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Theater Deconfliction of Video/Data-link Guided Munitions

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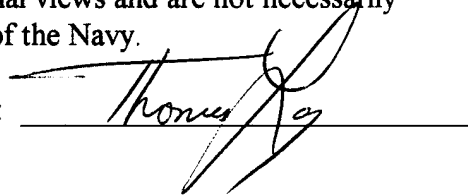
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The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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ABSTRACT

Video data-link guided munitions are among the most technologically sophisticated weapons in the U.S. arsenal today. Able to strike with precision accuracy against targets from stand-off distances, these weapons bring unprecedented capability and flexibility to the operational commander. Yet, their on-board data-link systems, which support their unique man-in-the-loop targeting method, have demonstrated a susceptibility to unintentional interference from other weapons of the same class in use at the same time. Essentially unanticipated until it occurred in actual combat operations, the problem has significant implications for operational commanders. This paper examines both the problem and potential solutions that could minimize or eliminate the possibility of these weapons failing due to data-link interference.

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Because there was essentially no supporting literature to be had on this subject, most of the real information I gathered came from the phone conversations I had with the experts and discussions with other knowledgeable people. Each and every one of the individuals listed in the bibliography, and a number of others that are not, could not have been more helpful once they understood what I was working on. I am particularly grateful to Air Force Majors "Two Dogs" McIntyre and "Moose" Barlow as well as Capt. Bret Knaub for their insight and patience in explaining their systems, procedures, manuals, terminology, and recommendations; Lieutenant "Box" Gear for his exceptionally useful information and new ideas from the Navy side of the house, and to my friend Commander "Shaker" Adamshick for pulling it together and helping me put it all in perspective. Finally, but by no means the least, to Lieutenant Commander Mark Converse who, I think, not only hatched this idea but was a bigger help than he probably realizes.

INTRODUCTION

In a February 1996 address General Ronald R. Fogleman, U.S. Air Force Chief of Staff, discussed what he sees as an emergent "new American way of war."¹ In the past, the United States has "relied on large forces employing mass, concentration, and firepower to attrit [sic] enemy forces and defeat them in what many times became costly but successful battles." Now, in his view, technological advances, particularly in airpower, are contributing to the development of military advantages that will enable American forces to achieve victories "at the least cost to the United States in both lives and resources." U.S. forces are poised to move from a strategy of "brute force" and attrition to "a concept that leverages our sophisticated military capabilities to achieve U.S. objectives by applying ... an asymmetric force strategy," one in which American strengths are brought to bear directly against enemy weaknesses. General Fogleman went on to say that among the elements contributing to making this impending transition a possibility are "the extended range, the precision, and the lethality of modern weapon systems."

As a class, video data-link guided weapons fit well into General Fogleman's concept and constitute an important component in the foundation of this next evolutionary step forward in America's military capability. Among the most technologically sophisticated weapons in use today, they are designed specifically to provide pinpoint accuracy while enabling the launch platform to stand-off or remain outside of an enemy's defensive capabilities. Unique among air-to-surface weapons in that they incorporate man-in-the-loop targeting, these weapons characteristically carry a television (TV) or imaging infra-red (IIR) seeker and an on-board data-link system consisting of a video link and a command link. The video link is used to transmit images received through the weapon's seeker back to a control aircraft while the command link carries specific aimpoint correction commands from the aircraft back to the weapon.² The

weapons achieve their stand-off capability by either gliding unpowered to the target or being propelled by rocket motors or turbojet engines. Included in this family of munitions are the Navy's AGM-62 Walleye ER/DL (extended-range/data-link) and AGM-84E Standoff Land Attack Missile (SLAM) and the Air Force's GBU-15, AGM-130, and AGM-142 Have Nap.³

By their nature, this family of tremendously capable weapons affords commanders great latitude and exceptional flexibility in planning operations and campaigns. Owing equally to their particular features however, is the potential for a serious limitation in the use of these weapons as well. Because of the way these weapons function, the possibility exists that data-link signals from one weapon could interfere with those of another being used at the same time.⁴ When such interference occurs the likelihood of one of the munitions failing to function properly increases. The implications of video-data-link guided weapons failing to perform as designed is significant to the operational commander. This paper will examine this issue and potential solutions to the problem.

BACKGROUND

Today's modern video data-link guided weapons trace their origin to the time of the Vietnam War and the advent of the first television guided bombs. From the start, TV guided weapons were designed with one main purpose: to provide a level of accuracy equal to that of other air-to-surface guided weapons while allowing the launching aircraft to stand-off or even retire from the vicinity of the intended target.⁵ This type of weapon first became possible in the late 1960s when advances in electronics technology finally caught up with the dreams engineers had pursued since the days of World War Two.⁶

One of the first weapons of this type, the AGM-62 Walleye, entered service with U.S. forces in 1967. Typical of the first generation of these weapons, the early Walleyes required the pilot to lock the bomb's seeker on the target before releasing the weapon. Once dropped the weapon autonomously homed in on the target the pilot had chosen. The system worked, but was not without its problems. Perhaps the biggest difficulty in effectively operating the weapon was in getting its TV camera to lock-on to the target; a procedure which typically took 15 seconds. A Defense Department study at the time found that because of the delay involved, the average slant range to the target was only 1.5nm by the time it was designated. This consequently resulted in the aircraft delivering the weapons being hit by anti-aircraft fire four times as often as those employing conventional bombs.⁷ So much for the promised advantage of stand-off that Walleye was supposed to bring.

These setbacks, however, were not enough to cause the American armed forces to give up on the concept. As electronics technology continued to mature, it eventually became possible to incorporate a two-way data-link in these types of munitions. This addition improved both the weapons' overall stand-off capability and their accuracy. With the addition of the data-link system the weapons could transmit what the seeker was seeing back to the launching or other controlling aircraft and simultaneously receive commands back to the seeker. This enabled the weapon to be dropped without having the seeker locked on the exact target aimpoint at the time of release. Once in flight, the crew of the controlling aircraft could select a particular target or refine the aiming of the weapon by adjusting the seeker positioning.

Having the capability to maintain a command link with the weapon offered obvious advantages in stand-off capability as well as accuracy. No longer did the attacking aircraft need to continue in as close to ensure the target was resolved well enough through the weapon's

seeker to be assured of success. Furthermore, since the interface for the aircraft to communicate with the weapon was by means of a data-link pod carried externally, it became possible to have separate aircraft for launching the weapon and controlling it, thereby reducing the risk to the attacking aircraft. The data-link system also improved the accuracy of the weapon since aiming adjustments could be made after initial seeker lock-on. Advances and improvements continued, leading to the use of more capable TV and Imaging Infra-red (IIR) seekers to provide night time capability. During the late 1980's rocket motors and turbojet engines were incorporated into the design of some of these munitions to greatly extend stand-off capability.⁸

The primary factor making video data-link munitions so attractive and useful today is that they are the only weapons combining both exceptional accuracy and the ability to be launched at stand-off distances from their targets. Because of these traits, weapons such as these not only fit in well with the newly emerging concepts of how the United States will fight its wars, they are, along with other modern high-technology munitions, directly responsible for enabling the America's reassessment of its traditional concepts of warfare.⁹ Of these characteristics, the key component in any discussion of these munitions is precision guidance. Video data-link weapons are not merely accurate, they are precise; some of them possessing accuracy on the order of 15 feet or less Circular Error Probable (CEP).¹⁰ The significance of this is that fewer weapons and therefore aircraft are required to achieve the same level of damage to a target with precision munitions than without. This translates into fewer aircrew being placed at risk in a hostile environment. Additionally, when precision weapons are used collateral damage tends to be limited; an important factor when considering the American public's seeming growing intolerance for casualties on both sides in military operations.¹¹

Video data-link guided weapons transmit their video and receive commands from the

controlling aircraft simultaneously on separate frequencies. These video and command link frequencies are set and paired together as channels which cannot be altered. Depending on the specific weapon type, the channels may be either preset or selectable at the time of the mission.¹² Because these weapons use normal RF energy to transmit their signals, they have the potential to interfere with the signals of other weapons operating on or about the same frequency. Between the separate frequencies for the video and command links, it is the video portion, transmitted from the weapon to the controlling aircraft, that is most likely to experience interference. This does not mean the command link is immune from interference entirely but because of the frequency tolerances or bandwidths of each part of the link it is the video signal that is more susceptible. Typically the video frequency operates at a wider bandwidth than the command link making it more open to being penetrated by transmissions not originating from the weapon being controlled.¹³ When two signals on the same frequency arrive at a receiver together it is the stronger of the two that is processed and used regardless of the source. If that signal comes from another weapon in flight at the same time, even if it is in a different location, the signals could be corrupted thus causing the weapon to fail in its performance. It is not necessary for the weapons to be used against the same target or even on the same strike. If they are operating on the same frequency at the same time and the ranges, positioning of weapons and control aircraft, and environmental conditions are right, it is possible for the data-link signals to interfere with each other. When such interference occurs the likelihood of one of the munitions failing to function properly increases. It was just this sort of interference that occurred during recent actual combat operations with these weapons.

In August and September 1995 Operation Deliberate Force was conducted in which NATO air forces carried out attacks on Bosnian Serb targets to reduce the military advantage

the Serbs held in the conflict.¹⁴ During the operation, one particular mission was conducted jointly by U.S. Navy and Air Force strike aircraft, each employing precision munitions with video data-link guidance. Because proper coordination had not been completed before the strike some of the weapons involved experienced video-link interference from others launched at the same time. The weapons that encountered the interference failed to perform as expected.¹⁵ The details of this incident, many of which are classified, are irrelevant to the purpose and scope of this discussion. What is important is simply that the situation did occur and has now, therefore, moved from the realm of purely theoretical possibilities to that of an actual problem requiring a solution.

Prior to the Deliberate Force incident, the problem of data-link interference among these weapons had been recognized by the tactical users but only in the narrowest and most tightly focused manner. There was, in fact very little written material discussing the issue at the tactical level. For the most part, the documentation that was available concentrated on the problem only to the extent that deconfliction was required between weapons of the same type or closely related types within a given strike. Navy users, for instance, were aware of the potential for conflict whenever multiple SLAMs and/or Walleyes used on the same strike. Similarly, Air Force operators knew of the need to deconflict launches of GBU-15s and/or AGM-130s. While cautions were included in the weapons and tactics manuals of the individual services pointing out the need for such coordination, there was no joint perspective and no consideration of possible consequences of failing to coordinate the use of these weapons beyond those being employed by a particular single service attack. The bottom line is, quite simply, both Air Force and Navy strike leaders were aware of the requirement to deconflict the individual frequencies of

the weapons in their own strike groups but were generally not aware of the need to coordinate the same items when conducting joint strikes.¹⁶

Following the incident in Bosnia, steps were taken to address the problem in some of the tactical publications and directly with the users of the weapons. The Naval Strike Warfare Center's Strike Leader and Tactics School Notebook almost immediately issued a change notice which did point out the potential for interference between the Air Force and Navy data-link weapons involved in the incident and recommended coordination in their use.¹⁷ Likewise, the Navy's Strike/Fighter Wing Atlantic Weapons School which is creating a soon to be released personal computer based interactive instructional course for the SLAM weapon system, to be distributed to tactical users, has included five slides specifically on the issue of video interference.¹⁸ These two efforts notwithstanding, however, most of the information on this topic was passed verbally during squadron or other training sessions. None of the specific Air Force or Navy user manuals for video data-link weapons or the tactics guides that cover their employment have been changed. Furthermore, while changes for these publications have been contemplated none are yet forthcoming due, in at least some instances, to more pressing priorities and a feeling that the information had gotten out to the tactical users in an adequate manner to cover the problem.¹⁹

OPERATIONAL CONCERNS

Awareness of the problem of data-link interference at the tactical level, while crucial to the proper employment of these weapons, does not solve the problem of synchronizing their use across an entire theater of operation. Mindfulness of the situation by strike leaders does make it more likely the right questions will be asked, thereby ensuring proper consideration is given to

the issue during combat planning, but it is beyond their capability to deconflict the entire area. That responsibility lies with the theater or operational commander.

When high-technology weapons like those with video data-link guidance systems fail to operate as expected it is of significant concern to the operational commander for several reasons. First the target being struck may not have received the expected level of damage thus requiring a restrike. Not only is having to attack a target multiple times when one strike was expected to do the job inefficient, it puts friendly forces at risk more than was originally necessary. Additionally, in the case of these weapons it could have a greater effect on the sequencing of the campaign itself since they are most often used to attack targets with operational or strategic significance. Frequently employed as operational fires, they tend to have an influence on the operation as a whole, future battles, or the enemy's ability to synchronize his own actions and conduct his own command and control. As such, a failure in the performance of these weapons has the possibility of creating an impact felt at the operational level.

A second cause for concern by the operational commander is due to the issue of collateral damage. Precision weapons are clearly selected for their use because of their accuracy. When precision weapons do not perform precisely, collateral damage can result. Today more than ever before, collateral damage and especially non-combatant casualties are coming to be viewed as intolerable by nearly all facets of American society. When the "CNN Effect" is factored in--near real time television reporting of the horrors of war--a single significant failure could serve to undermine public support for the entire operation.²⁰

A third consideration has to do with the cost and availability of these types of munitions. Warfighters, rightly, tend to be more concerned with the availability of a given type of weapon than with its particular cost. Getting the job done in the most efficient manner while minimizing

casualties are the primary factors driving weapon selection. Cost does enter into the picture indirectly, however, since it ultimately is the main determinant in deciding how many of the weapons are actually procured. Because of the high-technology nature of the video data-link weapons in the U.S. inventory, they tend to be relatively expensive both in real terms and in comparison to other weapons, including other precision munitions that do not have stand-off capability. Acquisition costs can run from less than \$300,000 for a GBU-15 to as high as \$1.5 million for powered weapons like SLAM or AGM-142.²¹ Because of their expense, these “silver bullets” typically are purchased in smaller quantities than other weapons, which may perhaps affect their availability under some circumstances, such as in a protracted campaign. In any event, when such high-priced munitions fail to perform, they have a tendency to draw attention to themselves that is difficult to overlook.

The tendency in video data-link weapons is toward more and varied types and closely parallels the use of precision guided munitions in general. The trend began with the data-link modifications to Walleye following the Vietnam War where only about 0.2 percent of the total weapons expended were precision munitions. Continuing in the Gulf War where nine percent of the weapons had precision guidance capability the U.S. inventory had grown to include not only Walleye but the Air Force’s GBU-15 and AGM-142, the latter of which was not actually used during the conflict, and the Navy’s SLAM. Four and a half years after Desert Storm, Operation Deliberate Force tallied over sixty percent of the weapons employed by NATO forces as precision munitions and the U.S. Air Force had added the AGM-130 to its inventory.²² Continuing the trend, many see a continued increase in the use of greater numbers of precision guided munitions in future conflicts with a coinciding expansion in development of additional new weapons with video data-link guidance systems as well. A number of future air-to-ground

weapon systems in various stages of development or planning are either intending to include video data-link guidance or are considering the possibilities of incorporating it. Among those weapons are SLAM-ER, the Joint Air-to-Surface Standoff Missile (JASSM), the Baseline Improvement Program upgrade to the Tomahawk Land Attack Missile (TLAM), and the unitary warhead variant of the Joint Standoff Weapon (JSOW).²³

Since all the video data-link guided weapons in the American arsenal today operate in the same frequency spectrum and since it is not uncommon today for new systems to leverage off current successful technologies, it is reasonable to expect some if not all of the near term future video data-link weapons produced for American forces will operate in the same frequency range as well. Such a situation will increase the number and type of weapons that could potentially interfere with each other during use. Couple this with the upward trend in precision guided munitions previously discussed and one can easily arrive at the conclusion that the problem of video and command-link interference during the employment of these munitions could become even greater in the future.

Unfortunately the problem of inadvertent friendly interference in the control of these weapons may not be limited simply to times when other similar weapons are being employed. The frequency spectrum across which video signals of various types can be broadcast is larger than that in which these munitions operate. As such, there are many TV signals transmitted that will never have an effect these weapons. There are, however, other systems in use today that do make use of same frequency range and can cause interference. For instance, the video signals of some unmanned aerial vehicles (UAV) operate in the same range as these weapons²⁴ as will the Air Force's soon to be deployed Gold Pan Rapid Targeting System (RTS).²⁵ During test drops of the GBU-15 interference from video monitoring systems was noted and during an operational

launch of a SLAM interference from a commercial television station was discovered following playback of the mission recorder.²⁶ While in these last two instances the weapon's performance was not diminished, they are offered as examples to illustrate that video transmissions from even unanticipated sources can cause interference. Although it was beyond the scope of this research to examine the frequency ranges of all U.S. military systems transmitting video signals, particularly airborne systems, it does not imply other systems are not capable of causing interference. Of particular concern would be electro-optical systems carried on some surveillance aircraft which then transmit real time video to various command and control facilities and TV broadcasts used as part of psyops operations that may run coincident to times video data-link weapons were being employed.

SOLUTIONS

Given that the problem of unintentional friendly interference of the video and command-links exists for these weapons it should be of significant concern to operational level commanders that a solution be found to minimize or eliminate its occurrence. Eventually future weapons of this type may reduce or eliminate the problem through hardware design changes. Waveform adjustments may be built in to weapon systems to preclude interference or they may become versatile enough to notify the operator of a problem or autonomously hop from the original frequency to one without interference.²⁷ These sorts of solutions are not, however, near term and would likely add to the cost of a class of weapons that is arguably already the most expensive in the U.S. inventory. For the same reason, modifications to today's video data-link weapons systems are equally unlikely given that other solutions with virtually no cost at all are possible.

If the situation is approached as a problem in management, today's theater commanders currently possess the structure and tools necessary to solve the problem. What is required is a plan to properly organize and coordinate these valuable assets. The Joint Force Air Component Commander (JFACC) or his counterpart in the NATO Combined Air Operations Center (CAOC) is best able to handle the issue of deconflicting these weapons.* Already responsible for sequencing theater air assets through the singular Air tasking Order (ATO), the JFACC is the reasonable choice for ensuring video data-link weapons frequencies are properly deconflicted. Other potential solutions do not seem to offer as complete of a solution without sacrificing valuable capabilities or limiting availability. Such ideas as doctrinal changes affecting how and when these weapons would be chosen for use or logistic based concepts that might affect the distribution of these weapons within a theater do not appear as advantageous as overseeing the problem and directing the solution as required.

The bottom line in ensuring these weapons do not interfere with each other is that their operating frequencies must be deconflicted. This is done, quite simply, by ensuring no two weapons on the same frequency are employed at the same time. If for some reason distinct frequencies cannot be used then the weapons must be sequenced in time so that both are not in flight together. In some instances it may be feasible to designate certain areas for exclusive use of particular frequencies. This would, perhaps, be most useful for missions where the weapons might be used for an "on-call" mission or against targets of opportunity where the attacking aircraft would not be working with a specified time on target (TOT). In any case frequency assignments must be fragged on the Air Tasking Order (ATO) to ensure deconfliction.²⁸ This procedure is not without its drawbacks, though. Those assigning frequencies on the ATO likely

* For simplicity in this discussion the term JFACC will be synonymous with CAOC.

may not know the availability of specific weapons or data-link control pods for a given mission. Still, this is not an insurmountable problem. Assuming the normal 72 hour planning and 48 hour tasking cycles for the ATO, ample time should exist to work out the details with the strike leaders if required. This coordination could be most effectively worked out by using the Contingency Theater Automated Planning System (CTAPS) when necessary; a tool specifically designed and deployed to permit a JFACC to complete such coordination even after the ATO has been published.²⁹

The JFACC should assign responsibility for theater wide deconfliction of video data-link weapons to one of the members of his staff charged with developing and producing the ATO. Once designated the individual would act as a single clearing house for the tasking and/or use of all these particular weapons. Wing and squadron officers assigned as liaisons to the JFACC would be particularly helpful in assisting in this process. While coordinating proper deconfliction is certain to be a labor intensive effort, particularly when many of these weapons are being used in a short time period, it remains, perhaps, the only viable alternative to ensure the munitions do not fail due to a preventable cause. The task may even expand, requiring greater efforts, if it is discovered that other U.S. or allied assets in theater are using the same frequencies as these weapons. Eventually the software used to generate the ATO may be able to be modified to provide for at least some, if not all, of this deconfliction automatically in the normal process of constructing the document.³⁰ Until such a time, however, direct personal attention to the problem seems the only reasonable means to success.

One tool that could prove useful to anyone tasked with deconflicting these weapons would be a matrix listing the channels and frequencies for all U.S. video data-link weapons as well as all other U.S. systems known to operate in the same range.³¹ The document would

require periodic review to ensure its accuracy. Supplements could be issued for coalition operations which would delineate allied weapons and other systems which operate in the same spectrum as the munitions being discussed. Development of the document could be under the authority of the Joint Chiefs of Staff and should be distributed to theater commanders and tactical units employing these weapons.

A final suggestion is that both the Air Force and Navy commands responsible for updating the weapons manuals and tactics guides dealing with data-link weapons ensure this issue is adequately covered in their respective publications. Strike/fighters and bombers today employ such a wide variety of sophisticated munitions that there are typically only a few experts on any given weapon system in each squadron. While these individuals are extremely valuable assets, the central repository for definitive information on these systems must be the publications. Individual training on the subject is certainly useful but transitory. In a few short years, because of the personnel turnover in our units, new people will have arrived who may not have received the benefit of training deemed important in the current environment. Furthermore, when officers from the squadrons and wings serve as liaisons to the operational staffs it is the manuals and guides that will serve as their primary references.

CONCLUSION

Among the most modern high-technology weapons in the U.S. arsenal today, video data-link guided munitions provide the operational commander with tremendous capabilities and a wide range of options for planning and executing combat operations. Yet, owing to their sophisticated man-in-the-loop characteristic, they have demonstrated an Achilles' heel in the vulnerability of their data-link systems to friendly interference from other weapons of the same

type in use at the same time. The consequences of these weapons not functioning properly are significant given the emerging new way American commanders are thinking about military operations. An issue to be addressed today, it is likely to take on even greater magnitude in the future as even more U.S. weapons have video data-link systems incorporated in them.

Until such time when hardware modifications to correct the problem may become available at reasonable cost, the most practical solution is to manage the available assets to avoid the pitfalls. Because of the scope of the problem and because it possesses implications for the operational level of war, it is with the operational commander that the answers should be sought. To ensure these weapons deliver their optimum performance, the JFACC is best equipped to regulate the factors influencing the performance of these weapons across the entire theater. With clearly understood responsibilities and appropriately updated publications the risk of data-link interference for these weapons could be minimized.

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- ¹⁶ Gear; Telephone conversation with MAJ Robert G. Barlow, USAF, F-15E Weapons and Tactics Officer, Headquarters USAFE/DOTW, Ramstein AFB, Germany. 2 May 1996; Telephone conversation with CAPT Bret Knaub, USAF, Flight Commander/Director of Weapons, 20th Bomb Squadron, Barksdale AFB, LA. 22 April 1996.
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- ¹⁸ Gear.
- ¹⁹ Gear; Barlow; Knaub.

²⁰ Correll, 22-23.

²¹ U.S. General Accounting Office, Weapons Acquisition: Precision Guided Munitions in Inventory, Production, and Development, Report to Congressional Committees (Washington: June 1995), 18-19, 28, 45-46, 50.

²² Correll, 22; U.S. Naval Institute. "AGM-130, AGM-142, GBU-15, SLAM, and Walleye."

²³ U.S. General Accounting Office, 39, 46, 49.

²⁴ Goldfinger and Waters. "UAVs and USN." U.S. Naval Strike Warfare Center Aimpoint, Winter 1996, 24-29.

²⁵ Telephone conversation with MAJ Tom McIntyre, USAF, Headquarters ACC/DOTW, Langley AFB, VA. 18 April 1996; Barlow.

²⁶ Barlow; Gear.

²⁷ Adamshick.

²⁸ Ibid.

²⁹ Marcus Hurley, "JFACC: Taking the Next Step," JFQ, Spring 1995, 62-63.

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- Telephone conversation with MAJ Robert G. Barlow, USAF, F-15E Weapons and Tactics Officer, Headquarters USAFE/DOTW, Ramstein AFB, Germany. 2 May 1996.
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