



AOC ISSUE REPORT

SELF PROTECTION: A CONTINUED REQUIREMENT | JAN 2020

Before the Vietnam War, fighter aircraft were not equipped with electronic warfare systems to warn the pilots of radar threats, nor were there systems to jam those threats or to assist the pilot in maneuvering the aircraft to avoid the threat (such as turning to the beam and dispensing chaff). In the fifty plus years since the early days of Vietnam, enormous progress has been made, and engineers and aircrew continue to hone the systems to best provide warning, jamming, and the tactics, techniques, and procedures to reduce vulnerabilities. Self-protection systems are among the most important tools pilots have in their kit-bag to complete missions unhindered. This issue brief describes some of the history of such systems and what the future portends.

During the first seven months of 1965, fifty-one Air Force, Navy, and Marine Corps jets were lost over North Vietnam. Those fighters were not equipped with self-protection systems. The only aircraft in the U.S. inventory equipped with electronic warfare systems were those of Strategic Air Command. Tactical Air Command had not considered electronic warfare as a solution to the various enemy systems. They were not interested in hanging anything other than munitions on their aircraft, and any extra weight inside the aircraft was considered a few knots of speed they might give up.

Because of the initial losses in 1965, the Air Force produced the QRC-160-1 jamming pod that countered the ground-based gun and missile control radars. It was little used and was deemed unreliable. The pods were eventually sent back to the U.S. This was, however, the first time that an electronic warfare system was deployed on a fighter.ⁱ

The wake-up call that on-board self-protection systems were necessary was the 24 July 1965 flight of 47th Tactical Fighter Squadron – eight F-4C Phantoms were escorting a force of F-105s northwest of Hanoi. The North Vietnamese had recently brought two SA-2 missile sites to readiness. The Phantom formation received a radio warning from an RB-66C ELINT plane warning of a Fan Song radar active, but they saw no signs of enemy action, until a missile penetrated their formation, destroying one aircraft and damaging three others. The back-seater died instantly, but the pilot, Captain Richard “Roscoe” Keirn ejected, parachuted to the ground, and was captured, beginning his second spell as a prisoner of war (he was a POW in WW II after his B-17 was shot down over Germany).ⁱⁱ

Two weeks after the loss of the Phantom, USAF Chief of Staff General John McConnell ordered the formation of a “SAM Task Force” to investigate options for countering the SA-2 system. The initial result was known as Project “Shoe Horn” which installed the ALQ-51 deception jamming system into the A-4 Skyhawk. Marginally successful, it began a cultural change that recognized the importance of EW. Aircraft wouldn’t launch without both engines or if a radio didn’t work. They soon began to consider functional EW equipment as “go/no-go” systems.

In the more than 50 years since the “SAM Task Force,” fighter aircraft self-protection has matured into a capable and effective part of mission essential equipment, a bit more armor for those jets going into harm’s way. The engineering challenge is significant. First, it requires that receivers be placed on the aircraft, covering all 360 degrees. Those receivers must be sensitive enough to detect threat radars. They must be sophisticated enough to properly identify and categorize the threat. False positive indications can be as harmful to mission accomplishment than a failure to detect the threat. They must be shielded and not hampered in their performance by the emissions coming from the fighter. The jamming systems must also transmit when required without producing electromagnetic interference (EMI) that would hamper other aircraft systems (communications, navigation, etc.). And they must localize or locate the threat radar with sufficient precision to assist the pilot to maneuver appropriately (or even, perchance, locate the threat so it can be targeted).

The radar warning systems came to be known as RWR, or radar warning receivers. Most Air Force fighter aircraft were equipped with the ALR-69 (F-16, A-10, C-130, MH-53) or the ALR-56 (F-15, F-16 Block 50). Most Navy and Marine Corps fighter aircraft were equipped with the ALR-67 (AV-8B, F-14, F/A-18), and most rotary wing aircraft were equipped with the APR-39 (AH-1, AH-64, CH-46, CH-47, CH-53, UH-60, KC-130, V-22).

In a circumstance in which the RWR functions as it is hoped, the scenario would look something like this: a pilot flying over terrain with an unknown or unlocated threat. On the display screen an alert pops up with an icon alerting the pilot that a radar site is active, with a bearing and distance. The pilot hears an alert “chirp” that transitions to a long tone indicating that the radar is tracking, and then the launch of a surface-to-air missile. The pilot responds by maneuvering the aircraft appropriately and dispensing expendables (chaff and flares).



Soon after the Leopard flight event in 1965, in addition to the development of RWR systems, a significant effort was made to put on-board jamming systems that could defeat radar threats. Beginning with the ALQ-51, fighter aircraft were outfitted with jammers designed to detect a radar threat, analyze the signal, and then form the optimum countermeasure to defeat that threat. These only countered the SA-2 threat, which was the nemesis of fighter aircraft during that war, shooting down hundreds of U.S. fighters.

The ALQ-100 was a direct replacement of the ALQ-51, and then a further development of the ALQ-100 was the ALQ-126, which was installed on nearly every Navy and Marine Corps aircraft. In addition to these on-board jamming systems, systems flown as external stores were also developed, such as the ALQ-131 pod, which contained both receivers and transmitters to detect and defeat radar threats, and the ALE-50 towed decoy system, a one-time use decoy towed

behind the aircraft that casts a larger radar cross-section than the aircraft it is protecting, making it a more attractive target to an incoming missile's guidance system.

The third system developed for aircraft self-protection is the expendables system, known commonly as a counter measure dispenser system (CMDSD). These systems dispense chaff and flares to defeat missiles in the end game of flight. The early systems were the ALE-29 and ALE-39, which were not integrated with the RWR systems, and the pilot had to manually dispense the expendables. The newer systems, specifically the ALE-47, is fully integrated into an aircraft's EW suite. In action, the aircraft RWR would detect a threat, its ALQ jammer would transmit jamming signals to defeat the threat, and the ALE system would automatically dispense chaff and flares to defeat the missile.

The systems today on legacy fighters are fully integrated. The F/A-18 is outfitted with the ALR-67, ALE-47, and ALQ-214 working together in what is termed the integrated defensive electronic counter measures system (IDECM).ⁱⁱⁱ On the F-16 the ALR-93, ALE-47, and ALQ-187 (V)2 provide the same capabilities, known as the advanced countermeasures electronic system (ACES).

The most integrated and capable systems are on the F-22 and F-35. The F-22 is configured with the ALR-94 electronic warfare suite, and the F-35 is configured with the ASQ-239 electronic warfare/countermeasure system. These systems are the next step in both utilizing the most advanced technology and fusing the data into the best possible situational awareness picture, while responding automatically to the detected threats.

Optimally, the system performs in this manner. The systems have receivers which constantly scan the electromagnetic spectrum, with system that are sensitive enough to detect any threat emitter and correctly identify the threat, with 360 degree coverage. Simultaneously, there are infrared sensors, also covering a 360 degree spectrum around the aircraft to detect any IR event (missile launch). All of these systems are precise enough to accurately locate the threat, in the best case to provide the pilot with coordinates that could be used to attack the threat. And should a missile launch be detected (either through an IR sensor or by sensing a missile guidance or tracking radar), that the pilot would almost immediately be given a coordinate of the threat. The "distributed aperture system" of six infrared cameras located around the airframe provide an unparalleled IR view of the battlespace that no previous fighter aircraft has possessed. Jamming signals are initiated, and should a missile launch be detected, appropriate countermeasures are automatically transmitted and expendables launched to protect the aircraft, without any pilot action required.^{iv}

The effort to improve self-protection capabilities continues. The Air Force Research Lab recently conducted tests at the Army's White Sands Missile Range in New Mexico, using a laser weapons system to shoot down multiple missiles in flight. Designated as the Self-Protect High Energy Laser Demonstrator (SHIELD), it holds the possibility of using directed energy weapons to provide another layer of protection to fighter aircraft.^v

Today it seems unimaginable that the U.S. military would lose 51 aircraft in seven months as occurred in 1965. We have not lost an aircraft to enemy fire since 1999, in the Kosovo air

air campaign. That trend will only continue if we invest in the improvement of self-protection systems. Aircrews flying over Syria after the Syrians acquired the Russian SA-21 Growler (also known as the S-400 Triumph), wryly noted that if this most capable and lethal long range missile system were to be employed aggressively against coalition forces, “that would not be even remotely awesome.”

ⁱ Price, Alfred. *The History of US Electronic Warfare, Vol III*. United States: Association of Old Crows, 2000, pp. 23-28.

ⁱⁱ *Ibid*, p. 33.

ⁱⁱⁱ <https://www.crows.org/news/387888/Harris-to-provide-sophisticated-electronic-warfare-EW-jamming-systems-for-combat-aircraft.htm>

^{iv} <https://www.forbes.com/sites/lorenthompson/2019/05/13/how-a-super-agile-electronic-warfare-system-makes-f-35-the-most-invincible-combat-aircraft-ever/#7008a01b4382>

^v <https://www.theverge.com/2019/5/5/18530089/us-air-force-research-laboratory-shield-laser-weapons-system-test>