"They Don't Call Them '*Hittles*'"

By: Brian Duddy, Staff HIstorian

Paths to the Present

FLASHBACK

Air-to-Air Missile Reliability Problems During the Air War Over North Vietnam

5 November 1966: *Opal Flight - Four USAF F-4C Phantoms escorting EB-66 electronic warfare aircraft engage North Vietnamese MiG-21 fighters near Hanoi. The F-4s maneuver to get behind the MiGs to line up air-to-air missile shots. Opal 01 attempted to fire an AIM-7 radar-guided Sparrow at the first MiG-21 but the missile's rocket motor failed. The Opal 01 crew set up their armament switches to fire an AIM-9 infrared-guided Sidewinder but they disarmed the system by mistake, so they reverted back to their AIM-7s and launched a Sparrow. The missile passed over the MiG but did not detonate. The F-4s continued to maneuver for another shot. Opal 01 dropped back to gain enough separation from the MiG for the missile to arm, got a radar lock on, and launched his third AIM-7. The missile passed close behind the MiG but again did not detonate. Opal 01 pressed the attack until he was in position to launch his fourth and last AIM-7. The missile appeared to pass by the MiG and did eventually detonate in front of it. The debris from the explosion was enough to damage the MiG and cause the North Vietnamese pilot to eject.*[1]

The problems experienced by Opal Flight with their missiles were a familiar story to aircrew operating missile-armed USAF and USN fighters over Vietnam during the entire period of the war. Because missile effectiveness was so questionable, Air Force and Navy aircrew routinely ripple-fired several missiles at once to improve their chances of getting at least one hit on one target. In this particular lengthy engagement, the F-4s of Opal flight at that time lacked a cannon, so when their missiles failed to work or they launched all they carried, they had no hope of countering the North Vietnamese MiGs. Similar engagements where the MiGs escaped pointed to serious reliability problems with US missiles, and also signaled to the North Vietnamese that the US F-4s lacked a cannon, so they were less of a threat in a close-in fight.

During the Vietnam war, the USAF operated three models of air-to-air missiles, the AIM-4D Falcon and AIM-9 Sidewinder were both guided by infrared energy which required the attacking aircraft to have a clear view of the engine exhaust of the target. The AIM-7 Sparrow was radar guided, which did offer a greater range, a more all-aspect engagement zone but required the attacking aircraft to keep a target "locked" in the radar so the missile would guide properly.

Right: USAF F-4 with a typical air-to-air weapons load: AIM-9 Sidewinders on wing station pylons and AIM-7 Sparrows under the fuselage.

All three missiles were carried by the F-4 Phantom but only versions of the AIM-9 could be carried by the F-105 Thunderchief. The US Navy also operated variants of the AIM-7 and AIM-9 on the F-4 and the AIM-9 on the F-8 Crusader.

Right: Rare photo of F-105 in Southeast Asia armed with both bombs and AIM-9 Sidewinders. In this case, the flight of F-105s is escorted by an EB-66 electronic warfare aircraft.

Left: Soviet-era MiG-21 in North Vietnamese Air Force markings, on display at the National Museum of the US Air Force. This was a typical adversary encountered by USAF and USN aircrews during Operations ROLLING THUNDER AND LINEBACKER I and II. The MiG-21 was also armed with heat-seeking missiles similar to the AIM-9. (NMUSAF)

The engagements in Vietnam from 1965 were actually the first sustained use of air-to-air missiles in combat. All three of these missiles had been developed in the late 1950s and early 1960s and tested with the requirement to engage large, non-maneuvering targets at high altitudes, such as incoming Soviet bombers. As such they were not optimized for low level or high-G maneuvering in a "dog fight" type of combat of the type in Vietnam against very maneuverable MiG-17s, -19s and -21s. Nonetheless, pre-war missile testing gave the services an artificially high expectation of missile performance in combat – results from operational tests predicted that the AIM-7 would hit 71 percent of the time and the AIM-9 was expected to hit 65 percent of the time.[2] Some airmen experienced in air combat were reluctant to completely abandon cannon-equipped aircraft and place their faith completely in missile technology. They pointed out the usefulness of a close-in weapon with an analogy to an infantryman armed with a rifle, a pistol and a knife as a "last resort." However, they were dismissed with the assurance a cannon was not needed because close-quarters dog-fighting was a thing of the past and, "All the missiles work." [3]

Right: USAF F-4E launching an AIM-7 Sparrow from its under-fuselage station. The Sparrow is guided by radar energy from the launching aircraft.

As the crew of Opal 01 and scores of other airmen discovered to their extreme frustration, all the missiles did not, in fact, "work." Data from the entire period of the Vietnam air war shows that in reality the missiles rarely worked. Contemporary rules of engagement also limited their effectiveness in order to avoid shooting down a friendly. The Sparrow aided by the aircraft radar had an adequate beyond-visual range, but it was not often used in that mode over North Vietnam for fear of fratricide with other US aircraft. Until a radar target could be positively identified as hostile, it was held back from launch.

The Vietnam war air-to-air combat, particularly over North Vietnam itself, was divided into two distinct periods: engagements from mid-1965 up to the bombing halt over the North in October 1968 which ended Operation ROLLING THUNDER; and from early 1972 and Operations LINEBACKER I and II, until the end of the US involvement in January 1973.[4] Effectiveness data was collected for the missiles used in the early part of the war. Up to the end of ROLLING THUNDER, roughly 330 AIM-7s were fired – resulting in 99 misses, 214 failures of various types and only about 27 kills. For the AIM-9 during ROLLING THUNDER: about 187 AIM-9Bs were fired, resulting in 105 failures, 53 outside the launch envelope (launched but not locked,) and 29 kills. Navy figures for their improved AIM-9D during the same time registered 99 launches for 18 kills.[5]

Right: US Navy F-4B off the coast of North Vietnam with AIM-9 missiles on external under-wing pylons. Navy aircrews experienced similar frustrating missile failures as their USAF counterparts.

As the war progressed, improved versions of the missiles were deployed to the warfighters. At the start of the conflict, the USAF used the AIM-9B, which was later upgraded to the AIM-9E (the USAF never adopted the Navy AIM-9D.)[6] The AIM-7D was eventually upgraded with additional features to the "Dog Fight Version" AIM-7E-2. Although equipped with better missiles, their effectiveness was still well below expectations. In the first seven months of 1972 (LINEBACKER I,) 149 AIM-7s were launched, resulting in only 20 MiG kills (13%.) The AIM-9E was not any better – 30 launches for only 3 kills (10%.) Missile reliability still remained a significant Air Force problem. Feedback from aircrew was clear – they needed a highly reliable, short range, high-G, high-angle-off missile.[7]

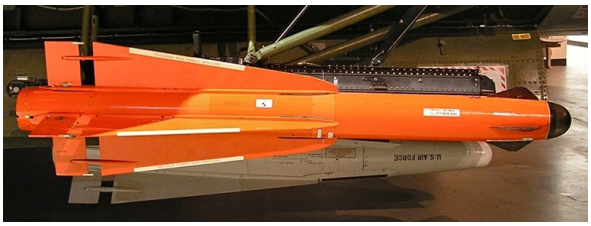
Cost was also a factor in the need for improvements – missiles that were expended with no results meant that those funds were not available for other priorities. Air-to-Air missiles of the era were extremely expensive. The Philco/Ford AIM-9 cost approximately $55K per missile in 1969, and the Raytheon AIM-7 cost approximately $225K per round. As the MiG-21 was being produced by the Soviets and provided to North Vietnam at less than $1M per copy it was difficult for DOD to justify spending millions on missiles that had only limited effectiveness.[8]

The problems with both types of missiles were elusive - and the recurring failures not limited to a single cause. "What was especially baffling was the fact that time after time, the missiles would check out perfectly on the maintenance/calibration test stands, with no apparent reasons for the failures," observed one F-4 maintenance officer at Korat RTAB, Lt Karl Eschmann. One of the causes he attributed to the problem was the way the missiles were handled during transportation. During Operation LINEBACKER in late 1972, Eschmann was sitting in his jeep awaiting the completion of pre-flight inspections for several F-4 Phantoms. As a passing interest, he was watching the normal flow of vehicular traffic moving on and off the flight line area at the entry checkpoint. All of the traffic driving onto the aircraft parking areas were normally required to drive over a Foreign Object Damage shaker-and-catcher device set into the road. This device was a metal plate with welded steel bars which formed a series of ridges much like small speed bumps. The purpose of the device was to shake loose any debris caught in the tire treads of ground vehicles, and thus keep it off the flightline where it could damage an aircraft. The shaker device was not meant to be used by vehicles pulling trailers with sensitive equipment on board such as ordnance or ground support equipment. As Eschmann watched, he noticed an airfield munitions tractor pulling a trailer full of AIM-7s and AIM-9s missiles directly over the FOD shaker. The missiles were literally bouncing up and down in their holding fixtures as the trailer was shaken by the grillwork.

The impact of this type of shock and vibration environment on the missile's electronic components was clearly a cause for concern, so Eschmann caught up to the tractor driver as he was headed to the flightline to load the missiles on an F-4. When questioned, the driver remarked that this was normal transportation practice but was unaware that this might be damaging to the internal components of the missiles. Eschmann requested a re-check of the missiles prior to loading, and this revealed that some of the fragile electronic components had indeed been displaced or damaged. While on the ground damaged missiles might still check out, but at higher altitudes and colder temperatures during flight, potential breaks in solder joints could occur due to contraction of the metal connections, rendering the missile inoperable. There was no way to determine how many missile failures might have been caused by this, but it was widespread practice for all vehicles to drive over the FOD shaker before transiting the flight line. Due in part to Eschmann's alert action, the practice was stopped at Korat, although the air war was all but over at that time. It would not solve all of the reliability problems of the AIM-7, though it did eliminate one potential cause.[9]

Major General Alton Slay, who would later become Commander of AFSC in March 1978, at the time on the staff of 7th Air Force, wrote his end-of-tour report in 1971. Among the issues he summarized was an evaluation of the effectiveness of air-to-air missiles: "There have been numerous studies and papers on this topic recently, so I'll just dispose of it very quickly: Generally poor performance. The missile design was a problem and reliability was a problem. Missile design contributed to errors by load crews and maintenance people and in the cockpit. We had a lot of switchology errors and a lot of out-of-parameter launches partly the result of missile and aircraft systems design. The net result of all this was that our missile performance – the total system performance – the missile, the ground crew, the aircraft and the aircrew - was not the best. We abandoned the AIM-4D for a couple of reasons. We never used it much because the pilots didn't have confidence in it,. Also, when we tried to use it, we didn't have much luck with it. We also wanted to get rid of one of the missile types for maintenance reasons. Most of the missile kills that we got were with the so-called "Dog Fight" Sparrow. It really wasn't a "Dog Fight" missile by the way, but it was the best missile that we had and we got the most missile kills with it. The AIM-9E was disappointing and I don't really know why. The Navy Sidewinder (the AIM-9D) performed much better. I think one of the reasons was that our crews felt that the AIM-7

was just a better missile and they tended to use it more than they did the AIM-9E. But, at any rate, generally poor performance of the total system as far as the air-to-air missile is concerned."[10] He finished his detailed analysis of all the USAF air-launched weapons with another plea: "And of course, we need a better air-to-air missile."[11]



The USAF AIM-4D (above) and AIM-9B (right) were both used extensively in the early part of the Vietnam air war.

A better "interim" air-to-air missile was already on its way. A team of representatives from the USAF and contractors involved studied the operational failures in detail and were working on an upgrade to the AIM-9. In November 1968, as part of Air Force Logistics Command, Warner Robins Air Materiel Area (WRAMA) had already received authorization from the CSAF to begin work on a project titled, "AIM-9 End Game II Development Program." The initiative, eventually renamed COMBAT SNAP, involved testing an upgraded version of the missile produced by Philco-Ford Corporation, the AIM-9J. It was an advanced version of the AIM-9E, and the redesign was intended to deliver a more reliable missile, suitable for short-range engagements against a maneuvering enemy fighter. AIM-9Js were extensively tested at Holloman and Eglin through July 1972, but due to the urgency of the LINEBACKER operations, the CSAF had already authorized its early deployment to Vietnam in June 1972 as part of a further operational testing phase. Missiles were delivered to the theater in July 1972, and a USAF/contractor team, including representatives from WRAMA, oriented operational and maintenance personnel on the new missile. On 31 July 1972, PACAF approved employing the new AIM-9J on operational missions.[12]

Although there were numerous MiG encounters throughout the month of August 1972, no AIM-9J combat launches were made. As the missile's captive-carry flight hours increased, technical problems arose and indications of its deficiencies became evident. For example, a status Report dated 19 August 1972 noted that four AIM-9Js returned from combat flights with broken Infrared nose domes, and one AIM-9J had been inadvertently launched from an aircraft. These deficiencies would have to be resolved if the AIM-9J was to be an effective weapon in aerial combat.[13]

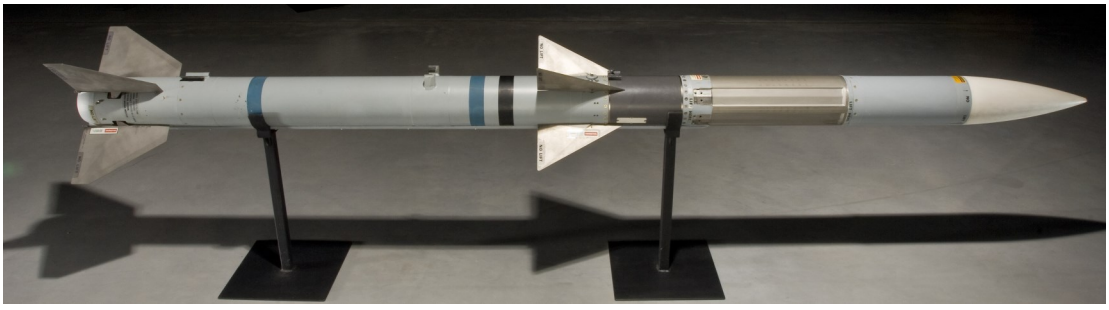
The upgraded AIM-9J made its combat debut on 9 September 1972, during Operation LINEBACKER I. Operationally, the new AIM-9J was still not achieving the desired results. In one of the first engagements using the weapon, Chevy Flight, four USAF F-4Es from Udorn, Thailand were chasing a MiG down the Red River towards Hanoi. Chevy 01 fired all four of his AIM-9Js, but all missed. Two impacted the ground and the other two disappeared into the haze. Chevy 03 continued the pursuit and fired all four of his AIM-9Js. The first two missiles went ballistic. The third missile had good "tone" (meaning lock on the target) and guided but did not detonate. Only the fourth missile, the eighth of eight fired at this one aircraft, guided straight for the MiG and impacted the tail. It took eight missiles from two different aircraft to finally down the MiG. The high speed encounter was a straight and level, low-altitude tail chase with little maneuvering – on paper the ideal engagement parameters for the AIM-9.[14] US aircraft vastly outnumbered the small air force of North Vi-

etnam, but expending eight missiles to down one MiG would not be acceptable in the much more contested skies of Europe if the US and NATO aircraft had faced hundreds of Soviet fighters in a major conflict.

The AIM-9J saw combat operations from September 1972 to the end of the air war in January 1973. The results of its employment were still disappointing. There were 31 attempted launches in combat situations. Of these 23 missed the target, 4 failed to launch and only 4 hit the target. The AIM-7E-2 Dog Fight Sparrow was also still having difficulties. During this same period, there were 100 AIM-7E-2 attempted launches that only resulted in 5 confirmed kills. The other 95 missiles either did not launch, did not fire, or were unobserved. The legacy AIM-9E was also still in the operational inventory, but of 24 launches, it had 14 misses, 1 hit without a kill and only 2 hits with a kill. The remainder either failed to launch or were unobserved.[15] Clearly, US missile reliability deficiencies needed to be addressed if the US was to prevail in an air war with Warsaw Pact forces.

After Vietnam, continual product improvement, plus the increased availability of the E-3 AWACS aircraft and revised rules of engagement that allowed beyond visual range firings, boosted the effectiveness of air-to-air missiles. An upgrade to the AIM-7E, the AIM-7F, was initiated immediately after the end of the war in March 1973. By the time of Desert Storm, improvements in both missiles saw a modest increase in effectiveness. During the 1991 air campaign, 67 AIM-7s were fired, and 23 hits were scored (34%). Many of these AIM-7 engagements were beyond visual range and some were at night as well. For the Sidewinder, 11 AIM-9s were fired and 6 hits were scored (55%.)[16]

The DOD ultimately took long-term action on General Slay's blunt recommendation regarding a new missile. The problems and shortfalls with the AIM-7 Sparrow noted in Southeast Asia led almost immediately to the development of the AIM-120 Advanced Medium Range Air to Air Missile (AMRAAM) as its replacement. The Air Force Systems Command and the Navy jointly developed the AMRAAM beginning in 1975 as an all-weather, medium-range missile capable of engaging multiple aircraft. The AMRAAM system requirements were established by a Joint Service Operational Requirement (JSOR) document dated September 1976. Following a Defense Systems Acquisition Review Council decision in November 1978 to approve program initiation, five contractors submitted prototype proposals and Hughes Aircraft was selected to develop the new AMRAAM.



Left: The AIM-120 AMRAAM was developed to supersede the AIM-7 Sparrow (NASM)

The six key performance parameters at the inception of the missile development program were: Ability to guide on a target with a high probability of kill while operating in all weather conditions and electronic countermeasure (ECM) environments; easy to use and universally adaptable to all front line fighters (at the time, F-14, F-15, F-16, F/A-18, and later F-22); capable of "launch-and-leave," thus providing a fighter the opportunity to maneuver against enemy air and ground threats; lighter than the AIM-7 Sparrow, allowing a fighter to carry an increased number of missiles; easily maintainable with a high degree of reliability; and affordable.[17]

Right: Test launch of an AIM-120 AMRAAM from an Eglin AFB Armament Division F-15.

The AMRAAM was designed to attack targets beyond the visual range of the fighter and was not only to replace the Sparrow missile but was intended to enhance aircraft combat effectiveness. Improved performance features over the Sparrow included higher speed, greater range, increased maneuverability, better resistance to electronic countermeasures, and an active terminal seeker. The missile's seeker and the launch aircraft's radar enable the pilot to simultaneously track multiple targets, launch multiple missiles, and maneuver to avoid counterattack – significant improvements over the AIM-7 design. The missile was also developed to be more reliable and maintainable than the Sparrow. Perhaps learning from the Vietnam experience, the AMRAAM program included, as part of operational testing, a Captive Carry Reliability Program (CCRP.) The CCRP was set up to achieve and demonstrate contractual reliability and maintainability (R&M) targets, and maintain that performance throughout the missile production lots. The CCRP project planned for 12 captive-carry test missiles to accumulate at least 800 hours of captive flight to identify high-failure components which could be redesigned prior to production. Along with the CCRP, the joint program conducted a Test, Analyze and Fix (TAAF) evaluation at the Navy Missile Test Center. The TAAF ground testing identified and corrected failure modes which would potentially degrade the missile reliability. Identified corrections were incorporated in the missile and launchers programmed for the CCRP to verify the adequacy of the corrections.

Air Force Systems Command and Tactical Air Command also recommended a Pre-Planned Product Improvement (P3I) program for the missile beginning in FY1990. The P3I program was structured to permit missile performance enhancements, to meet new threats, integrate high-payoff emerging technologies, enhance compatibility with new aircraft and conduct special/alternate missions. Although the AMRAAM was available to operational units at the time of Desert Storm, as noted earlier, all the coalition engagements were fought with either the AIM-7 or AIM-9. As a postscript, the first AMRAAM victory was not until 1992 in the post-Desert Storm Operation SOUTHERN WATCH No-Fly Zone.[18]

Questions to think about:

What actions can we, as a command, take if the warfighter is experiencing deficiencies in the materiel we deliver?

How can we integrate lessons learned from legacy systems into the new or replacement systems we acquire?

What system design factors should we consider (reliability, human systems integration) when we specify requirements to the defense industry?

END NOTES

1) "Hittles" title quote and the Opal Flight engagement story from Marshall L. Michel, *Clashes: Air Combat Over North Vietnam 1965-1972*, Annapolis, MD: Naval Institute Press, 1997, pp. 44 and 65.

2) Michel, *Clashe*s, p. 151-157.

3) Steven A Fino, *"All The Missiles Work:" Technological Dislocations and Military Innovation A Case Study in US Air Force Air-to-Air Armament, Post–World War II through Operation Rolling Thunder*, Drew Paper Number 12, Maxwell AFB, AL: Air University Press, January 2015, p. 51.

4) Lou Drendel, *... And Kill MiGs: Air To Air Combat in the Vietnam War*, Warren, MI: Squadron/Signal Publications, 1974, p. 29.

5) Michel, *Clashes*, pp 151-154.

6) Navy F-4B/Js did not carry gun pods or have an internal cannon as later fitted to the USAF F-4E version. Only the Navy F-8 Crusader and A-1 Skyraider had internal 20mm cannons.

7) *COMBAT SNAP, AIM-9J Southeast Asia Introduction*, Project CHECO Report, Headquarters Pacific Air Forces Directorate of Operations Analysis, 24 April, 1974, pp. xv-xvi. (Hereafter cited as COMBAT SNAP Report.)

8) Tim McGovern, *McDonnell F-4E Phantom II*, Aerofax Minigraph 20. Arlington, TX: Aerofax, Inc, 1987, p. 2.

9) Karl J. Eschmann, *Linebacker: The Untold Story of the Air Raids Over North Vietnam*, New York: Balan tine Books, 1989, p. 128. (Lieutenant, later Colonel, Karl Eschmann eventually rose to be a program manager with the AMRAAM Joint Program Office.)

10) US Navy Captain Frank Ault concurred with General Slay's assessment in the area of human factors in contemporary fighter aircraft. In his much-publicized findings from the *Report of The Air To Air System Capability Review July-November 1968*, (Naval Air Systems Command, 1 January 1969, p.21; known informally as "*The Ault Report*,") he categorized it this way: "By and large, U.S. fighter pilots have been required to fight a "heads up" engagement in Southeast Asia with a "heads down" system. This, of course, is particularly true for the F-4."

11) *End of Tour Report*, Major General Alton B. Slay, 7th Air Force Deputy Chief of Staff for Operations, 1 August 1971 to 14 August 1972, pp, 89-92.

12) COMBAT SNAP Report, pp. 15-16, 21.

13) COMBAT SNAP Report, p. 22.

14) COMBAT SNAP Report, pp. 24-25.

15) COMBAT SNAP Report, p. 26.

16) Benjamin Lambeth, *The Winning of Air Supremacy in Operation Desert Storm*, RAND Report P-7837, 1993, p. 11, and U.S Air Force Gulf War Air Power Survey, (Eliot Cohen, Director) *Volume IV, Part I, Weapons, Tactics and Training*. Washington DC: Department of the Air Force, 1993, pp. 112-115.

17) Steven J. Allen, *AMRAAM, the Air-to-Air "Force Multiplier,"* Maxwell AFB AL: Air Command and Staff College Student Report 88-0090, April 1988, p. 3-4.

18) Background on the AMRAAM program from Kenneth Meyer, *The Advanced Range Air-to-Air Missile: A Case Study of Risk and Reward in Systems Acquisition*, RAND Report N-3620-AF, ca. 1993, pp. 14-17;

Eglin AFB Armament Division History Office, *History of the Armament Division, 1 October 1985 to 30 September 1986; Volume 1,* 31 July 1987, pp. 130-131; and Eglin AFB Armament Division History Office, *History of the Armament Division, 1 October 1987-30 September 1988*, *Volume 1*, 15 June 1989, pp. 87-104.

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