Drone Spending in the Fiscal Year 2017 Defense Budget

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The Center for the Study of the Drone at Bard College is an interdisciplinary research institution founded in 2012 that examines the novel and complex opportunities and challenges presented by unmanned technologies in both the military and civilian sphere.

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Key Takeaways

- The U.S. Department of Defense has allocated approximately $4.457 billion for drones in the proposed Fiscal Year 2017 budget.
- Funding for drones is lower in the proposed Fiscal Year 2017 budget than in Fiscal Year 2016, although it is slightly higher than in Fiscal Year 2015.
- The Air Force's MQ-1 Predator and RQ-4 Global Hawk, the Navy's MQ-8C Fire Scout, and the Army's MQ-1C Gray Eagle and RQ-7 Shadow acquisition programs are drawing to a close, while research into new technologies is emerging as a priority.
- Funding for construction will go toward new drone outposts in Alaska, Washington State and other undisclosed locations around the world and to updating Chabelley Airfield in Djibouti.

Spending Summary

	MQ-9 Reaper	$1.2 billion
	RQ-4 Global Hawk	$305 million
	MQ-4C Triton	$944.1 million
	MQ-8C Fire Scout	$119.5 million
	MQ-1C Gray Eagle	$148.4 million
	Unmanned Undersea Vehicles	$325.9 million
	Unmanned Ground Vehicles	$74.2 million

Introduction

On February 9, 2016, President Obama unveiled the federal government's Fiscal Year 2017 budget. The proposed request includes $587.2 billion in military spending, which is split between a $523.9 billion base budget and a $58.8 billion Overseas Contingency Operations fund for wartime operations.[1] In announcing the Pentagon's spending request, Deputy Secretary of Defense Bob Work said that one of the main lines of effort in Fiscal Year 2017 would be to "seek game changing technologies and make more discreet technological bets that exploit our advantages as well as adversary weaknesses."[2] In earlier appearances, Deputy Secretary Work has touted the budget proposal as the first step towards the so-called "third-offset strategy," a plan to maintain the technological superiority of the U.S. military.[3]

Drones are an important part of this strategy. The military has allocated approximately $4.457 billion for drone-related spending in the FY17 budget proposal. On the whole, the proposal reflects a technology in transition; as major drone acquisition programs wind down, funding is allocated for new research and procurement initiatives. In fact, with the exception of the Air Force's General Atomics MQ-9 Reaper and the Navy's MQ-4C Triton, the military plans on spending significantly less to purchase new unmanned aircraft in FY17 than in previous years. This is because most of the current major acquisition programs have already met their aircraft totals or have gone over budget. 31 Unmanned aerial systems will be purchased in FY17, a marked—though not unexpected—drop from previous years.

As a result of the gradual reduction in funding for these programs, the total amount allocated towards drones is $1.16 billion lower in the FY17 proposal than in FY16. While medium and large unmanned air systems continue to take the majority of drone spending, growing emphasis is being placed on other types of unmanned vehicles. The Navy, for example, will begin procuring new unmanned undersea vehicles for detecting sea mines, and will add tens of millions of dollars for research and development of new, larger UUVs. The Army, meanwhile, will boost funding for unmanned ground vehicles and will initiate new projects to research swarming weapons and increased autonomy. Although spending for these projects is much smaller than for a larger aircraft system like the Global Hawk, they reflect what are perhaps the beginnings of a long effort by the military to maintain the technological upper hand by investing in the next generation of unmanned technologies.

This paper provides the general public with a guide to military spending on drones and robotics. Spending items are arranged by service and, when applicable, funding levels are compared to amounts in previous years. Two sections address the history of the Air Force's MQ-9 Reaper and the Navy's MQ-4C Triton, providing the reader with some perspective into Pentagon's acquisition process for these two large programs.

1 Department of Defense. (2016, February 9). Department of Defense (DoD) Releases Fiscal Year 2017 President's Budget Proposal [Press release]. Retrieved February 10, 2016.
2 Department of Defense Press Briefing by Deputy Secretary Work and Gen. (2016, February 9). Retrieved February 10, 2016.
3 Freedberg, S. J., Jr. (2015, November 3). We'll Unveil Third Offset Details In FY17 Budget, Except The Black Part: Bob Work. Breaking Defense. Retrieved February 10, 2016.

Note on Final Spending Totals

The research for this paper is based on the budget justification books for each service. These books are published along with the budget to provide a breakdown of where the military's funds are being spent. Each project mentioned in this paper is accompanied by its "Line Item" number (for procurement programs) or "Program Element" number (research and construction projects). This paper only covers the investment appropriations—procurement, research and development, and construction—and does not include operations and maintenance appropriations. The budget documents may be found at the website of the Department of Defense comptroller.

The funding totals published in this paper are likely to be lower than the actual dollar amounts that the military will spend on drones in FY17. Congress will very likely alter a small number of the dollar amounts in the proposed budget before passing a definitive spending bill later this year. Last year, for example, Congress pumped $300 million into what was then the Unmanned Carrier-Launched Airborne Surveillance and Strike system.

Furthermore, while we have sought to isolate spending specifically for drones, there are a number of research projects in each service's budget where spending for drones is mixed up with spending for many other types of technology. We have left out these projects in the interest of obtaining totals that are as accurate as possible.

Air Force

In Fiscal Year 2017, the Air Force is asking for roughly $1.136 billion in drone procurement spending, $551.9 million in research and development and $10.5 million for construction. The total—$1.698 billion—is down 26% from the $2.279 billion allocated in Fiscal Year 2016, though it is on par with the $1.648 billion from Fiscal Year 2015.

Procurement

The biggest procurement spending item in the Air Force is the MQ-9 Reaper. Other major acquisition programs like the RQ-4 Global Hawk, a high-altitude long-endurance surveillance drone, are nearly at the end of their procurement schedule. Air Force procurement spending is down by around $600 million in Fiscal Year 2017 from 2016 due largely to a decrease in the number of Hellfire missile purchases for the MQ-1 Predator and MQ-9 Reaper.

- The Air Force plans to spend $906.1 million on the General Atomics MQ-9 Reaper. Of this, $575.6 million will go toward purchasing 24 new aircraft, $254 million will go towards modifications and upgrades, $40.1 million for spare parts and repairs, and $35.65 million for miscellaneous production charges. Half of the Reaper purchases will be replacements for aircraft lost in combat operations and half will go toward the contractor-owned, government-operated Combat Air Patrols. Unlike the previous year, procurement spending for the MQ-9 Reaper in Fiscal Year 2017 relies mostly on the Overseas Contingency Operations (OCO) budget; nearly 80% of the $575.6 million will draw from OCO funds as opposed to 3% in the 2016 budget. The Air Force will purchase 26 Ground Control Stations using funds from the Base Budget. Likewise, of the $254 million allocated for modifications and upgrades, $112.1 million will draw from the OCO budget. (Line Items PRDTB1, 000999, PRDTB2, and 0000751)
- After the Reaper, the second largest drone-specific procurement item in the Air Force budget is for 1,536 Lockheed Martin AGM-114 Hellfire missiles to arm the MQ-1 Predator and MQ-9 Reaper drones. Again, a large portion of these funds—$145 Million of the $179 million—will draw from the OCO budget. In FY16, the Air Force allocated nearly $700 million for 6,256 Hellfires—an unusually large purchase that was likely needed to restock supplies of the missile that are being expended in the anti-ISIS air campaign. It takes around two years from the day the contract is issued for the missiles to be delivered to the Air Force. (Line Item PRDTA2)
- The Air Force allocated $49.3 million in procurement funds for the RQ-4 Global Hawk. Since the Air Force is no longer buying Global Hawks, the procurement funding for these programs is centered primarily around providing spare parts, modifications and upgrades, and other miscellaneous items like logistics. (Line Items HAEUAV, 000999, RQ4DIS, HAWK00, and 0000751)
- The Air Force allocated $949,000 for spare parts for the MQ-1 Predator. (Line Item PRDT01)

- The biggest unmanned technology spending item in the Air Force budget is the MQ-9 Reaper, which has been allocated $906.1 million for procurement, $151.4 million for research, and $10.5 million for construction.
- The Air Force has not allocated funds for the purchase of new RQ-4 Global Hawks, though the Global Hawk program is receiving $256 million in research funding.
- The Service is investing $52 million in research to improve human-machine interaction and the autonomous capabilities of unmanned vehicles.

Research, Development, Testing & Evaluation

The Air Force plans to spend approximately $525.3 million on drone-specific research in Fiscal Year 2017. This is roughly in keeping with Fiscal Years 2016 and 2015, when the Air Force allocated $466.3 million and $511.3 million, respectively.

- The Air Force allocated $120 million for MQ-9 Development and Fielding, a standard research spending line that accompanies major acquisition programs. Development and Fielding research focuses on improving the hardware and software in the Reaper system. This includes developing and testing the next generations of the Reaper aircraft and Ground Control Systems—the Block 5 aircraft and Block 50 GCS—and improving the sensors onboard the aircraft. The second main research initiative is the MQ-9 Upgrade, a new $30 million project that aims to deliver improvements to the Reaper system on a shorter timeline than traditional Development and Fielding research. This project takes place under the aegis of the Hybrid Acquisition Strategy, a new initiative inspired by the Air Force Special Operation Command's Lead-Off Hitter project, which aims to deliver upgrades to the MQ-9 every six months. In FY17, this project will focus primarily on communications technologies such as encrypted data links and improved satellite communications. (Program Element 0205219F)
- The Air Force allocated $256.3 million toward research for the RQ-4 Global Hawk, a $68 million increase over Fiscal Year 2016 and roughly on par with 2015. Two projects, RQ-4 Block 30 and RQ-4 Capability Enhancements, take the largest share with a combined $248.5 million. The RQ-4 Block 30 project is a push to modernize an older generation of the Global Hawks—the Block 30s—with upgrades to the onboard suite of surveillance technologies like signals intelligence sensors. The RQ-4 Capability Enhancements project receives $121 million in funding and will focus on testing and fielding general system upgrades for the Global Hawk. (Program Element 0305220F)
- The Air Force is investing in three projects that aim to improve human-machine interaction and the autonomous capabilities of unmanned vehicles. For example, the goal of Autonomous Systems Control, a $14.3 million project, is to develop capabilities that could enable safe, autonomous flight and cooperative operations between unmanned and manned aircraft. Manned and Unmanned Teaming Technologies, an $11.5 million project, aims to develop safe interoperability between drones and manned aircraft in active battlefields. The Air Force is also investing in researching new methods for quickly analyzing the reams of raw intelligence collected by drones. (Project Elements 0603211F and 0602201F)
- The Human Dynamics Evaluation project, allocated $26.174 million, investigates ways of augmenting human analysts with autonomous processes in order to improve the efficiency of the analysts. Within this program, the Human Analyst Augmentation project seeks to use autonomous processes to enhance the effectiveness of the human intelligence analysts that examine ISR

Photo: MSgt Joseph Swafford / US Air Force

data, often a laborious process. Meanwhile, the Human Trust and Interaction project is investigating ways of improving trust between humans and machine operators. Finally, the Human signatures project seeks to develop algorithms that might allow the detection and tracking of human biomarkers like sweat and exhaled breath using full-motion video. (Program Element 0602202F)

- The Dynamic Systems, Optimization, and Control project, allocated $26.575 million, seeks to advance the study of autonomy by developing the means to control networks of autonomous and semi-autonomous air vehicles in dynamic environments. Previous accomplishments include the development of an algorithm for controlling multiple robots with a tablet. (Program Element 0601120F)
- The Common-Airborne Sense and Avoid project, allocated $14.8 million, will work to create requirements that will enable the integration of drones into the National Airspace System—a significant issue for both civilian and military developers. (Program Element 0604257F)
- The Airborne Signals Intelligence Development - Special Platforms program, allocated $3.4 million, will work to modernize the signals intelligence collection capabilities that are already on board the MQ-1 Predator and MQ-9 Reaper. (Program Element 0304260F)
- The Missile/Remotely Piloted Aircraft Engine Performance project which will receive $11.8 million, aims to create a durable, medium-sized jet engine for drones. Smaller projects like Data Compression, allocated $1.5 million, and Undergraduate Remotely Piloted Aircraft Training, allocated $734,000, will also serve to enhance drone operations. (Program Elements 0603216F, 06044257F and 0604233F)

Construction

In previous years, the Air Force has set aside funding for building new facilities for drone operations at Air Force and Air National Guard (ANG) bases. In Fiscal Year 2016, for example, the Air Force allocated $50 million for three different projects: a secure operations center at Fort Smith Municipal Airport for the Arkansas ANG, an operations facility at Niagara Falls International Airport for the New York ANG, and a new drone base in Agadez, Niger to support counterterrorism efforts in West Africa. Some of these projects provide facilities in the United States from which drone pilots fly, while others, like the base in Agadez, support new drone deployments and operations around the world.

Chabelley Airfield. Image via Digital Globe

In Fiscal Year 2017, the Air Force's drone construction budget is much smaller. For its drone base at Chabelley Airfield in Djibouti, the service is allocating $3.6 million to pave a 3.4 mile gravel access road, which is currently prone to flooding, and $6.9 million for an asphalt apron and taxiway. These projects are a significant upgrade for what was once intended only as a temporary base for U.S. military drone operations in the Horn of Africa. The new asphalt apron and taxiway will provide 13 concrete hangar pads and a taxiway that will allow for a Boeing C-17 Globemaster to be unloaded of cargo without significantly interrupting normal flight operations. Funding for these projects will draw from the Overseas Contingency Operations budget. (Program Element 14994)

General Atomics MQ-9 Reaper

Photo: Staff Sgt. Brian Ferguson / US Air Force

The MQ-9 Reaper is a medium-altitude long-endurance surveillance and strike drone. The primary contractor for the program is General Atomics Aeronautical Systems, Inc., which is responsible for manufacturing the aircraft and the ground control system. Other contractors include Raytheon, which supplies some of the advanced sensors on the drone, and L-3 Communications, which provides training simulators and satellite communication infrastructure. While the U.S. Air Force (USAF) is the primary user of the MQ-9 Reaper, other military departments such as the Missile Defense Agency and Special Operations Command (USSOCOM)—both of which operate Reapers for certain operations—also allocate procurement and research funding for Reapers. Outside of the military, the Customs and Border Protection agency and NASA also operate Reaper variants, though these programs are funded through separate budgets.

The U.S. Air Force Air Combat Command initiated the MQ-9 Reaper program (then known as the MQ-9 Predator B) on May 2, 2002 as a sub-item within the MQ-1 Predator program.[1] In the four years that followed, the Air Force purchased a handful of aircraft for testing and development. The first Reaper squadron, the 42nd Attack Squadron, was activated on November 6, 2006, and became operational in 2007.[2] In FY08, the Air Force purchased a set of four Reapers and officially separated the program from the MQ-1 Predator. [3]

In 2011, Secretary of Defense Robert Gates ordered the Air Force to expand its drone use significantly, setting a goal of 65 Combat Air Patrols—24/7 drone operations each consisting of four Predator or Reaper aircraft—by 2013.[4] In 2012, the U.S. Air Force established a baseline estimate of how many drones it planned to acquire—a total of 391, to be purchased throughout the lifetime of the program—and how much it estimated the entire program would cost—$10.75 billion. The demand for the drones peaked in 2012 and 2013, prompting the Air Force to increase its planned total purchase number of Reapers to 401.[5] In 2014, however, an Inspector General's report concluded that the Air Force incorrectly estimated how many Reapers it needed to purchase.[6] The planned total dipped to 349 in the Fiscal Year 2015 budget and, in the budget for FY16, the Air Force estimated that the Reaper program will produce 364 aircraft by 2019.

At this point in the life of the acquisition program, there appears to be a greater emphasis within the Air Force budgets on improving existing aircraft than on procuring as many drones as possible. In an assessment published by the Department of Defense on September 23, 2015, Colonel William S. Leister, the

1 U.S. Department of Defense, Office of the Director, Operational Test and Evaluation. MQ-9 Predator B Unmanned Aerial Vehicle System. Washington, D.C.: United States Government Printing Office, 2002.
2 Factsheets : 42 Attack Squadron (ACC). (2012, May 15). Retrieved February 10, 2016, from http://www.afhra.af.mil/factsheets/factsheet.asp?id=19324.
3 U.S. Department of Defense, Department of the Air Force. Committee Staff Procurement Backup Book FY2008/2009 Budget Estimates: Aircraft Procurement, Air Force: Volume 1. Washington, D.C.: United States Government Printing Office, 2007
4 U.S. House. Armed Services Committee. 2012 Budget Request for the Department of Defense Hearing, 16 February 2011. Washington, DC: Government Printing Office.
5 U.S. Department of Defense, Department of the Air Force. Department of Defense Fiscal Year (FY) 2013 President's Budget Submission: Air Force Justification Book Volume 1 Aircraft Procurement, Air Force. Washington, D.C.: United States Government Printing Office, 2007
6 U.S. Department of Defense, Office of the Inspector General. Air Force Did Not Justify the Need for MQ-9 Reaper Procurement Quantities. Washington, D.C.: United States Government Printing Office, 2014

program manager for MQ-9 Reaper acquisition, identified several worrying trends in the development of the aircraft and ground control systems.[7] "The program sprinted for so long, there are bound to be insidious artifacts lurking in the system that we missed; some may be significant," Leister wrote. One early issue with the Block 5 aircraft—the latest generation of the Reaper—was that the avionics and other internal systems could not handle hot weather. According to Leister, although this problem was quickly solved by General Atomics, other issues like a starter-generator issue that can cause the abrupt mid-flight loss of electrical power have continued to plague the program.[8] Leister also pointed out in the assessment that the development of the newest ground control stations—the GCS Block 50—were producing "less than stellar results."

Two projects within the Reaper acquisition program have experienced precipitous cost increases: the Multi-Spectral Targeting System (MTS-B) and the MQ-9 System Development and Demonstration Bridge (SDD), which saw total cost growth of 797 percent and 327 percent, respectively. The overruns were identified and compared to other defense programs in the "Performance of the Defense Acquisition System: 2015 Annual Report" released by Undersecretary of Defense of Acquisition, Technology, and Logistics Frank Kendall on September 16, 2015.[9] According to the April 2014 Selected Acquisition Report (SAR) for the MQ-9, a periodic summary of the program, the MTS-B project had difficulty developing and integrating the Tri-Beam Emission and Receiver, the laser on the drone that identifies targets for engagement.[10] The increases to the MQ-9 SDD, a General Atomics project to provide system improvements to the aircraft, is due to "contract overruns, rebaselining and contract modifications," according to the 2014 MQ-9 SAR.

In spite of these issues and unlike other acquisition programs, the Reaper program as a whole has not experienced tremendous cost overruns, at least in the years since a baseline for the project was established in 2012. Since then, costs have risen by 8.3 percent, according to the annual summary of Selected Acquisition Reports released by the Pentagon in December 2014.[11] This number reflects the change during the years since the baseline was established in 2012 and not the total change since the first Reapers were purchased. The Reaper program finances run quite low compared to the costs of the Navy's MQ-8C Fire Scout drone—which have risen by 64.7% in the years since a baseline was established for that program—and the Air Force's RQ-4 Global Hawk drone, which increased by 88.6%. The reduction in the total number of aircraft to be purchased, from 391 to 364, helped bring costs down. The savings from this reduction have been partially offset, however, by modifications, production delays, and requirement changes. The estimated lifetime cost of the Reaper program is up from $10.75 billion in 2012 to $12.31 billion as of December 2014, with $6.82 billion already spent prior to Fiscal Year 2016.

In Fiscal Year 2017, the Air Force intends to spend around $1.068 billion on the Reaper. Of this total,

7 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Compendium of Program Manager Assessments for 2015. Washington, D.C.: United States Government Printing Office, 2015.
8 Everstine, B. (2015, July 30). Air Force: Depleted batteries, failed generator caused MQ-9 Reaper crash. Air Force Times. Retrieved October 10, 2015.
9 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Performance of the Defense Acquisition System, 2015 Annual Report. Washington, D.C.: United States Government Printing Office, 2015.
10 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Selected Acquisition Report (SAR): MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper) (RCS: DD-A&T(Q&A)823-424). Washington, D.C.: United States Government Printing Office, 2014.
11 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Selected Acquisition Report (SAR) Summary Tables. Washington, D.C.: United States Government Printing Office, 2014.

$906.142 million will go towards procurement, $151 million will be spent on research and modernization efforts, and $10.5 million on construction. While this figure is down slightly from the $1.14 billion dedicated to the program in Fiscal Year 2016, there is a good chance that it will not be the final total amount spent on the Reaper in Fiscal Year 2017. This number does not, for example, take into account funding for the Reaper allocated in the Special Operations Command or Missile Defense Agency budgets which, in FY16, amounted to approximately $58.1 million. Congress may also alter the amount of funds spent on the Reaper.

This year, the Air Force has decided to draw nearly all of the $575.6 million for procuring new aircraft from the Overseas Contingency Operations budget. Normally, the Air Force purchases Reapers using funds from the base budget—the Pentagon's regular operating budget—and draws a token amount from the OCO. In Fiscal Year 2016, the Air Force asked for only $13.5 million in funding from the OCO for four Ground Control Stations. In 2015, no OCO funds were requested. This year, the Air Force is requesting $453 million in OCO funds for 24 aircraft: 12 to replace drones that were lost during operations, and 12 for contractor-operated Combat Air Patrols, part of a Pentagon initiative to increase the number of intelligence, reconnaissance, and surveillance CAPs flown by civilian contractors. The Air Force is also drawing $112.1 million in OCO funds for modifications and $10.5 million to update Chabelley Airfield in Djibouti.

Breakdown of MQ-9 Reaper Spending

All figures in millions.

	Item	Base	OCO	Total	FY16	FY15
Procurement	Aircraft and GCS	122.5	453	575.6	627.4	418.2
	Spares	40.9	0	40.9	129.3	76.6
	Modifications	141.9	112.1	254	184.1	155.5
	Other - Production	35.7	0	35.7	5	48.6
	Special Operations Command	10.6	0	10.6	17.2	18.6
Research	Upgrades	30.9	0	30.9	0	0
	Development	120.5	0	120.5	122.7	141.6
	Special Operations Command	17.8	0	17.8	22.2	14.4
	Missile Defense Agency	105.1	0	105.1	69.8	53.4
	Construction	0	10.5	10.5	72	21
	Total	625.9	575.6	1201.5	1249.6	947.8

Navy

The Navy budget, which includes the Marine Corps, includes $1.74 billion in spending for drone procurement, research and construction projects. This is down from $2.14 billion in Fiscal Year 2016 and up from $1.2 billion in 2015.

Procurement

The Navy is purchasing a range of systems in FY17 that will operate both in the air and under the sea. It will continue the second year of production on the Northrop Grumman MQ-4C Triton—a high-altitude, long-endurance surveillance aircraft—and slightly increase funding for the Boeing Insitu RQ-21 Blackjack, a small reconnaissance plane.

- After delays, the Northrop Grumman MQ-4C Triton program is gradually shifting from testing and development to production. The Navy initiated low-rate initial production for the Triton in FY2016; in 2017, it plans to spend $464.7 million for two more Tritons, as well as $114.5 million on spare parts and repairs.
- The Northrop Grumman MQ-8C Fire Scout, an unmanned helicopter, has been allocated $72.4 million in procurement funds, which will be used to purchase a single aircraft system, $19 million for modifications and upgrades, and $1.51 million on spare parts. At $92.5 million, the total is down from $180 million in FY16. In 2014, the Navy reduced the number of Fire Scouts that it planned to buy after the unit cost for each system increased significantly.
- The Marine Corps allocated $70 million to buy four Boeing Insitu RQ-21 Blackjack systems, each comprising of five aircraft, ground control stations, and other ancillary equipment. The funds allocated for the Blackjack include $18.1 million for Interim Contractor Support, meaning that the contractor—Insitu—is responsible for the spare parts, supporting and training equipment, and mission support for the program. This program is funded entirely out of the Overseas Contingency Operations budget for operations against the Islamic State.
- The Marines allocated $3.5 million in spending for modifications to the AAI RQ-7 Shadow tactical UAV.
- The Navy allocated a total of $70 million for four different unmanned undersea vehicle (UUV) and unmanned surface vehicle (USV) procurement programs. Four of these programs are either new starts or received large increases in funding in the Fiscal Year 2017 budget. Two programs—the Unmanned Influence Sweep System (UISS) and UISS Trainers, Knifefish Unmanned Undersea Module—are related to the Navy's push to develop a family of unmanned maritime vehicles to counter sea mines. The Littoral Battlespace Sensors program, which procures UUVs to conduct meteorological testing, received a $16.8 million increase in funding, bringing it to $21.7 million in FY17. Noticeably absent from this group is the Remote Minehunting System program, which is currently under review after coming under criticism for failing to meet key requirements.

- The biggest unmanned technology item in the Navy budget is the MQ-4C Triton, which has been allocated $464.7 million for the purchase of two aircraft, as well as $292.9 million for research initiatives and $71.9 million for construction projects.
- The Navy's X-47B strike drone demonstrator is being retooled as an aerial refueling aircraft. The program has been allocated $90.4 million in research funding.
- The Navy has allocated $279 million for procurment and development of underwater drones.

Research, Development, Testing & Evaluation

In Fiscal Year 2017, the Navy's research and development funds are oriented primarily toward underwater drone technologies and general unmanned systems development and integration. A total of $806 million in Navy RDT&E funds have been allocated towards drone research in FY17.

- Research funding for both the MQ-4C Triton (Program Elements 0305220N and 0305421N) and MQ-8 Fire Scout (Program Element 0305231N), the two largest drone platform-specific research programs in the Navy, decreased, while funding for the smaller drones like the RQ-21 Blackjack (Program Element 0305234M) stayed the same as in 2016. The two Triton research and development programs will receive a combined $292.9 million, the MQ-8 was allocated $26.5 million in research funds, and $5.1 million was set aside for the RQ-21 Blackjack.
- The X-47B Unmanned Carrier-Launched Airborne Surveillance and Strike program (UCLASS), a major research initiative for the development of a combat drone, is coming to an end; in its place, the Navy has decided to retool the X-47B as an aerial refueling aircraft. The new Carrier Based Aerial Refueling System program (CBARS) will receive $89 million in research funding and $1.4 million in operational test funding. This represents a significant drop from the $439.1 million that the X-47B program received in Fiscal Year 2016 (which was due in part to a $300 million boost for the program from Congress).
- The Navy has allocated increased research funding for unmanned underwater and surface drones for countering sea mines. Cumulatively, allocations for the Unmanned Surface Vehicle project, Mine Hunt Systems, Surface Mine Countermeasures Mid-life Upgrade, Large Displacement Unmanned Undersea Vehicle, Surface Mine Countermeasures (Knifefish UUV), Minecountermeasures Force Protection UUV, and Remote Minehunting System rose from $92 million in 2016 to $157 million in Fiscal Year 2017. Funding for the Unmanned Surface Vehicle and the Large Displacement Unmanned Undersea Vehicle, received large boosts of 83 and 450 percent, respectively. Funding for the Remote Minehunting System is down from $17.6 million in 2016 to $3 million in 2017. (Program Elements 0603502N, 0604122N, and 0604122N)
- Another project associated with the Large Displacement Unmanned Undersea Vehicle, although not strictly related to Mine Countermeasures, is the LDUUV Universal Launch and Recovery Module, a new $8.4 million project aimed at developing a means of deploying and retrieving the LDUUV from submarines. (Program Element 0603561N)
- The Navy is starting a new $78.6 million project dedicated entirely to the development of Extra Large Unmanned Undersea Vehicles (XLUUVs)—underwater drones that are 54 inches or more in diameter. (Program Element 0604536N)
- Force Protection Advanced Technology, an Office of Naval Research program, includes

An MK18 MOD2 Unmanned Undersea Vehicle. Photo: Specialist 3rd Class Jonah Stepanik/US Navy

$13.5 million in funding for Surface Ship & Submarine Hull Mechanical & Electrical. This project supports the development of a Medium Displacement Unmanned Surface Vehicle Lead Ahead effort and the study of autonomous control. (Program Element 0603123N)

- Force Protection Advanced Technology, also includes an Aircraft Technology initiative dedicated to developing new Naval air vehicles and studying autonomous air vehicle command and control. In FY17, this project will support the development of the Tactically Exploited Reconnaissance Node (TERN), a vertical take-off and landing aircraft that is a collaboration between ONR, DARPA, and Northrop Grumman. Funding for Aircraft Technology rose to $32.2 million in FY17 from $21.6 in FY16 due to increased investment in the TERN. (Program Element 0603123N)
- Like the Army, the Navy is developing a common controller that can be used to operate more than one type of drone. This year-old, $36.5 million project will start by concentrating on a common controller for air vehicles like the Triton, Fire Scout, and Blackjack. (Program Element 0305205N)
- A new project, the $15 million Unmanned Rapid Prototype Development, seeks to quickly deliver unmanned systems to meet the needs of the fleet. This project should be viewed in conjunction with the Navy's new office dedicated to unmanned systems that was created last year. Program Element 0603382N)

Note: The Navy has a number of drone research and development projects that are tucked within much larger funding packages that encompass research in a variety of fields. For example, the $52.1 million Defense Research Sciences spending package for research into Air, Ground and Sea Vehicles includes a section on the study of the unmanned aircraft and autonomy. This spending item also includes, however, research into ship hydrodynamics, structures and materials, machinery, and many other areas unrelated to drones. As such, these projects were left out of the tally.

Photo: Specialist J. Michael Smevog / US Navy

Construction

The Navy will spend $30.5 million to build two mission control systems for its largest drone program, the MQ-4C Triton, at Naval Air Station Whidbey in Washington State. These facilities will help sustain the planned deployment of 166 personnel who will remotely operate the Tritons. The Navy has also allocated $41.4 million to build parking aprons, taxiways, and multi-story, steel frame hangars that will house the Tritons at several undisclosed locations around the world. In Fiscal Year 2016, the Navy allocated funds for a similar project at Naval Air Station Sigonella in Italy. The Navy will additionally set aside $40.6 million for a hangar for the Carrier Based Aerial Refueling System—formerly known as the Unmanned Carrier-Launched Airborne Surveillance and Strike system—at Naval Air Station Patuxent River, Maryland. (Program Elements 0816376N, 0212176N, and 0815976N)

Northrop Grumman MQ-4C Triton

Photo: Erik Hildebrandt / US Navy

The Northrop Grumman MQ-4C Triton is a high-altitude long-endurance surveillance drone. Development of the Triton began in 2008 under the Broad Area Maritime Surveillance—Demonstrator (BAMS-D) program, which sought to provide the Navy with the capability to collect intelligence for long periods of time and over large swaths of the ocean.[1] On April 22, 2008, the Department of the Navy announced that it had awarded Northrop Grumman Corp. a $1.16 billion contract to build a BAMS aircraft based on the Air Force's RQ-4 Global Hawk.[2] The Triton was the Navy's first major investment in unmanned systems. It is intended to replace the Navy's P-3 Orion manned surveillance planes.

The Triton, which has a slightly different airframe design and sensors than the Air Force's RQ-4 Global Hawk, is currently in the final phases of testing and evaluation. Following the unveiling of the first Triton test aircraft in 2012, the program experienced immediate challenges in software and hardware development, resulting in the delay of flight tests by over a year.[3] In his assessment of the Triton program last year, Program Manager Sean J. Burke acknowledged that "it has made clear to me that one of the initial framing assumptions of the program—that there would be a high degree of [hardware] and [software] developmental commonality between the Global Hawk (GH) and Triton—was incorrect." The software complications resulted in $355 million in research and development cost overruns during Fiscal Year 2012, breaching the Acquisition Program Baseline—the parameters for how much the program may spend within a given area.[4]

In 2013, after cost changes and delays, the Navy also paused the development of the Air-to-Air Radar Subsystem, which would have enabled the Triton to autonomously sense-and-avoid other aircraft.[5] While that project remains officially dead, the Office of the Director, Operational Test and

1 Persistent Maritime UAS. (n.d.). Retrieved February 10, 2016, from http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=624BC6D7-45CE-446C-BA1E-5818E57F9914

2 Department of Defense. (2008, April 22). Navy Awards Northrop Grumman Unmanned Aircraft System Contract [Press release]. Retrieved February 10, 2016, from http://www.defense-aerospace.com/article-view/release/93541/us-navy-picks-global-hawk-for-$1.1-billion-bams-program.html

3 Rosenberg, Z. (2012, June 14). PICTURE: Northrop unveils first MQ-4C Triton for US Navy. *Flight Global*. Retrieved February 10, 2016, from https://www.flightglobal.com/news/articles/picture-northrop-unveils-first-mq-c-triton-for-us-navy-373027/

4 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Selected Acquisition Report (SAR): MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton) (RCS: DD-A&T(Q&A)823-373). Washington, D.C.: United States Government Printing Office, 2014.

5 MAJUMDAR, D. (2013, August 15). AUVSI: US Navy pauses development of MQ-4C Triton 'sense and avoid' radar. *Flight Global*. Retrieved February 13, 2016, from https://www.flightglobal.com/news/articles/avusi-us-navy-pauses-development-of-mq-4c-triton-sense-and-avoid-radar-389504/

Evaluation (DOT&E) Fiscal Year 2015 report stated that the Navy continues to develop some sort of avoidance system and will make a final decision in 2016. [6]

In November 2015, the Navy initiated operational assessments of the Triton, the first step in the final round of tests leading to Milestone C designation, which marks the end of the engineering and development phase.[7] In spite of the cost overrun in 2012, according to the 2015 Selected Acquisition Report (SAR) Summary Tables, the cost of the Triton program actually decreased by 6.8% due to changes in support contracts and equipment cost estimates.[8] In contrast to other drone programs like the Navy's MQ-8C Fire Scout or the Air Force's MQ-9 Reaper, the Triton has not experienced major changes to requirements or planned purchase quantities, two factors that typically drive up the cost of an acquisition program. In September 2015, the Department of Defense Inspector General reported that the Navy had therefore justified the purchase of a total of 70 Tritons.[9]

The Fiscal Year 2016 budget—released in February 2015—marked the beginning of the transition from research and development to low-rate production. The Navy allocated $619.662 million in procurement funding for the first set of three Tritons and $154 million in spare parts and repairs. It also allocated nearly $52 million for the construction of an avionics and fuel system trainer at Point Mugu, California; a mission control facility in Jacksonville, Florida; and a hangar and operations facility in Sigonella, Italy. Funding for research and development decreased from a total of $449 million in Fiscal Year 2015 to $357 million in 2016 due to the general shift from research to procurement. In all, funding in Fiscal Year 2016 for the Triton is estimated to be $1.028 billion.

The Fiscal Year 2017 request for the Triton is lower than in 2016. In all, the Navy intends to spend around $943 million on procurement, research, and construction for the Triton in 2017. This decrease can be partly attributed to the fact that in Fiscal Year 2016, the Navy purchased four Tritons, as opposed to the two planned for 2017. Procurement funding in FY16 also received a $65 million boost from Congress. Research and development spending in FY17 continues to track lower than previous years, although the drop—$64 million—is not as large as the decrease between 2015 and 2016. Construction funding is up slightly as the Navy continues to build out the physical infrastructure that will sustain Triton operations. In FY17, the Navy is planning to build mission control facility at Naval Air Station Whidbey, Washington and forward operating base hangars at various undisclosed locations around the world.

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6 U.S. Department of Defense, Office of the Director, Operational Test & Evaluation. FY 2015 Annual Report. Washington, D.C: United States Government Printing Office, 2016

7 Tompkins, R. (2015, November 19). Navy starts pre-Milestone C tests on MQ-4C Triton UAS. Retrieved February 10, 2016, from http://www.upi.com/Business_News/Security-Industry/2015/11/19/Navy-starts-pre-Milestone-C-tests-on-MQ-4C-Triton-UAS/5901447955776/

8 U.S. Department of Defense, Under Secretary of Defense, Acquisition, Technology, and Logistics (USD[AT&L]). Selected Acquisition Report (SAR) Summary Tables. Washington, D.C.: United States Government Printing Office, 2014.

9 U.S. Department of Defense, Office of the Inspector General. Navy Officials Justified the MQ-4C Procurement Quantity. Washington, D.C.: United States Government Printing Office, 2015.

Army

Funding for the Army's drone-related procurement, research and development, and construction projects amounts to $521 million in Fiscal Year 2017. This is down from $706.2 million in Fiscal Year 2016 due largely to the absence of unmanned aircraft purchases in this budget. While procurement funding is down, allocations for research and development increased, as did funding for construction.

Procurement

The Army's procurement budget is split between upgrades and modifications to existing unmanned aircraft and funds for the purchase of a number of unmanned ground vehicles. The Army is transitioning a number of important projects, like the Tactical Signals Intelligence Payloads and Autonomous Mine Detection System, from the research and development phase to procurement.

- The Army intends to spend $99 million on the General Atomics MQ-1C Gray Eagle system, the Army's version of the Air Force MQ-1 Predator. None of the funds allocated in FY17 will go towards buying additional aircraft. Instead, $55.4 million will be spent on a variety of system upgrades, training, and support functions, including $24.3 million for contractor logistics support. Another $43.7 million will go towards purchasing upgraded payloads for the Gray Eagles, the majority of which, $32.8 million, has been earmarked for 17 Tactical Signals Intelligence Payloads, a BAE Systems product used to detect and geo-locate radio frequency emitters associated with high-value targets. The Army has already purchased 158 MQ-1C Gray Eagles and it does not appear as though it will purchase additional aircraft in the future (in FY16, the Army purchased 17 Gray Eagles). (Line Items A00005 and A01001)
- The Army has allocated $72.9 million for the AAI/Textron RQ-7 Shadow, a medium-sized tactical unmanned air vehicle. The majority of these funds will go toward upgrades for the Shadow, including 120 engines, 80 mission computers, 50 weatherization kits, 18 laser designator payloads, 12 boresight tools, 8 launchers, 8 maintenance spare kits, and 6 simulator trainers. A further $1.8 million has been allocated from the Overseas Contingency Operations budget for one Shadow aircraft and an accompanying full-motion video payload to replace a Shadow that was lost in Afghanistan. (Line Item A0018)
- The FY17 budget includes $26.2 million in procurement funding for 28 Textron One System Remote Video Terminals, which allow soldiers on the ground to view the video from multiple unmanned aircraft. Fiscal Year 2017 funding includes $4.4 million under the OCO budget for an additional 27 systems, which will contribute to the European Initiative. Prior to Fiscal Year 2017, this project was filed under funding for modifications to the RQ-7 Shadow. (Line Item A01002)
- The Army budget includes $20.6 million in procurement funding for an assortment of unmanned ground vehicles, including several new projects. The Carnegie Robotics Autonomous Mine Detection System (AMDS) carriessupplies payloads like Ground Penetrating Radar that enable unmanned systems to detect mines. With $10.5 million in FY17 funds for 16 systems, the AMDS will transition

- The Army is buying just one new unmanned aircraft in its FY17 budget, an RQ-7 Shadow.
- The budget includes $16 million in funding to buy 44 unmanned ground vehicles, and more than doubles research spending on UGV research projects.
- The Army has allocated $2.7 million for a counter-drone technology research initiative. and $4.7 million to study swarming.

from a research and development project to low-rate initial production. Another project, the Man-Transportable Robotic System (MTRS) Inc II, will enter production in FY17 with $5.5 million in funding for 28 systems. The MTRS is designed for mine detection and route clearance and can haul 200-lbs. Four of the MTRS systems will go towards the European Reassurance Initiative and will be paid for using $268,000 in OCO funds. The Robotic Combat Support System (RCSS) has been, allocated $3 million for, will procure 16 tracked engineering vehicles for route clearance that will be split among the Army, Reserve, and National Guard. The $1.9 million in EOD Robotics Systems Recapitalization spending will procure 18 MTRS robots for explosive ordnance disposal. (Line Items W12002, R68260, M80400, W12001)

- The Army has allocated $13.35 million for the Family of Persistent Surveillance Capabilities, tethered surveillance aerostats, which will go toward buying two tether-up kits—one for Operation Freedom Sentinel and one for Operation Inherent Resolve. The majority of funding—$11.6 million—will draw from the OCO budget. (Line Item BL5287)

Research, Development, Testing & Evaluation

Despite being smaller than the Air Force or Navy's drone research funds, the Army's research and development budget is quite varied. The budget for FY17 amounts to $236.5 million in FY17. It encompasses modernization efforts for platforms like the MQ-1C Gray Eagle and research into micro air vehicles and 3-D printed drones. A significant focus in the Army budget is research into autonomous systems and robotics. Cumulatively, funding for these research projects increased in FY17 over the previous two years.

- Research funding for the General Atomics MQ-1C Gray Eagle amounts to $49.3 million, split between two programs: $35.8 million for the MQ-1C Gray Eagle Modification/Product Improvement Program, which includes developing improved Ground Control Stations, munitions integration upgrades, and Ground Based Sense and Avoid; and $13.5 million for testing the Improved Gray Eagle, a new iteration of the drone that comes with increased endurance, range, and airspeed as compared with previous models, as well as autonomous take-off and landing capabilities. (Program Elements 0203744A and 030521A)
- The Army has allocated $8.2 million for three projects to develop advanced drone payloads and technologies. These three projects apply to the MQ-1C Gray Eagle, as well as to smaller drones like RQ-7 Shadow or RQ-11 Raven. The Joint Technology Integration Center, a $3.9 million project, develops training programs and simulators for the Army's family of unmanned aerial systems. The $2.8 million Small Tactical Radar is a multi-weather synthetic aperture radar system intended for the Gray Eagle. Funding for the Tactical Signals Intelligence program is down from $7.1 million in FY16 to $1.5 million in FY17 due to the transition of the program from research to production. (Program Element 0305204A)
- The Army will also spend $1.6 million on improvements to the RQ-11 Raven, a small tactical reconnaissance drone, and $4.6 million on the RQ-7 Shadow. The funds for the Shadow will be spent on researching ways that the aircraft might operate in areas without access to a GPS signal. (Program Elements 0305232A and 0305223A)
- The Army has allocated $45.5 million for spending on the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) surveillance aerostat. All of these funds will be used foron the NORAD-U.S. Northern Command military training exercise. (Program Element 0202429A)

Photo: Adrian Muehe / US Army

- Three ongoing research projects look into ways for manned and unmanned aircraft to work together. The Unmanned and Optionally Manned Technologies program, to which $6.9 million is allocated, will develop algorithms to advance autonomous capabilities in unmanned aerial vehicles. TMeanwhile, the $8.4 million Unmanned and Optionally Manned Systems program will research how to have multiple drones fly autonomously at once. The Systems of Systems Cooperative Engagement Test Infrastructure, $973,000, will begin a series of tests to explore Manned-Unmanned Teaming. (Program Elements 0602211A, 0603003A, and 0604759A)
- The Micro-Autonomous Systems Technology, Advanced Micro and Nano Devices, and Micro/Small Unmanned Aerial Systems projects are invested in developing micro-drones, including 3-D printed drones. The Army has allocated $12.4 million for these projects. (Program Elements 061104A, 0602705A and 0602211A).
- Six robotics research projects have been allocated a total of $37.1 million for developing autonomous capabilities and researching ways that robots that can assist soldiers. The Robotics Collaborative Technology Alliance, allocated $4.04 million, supports research into autonomous systems and "peer-to-peer" teaming between humans and robots. The Robotics CTA is a partnership between the Army Research Laboratory and a number of companies and academic institutions. The Robotics Autonomy, Manipulation, & Portability Research project, allocated $8.8 million, enables research into machine perception: developing algorithms that enable robots to better understand their environment. The Robotics Technology project, allocated $8.5 million, supports the Robotics CTA by providing funding for a number of initiatives including research into machine perception, communication, and intelligence. The Human-Robot Interaction project, allocated $3 million, is dedicated to researching how a soldier might interact with multiple semi-autonomous and autonomous vehicles and how to createcreating "trust and transparency" between the robot and human. The Robotics/UAS Instrumentation Suite, $3.03 million, provides funding for testing robotic and autonomous vehicles. The Intelligent Systems Technology Research project, $9.8 million, will look into ways that autonomous capabilities and robotics might aid the operation of manned vehicles. (Program Elements 0601104A, 0601102A, 0602120A, 0602716A, 0604759A, and 0602601A)
- The Army will increase spending on unmanned ground vehicles in Fiscal Year 2017 from $24.38 million in FY16 to $53.31 million in FY17. Funding for the Common Robotic System-Individual, a two-year-old project working to develop a versatile robot for surveillance and bomb disposal, is up to $39.3 million in FY17 from $15.4 million the previous year. Funding for Robotic Ground Systems, a project that researches technologies for unmanned ground vehicles

Photo: Sgt. Mike MacLeod / US Army

such aslike light detection and ranging (LIDAR) and behavior algorithms, is up from $7.6 million in FY16 to $12.7 million in FY17. The Tank-Automotive Research, Development and Engineering Center will receive $1.4 million for researching autonomous systems and Big Data analytics. (Program Elements 0604641A, 0601101A, and 0603005A)

- The Army has allocated $36.9 million for a program that covers an assortment of projects involving research into robotic and autonomous systems for detecting and clearing mines. The Man-Transportable Robotic System and the Route Clearance & Interrogation System—two robotic systems for clearing mines and explosive ordnance—will receive $16.7 million in FY17, an increase of $3.3 million over the previous year. The Husky Mounted Detection System, $6 million, is an optionally-manned system that uses ground-penetrating radar to detect and identify mines. (Project Element 0604808A)
- The Autonomous Vehicle Architecture project, allocated $1.4 million, is a new initiative that looks to use Lockheed Martin's Autonomous Mobility Applique System to add an optional autonomous capability to manned ground vehicles. Meanwhile, the Future Autonomy - Optimizing Training Strategies project, allocated $600,000, will seek to develop training programs that pair soldiers with autonomous vehicles. (Program Elements 0602308A and 0602308A)
- The Swarming Weapons Technologies project, allocated $4.7 million, is a new initiative that will research ways lethal payloads might be delivered in contested environments using collaborative teaming and distributed intelligence. (Program Element 0602618A)
- One project focuses solely on detecting, tracking, and destroying incoming drones: funding for the Counter-Unmanned Aviation System (C-UAS) Technology is set at $2.7 million for Fiscal Year 2017. (Program Element 0603004A)

Construction

The Army will spend $47 million on a cold-climate drone hangar at Fort Wainwright, Alaska. The Army announced in June 2015 that a squadron of nine MQ-1C Gray Eagle drones and 128 personnel will be stationed at Fort Wainwright. The Army will also spend $5 million on a maintenance hangar at Fort Carson, Colorado. This hangar will house tactical unmanned vehicles like the RQ-7 Shadow and will expand the facilities for training UAV maintenance and repair crews. (Program Elements 22096A and 22212A)

Special Operations Command

For FY17, SOCOM has allocated $96.7 million for drone procurement, research and development, and construction. This is down from $131.7 million in FY16 and up from $62.7 million in FY15. The FY17 budget includes $43.7 million in procurement spending, $48.2 million for research, and $4.8 million for construction.

Procurement

- SOCOM expects to operate 50 MQ-9 Reaper drones in FY17, up from 37 in FY15. While these aircraft are purchased through the regular Air Force budget, SOCOM sets aside funds to upgrade the sensors and weapons to fit its mission requirements. Some of these payloads include improved full motion video and communications, new weapons, extended flight range capabilities, and advanced sensors. In FY17, SOCOM has allocated $10.6 million to purchase new mission kits. (Line Item 1108MQ9)
- SOCOM plans to consolidate several procurement programs that focus on upgrading smaller drones into a single line item in FY17. The Unmanned ISR (Intelligence, Surveillance and Reconnaissance) program will purchase new payloads for the RQ-11 Raven, RQ-20 Puma, and MQ-1 Predator. In all, this program will procure 90 mission kits for these aircraft, amounting to $33.1 million, including $11.9 million drawn from Overseas Contingency Operations funds. (Line Item 0201UMNISR)

Research, Development, Testing & Evaluation

- The MQ-9 research program, allocated $17.8 million, will develop mission kits and payloads unique to Special Operations Forces. In FY16, Congress added $4 million to this program. (Program Element 1105219BB)
- The Unmanned ISR research program, allocated $22.1 million, develops new capabilities for small reconnaissance and surveillance aircraft. Efforts will focus on improving signals and imagery intelligence and electronic warfare payloads. Several research programs have been consolidated to create this budget item, including the Special Applications for Contingencies program, which received $65.1 million in FY16. (Program Element 1160434BB)
- The Platform Engineering Analysis program, allocated $5 million, supports research into payloads, sensors, air-ground interoperability, precision munitions, and ISR capabilities for small UAVs. (Program Element 1160402BB)

Construction

SOCOM has allocated $4.8 million to construct a hangar and maintenance facility for tactical unmanned aircraft at Fort Benning, Georgia. The facilities will serve a new drone platoon in the 3rd Battalion, 75th Ranger Regiment and the project is expected to be completed by June 2018. (Program Element 1140494BB)

Defense Advanced Research Projects Agency

In FY17, DARPA will allocate $301.5 million for research into drones, autonomy and robotics. This is up from $283.9 million in FY16 and $233.2 million in FY14.

Research, Development, Testing & Evaluation

- Two projects that are new in FY17 focus on developing autonomous capabilities and artificial intelligence: Understanding Machine Intelligence, allocated $10 million, and Science of Human and Computer Teaming, allocated $15 million. Understanding Machine Intelligence is an initiative to research ways to improve transparency in artificial intelligence. Science of Human and Computer Teaming will develop systems for getting humans and machines to work together as a team. (Program Elements 0602303E and 0602702E)
- Aircrew Labor In-cockpit Automation System (ALIAS), allocated $19.9 million, is an ongoing research initiative aimed at developing software that can automate aircrew functions using autonomous systems architecture. The goal of the research project is to improve aircrew performance. (Program Element 0602702E)
- The Communicating With Computers (CWC) project will develop systems for computers to "comprehend language, gesture, facial expression and other communicative modalities in context," according to the program justification text. One goal in FY17 is to demonstrate how humans and machines can communicate and collaborate on “a physical problem solving task.” Funding for this program rose from $5 million in FY15 to a proposed $16.2 million in FY17. (Program Element 0601101E)
- Two projects will explore the role that unmanned ground systems can play in teams of human soldiers. The Squad X program, initiated in FY14 and allocated $36.8 million, will study the use of unmanned systems in the air and on the ground to enhance the situational awareness of infantry units in complex urban environments. For example, in the near future, infantry squads might be deployed with an unmanned aircraft to monitor the squad from above and robots on the ground to screen the soldiers and carry their gear. The Mobile Infantry program, allocated $7 million, will study the performance of teams of humans and semi-autonomous platforms, focusing on how machines could execute some missions without the interaction of a human operator. (Program Element 0602702E)
- The Counter Unmanned Air Systems and Force Protection program, allocated $9 million, is a new initiative that will study systems for detecting, tracking and destroying unmanned aircraft that pose a threat to military personnel. This project will also examine how non-state and state actors could use drones to gain an asymmetric advantage on the battlefield. (Program Element 0602702E)
- Two projects are dedicated to developing prototypes for large unmanned air vehicles. The Vertical Take-Off and Landing Demonstrator,

An artist's rendering of the TERN. Image: DARPA

allocated $52 million, will build an experimental aircraft, combining features of a fixed-wing airplane and rotary-wing technology. The hope is to produce an aircraft that can fly relatively fast (at least 350 mph) and takeoff and land without the need for a runway. The intended customers are the Army, Marine Corps and Special Operations Forces. The Tactically Exploited Reconnaissance Node (TERN), a large vertical takeoff and landing drone intended for small Navy ships, is being phased out of the DARPA budget and moving to the Navy's budget for the next stage of development. The TERN project will receive $12 million in DARPA funding in FY17. (Program Element 0603286E)

- The Collaborative Operations in Denied Environment (CODE) project, allocated $29 million, seeks to create new algorithms and software that would enable a fleet of existing drones to be controlled by, for example, a single fighter jet pilot. In FY17, DAPRA will continue to develop algorithms for collaboration between drones and human supervisors, as well as among drones themselves. For example, one goal will be to develop an algorithm that will enable unmanned systems to re-assign targets based on the loss of a friendly drone. (Program Element 0603286E)
- The Gremlins program, allocated $36 million, will develop prototypes for small, low-cost drones that could be launched en masse from a cargo plane. The swarm of drones could carry out a reconnaissance or strike mission and eventually recovered by the host platform. These

The Upwards Falling Payloads concept. Image: DARPA

The Gremlins concept. Image: DARPA

small drones could also act as a defensive line for manned aircraft by providing intelligence and reconnaissance capabilities. (Program Element 0602702E)

- The Anti-Submarine Warfare Continuous Trail Unmanned Vessel, allocated $4 million, seeks to develop an autonomous unmanned surface vehicle that could aid manned ships in countering enemy submarines. The underwater vehicle could remain submerged for months at a time. In FY17, this program will transition from DARPA to the Office of Naval Research. (Program Element 0602702E)
- The Upward Falling Payloads project, allocated $14 million, will develop a distributed network of underwater unmanned systems that can provide situational awareness and strike capabilities across a large maritime area. These payloads could be concealed on the ocean floor in contested areas and then remotely activated to carry out a mission on an unsuspecting enemy. The Hydra program, allocated $24.2 million, also seeks to overcome the challenges posed by controlling large maritime areas. The goal of this project is to develop a network of different types of undersea vehicles that could, when awakened, carry out a variety of missions and augment the capabilities of a manned ship. The Mobile Offboard Command Control and Attack program, allocated $16.3 million, will develop an unmanned undersea vehicle to detect enemy submarines. (Program Elements 03603766E and 0302702E)

Missile Defense Agency

Funding for unmanned systems by the Missile Defense Agency is divided between two large programs aimed at detecting and intercepting incoming ballistic missiles. Together, these two programs amount to $105.1 million in funding, up from $69.8 million in FY16 and $54 million in FY15.

- The Discrimination Sensor Prototype Development program, allocated $57.4 million, studies how to use an MQ-9 Reaper to detect and track an incoming missile and hand off the information to another missile that could intercept the incoming threat. The idea is that the Reapers could be a cheaper alternative to expensive satellites. This budget allocation is more than double the amount allocated in FY16 due to the transition of the program from research phase to test phase. (Program Element 0604115C)
- The Directed Energy Research program, allocated $47.7 million, aims to develop a laser, which could fit aboard an unmanned air vehicle like the Reaper, to intercept incoming ballistic missiles. These funds are divided between two laser development programs: the Diode Pumped Alkali Laser at the Lawrence Livermore National Laboratory and the Fiber Combined Laser at the Massachusetts Institute of Technology Lincoln Laboratory. The goal is to develop a relatively lightweight laser that can scale up in power quickly without burning out the drone's onboard electrical systems. (Program Element 0603178C)