
Next Generation Jammer
Essential Protection in the Digital Age
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Findings In Brief

Electronic devices dominate modern combat. Warfighters depend on access to the electromagnetic spectrum to communicate with friendly forces, track enemy movements, navigate in the fog of war, collect intelligence, and perform many other vital functions. Electronic warfare is the military specialty concerned with denying enemy forces use of the spectrum while assuring that friendly forces have unfettered access.

Airborne jammers are essential to the successful conduct of most electronic warfare missions. Jammers are used to prevent enemy radars and communications devices from functioning effectively by dominating the frequencies in which such systems operate. This is accomplished by either overpowering the transmissions of hostile emitters or manipulating traffic on the spectrum to confuse enemies. Jammers can also be used to prevent detonation of improvised explosive devices and accomplish more exotic information operations.

The U.S. Navy is the lead service in providing electronic warfare capabilities to the joint force. The main electronic warfare aircraft in the joint fleet today is the EA-6B Prowler, which has been upgraded many times since its inception in the 1970s. The Prowler is being replaced by a more capable variant of the carrier-based Super Hornet designated the EA-18G Growler. However, initial versions of the Growler will carry the same Cold War jamming system used by the Prowler.

The current jamming system has served the joint force well, but it cannot keep up with emerging dangers. It lacks the capacity to cope with numerous threats at the same time, the power to address distant emitters, and the precision to avoid impeding transmissions of friendly forces. In addition, it is frequently out of service due to maintenance needs and sometimes is incompatible with the warfighting systems of allied forces. As a result, the joint force is gradually losing its edge in electronic warfare.

The Navy is leading a joint effort to develop a Next Generation Jammer that will remedy these deficiencies by providing greater power, agility, precision and reliability. The new jammer will be able to cover a wider range of threats and operate seamlessly with allied forces, while providing growth capacity for coping with new threats that emerge in the years ahead. Development of the Next Generation Jammer must be kept on track for initial operating capability in 2018 if the joint force is to continue providing adequate electronic protection to U.S. warfighters.

Table of Contents

America's Military Must Have A New Airborne Jammer Soon

Electricity drives modern combat, just as it powers global commerce and culture. Without electronic sensors, computers, communications links and navigation aids, U.S. warfighters would be unable to operate safely or successfully. The joint force therefore must have assured access to the electromagnetic spectrum at all times, and its ability to deny that access to enemies provides a crucial advantage in combat.

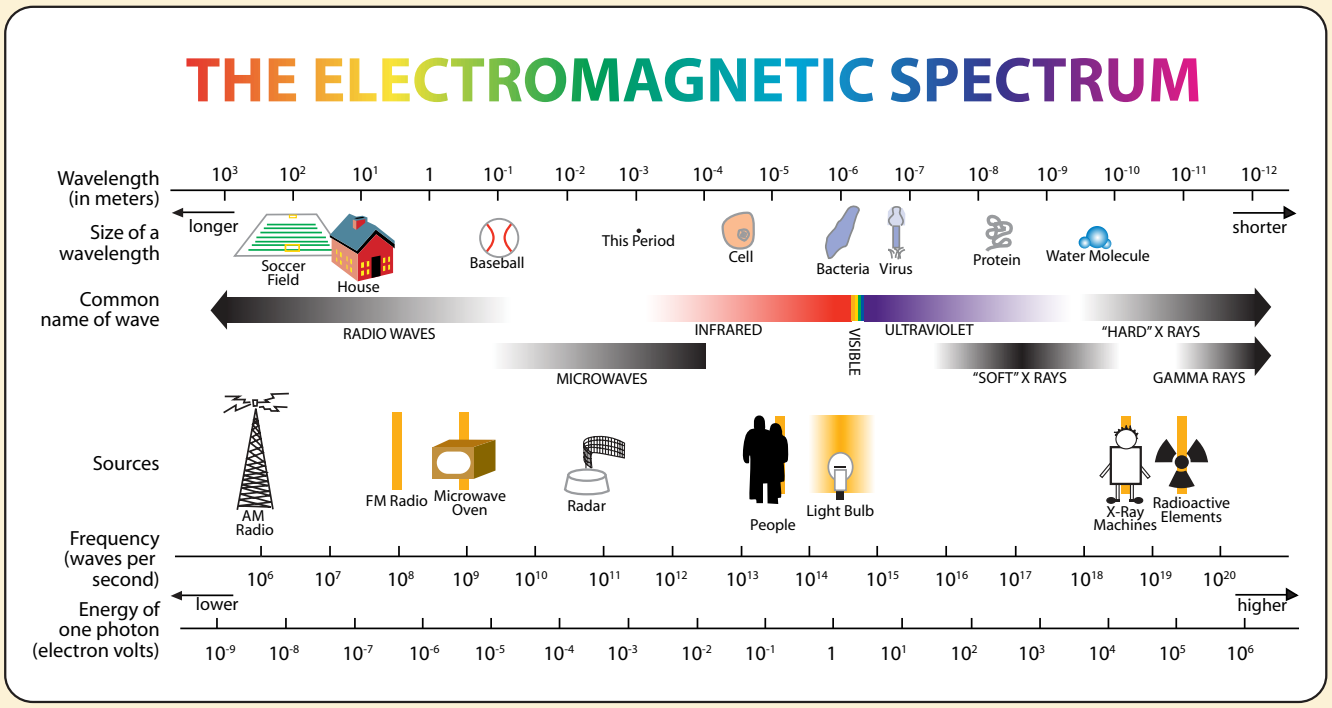
Jammers are the key tool employed by U.S. warfighters to deny adversaries use of the spectrum. They generate bursts of energy tuned to the signals of enemy radars and radios so that friendly forces cannot be targeted and hostile combat units cannot communicate. Sometimes this is accomplished by the simple tactic of overloading relevant frequencies with energy, and other times it involves more subtle manipulations, but the goal is always to deny the enemy effective use of its electronic systems.

However, the edge that U.S. forces have traditionally enjoyed in electronic combat is eroding. The principal airborne jammer used by today's joint force was first fielded 40 years ago, and its basic design has not changed since then. Although it is periodically upgraded to deal with new threats, so many new technologies are becoming available to friends and foes alike that it cannot cope with all the emerging threats.

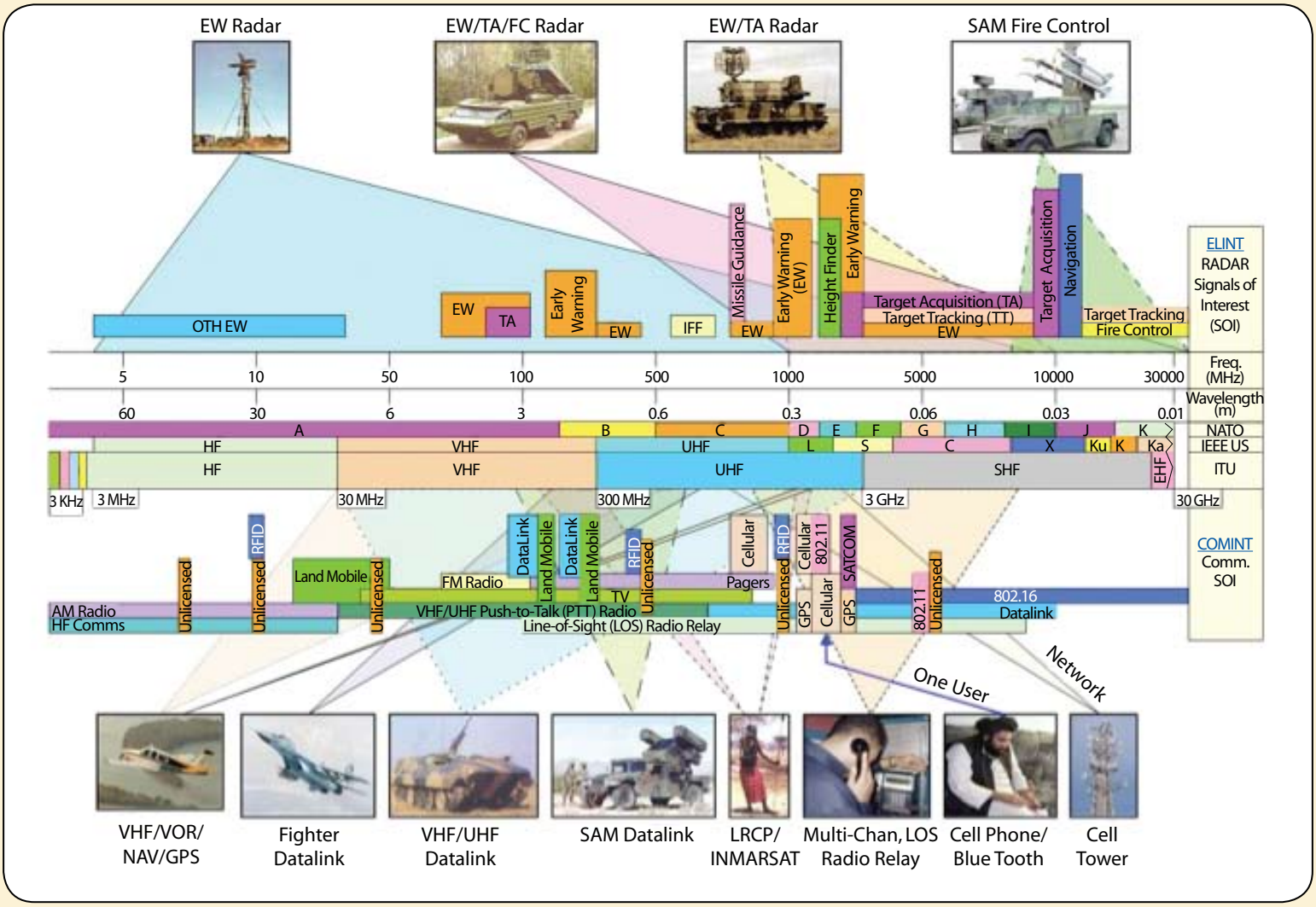
The current jammer not only lacks the agility, reach and precision to deal with new dangers, but it often is in need of repair and sometimes interferes with the operations of friendly forces.

The Department of Defense has begun a program called the Next Generation Jammer to remedy these deficiencies. The program will soon select a winning design that must be developed and produced in time for fielding on the Navy's EA-18G electronic attack aircraft in 2018 and the Marine F-35B shortly thereafter. Any significant delay in fielding the new jammer beyond that deadline could put U.S. forces at risk due to rapid advances in technology available to enemy forces.

The purpose of this report is to concisely explain the urgency of fielding the Next Generation Jammer on its currently planned schedule or sooner. The report explains the importance of jamming systems and describes the status of current jamming capabilities. It then sets forth the key features of the Next Generation Jammer and explores how it will deal with the increasingly diverse range of electronic threats the joint force faces. It concludes by stressing how vital timely fielding of the new jammer is to assure U.S. forces are not overwhelmed by emerging dangers.



The chart at the top of the page reflects the distribution of various frequency-wavelength combinations on the electromagnetic spectrum. The Next Generation Jammer is designed to counter radio wave emitters in the part of the spectrum where frequencies are lower and wavelengths are longer. The chart at the bottom of the page reflects where the radar and communications links that must be jammed originate in the radio wave region of the spectrum.



Jammers Address Threats on the Electromagnetic Spectrum

The universe is shaped by four fundamental forces -- gravity, the strong nuclear force that binds atoms, the weak nuclear force that causes their decay, and electromagnetism. Until about 200 years ago, all of these forces were beyond the ability of human beings to manipulate. During the 19th Century, though, inventors such as Morse, Marconi and Edison began to exploit scientific insights into electromagnetism to develop useful devices. Within a few generations, electricity and electronics had become a central feature of virtually all modern technology.

The electromagnetic energy driving computers, cell phones and radars occurs in nature as waves that vibrate. Different types of electromagnetic energy such as radio waves and visible light vibrate at different rates, a phenomenon called frequency. Frequency describes the number of times a signal vibrates per second, usually expressed in hertz (after German physicist Heinrich Hertz). As frequency increases, the length of waves decreases, changing the properties of the energy. The electromagnetic spectrum reflects all frequency-wavelength combinations that occur in nature, from the lowest frequencies and longest waves to the highest frequencies and shortest waves.

Electronic warfare and the jammers used to wage it are mainly concerned with the radio frequency (RF) portion of the electromagnetic spectrum. Radio waves extend from the lowest-frequency forms of electromagnetism, which vibrate only a few times per second, to frequencies of several hundred billion vibrations per second. The highest frequency radio waves are called microwaves; because more information can be captured or conveyed in a given period of time at these higher frequencies, radars typically operate in the microwave region of the RF spectrum.

Most RF communications systems, such as cell phones and GPS devices, operate at lower frequencies. Specific frequency-wavelength combinations have been set aside for the communications purposes to which they are best suited. These narrowly-defined regions are called "bands." For example, the lowest frequencies are used for submarine communications because long wavelengths penetrate deeper into water. Line-of-sight communications between aircraft typically utilize frequencies a thousand times higher, and secure satellite communications occur at frequencies a million times higher.

In order to effectively interfere with hostile RF devices, jammers must be able to operate in the same band utilized by those devices, and to generate enough power in the vicinity of receivers to overwhelm the energy produced by the devices. Jamming energy generated outside the frequency-wavelength regions in which hostile actors are operating will have no effect on their signals. However, because virtually every region of the radio frequency spectrum is now used for some communications or other purpose, jamming energy can potentially cause major disruption of other signals, including those of friendly forces.

The EA-6B Prowler has been the principal electronic warfare aircraft in the joint fleet since the Cold War ended. The four-seat Prowler typically provides standoff jamming of air defense radars and communications links, and more recently has added new roles such as jamming the devices used by insurgents to detonate improvised explosives. The two outer wing pods in this image house the current jamming system, which has been repeatedly upgraded to cope with emerging threats.

Electronic Warfare Is A Central Feature Of Modern Conflict

Modern combat unfolds in a dense electronic environment. Opposing forces use the electromagnetic spectrum to communicate, to detect and target adversaries, to collect and analyze intelligence, to determine location, to deliver logistical support and accomplish a host of other functions. Without access to the spectrum, it is impossible to deploy a military force effectively. By the same token, the ability to deny an enemy access to the spectrum is a key ingredient in military success.

Electronic warfare (EW) is the cluster of military skills associated with assuring the access of friendly forces to the electromagnetic spectrum while denying its use to adversaries. EW is typically divided into three distinct areas of competence:

- *Electronic support* activities associated with detecting, identifying, localizing and tracking hostile emitters.
- *Electronic protection* activities aimed at reducing the vulnerability of friendly forces to hostile uses of the electromagnetic spectrum.
- *Electronic attack* activities aimed at disrupting, degrading or destroying adversary capacity to exploit the electromagnetic spectrum.

Jammers are one of the tools used to accomplish the latter activities. They typically are employed to neutralize enemy radars, disrupt enemy communications, and prevent the use of electronic devices to remotely detonate munitions (a favorite tactic of insurgents in Southwest Asia). Jammers can be used as a non-kinetic means of disabling enemy sensors and communications links, or they can be used in support of kinetic attacks employing munitions. In principle they can be mounted on and employed by any type of properly protected military vehicle, but they typically are most effective when used from the air, because electromagnetic energy travels in a straight line until it encounters conductive media. Geography, structures and the curvature of the earth may interfere with jammer signals when they are operated on the ground.

Airborne jammers can be mounted on manned or unmanned aircraft, and they can operate both inside and outside an enemy's defensive perimeter (the maximum range of defending radars and missiles). The most common concept of operations today involves manned jamming aircraft in standoff roles beyond the reach of enemy defenses, or in escort roles accompanying friendly strike aircraft on penetrating missions. However, the missions assigned to jamming aircraft are becoming more diverse due to the emergence of unconventional adversaries who use electronic devices in non-traditional ways. In addition, many conventional adversaries are acquiring advanced digital technologies that fundamentally alter their military capabilities. The Cold War jamming systems currently employed by U.S. forces are not well suited to dealing with these new challenges.

The EA-18G Growler will replace the Prowler as the main electronic warfare aircraft in the joint fleet. Based on the F/A-18 E/F Super Hornet, the Growler will offer a more agile, survivable airframe and more sophisticated on-board electronics, enabling a reduction in the crew size from four to two personnel. However, the Growler debuted carrying the same basic jamming system as the Prowler, a problem that must be remedied to assure U.S. forces retain their edge in combat.

Jammers Are A Weak Link In Current Electronic Warfare Capabilities

The EA-6B Prowler electronic warfare aircraft is the principal airborne jammer in the joint fleet today. The Prowler flies from aircraft carriers and land bases in support of Navy, Air Force and Marine strike operations, masking the location of attacking planes so they cannot be tracked by enemy radar. In addition, it collects electronic intelligence, disrupts hostile communications, and neutralizes systems used to detonate improvised explosive devices on the ground. Because they have been flying for nearly 40 years, the 125 Prowlers in the current fleet are experiencing age-related problems with both their airframes and their on-board equipment. These problems reduce aircraft readiness and increase the cost of operations.

Some Prowlers have recently been upgraded with new electronic receivers for detecting hostile emitters, software that improves the precision of jammers, and digital datalinks. These same improvements are being incorporated into the EA-18G Growler that began replacing Prowlers in 2009. The Growler, based on the Navy's carrier-based F/A-18 Super Hornet, will provide a more versatile and maintainable airframe for electronic warfare missions. Automation of electronic functions will enable it to perform jamming missions with a crew of two rather than the four found on the Prowler. However, the Growler debuted carrying the same aged jamming pods used on its predecessor -- technology which first saw service when the Prowler joined the fleet in 1971. The jamming pods exhibit several deficiencies:

- Their availability is limited by the need for frequent repairs and maintenance.
- Their ability to cope with numerous, diverse adversaries simultaneously is limited.
- Their operating modes impede the ability of friendly forces to function seamlessly in wartime.
- Their precision in generating jamming signals is not sufficient to avoid interfering with friendly forces.
- Their design specifications do not provide sufficient power and other features to cope with emerging threats.

Even carrying multiple jamming pods per aircraft, the Prowler and Growler will not be able to deal with the entire array of emerging threats. For example, adversaries are gradually learning how to unmask the low-observable ("stealth") technology employed on the latest U.S. tactical aircraft, which means they will need sophisticated jamming support in the future to safely accomplish some strike missions. More generally, the proliferation of new communications devices, digital sensors and other novel warfighting technologies creates an electronic environment too complex for Cold War jammers to fully address. It therefore is necessary to develop a new jamming system incorporating the full range of technological innovations that have appeared since current jammers were fielded four decades ago.

Some of the F-35B joint strike fighters being developed for the U.S. Marine Corps are expected to carry the Next Generation Jammer. The F-35B will have a short takeoff and vertical landing capability that allows it to be based closer to forward-deployed ground forces than other tactical aircraft. Its design and concept of operations are very different from those of the EA-18G, underscoring the need for a modular jamming system that can be installed on airframes with varying characteristics.

The Next Generation Jammer Will Preserve U.S. Dominance

A series of studies conducted by the Department of Defense over the past decade have determined that the joint force must develop and field a replacement jammer in the near future to maintain its dominance of the electromagnetic spectrum in combat. In 2008, senior policymakers approved an acquisition decision memorandum providing guidance for the development of a Next Generation Jammer and designating the Navy as lead service. The Navy is directed to coordinate with other services in formulating specifications for the new jammer that will enable it to satisfy all airborne jamming requirements anticipated through mid-century.

Because the proliferation of new radio frequency threats is expected to persist throughout the service life of the Next Generation Jammer, the system will utilize a modular, open architecture that permits frequent upgrades to cope with emerging challenges. Modularity enables the system to be reconfigured so that it can be deployed on aircraft other than the EA-18G that will be its initial host, including the F-35 joint strike fighter, unmanned aircraft and even naval surface vessels. Open architecture enables the system to readily incorporate new military and commercial technologies that enhance performance as they become available. The overriding design goal is to develop a tactical jamming system with sufficient flexibility and growth potential to cope with virtually any imaginable radio frequency threat.

The Next Generation Jammer is expected to be fielded initially as a series of external pods on the Growler, with each pod configured to address specific types of electromagnetic threats. Within the pods, every component of the jamming system will be substantially improved. For instance, power generation will be boosted to support a larger number of simultaneous jamming beams that can reach further into contested airspace. Antennas will be electronically shifted rather than mechanically steered, affording continuous 360-degree coverage while eliminating moving parts that require frequent repair. These and other improvements will allow the Next Generation Jammer to deal with dangers across the entire radio frequency portion of the spectrum while producing more precise responses that minimize harm to friendly sensors and communications equipment.

Because the Next Generation Jammer is still in the early stages of development, many features of the system have not been finalized. For example, the winning design developed by competing industry teams may rely heavily on reconfigurable software to facilitate future performance upgrades rather than new hardware, but that aspect of the design is still in flux. Because the new technologies being applied to the system are intrinsically versatile, provision may be made in the design for non-traditional missions such as cyber attacks. Under Navy sponsorship, the industry teams are currently maturing relevant technologies that will be used to demonstrate different approaches to the jammer design in 2012. The goal is to begin fielding new jammer pods on the Growler in 2018.

Because the Next Generation Jammer will provide defense against a wide array of electronic threats through mid-century, it probably will be installed on unmanned aircraft such as this X-47B being developed for the Navy. Many experts believe unmanned systems will become increasingly common in combat, creating a need for electronic warfare capabilities even when people are not present.

The New Jammer Must Satisfy Ten Key Goals

The requirement for a new airborne jammer is well documented and widely recognized across the joint warfighting community. However, program managers will need to make a series of difficult decisions to reconcile all of the performance requirements specified by warfighters. Here are the ten goals that appear most important in shaping the design of the Next Generation Jammer:

- The *effective radiated power* of the new jammer must be adequate to support successful suppression of threats from increased standoff distances.
- The *field of view*, also known as the field of regard, for the new jammer must be 360 degrees so that it can respond instantly to threats emanating from any direction.
- The *number of signals* the new jammer can generate simultaneously against diverse threats must be considerably greater than what is feasible with current jammers.
- The *steering agility* of the new jammer must be optimized by eliminating mechanical movement of antennas and relying on electronic shifting to direct jamming beams.
- The *spectrum coverage* of the new jammer must be sufficiently broad to address all radio frequency threats, conventional and unconventional, through mid-century.
- The *spectral output* of the new jammer must be sufficiently precise to avoid interfering with the communications and other electronic devices of friendly forces.
- The *size and weight* of the new jamming system must fit within the operating constraints of all potential host aircraft, including the EA-18G and F-35 joint strike fighter.
- The *interoperability* of the new jammer across the joint force must be maximized to facilitate seamless operations by diverse warfighting units.
- The *reliability and maintainability* of the new jammer must be sufficient to assure high mission capable rates and reduced support costs across the life of the program.
- The *growth potential* of the new jammer within established weight and space constraints must be adequate to accommodate frequent upgrades and response to novel threats.

It will be a challenging task for program managers to trade off so many goals while keeping the program affordable and on schedule. One approach to dealing with this challenge is to use multiple pods rather than trying to compress all desired functionality into a single package. Another approach is to substitute reconfigurable software for hardware. A third approach is to utilize all available technology that is sufficiently mature, whether it is military or commercial. A fourth approach is to rely on modularity and open architecture design principles. The Next Generation Jammer program is expected to embrace all of these ideas, plus a variety of more arcane design innovations.

The Danger Of Waiting Is Too Great

The joint force has waited four decades to begin developing a successor to its Vietnam-era airborne jammers. During that time, the technological landscape has been transformed by hundreds of innovations associated with the digital revolution. Meanwhile, the geopolitical landscape has been similarly transformed by the collapse of communism and the rise of new, non-traditional threats. Thus, the jammer carried on U.S. electronic warfare planes today was designed for a world that no longer exists. A new jammer must be fielded soon to avoid severe, potentially fatal danger to U.S. forces.

The U.S. Navy and Marine Corps have a good track record of keeping their electronic warfare skills current. Upgrades to the electronic attack architecture have extended the life of the existing jammer while replacing Cold War receivers, enhancing software, and improving datalinks. The other services have come to rely on the Navy for electronic warfare support as their own warfighting plans have not adequately addressed electromagnetic threats. But there is a limit to what can be done with obsolete technology, and so the continued success of the Navy in supporting its own combat units and those of other services requires that a new jammer join the force by 2018.

If that does not occur, U.S. strike aircraft will gradually lose their capacity to safely transit hostile airspace even when they are equipped with low observable technologies. The ability of forward deployed aircraft to collect vital electronic intelligence will be impaired. And insurgents in places like Afghanistan will develop new options for targeting U.S. ground forces. In other words, if the joint force allows its dominance of the electromagnetic spectrum to erode any further, the consequences could be catastrophic for U.S. warfighters and security plans. This is not an era when incrementalism and delay are likely to serve national security well.

Against the backdrop of all U.S. defense expenditures -- which currently average about two billion dollars per day -- the Next Generation Jammer is not a major item. There is not a single year during its entire life cycle, from development to production to service, when it will claim even one-percent of the defense budget. But failure to field a capable new airborne jammer in the timeframe currently planned could have operational consequences far exceeding the cost of the jammer. The reason a new jammer was not developed sooner was because policymakers chose to consume the margin of safety the joint force had built up on the electromagnetic spectrum in order to address other challenges. That safety margin is now largely gone, and it would be very dangerous to delay modernization any longer.

Related Lexington Institute Studies:

Loren Thompson, *P-8A Poseidon: A New Model For Military Procurement,* October 2010

Rebecca Grant, *E-2D And Maritime Security,* May 2009

Loren Thompson, *Netting The Navy,* September 2008

Printed in The United States of America
December 2010

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