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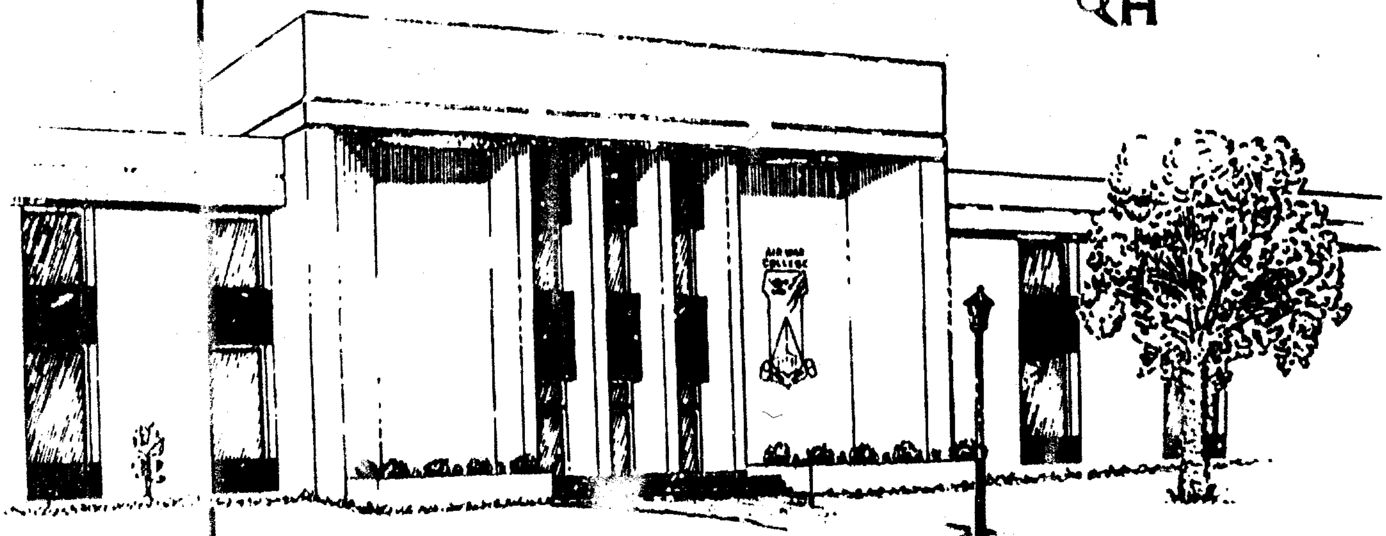
AIR WAR COLLEGE

RESEARCH REPORT

PRECISION GUIDE WEAPONS TRAINING AND EMPLOYMENT

LT C L BARRY L. REAM

1988



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PRECISION GUIDED WEAPONS TRAINING AND EMPLOYMENT

by
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A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Colonel Thomas J. Yax

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Precision Guided Weapons Training and Employment

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A historical review of the requirement and use of precision guided weapons in Vietnam begins with a discussion on three current guided weapons in the Air Force inventory, the GBU-15, the GBU-24 and the AGM-65. The need for adequately trained aircrews and current constraints on that training is reviewed prior to a discussion on employment of these weapons. A look at future capabilities of weapons and aircraft includes an analysis as to how many weapons is enough. The conclusion reinforces the need for increased training of aircrews for future conflicts. Keywords: Guided bombs, Guided missiles, Laser weapons, Data links, Flight training, Flight crews. (SDW)

BIOGRAPHICAL SKETCH

Lieutenant Colonel (Colonel Select) Barry L. Ream received his commission in the USAF in 1967 from Officer Training School and was assigned to Undergraduate Pilot Training at Reese AFB, TX where he earned his wings in March 1969. He was then assigned as a Forward Air Controller in Vietnam, where he flew over 700 combat hours. Upon returning to the U.S., he was stationed at Columbus AFB, MS as a T-37 instructor pilot. In 1974, he transitioned to the F-111F at Mountain Home AFB, ID and then transferred to RAF Lakenheath, United Kingdom in March 1977. In October 1979, Colonel Ream was assigned to the Director of Operations, HQ USAF. He served as an Action Officer and as a Briefing Officer for the Chief of Staff of the Air Force. Colonel Ream returned to the cockpit in 1983 when he served as Operations Officer and Commander of the 431st Test and Evaluation Squadron until January 1987. During the three and one half years of assignment, he was directly involved in the operational test and evaluation of many of the newest precision guided weapons to include the GBU-15TV & IR, the GBU-24 low-level laser guided bomb and the AGM-65D IR Maverick missile. His awards include the Distinguished Flying Cross, Meritorious Service Medal with two OLC and Air Medal with eight OLC. Colonel Ream is a graduate of the Air War Collage, class of 1988.

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CHAPTER I

INTRODUCTION

Many civilian and military leaders along with target planners have the false impression that precision guided weapons are easy to employ effectively. The overall effectiveness of these weapons is determined by two primary factors. First is the capability and accuracy of the aircraft that is used to carry and release the weapon. Second is the qualification and training of the aircrew that employ the weapon. This paper will explain the training, preplanning requirements, and employment considerations necessary to put a precision guided weapon on target.

I will focus on three particular types of guided munitions. They are the GBU-24 low-level laser guided bomb, the GBU-15 data link controlled bomb, and the AGM-65 Maverick missile.

The requirement for precision guided weapons was established during the Vietnam conflict. Improvements in technology provided the capability to more accurately deliver guided weapons against a target than was possible with unguided munitions. This increased accuracy reduced the number of strike aircraft required against a target which correspondingly reduced aircraft losses. A third factor was limiting collateral damage to civilian population.

With the need and performance of guided weapons established over 20 years ago, Chapter III will describe three of the newest guided munitions. These new weapons have their own unique seeker and guidance system.

Properly trained aircrews are essential to accurately employ guided weapons. However, there are many peace-time constraints that limit the amount and effectiveness of training. These constraints include limited simulators, aircraft availability, range size and targets, training weapons, and the weather. These factors must be considered when training aircrews to employ guided munitions.

The employment of guided weapons includes an extensive amount of preflight planning by the aircrew. Many items must be reviewed and considered such as: weapon type, aircraft and equipment, target, tactics, and the environment. Adequate time must be available for planning so the weapon can be effectively employed against a high-value target where destruction is possible with one sortie.

Future capabilities of guided munitions are limited only by the technology available. Some weapons are an improvement to current ones while others are completely new. Aircraft improvements and new procurements will add to these capabilities. However, we must be concerned with how many weapons are enough based on the threat and how many the Air Force can afford.

CHAPTER II

HISTORY AND INITIAL REQUIREMENT

The requirement for precision guided weapons came to the forefront during the Vietnam conflict. New technology provided the means to employ weapons on a pin-point target or a particular area of a target with extreme accuracy. The United States Air Force became involved with laser guided bomb technology in May 1965, when it funded the development of prototype weapons by Autonetics Division of North American Aviation (NA-A) and Texas Instruments (TI). The competition between these two companies concluded with a feasibility test of the two companies' weapons from July 1966 to January 1967. Both companies' laser guided weapons made significant improvements in accuracy over unguided bombs. However, the tests proved the TI weapon was more accurate than the NA-A weapon and cost about half per unit. The Air Force test team recommended the TI weapon be put into production as soon as possible due to its demonstrated capabilities. In January 1967, TI was awarded a contract to provide 50 additional laser seeker kits for further evaluation and employment. The specifications for these weapons were that the circular error probable (CEP) be no more than 25 feet and the guidance reliability be 80 percent or greater. Thus began Project Paveway, the USAF's first laser guided bomb program.(3:10-22)

These new weapons soon found their way to Southeast Asia. They were employed against targets associated with interdiction of the transportation and logistical systems, and command and control centers of the North Vietnamese. The laser guided bomb proved to be very effective in damaging bridges during the bombing up north in 1972. These pin point targets, in good weather conditions, were damaged and destroyed using the laser weapons. The probability of damage with a single weapon was 80 90%. During a bombing mission on 22 May 1972, eight F-4 aircraft carrying 16 laser guided bombs destroyed five bridges and damaged a sixth. A much larger number of sorties would have been required using unguided weapons to achieve the same amount of destruction providing the targets could have been hit in the first place.(11:236) In previous attempts to shut down the strategically important Thanh Hoa bridge, a total of 871 sorties were flown over a period of time with eleven aircraft lost in unsuccessful attempts. The introduction of the laser bomb accomplished the job in four sorties with no aircraft losses.(15:79)

The laser guided bombs proved their accuracy capability and built confidence in the mission planners and commanders. The following story from General Vogt, the Commander of Seventh Air Force, describes the use of LGBs in North Vietnam.

> We saw them in desperate frustration one day, in broad daylight, trying to construct a bridge over a river. We

had destroyed the regular bridge. They were doing this in daylight. I said, 'Don't hit it yet. Wait until they get everything committed and the bridge almost done.' The North Vietnamese brought in some more trucks and cranes. They had two giant cranes placing these spans in. About the time they had the bridge ready, in came a laser bomb and blew them all to hell.(10:80)

In addition to the accuracy improvements associated with these new smart weapons, three other important planning considerations evolved: First, fewer strike aircraft required per target; second, decreased aircraft losses; and third, a greater probability of limiting collateral damage to civilian population. These three factors played an important role when planning an attack on a target. The size of the employment package could be reduced to fewer strike aircraft. The reduced aircraft requirement afforded the opportunity to add extra combat air patrol (CAP) and defense suppression aircraft into the entire package. The combination of the reduced strike aircraft and the additional defensive aircraft produced the second factor, that of decreased aircraft losses. In fact, with the resumption of the bombing in North Vietnam in 1972, the strike package consisted of at least a four to one ratio of support forces to strike aircraft.(11:236) During the resumption of the bombing of the north, General Vogt had this to say:

The premium is on the precision of those few airplanes that are going to drop. They have to kill the target with certainty. The commander must ensure that they get in and out alive. That was the name of the game for me in 1972: a small number of highly accurate airplanes, with the enemy kept off their backs by whatever means required, so that they could destroy the target. (10:87-88)

The third advantage, that of limiting collateral damage to civilian populations and non-military targets, is an important factor for planners and commanders to consider. The natural consequence of a high hit probability produces this advantage. In fact, the limited damage outside the target area would have a positive effect on the political decision to attempt to strike certain highly congested targets.(5:9)

Thus, the very successful use of precision guided "smart" bombs proved that seeing the target would usually lead to its destruction. There were some short comings, however. Weather and darkness hampered the effective use of the weapons.(17:17) All in all, these new weapons had a tremendous impact on the total war effort. Major General Maxwell, the Commander of Armament Development and Test Center, stated in 1972 that the . .

> Quantum jump in target detection and accuracy, which resulted from the introduction of laser-guided bombs, electro-optics, and other guidance and sensor technologies, makes it possible for us to fight conventional wars in a way and under conditions that we would have considered impossible just a few years ago. (14:26)

With the preceding information provided as background, the next chapter will focus on a description of current precision guided weapons.

CHAPTER III

CURRENT AIR TO GROUND GUIDED WEAPONS

The United States Air Force has continued to improve precision guided weapons since the Vietnam conflict. This chapter will discuss the characteristics of three of the newest precision guided air-to-ground weapon types. They are the GBU-24/B Low Level Laser Guided Bomb (Paveway III), the GBU-15TV/IR data link guided bomb, and the AGM-65 Maverick missile. The following is a description of each of these three weapons:

GBU-24/B Low Level Laser Guided Bomb

The GBU-24/B, also referred to as Paveway III, is the third generation of laser guided weapons developed by Texas Instruments since their early involvement with the Paveway project. The weapon is made up of a guidance control unit and an airfoil group that are attached to a Mark-84, 2000 pound general purpose high explosive bomb. The entire unit can be loaded on an aircraft much like a standard general purpose "dumb" bomb. The guidance control unit is able to detect reflected laser energy by using an optical seeker mounted on a gimbal that is controlled by the weapon auto-pilot. The auto-pilot provides a proportionally controlled trajectory of the weapon to the laser spot on the target. The guidance section has a laser coding capability that permits accurate employment in a dense laser environment.(12:1-1)

The GBU-24/B is designed to operate in weather conditions as low as a 2000 foot ceiling and three miles visibility. It can be launched in a dive, a loft, or in a near level attitude. Immediately after launch, it automatically selects the appropriate midcourse guidance profile depending on whether the launch occurred above or below 15,000 feet altitude. A description of the five guidance profiles follows and is also shown in Figure 1 on page 38. (12:1-5,6,8)

1. When launched below 15,000 feet, the auto pilot will execute a bump-up maneuver approximately two seconds after release. The bump-up causes the weapon to climb about 450 feet and then pitch down to parallel the original launch vector. This is necessary to prevent a low level launch from sagging into the ground. Also, for launches below 15,000 feet, the weapon must decide whether it was released in a dive, loft or level attitude. The angle of climb or descent is computed and a decision is made as to which of the following three midcourse modes is necessary.(12:1-6,8)

A. In a near level launch (+15 degrees to 10 degrees) the auto-pilot will maintain an altitude hold after the bump-up. It maintains straight and level flight until the target is acquired by the seeker. The auto-pilot then goes to the pitch-angle G biased terminal mode that provides an approximate 20 degree impact angle for level deliveries.

B. Launched in a loft profile (above +15 degrees) the auto pilot zeros out to a ballistic trajectory after the bump-up maneuver. This flight profile is maintained until acquisition of the laser spot. Transition to the terminal mode occurs after the weapon apexes.

C. A weapon launched in a diving profile (below -10 degrees) follows a constant glideslope after the bump-up maneuver. It then transitions to the terminal mode after acquisition.

2. When launched above 15,000 feet, the auto-pilot commands a zero position ballistic profile after the bump-up. This ballistic trajectory is maintained until transition to terminal guidance is achieved after target acquisition.(12:1-8)

The GBU-24/B does not require power connection to the aircraft that it is being launched from. At weapon release, the bomb is unlocked from the aircraft rack and ejector feet push it away from the aircraft just like a conventional unguided bomb. Upon release, a lanyard attached to the aircraft bomb rack is pulled from the bomb which activates a thermal battery in the guidance unit. This sequence applies power to the weapon from 0.2 to 0.5 seconds after the lanyard is pulled and provides necessary power for the weapon to function properly throughout the flight profile to target impact.(12:5-1,2)

The laser spot for target illumination can be directed from three different sources. The launch aircraft, if it has a laser capability, or another airborne aircraft or helicopter, and lastly, a ground designator may be used. These three capabilities allow the GBU-24/B to be employed by many different type aircraft from various delivery profiles at varying angles and airspeeds.

GBU-15 Data Link Guided Bomb

The GBU-15 is a data link guided weapon that was designed primarily for use against high value targets such as industrial complexes, bridges, tunnels, bunkers etc. Like the GBU-24, it consists of a Mark-84, 2000 pound general purpose high explosive bomb. It is made up of a control module, airfoils, data link control, and an optical or infrared guidance unit. The weight of the entire weapon is over 2500 pounds. Another part of the system is the aircraft data link control pod that allows the aircrew to control the weapon in flight. The pod must be mounted on the aircraft and, although it is not very heavy, (only 450 pounds), it is quite large at 20 inches in diameter and nearly 11 feet long.(8:i,ii,vi)

The GBU-15TV optical guidance unit was the first one developed and is in operational service in the United States Air Force. However, it is limited to daylight operations. The GBU-15IR infrared guidance unit is currently going through final operational test and evaluation prior to fielding. The IR unit expands the use of GBU-15 into night operations, some adverse weather conditions, and against visually camouflaged targets. Both models of the weapon are launched the same way from either a level attitude at 500 feet above ground level (AGL) and above, or from a stabilized climb of plus four degrees from 500 feet or less. For low altitude launches below 5000 feet AGL, the weapon will automatically pitch up to provide the altitude necessary for ground clearance, target acquisition and weapon guidance (See classified Dash 34 for exact weapon profile.) This profile is maintained unless terminated by the aircrew selecting transition mode or terminal mode.(See Figure 2 on page 39)(8:2.18) For medium or high altitude launches above 5000 feet AGL, the pitchup maneuver is not necessary and the weapon maintains a slightly decreasing glide profile.(See Figure 3 on page 40)(8:2.17)

After either type of launch, the weapon will remain on the launch heading since the seeker position in the nose of the bomb has no effect on the auto-pilot guidance. This allows seeker movement needed for area and target acquisition without depleting weapon energy and reducing standoff range. However, when the transition mode is selected, lateral steering follows the seeker movement to steer the weapon. The pitch mode is still controlled automatically to a given flight path. The last guidance mode is terminal and, like the name implies, is used in the final phase of weapon flight prior to target impact. When selected, the weapon auto-pilot follows both pitch and yaw commands from the seeker.

Not only can the weapon be guided manually to the target, but it also has an automatic track mode. This can be used if the target has a defined edge that allows the seeker to lock-on to the target. Automatic track has three advantages, that of reducing aircrew workload, enabling auto-terminal in case of a loss of data link, and providing more accurate terminal steering than manual. However, most real world targets do not have the necessary definition to permit a lock-on for auto track.(8:2.15,16,19)

Finally, data link control of the weapon can be provided from two different sources. Either the launch aircraft can guide the weapon or a buddy aircraft can control the weapon after launch. In either case, data link line of sight must be maintained between the data link aircraft and the weapon. Thus, on a standoff control scenario, the further away from the target the control aircraft is, the higher altitude it must maintain. Even though this may not appear to be tactically sound, the standoff range is impressive.

AGM-65 A/B/D Maverick Missile

The AGM-65 Maverick is a 500 pound air-to-ground missile designed primarily for use against armored vehicles, vans, bunkers, small buildings, and boats. The warhead has two kill mechanisms: a penetrating forward firing jet and a residual blast. There are two types of guidance systems available, the AGM-65A/B is optical guided and the AGM-65D model is infrared guided. The TV guided weapon must be used in daylight operations only while the IR version provides a night capability and a much longer lock on range. This longer lock-on range may exceed the aerodynamic capability of the missile. Both missiles must be locked onto the target by the aircrew prior to launch. When the weapon is locked on and the aircraft is in missile firing range, the missile can be launched. Once launched, the missile maintains a lock on to the target and guides autonomously, providing a standoff launch and leave capability. The aircraft can then egress the target area or set up to fire again in a target rich environment. (7:iv,2-1,12)

CHAPTER IV

TRAINING FOR EMPLOYMENT

Properly and adequately trained aircrews are the most important part of the equation in accurately employing precision guided weapons. There are many areas that must be considered to ensure training is available and correctly used. They include, but are not limited to, simulator capability, aircraft availability and accompanying components, range availability, including size and target capability, practice weapon drops, and weather requirements. I will look at each of these areas in detail, but first I'll focus on the aircrew.

All aircrew members within a unit should not be used to employ precision guided weapons, particularly laser guided bombs or GBU-15s. There are two reasons for this. First, in order for aircrews to effectively employ a precision guided weapon, they must be thoroughly familiar with and proficient in the aircraft they are flying. This is essential since the precision guided weapon control are additive to the necessary proficiency required to drop "dumb" bombs. Therefore, one cannot expect a young, inexperienced crew to be capable enough to, not only master the aircraft systems of complex aircraft such as the F-4E, F-111F, F-16C or, in the future the F-15E, but also be able to successfully employ a complicated guided weapon.

Secondly, as I eluded to previously and will expand on later, the training assets available are extremely limited and not nearly sufficient to train the total number of mission ready aircrews in a wing.

Simulators

The first area of concern is the capability of simulators to help train individuals in employing these sophisticated weapons. While it would be ideal to have a fully integrated aircraft simulator with a guided weapon package included so that the entire mission profile can be performed, the cost and technology interface may be prohibitive. Therefore, what is needed and probably more cost effective is a weapon trainer simulator. This would allow the crew member to become familiar with all of the switch positions necessary to operate the weapon. It could be designed to allow the aircrew to identify and track targets with different scene backgrounds, various visual or thermal contrasts, and day or night operation. This type of simulator would have application to the three systems discussed in Chapter III, laser guided bombs, GBU-15 TV/IR and AGM-65A/B/D.

A more complete simulator is currently available for GBU-15 training. In addition to switchology practice and target identification, it allows the aircrew to fly the weapon throughout the entire profile to impact on the target. However, this is a one of a kind simulator located at the Rockwell International plant near Atlanta, GA. Time must be rented by the United States Air Force to train crews from the U.S. and overseas on GBU-15 procedures. Limitations on the use of this simulator are that it is costly to operate at $30,000 a day, time consuming when you consider transportation time involved, and less than desired security arrangements if required to practice against certain targets in a hostile country.(Note 1)

Therefore, simulators need to be improved or developed to properly train aircrews in the use of guided weapons at their home station. This current lack of ground training devices requires that most training be accomplished in the aircraft.

Aircraft

Aircraft availability is an important ingredient for properly trained aircrews. Aircraft must not only be available but they must be fully operational. A smart aircraft to employ a smart weapon is a necessity. In many cases, the weapon may be released five miles or more from the target area. Therefore, it is important to have an aircraft that can navigate to the precise launch point. Additive to the basic aircraft is the Pave Spike or Pave Tack Pod for laser guided bombs and the Data Link Pod for GBU-15. While the AGM-65 Maverick does not require an additional guidance system, it does need unique launcher rails for carriage and release of the weapon. Lastly, the

GBU-15 and Maverick have captive carry training weapons that are used to simulate looking through the weapon seeker for target acquisition, tracking and launch. They require the same testing and loading on the aircraft as the actual weapon. In fact, the GBU-15 training weapon requires a Mark-84 2000 pound inert bomb to complete the captive carry training device. This makes the GBU-15 training device the same weight as the actual weapon, over 2500 pounds. (8:1,3.1,2/7:3.1,4)

The design of this type of training device causes some problems that must be corrected in the future. First, the additional weight carried on one wing station on an F-111F causes some roll control problems, particularly at airspeeds below 220 knots. While the problem is not a dramatic one in the takeoff phase of flight, it is much more pronounced when making an approach and landing with a live or training weapon on board. The situation is made more difficult if landing in any type of crosswind condition. Secondly, the weight of the bomb requires that a jettison capability be available in case of an aircraft emergency. This requirement increases the maintenance load time and preflight requirements for weapons release system check. A new captive carry training device with only the seeker head and guidance control unit needs to be developed. This would be a more operationally suitable trainer for current and future aircraft.

It is necessary that all parts of the complex guidance system work prior to launching even a training sortie. In fact, a requirement for two or more aircraft equally equipped may be required to train one or two crew members in buddy laser employment tactics or standoff data link for the GBU-15. Also, to train effectively requires a large amount of range airspace.

Ranges

Range availability for precision guided weapon training in the United States and overseas is a definite shortfall. The three main areas of concern are laser or data link restrictions, range size, and realistic targets. Many ranges either prohibit or restrict the use of laser equipment from an aircraft. In fact, of the 51 ranges operated by the Tactical Air Command, Air National Guard, and Air Force Reserves,only 26 permit the use of a laser firing device. Some of the same restrictions exist in Europe. Similarly, the use of data link control signals for the GBU-15 are restricted and limited to only training frequencies.(Note 2)

An important factor in training is that the size of the range must allow for realistic combat profiles. All three of these precision guided weapons are designed to avoid over-flight of the target by the delivery aircraft. The Maverick is a launch and leave weapon while the other two must be guided until target impact. Thus, range space must be large enough to permit the laser designator aircraft to maneuver or a standoff data link aircraft to position a considerable distance from the target.

An essential, but often overlooked, part of training is the realism of the targets. Most of the current targets on a range are in the form of a vehicle, wooden structure or barrels. They are located in the middle of the range or floating on a raft at one of the water ranges around the United Kingdom. In either case, these targets are not very realistic for practicing difficult target acquisition and tracking. The difficulty of locating a building in a town for a laser guided bomb and GBU-15 or attempting to locate and track a tank near a wooded area with a Maverick must be practiced. Equally important is the necessity to simulate an infrared target such as a running tank or power plant for an infrared Maverick or GBU-15. These types of targets need to be constructed for practicing acquisition and tracking. They would not be used for launching a weapon because destruction would be certain even with an inert weapon.

Weapons

Actual weapon drops for proficiency of aircrews are extremely limited. Even though laser guided bombs and Mavericks are launched more often than GBU-15s, they are not at a desired training level. The primary reason for the limited drops is the high cost per weapon with the TV guided GBU-15 costing approximately $128,000.(15:80)

Weather

Even though many of these training issues can be overcome, there remains the ever present problem of weather. None of the three weapons will work effectively in heavy cloud conditions. The laser guided bomb will not see the laser spot through clouds and, if using a GBU-15 or Maverick, the aircrew cannot see through clouds to identify the target. Not only cloud cover but wind conditions, sun angle, and temperature may impact target acquisition. Therefore, weather conditions around the target area must be considered in the pre-mission planning.

Summary

A final thought about training concerns the ability of aircrews to train at night. The night low-level attack profile is the most demanding mission to properly train for due to the denial of day visual cues. The mission requires detailed planning and relies heavily on the use of all available sensors such as the attack radar, flight instruments, forward looking infrared (FLIR), and terrain following radar (TFR) if available. Task saturation can occur very easily at night as most day tactics are not transferrable to a night environment. This means that night low-level operations and weapon employment are demanding and the skills are perishable. Therefore, if one wants to successfully employ precision guided weapons at night, one must train at night.(Note 3)

While it is easy to say one must train at night, this may be difficult to do under certain peacetime constraints. First of all, not all ranges are open after sunset and some low-level training routes are either closed or restricted to a higher altitude during night operation. Training in other countries at night, in many cases, is even more difficult than in the United States due to low-level training route constraints, quiet hour restrictions, and sunsets later than 2200 hours, as in England during the summer months. These problems will be compounded throughout the Air Force as more night capable aircraft, such as the F-16 and F-15E, come on board equipped with the Low Altitude Navigation Targeting Infrared for Night (LANTIRN). We must identify ways to train better at night so we are prepared to fight in future conflicts.

CHAPTER V

EMPLOYMENT OF WEAPONS

The employment of precision guided weapons requires an extensive amount of preflight planning by the aircrew. Therefore, adequate time must be provided to allow for proper planning so that a precision weapon can be effectively employed against a high value target. This means that it may be difficult for an aircrew to fly more than once a day or that a rapid turn around from one sortie to another would be impossible. These factors must be considered when deciding what aircrews will be tasked against certain targets. Once the aircrew has been selected for a mission, the following items must be considered in the preflight planning: the weapon, aircraft and equipment, target, tactics, and the environment. I will review each of these areas in further detail.

Weapons

The type and number of weapons planned for employment against a target must be of primary consideration. There are some unique advantages to each of the three types of weapons. First, the AGM-65 Maverick affords the opportunity to launch more than one weapon on a pass at more than one target. The launch and leave capability of the Maverick makes it perhaps the least aircrew intensive weapon for preflight planning and eliminates of the requirement for man in the loop terminal guidance.(7:iv,2-1) While it has these definite advantages, it lacks the explosive power necessary to destroy larger targets. These targets can be more effectively damaged or destroyed with the Mark-84 2000 pound bomb used in the GBU-15 or the GBU-24. The GBU-15 is designed to be used against fixed targets. It provides the capability to see and guide the weapon to a particular area, side, door or window of the overall target. This can be accomplished from a substantial standoff distance. While the accuracy and explosive power are impressive, one aircraft and aircrew can only guide one weapon at a time.(8:i,ii,vi) Therefore, if more fire power is necessary on a concentrated target, the laser guided bomb may be the correct weapon to use since more than one weapon can guide to the same laser spot on a target. This was the tactic used by the F-111F aircrews during the attack of Libya on 15 April 1986. The attack aircraft were loaded with four 2000 pound laser guided GBU-10 bombs.(2:95)(The GBU-10 is an earlier version of the GBU-24 that recently came into the inventory.)

To ensure proper control of the weapons, the LGB has a laser code that can be set so the weapon guidance unit only interrogates and guides on a certain laser spot. This prevents the weapon from tracking on one of the many other laser spots that may be used in the battle area.(12:1 ?) The GBU-15 has a similar protective guidance system through the use of different channels for weapon control. The channels are selectable in the cockpit.(8:xix)

Aircraft and Equipment

The aircraft used to employ precision guided weapons must provide an accurate navigation platform. While this may not be as important in using the AGM-65 Maverick, it is of the utmost importance when dropping a GBU-15 or GBU-24. Both of these weapons fly a planned ballistic profile from the release point to the target area. Therefore, actual range and bearing of the weapon to the target must be as planned. If not, the weapon will over fly the target without laser acquisition if launched too close to the target. It will also under-fly the target if launched too far away and fall short of the intended target. The direction of release is also very important. If it is not released pointed in the correct position, target acquisition may be impossible or the weapon may not have sufficient energy to correct back to the target. All of these factors need to be considered for precise aircraft placement prior to weapons release.(Note 4)

The number of switches that need to be manipulated for precision guided weapons is far too many. Some are controlled by each crew member in an F-4E or F-111F and must be operated in a certain sequence. This adds to the crew coordination problem. The switchology requirements need to be simplified for current and future aircraft.(8:45-47)

The equipment available on the aircraft to control the weapon, either by a laser spot or data link control, must be completely operational prior to launching a weapon. An important aspect of the employment is the ability of the aircrew to track the target with the laser spot while egressing the target area and avoiding both air and ground defenses. This target tracking is done manually in the F-4 or F-111 by the Weapon Systems Officer (WSO) using the Pave Spike or Pave Tack system. Normally, from weapon launch to target impact,the WSO must manually track the target while the pilot is maneuvering the aircraft 90 degrees or more from the target using four or five G forces.

A Video Augmented Tracking System (VATS) was designed and tested on the Pave Tack system to ease the aircrew workload. The VATS system allowed automatic target tracking with the Pave Tack pod. The auto track remained on the target a higher percentage of time than manual track and produced a significant reduction in cockpit workload. It allowed both crew members to perform normal cockpit functions even during the most critical phases of weapon delivery when it is necessary to look out for hostile aircraft or ground based threats. The degree of workload reduction was very apparent and a recommendation was made on human factor considerations that VATS be installed on all Pave Tack pods.(9:V&VI) However, it was not purchased due to cost factors. This type of a system is still needed now and for future aircraft. The autotracking feature in LANTIRN is essential for single seat aircraft employing laser guided bombs.

Target

Target planning must be accomplished in great detail. Destruction can be assured if mission planning includes a realistic plan for target acquisition. The target area topography, size, location and background clutter, and attack heading must all be taken into consideration.

The topography around the target area is very important for target acquisition. Cultural features such as trees, rivers, open fields or built-up areas need to be considered and evaluated, particularly when using an infrared weapon since all of these features have different IR signatures. These signatures will change dramatically depending on sun angle and day or night conditions. They will be discussed in more detail in this chapter under environment.

Target size can vary from armored personnel carriers or tanks to bridges or power plants. In the first case, the target is the vehicle, where as in the latter it may be a particular area on the much larger complex. An important element of this planning process is recent photography of the target and surrounding area. This should include both overhead and tactical photos taken from the direction of intended attack. These photos must be time sensitive and made available to the aircrews for lengthy target study prior to employment. The photos are necessary to determine the precise location of a target within a large complex or a specific aiming point on a building. They also allow the launch of a GBU-15 or GBU-24 prior to target identification with precise aiming to occur on the target as the weapon is in flight. This procedure will not work with the AGM-65 since it must be locked on to a target prior to launch. However, the need for photos is necessary to determine the location of tank parks or convoys that could be hidden by trees or camouflaged netting.(Note 4)

The attack heading must be planned to ensure the best target acquisition, to produce the most destructive weapons effect, and to limit exposure to the defenses. In the case of the Maverick, this means the ability to acquire the target, lock-on, and launch with the shortest exposure time to the threats. The attack heading for the GBU-15 and GBU-24 may need to vary to achieve the desired impact angle on the target. The GBU-15 should be planned for a direct perpendicular attack against the face of the structure. This will provide the best possible guidance picture and lock-on potential while producing the most desired impact angle. By contrast, the GBU-24 may need to be released at an angle off the face of the target. This allows the launch aircraft and laser designator aircraft to be the same, so that it can turn and lase the front of the target while the weapon is in flight. If a perpendicular attack is planned, as the aircraft turns, the laser spot may spread over the angle on the target face or worse yet, spill beyond the side to the background.(Note 4)

Tactics

The tactics used for employment of precision guided weapons must be determined to a large degree on the threat characteristics in and around the target area. Such factors as exposure time and stand-off range must be considered. These factors, along with others provided by intelligence sources, will determine the type of weapon used. The option of day or night attack must also be evaluated. The United States attack on Libya was conducted at night due to many of these considerations. The Libyans launched no interceptor aircraft and the ZSU-23/4 anti-aircraft guns, SA-7 missile, and small arms were rendered nearly useless.(4:90)

Tactics also involves delegation of certain crew duties in a two seat fighter. Depending on the various employment scenarios used, the navigation, threat assessment and counter measures activation may be transferred between or shared by the pilot and WSO. However, when it comes down to controlling a GBU-15 or lasing for a GBU-24, it is the WSO that has the responsibility and necessary equipment to carry it out. Major Steve Madley, the most experienced WSOs that I know who has tested and launched more GBU-15s and

LGBs from an F-111F, describes these responsibilities quite accurately when he says, "You row the boat and I'll shoot the ducks."(Note 5)

Environment

The environment for employing precision guided weapons includes, not only the weather around the target, but the time of day as well. Normally, any restriction to visibility will degrade the standoff capability of a precision guided weapon. Overcast cloud cover will most certainly decrease ambient light levels. A scattered cloud condition will cause shadow patterns on the ground which can obscure or camouflage previously distinctive terrain patterns. The sun angle on the target is an additional factor to consider. The presentation on a TV weapon will vary depending on whether the target is in shadow or sunlight. An IR weapon presentation will vary depending on the temperature difference between the target and the surrounding background.(13:16,24,25)

The United States Air Force developed a system to help the weather personnel forecast some of these variables about the target. It is called a Tactical Decision Aid (TDA) and can be used for both TV and IR sensors. The target contrast portion has the capability to estimate the contrast between the target and background. The atmospheric transmission part predicts how well the target contrast is transmitted through the atmosphere. However, this can be a time consuming process depending on the experience of the operator, complexity of target and background, and the type of weapon used. It is recommended that preparation for using the model should begin one to one and a half hours prior to aircrew brief time.(13:1-3)

In order to operate this system, certain information is required from the intelligence staff and the aircrew prior to beginning the process. Target description and photos of the target are provided by intelligence and the tactics, to include attack heading, are provided by the aircrew.(13:11,13,54) Although the procedure is a lengthy process that requires advanced planning, the outcome can be very helpful to the aircrews ability to acquire and track the target.

CHAPTER VI

FUTURE CAPABILITIES

The future capabilities of precision guided munitions is dependent on many different variables. Of primary importance is they depend on technology available to produce the type of weapon required for the mission. In addition, current and future aircraft in the Air Force must be able to employ the new weapons effectively. Lastly, we must be able to afford this sophistication and precision by determining a realistic requirement and then ensuring funding support is provided until production is completed. This chapter will focus on new weapons, new aircraft and modification to older models, and address a concern as to how many weapons are enough.

New Weapons

There are many new precision guided weapons planned for the future. Some are completely new weapon concepts while others are modifications to current weapons. One such planned modification is designated the AGM-130A. This is a GBU-15 with a rocket motor attached to increase range. This powered version of the GBU-15 has nearly three times the range of the unpowered weapon when launched in a low altitude profile. It is currently undergoing operational testing. The Air Force planned to buy 2000 of these weapons.(15:80) However, poor test performance with only one success in six attempts, may force a decision to stop the program completely.(1:19)

Another modified weapon designed as a hardened target munition is the I-2000. The I-2000 warhead is encased in one-inch thick high grade steel and can penetrate seven to ten feet of concrete or four inch thick ship steel plate. It is currently mated on a GBU-10, Paveway II laser guided bomb guidance kit. The I-2000 weapon is being considered for use with the GBU-24, GBU-15 and AGM-130A. The Air Force originally planned on 20,000 I-2000 weapons by the early 1990s but budget reductions may considerably reduce the total procurement.(15:81)

A long term project is called the Autonomous Guided Bomb(AGB). This program is designed to develop an autonomous target acquisition and guidance seeker. They can be integrated onto current weapon structures for use in day, night, and limited adverse weather. The advanced seeker concept can be coupled with existing GBU-15, GBU 24 or AGM-130A weapons to incorporate a true launch and leave concept. This would allow for multiple launches of weapons with one pass, since it would not require a man in the loop for laser designation or data link control.(15:81)

New Aircraft

The Air Force is planning to purchase 392 F 15E aircraft equipped with LANTIRN to help augment the limited number of F-111s in the deep interdiction role. The F 15E will be capable of operating at night and under the weather. It will employ current and future laser guided bombs in addition to the GBU-15 and the longer range AGM-130. The LANTIRN pods will also be purchased for designated F-16C/Ds. They will allow the F-16 to fly low at night and engage tactical targets with IR Maverick, laser guided bombs, or conventional munitions.(16:3-2,3,4)

Current Aircraft Improvements

Two possibilities exist to improve the current capabilities of our deep interdiction force of F-111 aircraft with precision guidance capability. Only the F-111F model at RAF Lakenheath currently has this capability. This model is assigned to NATO with no deployment tasking. There is a program to modify some F-111D aircraft assigned to Tactical Air Command with precision guidance capability. They would be modified with the same Pave Tack system that is now on the F models. The Pave Tack pods will be the ones in the Air Force inventory that are used by F-4 and RF-4 aircraft. However, an extensive modification is required to the aircraft and may not be funded in the current budget reduction negotiations. A second possibility may be the use of LANTIRN pods on numerous F-111s such as the A,D and E models. Although either of these modifications seem expensive, they would greatly improve the capability and flexibility of the F-111s that are programmed to be in the inventory beyond the year 2000.

How Many Are Enough?

The question of how many weapons are enough is a difficult one that must be addressed. Considerations that need to be taken into account are the number of targets, number of aircraft capable of employing precision weapons, number of adequately trained aircrews, and cost of the weapon.

The Air Force must ensure that precision guided munitions such as the GBU-15 and GBU-24 are planned for employment against only high value targets. General Donnelly, the former Commander in Chief of the United States Air Force in Europe, stated concerning PGMs, "Are we buying too many expensive weapons? We need to only buy enough to destroy the targets they are effective against and what we can afford. Use the PGMs against bridges, dams, reactors and industrial complexes."(Note 6) The planned inventory of 3000 GBU-15s and 5000 GBU-24s may be overkill compared to the amount of valid targets throughout various theaters of conflict.(15:79,80)

Even if these procurement numbers are accurate, compared to the threat, the current number of aircraft capable of employing them is extremely limited. Only certain F-4E and all F-111F aircraft are capable of employing the GBU-15. With regards to the GBU-24, only F-4s and RF-4s equipped with Pave Tack or Pave Spike and F-111F aircraft are capable of airborne laser designation.

Granted, other aircraft could drop the weapon, but a ground or buddy airborne laser designation is more difficult to coordinate and execute properly. The plans for F-15E procurement will greatly increase the available aircraft to launch and guide both the GBU-15 and GBU-24.

However, even with these additional aircraft, the problem of adequately trained aircrews remains a factor in the amount of weapons that can be employed. Therefore, if the number of weapons procured are accurate compared to the viable targets, then a serious effort must be made to reduce the precision guided training deficiencies.

A most important factor when considering how many are enough is how many can we afford. This point was stated recently by General Robert D. Russ, Commander of Tactical Air Command, when he said, "Very accurate means very expensive. The Air Force will continue to need a few golden BBs, but million-dollar missiles will generally be reserved for million-dollar targets."(6:48) Therefore, in this time of declining defense dollars, it is necessary to buy the correct number and type of weapons that can be operationally employed against valid targets.

CHAPTER VII

CONCLUSION

History has shown the need for precision guided munitions that can accurately hit and destroy a pin point target while limiting collateral damage. This was proven in Vietnam when numerous bridges that could not be destroyed with unguided bombs were destroyed in only a few missions using laser guided and data link guided weapons. In addition, the United States' raid on Libya demonstrated the ability and advantages of precision guided weapons against high value targets. These two examples not only established the need for guided munitions but also demonstrated the precision accuracy available in modern weapons.

This accuracy does not come easily, however. It requires extensive realistic training by aircrew members. In both cases above, the bombing was accomplished with a limited number of personnel. The Vietnam bombing was done by a few highly qualified crews over an extended period of time; whereas, the Libya raid was accomplished by only a dozen or so crews on a one time mission. These same constraints will not occur in a future conflict with the Soviets in Europe.

Therefore, it is necessary for the Air Force to have enough aircraft and properly trained aircrews qualified to employ the precision guided weapons. This means spending money on aircraft procurements or modifications, ground and airborne training devices, range expansion, and realistic targets to train against. Granted, this will all take money to accomplish. However, the money could be made available by reducing the number of total weapons procured and using the money saved to expand the necessary resources. Because, after all, what good are the new very expensive precision guided weapons if we do not have a sufficient number of aircraft and aircrews to employ them effectively on the target.

Returning to my opening statement that many civilian and military leaders, along with target planners, have the false impression that precision guided weapons are easy to employ effectively. As I hope this paper has shown, precision guided weapon employment is a very complicated and time consuming process. It requires properly trained aircrews to assure success. We must have crews prepared to employ these sophisticated weapons accurately in any type of a conflict from a single mission raid to a general war in Europe. Because, as General Douglas MacArthur said, "In war there is no substitute for victory."(Note 7)

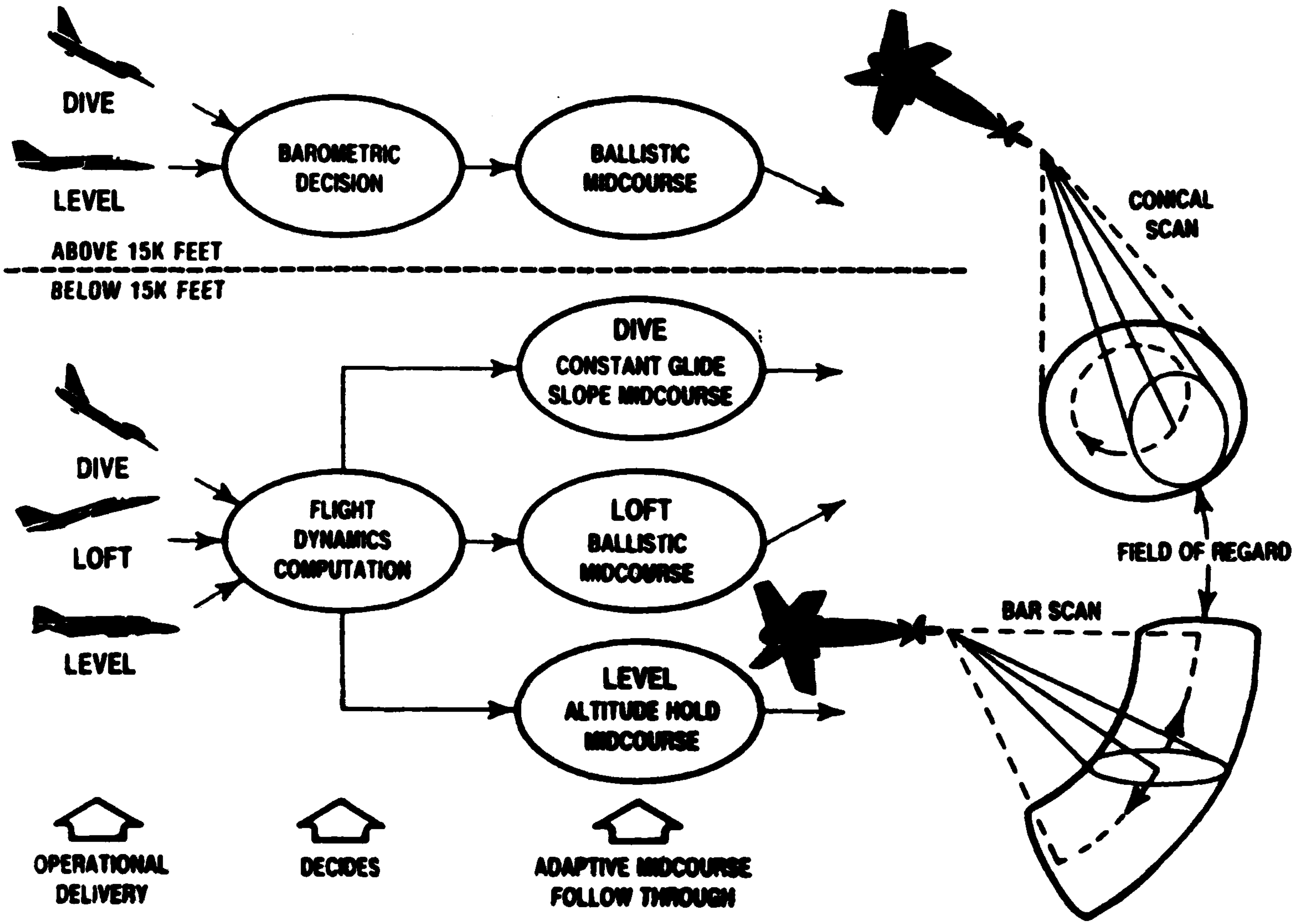
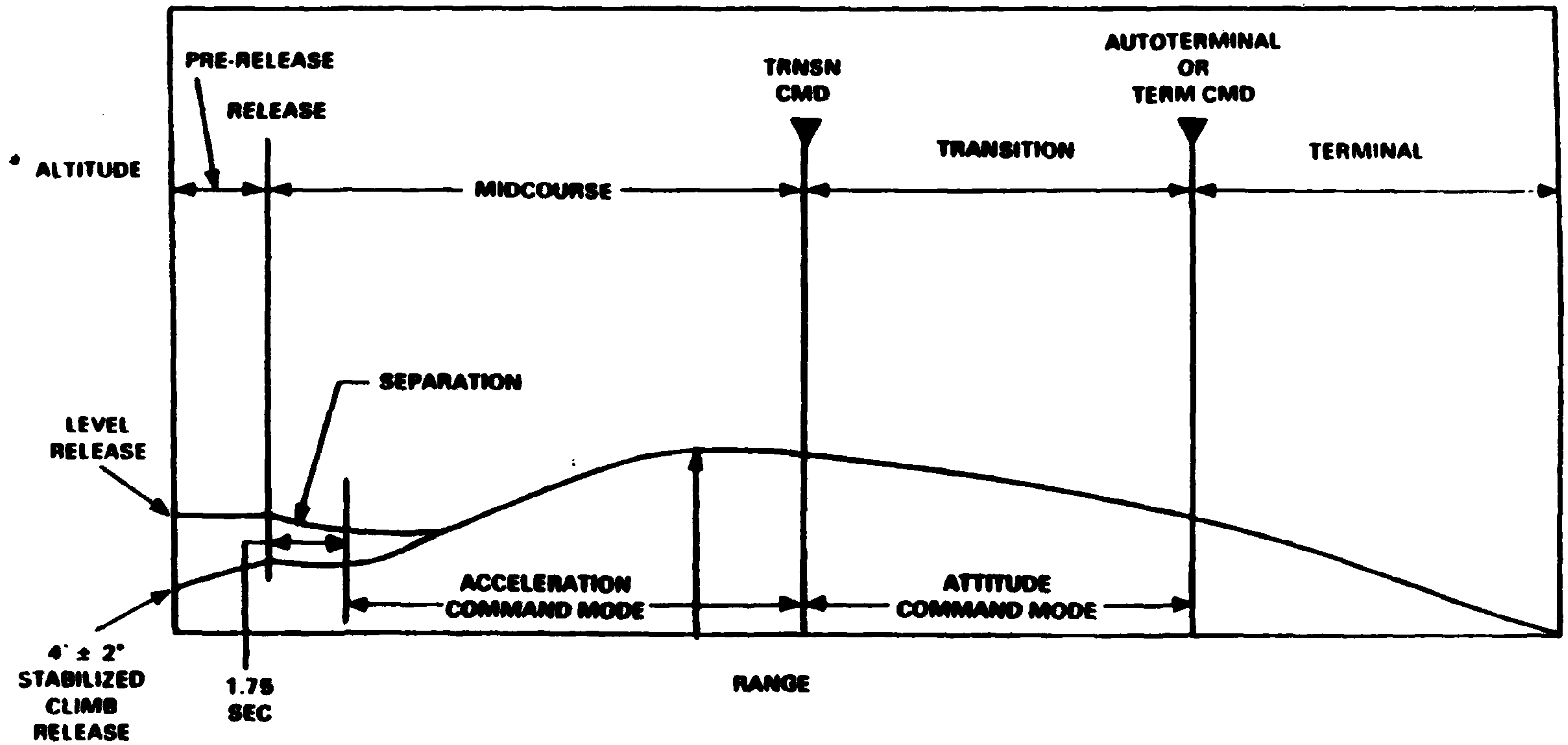


Figure 1 LLLGB Adaptive Autopilot Flexibility

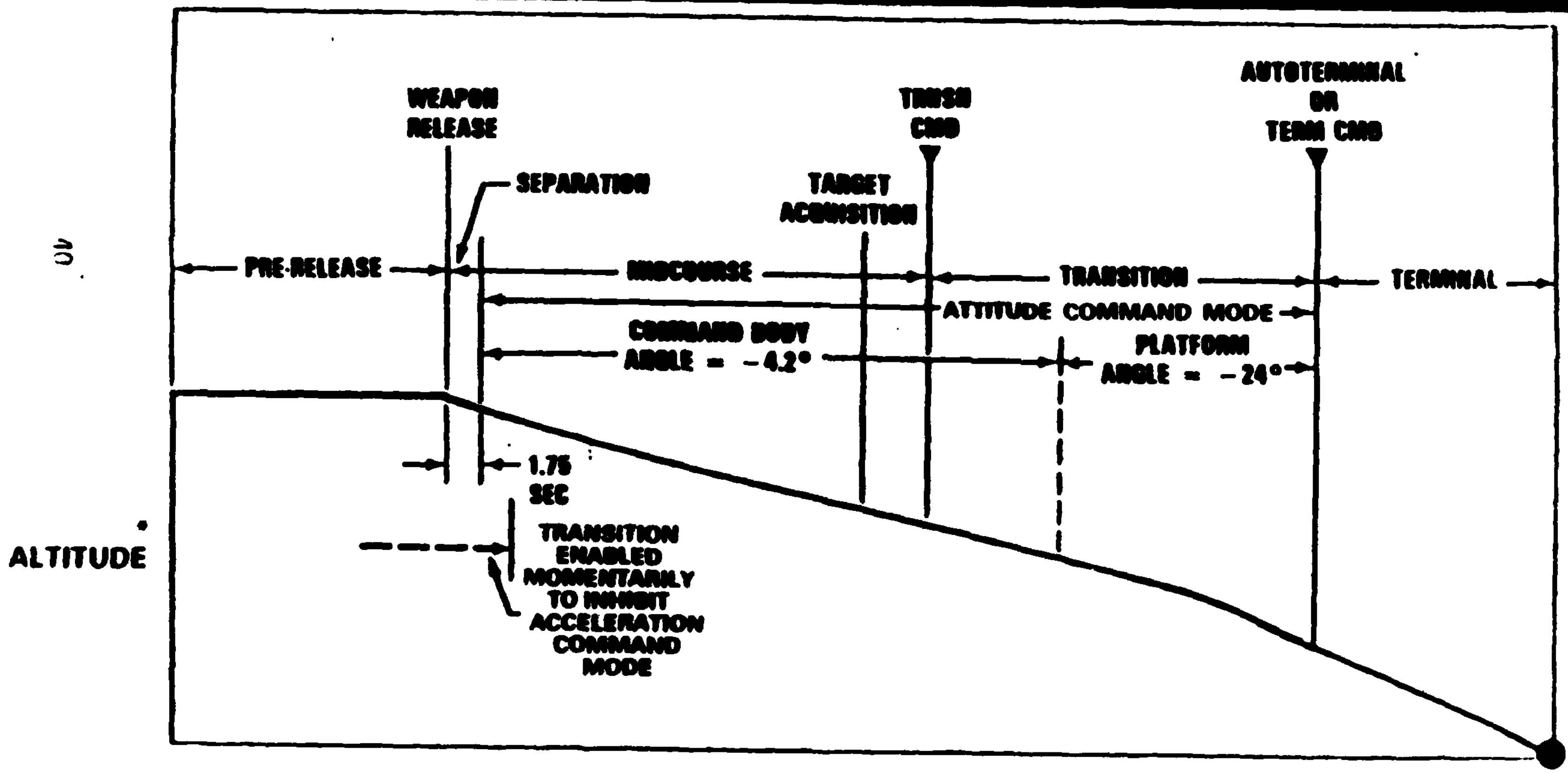
LOW ALTITUDE MISSION PROFILE
(Less Than 5000 Feet AGL)



* NOTE: ALTITUDE SCALE IS EXAGGERATED FOR DISPLAY PURPOSES. REFER TO DASH 34 FOR ACTUAL WEAPON ALTITUDES.

Figure 2

HIGH ALTITUDE MISSION PROFILE
(Greater Than 5000 Feet AGL)



*NOTE: ALTITUDE SCALE IS EXAGGERATED FOR DISPLAY PURPOSES. REFER TO DASH 34 FOR ACTUAL WEAPON ALTITUDES.

Figure 3

NOTES

1. HQ Tactical Air Command/DRAV, Major John A. Driscoll, 08 February 1988.

2. AFR 50-46, Weapons Ranges and HQ Tactical Air Command/DOXR, Major Robert Short.

3. Background paper on Pave Tack problems and lessons learned, Night Warfare Working Group, 10 July 1982.

4. Interview with Major John A. Driscoll, HQ Tactical Air Command, and former member of the 431st Test and Evaluation Squadron, Test Project Officer for GBU-24 and GBU-15 weapons testing, 26 October 1987.

5. Statement by Major Stephen Madley, USAF at 431st Test and Evaluation Squadron, McClellan AFB, CA, 13 Oct 83.

6. Discussion by General Donnelly, USAF Retired, at Air War College, Maxwell AFB, AL, 14 Oct 87..

7. Address to Congress by General Douglas MacArthur, 19 April 51.

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