandia Park, NM 87047
(505) 286-2789
E-mail: Bernard.Udis@colorado.edu

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I. Introduction

This report continues an ongoing project aimed at a better understanding of the international defense marketplace—a complicated environment that is becoming ever more so. Our intent has been threefold: to understand current defense industrial developments, place those developments in context, and find explanatory paradigms suitable for better explanation of ongoing developments in the international defense industrial base.

Our first report in this series, *Echoes Across the Pond: Understanding EU-US Defense Industrial Relationships* (Franck, Lewis, & Udis, 2008a), considered three current episodes in the transatlantic defense-industrial complex(es). The cases under consideration were the F-35 Joint Strike Fighter (JSF), the UK Defense Industrial Strategy, and the European Aeronautic Defence and Space Company (EADS)-Airbus KC-30 aerial tanker proposal. We also discussed three well-known analytical perspectives as candidates for understanding those cases: offsets in international defense trade, Transaction Cost Economics (TCE), and Corporate Strategy models. In the style of Graham Allison (1977, 1999), we essayed explanations of all of our "cases" using all three paradigms. We assessed the offsets perspective as best for understanding the JSF, TCE for the UK's Defense Industrial Strategy, and corporate strategy models for the EADS-Northrop Grumman KC-30 proposal.

Our second report, "New Patterns of Collaboration and Rivalry in the US and European Defense and Aerospace Industries" (Franck, Lewis, & Udis, 2008b), emphasized defense industrial firms—with consideration of Boeing's Model 787 development and production; the KC-45 (or KC-X) competition (through the Summer of 2008), which involved the EADS-Northrop Grumman alliance and the Boeing Company; and European defense firms' strategies (BAE Systems, EADS, Finmeccanica) for entering the North American defense market through direct investment. Two major themes that emerged were the increasing technical and

managerial complexity in modern aerospace systems, and the increasing power of relatively agile defense suppliers relative to their increasingly bureaucratic customers.

Our third report, “Global Cooperation and Competition in the Defense and Aerospace Industries” (Franck, Lewis, Udis, 2010), continued inquiries along the same general lines of this overall project. We continued our exploration of the international defense industrial “terrain,” and our search for useful paradigms. The KC-X competition (third installment) considered the explanatory power of two views of the defense establishment customers in the defense marketplace: the traditional model of the sovereign monopsonist, vs. the Governmental Politics perspective (Model III) offered by Graham Allison (1977, 1999). We considered the remarkable travails of the A-400M military transport development effort—which came in very late and much over budget. (There are also likely some performance problems lurking.) The A-400M (military) was a useful companion piece with our previous Boeing 787 (commercial). Both cases illustrate the increasing complexity of large, international development projects—and the problems that can emerge. A potentially significant change in the structure of the international defense marketplace is the possibly - emerging Nordic defense bloc. In this instance, we found a rather complex story—with significant attractions to the other Nordic states, but also close and useful relationships with partners outside of the Nordic region (especially the United States).

In this report, we discuss three topics with the same aims as above. First is the latest chapter of the KC-X story. Our concern is primarily keeping a continuous track on the remarkable set of events leading (or not) to an aerial tanker replacement for the KC-135.

This is clearly not a case of delays due to technological immaturity. The KC-X—whether based on Boeing or Airbus designs—is well known, with tanker conversions of the A330 (or A310) and B767 already operational in other air forces. Wikipedia articles on the Boeing KC767 (2010), A310 MRTT (2010), A330 MRTT

(2010) summarize nicely the essentials of these systems' characteristics and their histories. The KC-X case illustrates well the bureaucratic, legal, and political obstacles to acquisition in the United States—and their potential to sidetrack the acquisition process.

Second is the C-27 transport—an Italian design in wide use worldwide. The C-27 is a good example of increasingly international projects in the aerospace industry and the sometimes complicated relationships between aerospace enterprises and their defense customers.

We have devoted a great deal of attention to our third topic, Unmanned Air Vehicles (UAVs). We take on a range of aerial vehicles developed for reconnaissance, or both reconnaissance and strike. We also attempt to place the rapid growth of UAVs in the U.S. inventory in context; we believe this is a major development both in military affairs and also in the defense industrial base. Unmanned vehicles are a remarkable development within the two ongoing Revolutions in Military Affairs (RMAs). Within that context, UAVs are an important continuation of the reconnaissance-strike embodiment of the Information Technology (IT)-enabled RMA first demonstrated in the Gulf War of 1991.

Broadly speaking, UAVs have been a useful counter to the ongoing RMA associated with Al Qaeda, the Taliban, and other terrorist-insurgent movements. Among other things, UAVs, with their longer endurance, provide a better approximation to continuous battlefield presence. This leads to a number of useful military capabilities—which we discuss further in this report.

The effect on the international defense marketplace has, quite possibly, been even more profound. The relative simplicity and cheapness of UAVs means that these systems can be developed with company resources outside the "normal" defense acquisition system, with its highly complex and potentially burdensome processes. A closely related point is that defense systems in this realm are open to a much wider range of suppliers than the highly complicated and expensive aerospace systems—such as fifth-generation fighters. In fact, a large number of

enterprises have been able to finance UAV development projects with their own funds (beyond the defense giants such as Boeing and Lockheed-Martin). Countries with high technology and small size, such as Israel, are world leaders in unmanned systems (as discussed in some detail in Chapter IV,B).

Specifically, we consider the case of the UAV market through perspectives offered by a number of the leading suppliers, whose representatives have chosen to remain anonymous. We also consider the Raven—a small tactical UAV developed by the US Army for use by lower-echelon combat units. Our focus is first on the unorthodox methods used to develop and field this particular UAV, but also on how the Raven was integrated into the Army's "system" for continuous support.

II. The Ongoing KC-X Drama

A. Introduction

We've dealt with this particular issue much longer than anticipated, originally expecting to wrap up the topic of KC-X source selection some time in 2008 following a contract award in February of that year. However, Boeing successfully appealed the award to the KC-30 proposal—with the GAO recommending a rerun of the source selection process. An attempt to do that quickly in 2008 fell apart—due, among other things, to Boeing's threat not to respond to the revised Request for Proposal (RfP).

And the story has continued with the next KC-X source selection decision scheduled for the Fall of 2010, which has come and gone. Our purpose in this report is to continue a useful narrative of this affair, with a view to providing a more comprehensive assessment at some future time that combines the research in our first four reports (including this one), and probably some of our future reports.

Although aerial tankers are not terribly glamorous, they are very important. And this particular case provides interesting perspectives—most of them negative—on the U.S. defense acquisition system. In fact, this particular program should have been very simple. Both candidate aircraft (the Boeing KC-767 and the Airbus KC-30) are very mature technically. In fact, both are proven concepts (or mostly proven) with variants of both aircraft types having been developed for a number of customers, including Japan and Italy for the KC-767, and the UK and Australia for the KC-30. Despite that, the source selection process has drug out over one full decade in its various incarnations. The KC-X story nicely highlights many shortcomings of the U.S. source selection system and hopefully will, at the end of the day, suggest ways to improve it.

B. Third Attempt: Overview of the Current KC-X Competition[1]

Following the termination of the buy-and-lease proposal for KC-767s in 2003, the successful protest of the KC-45 contract award to the KC-30 in 2008, and the aborted re-competition of 2008, the third (perhaps fourth) chapter of the dismal KC-X saga opened in 2009. On 16 September 2009Secretary of Defense, Robert Gates, announced a new effort to replace the KC-135 aerial tanker fleet (Amani, 2009).

On 25 September 2009, the Air Force published a draft Request for Proposal (RfP), which included a fixed-price contract award for 179 aircraft with a heavy emphasis on cost (U.S. Air Force, 2009). With the number of aircraft (but not total capability) fixed, the announced emphasis on cost seemed initially to strongly favor the smaller Boeing KC-767 over the EADS-Northrop Grumman KC-330. Accordingly, the EADS-Northrop Grumman team made multiple threats to withdraw from the competition (as related, e.g., in Tiron, 2009, 1 December). These statements had little substantive effect on the final RfP that was issued on 25 February 2010. (Gertler, 2010, 14 May, esp. pp. 6–7).

The RfP included a large number of requirements (*key performance parameters*) in the following areas:

(1) aerial refueling of all current and programmed fixed-wing receiver aircraft including same-sortie boom and drogue capability;

(2) fuel offload capability at least as good as the KC-135R;

(3) ability to operate globally;

(4) significant airlift capability;

(5) tanker receiver air refueling capability;

(6) crew protection for operations in chemical and biological environments;

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[1] Franck, Lewis & Udis (2008a, 2008b, 2010) taken together provide a fairly complete narrative of the KC-X affair. Also, Wikipedia KC-X (2010), updated 13 August, contains an accurate, well-written, and reasonably brief summary.

(7) interoperability for network centric operations;

(8) various defense and survivability features; and

(9) simultaneous, multi-point drogue refueling capability (U.S. Air Force, 2010, 25 February).

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An Air Force-Department of Defense (DoD) briefing explained the RfP of February 2010 and the selection process (Lynn, Carter, & Donelly, 2010; see Figure 1). The first stage in the selection process is a screen for 373 "mandatory requirements" (scored as pass/fail). The second is a calculation of "total proposed price," to include a transitional five years of contractor support of the system. Third is an adjustment for system effectiveness, fuel costs, and military construction costs, resulting in a *Total Adjusted Price (*TAP). If the TAPs are within 1%, then 93 non-mandatory (i.e., desirable attributes) are evaluated, including above-required fuel offload capability.

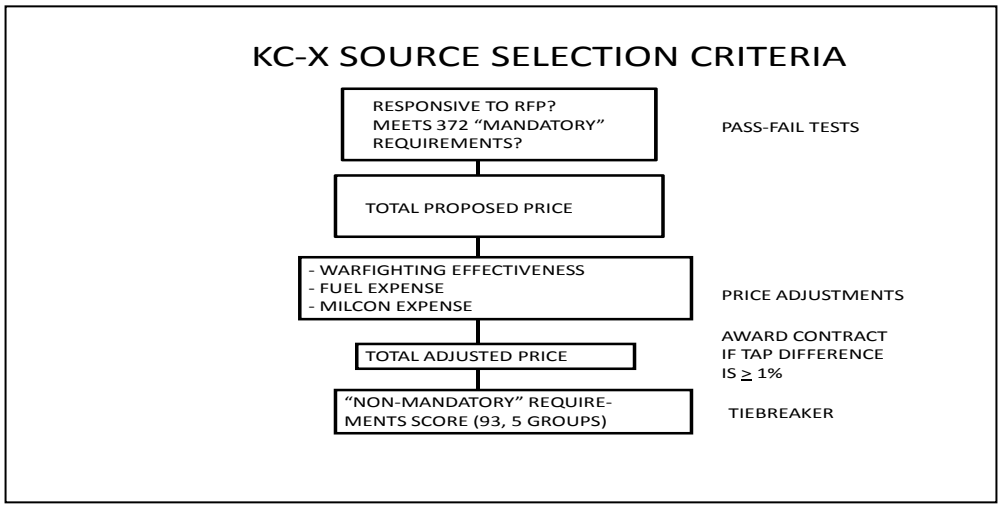

Figure 1. Summary of KC-X Source Selection Criteria
(adapted from Lynn et. al., February 2010)

Continuing in the spirit of Allison's Model III (Franck, et al., 2010), the rest of this section is organized around the decisions of the relevant "players": the World

Trade Organization (WTO), Northrop-Grumman, EADS, Boeing, third bidders—United Aircraft (maybe), and U.S. Aerospace-Antonov.

C. World Trade Organization (WTO) Litigation

The issue of subsidies for both Airbus and Boeing has been a matter of charges, counter-charges, and intermittent attempts at settlement. In 2004, the Airbus (and EADS) consortium was the subject of a complaint alleging improper subsidies being an integral part of the Airbus consortium in the category of Trade in Large Civil Aircraft. After a prolonged process, the WTO reported its findings and conclusions in 2010 (World Trade Organization [WTO], 2010d, 16 August).

The WTO concluded that various policies of EU member states were specific subsidies prohibited by international trade agreements. They took the form of (a) launch aid, (b) infrastructure grants and provisions, (c) various transfers of ownership interests, (d) equity infusions, and (e) research and development funding. The report also concluded that the U.S. complaint had established the subsidies in question displaced goods provided by U.S. suppliers (primarily Boeing) throughout the world. The report recommended prompt action to "remove the adverse affects or … withdraw the subsidy" (WTO, 2010a, 30 June, pp. 1049-1053).

However, that report specifically avoided any suggestions for steps to implement the recommendations—citing no requirement to do so, nor any request from the United States (WTO, 2010a, p. 1053). The EU appealed the determinations made in the DS316 report on 21July 2010 (WTO, 2010d, 16 August).

The U.S. was likewise the subject of a complaint filed in 2005. Using a similar process to the complaint against the EU, the WTO was originally expected to complete its work in July 2008. At that time, the Chairman of the Panel convened to settle this dispute revised the completion estimate to 2009. In December of 2009, the completion date was revised to June 2010. The estimate for publishing the interim report was again revised to September of 2010, with completion in early 2011 (WTO, 2010c).

The European Union (EU) deplored the timing of the DS316 Report—given that the results of the investigation of complaints against the U.S. had been delayed. The EU has been found to have offered prohibited subsidies to the Airbus consortium (including the A330), but nothing was expected to be released concerning Boeing until after the due date for responses to the KC-X RfP.

An interim WTO report[2] on the complaint against the U.S. similarly found prohibited subsidies to Boeing. Some observers (e.g., Drew, 2010b) have concluded that the two reports neutralized each other—leaving no clear advantage for either Boeing or Airbus; however, that is far from a consensus opinion. Boeing spokespersons and supporters have stated that the WTO findings regarding Airbus violations were far more significant than those against Boeing (Miller & Michaels, 2010). Also, Senator Patty Murray, a Democrat from Washington State, reintroduced legislation to take those improper EU subsidies into account as a KC-X source selection criterion (Tiron, 2010). Additionally, there are reports that Senator Murray's position played well politically back in Washington State (Blumenthal, 2010).

The implications of the WTO disputes are interesting, but not yet fully resolved. With both Airbus and Boeing found to be recipients of improper subsidies, the current state of public discussion is one of the relative degree of subsidies received by Boeing and Airbus (Wall & Kingsley-Jones, 2010). As noted, Boeing was at some pains to pronounce itself at an unjust disadvantage in the KC-X competition, and Boeing's congressional supporters introduced legislation requiring that the Airbus subsidies be used in evaluating the cost of the KC-30.

[2] Report published on 15 September, but distributed to only a few parties initially (Miller & Michaels, 2010). We have access only to press accounts available at the time of our report.

D. The Industrial Players

1. Northrop Grumman (NG)

Quite possibly reflecting a new strategy from its new CEO (Wes Bush), Northrop Grumman (NG) reacted negatively to the draft KC-45 Request for Proposal. Bush's mandate was reported to be profitability—especially relative to peer firms (major defense enterprises; Ratnam, 2010). Both NG and its European Aeronautic Defence and Space Company (EADS) partner publicly disparaged the proposal as not providing for any significant technical improvement relative to the existing KC-135R (Clark, 2010). Simply recapitalizing the KC-135 fleet would, in all likelihood, tilt the competition toward Boeing's smaller, older design KC767. In that context, continuing to participate in the KC-X competition arguably involved throwing good money after bad.

Despite NG-EADS objections, the Air Force stuck fairly close to its original specifications in the Request for Proposal (RfP) published on 24 February 2010. Boeing supporters in Congress responded positively to the RfP (briefed to Congress that same day), while EADS-NG supporters were decidedly negative. According to press reports, Boeing supporters such as Representative Tiahrt, a Republican from Kansas, praised the RfP for "rejecting the narrow interests of a foreign company," while wishing to also penalize subsidies for the A330 project. Senator Sessions, a Republican from Alabama, stated that "the final RfP discredits the integrity of the entire process" (Matthews, 2010).

On 8 March, not long after the RfP's publishing, Northrop Grumman announced it would not continue in the KC-X competition—apparently leaving the Boeing KC767 as the sole prospective bidder. Being "very disappointed" with terms that "dramatically favor" the expected Boeing proposal, CEO Bush announced NG's withdrawal (Hennigan, 2010; Northrop Grumman, 2010). This decision left Northrop Grumman without a major manned aircraft system in its product line (Sanders, 2010).

At the time, it appeared that the entire NG-EADS team was dropping out of the competition. As reported in the press, EADS North America's Chairman, Ralph D. Crosby, Jr. stated, "As a team, our serious concerns were expressed to the Department of Defense and the U.S. Air Force that the acquisition methodology … would heavily weight the competition in favor of the smaller, less capable Boeing tanker" (EADS-North America , 2010a; Sanders, 2010). EADS Chairman, Louis Gallois, concurred, "We will not compete because the RfP is based on the smaller, less capable airplane. This is giving a huge advantage to the 767" (Tran, 2010). Despite the criticisms and withdrawals, the Air Force reaffirmed its commitment to the RfP terms as stated (Reed, 2010a).

2. European Aeronautic Defence and Space Company (EADS)

Even though EADS originally joined NG in dropping out of the KC-X competition, the Europeans had second thoughts rather quickly. By early April, news sources reported that EADS was courting American partners for a KC-X bid, with L-3 receiving prominent mention. At the same time, EADS requested a 90-day extension for responses to the Air Force RfP. The Air Force agreed to a 60-day extension (from 10 May 10 to 9 July; Reed, 2010b; Butler, 2010a).

Later in April, EADS publicly and confidently touted the KC-30's strengths and EADS' ability to compete without a North American partner (EADS North America, 2010b; Reed, 2010c). Among the advantages cited for the KC-30 proposal was a more mature design, already flying as part of the A330 Multi-Role Tanker Transport (MRTT) program—which was touted as having a high degree of commonality with EADS' planned KC-X proposal. (Butler, 2010a; Michaels, 2010). EADS also announced its intention to assemble tankers in the United States (Mobile, AL), as well as A330 freighters (Butler, 2010a; Talbot, 2010).

As promised, EADS did submit its KC-X proposal (with 8800 pages) on 8 July 2010. Timing for the A330 proposal was somewhat unfortunate, given the WTO's final decision finding that EADS had significantly benefited from large-scale

subsidies from European governments (Drew, 2010a). Nonetheless, EADS officially opened its Mobile office on 12 July (Douglas, 2010).

3. Boeing

Boeing's role in this latest competition has been untroubled so far—relatively speaking. Although there was some speculation and reports regarding multiple responses to the RfP (generally including a Boeing 777 variant), Boeing settled on a KC-767 variant—but not the KC-767 version developed for Italy and Japan. New features reported were structural enhancements, a digital cockpit (based on 787 designs), larger wings, and a newly designed refueling boom (Butler, 2010).

However, Boeing apparently also had second thoughts. Boeing's executive team was reported to be considering not bidding according to an anonymous company source. The issues aired in public were Airbus subsidies and the fixed-price nature of the Air Force RfP. Regarding the subsidies, the Boeing source was quoted as follows:

> It gets difficult when you're dealing with a competitor who has flat-out said on several occasions that they're going to underbid us. How can they do that if the list price of their plane is higher than the list on our plane? Because they are subsidized and we're a for-profit company, so the question we're asking is: How do we compete against four governments? (Muradian & Reed, 2010, 16 May)

Second, there was reported to be some concern that even a winning bid would not be profitable: "Your heart says you have to be part of it, but a CEO's job is to make sure that the heart doesn't make a decision the head can't live with" (Muradian & Reed, 2010, 16 May). Airing the no-bid debate might well have been motivated by a desire to have A330 subsidies factored into the source selection criteria. Indeed, legislation to that effect was introduced in Congress by Boeing supporters—with the sum of $5 million per airplane being mentioned (Muradian,

2010, 16 May). Also, a Boeing executive spoke publicly in favor of such legislation (Agence France Presse [AFP], 2010a, 4 June).

In the end, Boeing submitted a bid on the due date of 9July 2010—with a *NewGen* tanker based on its 767 aircraft (Scully, 2010, 9 July). Boeing also announced it was revamping its 767 production line in order to cut costs and accommodate planned 787 production (Drew, 2010a, 9 July).

4. Other Bidders

Given the prolonged nature of the competition, and given that Airbus and Boeing are not really the only enterprises capable of producing large transport aircraft, it was inevitable (at least in retrospect) that other parties would at least consider joining. However, the sequence of events that accompanied these players is as unusual as the rest of the KC-X story.

United Aircraft Corporation (UAC, Russia) was reported to be interested in submitting a bid—as publicly announced by U.S. attorney John Kirkland. The substance of the announcement was that the UAC would form a joint venture with an unnamed U.S. defense contractor for the purpose of offering an Il-96 (Iluyshin wide-body transport) variant as a candidate for the KC-X. This report quickly became a matter of some controversy, as the UAC denied any connection with Kirkland and stated that any documents purported to support Kirkland's statements were fakes. (Ria Novisti, 2010, 23 March). Regardless of the underlying facts in the matter, the UAC candidacy (real or not) has faded completely from the scene.[3]

Late in the RfP response process, a third bidder publicly materialized in the form of the Antonov Aircraft—a Ukrainian enterprise partnered with U.S. Aerospace

[3] While this supports no particular conclusion, itis interesting that Kirkland's firm website (luce.com) contained no mention of this incident when it was accessed in August of 2010. Some particulars on John C. Kirkland, Esq., are available at Lawyers.com. It is interesting to note that Mr. Kirkland also provided representation for the U.S. Aerospace-Antonov bid, which did materialize.

(a small corporation based in California).[4] The basic aircraft model proposed was reported as perhaps the AN-124-KC—a very large four-engine transport, or the AN-122-KC—based on a two-engine version of the AN-124 ("AN-124," 2010). Also discussed was the AN-112-KC, a variant of the Antonov AN-12.[5] Some reports indicated that all three aircraft would be in the final proposal (Shalal-Esa, 2010a, 2 July). However, the proposal submitted involved only the AN-112-KC.

U.S. Aerospace CEO, Chuck Arnold, explained that the AN-112-KC was the aircraft entered into the KC-X competition—with the AN-122 and -124 variants intended for later tanker competitions (generally referred to as the KC-Y and KC-Z[6]; Trimble, 2010, 2 July). The strategic cooperation agreement between U.S. Aerospace and Antonov was specifically limited to seeking contracts with the U.S. DoD, dissolving within five years if no contracts are forthcoming (AFP, 2010b, July 2). Basic airframe assembly would take place in the Ukraine, with final assembly in the United States. According to press reports, both parties were to individually bear their own costs (Bennett, 2010a, 2 July).

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[4] The *New York Times* reference resource provides the following general description of the company (based on SEC filings): *U.S. Aerospace, Inc., formerly New Century Companies, Inc. is engaged in the production of aircraft assemblies, structural components, and highly engineered, precision machined details for the United States Department of Defense, United States Air Force, Lockheed Martin Corporation, The Boeing Company, L-3 Communications Holdings, Inc., the Middle River Aircraft Systems subsidiary of General Electric Company, and other aircraft manufacturers, aerospace companies, and defense contractors. The Company supplies structural aircraft parts for military aircraft, such as the P-3 Orion, and wide-body commercial airliners, such as the Boeing747. The Company operates through its wholly owned subsidiaries, Precision Aerostructures, Inc. (PAI) and New Century Remanufacturing, Inc. (NCR).*
Its market capitalization as of August 10, 2010 was $3.5 million. (New York Times, accessed 10 August 2010)

[5] The AN-12 is roughly equivalent to the US C-130. Both have straight wings, four turboprop engines, payloads of about 20 tons, and full-payload ranges around 2000 nautical miles ("AN-12," 2010; "C-130," 2010). The AN-112 was touted as a "swept-wing, jet-powered" version of the AN-12, but larger based on claimed wing span of 166 feet (Trimble, 2010, 2 July). U.S. Aerospace CEO Chuck Arnold calls the AN-112 a AN-12 variant "not quite that, but close to that" (Trimble, 2010, 2 July). After submitting the bid, the AN-112 was announced as an AN-70 variant (which resembles the A400M) ("AN-70," 2010; "A-400 M," 2010).

[6] The Air Force aerial tanker recapitalization plan includes three hypothesized models (KC-X,-Y, and –Z). These are discussed, for example, in Knight (2008). Knight, William, et. al. (28 February).

Nonetheless, there is no reason to believe that the AN-112-KC proposal is based on anything more than a proverbial paper airplane. Moreover, there is no particular reason to have confidence in U.S. Aerospace's capacity to conduct its part of the competition—or in its ability to attract the necessary resources (Bennett, 2010b, July 8).

Despite a rather hectic preparation schedule, a U.S. Aerospace-Antonov proposal was delivered to the Air Force on 9 July (the due date). After some difficulties in delivering the documents, the proposal itself was reported to have been time stamped at 1405 ET—five minutes after the suspense. As a result, the Air Force chose not to consider the AN-112-KC proposal. U.S. Aerospace protested this decision to the Government Accountability Office (GAO; Butler, 2010c, August 5).

The Air Force requested expedited handling of the complaint. On 17 September 2010, the GAO found "insufficient support" for the allegation that the Air Force may have intentionally delayed the delivery of the proposal. U.S. Aerospace specifically kept open the possibility of taking the case on to federal court (Shalal-Esa & Jacobs, 2010b, 17 September). However, it seems very likely at this writing that U.S. Aerospace will not pursue the matter further.

E. Remarks

Does anyone seriously doubt (at least in hindsight) that committing to the acquisition of 100 KC-767s early in the past decade would have served the national interest better than the current history of this sad affair? The new tankers would have permitted retirement of all of the KC-135Es and a fair number of KC-135Rs.[7] Retirement of reasonably well chosen KC-135 airframes would have done much to

[7] A good first-order estimate is that the presence of 100 KC-767s would have permitted retirement of all the less modern E models, and about 55 R models. This would leave about 360 KC-135Rs still to be recapitalized.

lessen the supportability problems the Air Force is now experiencing.[8] The KC-767 would have nicely filled the role of the KC-X, with a KC-Y competition between Boeing and Airbus proposals to follow.

As noted above, our original interest in the KC-X competition was couched in terms of EADS' corporate strategy for entering the North American defense market (Franck, et al., 2008a). We then expected to study the competition between Boeing and EADS (with a source selection decision in early 2008). What actually followed was a series of events of great interest to defense acquisition research, but which clearly damaged the national interest. Boeing protested the February 2008 selection of the KC-30 proposal—which was sustained in June of that year. An accelerated recompetition was abandoned—due, in our opinion, to election-year concerns and Boeing's threat to withdraw from the competition (Franck, et al., 2008b). In our 2008b report, we offered the "quarrelsome committee" characterization of the U.S. Government in the KC-X selection process. In our 2010 report, we offered Graham Allison's Model III as having superior explanatory qualities to the well-known sovereign monopsonist model in standard economic theory (Franck, et al., 2010).

What has emerged appears to be the convergence of multiple dysfunctionalities in the U.S. defense procurement system—which resonates with one of our fundamental concerns with that system; namely, that defense acquisition processes have become hyper-bureaucratized, hyper-legalized, and hyper-politicized, and that these characteristics have caused a growing disconnect between our methods of equipping the troops and the hyper-adaptive combat environment in which they must operate.

Purchasing the KC-X is motivated by the need to recapitalize the aerial refueling fleet using highly mature technologies. That means that the well-worn explanation of technical immaturity is simply not relevant here. Yet the process has

[8] The note just above indicates that about 30% (155/515) of the KC-135 airframes could have been retired. If the least supportable airplanes were in fact retired, more than 30% of the supportability problems would go away.

dragged on—seemingly interminably. The original lease-with-buy decision for Boeing KC-767s was completely derailed by discovery of ethical improprieties, which delayed selection for about four years (until February of 2008). The successful contract award protest of 2008 has delayed the KC-X program by almost three years (until 2011—and perhaps longer).

The litigation of acquisition protests (through a number of channels including the GAO and the federal court system) has provided yet another means of delaying the KC-X acquisition. The effects of the 2008 Boeing protest speak for themselves, and the current U.S. Aerospace protest is still in play.

The political system has been fully engaged—with two significant Congressional blocs contending over the KC-X source selection. Not surprisingly, these are divided along economic geography (which states stand to gain jobs) rather than political parties.

F. Wild Cards Remaining

To our knowledge, there are at least three wild cards remaining in this particular deck. If any of the events below come to pass, the KC-X selection process might well experience yet another significant delay.

U.S. Aerospace protest. The press reports of the circumstances surrounding the Air Force rejection of the U.S. Aerospace-Antonov proposal—which seems to have been 5 minutes late as a result of delays due both to U.S. Aerospace's lack of familiarity with the rituals associated with submitting a major bid, and bad directions supplied by Air Force officials (albeit unintentionally) at Wright-Patterson AFB. Given the circumstances, there was a reasonable chance that the GAO would find in favor of the protest. However, though the GAO opinion of 6 October 2010 went against the protest, there is also the possibility of the case continuing to the federal

courts.[9] In the now unlikely event that the case goes on and the GAO ruling is reversed, this would probably mean yet another significant delay in the source selection process.

WTO interim report on Boeing. The WTO released its interim report regarding the EU complaint on September 15. Boeing was found to have received improper subsidies, which leaves the interested parties free to quarrel over degrees of transgression. If a sufficient number of policy makers believe (or want to believe) that Boeing's subsidies were much smaller in size and much lesser in effect than Airbus', there will almost certainly be renewed Congressional pressure to dictate an adjustment to the EADS KC-30 proposal's price to reflect the effect of the Airbus subsidies. If there is a legislative requirement to modify the selection process accordingly, then the competition process will have to be modified to accommodate this additional factor. It appears that the subsidy effect could be readily included as yet another price adjustment. (As Figure 1 above shows, the current adjustments involve refueling effectiveness, fuel costs, and military construction requirements.) However, a major revision to the selection criterion would probably entail an amended RfP; that is, there is yet another possibility for delay.

Politics. The Republicans emerged from the November 2010 elections as the majority party in the House, and as a significantly stronger minority in the Senate. Congressional power will likely shift toward members such Senator Richard Shelby, a Republican from Alabama—who has repeatedly and publicly impugned the integrity of the current source selection process as favoring Boeing (Matthews, 2010, 24 February; Shalal-Esa, 2010c, 20 September). While Republican Members of Congress can be found in both the Boeing and Airbus camps, it's likely that the KC-30 supporters will find a stronger voice—which might well revive the chances for a Congressional mandate for a dual buy.[10] Because Secretary Gates has been

[9] Recent statements by U.S. Aerospace indicate this option will likely not be pursued (U.S. Aerospace News, 2010, October 6).

[10] As indicated in our previous reports, we would certainly not consider this a bad outcome.

especially careful, or sufficiently rash, to stake his reputation on a winner-take-all KC-X competition, there is again a real possibility of more delays in the process. If the affair drags on sufficiently, there might well be a delay into 2013—motivated by a combination of deadlocked source selection coupled with an impending Presidential election just as happened in 2008. Dunlop (2010, 3 August) discussed some interesting possibilities along these lines.

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III. C-27 and Globalization of the Aerospace Industry

The C-27J Spartan is manufactured by the Alenia subsidiary of the Italian defense firm Finmeccanica. The twin-turboprop multi-purpose transport aircraft is currently being delivered to the U.S. Department of Defense (DOD) through a partnership with the U.S. prime contractor, L-3 Communications. Acquisition of the Spartan represents a return to the DoD inventory of fixed-wing, tactical aircraft in support of Army missions, as well as a smaller version of the Lockheed Martin (LM) C-130J Super Hercules. The Spartan and Super Hercules (C-130J) share important features, including engines, avionics, and flight controls, which will have a favorable impact on support costs due to commonality ("Alenia C-27J Spartan," 2009).

To begin our discussion of the Spartan, we return to the Vietnam War period and examine the Army's approach to the provision of tactical airlift. We then discuss the Italian defense industry and the factors behind the success of the C-27J and its predecessor, the Fiat (later Alenia) G.222. After discussing the details of the current acquisition of the C-27J by the DoD, we briefly review the purchase and modification of G.222s by the U.S. for eventual service in the Afghan military.

A. Changing U.S. Army Doctrine on Tactical Airlift

During the Vietnam War, U.S. Army doctrine on tactical mobility shifted away from a combination of helicopters and fixed-wing aircraft toward almost exclusive use of helicopters. This change was codified in the 1966 Johnson-McConnell agreement, which transferred Army fixed-wing assets, notably the DeHavilland C-7 Caribou and the larger Fairchild C-123 Provider, to the United States Air Force (USAF). In turn, USAF helicopter use was to be limited to Combat Search and Rescue as well as special operations. Intra-theater transport of troops and equipment that had been traditionally performed by the Caribou could be taken on by Army helicopters, notably the CH-47 Chinook. Where fixed-wing aircraft were required, they would be provided by the USAF (Bowers, 1983, pp. 673–674).

Bowers (1983) explained the effects of the Johnson-McConnell agreement as follows:

> The agreement was not warmly received by either service. Many Army officers felt that the Army had traded a real and valuable capability (the Caribous) for “empty guarantees of the status quo in helicopters”. For its part, the Air Force was now responsible for manning and funding an aircraft that it had long opposed in return for renouncing rotary winged aircraft. Should technological progress ever favor such aircraft, then the Air Force would be in serious trouble. In the short term, the agreement ushered in an era of “lukewarm cooperation” between the two services, and relief for the Army's critical pilot shortage; but the implications stretched far into the future. Once the war in Vietnam ended, the Air Force soon transferred all the C-7s and C-123s to the Air National Guard and Air Force Reserve. (p. 238)

The implications of the Johnson-McConnell Agreement began to be felt after the attacks of September 11, 2001. During Operations Enduring Freedom and Iraqi Freedom, which began with the invasions of Afghanistan (2001) and Iraq (2003), shifts began to occur in Army thinking with respect to tactical aviation, including the use of fixed-wing aircraft. A significant need arose to minimize the use of vehicle convoys in certain areas because of the threat of attack from insurgents. Accordingly, “convoy replacement” missions began to be flown by USAF aircraft such as the C-130 Hercules and C-17A Globemaster III.

Additionally, the effects of the intense use of helicopters for transport functions in hot or high environments resulted in metal fatigue, corrosion, and strains associated with carrying large loads through dusty and thin airspace. The USAF did have one remaining small tactical transport, the Air National Guard C-23 Sherpa, but it was too small for the Army’s needs and was at the end of its service life. The Sherpa’s lack of pressurization also precluded its use for aeromedical missions Squitieri, 2004).

The Army, in particular, began to see value in having smaller fixed-wing aircraft available. Such aircraft could replace both heavily used and rapidly aging helicopters and the larger C-130s and C-17As that could best be used to carry truly

large loads over long distances (U.S. Army, 2008). As explained by one Army report:

> Employing a light cargo airplane like the C-27J Spartan is a far more capable, flexible, efficient and economical solution to meeting Army intra-theater airlift mission requirements. The service will conduct more effective intra-theater airlift and save a significant amount of defense funds by acquiring and employing a greater number of Spartans to assume or supplement helicopter utility and cargo mission sets. The Spartan is the best platform to transport a 25,000 lb payload to forward locations due to its superior performance and fuel range over every Army helicopter in the inventory. By evaluation of functional and practical lift capability with similar numbers of aircraft and payload weight, it is concluded that these helicopters will always be outpaced by the C-27J due to their slower airspeeds and shorter fuel ranges.
>
> The weight carrying capacity and cargo compartment dimensions of the Spartan make it the perfect airlifter to fill the gap between inter-theater and tactical airlift. The 102 flexible transloadability characteristics facilitate timely, efficient and effective transport while integrating with Air Force C-5, C-17 and C-130 cargo airplanes and Army CH-47 and UH-60 helicopters. Efficiencies gained by flying faster airspeeds and greater flight performance have direct impacts to providing improved swift mission support to the warfighter across extended operational distances. The C-27J is a sound acquisition decision because cost savings are realized upfront and over the course of the program. With a cost per unit of $26 million dollars each and an operating cost of $2,500 per flight hour, a new C-27J is approximately $6 million dollars less to purchase and $7,900 less to operate than a CH-47F Chinook. (Chaffee, 2009, pp. 101-102).

Given the renewed need for a tactical fixed-wing transport smaller than the C-130, the DoD initiated the Joint Cargo Aircraft (JCA) competition, which was won by Finmeccanica with LM serving as U.S. prime contractor ("Alenia C-27J Spartan," 2009).

B. Italy's "Special Relationship"

Since the end of World War II, Italy has been viewed as having a "special relationship" with the U.S. second only to that enjoyed by the United Kingdom. Approximately 13,000 active duty U.S. personnel are currently stationed at nine bases in Italy. Italy participated in the Gulf War and in the current conflicts in Iraq and Afghanistan, which has reinforced the positive perception of U.S. defense

systems in Italy and the importance of interoperability between Italian and U.S. forces. There is also a U.S.-Italy reciprocal Memorandum of Understanding (MOU) providing for national treatment of the other nation's firms in each other's defense markets (Bialos, 2009, pp. 406–408).

Finmeccanica, the largest Italian defense firm, and other Italian firms in the same market are aggressive about taking advantage of binational cooperation in defense products:

> Italian defense companies, for example, argue that Italy has supported America in Afghanistan and had more troops in Iraq than any major nation except Britain and the United States. As Finmeccanica's chief executive, Pier Francecsco Guarguanglini, asserted, "As allies we collaborate, but we must also be considered allies when it comes to accessing the U.S. market." The Italian government has aggressively supported these claims, calling for greater technology transfer from the United States. The 2008 purchase of DRS by Finemecccanica tested the potency of Italy's "loyal ally" strategy. (Neuman, 2009, p. 81)

Italian participation in the F-35 Lightning II (also known as the Joint Strike Fighter, or JSF) has served to further strengthen the bilateral relationship with the U.S. Final assembly and checkout (FACO) work for the F-35 will be carried out in Italy by Finmeccanica's Alenia Aeronautica subsidiary. All Italian (131 aircraft) and Dutch (80 aircraft) FACO will take place at Alenia's facility near the northern Italian city of Carmeri (Bialos, 2009, p. 409). The importance of the FACO deal to Italy is explained below:

> Following a June 12 [2006] meeting with Italian air force chief Lt. Gen. Leonardo Tricarico, U.S. Air Force Secretary Michael Wynne says the Italians are "very satisfied with the return they are getting on their investment." Besides the U.S. Air Force, Italy is the only other nation expected to buy multiple F-35 variants. Rome is interested in both the conventional takeoff-and-landing version that will be used by USAF as well as the short-takeoff-and-landing (Stovl) version primarily designed for the U.S. Marine Corps. Lockheed Martin is also developing a carrier variant for use at sea.
>
> The final assembly deal is another bridge between the defense industries of Italy and the U.S. Last year, a Lockheed Martin team was chosen over incumbent U.S. contractor Sikorsky to supply an AgustaWestland-designed helicopter to transport the president.

> "The U.S. administration has realized that Italian products are very, very competitive products," [Alenia North America President and CEO Giuseppe] Giordo says. "During last year, the U.S. industry and U.S. administration realized that we can really contribute." (Butler & Barrie, 2006)

The evolution of the Italian defense industry and market has been effectively summarized as follows:

> The role of Finmeccanica as a "natural" partner for foreign companies willing to operate in the Italian market has grown recently, parallel to the process of internationalization and globalization of defense markets. In light of its superior knowledge of the Italian environment and its direct links with the political and military leadership, this Italian industry leader has significant leverage *vis-à-vis* foreign firms and its own subcontractors given its size and dominance in the internal market.
>
> As a general trend, the relative degree of Italian-national content is slowly diminishing and the international dimension of the procurement programs is growing in light of customer preferences to acquire better capabilities at a relatively cheaper price. This is a natural result of the increase in multinational programs in the last 15 years, and the pressures toward the European market's overall globalization of the defense industry. (Bialos, 2009, pp. 431–432)

C. Italian Defense Industrial Strategy

Since the end of the Cold War, Italian defense procurement strategy has shifted significantly. Prior to 1990, the Italian government's preference was for imported U.S. defense systems or licensed domestic production. Since then, there has been an evolution toward a preference for higher value-added work to be performed in Italy, in order to grow the nation's industrial base (Bialos, 2009, p. 399).

The rapid growth of Finmeccanica, Italy's largest defense supplier, has been a cornerstone of Italian defense industrial strategy. Once owned entirely by the national government, that state holding has declined to a minority of 30%. Finmeccanica also has significant holdings in the United Kingdom and in the U.S. Finmeccanica, with a 70% share of Italian defense expenditures, is in many respects "Italy's BAE."

The Italian government tends to hold very few open competitions, particularly for major programs. There is a definite preference for sole-source procurement, with open competition averaging about 15% of contracts by value. Within the other 85% of contracts awarded, there is an increasing trend toward multinational projects with both European and U.S. firms. Intergovernmental agreements are traditionally handled by MOUs, rather than by more formal or binding agreements or treaties (Bialos, 2009, pp. 398-400).

D. The G.222 Tactical Transport

The C-27J's predecessor is the Alenia G.222, which has a similar airframe. The G.222 remains in service with the Nigerian Air Force, the Royal Thai Air Force, the Argentine Army, the U.S. State Department (DOS), and the Italian Air Force—for electronic warfare missions (Alenia North America, 2009.

The USAF also purchased ten G.222s, which entered service in 1990. These aircraft were classified as C-27A Spartans, and used mostly by U.S. Southern Command in drug interdiction missions. Following delivery from Alenia, Raytheon E-Systems provided USAF-directed modifications to the G.222s received from Alenia, followed by "aircrew academic and flight training, maintenance training and complete logistical support" ("Raytheon E-Systems," 2005).

The C-27As were mostly based at the former Howard Air Force Base (AFB) in Panama, and had the ability to land on short strips in remote areas. Ostensibly, due to high maintenance and parts costs and concurrent with the closure of Howard AFB mandated by the 1979 Panama Canal Treaty, the C-27As were withdrawn from USAF service in 1999. Four aircraft were eventually transferred to the State Department, which operated them from Patrick AFB, Florida, providing transportation services to, from, and within Colombia (U.S. Embassy, 1999).

E. Italian Procurement of the C-130J

Twenty-two C-130Js were delivered to the Italian Air Force during 2000–2005 ("Lockheed Martin 382," 2010, February 1). This sale included an offset

requirement; Lockheed Martin (LM) was required to invest in an appropriate Italian aerospace firm and provide a suitable degree of technology transfer as specified in the contract with Finmeccanica (Udis, 2009). Given that LM is the largest U.S. defense contractor, Italy had much to gain from this offset package.

Possibilities for technology transfer were related to LM's market leadership in transport aircraft and avionics, as well as in many related fields. Finmeccanica, as Italy's largest defense firm and one with a strong focus on building relationships with U.S. industry as well as with the DoD, was a logical choice (Finnegan, 2009, pp. 95–86). A joint venture, Lockheed Martin Alenia Tactical Transport Systems (LMATTS), was established to provide the required technology transfer.

Following the completion of the offset program, LM retreated to being a subcontractor to Alenia and LMATTS was wound down. However, the LM legacy continues within the C-27J, making the Spartan particularly attractive to flying services that already operate or plan to operate the C-130J Super Hercules. Approximately 30% of the avionics and propulsion system (engine and engine-related) components are common to both the Spartan and to Super Hercules, and the avionics system architecture is 100% common. LM also continues to market the C-27J internationally ("Alenia C-27J Spartan,"2009).

Why LM did not emerge as the C-27J U.S. prime contractor is a matter of speculation. The firm had originally responded on its own to the JCA proposal with a shortened C-130, which was rejected by the DoD due to its excessive size (Sirak, 2006). In addition, given LM's continuing strong sales of the C-130J and the company's potential (and much criticized) emergence as the only U.S. fighter manufacturer, the firm decided that perhaps it was a better strategic choice to remain a lower key supplier to Finmeccanica rather than a full partner.

The change to subcontractor status lowered LM's political profile with respect to any potential European complaints of domination of both the small and heavy tactical airlift markets, particularly given that the Airbus A400M was also being developed during this period. However, being off the political radar screen would not

have prevented the commonality that so many defense organizations value with respect to logistics, maintenance, and personnel costs.

F. L-3 Communications: The Lead U.S. Partner

Unlike the C-27A, the C-27J Spartan represents, according to the prime contractor L-3 Communications, the newest military airlifter in the world. Its landing gear, engines, avionics, and structure are certified by both military (Italian Air Force) and civil (European Aviation Safety Agency) authorities (L-3 Communications, 2006). The DoD FY2011 Budget Request summarizes the C-27J program as follows:

> The C-27J Joint Cargo Aircraft (JCA) is an intra-theater light cargo fixed-wing airlift platform that will meet the warfighter need for intra-theater airlift. The aircraft is a commercial derivative aircraft that meets the Army's immediate requirements and provides the Air Force an additional capability in meeting intra-theater airlift missions. The mission to support direct delivery of Army time sensitive mission critical cargo was transferred from the Army to the Air Force. (Department of Defense [DoD], 2010)

The C-27J's carrying capacity is considered "unmatched in its class," capable of carrying a variety of fighter jet engines as well as a High Mobility, Multiple Wheeled Vehicle (HMMWV) in a cargo compartment 2.25 m high and 3.33 m wide. It is also a useful search and rescue aircraft, with the ability to remain on station 200 nautical miles from its base, reaching the search area at 310 knots (Global Security.org, 2009). The Spartan can cruise at a maximum altitude of 30,000 feet, and can take off and land fully loaded on unprepared fields or grass strips of less than 2,000 feet ("Alenia C-27J Spartan," 2009).

In addition to the USAF purchase, C-27Js have been acquired at the time of writing by the flying services of Bulgaria (3 aircraft), Greece (12 aircraft), Italy (5 aircraft), Lithuania (2 aircraft), Morocco (4 aircraft), and Romania (7 aircraft; "Alenia C-27J Spartan," 2009). Taiwan may also purchase six aircraft and there is the possibility of a sale to Slovakia ("Procurement," 2010a). Australia finally withdrew its De Havilland Canada DHC-4s (C-7 Caribou equivalents) during 2009, because of

severe parts shortages and the piston-powered aircraft's need for aviation gasoline. The Royal Australian Air Force anticipates obtaining government approval to buy ten C-27Js in 2012–2013 ("Procurement," 2010b).

Prospects for a sale to the Canadian Forces (CF) are uncertain. In 2005, the CF selected the C-27J for the Fixed Wing Search and Rescue (FWSAR) mission along Canada's west coast. Because of the rugged topography, aircraft such as the C-130 Hercules are not suitable for the FWSAR mission. Lacking any other suitable aircraft, Canada continues to use the aging (1973) De Havilland Canada DHC-5 Buffalo aircraft in this role. The DHC-5s (known as CC-115s in the CF) are a subsequent development of the C-7 Caribou. The U.S. Army, seeking an upgraded aircraft, purchased four Buffaloes in the early 1960s, with the designation C-8A. Once transferred to the USAF under the Johnson-McConnell agreement of 1966, they were quickly disposed of.

Between 2005 and 2008, Canada procured the C-17A Globemaster III, CH-47D[11] and CH-47F Chinooks, and C-130J Super Hercules using sole-source contracts. These acquisitions have drawn complaints from the domestic aerospace industry, which complained of insufficient "quality work" being generated by the 100% open-ended offset requirement associated with the sole-source buys. When a Canadian firm acquired the plans of the DHC-5 Buffalo and proposed to update and manufacture the aircraft in Canada, the government placed the matter of FWSAR "under review."

The CF leadership has remained clear on its preference for the C-27J based on operational requirements. Commonality is another significant military concern,

[11] The CF removed its CH-47C Chinooks from service in 1992. In 2008, the need for the Chinook's capabilities in Afghanistan became such that six U.S. Army CH-47Ds were left behind in Afghanistan during 2008, and transferred *in situ* to the Canadian Forces. One has since crashed. This measure was undertaken pending delivery of sixteen CH-47Fs from Boeing, to begin in 2011 (Jane's, 2010, January 25; Jane's, 2010e, March 25).

given that future C-27J operators Australia and the U.S. are, along with the UK, Canada's closest allies. Finmeccanica has also promised a $3 billion industrial benefits package to Canada. However, Canada would be the only nation purchasing the Spartan solely for search and rescue. The political *dénouement* of the Canadian acquisition may be lengthy, particularly as the government tries to restrain spending in a time of recession (Canadian Forces, 2010; Chase, 2009).

G. Impact of the FY2010 Defense Budget

The U.S. Administration's FY2010 budget request reduced the quantity of C-27Js to be purchased by the DoD from 78 to 38. Certain consequences have resulted from the reduction in quantity. First, the remaining 38 aircraft will be operated solely by the USAF, as tactical support for Army missions, in particular in intra-theater airlift. Second, the USAF Special Operations Command mission for the C-27J was eliminated.

Third, program management for the C-27J, formerly a joint USAF-Army responsibility, now rests entirely with the USAF. Which service's pilots will fly the Spartan has yet to be determined. The DoD has designated the Spartan as a "direct mission support aircraft" while the USAF views it informally as a "mini-C-130 Hercules" (Diamond, 2009; DoD, 2010). Alenia has also stated that the Spartan was designed to complement the larger Hercules ("Alenia C-27J Spartan," 2009).

Because of the reduction, Alenia may drop plans to assemble the Spartans ordered by the DoD at Cecil Field in Jacksonville, Florida. The following report indicates that Finmeccanica does not see the cut in the Spartan buy as a major obstacle to its long-term plans to expand its U.S. operations:

> Finmeccanica CEO Pierfrancesco Guarguaglini marshaled 15 of his top defense executives at a meeting with investors in New York on May 19 [2009] to help back his claim that DRS [a major U.S. defense electronics contractor], acquired last year, will see orders climb in the next three years and find solid synergies with its Italian owner. "The updating of existing products and maintenance to make U.S. Army equipment efficient, as requested by U.S. Defense Secretary Robert Gates, can be guaranteed by our DRS unit," he said.
>
> On the downside, a spokesman at Finmeccanica unit Alenia Aeronautica said that if the Pentagon sticks to its recently announced decision to buy 38, not the planned 78, of its C-27J tactical transport aircraft, Alenia could scrap its planned final assembly line in Florida and dispatch them instead from its plant in Turin. The Florida plant made sense when the U.S. Army and Air Force wanted an initial order of 78 and had a Defense Department-approved requirement of 145 Joint Cargo Aircraft, the spokesman said. "If this buy is prematurely terminated or capped at 38, then we will have to re-examine our business case to determine if the need versus the anticipated cost still remains," he said. (Kington, 2009)

The USAF has also announced that all C-27Js will be assigned to the Air National Guard (Trimble, 2009; Buzanowski, 2009). The Army study mentioned above took issue with even the original number of aircraft to be assigned to airlift duties: "Acquiring, integrating, and operating a larger number of C-27J Spartan cargo airplanes to assume or supplement existing utility and cargo helicopter missions is a more capable, flexible, efficient and economical solution to meeting Army intra-theater airlift mission requirements" (Chaffee, 2009, p. 9).

The small initial quantity of Spartans may be viewed with skepticism with respect to the aircraft's long-term survival within the USAF fleet. However, the practical need to better utilize over-committed and aging helicopters, and similarly overstretched C-130 and C-17A fleets, should logically lead to significant follow-on orders for the C-27J.

As the Army and USAF rediscover the advantages of small airlifters, and helicopter fleets are able to refocus on VTOL and combat operations, the C-27 appears to have a reasonably secure future within the USAF inventory. One emerging factor is the development of unmanned aircraft for troop resupply and related missions. Boeing, LM, and Kaman Aerospace have demonstrated unmanned helicopters capable of forward resupply (Warwick, 2010a).

H. The Afghan National Army Air Corps C-27/G.222

As part of U.S. defense security cooperation with the nascent Afghan National Army, the U.S. has contracted with Alenia North America to acquire and modernize 18 G.222 aircraft (Alenia North America, 2009). These aircraft have been designated C-27/G.222 and will be donated to Afghanistan, after which the fleet will become part of the Afghan National Army Air Corps (ANAAC). The USAF is also providing English-language instruction and specialty training to pilots, loadmasters, and maintenance personnel at U.S. installations prior to follow-on C-27/G.222 training in Afghanistan ("USAF Receives," 2009). The program has been described as follows:

> Thirty experienced ANAAC fixed-wing pilots moved to the US in May for English-language training and instrument flight training. They are due to return to Afghanistan for C-27 transition training, which will be conducted by USAF instructor pilots. In the meantime, Afghan aircraft maintainers who are also undergoing a training programme will work alongside contractor support personnel.
>
> All 18 G.222s are former Italian Air Force aircraft that Alenia Aeronautica bought back at the time of the Italian C-27J purchase. The aircraft were built between 1977 and 1985 to different production standards and kept at open-air bases in Pisa and Pratica di Mare after being dismissed from the service because of corrosion problems.
>
> Alenia Aeronautica's Capodichino facility will repair and refurnish the airframes and provide them with an additional service life of at least 10,000 flying hours, replacing all the onboard systems affected by obsolescence problems. As the aircraft have different production standards, the avionics and systems are being replaced or upgraded and standardised to a common configuration, including an updated cockpit, a new autopilot and navigation

> system with colour map display and GPS [Global Positioning System] receiver, as well as ballistic protection. (Peruzzi, 2009)

The success of the ANAAC C-27/C.222 program will depend in the longer term on Afghanistan's ability to field and maintain an air force. The project is interesting from a number of viewpoints: the aircraft will have some commonality with Italian, U.S. and other allied aircraft, promoting interoperability and security cooperation, and U.S. funding for the upgrade has been used to further relations with Finmeccanica and Italy.

I. From Italian Offsets to U.S. Aircraft Commonality

The C-27J Spartan represents an example of an offset program that has produced significant benefits for the U.S., Italy, and the nations who will be using the aircraft. What began as a way to support the Italian aerospace industry in compensation for that nation's purchase of the C-130J Hercules became an essentially new airlifter that has been purchased by several countries as well as the U.S. and Italy. International sales prospects are strong given the aging fleets of similar aircraft in the flying services and government departments of many countries. Commonality, both within the C-27J worldwide fleet and between this aircraft and the C-130J Super Hercules, is a further bonus. As nations place increasing emphasis on minimizing operating costs and exploiting commonality with other countries for training, logistics, and operations, the C-27J has a bright future.

At the same time, if the Spartan is seen from the U.S. perspective as a "descendent of the Caribou" or a "mini-Herc," its worldwide deployment is taking place during the early stages of development of unmanned cargo aircraft. The C-27J has additional potential roles such as airdrop, refueling, troop transport, and patrol/reconnaissance. The last of these is already firmly in the unmanned domain for those countries that have chosen that route.

There will always be a role for fixed-wing manned aircraft, particularly given the pessimistic outlook for replacement of the aging transport helicopters maintained by the U.S. and her allies. The tactical, high-performance, short-field role of the Spartan will certainly prove valuable to those countries that acquire the aircraft.

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IV. The Rise of Unmanned Aerial Systems (UASs or UAVs)

Like most new and good ideas, the new generation of Unmanned Air Vehicles (UAVs) have been significantly oversold during the period of initial enthusiasm. We think one such overreach is asserting that unmanned systems are the centerpiece of a new Revolution in Military Affairs (RMA). While the rise of unmanned combat systems is certainly important, it does not rate the appellation "RMA," at least not yet. A better view, we believe, is that unmanned military systems are (a) a continuation of the US-led RMA, and (b) a set of offsetting counters to the counter RMA (led by Al Qaeda, Hezbollah, and similar organizations). Additionally, they have considerable potential to be "game-changing" innovations in defense industrial affairs.

As stated in our previous reports (esp., Franck, et al., 2008a), we believe there are two RMAs now ongoing. The U.S. RMA emerged from a number of initiatives which date back at least as far as the Vietnam War. One of the precursor conflicts in this RMA was the highly successful Israeli invasion of Lebanon in 1982. A relatively mature demonstration occurred in the operations of the U.S. Reconnaissance-Strike Complex (RUK[12]) employed in the Gulf War of 1991[13] (Franck & Hildebrandt, 1996). Since then, the U.S. and its allies, have made significant efforts to advance this RMA.[14]

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[12] "RUK" is an acronym for a Russian term—which translates as "Reconnaissance-Strike Complex."

[13] This was, we believe, a point in the progression of this RMA roughly comparable to the German invasion of Poland in 1939 within the Interwar RMA.

[14] Just as, for example, the Prussian General Staff worked to advance the Napoleonic RMA (Franck, 2004).

A. Unmanned Systems in Context: The Enthusiasts' Story, and Why It's Not True

According to the enthusiasts (such as Robert Finkelstein), UAVs and other robotic devices have spent decades being kept on the sidelines stupidly (maliciously?) by a cabal of pilots, whose white-scarf mentality includes an ill-considered prejudice against unmanned systems (Singer, 2009, pp. 53–55). It isn't so.

The early experiments produced very useful extensions of the state of the art. They also revealed serious limitations. For example, the original UAV experiments included reconnaissance aircraft, which flew preplanned tracks with data recovery after completion of the mission. This approach involved at least two problems. First, the vehicle's navigational accuracy was limited to then-existing equipment—e.g., inertial navigation. Second, data retrieval was generally done after completion of the mission. This, by necessity, delayed the cycle of processing, interpretation, and (most importantly) taking action based on the intelligence gathered. Finding a useful target without taking action before it moves (i.e., inside its "dwell time") has only limited operational value. These unmanned systems were, not yet cost-effective substitutes for a trained human crew on the scene. This was especially true in the emerging lethal, fast-paced combat environment—as shown in the 1973 Yom Kippur War.

These earlier experiments and concept demonstrations also revealed important difficulties. These included very high accident rates, high cost, and technical immaturity (Hirschberg, 2009, pp. 3, 5, 6, 8, 10, 11). Perhaps most important, the panoply of UAVs—especially its high-altitude, long-endurance component—is dependent upon air supremacy – a dicey proposition at best when opposing the air forces of the Warsaw Pact. In short, because of their technical limitations, and the nature of the planning threat, UAVs were not yet well suited to U.S. needs.

Accordingly, the U.S. Air Force, for example, sensibly chose to use its decidedly limited post-Vietnam resources to secure air superiority against large and capable Warsaw Pact air forces (with F-15s, and F-16s); to contribute to victory in a large-scale Air-Land Battle against the Soviets (F-16s and A-10s); and to enhance power projection and deep strike capabilities by improving tanker and transport forces (KC-10s, KC-135Rs, C-5Bs and C-17s). In the end, what made UAVs candidates for serious combat roles was the same cluster of technical advances that made possible the rest of the U.S.-led RMA. In particular, communication and data transfer capabilities—enhanced by space assets—made unmanned systems much more effective. The Global Positioning System (GPS) greatly increased navigational accuracy. Broad-band, long-range satellite-enabled communications enabled faster data recovery. Furthermore, those new communications capabilities enabled remote (sometimes very remote) control of unmanned systems, which meant that unmanned systems could adapt quickly to changes in the operational environment.[15]

Finally, conflicts of the early 21st Century created something of a hothouse environment that enabled the growth and flourishing of unmanned systems. Air superiority was quickly established and easily maintained in both Afghanistan and Iraq. Being able to take air superiority for granted quite literally opened the skies for UAVs. Moreover, both conflicts rather quickly changed to operations against terrorists and insurgents. And, as discussed below,, UAVs capabilities provided useful counters to the insurgents' methods.

[15] This was an advantage whose value was nicely captured by John Boyd's concept of OODA loops, and their implications. Unfortunately, Boyd didn't systematically put his thoughts to writing (although some of his briefings are available on the internet). Nonetheless, there's a hagiographic body of literature on Boyd in print (for example, Hammond, 2001) which explains his ideas (especially Chapter 8).

1. Unmanned Combat Systems in Contemporary Military Affairs

Fundamentally, Reconnaissance-Strike Complexes (the primary manifestation of the U.S.-led RMA) perform traditional tasks associated with high-intensity conventional combat with great speed and lethality: detecting targets of interest, tracking them, allocating forces to strike them, engaging the targets, and assessing the results of the engagements. Because of cheap and plentiful IT applications—such as computers, sensors, and precision guidance—all of those tasks are performed with unprecedented speed and effectiveness. The results were amply demonstrated in U.S.-led operations against Iraq in 1991 and 2003.[16]

The second RMA is usefully understood as a counter to the first. This revolution is led by insurgent and terrorist organizations throughout the world—following strategic scripts patterned on those traditionally used by terrorists and insurgents—and as codified by theorist-practitioners such as Mao Tse-Tung (Mao, 1960). The true believers in the U.S. RMA proclaimed the coming end of Clausewitzian fog and friction in warfare (e.g., Hazlett, 1995). The terrorist-insurgent RMA was intended to (a) reintroduce fog and friction with a vengeance, and (b) extend the theater of operations to public perceptions. And, as a bypassing response to the U.S. RMA,[17] those were well suited to exploiting the vulnerabilities of liberal democracies: strategic impatience, bureaucratic slowness, and the operations of a free press (Franck & Pierce, 2006).

Exploiting the possibilities of cheap and plentiful IT applications, the insurgent and terrorist movements have proven highly adaptable, flexible, and opportunistic.

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[16] This example is true only if we confine the 2003 operations to the march on Baghdad, and not the insurgency that followed.

[17] "Bypassing" responses, if successful, make the opponent's mode of operation either obsolete or irrelevant. For example, the U.S.-led RMA made obsolete armed forces modeled on the Interwar RMA (which introduced mechanized air-land combat). The intent of the terrorist-insurgent RMA was (in effect) countering the U.S.-led RMA by making Reconnaissance-Strike Complexes irrelevant. Among other things, this involves denying information about insurgent forces by blending in with the general population—emerging from cover only to pursue active operations. For a discussion of "emulating," "offsetting," and "bypassing" responses, see Franck and Hildebrandt (1996). For a more specific discussion of the terrorist-insurgent RMA, see Franck and Pierce (2006).

One of the manifestations of these characteristics has been the ability to switch modes of military operation quickly, labeled as "hybrid war" by Western commentators—including officials at the U.S. DoD.[18]

What these two RMAs have in common is being enabled by modern Information Technology (IT). The U.S. RMA is enabled by a large set of IT applications (Franck & Hildebrandt, 1996). It performs traditional military tasks in conventional combat with very high speed and lethality. The new insurgent movements have made good use of IT methods—especially the internet, to publicize their cause,[19] coordinate operations, conduct training, and spread the word regarding best practices.

The contest between these two military systems (formerly called the Global War on Terror) continues. Within that framework, the emergence of unmanned military systems (including UAVs) is an offsetting counter to the ongoing terrorist-insurgent RMA. Among other things, unmanned systems have been very helpful (but not the only factor) in increasing the U.S. and allied forces' ability to maintain extensive (ideally continuous and pervasive) surveillance of the relevant "battlespace." The operational effect is to disrupt the insurgents' preferred tactical mode of emerging from cover within the population to conduct military operations, and then fading back into cover. For example, there are many documented incidents of insurgents being continuously tracked from aerial assets (manned or unmanned) which permits rolling up not only the operational forces—but also the support infrastructure (e.g., safe houses; Seifert, 2007).[20] Within the Franck-

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[18] However, Mao's three stages model of insurgent warfare included the possibility that guerrilla forces could switch from one stage to the next (and revert back) based on the current situation and correlation of forces (Mao, 1960).

[19] An intercepted letter from al-Zawahiri (Al Qaeda) to Al-Zarqawi (Al Qaeda Iraq) reads as follows: "more than half of this battle is taking place in the battlefield of the media" (ODNI, 2005, p. 10 of the letter's text).

[20] It is worth noting that the article cited in the text above is about using manned systems (gunships) as disruptive counters to insurgent-terrorist operations. However, the AC-130 featured in the article had to leave the areas of operations for aerial refueling. UAVs can stay on-scene longer.

Hildebrandt (1996) classification scheme, UAVs are part of a large-scale disruptive offsetting response to the insurgents and terrorists.

Additionally, unmanned systems have been extensively employed to counter Improvised Explosive Devices (IEDs). UAVs provide aerial surveillance and detection of likely IED sites. Also, unmanned land systems have been used to disarm those IEDs. Thus, unmanned systems have also been defensive offsetting counters to the ongoing insurgent RMA.

2. Unmanned Systems in Contemporary Defense Industrial Affairs

a. Ahead to the Past

Clearly the most interesting (but perhaps not the most important) effect on defense industries has been the return of relatively small firms as prime contractors—General Atomics (Predator UAV) being one of many good examples. Since unmanned airframes are relatively cheap and simple compared to their manned counterparts, firms other than giants such as Boeing and Lockheed-Martin can take the lead on developing and producing these platforms. Also, given the relatively low cost and simplicity, firms can finance development projects with their own funds. For example, the B-17 Flying Fortress was developed in the 1930s with Boeing Company funds (with upwards of 12,000 eventually produced). One of the last ventures along these lines was the Northrop F-20 (nee FX and then F-5G), which was pursued with company funds from 1975 to 1986, and then cancelled with costs in excess of $1 billion dollars and no airplanes sold (Northrop F-20, 2010).

With UAVs being an integral part of all Services' inventories, defense industrial affairs have, in some sense, returned to the 1930s, when the size and risk of the project did not dwarf the size of the firm. Thus, for example, Northrop Grumman is currently continuing a UAV project (Killer Bee) despite no offers from the U.S. DoD, but with the hope of international sales (Butler, 2010c).

b. The Great Escapes, Maybe

The newly achieved effectiveness of UAVs has offered some relief from major problems currently plaguing the U.S. defense industrial system. These include the cumbersome nature of the defense acquisition process, and the seemingly inexorable (and rapid) rise in the cost of manned aircraft systems.

One of the fundamental disconnects between the DoD acquisition system and the real world of military affairs is the increasingly adaptive nature of modern warfare—with rapid changes in modes of operation—contrasted with the time-consuming and delay-prone DoD acquisition process. (The KC-X is one of the many projects whose results speak for themselves.) Given that UAV development projects are relatively cheap; they can be financed within firms, or can be undertaken within the DoD as special projects—outside the usual system of extensive oversight. Also, many UAV projects have been taken to production and operational capability much more quickly than their manned aircraft. The new equipment must then be integrated into the day-to-day operations and support structure of the military.

Even with its faults, the DoD acquisition system nonetheless integrates new equipment types into the Services' logistics and support systems. For the UAVs developed more-or-less on the fly, this integration has been more problematic—as the case of the Army's Raven UAV illustrates below.

Another disconnect is the long-term rise in the price of manned aircraft systems—especially manned fighters. One characterization of this trend was offered by aerospace executive Norman Augustine as one of "Augustine's Laws" of defense acquisition. Given the rate of growth of tactical fighter cost growth relative to U.S. GDP and extrapolating those trends into the indefinite future, one of Augustine's Laws predicted that the entire defense budget would support purchases

of tactical fighter aircraft around 2054 (Augustine, 1987, pp. 139–147).[21] A quarter century later, Augustine claims we're "right on target" to reach that state ("The Cost of Weapons," 2010).[22] One way out of this difficulty is to rely on unmanned systems, which are smaller in scale and less expensive to develop and purchase.[23]

Sections IV.B. and IV.C. below are complementary inquiries into UAVs and their effects on the global defense market. IV.B. covers UAVs in general, but focuses primarily on larger unmanned systems (generally operated by the U.S. Air Force). IV.C. is about one interesting small UAV—the Army's Raven. It details the methods used in its development, production, and employment. An especially interesting feature is what it took to integrate the Raven into the Army's logistical and support systems

B. Unmanned Aerial Vehicles (UAVs)

1. Background

Though this section is about the development and employment of unmanned systems by the U.S. military, it should be regarded as the first stage of a larger investigation of the subject. Though unmanned systems have been utilized for ground and maritime environment operations as well, this report will focus largely on unmanned aerial systems (or vehicles). According to a recent article,

> The Air Force, not surprisingly, possesses the most sophisticated inventory and has made the greatest investment in unmanned aircraft, with nearly 66 percent of all service RPA (remotely piloted aircraft) spending coming from Air Force accounts over the past decades. (Bowie & Isherwood, 2010; OSD, 2010)

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[21] This is, in fact, Augustine's most famous law, number XVI. It is interesting to note that other laws, such as XIV (p. 124)—which predicted that electronics would constitute the entirety of aircraft systems' weight in 2015, and will almost certainly be proven false, have received much less publicity.

[22] The article cited includes charts which plot that trend.

The broadest definition of unmanned aerial vehicles or systems describes them as "an aircraft that flies without a human crew on board the aircraft." Unlike missiles, they are "reusable" and are "capable of controlled, sustained , level flight and powered by a jet or reciprocating engine." Unlike missiles, while unmanned and often remotely guided, the vehicle itself is not a weapon (OSD, Unmanned Aerial Vehicles, 2010).

UAVs exist in a wide range of sizes, shapes, and capabilities.[24] While originally remotely piloted drones, they are increasingly controlled autonomously, either from a remote location or by a pre-programmed flight plan based on complex dynamic systems. Though traditionally used primarily for intelligence, surveillance, and reconnaissance missions, they are now more often "weaponized" for use in an attack mode.[25]

It has been estimated that during the first half of the 20th century, the Department of Defense spent something in the vicinity of $25 billion on various unmanned aircraft programs without ever having developed "an effective, operational air system" (Bowie & Isherwood, 2010). During this fifty year period, several cycles of usage and expenditures on unmanned aerial systems can be identified, growing during periods of war or crisis and diminishing sharply in peacetime.

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[23] Some skeptics question whether unmanned systems are cheaper to operate. These are detailed in the discussion below.

[24] The sizes range from as big as a large commercial airplane down to mini or even nano size. The large ones can fly very high and remain on station for days or even months. The small ones can fit into a pocket and approximate insect size with some able to operate within a building and perch on vertical walls and roofs (U.K. Ministry of Defence, 2011, pp. 2-7 and 3-1 to to 3-12).

[25] A useful distinction between the terms "reconnaissance" and "surveillance", often employed erroneously as synonymous, focuses on the element of time. Thus, reconnaissance implies a brief view of a target, often requiring additional interpretation in order to fully comprehend what has been observed. On the other hand, surveillance yields a more complete understanding of the target area usually obtained by extensive loitering (see Ehrhard, 2010, n. 62, 93).

Thus, during the 1960s, the Navy installed large numbers of QH-50 DASH torpedo-launching helicopter drones on U.S. destroyers as an emergency measure to meet a threat coming from a growing number of Soviet attack submarines, only to replace that entire fleet when larger destroyers became available capable of accommodating manned helicopters armed with more accurate and powerful torpedoes ("History of Unmanned," 2010). During the air war over Vietnam, UAVs played an important role and "at the zenith of drone operations in December 1972, the Air Force depended almost entirely on them for bomb damage assessment due to bad weather"[26] (Erhard, 2010, p. 2). In the mid-1990s, the Air Force was employing Predators over Bosnia and Kosovo during the conflict resulting from the disintegration of the former Yugoslavia (Erhard, 2010, p. 3).

These successes were recognized in a Defense Science Board report in early 2004. The cover letter of transmission observed that

> There is no longer any question of the technical viability and operational utility of UAVs. The success of UAVs in recent conflicts represents a historic opportunity to exploit the transformational capabilities inherent in UAVs/UCAVs (Uninhabited Combat Aerial Vehicles). Indeed, these recent combat operations appear to indicate that unmanned air systems have at last come of age. (Defense Science Board, 2004)

The words "at last" are worthy of attention. Why, after all, did it take half a century for their promise to be recognized and developed?

A painstakingly detailed explanation has been provided by Ehrhard (2010). No brief summary of his work can do it justice, but his history is divided between technological and organizational factors. The first are easier to understand and basically focus on levels of technological maturity in UAVs which, at critical times, lagged behind that found in competitive systems such as guided missiles, satellites,

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[26] During the Vietnam War, UAVs such as the Firebee were also used to monitor trail networks and to locate surface-to-air missile sites. See Isherwood (2010, p. 58). Even earlier, uses were found for UAVs such as training antiaircraft crews for the Army and Navy before World War II, and flying unmanned Air Force B-17 aircraft to collect radioactive samples after tests of atomic bombs in 1947 and 1948 (Isherwood, 2010, p. 58).

and very high flying reconnaissance aircraft such as the U-2. It has taken time for the present levels of technical sophistication to be achieved. On the other hand, the organizational factors may be more difficult to correct. Likewise, there were the inconvenient truths of technical maturity, operational capability, and the nature of combat threats during the Cold War.

Over the earlier years of its history, financial and other support provided by non-military service branches such as the intelligence community via the National Reconnaissance Office and the Defense Advanced Research Projects Agency were critical but when it was withdrawn, no home was offered to the new "orphan" in the armed services. No support community had been developed and, over the years, UAVs became a political football in inter- and even intra-Service rivalries. In addition, Ehrhard (2010, p. 56) believes that attempts at centralized management of UAVs via civilian authority in the Office of the Secretary of Defense failed to recognize and deal with the forces of political and operational reality.

The following quotation well describes Ehrhard's view on military acquisition of new systems. "Structurally, the centralized management construct, atomized an already sparse UAV constituency. Essentially, DARO (Defense Airborne Reconnaissance Office) 'outsourced' UAVs , stripping whatever internal service advocacy existed and making integration that much more difficult" (Ehrhard, 2010, p. 33).

The 1990s reinforced an immutable truth concerning weapon system innovation in the United States. The Services, as end-users, require substantial autonomy at each stage of the weapon system innovation process. Although external advocates and agencies undoubtedly play an important role in weapon system development and adoption, the symbiosis between the Service and the machine required for combat innovation depends on the mobilization of an internal constituency. The weapon system must be able to function in the Service's peculiar environment, which implies not only unique air vehicle designs but also extensive, often expensive militarization. The service members must also adapt themselves to

the machine, but typically the machine (through design, technology integration, and militarization) has to reach some minimum level of congruence before the Service will begin to move.

Having said that, there remains little doubt that the Services, like all organizations, will not change without an external catalyst. However, it is the nature of the catalyst that matters. Policies that stimulate internal, organic adjustments in a Service and allow control over the machine's design can encourage the man-machine symbiosis and enable innovation. The Defense Airborne Reconnaissance Office (DARO) saga showed that external containment of the prime implementers disassociates the Services, dampens internal change processes, and ultimately hinders weapon system innovation.

In the final analysis, the vanguard of the UAV proletariat proved no more, and arguably less, capable of UAV development than the Services. They did so in the most positive external environment encountered in the study. Weapon system innovation by containing the Services and constricting funding ignored reality—it requires energetic service participation, weapon system differentiation and militarization, and the realization on all sides that UAVs are not cheap in dollars or manpower. The ultimate goal of weapon system innovation is its novel, effective use in combat, and as a byproduct, its enduring integration into a Service's force structure. Centralized UAV management as practiced by DARO inhibited that process by putting UAVs in direct conflict with manned reconnaissance systems by further diffusing internal structures in the Army and Navy, and by pushing UAVs into an idealized box into which they could not fit from a design, utility, or cost perspective. The meteoric rise and fall of centralized UAV management provided strong evidence that "pluralism and untidiness" indeed may be the only way for the U.S. military to achieve weapon system innovation with the UAV (Erhard, 2010, p. 57).

The analysis by Bowie and Isherwood (2010) identifies "a confluence of technical and operational factors which finally pushed RPAs to the forefront" (p. 1).

They attempt to explain the fact that by the year 2008, more than 500,000 flying hours were logged by the U.S. armed forces, an incredible sixteen times gain over 2002. Their principal points follow below.

A major shortcoming in the utilization of UAVs (or RPAs, Remotely Piloted Vehicles) was found in their navigational limitations. In the 1960s, such vehicles as the Tagboard and the Compass Dwell/Cope systems often displayed "meandering" flight paths which sharply limited their usefulness. This deficiency has been largely corrected by the use of Global Positioning Systems based on satellite constellations which accurately identify not only the position of the UAV itself but also that of the precise area targeted by its sensors. This development was a precondition to the weaponizing of UAVs.

Vast improvement in computational capabilities and in advanced software since the late 1960s have expanded the tasks that these vehicles are capable of handling reliably and the accompanying miniaturization of computers allowed for their installation and operation on smaller vehicles. Predators and Reapers can now assume a hold position or return to base if their communications links to controllers are disrupted.

The operating range of UAVs has been expanded by satellite communications and associated bandwidth which permits them to be employed beyond the horizon compared to their prior limitations imposed by the necessity for them to remain in line of sight from the ground station. Sensor output data are also now transmitted via satellite communication.

Removing a human pilot from the cockpit has the obvious advantage of reducing the number of military personnel in harm's way. However, very important military advantages also flow from such a development, because pilot duty time limits the potential length of a mission or sortie. In small, fighter-sized aircraft with limited cockpit space, the typical pilot duty day has been estimated at 12 hours. However, that does not mean 12 hours over the target because three hours are typically devoted to mission preparation and debriefing after the mission. Moreover,

travel time from base to target and return can absorb the bulk of the remaining 9 hours. This has been particularly true for U-2 missions over Afghanistan which originated at a U.S. base. The comparison of manned with unmanned missions is impressive. Bowie and Isherwood (2010, p. 5) estimate that to maintain a 24-hour orbit over a target 1,150 miles from base with a Global Hawk requires one sortie; performing the same mission with U-2 aircraft would require five sorties, with approximately 50% of the flying time spent in transit. Each of those sorties would require a different aircraft and pilot with associated ground crew, equipment, and supplies.

Until recently, data monitored from wide-area surveillance sensors still required further interpretation and analysis before it could be directly useful to combat commanders and their troops. Predators and Reapers with Intelligence, Surveillance, and Reconnaissance (ISR) sensors and full-motion video cameras mounted on their airframes changed all this, allowing military personnel to observe what is happening in the target area, even when it is beyond their line of vision. When these capabilities are merged with ground attack weapons, the UAV has the capacity to attack the target in almost real-time.

On occasion, when an immediate attack is not possible due to the risk of collateral damage or other considerations, tracking the target requires the capacity for persistence which is increasingly available. Reducing the sensor-to-shooter time to minutes from hours or days, as was previously the case, has proven particularly useful in the pursuit of terrorists in Afghanistan and neighboring regions (Erhard, 2010, p. 5).

2. Continuing Problems

An important point has been raised recently which reveals serious limitations to UAVs' operational utility—their vulnerability to hostile air defense systems. The bulk of UAV successes have taken place in environments in which U.S. forces enjoyed almost total control of the air. This air supremacy has enabled them to operate with very little concern about their vulnerability to hostile surface-to-air

challenges. If they were to operate against hostile forces with sophisticated air defense measures, their design, which often omits defensive capabilities, and their limited maneuverability could become serious matters of concern. To correct this condition is technically possible but would surely not be cheap. UAVs capable of operating at high altitudes, say between 60,000 and 70,000 feet might be less vulnerable to enemy surface-to-air missiles, but most UAVs currently in use are not capable of operating at such elevations.

Another source of concern focuses on the growing efforts of hostile forces to electronically jam UAV connections to GPS systems and otherwise interfere with their control mechanisms. Such tactics would be particularly effective against smaller UAVs with limited ceiling capabilities.

From the viewpoint of the producers, a somewhat different problem exists, which involves figuring out how unmanned systems fit into the future strategic vision of the U.S. armed forces. UAVs attained their current high level of visibility and demand in the midst of what appeared to be atypical combat situations—asymmetric attacks from non-state actors. The difficult but important question facing UAV producers is whether this form of warfare will be viewed as the wave of the future, superseding more traditional threats from legacy foe states. At the macro level, the DoD's view of the future strategic environment faced by the U.S. can be found in official documents such as the periodic National Security Strategy issued by the Office of the President (the most recent of which is dated May 2010) and the Quadrennial Defense Review Report issued by the Office of the Secretary of Defense (the most recent of which is dated February 2010).

Drawing on such documents, Michael Isherwood (2008, p. 58) has identified four challenges, all of which must be ever present in strategic planning: traditional challenges, from countries utilizing modern armed forces in a theatre conflict; irregular challenges, which may originate from a variety of foes ranging from international terrorist organizations like *al Qaeda* to widespread insurgencies; catastrophic challenges involving the acquisition and possible use of weapons of

mass destruction which may come from either sovereign states or non-state actors; and disruptive challenges by an adversary using revolutionary technology or doctrine to checkmate U.S. military superiority. The relevant point here is Isherwood's judgment that countering all or any of these challenges will require that military commanders obtain "persistent awareness" which he defines as "the sustained ability to monitor or surveil a wide area while concurrently obtaining detailed, precision target quality information on targets, forces or similar points of interest" (Isherwood, 2008, pp. 3–4). Given the unique ability of unmanned systems to provide such persistent awareness, their future need would appear secure.

A more micro approach to ascertaining their future role would be to examine a variety of real world cases in which they have already demonstrated or logically fulfilled a complementary role with traditional manned weapon systems. One example occurred in 1999. UAVs flew low over Kosovo as spotters, identifying targets to be attacked by manned aircraft operating above 15,000 feet to reduce the danger from enemy surface-to-air missiles (Mahadevan, 2010, p. 2).

Other hypothetical uses are receiving serious consideration. For example, the Navy has been examining the Next Generation Jammer (NGJ) to help protect expensive fifth generation aircraft from increasingly capable antiaircraft defenses. The Navy program manager for Airborne Electronic Attack and the EA-6B Prowler has commented that "one of the reasons that the chief of naval operations aligned UAVs and electronic countermeasures is because he sees it as all part of information dominance" (Fulghum, 2010b, August 9, p. 48). In a companion article, the same official suggested that a long-term solution might be found in the combined use of stealthy and non-stealthy and manned and unmanned aircraft in support of one another in standoff jamming[27] (Fulghum, 2010b, August 9, pp. 46–47).

[27] According to Fulghum (2010b), sophisticated antiaircraft missile threats will endanger even stealthy designs. (p. 47).

Even more exotic missions have been imagined for UAVs. Thus, the Reaper (Predator B) and Avenger (Predator C) especially, have been suggested to carry interceptors designed to destroy tactical ballistic missiles directly after launch (Fulgham, 2010c, September 20, p. 72).

Air Force leadership has cautioned against assuming that the future will bring only irregular warfare. One anonymous respondent interpreted this concern as follows:

> The battle will be to balance the way the military wants to fight in Afghanistan now against how it wants to fight elsewhere in the future. Air Force officials want to keep those two needs from becoming widely divergent points in geography, technology and operational techniques.

They see combat in Afghanistan as possibly having direct benefits for conventional wars, and given the important role played by UAVs in this conflict, it seems reasonable to conclude that their capabilities would be found useful in more conventional warfare (Fulghum & Sweetman, 2009, pp. 26–27).

In an interesting look at developments in the UAV field, David Voss (senior director of control technologies at Rockwell Collins) and John Langford (president of UAV developer Aurora Flight Sciences) expressed the belief that manned aviation will ultimately benefit from advances in unmanned. According to Voss, "It is a strategic thrust [at Rockwell Collins] to take unmanned into manned." He provided an example of Rockwell's work for DARPA on damage—tolerant autonomous flight controls, which could be used to improve the safety of manned aircraft (Warwick, 2010b, June 8, p. 51).

The very successes of UAVs in Iraq and Afghanistan have introduced a significant problem. UAV flight hours in that theatre of operations more than tripled between 2006 and 2009 and yet ground commanders complain that only a third of their requests are being met due to shortages of aircraft and pilots (Zucchino, 2010). Mass production requires standardization, and even if the production facilities were

available, the great variety of UAVs in action would make such an increase in production difficult to achieve.

A more immediate problem is the shortage of trained operators and the fact that at present, the ratio of UAVs to operators in a mission is 1:1. Efforts are underway to enable operators to control multiple drones and more than one type simultaneously because the need is serious. Press accounts indicate that Army engineers are installing devices in such helicopters as the Apache and the Chinook to allow their pilots to communicate with and, perhaps control UAVs. In addition, Boeing has developed its "advanced tactical network system" which allows pilots and ground crews to simultaneously watch video feeds. The system permits instant messaging and has a GPS tracker to pinpoint locations on a map (Wright, 2010, July, pp. 26–27).

The rushed circumstances surrounding the critical need for UAVs in the Iraq/Afghanistan conflict explains, in part, the absence of a uniform approach to unmanned aircraft in the Defense Department in the post 9/11 period. After examining acquisition programs for eight UAVs and two payload development programs, the Government Accountability Office (GAO) concluded that most programs "experienced cost increases, schedule delays, performance shortfalls, or some combination of these problems" (GAO, 2009, July, p. 2). The report identified service-driven requirements and funding processes and ineffective collaboration as key factors which limited the attainment of commonality and made recommendations to correct the problem. It attributed much of the cost growth to "changes in program requirements and system designs after initiating development" (GAO, 2009, July, p. 7). This behavior is too familiar to be attributed entirely to the circumstances surrounding this conflict, and suggests an underlying problem in the weapons acquisition process.

An effort to address at least part of the cost consequences of duplication in UAV operations motivated a memorandum of agreement signed on June 12, 2010 by the chiefs of Staff of the U.S. Navy and Air Force. Its goal was to achieve

operational and financial efficiencies in the Air Force Global Hawk and Navy Broad Area Maritime Surveillance (BAMS) programs. The two systems are to be collocated at several bases and a single pilot and maintenance training program is being established for both fleets (Butler, 2010b, p. 27).[28]

Another troublesome problem in the operation of UAVs has been their limited sense-and-avoid capabilities, which are necessary to reduce the likelihood of mid-air collisions. This is not a major factor in the skies over Afghanistan, but it is a potential nightmare over densely populated areas. As UAV exercises and training become more widespread in the U.S., this problem will demand attention. A first step has been taken through an Army proposal for the FAA to grant the Army permission to fly unmanned aircraft in national airspace at night using ground-based radar and GPS systems to avoid civilian and commercial traffic (Jean, 2010).

3. Interview Responses

During the late spring and summer of 2010, interviews were conducted with anonymous respondents from seven UAV producing firms, six headquartered in the U.S. and one abroad. One additional U.S. firm was approached but declined to participate in the study. The participants were guaranteed confidentiality and non-attribution, thus responses will be presented by topic area, rather than by company. In the event that company name or product line is mentioned in published material that is already in the public domain, we will feel no obligation to refrain from using that quotation if it appears relevant to the topic under discussion. The cooperating firms were AAI Corporation, AeroVironment, Boeing, Israel Aircraft Industries (IAI), L-3, Lockheed Martin, and Northrop Grumman.

[28] Another example of a movement from the unmanned to a manned version is found in the advertisement by General Atomics of its Griffin Eye – Manned All-Weather ISR (*Defense News*, 16 May 2011, p. 17).

4. Industrial Structure

Since the end of the Cold War the number of major prime defense contractors in the U.S. has declined sharply with the current number of firms meeting that definition now numbering three—Boeing, Lockheed Martin and Northrop Grumman. Interestingly, the situation in the unmanned systems industry is quite the reverse, with the number of competitors, depending on definition, registering in the dozens.[29] In part, this growth reflects such factors as relative ease of entry resulting from low capital requirements, modest patent barriers, and a sudden explosive increase in demand for the product. Such an environment encouraged the appearance of the mythical bright persons operating in a garage. Indeed, the defense industry experienced something of a turmoil which, in turn, resulted in a wave of mergers and acquisitions by the major contractors

Such factors resulted in significant changes on both the supply and demand sides of the market which our interviews were designed to examine in the hope that the information unearthed might lead to a better understanding of likely future developments in the industry.

5. Cost Considerations

Several of our respondents cautioned against accepting the Hollywood vision of unmanned vehicles which tends to focus on the absence of a human pilot and the expectation that somehow, robotics provide a path to a cheaper product capable of previously undreamed of capabilities. A more realistic picture was painted by Air Force General Roger A. Brady at a July 2010 conference at which he emphasized that "There is nothing unmanned about an unmanned aerial system." The crucial word in this statement is "system." He went on to note that

[29] Indicative of this growing community is the fact that over 6,000 persons registered to attend the August 2010 Denver meetings of the Association of Unmanned Vehicle Systems International, the industry trade association.

> the support tail for an unmanned system can meet and exceed that of a piloted plane. The ratio of crew members to UAS can approach 10 to one…while fighter jets require two crew members at most and usually just one pilot. …Manpower costs are ultimately more challenging for restricted defense budgets than the systems they operate. (Beidel, 2010, pp. 28–31)

This point was further expanded by a respondent who noted that removing the man from the cockpit does not change, and may even increase, the size of the footprint on the ground of the support crew that provides maintenance, logistical, and weapons support. He added that comparing the cost of an F-16 fighter with a comparable sized UAV does not yield a wide difference because both must be equipped with similar engine, payload, and sensors and that the cost consequences of removing the pilot would be small—essentially removing the ejection seat.

A recent study made the point that "For a large strike aircraft required to carry sizable internal weapons payloads, the dimensions of its platform are driven by the dimensions of its weapons bay. …Removing the cockpit would not significantly change the aircraft's platform." While conceding that "Their freedom from the limitations of a human pilot makes the UASs the platform of choice for very long-duration missions" the author counters that "Maintaining a "man-in-the-loop for hundreds of unmanned aircraft operating simultaneously in future air campaigns would require a complex infrastructure of secure C2 links and huge bandwidth capacity." He cautions that "Unfortunately, providing true autonomy for complex unmanned systems that must operate in dynamic high-threat combat environments is beyond today's state-of-the-art technologies" (Gunzinger, 2010, pp. 40–42).

When the mission is essentially ISR, and the manned equivalent is a high flying U-2 type aircraft, the UAV would seem to have an advantage. As noted above, limitations of range and loitering ability would require multiple U-2 sorties to acquire what a single UAV with a 24 hour loitering capacity could obtain. This advantage would also be reflected in a reduction in the manned aircraft's fatigue life cycle, which builds up especially during aircraft takeoffs and landings which would

be reduced with the reduced number of sorties. One of our respondents added another possible source of savings resulting from reduced training costs associated with reduced missions. He noted that in peacetime, two thirds of flying hours are devoted to training.

6. Reception of the UAV Concept by the Military

The UAV history during the post-9/11 period is a classic case of responding to active opponents resulting in new modes of operation. Thus, the need for devices to ease the lot of U.S. ground forces—especially in urban combat environments—was important and recognized by combat commanders and industrial organizations. Individuals on both sides recognized that there was hardly time to follow standard procedures and have the defense establishment prepare carefully drafted Requests for Proposals. Unsolicited proposals were received and acted upon.

Fortunately, the Air Force had an organization designed to handle such a circumstance, the Big Safari program office. It is responsible for sustainment and modification of special mission aircraft and weapons systems and has been described by the Air Force as a "rapid procurement force" ("Big Safari," 2010). It provided an imprimatur of legitimacy for acquisitions which had not emerged from the standard RFP procedure. Almost without exception, our respondents considered this arrangement favorably. In the words of one, "It took visionary engineers at the laboratory and majors in the field to make the product useful and get it to the troops. Dedicated people were busy saving lives and, in the process, cut many corners in the standard acquisition process." Another respondent noted that "The whole UAV community is now making up rules as we go along. We needed and found risk takers in the program office."

Another respondent emphasized that the process by which requirements are determined could be improved upon. He noted that his firm had imbedded field service representatives with the troops and established chat rooms in the field to allow users to confer with the company engineers to learn how the product could be improved. His firm was able to gain the cooperation of other competitors in devising

a way to significantly reduce the weight of a device designed to be carried in the backpacks of troops. This approach enabled the people in the field to influence those writing specifications in the Pentagon. The underlying philosophy is that UAVs represent a novel technology which is not old enough to devise a useful cookbook of answers to problems likely to be encountered in the field.

There seemed to be general agreement and understanding of the fact that all the armed Services have their own traditions and procedures which are difficult to change. One respondent commented that there was no shortage of legacy engineering talent at NAVAIR, but questioned the necessity to apply the same level of scrutiny of work on UAVs that was required for fighter aircraft. He gave the example of a requirement for redundant mechanical fasteners when, in his opinion, aerospace adhesives would be adequate. He summarized his position by comparing the requirements applied to UAVs to those that would have been used for B-2 bombers. In other words, nothing short of a 100% solution was acceptable. The Air Force did not escape similar criticism, and another respondent observed that the Air Force was skeptical of any idea that had not originated within the Service, an unwelcome attitude in a time of crisis.

A spokesman for one of the major prime contractors made the interesting point that “If you wait for the RfP you lose it”, which emphasized that the contractors play a role in turning the thinking of the Services in directions “outside of the box”, so to speak. Another respondent from a major producer gave credit to smaller firms for having “practically reinvented the airplane”. He confirmed the fact that UAVs were handled outside the Federal Acquisition Regulation (FAR) acquisition process, which provided a means to the rapid fielding of the product.

However, this same individual drew a distinction between relatively short-lived UAVs and very large projects yielding products that were expected to remain in service for decades, such as nuclear submarines, aerial refueling tankers, and the like. In such cases, rapid fielding is not usually possible, and the development of

such products might well require very high quality standards and other safeguards provided within the mainstream of the standard acquisition process.

The frustration within the command structure in dealing with UAVs was well expressed by the comments of Air Force General Roger A. Brady, already quoted above: "It [the UAV] does not meet my definition of a weapons system. If I see an F-16, that's a weapons system. You know where it is, you know where all the electrons are going, you know what's happening, you know who's responsible. There's a program manager you can call and yell at. There are operators. There's a command chain" (Beidel, 2010, pp. 28–31).

This is a practical recognition of the necessity to accelerate the introduction of UAVs into the force structure, which, incidentally, was the first and most important (their words) recommendation made by the Defense Science Board (2004) in its report cited above (in the Executive Summary, p. v).

A sympathetic view of the military's response to the way UAVs have been introduced was presented by a respondent with extensive experience as a naval pilot. In his words: "The military has been 'burned' by numerous smallish manufacturers of UAS products. Because they grew out of the Remote Control airplane community which has no milspec standards, reliability has been a problem with most of these efforts, and the military has migrated to established companies with more of an aircraft production legacy."[30]

This same individual presented interesting written comments on a number of these topics.

> **Question:** Has the adoption of UAVs been resisted by the Services that, perhaps, see them as competitors for missions, status, personnel and funds?

[30] This same point is emphasized in a recent British Joint Doctrine Note (op cit., pp. 3-10, 5-6 and 5-7) which observed that as UAVs become larger and more complex the issue of their airworthiness becomes a more important factor in decisions by MOD puchasing authorities. It was noted that such authorities might be more likely to concentrate their contracts in the hands of more traditional aircraft producers for whom airworthiness has long been an essential ingredient of product acceptability.

Answer: Answers vary by Service. In general the USAF has been first to realize the benefits of UAS integration. The ISR role was acknowledged early on, and they have transitioned large portions of their airborne assets to UAS. [In] the next ten years, that will get even more aggressive (see USAF "Flight Plan"). Second to embrace is the Army, which has more UASs now than any other service. They're struggling a bit with manning/equipping and establishment of a "UAS Community" but are making progress. Third is USMC, fourth is USN. Much reluctance to integrate at sea, which is a much more complex environment.

Question: Are UASs seen as replacements for, or complements to, manned systems?

Answer: Answer is complicated. Right now, primary role across the board for UASs is ISR, and they are seen as both complements to existing force structure (they can maintain a presence which manned aircraft simply cannot do), but they are also taking the place of manned ISR assets (USAF U-2, USN P-3/S-3). Outside the realm of ISR (strike platforms), they are not replacing manned assets as quickly as some would like. There are serious training, joint fires, coordination, and airspace issues when evolving into more advanced mission sets (i.e., it's relatively easy to get pictures/video, it's a lot more complicated to start delivering weapons. [A point might be interjected here to call attention to the high level of complementarity demonstrated by Israeli UAVs and strike aircraft in the conflict over Lebanon in 1981.]

Question: Are UASs seen as equally useful in dealing with legacy foes as with challenges from asymmetric, non-state actors?

Answer: In a word, yes. They have reached the point where, from a strict capability perspective, UASs can physically do approximately 60-70% of the missions which manned aircraft can do. Again, the issues become primarily training of the operators. There will always be some missions where the situational awareness resident in the cockpit cannot be transferred to a console (i.e., air to air dogfighting, dynamic close air support or dynamic search and rescue).[31]

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[31] The issue of operator recruitment and training is one of growing importance. The size and complexity of the UAV suggests that no single formula for operator training will be optimal for all cases. The U.S. Air Force presently requires that its UAV operators be fully rated pilots who work in flight suits and receive flight pay. Such a rule might make sense for those controlling large and complex vehicles engaged in air combat and other missions where a significant level of airmanship could be essential. On the other hand, such a requirement would seem excessive for a soldier or marine operating a hand launched, relatively simple vehicle.
Relevant to this point is the comment of an Army Raven Equipping Detachment officer in Kuwait: "The Raven is not MOS (Military Occupational Specialty) specific. One of the best pilots in the 1st Cav is a cook...The soldiers are trained...at the training base in Kuwait with a two week program of

A comment by another respondent supplements the last answer above. If UAVs were used against more capable legacy foes, survivability problems would have to be addressed -- which will doubtless make them heavier and more costly. Under such circumstances, requirements creep and gold plating will almost inevitably appear.

7. Defense Industrial Base Considerations

In this section, we present a series of questions and the set of written answers offered by the respondent referred to above. Then, these answers will be supplemented with observations on the same subject presented in private conversations with the other respondents.

Question: Can changing trends be identified in UAS usage with possible impacts on the defense industrial base?

Answer: Yes. As we migrate to more missions for UASs (beyond ISR), there will be a shift required to weaponization and increased situational awareness at the UAS operator console. The UAS Command, Communications and Control architecture will become more important than the actual air vehicles.

Question: Are there significant differences between the experience of free standing UAS firms and UAS divisions of large multiproduct firms?

Answer: In a word, no. Most of the larger companies without UAS manufacturing capability have formed Teaming Arrangements with smaller

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instruction. We've trained 44 different MOSs...from Apache pilots to cooks." (Jenkins and Snodgrass, 2005, p. 36

Such an opportunity for an enlisted soldier might well be considered an upgrade in responsibility, perhaps rewarded by promotion to warrant officer rank. However, given the ethos of fighter pilots, such a transfer of a pilot to operate UAVs from a trailer truck somewhere far from the fight might not appear an attractive opportunity. Under present circumstances of operator shortage, temporary transfer of pilots from other aircraft has been the typical path taken by the Air Force. If this pattern continues but such an assignment becomes a necessary requirement for an Air Force officer's career promotion, it might be seen as an acceptable stint.

However, such a temporary assignment would appear to run counter to a recent statement by the Air Force Chief of Staff expressing a need for a career path for UAV professionals equivalent to their rated counterparts (IISS, Weber, 2011).

firms who do. As previously discussed, the "cottage industry" folks have been marginalized to some extent due to the importance of milspec/milstandards.

Question: Are there ways to integrate previously independent and innovative firms into larger organizations without stifling their creative capabilities?

Answer: Yes and no. There are ways to do it, and many have been successful (Boeing/Insitu, L-3/Geneva Aerospace, Northrop Grumman/Scaled Composites). What typically happens is the overhead of the larger companies drives costs way up.

This answer is supplemented by other responses obtained in the interviews. A top executive of a company absorbed into a larger multiproduct firm considers the transaction successfully conducted. He noted that top management recognizes that the small company perspective developed in the absorbed firm added much to its success. Hence, it would be foolish to change that, and endanger the creativity which motivated the absorption in the first place. Another consideration was focused on the history and nature of the absorbing firm, which for most of its existence operated principally in civilian markets where considerations of cost and customer awareness were important.

The degree of control exercised over the acquired firm may also reflect the philosophy and structure of the acquiring firm. An executive of one firm focused attention on this point, noting that if the acquirer was controlled by venture capitalists rather than by an entrenched industry management, the bottom line, or economic success of the operation would be uppermost, rather than the inner details of the organization's bureaucracy.

Another respondent from a firm with experience in such organizational change conceded that experience suggests the likelihood that small creative firms bought by larger multiproduct companies will find it difficult to retain their creativity. To do so would require that they successfully resist the strong tendency for the bureaucracy of the larger organization to take control and force corporation-wide consistency in the application of its rules and policies. Decision makers in the larger firm have the difficult choice of weighing the possible synergistic benefits found in corporate integration against the risk that doing so will stifle the creativity that

originally motivated the acquisition. Top management must tailor its policies to secure the objectives behind the acquisition. If creativity is uppermost, then the required policy will be to leave the new unit essentially alone. This may require allowing it to operate in its own premises and to take serious steps to discourage visits from officials of the acquiring firm, especially from such bureaucratic departments as human relations, accounting, etc. In other words, the absorbing firm should attempt to maintain the fiction that nothing has changed except for the new availability of more capital and advice when desired.

One respondent admitted that such an operation would be difficult to carry out successfully, and, interestingly, doubted that the chances were good that such independence, even if attained, could be sustained over the long run. He appeared to believe that, however gradually, integration into the mainstream of the company was probably inevitable. A suggestion that Lockheed's famous "Skunk Works" might be an example to the contrary was rejected by another participant on the grounds that its history has been limited, largely, to work in the "black world" and that it has never been an incubator of new ideas that migrated into the company at large.

> **Question:** Is there a future for the smaller, independent firm in dealing with the DoD or are obstacles such as mastering the intricacies of procurement regulations an insurmountable hurdle?
>
> **Answer:** My experience the last ten years is no. The smaller companies need the backing of the larger scale firms to adequately compete (teaming agreements/partnering/etc.). Go it alone and you're under-resourced in the "FEDBIZOPS."[32]

Another respondent suggested that it wasn't necessarily the size of the acquiring organization but the presence or absence of the risk takers. At some point, he felt that people in any organization have to learn how far they can go, or what the "thou shalt nots" are. He emphasized that companies differ in their cultures and how they respond to failure. He felt a critical question was whether you were

"shot for failure" or, whether you operated in an environment in which decision makers believed that "nothing succeeds like failure" in the learning process.

Question: How important are UAS divisions within larger multiproduct firms in terms of sales, revenue, and/or other measures of performance?

> **Answer:** It's all related to the business case in each opportunity. Those who can compete for large scale DoD business with superior products (success breeds success) can justify a larger portion of the company's business development budget.
>
> **Question:** How important are foreign firms in UAS supply chains or as customers, and have U.S. export control and technology transfer regulations constituted significant obstacles?
>
> **Answer:** The foreign UAS market is expanding but is still a distant second to the DoD. The Israelis have the lead on numerous fronts but the US is starting to make inroads. Export licensing has not been a huge problem for tactical class UAS and below, but the Medium Alt Long Endurance (MALE) market is "handicapped" by CMTR (Cruise Missile Treaty Regs regulations prohibiting the sale of longer range UASs to non-signatories of the CMT).

Another respondent described the International Traffic in Arms Regulations (ITAR) as "the bane of our existence", and complained that the interpretation of the rules by the State Department's Bureau of Political and Military Affairs has been inconsistent.

An industry veteran made some general comments about dealing with the government which may be applicable to the topic of export controls as well. He noted that today's environment is the most risk intolerant he had seen in his 30 years in the industry. His impression was that the present system appears designed "not to succeed, but rather, not to fail". The bottom line was that risk taking is being discouraged.

The issue of export controls has attracted the attention of top industry executives. At the July 2010 Farnborough air show, Wes Bush, CEO of Northrop

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[32] A US General Services Operation web site which serves as the "single government point-of-entry for federal government procurement opportunities over $25,000." (www.gsa.gov/portal/content/103541)

Grumman, noted that U.S. export controls could harm the nation's advantage in unmanned aircraft technologies by encouraging foreign competitors to develop their own systems. In his words, "We need to realize exactly what it is we're trying to protect. There are a lot of folks around the world that understand how to build really good airframes. And a UAV is basically an airframe" (Anselmo, 2010).

8. Remarks

Academics and scholars have concerned themselves with the question of whether UASs are transformational and represent a revolution in Military Affairs. One such treatment described a transformational change as one which "convey[s] an asymmetric and possibly decisive advantage to the side that possesses" [such devices or technology]. The author contrasts such a revolutionary change with an evolutionary change, which can be countered by matching innovations (Mahadevan, 2010). He considers drones as belonging to the latter category.

Other commentators' opinions may differ with this categorization. Historically, a number of innovations with important military applications can be identified: the replacement of sails with steam engines on naval vessels; the introduction of the tank during World War I; the development of manned aircraft following the appearance of balloons; and the development of nuclear power and of space satellites. Whatever they were labeled, the military was obliged to apply them to military purposes, and the development of UASs was no exception.[33]

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[33] It is of interest to note that after a long and rather unsuccessful history of attempts to reform the cold-war vintage collection of U.S. arms transfer regulations, a fresh attempt appears to show promise of adoption. In April 2010, Defense Secretary Robert Gates announced a new Administration plan for sweeping reforms aimed at the establishment of a single control list, administered by a single agency for licensing and enforcement, using a single information technology.
The plan was the product of a widespread interagency review of the current system directed by the President in the summer of 2009. In an August 2009 statement, he commented that "we need fundamental reform in all four areas of our current system in what we control, how we control it, how we enforce those controls, and how we manage our controls."* If successfully implementd which will require both Executive and Congressional action, many of the problems resulting from the implementation of current regulations may be significantly alleviated (The White House, 9 December 2010; Censer, 27 March 2011).

Since no nation has a monopoly on creativity, time becomes an important element in the process of development, and it must always deal with the human preference to stay with the familiar. Thus, the role of the person with foresight and the capacity to take risk remains highly important. In this context, one may watch the influence of a recent product of the Naval War College which recommends a virtual restructuring of the U.S. Navy around the concept of Unmanned Systems (Chief of Naval Operations Strategic Studies Group [CNO SSG], 2009).

9. A Small Unmanned Aerial System: Raven

The U.S. Army made its first efforts to develop a relatively small battlefield Remotely Piloted Vehicle (RPV) in the early 1980's. That program was named *Aquila* and was sponsored by the Field Artillery community as a new target acquisition capability. The program was not successful due to many reasons, not the least of which was "requirements creep." Users, as the program evolved through early developmental stages, wanted increasing sensor capabilities that exceeded the original design payload. Attempts to "scale-up" the original design to accommodate the increased weight were not successful and the program suffered many test failures.

The inaugural Vice Chief of Staff, Army (VCSA) Field Artillery Functional Area Assessment (FAA) in 1984 sealed the Aquila's fate. General Maxwell Thurmond, after taking the Aquila's Assessment Briefing, determined that the technology required to meet the Field Artillery requirements was insufficiently mature and ordered the program terminated. Army RPV efforts went back into the Technical Base and Exploratory Development Research communities.

From that beginning, Army and DoD RPV programs evolved into Unmanned Aerial Vehicle (UAV) programs that developed larger and more capable air vehicles that

eventually grew into Major Defense Acquisition Programs (MDAPs). The category of UAV was recently renamed Unmanned Aerial Systems (UASs).[34]

This section will focus on a case study from the smallest end of the UAS spectrum: the RQ-11 "Raven," a hand-launched small UAS, hereafter referred to by its popular name: Small Unmanned Aerial Vehicle (SUAV). Mawn and Tokumaru (2005) page 1 summarized the Raven's early history:

> The SUAV capability was identified during the [Military Operations in Urban Terrain, Advanced Capability Technology Demonstration] MOUT ACTD (FY98-02). This program focused on identifying technology solutions in 33 requirement areas for dismounted forces fighting in urban terrain. The Pointer SUAV, an AeroVironment, Inc. product, was provided as a technology solution for meeting the requirement for an organic intelligence-gathering tool. Initial warfighter experimentation with the system provided positive feedback and identified some shortfalls which were addressed by the program before the culminating demonstration. These included addition of an infrared (IR) camera for night operations, shrinking the ground control unit to a man-portable size, integration of the military P(y)-code global positioning system (GPS), and receipt of approvals from the Army spectrum manager for military use.

Experimentation data and soldier feedback gathered throughout the MOUT ACTD clearly demonstrated enhanced warfighter performance and resulted in user acceptance during experimentation. During the program's culminating

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[34] Another development is worthy of attention, that of the public perception of UAVs. Speaking at an April conference on UAVs (IISS, April 2011), Lieutenant General David A, Deptula, USAF (Ret.) and General Michael V. Hayden, USAF (Ret.) both cautioned against widespread misinterpretations of how UAVs work. Critics often assume that because there is no pilot aboard the vehicle, it can be viewed as an armed robot capable of taking over from the control of human beings. This overlooks the fact that there is a significant human footprint on the ground to control the aerial vehicle. Another component of the argument of the critics is that the very fact that UAVs remove the traditional pilot from harm's way serves to dehumanize combat and, thus, makes war more likely. Much use has been made of the famous comment of Robert E. Lee after the Battle of Fredericksberg in 1862: "It is well that war is so terrible, else we would grow too fond of it." The logic is clear: if war is less horrible, it is more likely. Another line of attack is that war is not less horrible and that "collateral damage" is substantial. A typical statement reads that "The evidence shows that the hyperbole surrounding UAVs and their vaunted precision is sheer fantasy, if not literally science fiction." Sluka, 2010) Such a view would appear to be written in complete ignorance of the civilian casualties of WWII from carpet bombings of Germany, firebombings of Japan (not to mention losses from the nuclear attacks on Hiroshima and Nagasaki) and the V-bombs used to attack London in the last year of that war. It also ignores the Al Quaida and Taliban tactic of positioning its forces and weapons among the civilian population.

demonstration in September of 2000, 28 technologies satisfying a variety of requirements were utilized. The Pointer SUAV was ranked third among those, thus validating the military utility of the SUAV capability.

Technology successes during the MOUT ACTD resulted in funding for an experimentation extension during the extended user evaluation period of the MOUT ACTD (FY01–02). During this period, limited funding allowed the team to pursue further development of technologies that had demonstrated military utility. The Pointer SUAV had been a clear success, but had also exhibited shortcomings which could not be addressed in time for MOUT ACTD's culminating event, chief among them were its size and weight. The MOUT ACTD funded AeroVironment in April 2001 to explore the feasibility of a platform with the same capability at half the size and weight. The Flashlite SUAV resulted. A subsequent Phase II contract award yielded the first RAVEN SUAV.

The program that became the Raven had initially received interest and some funding from the Special Operations Command (SOCOM). SOCOM wanted a small, man-portable and hand-launched aerial system that could carry sensors to extend the "vision" of small unit commanders beyond line-of-sight in order to gather intelligence concerning enemy dispositions. Major Aerospace Corporations were generally not interested in developing such a low-cost, unsophisticated system. However, a few small businesses with some aircraft and electronics capabilities were interested. One such company, AeroVironment of Simi Valley, CA, was selected to support the ACTD. The promise demonstrated in the MOUT ACTD led to further funding (Pathfinder ACTD-FY02–06) and a defacto "partnership" evolved between U.S. Army Natick Labs on the Government side and AeroVironment on the contractor side to develop an increasingly sophisticated small unit Intelligence, Surveillance, and Reconnaissance (ISR) system.

10. The Pathfinder Raven System

The Pathfinder Raven SUAV, hereafter referred to as just Raven, is essentially a semi-autonomous small aircraft that is powered by a battery-driven

electric motor. The use of a reliable and maintainable electric motor facilitates a relatively low noise signature to enable Raven to be difficult for the enemy to detect. It is controlled from a man-portable custom ground station that also receives sensor data for real-time battlefield use at small unit (company-sized and smaller) level. The Raven carries either a day (electro-optical) or a night (infrared) sensor.

Mawn and Tokumaru (2005) page 2 described the system:

> The air vehicle weighs 4 lbs, with a wingspan of 4.5 ft, and is capable of 80-minute flights using rechargeable batteries or 100-minute flights with one-time use lithium batteries. The air vehicle is capable of a nominal operating range of 10 km under manual, semi-autonomous, or full autonomous operations, and incorporates military GPS for navigation. The Pathfinder Raven SUAV requires no special equipment during launch and recovery. The system is hand-launched by a standing operator and recovered in a deep stall configuration allowing for operation in small complex terrains. The aircraft speed range is 20 to 70 mph.

The air vehicle is designed for rough use and is modular in construction in order to be easily portable as well as repairable using minimal tools. It is carried disassembled in a ruggedized and waterproof soft pack. Modules, including the wings and tail, are virtually "snapped together." This modular design also permits rapid replacement of damaged parts; the air vehicle was literally designed to be crashed.

Mawn and Tokumaru (2005), page 1, continued:

> The Pathfinder Raven SUAV is primarily a reconnaissance, surveillance, and target acquisition system. The SUV provides the small unit with enhanced situational awareness and increased force protection, by providing the means for expanded reconnaissance/surveillance, coverage of marginal maneuver areas, as well as increased target acquisition capability and an ability to reduce exposure in high-risk situations. The system has proven itself to be a critical asset, acting as a force multiplier in the conduct of intelligence, surveillance, and reconnaissance operations from remote locations, reducing or eliminating enemy contact.

11. System Development Approach

The Raven development was somewhat unorthodox. During its gestation period, the requirement evolved from the previously-discussed ACTDs on a rather ad hoc basis, outside of the formal Major Systems acquisition process. Formal, Pentagon-staffed requirements documents did not exist until the Raven program was well into the Engineering and Manufacturing Development (EMD).

SOCOM has acquisition authority that is independent of the Defense Acquisition Executive (DAE) and the Defense Acquisition Board (DAB) process and has their own, organic, Acquisition Executive. Some in the Congress grew tired of Special Operations and Low Intensity Conflict being under-resourced by the military services during the annual budgeting process and passed legislation establishing both an independent acquisition and appropriations process for Special Operations. Acquisition programs are supposed to generally mirror the DoD Framework and be modified to fit SOCOM's unique needs.

This independence has facilitated reduced cycle times and more timely fielding of new equipment. SOCOM's requirements generation process is far less bureaucratic and cumbersome than the DoD's processes. Therefore, when SOCOM decided that Raven capability showed promise and the potential for high military utility, they proceeded with development faster and less formally than with conventional acquisitions. Rather than starting with a "final" end-state requirements document, they used a "spiral development" method. Mawn and Tokumaru (2005) page 2 described it in this way:

> Spiral development is characterized by an iterative cycle of requirements definition (and re-definition), prototyping, systems architecture development, and user feedback. The development spiral is described in bullet form:
>
> - Concept is introduced to users.
> - Users identify requirements for the system.
> - Prototype is designed based on requirements
> - Users evaluate prototype (and requirements).
> - New requirements or design guidelines are created.

As success is achieved in each design cycle, the scope of each successive design cycle is increased to get closer to the final product and to include a larger representation of the user group(s).

A basic premise of the development cycle is recognizing that the user may not be able to clearly articulate a particular requirement. Most often the user is better at looking at an existing prototype and saying "these things I like," and "these things I don't like." During the development of the Pathfinder Raven SUAV, the Pointer SUAV [an earlier prototype] provided an initial reference point for both development and user feedback. Using this method, significant progress was made toward a user-accepted product using relatively low cost prototypes.

12. Issues

In 2002, the United States Special Operations Command (USSOCOM) decided to procure the evolved Raven for operational employment in response to an Urgent-Combat Mission Needs Statement (C-MNS). This meant that training had to be set up, manuals written and printed, and a limited logistics package developed. The Natick-AeroVironment Team had to establish a training cadre that consisted of many of the initial Raven developers. As they began training soldiers, they discovered that interacting with them every day led to further refinements to the Raven to make it as "user-friendly" as possible. Working with the students also facilitated the formulation of the necessary Tactics, Techniques, and Procedures (TTPs) for actual operational employment of the system. In addition, as experience was gained, more subtle refinements were incorporated into Raven.

Low Rate Initial Production (LRIP) of Raven Block I began in May of 2003 and an improved Block II Raven configuration was cut into production in September of 2003. In early 2004, a Rucksack-Packable Unmanned Aerial Vehicle (RPUAV) Operational Requirements Document (ORD) was formally adopted by United States Special Operations Command. In the special operations world, urgency frequently outpaces the traditional acquisition process.[35]

[35] USOCOM wrote the ORD with the USASOC as the proponent. The Army then adopted the ORD.

As the Raven became more successful, it attracted interest from 18th Airborne Corps and the U.S. Army Infantry School. The latter being the official requirements-developing activity for Infantry weapons. Since the Raven had been born in the Special Operations world, it had not followed the traditional Mission Area Analysis (MAA) route that identified deficiencies in combat capability and evolved a Mission Need Statement (MNS) that then further evolved into an Operational Requirements Document (ORD). At this time, the existing U.S. Army Project Manager-Unmanned Aerial Vehicle- Small (PM-UAVS) became involved and an Urgent Need Statement (UNS) was promulgated, further production of the Block II Raven was funded, and deliveries were deployed in Iraq and Afghanistan.

Mawn and Tokumaru (2005) page 6 state that

> In early October, the training cadre deployed to Afghanistan with the Block II Pathfinder Ravens and conducted the first Raven training session. Employment of the SUAV in-theater exposed weaknesses, most notably in the tail control surface servos, the motor, and the IR camera shutter. As each of these weaknesses surfaced, they were appropriately investigated and fixed.
> The system continued to show great promise and the U.S. Army exercised a buying option to increase their total buy to 179 3-bird systems. Concurrently, the USSOCOM issued a Combat Mission Needs Statement for 59 systems. The system is now in full-rate production.

13. Going Mainstream

The challenge for Raven now became integration into the U.S. Army. When Raven's utility at the small unit level was finally realized by the Army-at-large (and the U.S. Marine Corps), it was outside of the mainstream research, development, and acquisition "system." There was no formal doctrine beyond the TTPs developed by SOCOM. Raven was not currently incorporated into the Army school system and needed to be quickly institutionalized. In addition, there was resistance among some officers and units to this "model airplane." Its ISR capabilities were not intuitively obvious to field commanders.

Jenkins and Snodgrass (2005) page 2 summarized:

> Leader 'buy-in' to the Raven SUAV was recognized early by the Project Manager's office as being one of the most important issues for the success of the Raven system. The PM office's primary venue for gaining leader buy-in is the New Material Introductory Brief (NMIB). This briefing informs the leadership of the Raven SUAV capabilities and limitations. The PM Office should continue educating commanders at all levels to ensure they are fully aware of the Raven SUAV and how much of a combat-multiplier the system really has become.

Because Raven was so new to commanders, much of its doctrine was being developed "on-the-fly" by each of the small units that became convinced of its utility. Jenkins and Snodgrass (2005) page 2 continued:

> The differences in Raven SUAV usage among deployed commanders form the dichotomies between doctrine and practice with regard to this system. Using Doctrine, Organization, Training, Materiel, Leadership Personnel, and Facilities (DOTML-PF) as a framework, we discovered that Doctrine is the component of DOTML-PF that has the most dichotomies when comparing "Doctrine" to "Practice" in Raven SUAV operations. There are missions listed in the Raven TTP Manual that are executed as written and others that are modified to meet the commander's operational needs. Furthermore, commanders are using the system to conduct missions that are not written in the Raven TTP Manual, but are of value and continue to preserve lives and increase unit effectiveness.
>
> These differences, which many key leaders have deemed the "commander's innovativeness," bring into focus whether there is an efficient and effective feedback loop for lessons learned. The feedback loop for the Raven SUAV remains a work-in-progress as a result of its newness to the Army community. The current process for getting feedback information from the field is executed in two ways. In some cases an Operational Assessment (OA) team will travel to theater to collect information, and then report it to the Department of the Army and TRADOC. On other occasions, a Center or School House will do an independent survey either during or after a rotation by a certain unit. Usually those surveys are After Action Reports (AAR) conducted shortly after a unit has returned.
>
> The bottom line is that because dichotomies exist between doctrine and practice in Raven SUAV usage, it is imperative that units capture the good and the bad while operating the system. The mechanism for relaying this critical information from the field must be made standard and checks must be conducted to ensure that the information is put into doctrine for follow-on units to execute."

As Jenkins and Snodgrass (2005) have indicated, stabilizing and communicating doctrine and evolving TTPs was a challenge. The Project Manager UAVS, hosted several "feedback conferences" for commanders redeploying to the United States from Afghanistan and Iraq. Reports from these conferences were widely disseminated and led improvements in both doctrine and TTPs. Although institutionalization was initially challenging, Raven is now thoroughly accepted throughout the Infantry and Marine Corps.

14. The Future

One problem that is emerging for Raven (and other small UASs) is low altitude airspace congestion. As Raven's employment proliferates, the problem will worsen. There are many different aircraft trying to operate over the same battlefield space in Iraq and Afghanistan. Most of those at low altitude are relatively large helicopters operating under Visual Flight Rules (VFR). Helicopter pilots are accustomed to watching out for and avoiding other helicopters and light, fixed-wing aircraft. However, as Raven is a very small air vehicle, it is difficult for a fast-moving helicopter to see it in time to avoid a potential collision. Great concern has been expressed by pilots that unless some better protocols are developed, serious crashes will occur. Military aviation officials are studying the problem, but no clear-cut solution has yet emerged.

This concern has also been expressed in the civil aviation community in the United States as UASs also proliferate there. There has been much discussion in the aviation press of a recent incident in which a developmental U.S. Navy UAS lost communications with its Maryland test site and flew into restricted airspace. Civil aviation authorities also recognize the problem and are investigating potential solutions.

Raven has been so successful, that users are demanding increased capability. The fielded Block II Raven utilizes an electro-optical sensor for daylight operations and a thermal infrared sensor for night operations. An analog downlink is used to transmit video and imagery data to the man-portable ground control station

for near real-time viewing. Although the analog link has proven reliable, it consumes a far larger portion of bandwidth than a digital link would. Starting in 2006, the U.S. Army's Natick Soldier Research, Development, and Engineering Center's Advanced Concept Technology Demonstration and Urban Technology Office, began development of a digital downlink for Raven. The effort was funded by the DoD's Office for Advanced Systems and Concepts and USSOCOM, and matched by prime contractor AeroVironment with company Independent Research and Development (IR&D) money.

The digital data link's intent is to establish the ability to provide greater range and increase the number of discrete SUAS communication channels fourfold, add relay capability, offer improved video clarity, and provide encryption capability. A 2009 experiment at White Sands Missile Range, NM, helped to further refine and develop the Digital Data Link (DDL) prototypes. PM UAVS has contracted for production of 25 systems based upon the ACTD design. Fifteen systems were set aside for a Brigade Combat Team to conduct a Military Utility Assessment (MUA). The PM is already planning on success; an Army Acquisition Objective (AAO) of 2182 Raven systems has been established. Plans are in development to retrofit the entire Raven fleet with the DDL.

The actual Military Utility Assessment took place in Afghanistan from mid-July through mid-August 2010. Nine Raven systems were evaluated by a U.S. Army Special Forces Battalion and flown from an active Special Forces Operating Base. These systems were left behind for the unit's use during the remainder of their deployment.

Fields (2009), page 7, concluded:

> The OCONUS MUA achieved the stated goal of demonstrating the DDL Raven SUAS in an operational environment. Shortcomings in the Low Rate Initial Production (LRIP) system were identified that can be corrected prior to going into Full Rate Production (FRP). The EXFOR [Exercise Force] was provided with training, operational systems, and short-term fixes for those systems so that they can continue to use them for the duration of their deployment.

One of the most difficult challenges in DoD research and development is the transitioning of a demonstrated technology across what many have called “the valley of death,” into a fully-funded Program of Record (POR). Many promising technologies initiate the process, but relatively few actually cross the valley and attain POR status; the Raven is one of the relatively few that has.

The Raven has completed its transition into the “mainstream” acquisition process and is now PM-managed as an Acquisition Category (ACAT) III system by PM UAVS in Huntsville, AL. The evolutionary development process continues as new increments are authorized, developed, and fielded to improve Raven’s capabilities and military utility.

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V. Concluding Remarks

As noted, this report continues our research on international defense industrial affairs. We continue seeking to highlight key developments in the global defense industrial complex, place those developments in context (especially with respect to global economics and contemporary military affairs), and offer new paradigms for understanding contemporary defense industries. In this report we've continued our research into the ongoing KC-X affair, the C-27 as a case study in globalization of the aerospace and defense industries, and the rise of unmanned systems, with respect to their impacts on military affairs and defense industries.

The attempt to replace U.S. Air Force tankers (with some form of KC-X) continues as a perfect storm of systemic dysfunctionalities—a nasty confluence of bureaucratic, legal, and political obstacles to carrying out public business. What is especially noteworthy is that the usual explanation of technical ambition (pushing the envelope) most assuredly does not apply here. Also, it illustrates well the pervasive potential for unresponsiveness in the U.S. defense acquisition system—a particularly worrisome issue in an era of hyper-adaptive warfare.

The C-27 light military air transport is an excellent example of the growing integration of the aerospace industry along global lines. Intended primarily as a replacement for various types of light air transports, it may well indicate that the primary motivation for acquiring new airplanes is replacement, rather than modernization. (The KC-X is arguably a replacement aircraft also—and not part of fleet modernization.) C-27 developments illustrate well the changing relationships involving the aerospace industries and the global defense market. These relationships have been a major theme in our research agenda, and remain fruitful topics for further research.

Finally, we have commenced a serious inquiry into the rise of unmanned systems—aerial vehicles (UAVs) in our case—including larger types such as Reaper and smaller aircraft such as Raven. Unmanned military vehicles are likely to have a

pervasive effect on military affairs, the defense industrial base, and the acquisition system.

Viewing unmanned systems as innovations, we have examined what may be viewed as two aspects of a common phenomenon—the introduction of new ideas/products into established institutions, large industrial corporations, and large military organizations. This is a topic obviously worthy of further research—which we propose to do. Fortunately, there is an interesting body of theory recently emerging (e.g., Baumol, 2002 and 2010) which can serve as a foundation for such inquiries.

The relatively small size of development projects for unmanned aircraft has opened significant opportunities for smaller firms (like General Atomics), and smaller countries (such as Israel), to be major players in the unmanned systems market. In particular, the relationships between larger and more experienced firms and smaller firms with good ideas, is a promising topic for continued study.

Another interesting aspect of unmanned systems (such as Raven) is their origin in rapid-development programs outside the mainstream defense acquisition system. The next test comes with the integration of the quick-reaction responses with the standard maintenance and logistics structure. While Raven is an interesting example of dealing with the problem, a continued search for main themes in solving these problems is a valuable line of research.

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