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Applications for NAVY UNMANNED AIRCRAFT SYSTEMS

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Prepared for the United States Navy

Approved for public release; distribution unlimited

RAND NATIONAL DEFENSE RESEARCH INSTITUTE

The research described in this report was prepared for the United States Navy. The research was conducted in the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Department of the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community under Contract W74V8H-06-C-0002.

Library of Congress Cataloging-in-Publication Data is available for this publication.

978-0-8330-4965-0

Published 2010 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
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Summary

Background

There has been tremendous growth in demand for unmanned aircraft systems (UASs) by the United States military since 2001. The United States Navy is making large investments in a number of major UAS programs, including Broad Area Maritime Surveillance (BAMS) UAS, the Unmanned Combat Aircraft System Demonstrator (UCAS-D), the Fire Scout vertical takeoff/landing tactical UAS (VTUAS), and the Small Tactical/Tier II UAS (STUAS/Tier II UAS). Navy OPNAV N81 asked RAND to provide an evaluation of the Navy's ongoing and proposed UAS programs and to describe the most promising applications of UAS to operational tasks. These assessments were to include arguments for and against using manned vehicles to perform the same tasks as unmanned vehicles, where appropriate. Completed in September 2008, the study does not provide an exhaustive look at all DoD missions for UAS. It does, however, discuss the strengths and weaknesses of manned and unmanned aircraft for certain missions of importance to the Navy. We emphasized traditional Navy missions rather than Navy contributions to irregular warfare, though we examined a few nontraditional missions, such as counter-piracy.

Methodology

We evaluated current UAS applications and applications for future UASs that have been advocated in recent studies and U.S. government published roadmaps (Ehrhard, 2008; OSD, 2005, 2007; O'Rourke, 2006). We characterized UASs currently in use or development by the Navy, Air Force, and Army. We relied on information gathered during visits to the contractors that design, develop, and manufacture these systems to aid us in our characterization. Our primary focus was on applications for Navy UASs in the 2015–2025 time frame, when several of them will have reached initial operating capability and the Navy will potentially have an operational unmanned combat aircraft system. We contrasted the characteristics of these UASs with those of similar manned aircraft and identified potential advantages and disadvantages of the UAS in military applications.

For each Navy UAS program, we then identified the applications that best leveraged the advantages offered by UAS compared with similar manned aircraft, and when possible, we identified ways of mitigating potential disadvantages. We used operational performance as our criterion rather than financial cost.

This research drew on results from several recent studies of UASs conducted within RAND Project AIR FORCE. These included a study of future roles and missions of Air Force UASs led by James Chow, and multiple studies of maritime surveillance with Global Hawk led by Sherrill Lingel.

Advantages and Disadvantages of Unmanned Aircraft Systems

UASs tend to have advantages for applications that are too "dangerous," "dirty," "dull," "demanding," or "different" to be performed by manned aircraft:

- *Dangerous* applications are those involving a high potential for death or injury to the crew. The advantage of UASs in these applications is that the crew is displaced from the threat.
- *Dirty* applications are a subset of dangerous applications that include operating in an environment with dangerous chemical, biological, radiological, or nuclear materials.

- *Dull* applications are repetitive tasks that lend themselves to automation and would otherwise lead to crew fatigue. An advantage of UASs in these applications is that crew may be rotated without landing the aircraft.[1]
- *Demanding* applications include those that place high demand on the crew. For example, crew may be the limiting factor in high-endurance applications or those subjecting the aircraft to high g-forces. Demanding applications may also include those that place high demands on aircraft performance. Eliminating the weight and volume associated with a crew provides additional degrees of freedom in aircraft design, potentially enhancing aerodynamic performance.
- *Different* applications are those that are not feasible for manned aircraft. For example, small hand-launched UASs can provide quick input to organic intelligence, surveillance, and reconnaissance (ISR) and aid in providing situational awareness for Marines in the field; it may be difficult or infeasible to provide rapid access to these capabilities using manned aircraft.

There are also potential disadvantages in using UASs. We found that the most important disadvantage stems from their reliance on communication resources to connect the UAS to offboard operators and analysts.[2] High data rates, especially, are associated with sensors that provide imagery for ISR applications and may be on the order of tens to hundreds of megabits per second. For UASs, this information must be transmitted to offboard crew, and the data links may be vulnerable to attack. This is especially true for satellite communication

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1 It may be possible to cut back crew requirements for applications that are well suited to automation. For instance, a UAS operating as a communication relay may not require a dedicated pilot at all times. It might be possible, for example, to have one pilot controlling many communication relays except during takeoff and landing.

2 We also evaluated their dependence on GPS for position, navigation, and timing. We found that UAS and manned aircraft reliance on GPS is similar: Both rely on it for navigation, precision targeting, sensor and antenna pointing, and synchronization. Manned aircraft crew can aid in these tasks using their senses and decisionmaking capabilities. To some extent this can be done on a UAS by adding sensors and onboard processing capability, but it places additional burden on communication resources.

uplinks, which are vulnerable to noise jamming and kinetic threats. Also, applications in high-threat environments may require stealth for aircraft survival, and the active emissions necessary to connect the UAS to offboard crew make the UAS more susceptible to detection and, ultimately, attack. It is often desirable to send information from manned aircraft, too, but there is the option of exploiting the data onboard the aircraft—or at least filtering what information must be sent. Data-compression techniques can reduce the data-rate requirements, but at the expense of increased distortion in the data products. Technologies such as automatic target classification can also help reduce the data-rate requirements, but many of these technologies are still only in the laboratory and not yet ready for the battlefield.

Recommended Applications for Navy Unmanned Aircraft Systems

We made a detailed evaluation of options for an operational Navy Unmanned Combat Aircraft System (N-UCAS) and a broader evaluation of applications for other Navy UAS.

Airborne communication relays mitigate kinetic and noise jamming threats to satellite communication uplinks by providing an alternative set of links either directly to surface-based terminals or to satellites beyond the range of threats. They are less susceptible to noise jamming threats than satellites because an adversary has to detect, geolocate, and track the airborne asset and operate within line of sight of the receive antenna main beam. High-altitude, long-endurance UASs are particularly well suited to communication relay applications because high altitude extends the line of sight (LOS) and long endurance allows the communication link to be sustained for long durations. For these reasons, and since UASs are often highly dependent on satellite communication resources, we feel that communication relay is an important application for Navy UASs. We developed an operational concept for a theater relay system to provide communication resources to fleet assets, including other UASs. This system consists of two air-to-air links and an air-to-satellite link to provide connectivity to a satellite beyond LOS of jamming and kinetic threats. We also evaluated the design characteristics of communication relay equipment that would be needed.

We made a detailed evaluation of several potential applications for an operational N-UCAS that would follow successful demonstration of carrier capabilities for a low-observable (LO) design using UCAS-D (expected to be complete by fiscal year 2013).[3] The LO characteristics of UCAS-D make it well suited to applications in high-threat environments. Long-range and endurance attributes may give it advantages over manned aircraft, such as F-35C, for similar applications. However, as noted, reliance on communication resources is a disadvantage compared with manned aircraft. For this reason, we evaluated the communication requirements and examined the vulnerabilities that may result. We feel that development of low probability of intercept (LPI) tactical data links can mitigate many potential vulnerabilities and enable N-UCASs to support applications in high-threat environments. While there are ongoing efforts to develop LPI tactical data links—for instance, tactical targeting and networking technology and multifunction airborne data link—those efforts are focused on the needs of manned aircraft, not UASs. These observations led to our recommended applications for N-UCASs, but they are not the only observations that are described in detail in the monograph. Our evaluation of applications for the N-UCAS is summarized in the stoplight chart of Table S.1.

The Fire Scout VTUAS has an operational footprint that is a fraction of that of the multipurpose MH-60-class helicopters; it can operate from, and provide the UAS advantages to, surface ship platforms. Until recently, the Navy's testing and development of Fire Scout was closely tied to the evolution of the Littoral Combat Ship (LCS) program. Because of serious delays in the LCS program, the Navy decided to conduct operational testing on another vessel. With an electro-optical turret equipped with a laser designator and a small

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3 By low-observable, we mean that passive signature reduction techniques, such as fuselage shaping and the use of radar-absorbent materials, may be applied. However, we do not mean to exclude the possibility that active signature reductions would also be applied.

Table S.1
Evaluation of Applications for the N-UCAS

Application	Advantages for N-UCAS	Disadvantages for N-UCAS	Comments
Penetrating strike	Range, stealth, no danger to crew	Vulnerability of C2 data links	LPI data links could reduce vulnerability
Penetrating ISR	Range, stealth, no danger to crew	Vulnerability of data links for ISR products	LPI data links could reduce vulnerability
COMINT collection	Stealth	Large number of antennas required is detrimental to stealth	Useful secondary mission for high-threat environment
ELINT collection	Stealth	Antennas required are detrimental to stealth	Low data rate required for transmittal of data
Air-to-air combat	Range, stealth, no danger to crew, g-forces	Latency; vulnerability of C2 and sensor data links	Not useful in dogfight; manned/unmanned less ambitious
Airborne electronic attack	Stealth, range	Self-jamming; POD weight/power; LO compromised	Potentially useful in niche applications
SEAD	Close approach reduces kill-chain	Limited airborne electronic attack capabilities	Weaponized platform for niche applications
Close air support	Range, stealth		UASs already do it
CBRN detection	Range, stealth, no danger to crew	Accommodating sensors in stealth design and decontamination of aircraft are challenging	Sample collection may be good application for STUAS

NOTE: See the Abbreviations section for all acronyms.

surface search radar, the MQ-8B could provide a wide spectrum of surface vessels with an over-the-horizon maritime surveillance capability. Further, the Fire Scout has sufficient payload capacity to provide for a modest armament. Armed variants of Fire Scout could be used to interdict in a variety of small-boat threats. The Army plans to procure a variant of Fire Scout as its Class IV UAS for a Future Combat System (FCS) program during the middle of the next decade. Also, the U.S. Coast Guard is interested in Fire Scout as a sea-based surveillance platform. This provides the opportunity for a rather robust production run of a UAS vehicle family and may provide the Navy, the Coast Guard, and the Army with lower overall production costs.[4]

The A160T Hummingbird is a VTUAS under development by the Defense Advanced Research Projects Agency (DARPA) and Boeing. Flight tests are scheduled through the end of the decade. Although the aircraft is much larger than the Fire Scout with a footprint closer to that of the MH-60, it is expected to have higher altitude and payload performance.

The goal of the Navy and Marine Corps Small Tactical UAS/Tier II UAS (STUAS/Tier II UAS) program is to provide persistent ISR support for tactical-level maneuver decisions and unit-level force defense and protection for Navy ships and Marine Corps land forces. For the Navy, it may provide UAS operational capabilities to surface ships that are unable to support a larger platform such as Fire Scout. ScanEagle is one potential candidate for STUAS; it offers limited ISR capabilities in a high-endurance platform that can be launched and recovered from a wide spectrum of ships. STUASs may also be useful in chemical, biological, radiological, and nuclear (CBRN) applications—in particular, for detection, plume tracking, and collection of samples for offboard analysis after CBRN materials have been released due to an attack on a suspected CBRN weapon site.[5]

Study Recommendations

We recommend communication relay as an application for Navy UASs. Communication relay mitigates kinetic and noise-jamming threats to

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4 The FCS program was cancelled prior to publication of this monograph.

5 Boeing and a team of U.S. biodefense companies were awarded an $8.2 million contract by the Defense Threat Reduction Agency (DTRA) in 2006 to develop a biological combat assessment system for ScanEagle ("ScanEagle to Detect Biological Agents," 2006).

satellite communication uplinks. This will benefit fleet assets that are highly dependent on satellite communication resources, including other UASs. The BAMS UAS is particularly well suited to the communication relay application because of its high-altitude and long-endurance attributes, and the Navy has considered this application for the BAMS UAS.[6] However, a communication relay payload would compete for size, weight, and power needed for BAMS UAS sensors to support its primary role in providing ISR. This could be addressed by developing a modular payload capability for the BAMS UAS so that it could either be configured with multiple sensors to support its primary ISR roles or configured with a communication relay and fewer sensors for a more limited ISR role. Another alternative is to use the BAMS UAS for the air-to-air links only, and another platform, possibly a manned platform, for the air-to-satellite link. The air-to-air links require much less payload power than the air-to-satellite link, making more power available for sensors.

We recommend that the Navy support efforts to develop robust, LPI tactical data links, and to orient those efforts to meet the specific needs of the UAS. Development of this technology could be an enabler for LO UASs, such as the N-UCAS.

We recommend penetrating strike, suppression of enemy air defenses, close air support, and electronic intelligence (ELINT) collection as primary applications for the N-UCAS. We recommend that the Navy not invest in developing air-to-air combat capability for the N-UCAS because it will likely be less effective than manned aircraft in this application (in the 2015–2025 time frame). We also recommend that the Navy not invest in CBRN detection applications for N-UCASs because of the challenge of incorporating a suitable sensor into a stealthy design, and challenges associated with decontamination of the UAS upon recovery on an aircraft carrier. CBRN detection and tracking may be a promising application for other UASs, such as STUAS, but not for N-UCAS specifically. We see limited utility for the

6 Low-rate initial production vehicles are likely to include a basic communication relay package that leaves space for spiral development of a more capable communication relay package. See Richfield, 2007.

N-UCAS in penetrating ISR, comunication intelligence (COMINT) collection, and airborne electronic attack applications.

If the UCAS-D program is successful in addressing many of the challenges of operating UASs from carriers, we recommend the Navy consider development of nonstealthy, carrier-capable, medium-altitude, and medium-endurance UASs. The Army and the Air Force have realized tremendous operational advantages with this class of UAS (though they are not carrier-capable) for strike missions against time-sensitive targets. Operating similar UASs from carriers would be particularly advantageous in conflicts where carriers can be among the first assets on scene to project power and where access to air bases is limited. While the N-UCAS could be used for the same applications, it may not be the most cost-effective platform when operating in a benign environment where LO characteristics are not needed. If the UCAS-D program is successful in addressing the challenges of operating UASs from carriers, we recommend the Navy consider a mix of stealthy N-UCASs and potentially lower-cost nonstealthy UASs to meet its mission needs.

The Navy and the Marine Corps are currently leasing STUAS-class aircraft. For the Navy, the STUAS could support maritime interdiction operations by providing information about numbers of personnel aboard a vessel. It could be used to extend LOS communication range or to track vessels in support of counter–small boat attack or counter-piracy missions. STUASs may also be useful in CBRN applications, in particular for detection, plume tracking, and collection of samples for offboard analysis after CBRN materials have been released due to an attack on a suspected CBRN weapon site. Larger and more-capable platforms designed for a broader range of applications, such as Fire Scout, could be used for many of the applications envisioned for the STUAS. However, they would not operate from the same broad range of Navy ships and may not be cost-effective in these specific applications. If these applications are important to the Navy, then the STUAS/Tier II UAS program to acquire, own, and operate these platforms should move forward.