U.S. Drones

Smaller, Less Capable Drones for the Near Future

Maj. Zachary Morris, U.S. Army

The Department of Defense (DOD) has used drones in almost every military operation since the 1950s to provide reconnaissance, surveillance, and intelligence on enemy forces.[1] They have been called drones, robot planes, pilotless aircraft, remotely piloted vehicles, remotely piloted aircraft, and other terms describing aircraft capable of controlled flight without a pilot onboard.[2] The DOD currently defines unmanned aerial vehicles (UAVs) as:

> Powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.[3]

The UAVs are typically described as a single vehicle, including attached surveillance sensors, or as an unmanned aircraft system (UAS), which generally consists of three to six air vehicles, a ground control station, data links, support equipment, and personnel.[4]

Although drones have a long history, only in the last ten to fifteen years have advances in technology made a variety of current UAV missions possible. Still in a period of innovation, both in design and operation, UASs are analogous to early military aircraft, when technology and doctrine evolved at a rapid rate to exploit new capabilities.[5] The use of drones since the 1950s has illustrated the advantages of unmanned aircraft such as eliminating the risk to pilots' lives and enhancing aeronautical capabilities by removing human limitations; and, today, unmanned systems are cheaper to procure and operate than manned aircraft, though this may change in the future.[6]

As UASs comprise a growing portion of the defense budget, they continue to garner more interest from Congress and the military. Due to current budgetary limitations, the DOD has two realistic options for drone programs in the near future, and choosing between them largely depends on perceptions of the strategic and operational environment. The first option advocates fielding fewer, more expensive, and more capable drones such as the Global Hawk and Reaper. The second option encompasses fielding many smaller, less expensive, and less capable drones.

Based on the anticipated future strategic and operational environment, including contested airspace, the United States should pursue the second option. Constraining the military's proclivity to acquire more advanced and expensive systems will facilitate research and development into more advanced survivable systems for the future, sustain current high-end capability, and allow the DOD to procure numerous additional lower-level capabilities to create greater operational flexibility.

The justification for pursuing the second option is addressed in four sections in this article. The first examines the strategic environment and limitations high-end drone technology faces in contested environments. The second examines the evolution of drone force structure and the military emphasis on higher-end capabilities in the future. The third explains the budgetary evolution of drone programs and future budgetary challenges. The final section analyzes both potential solutions to future budgetary and strategic challenges.

The Strategic Environment

In the current strategic environment, drones have become central to the U.S. national security strategy, which combines counterinsurgency on the ground and airborne counterterrorism.[7] Drones were originally developed to

provide tactical and operational intelligence, reconnaissance, and surveillance, but since 2003, UAVs have transformed into the preferred counterterrorism tools for the DOD and the U.S. government. Beginning in 2002, when Predator drones were first armed, the United States has increasingly emphasized aerial strikes against our enemies.[8] By 2016, the United States killed an estimated four thousand enemy combatants using drones outside traditional battlefields.[9] Since 2003, no other nation has relied on such liberal use of unmanned aircraft to implement foreign policy. The United States was able to employ drones in this way largely because of uncontested airspace and prevailing technological dominance of drone capabilities.

Table 1. Force Structure February 2003

Unmanned aerial vehicle	Inventory
Global Hawk	4
Predator	48
Pioneer	47
Hunter	43
Shadow	21
Total	163

(Table by author)

However, the increasing likelihood of contested air and electronic warfare environments due to the growing availability of technology on the world market indicates many high-end UASs are becoming increasingly unsuitable for future conflicts. While drones currently play a prominent role in counterterrorism operations, the nature of expanding drone countermeasures potentially limits the future usefulness of current strategic drone programs. Drones currently lack the maneuverability, speed, stealth, and armament to survive in contested airspace. In fact, the single air-to-air combat engagement between a Predator drone and a manned fighter, in March 2003, resulted in the Predator's destruction.[10] Further, in 2015, a U.S. Predator drone was shot down in Syria by President Bashar al-Assad's dilapidated air defense system.[11] Finally, expensive high-capability drone losses in Ukraine have forced the Organization for Security and Co-operation in Europe to withdraw unmanned observer systems.[12]

Most drones employed successfully in Ukraine remain small (a ten-foot wingspan or less, approximately equivalent to the U.S. Shadow UAV) to increase survivability by minimizing observable signatures and to reduce the cost associated with their destruction.[13] An MQ-9 Reaper unit cost of approximately $30 million in 2011 represents over half the $55 million estimate for an F-16.[14] A simple comparison identifies the F-16 as a much more versatile combat aircraft with the ability to carry four times the payload and to perform numerous missions the Reaper cannot.[15] Therefore, based on current drone technology, it appears manned aircraft provide a more valuable combat capability in contested air environments. Because contested environments will probably limit current large drones' usefulness, the United States should focus on research and development while limiting the costs of procurement until drone capabilities mature further.

Previous page: Screenshot of U.S. Army "microdrone" commercial published 21 November 2016 on YouTube. (Screenshot courtesy of the U.S. Army)

Force Structure

Since 2003, the DOD has increasingly relied on UAVs for a variety of missions and dramatically increased the corresponding force structure and capabilities of numerous programs. In 2003, the DOD only had 163 drones across five different air frames, as depicted in table 1.[16] At that time, these 163 UAV aircraft comprised only 1 percent of the total U.S. aircraft inventory.[17] Between 2003 and 2012, the force structure expanded to 7,494 aircraft.[18] Due to drone expansion, manned aircraft dropped from 99 percent of all DOD aircraft in 2003 to 95 percent in 2005 and fell even further in 2012 to 59 percent.[19] The accelerated expansion of drones between 2007 and 2012 reflects the tenure of then Secretary of Defense Robert Gates and his emphasis on drones for combat missions in Iraq and Afghanistan.[20] The UAV force structure increase also reflects the military's emphasis on widening the capability range available, increasing UAV programs from five in 2003 to over seventeen programs in 2012.[21]

Presently, the DOD maintains a significant force structure and capability, including over 7,500 UAVs,

Table 2. Approximate Current Force Structure

Group	Unmanned aircraft system	Total number of vehicles	Ground control stations	Approximate cost per system
5	RQ-4 Global Hawk	36	7	$140.9-$211 million
	MQ-9 Reaper	276	61	$28.4 million
4	MQ-1 Predator	108	61	~$20 million
	MQ-1 Grey Eagle	26	24	~$20 million
3	RQ-7 Shadow	364	262	$11.1 million
2	Scan Eagle	122	39	$100,000
1	RQ-11 Raven	5346	3291	$167,000
	SAUS Puma	39	26	$250,000
	gMAV/T-Hawk	377	194	-

(Table by author)

providing tactical, operational, and strategic advantages globally. The U.S. military currently organizes drones into five groups based on capability, size, mission, and cost.[22] Table 2 depicts the approximate force structure of the nine largest drone programs organized into the DOD groups. Group five represents higher-end cost and capability, and group one represents the lower end.[23] The current structure maintains a relatively balanced mix of high- and low-end capabilities with the Air Force and Navy emphasizing higher-end capability, and the Army and Marine Corps favoring lower-end capabilities.[24] Because the UASs were originally designed for a fifteen- to twenty-year life span, some Predator and Global Hawk systems are nearing the end of their service life.[25] However, most systems were acquired between 2006 and 2012, making them relatively young. Further, because drones do not carry a pilot, service life extensions are more feasible as they are less risky and costly than manned systems.

In the future, the DOD plans to shift from the balanced high-low mix and emphasize higher-end capabilities predominantly, which will significantly increase the costs of drone operations over time. In the Air Force, current plans entail retiring the Predator fleet and acquiring seventy-five additional Reaper drones by 2021.[26] While procurement costs for such a move are approximately $2.1 billion, the real cost comes from increased operations and maintenance costs. Reaper squadrons currently cost $160 million annually compared to $70 million annually for a Predator squadron.[27] Changing the force structure from Predators to Reapers creates an annual increase in operations and maintenance costs of potentially over $550 million per year. Further, the Navy has invested over $1.4 billion in the Unmanned Combat Air System Demonstration (UCAS-D) program to assess the technical feasibility of operating unmanned air combat systems from an aircraft carrier.[28] The Navy also continues to develop the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) program to determine how to make an unmanned vehicle take on many aspects of a manned fighter.[29] Expanding these other group five drone programs will increase the operations and maintenance budget even further than the Reaper expansion alone.

Future drone emphasis indicates a desire to improve several specific capabilities including interoperability, reliability, autonomy, engine systems, air-to-air combat capability, and stealth.[30] These characteristics will likely dramatically increase both the capability of drones and their cost. In 1998, the DOD Darkstar research indicated that stealth characteristics alone for an UAV would cost over $1 billion (in Fiscal Year

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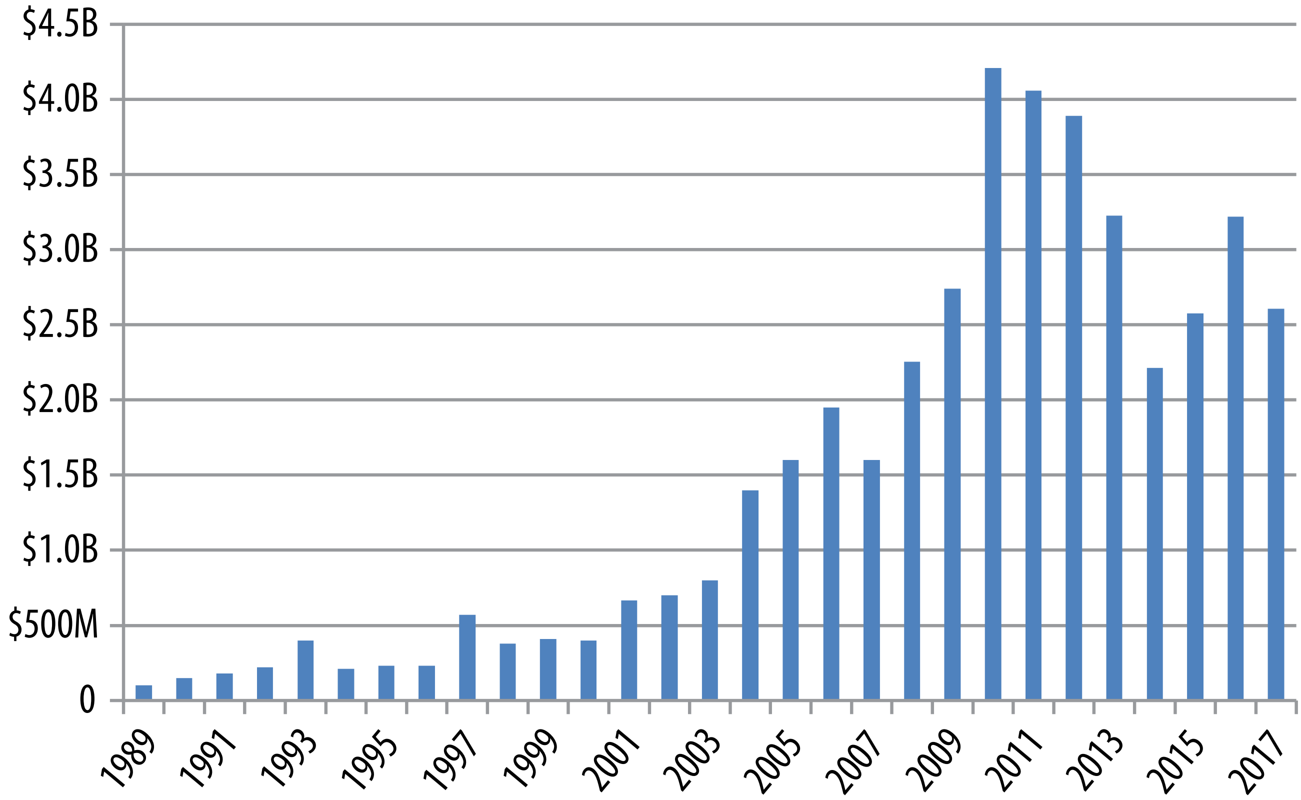


(Graphic by author)

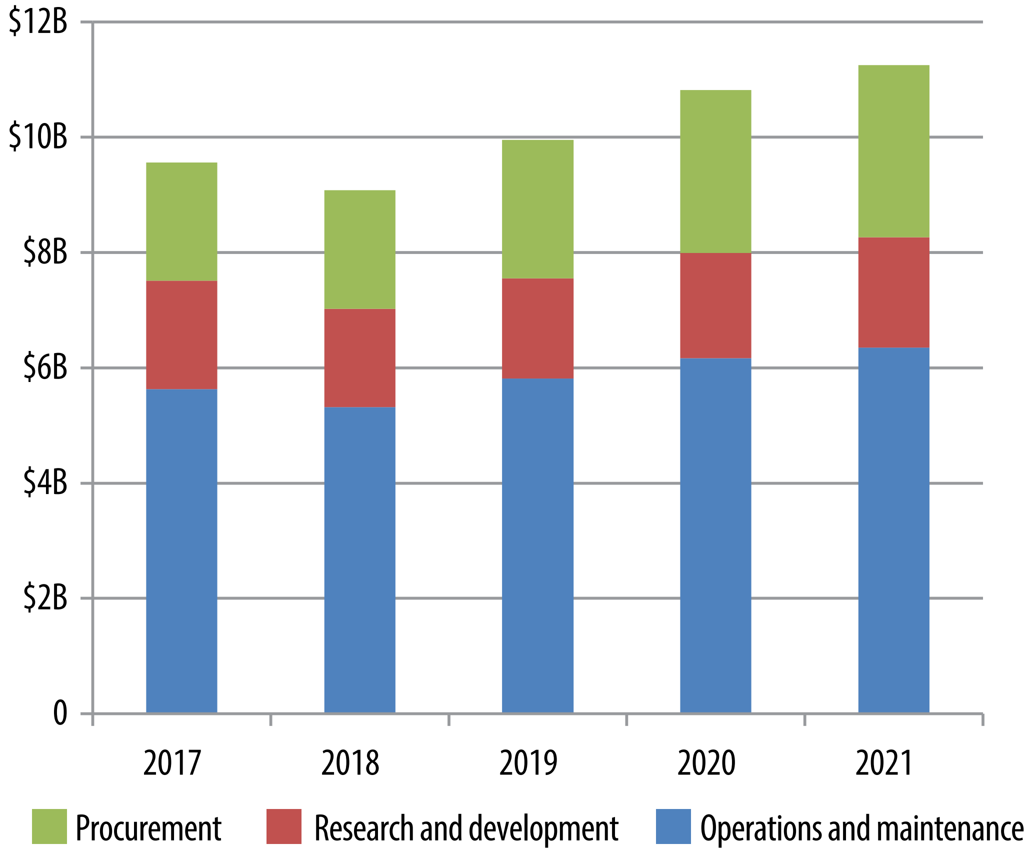
Figure 1. Total Unmanned Aircraft System Procurement Budget in Millions of Then-Year Dollars

1998 dollars) for the life span of one vehicle.[31] Adding the other capabilities indicated previously could easily cause drones to become more expensive than manned aircraft in the future. However, these future capabilities are likely required for drones to serve as viable and survivable tools in future contested environments.

Budget

Determining the UAS budget across the DOD remains difficult for numerous reasons. First, because drones operate as part of a system, including ground control stations, ground crew and operators, communication and data links, and multiple air vehicles, costs are often misleading.[32] Many capabilities required for drones, such as satellite-based communications networks, are not included in UAV costs. Second, monitoring and evaluating costs are further complicated due to differing budgeting conventions between services and the fact that some portion of drone costs are covered by the intelligence budget rather than the DOD budget.[33] Third, operations and maintenance costs are difficult to find and are often only tracked for larger unmanned systems.[34] Finally, an indeterminable classified budget exists for drones, such as the RQ-170 Sentinel program, that came to light only when one crashed in Iranian territory.[35] This article, therefore, generally focuses only on direct costs for larger drones.

Between 1989 and 2017, the procurement budget—a representative portion of the overall budget—for drones has increased dramatically, corresponding to the increasing force structure and priority accorded unmanned systems over time. Figure 1 depicts the procurement costs of drones from 1989 through 2017. The Reagan administration requested notably higher levels of UAS spending than previous administrations and marked the transition of drones from primarily experimental projects to procurement programs.[36] Figure 1 also illustrates the increasing importance of



(Graphic by author)

Figure 2. Projected Approximate Spending in Unmanned Aircraft System Group Four and Five through the Future Years Defense Program

unmanned systems following the 2003 invasion of Iraq and the substantial increase after the emphasis on UAS in mid-2007 by Gates.[37] The DOD spent approximately $4 billion total on UASs between 1989 and 2000, increasing to an estimated $39 billion for procurement since 2001.[38] In 2011, the UAS budget represented only 8 percent of all U.S. aircraft procurement funds, despite increasing costs.[39] However, not depicted here are the growing operations and maintenance costs, which could eventually crowd out various research and procurement programs.

The current budget, through 2021 in the Future Years Defense Program (FYDP), depicts considerable challenges for unmanned programs. Figure 2 depicts the approximate spending through the FYDP on only group four and group five drones.[40] First, operations and maintenance costs for UAV squadrons have begun to dominate the approximately $10 billion annual spending. The continued shift to larger and more capable drones will only increase this cost ratio as each Reaper squadron costs $160 million annually, compared to the $70 million in annual costs for a Predator squadron.[41] Further, Global Hawk units cost approximately $440 million annually for operations and maintenance.[42] The DOD expects similar or higher operations costs for future group five UASs such as the Navy UCLASS. Increasing operations and maintenance costs mean that current plans to increase higher-end capabilities are infeasible under current budgetary limitations.

Second, the DOD expects research, development, and procurement spending to grow steadily over the FYDP from approximately $4–$5 billion annually. This spending will also likely provide fewer actual platforms each year over that time as orders are reduced and technology becomes more advanced. Other larger programs such as the Air Force's LRS-B [Long Range Strike Bomber] program will complicate the picture and could crowd out smaller, newer research and procurement programs.[43] The Air Force's increasing competition for research and procurement dollars are likely to exacerbate budget tension already present in the president's projected budget, which exceeds the 2011 Budget Control Act's limits by a total of $107 billion (in 2016 dollars) through the FYDP.[44]

One significant example of increasing research and procurement costs revolves around the sensor package on higher-end drones. The second generation Global Hawk's sensor payload represents approximately 54 percent of the vehicle's flyaway cost.[45] Sensor costs are increasing due to the basic law of supply and demand. The growing DOD demand and desire for increased capability, matched with a lack of commercial sensor equivalents, means that drone sensor producers face little competition to keep costs down.[46] Further, reducing order sizes, due to increasing costs and limited budgets, increases the cost per airframe. In the Fiscal Year 2012 budget, reducing Global Hawk aircraft purchases from twenty-two to eleven caused Global Hawk unit prices to increase by 11 percent.[47]

Potential Solutions

The future problem centers on fiscal limitations for budget growth imposed by the 2011 Budget Control Act and the military's penchant for acquiring increasingly sophisticated high-end UAS capabilities. Unless budgets are increased, two reasonable options exist for future drone development, and the proper selection largely depends on how decision-makers define the operational environment and UAS requirements.

The first option advocates fielding fewer, more expensive, and more capable group four or group five drones such as the Global Hawk and Reaper.[48] The DOD currently plans to implement this option, expanding the Reaper force structure over 25 percent by adding seventy-five aircraft through 2021.[49] To account for increasing Reaper numbers, the Air Force plans to retire all 108 Predator drones by 2018.[50] However, to balance the operations and maintenance budget at $630 million per year of Predator funding, the Air Force could sustain less than four squadrons of twelve Reapers each.[51] Further, the four squadron mark fails to account for the approximately $350 million procurement cost for each Reaper squadron.[52] Thus, if topline spending limits remain fixed, the Air Force would likely only purchase two to three Reaper squadrons over the FYDP. Overall, this option would result in a decrease of 108 Predators and an increase of at most 36 Reapers.

The first option would likely remain a viable option if the primary mission remains counterterrorism in uncontested airspace. However, since current drones are unsuitable for contested environments, an alternate mission against a more capable adversary limits the usefulness of these platforms.

The second option advocates fielding many smaller, less expensive, and less capable UAVs controlled by local tactical and operational commanders.[53] Several measures under this course of action would sustain current U.S. high-end capability and continue building the foundation for potential future expansion. First, most of the Predator fleet would remain in service through the FYDP. Combined with restricted Reaper acquisitions, aimed only at replacing vehicles lost in service, limited expansion in higher-end drones would provide funds for the continued research and testing of more advanced drone programs. Continued research of sophisticated drone programs would facilitate the development of systems acceptable to future contested environments and provide the United States with options when budgetary limits decrease. Further, limited expansion into higher-end drones would allow the United States to focus on expanding the structure and capabilities of smaller tactical drone programs.

This option would likely serve as the correct and cost-effective solution if decision-makers believe future operational environments include contested airspace and electronic warfare similar to that occurring in Ukraine today. Recent events reveal larger sophisticated drones are vulnerable due to larger observable signatures and reliance on complex communications networks. In 2011, Iran claimed it brought down the classified American RQ-170 stealth drone.[54] Further, in June 2012, a University of Texas at Austin team successfully hijacked a Department of Homeland Security Predator drone for under $1,000.[55] Finally, in August 2016, the Organization for Security and Co-operation in Europe ceased all drone operations over Ukraine after three group four-equivalent drones were shot down in June and July.[56]

While larger drones have proven costly and less survivable, small drones have continued to demonstrate success in Ukraine by providing targeting information and tactical awareness for commanders.[57] Thus, until high-end technology (e.g., stealth, speed, autonomy, and maneuverability) improves, the smaller, cheaper drones provide a better option in contested environments as they are less observable and cheaper when destroyed.

No matter which approach decision-makers choose, there are several options common to both scenarios.

First, the DOD cannot continue the planned expansion into higher-level drones under the current budgetary limits. The immediate effects likely include a reduced expansion of Reaper systems and the prolonged lifespan of at least some Predator units. Second, increasing commonality among different service's systems could save substantial funds. For example, the Army Grey Eagle and Air Force Predator currently have 80 percent commonality, and the only difference is better and more expensive sensors on the Air Force Predator.[58]

Further, the Navy Broad Area Maritime Surveillance system and Air Force Global Hawk are essentially the same system with different sensors.[59] However, the Navy and Air Force have two separate depots, ground stations, and training pipelines for the aircraft.[60] By standardizing various platforms the DOD could reduce costs across research and development, procurement, and operations and maintenance, as repair parts, ground control stations, training, and data links could be consolidated and interchanged across services.

Conclusion

As an increasing number of state and nonstate actors acquire sophisticated air defense and electronic warfare capabilities, current high-end drones become less cost effective and capable. The United States should focus on sustaining current capabilities and improving lower-end capabilities while emphasizing research and development for future capabilities. Following this program will allow the DOD to operate within current budgetary limits, maintain flexible capabilities, and develop conceptual capabilities for future expansion if required. Until technological advances and increased budgets provide the ability to create survivable high-level drones, most programs should focus on smaller, cheaper, and more survivable and expendable tactical drones. The United States should not squander the distinct advantages potentially provided by smaller and more numerous lower capability drones employed at the tactical and operational level in future conflicts. ■

Notes

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3. Ibid.

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15. Ibid., 23.

16. Christopher Bolkcom and Elizabeth Bone, *Unmanned Aerial Vehicles: Background and Issues for Congress*, CRS No. RL31872 (Washington, DC: CRS, 2003), 5.

17. Ibid., 7.

18. Gertler, *U.S. Unmanned Aerial Systems*, 8–9.

19. Ibid., 9.

20. Robert M. Gates, *Duty: Memoirs of a Secretary at War* (New York: Alfred A. Knopf, 2014), 129.

21. Gertler, *U.S. Unmanned Aerial Systems*, 8.

22. Dyke Weatherington, "Current and Future Potential for Unmanned Aircraft Systems," Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD [AT&L]), Unmanned Warfare briefing, 15 December 2010, 4–5. See also Department of Defense (DOD), *Unmanned Systems Integrated Roadmap FY2013-2038* (Washington, DC: DOD, 2013), 5.

23. Data for table 2 was compiled from numerous sources to get the most accurate picture possible. The primary sources differ some in numbers, but each source is listed below. The various groups and which UAVs belong in them came from Weatherington, "Current and Future Potential for Unmanned Aircraft System," 4–5. Data on groups 1–3 came from Gertler, *U.S. Unmanned Aerial Systems*, 8. And, data

on groups 4–5 came from CBO, *The U.S. Military's Force Structure: A Primer* (Washington, DC: CBO, July 2016), 125. Reaper and Predator systems share a common ground control station.

24. Gertler, *U.S. Unmanned Aerial Systems*, 6.

25. CBO, *Unmanned Aerial Vehicle Programs*, xiii.

26. Jeremiah Gertler, *The Air Force Aviation Investment Challenge*, CRS No. R44305 (Washington, DC: CRS, 17 December 2015), 2.

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33. Ibid.

34. Ibid., 31.

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38. Gertler, *U.S. Unmanned Aerial Systems*, 13.

39. Ibid., 14.

40. Data for figure 2 was found across numerous sources and was verified against other available sources. However, most of the operations and maintenance (O&M) costs were calculated using CBO, *Military's Force Structure*, 100, 125. Procurement, and research and development projected spending primarily came from Teal Group Corporation, "World Unmanned Aerial Vehicle Systems," 2.

41. CBO, *Military's Force Structure*, 100.

42. Ibid.

43. Gertler, *The Air Force Aviation Investment Challenge*, 3.

44. CBO, *Long-Term Implications of the 2016 Future Years Defense Program* (Washington, DC: CBO, 2016), 2.

45. Gertler, *U.S. Unmanned Aerial Systems*, 15.

46. Ibid.

47. Ibid., 10.

48. Ibid., 15.

49. Gertler, *The Air Force Aviation Investment Challenge*, 2.

50. CBO, *Military's Force Structure: A Primer*, 125.

51. Ibid. Current Predator squadrons each cost $70 million annually or $630 million for all nine. Each Reaper squadron adds $160 million annual O&M costs. Thus four squadrons costing $160 million each result in $640 million additional O&M costs.

52. Procurement cost estimated using the current estimated cost of a single Reaper system $28.4 million. Each notional squadron contains twelve systems, resulting in approximately $340.8 million per squadron.

53. Gertler, *U.S. Unmanned Aerial Systems*, 15.

54. Clay Dillow, "Iran Puts Its Captured RQ-170 Drone on Display," *Popular Science* (website), 8 December 2011, accessed 11 December 2017, http://www.popsci.com/technology/article/2011-12/video-iran-puts-its-captured-rq-170-drone-display.

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Photo of Sgt. Ian Rivera-Aponte, U.S. Army Reserve sniper and infantryman 26 July 2017 at Joint Base McGuire-Dix-Lakehurst, New Jersey. (Photo by Master Sgt. Michel Sauret, U.S. Army Reserve)

The Men Who Have No Name

By Staff Sgt. Christopher M. Rance, U.S. Army

In woods of dark
I lie;
heart beating against the pine needle floor.
He is there, in sunlit place, marching up in haste,
up a sloping green meadow.
With the bend of my finger;
gliding metal hurries intensely for a private embrace.
Leaves rustle
(f
a
l
l)
in autumn mourning.
Through the looking glass, I cannot see reproachful eyes.
Therein meadow, blood *red poppies blow,*
a soft wind carries off a nameless soul.