Combat Fundamentals

Combat Fundamentals Handbook

For Arma 3

By John “Neptune” Crielaard

REFERENCES AND FURTHER READING

Tactical Brevity code - http://en.wikipedia.org/wiki/Multiservice_tactical_brevity_code

F16 combat fundamentals - http://www.fas.org/man/dod-101/sys/ac/docs/16v5.pdf

Table of Contents

Foreword

This manual is based on Multi-command handbook 11-F16 volume 5. Most information is left out due to the limits of Arma's air operations, avionics and area of operations. This brings a 290 page manual back to little less than 50 pages.

The manual is designed to provide pilots the needed information to make the right decisions during any phase of a tactical mission. This manual provides no authority or sanctions to depart from the established training procedures and directives, nor is it directive in nature.

Preparation

Establishing priorities

It is an acknowledged fact that during the heat of any mission, there are occasions when you can't do everything in the time available. This requires assigning priorities (task prioritization). At the top of the list are things you have to do—do them first. Lower on the list are things you'd like to do—do them later when they don't interfere with the have-to-do things. Your list of have-to-do tasks should be established long before you get near an airplane. Some basic top priority tasks are:

- Maintain aircraft control.
- Never hit the ground (or anything attached to it).
- Never hit anything in the air (i.e., your lead/wingman).
- Never run out of fuel.
- Never let anything shot from the ground or air hit your airplane.

Prioritising tasks

Lower priority tasks range from answering fuel checks on the radio to calling METRO with a PIREP. There may be some shifts in your high priority items, but they never go away completely. For example, at 20,000' in close formation in the weather, avoiding collision with members of your flight is a bigger concern than hitting the ground. Obviously, mission accomplishment has a high priority, but remember, if you don't get yourself and your airplane home, you've failed to accomplish a major part of the mission. In peacetime, there is no mission more important than safe recovery of your airplane. If you let nice-to-do things take priority over have-to-do things, you are guilty of misprioritization and you jeopardize yourself and those around you. Many of the revisions in this manual are the result of accidents that occurred because of mispriortization. If the rare occasion comes up where aircraft malfunction/emergencies make it impossible for you to perform your top priority tasks, it may be time to eject.

Mission objectives

Preparation for any given mission is based on mission objectives tailored to the lowest common denominator. The objectives are performance standards to measure individual and team success during any mission, and should give the "big picture" of what's happening. A valid objective has three parts: performance, conditions, and standards.

<u>Performance</u>

This is what each pilot or the flight is required to do during the mission. It describes action and is not vague. Use action verbs such as: demonstrate, employ, or practice.

<u>Conditions</u>

This is where it's happening, the environment. Examples include line abreast formation or outside the bandit's turn circle.

<u>Standards</u>

These state how well the performance must be done and are categorized by time limits, accuracy, and/or quality. Time-on-target (TOT) within plus or minus 30 seconds, hits within 10 meters, or ranging within plus or minus 500' are examples.

<u>Planning Considerations</u>

Defining objectives also depends on contingencies and other planning considerations: weather, sun angles, day or night, the threat, or the frag order are a few. Incorporating well defined objectives based on the mission requirements and the particular mission's lowest common denominator (e.g., weather, wingman experience) pays benefits in terms of combating misprioritization and increasing situation awareness.

Flight leadership

Flight leaders have the general responsibility for planning and organizing the mission, leading the flight, delegating tasks within the flight, and ensuring mission accomplishment. They are in charge of the resources entrusted to them. They must know the capabilities and limitations of each flight member. Once airborne, they have the final responsibility and controlling authority for establishing the formation(s), maximizing the flight's effectiveness, and leading the flight successfully to and from the target.

Wingman responsibly

Wingmen also have critical responsibilities in the flight. They help the leader plan and organize the mission. They have visual lookout and radar responsibilities, perform back-up navigation tasks, and are essential to target destruction objectives. Wingmen engage as briefed or when directed by the leader and support when the leader engages. It is essential wingmen understand their briefed responsibilities and execute their contract with discipline.

Discipline is the most important quality a fighter pilot can posses and leads to success in the aerial arena. Discipline is executing self-control, maturity, and judgment in a high-stress, emotionally charged environment. Teamwork is the foundation of the fighting element. If all flight members know and perform their respective duties, they work together as a team. Experience and realistic training leads to solid and professional air discipline.

Mission planning

The flight leader establishes priorities for mission planning and delegates them to flight members to ensure all planning considerations are addressed while precluding any duplication of effort. The air-to-air and air-to-surface chapters of this volume contain additional information specific to these roles. The depth of planning detail is dictated by the mission and flight experience level, but the bottom line is: all necessary mission planning is completed in time to conduct a concise, comprehensive briefing.

The two main factors which determine the direction of mission preparation are the role of the F-16 for the particular mission (offensive counter air, interdiction, combat air patrol, etc.) and the overall mission objective (student training syllabus objectives, continuation training profile, visual bombing qualification, target destruction, etc.).

Additional factors, determined by the role and overall objective, which must be addressed during mission preparation include:

- Flight composition.
- Size.
- Experience level of flight members.
- Higher headquarters (HHQ) guidance.
- Rules of engagement (ROE).
- Special instructions (SPINS).
- Support forces.
- Controlling agencies.
- Communications.
- Fuel considerations/refueling.
- Escort, SEAD, ECM support.
- Routing.
- Threats.
- Cockpit indications.
- Capabilities.
- Numbers and locations.
- EID requirements.

- VID requirements.
- Weather.
- Aircraft configuration.
- Fuel tanks.
- Low altitude navigation and targeting infrared for night (LANTIRN) pods.
- Weapons loads.
- ECM pod.
- Self protection missiles.
- Weapons delivery options.
- Egress and safe passage procedures.
- Contingencies.

Debrief

The objective of the debrief is to determine if the desired mission objectives were achieved, identify lessons learned, and define aspects of training needing improvement.

Reconstruction of the mission objectives occupies most of the debriefing. Before the debriefing, use everything available, such as the video tape recorder (VTR), notes, range scores, and air combat maneuvering instrumentation (ACMI), to reconstruct the mission and evaluate its success If telephonically debriefing adversaries, have a gameplan to include a debrief time. Preparation before beginning debrief with flight members and adversaries provides a well-controlled, effective debriefing.

An honest assessment of accomplishments is more important than "winning the debrief."

Get the small items out of the way first. Discuss significant departures from the briefed flow or established procedures without belaboring the items. Review the mission objectives and provide a general impression of mission success. It is essential to derive accurate lessons learned; not simply the mistakes made.

Some missions do not lend themselves to detailed reconstruction. Choose only the significant events that impact the objectives of the ride. The final summary includes an assessment of strong and weak points and the required corrections.

Formation

Basic formation

Formation discipline is essential for the safety and control of all formation flights. The integrity of a formation can only be maintained when the leader has complete knowledge and control of the actions of each flight member. The flight leader will brief the formations to be flown and formation responsibilities. Wingmen will maintain assigned formation position until change is ordered or approved by the flight lead.

Radio discipline

Discipline within a formation starts with communications. All communications must be clearly understood by every flight member. Radio discipline requires not only clarity and brevity in the message itself, but limiting unnecessary transmissions as well. The first part of any radio call should always be "call sign." This alerts the listener that a message is coming (attention step) and to specify to whom it is directed. The use of tactical or personal call signs or reliance on voice recognition or tone/inflection to identify another aircraft are poor practices, intolerable in combat. For an acknowledgment immediately following a radio call from lead, flight number (i.e., 2, 3, 4) with the appropriate response will be used. For all initiated calls or a response that is delayed, full call sign must be used. In exercise or actual combat with many aircraft and many people on the radio, proper use of assigned call signs and brevity words enhance situational awareness between and within flights; poor radio discipline will quickly degrade situational awareness with invariably disastrous results. In the event that a tasking agency gives you a cumbersome mission number to use as your call

Ground Operation

Before the formation can commence their flight a thorough briefing should be completed. Then after stepping all flight members must have established communication before the formation flight can continue. It is advised to brief a radio-check time in addition to the frequency used. Every pilot thorough checks his aircraft, game settings and other aids he will use during the flight, before he continues on the mission. This may include:

- Sound effects – Volume adjusted
- View Distance – Set
- Head Tracking – Centred
- ECM settings – Set
- Radio channels – Set

Departure

In this manual I will only describe interval departures since formation take-offs are not practical in ArmA3.
After the Pre-takeoff checks all aircraft of a flight line-up on the runway. Lead positions his aircraft on the downwind-lane side (Since wind is not modelled, go to the far side of the runway). The wingman lines up on other lane and positions his aircraft slightly forward of the Finger-tip formation position. The Element leader and his wingman line-up in the same way with some latheral displacement to stay clear of the jetwash. All aircraft apply full brakes.
At lead’s signal all aircraft push their powe forward 30% (80% Ng RPM) and check engine instruments are within limits; ‘In the green’. On lead’s signal all aircraft release their brakes as per pre-briefed interval and push their power all the way up for a normal take-of.

To account for safe separation every following aircraft may release the brakes only if the preceding aircraft is safely airborne.

Tactical formation

Varying factors of the tactical arena (weather, visibility, background, terrain, threat, etc.) will determine the position and responsibilities for the individual flight members. Central to all manoeuvring must be a capability to communicate intent, role, and threat information. Definitions of pilot responsibilities and emphasis on air discipline will help ensure success in a restricted communications environment. The formations described in this chapter are applicable for both air-to-air and air-to-surface operations. The guidelines given have proven to be the most universally applicable. As the tactical situation changes, the numbers given here may change. Remember, flying a given formation is not an end in itself; it facilitates proper task prioritization, lookout, and offensive/defensive considerations. If you cannot perform your responsibility in a formation listed, get into one which does permit you to carry out your formation responsibilities. The flight briefing should cover, as much as possible, any changes that may be necessary.

<u>Mutual Support</u>

A vital subset of situational awareness is mutual support (MS). Mutual support is a contract within a flight of two or more aircraft that supports the flight’s mission objectives. An effective mutual support contract will enable a flight to maintain the offensive while enhancing its survival in a hostile environment. Mutual support in the modern combat arena is more directly related to SA than ever before. It demands position awareness of other flight members and the threat as well as an understanding of the flight’s and the threat’s weapons capability.

<u>Formation Selection</u>

The basic combat formation employed by tactical fighters is the four-ship flight. The two-ship element is the basic fighting unit. The wingman's main duty is to fly formation on his leader and to support him at all times. He is to clear the area and perform his portion of the briefed mission. A four-ship flight consists of two elements directed by the four-ship flight lead, increasing the mutual support of all. Considering the variety of air and surface threats, terrain, weather, target arrays, and mission objectives that will be encountered in carrying out a wide range of wartime taskings, there is a need for both line abreast and wedge formations. Each of these two tactical formations has unique strengths. Conversely, each has weaknesses that restrict their utility and flexibility.

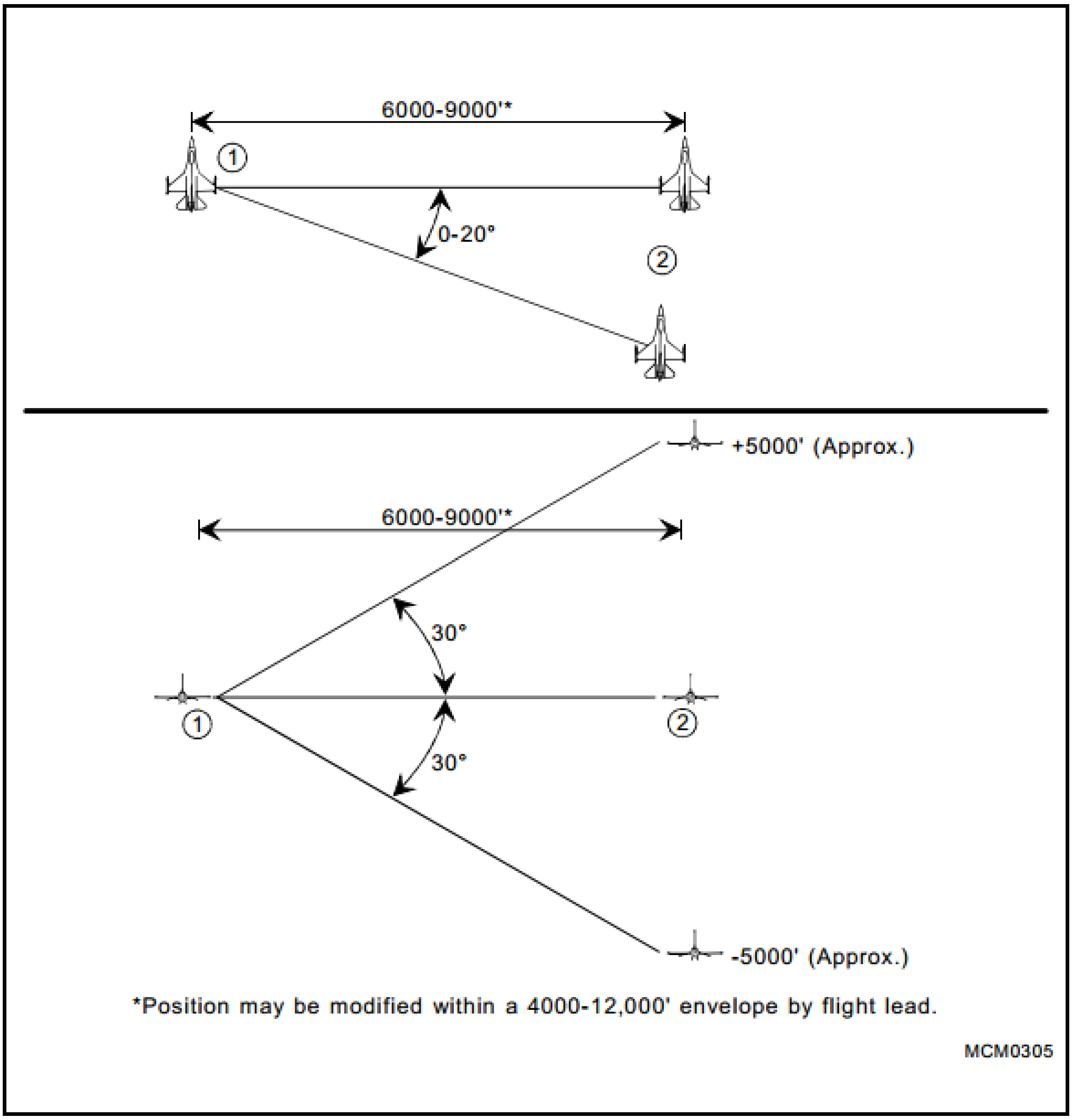
<u>Formation responsibilities</u>

The flight lead assigns responsibilities for each flight member. Dividing responsibilities ensures each pilot has a manageable number of tasks to perform. Flight member normal responsibilities are:

- Number One: Primary planner and decision maker, primary navigation and radar lookout, visual lookout for mutual support of #2, and primary engaged fighter, if practical.
- Number Two: Maintain formation position, visual lookout, mutual support of number one. Navigation position awareness, and radar awareness as other responsibilities allow.
- Number Three: Support number one. Secondary planner and alternate decision maker, maintain support position for lead element, secondary navigation and radar monitor, visual lookout for number four, mutual support of the entire flight, and secondary engaged fighter, if practical.
- Number Four: Maintain formation position, visual lookout for the flight, mutual support of number three. Navigation position awareness, and radar awareness as other responsibilities allow.

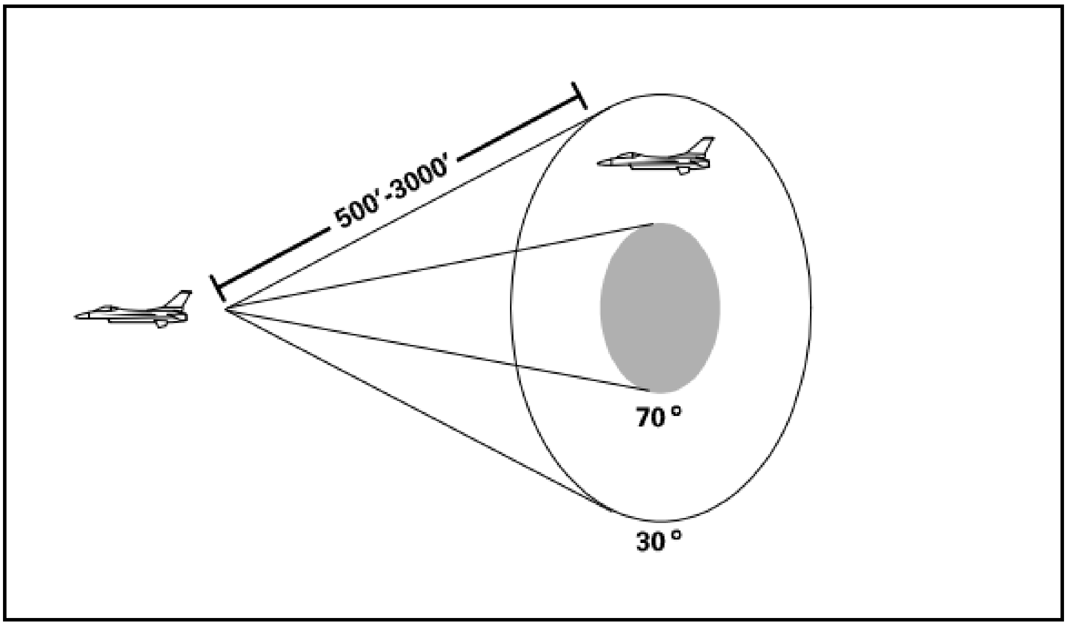
Line abreast

This formation allows element members to be in position to quickly bring ordnance to bear when a threat is detected. A vertical stack of 2000 to 6000 feet, when applicable, minimizes the chance of simultaneous detection by a bandit.



Fighting wing

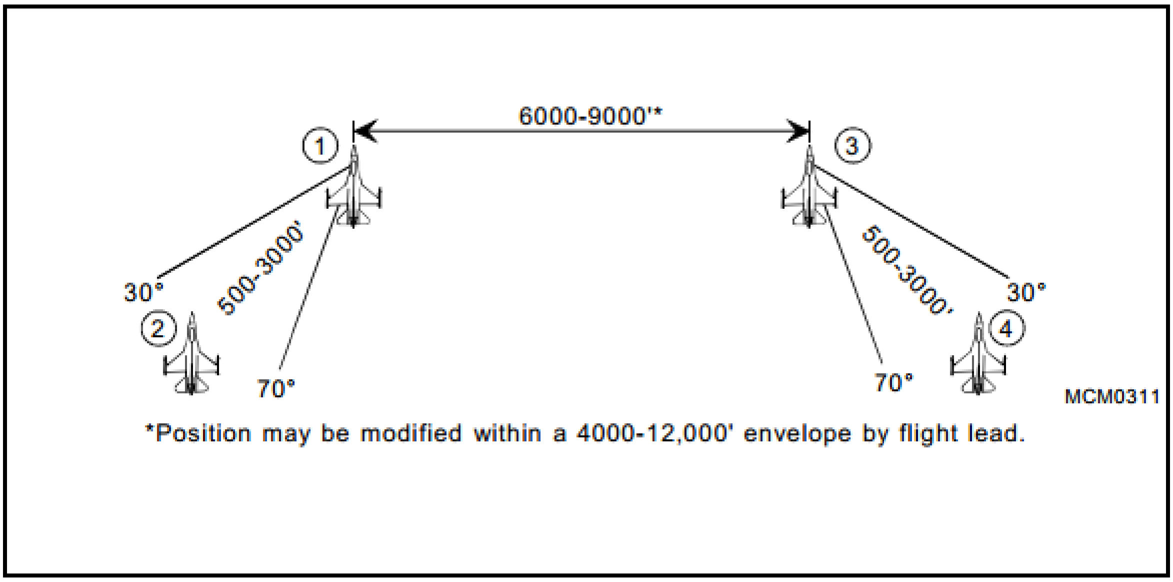
This formation, flown as a two-ship, gives the wingman a manoeuvring cone from 30º to 70º aft of line abreast and lateral spacing between 500' to 3000' (Figure 3.7). Number two manoeuvres off lead



with cut/off as necessary to maintain position. This formation is employed in situations where maximum manoeuvring potential is desired. Arenas for use include holding in a tactical environment or manoeuvring around obstacles or clouds. This formation is employed by elements when flying fluid four.

Fluid Four

Element leads maintain line abreast formation, while wingmen assume fighting wing (Figure 3.11). Number three manoeuvres off number one as if in line abreast. Number two and number four manoeuvre off their element leaders to maintain the outside of the formation. Element leads are responsible for deconfliction of elements when crossing the opposing element's six o'clock.



As a variety the second element can be in a trail of the first instead for better flight integrity at the cost of 6 o´clock lookout.

Tactical turns

The tactical turns will normally be initiated by the flight lead. The preparatory command for a turn is flight call sign and the command of execution is the type turn called. EXAMPLE: "Falcon One, 90 right" Turns of 90 are assumed to be delayed types unless called otherwise. EXAMPLE: "Falcon One, hook right."

Turns Into the Wingman

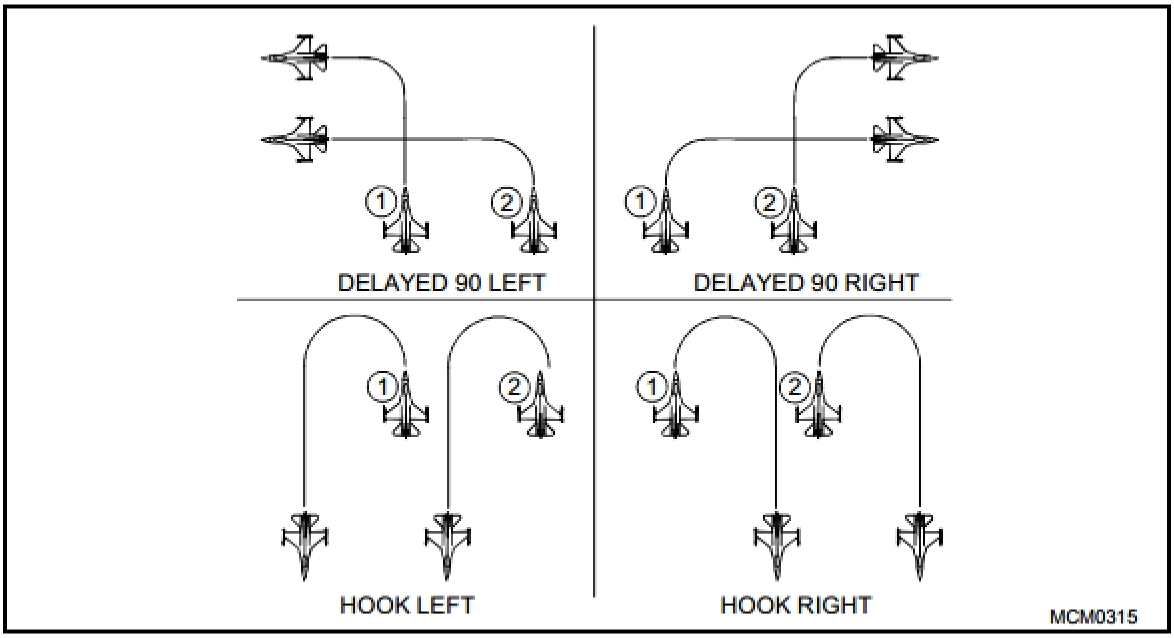
- Lead initiates the turn by turning into the wingman, normally at MIL power and a sustained 4 G's.
- The wingman continues straight ahead (or checks 20º - 30º as briefed) and searches the new six through lead.
- If lead rolls out short of passing through the wingman's six o'clock, the wingman now weaves to line abreast (delayed 45º - 60º turn).
- If lead turns through the wingman's six o'clock, the wingman assumes a 90º turn and turns to regain line abreast.
- If a 180º turn is required, it will be accomplished in increments of two delayed 90º turns.

Turns Away from the Wingman

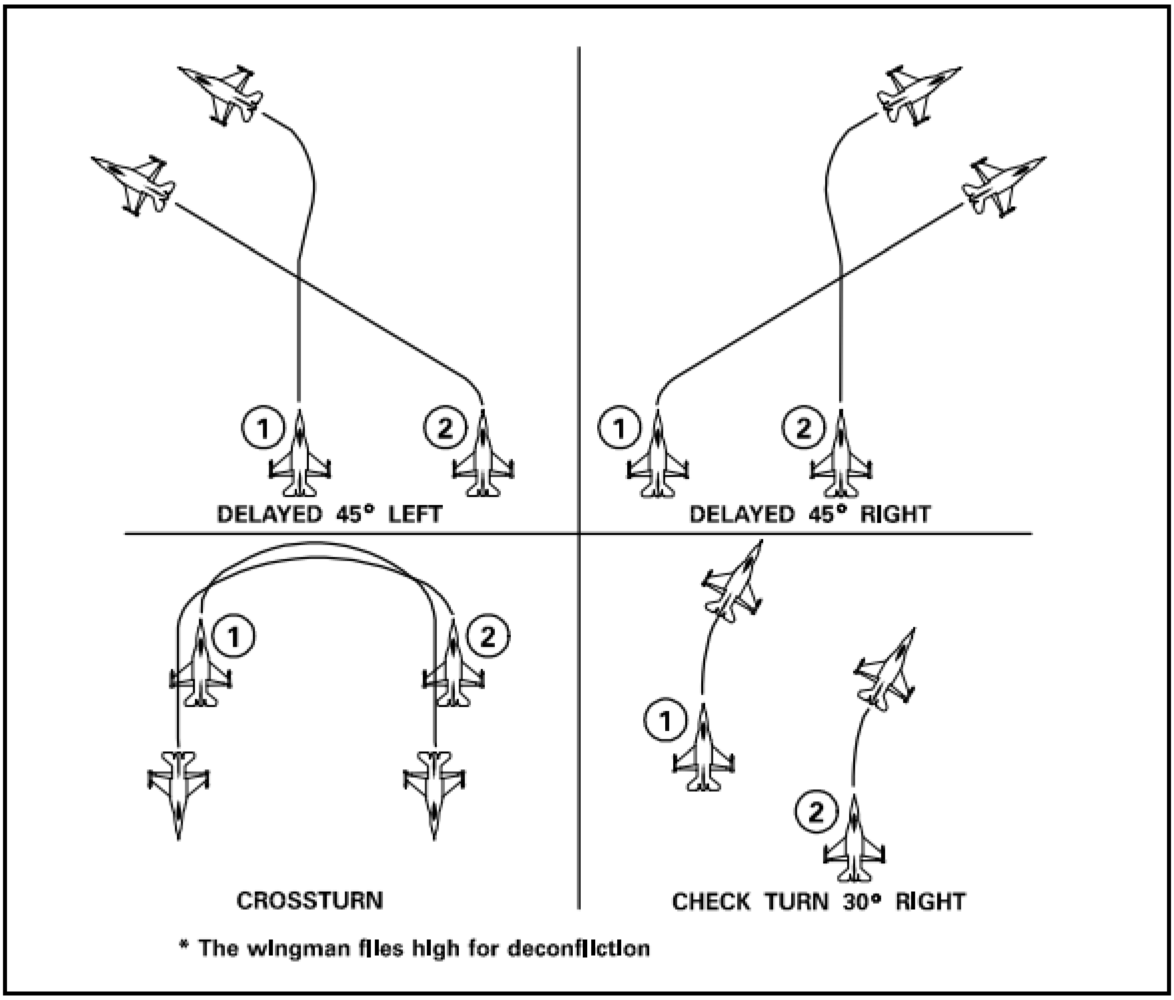
- Lead makes a distinctive wing flash or check turn of approximately 30º to signal the turn.
- The wingman sees the flash and begins the turn into lead using the briefed G and power setting (i.e., MIL, 4 G sustained, etc.).
- If lead wants a delayed 45º - 60º turn, he turns into the wingman when the wingman obtains the desired heading. This is the wingman's command to roll out.
- If lead wants a delayed 90º turn, he allows the wingman to continue turning through his six o'clock.
- If lead wants to turn 180º away, he initiates the turn with a continuous 180º turn.

Check Turns

- Lead turns to the desired heading using a gentle turn.
- Wingman sees either a divergence or convergence and strives for line abreast using an S-turn, vertical, or power.



Delayed 90 and hook turns



Delayed 45/Crossturn/Check turn

Air to Air

The purpose of the Air-to-Air (A/A) chapter is to review the basic training spectrum of the Fighter jet in aerial combat. This training consists of a series of mission elements and types that use a building block approach to reach the required level of proficiency. The areas include preparation, system/fence checks, aircraft handling characteristics (AHC), basic fighter maneuvers (BFM) and air combat manoeuvres (ACM). Aerial combat is by far the most difficult aspect of flight for the fighter pilot to understand and master. The arena is very dynamic, and the skills used must be learned over time. Personal desire and discipline will determine how quickly the individual masters the required skills.

Principles/Concepts Of Basic Fighter Manoeuvres (BFM)

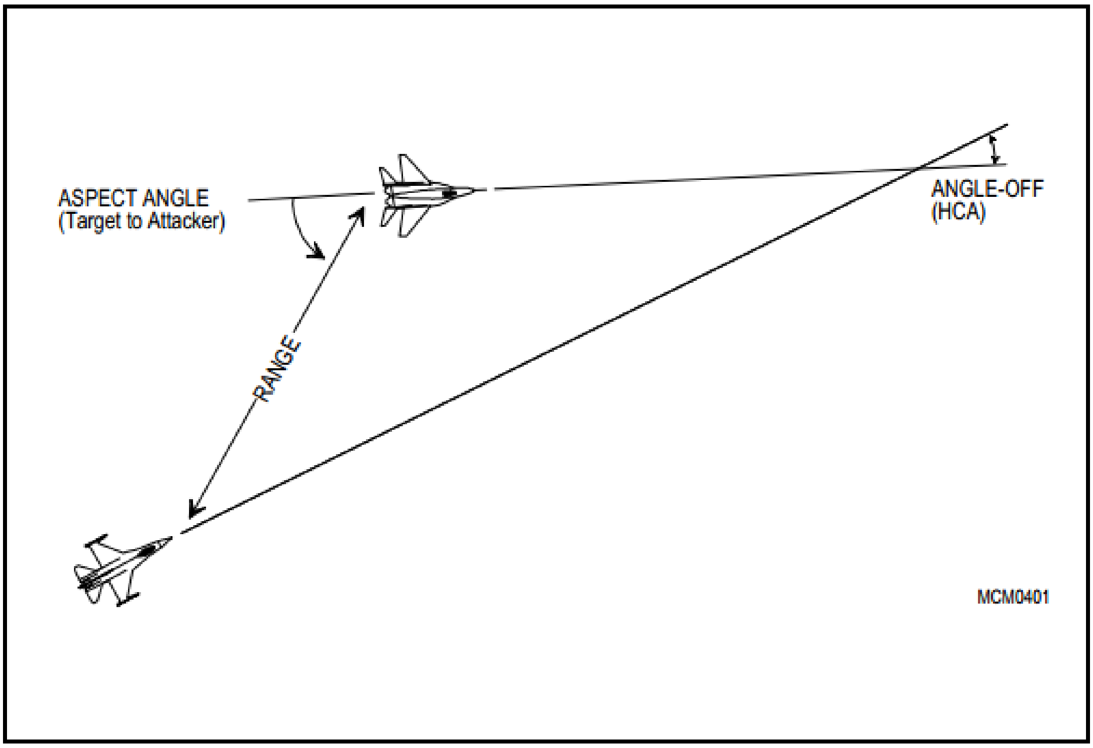
The manoeuvres required during a BFM engagement are nothing more than a combination of those learned during AHC. The primary objective of BFM is to manoeuvre your aircraft into weapons parameters to employ ordnance. To accomplish this you may first need to manoeuvre so as to keep a bandit from employing ordnance against you. The required manoeuvres are not pre-staged to arrive at the end game solution, but are combined as necessary based upon continual reassessment of the situation. The entire process of observing, predicting, and manoeuvring is repeated until either a kill or disengagement has been achieved. In order to successfully execute BFM, a pilot must understand his geometric relationship to the target and how it affects his ability to employ his weapons. The spatial relationship of two aircraft can be analyzed from three perspectives: positional geometry, attack geometry, and the weapon envelope.

<u>Positional Geometry</u>

When discussing one aircraft's position relative to another, range, aspect angle, and angle-off (heading crossing angle [HCA]) are used to describe angular relationships. These three factors dictate which aircraft enjoys a positional advantage, and how much of an advantage it is.

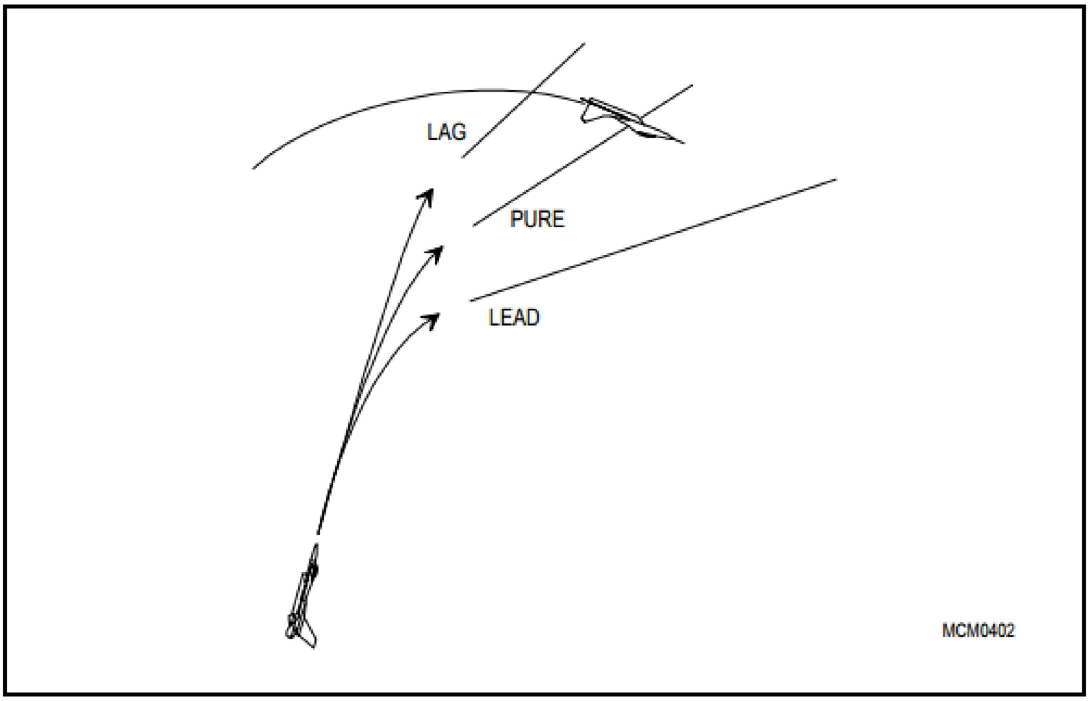
- Range is the distance between two aircraft.
- Aspect angle describes the relative position of the attacker to the target, without regard to the attacker's heading. It is defined as the angle measured from the tail of the target to the position of the attacker.

Angle-off is primarily concerned with the relative headings of two aircraft. Angle-off is defined as the angular distance between the longitudinal axes of the attacker and the defender. Whenever the attacker is pointing at the defender, the aspect angle and angle-off will be the same.

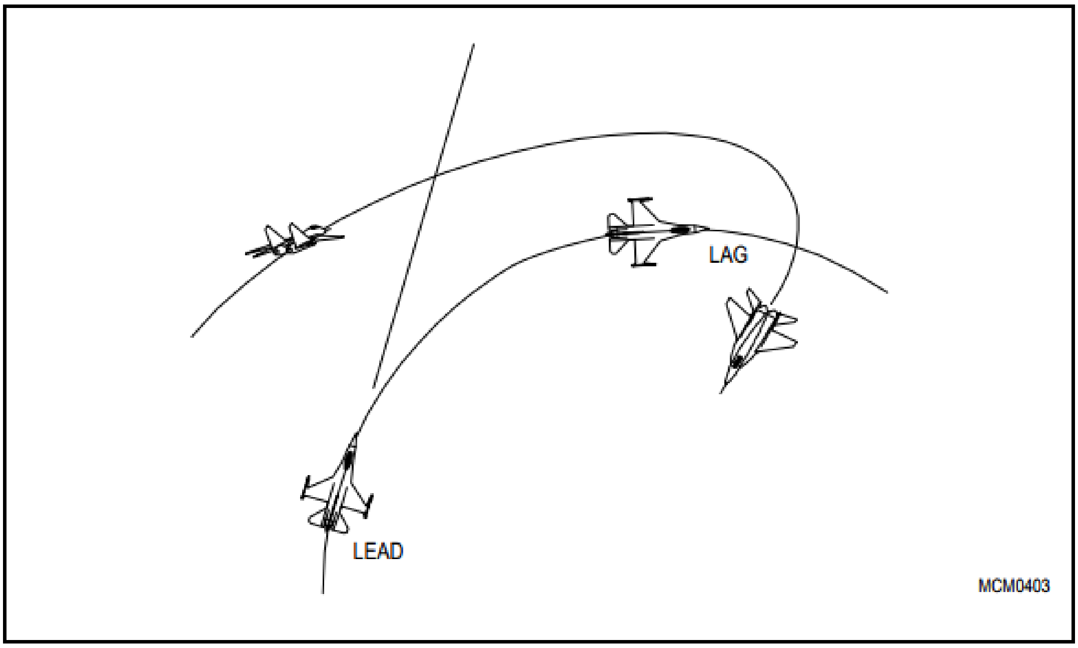


Attack Geometry

There are three available attack pursuit courses: lead, lag, and pure. The attacker's nose position or his lift vector will determine the pursuit course being flown. If the attacker is in the defender's plane of turn, the position of the attacker's nose determines the pursuit course. With his nose pointed in front of the defender (such as in the case of a gunshot), he is in lead pursuit. If he points behind the defender, he is in lag pursuit. If he points at his adversary, he is in pure pursuit. Note that an initial lead pursuit attacker could be driven into a lag pursuit course if he has insufficient turn rate available to maintain lead.



Attack Pursuit Courses



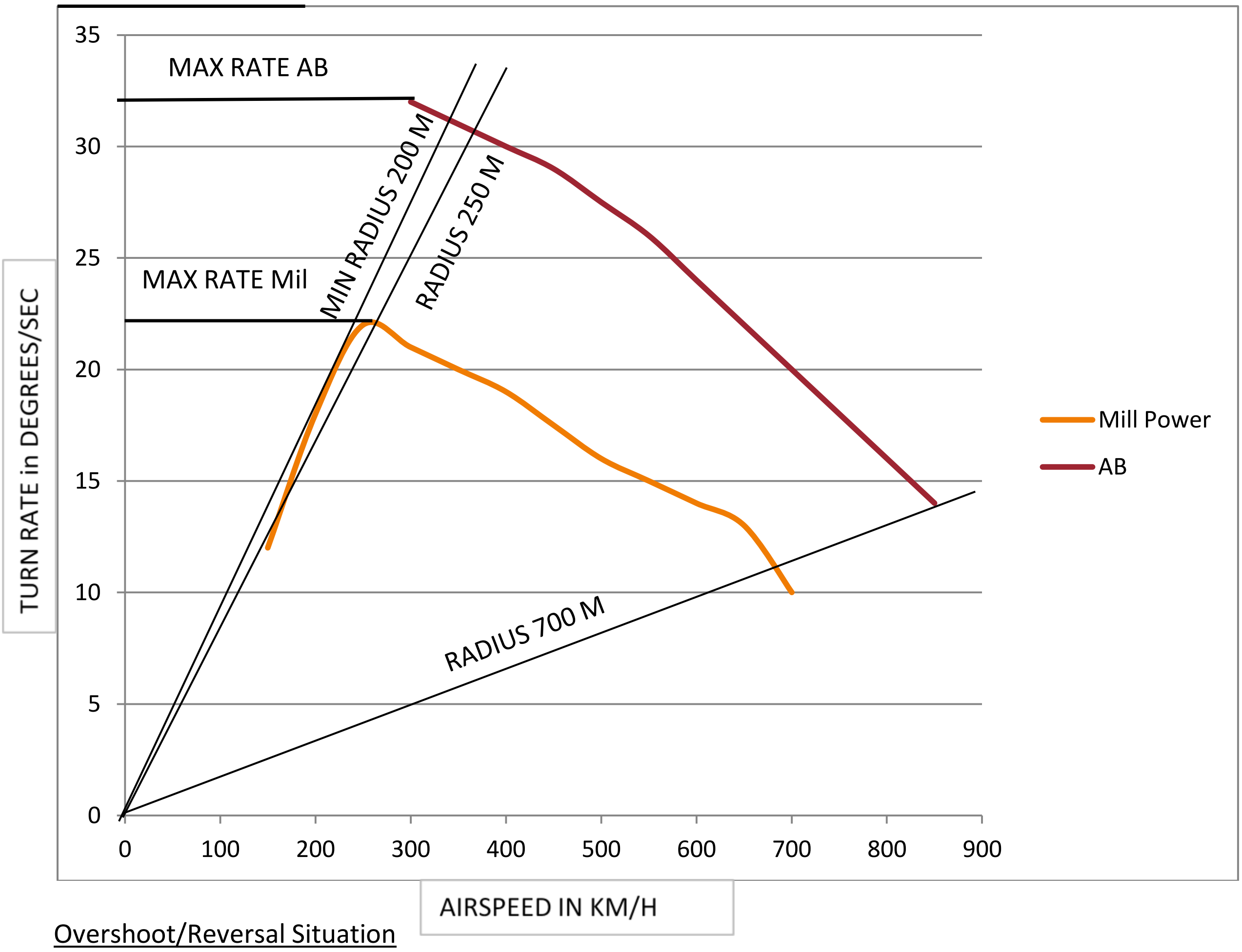
Insufficient Turnrate to maintain lead (Results in lag)

Offensive BFM

Turn

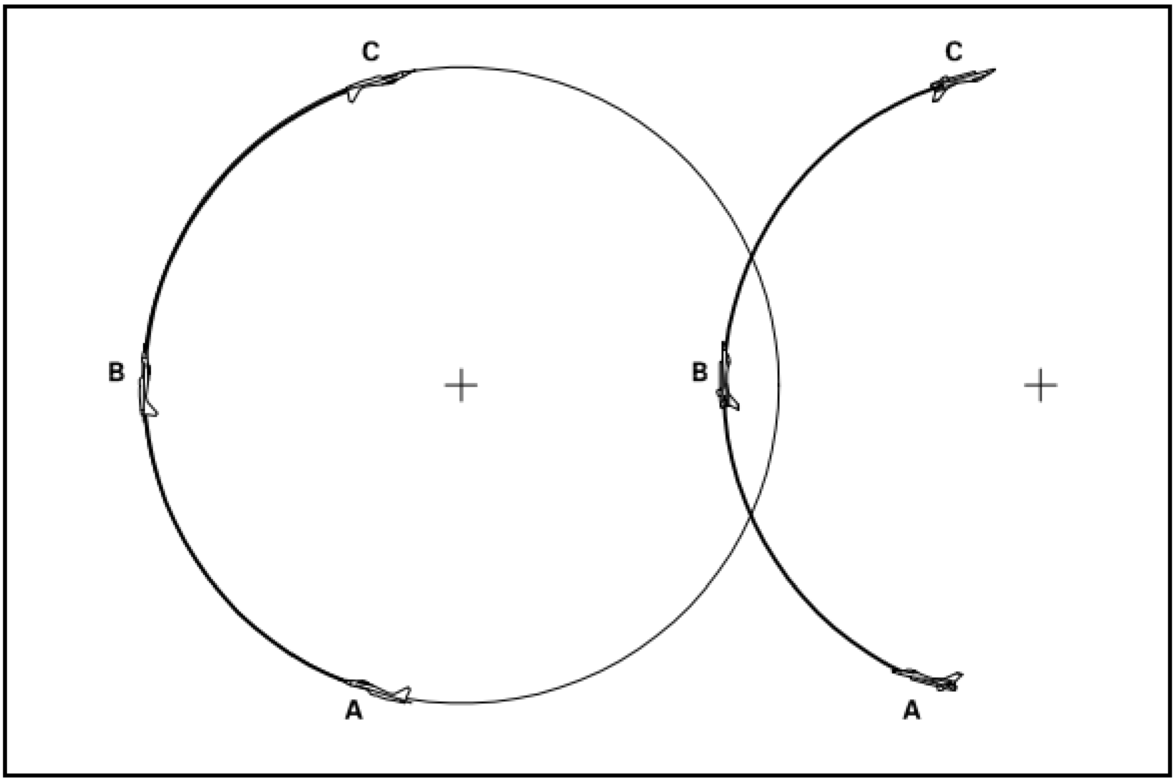
Turn radius determines the size of the turn circle. This radius is based on the aircraft's airspeed and radial G. The size of the circle and the relative turn rate capability of the two aircraft will determine how well the pilot can solve the angular problems the defender presents. The objective is to work to where available G will allow the attacker to point his nose at the defender to achieve a missile or gun shot with an acceptable specific power (Ps) bleed-off. How well an aircraft can turn is a function of the turn rate and radius it generates.

Radius defines the size of an aircraft's turn or its turning "circle." In Saul's & Spartan's F/A-18 mod turn radius as max AOA/G is relatively constant over an airspeed of 150km/h to 250km/h. Above 250Km/h, turn radius increases slightly as max G is obtained (550km/h). Above 550km/h, turn radius increases dramatically.



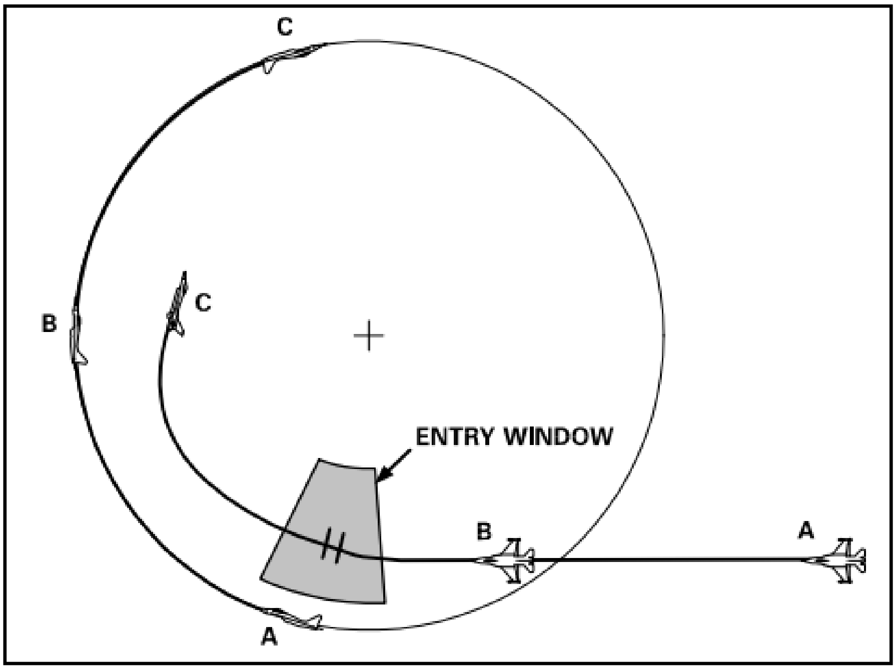
Overshoot/Reversal Situation

Even if the attacker has the identical turn rate/radius capability as the defender (1v1 similar), the attacker is unable to sustain operations in the same plane to the degree the center of the two turn circles are offset. In a gross example, if the attacker is outside the defender's turn circle and immediately turns, instead of accelerating into the defender's turn circle, roles will be reversed after 180° of turn.



The attacker's solution to the situation described above (outside defender's turn circle) is to manoeuvre into the defender's turn circle, aiming toward an "entry window". This involves initially pointing to lag. For example, at point B (Picture below) the attacker has just entered the turn circle and has his nose in lag. Upon reaching the "entry window," to close on the defender the attacker may need an out-of-plane manoeuvre to avoid overshooting, followed by a pull back towards lead pursuit. The ability to enter the defender's turn circle and control geometric closure by initially pointing to lag is an important concept in BFM.

A defender wants to decrease his turning circle as much as possible. This is because a superior turning aircraft cannot use his better turn capability until he is inside a defender's turn circle. An earlier turn would merely effect an "in-place" turn.



Defensive BFM

The following discussion of defensive BFM is predicated on an understanding of offensive BFM. In defence, realizing the mistakes of the attacker gives the defender his best chance of role reversal or escape. To recognize the attacker's mistakes the defender must know offensive BFM concepts. The primary objective of defensive BFM is survival.

Objectives During Defensive BFM

There is no magic manoeuvre you can use on defence which will automatically change you to an offensive position against a similar bandit. In order for you to go offensive or separate, he must make a mistake. Therefore, it is essential you maintain a tally so you can take advantage of his mistakes, assuming he makes any. Your manoeuvring on defence must be weighed with keeping the tally. If the bandit doesn't make any mistakes, or makes fewer than you, the best you can hope for is to keep him from employing ordnance against you. As the engagement continues, this can become extremely frustrating and there is a tendency to give up. Your will to live must remain high. As long as the bandit isn't shooting, your defence is working.

There are two basic objectives during defensive BFM:

- Survive the bandit's attack. Deny the bandit weapons employment opportunities. Defeat any weapons employed by the bandit.
- Separate or kill the bandit.

There are a few principles that are important if you intend to survive:

- First is the will to live. Whatever it's for it doesn't matter, but the instant you give up you die. Once this attitude has been established the fight may commence.
- A game plan is important, and a couple will be discussed later. However, if the game plan you decide on is not working, do something else.
- Keeping a tally is a must! Do whatever it takes not to lose the bandit once you have him in sight.
- BFM is a constant trade-off between energy and position. Only expend enough energy as required and no more. Airspeed is rate, and rate is critical in defeating ordnance and causing angular problems for the bandit. If you give up airspeed and don't get anything for it, you'll die. However if you try to conserve airspeed at the wrong time, you’ll offer the bandit a shot opportunity. Don’t die with airspeed or altitude below you.

Along the same line is nose position relative to the horizon. Don't get it buried or you become extremely predictable which makes the bandit's job a lot easier.

Air to surface

"Hauling iron" is a challenging mission that requires complete knowledge of your aircraft systems, handling characteristics, and ordnance. Given current surface-to-air and air-to-air threat capabilities, the surface attack role is demanding. This chapter presents discussions on premission planning, delivery parameters, surface attack checks, low and medium altitude considerations, visual and non-visual bombing, controlled range patterns, and pop-up deliveries.

Manual Bombing Delivery

In the event that there are no ways to directly lock targets for GBU to home on, you may be forced to resort to manual bombing. Good manual bombing demands rigid compliance with delivery parameters. If available in your game settings a waypoint you setup by Shift-clicking on the map can help you a lot of getting your Slant range.

Since the HUD symbology is incorrect and gives incorrect pitch information for every ladder not on the 'W', we need to use the old fashioned way of getting pitch reference. In the picture below, you see what cockpit/HUD references you can use to find where you should move your aircraft's nose to, to gain a certain pitch angle.

We can say roughly -10 pitch is the very bottom of the HUD. -20 is the top of the ICP and -30 is the top of the centre MFD. Take note of these references since you will use this as 'HUD reference' during manual bombing. i.e. if the Manual release able gives you 9 Aim-Off (AO) and the Flight path marker is between 0 and +5, the target should be about halfway between point -5 and -10.

Preparation and Planning

The following items should be accomplished even if manual bombing isn't planned.

Before the flight or the attack:
- Complete weapons employment data on the line-up card.
- Compute an upwind aim-point at release.
- Compute the Tip-in point
- Compute the release altitude (Taking geographic differences into account)
- Define your Minimum Release Altitude (MRA). Based on obstacles and threats

Area entry

Fly a downwind leg at your planned release altitude to find your target and aim-point. Then climb to Tip-In altitude.

Base leg

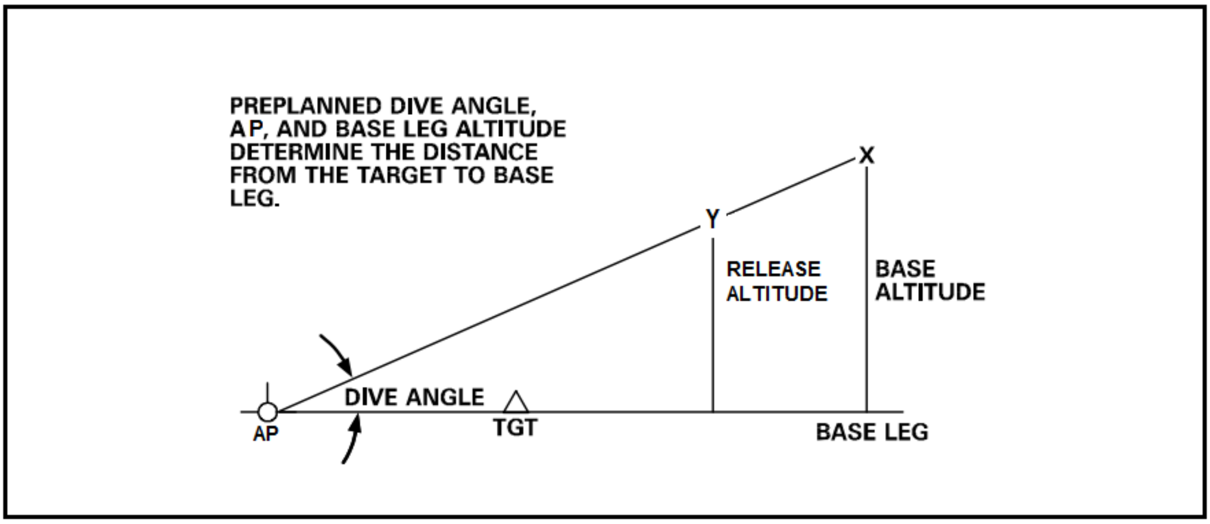
Roll out on a 90 degrees angle on your final attack heading. Keep and eye on the target while maintaining straight and level flight. As the target and aimpoint start to line up, roll in to your final attack heading. Your altitude and range from target at this point should be enough to give your self time to make speed and altitude corrections. Basically the longer your final run is, the easier the bombing run will become. As a rule of thumb, start at 1.5 times the Release to Aimpoint range and 1.5 times the Release altitude.

If you're at the proper base-leg position, altitude and speed, the roll in is easy. The importance of "base leg" cannot be overemphasized; it is the basic geometric factor affecting the dive angle. One roll-in technique is:
The bank will have to be approximately 90º plus about half the desired dive angle (105º–110º for 30º dive). Keep your eyes on the target area and use back stick as necessary to make a hard turn in the delivery plane. This means pull the nose directly to a point twelve o'clock to the target (your computed aim-off distance). A common tendency is to "dish out" during the roll in, resulting in a shallow dive angle. This is caused by excessive bank during the roll in, allowing the nose to stabilize short rather than long of the target. . If you must be off dive angle, it is better to be slightly steep than shallow.
During the roll out, don't use the HUD reference for azimuth control since even the slightest bank will cause a pendulum effect and give erroneous information. The FPM is a better reference for attaining the correct ground track through the target. If the FPM is not available, visualize your drift across the ground in relation to the W-reticle, guncross (or whatever your aircraft has as at fixed nose reference) and adjust accordingly.

Final

As soon as you roll out on final, set your Flight path marker at the Aim Point (AP) and note the dive angle. This is the most important part of the final delivery pattern as this ensures that your HUD bombing reference will arrive on the target at release altitude.
Adjust throttle to set planned airspeed. One technique is to pull the power at the planned delivery airspeed minus twice the planned dive angle. (Example: for a planned release airspeed of 740 Km/h during a planned 30º dive angle, pull the throttle back at 680 km/h.)
Observe the rate of track and altimeter decrease. If an accurate AP has been set, the HUD reference

would arrive at the upwind aimpoint at the preplanned altitude, airspeed, and dive angle. Since all these parameters are seldom met perfectly, you will have to adjust pickle altitude and/or sight picture to compensate. One technique of adjusting release for incorrect dive angle is to relate the change to a release altitude adjustment. With the correct AP set, for every 1º steep, pickle 30 meters above your planned release altitude. This is a generalization that applies to all dive angles, with the intent of being easy to remember. Never release below your set minimum release altitude (MRA).



Error Analysis

Since it is difficult to attain all the required release parameters simultaneously, you must understand the effect on bomb impact caused by not attaining one or more of the release parameters (See Table below).

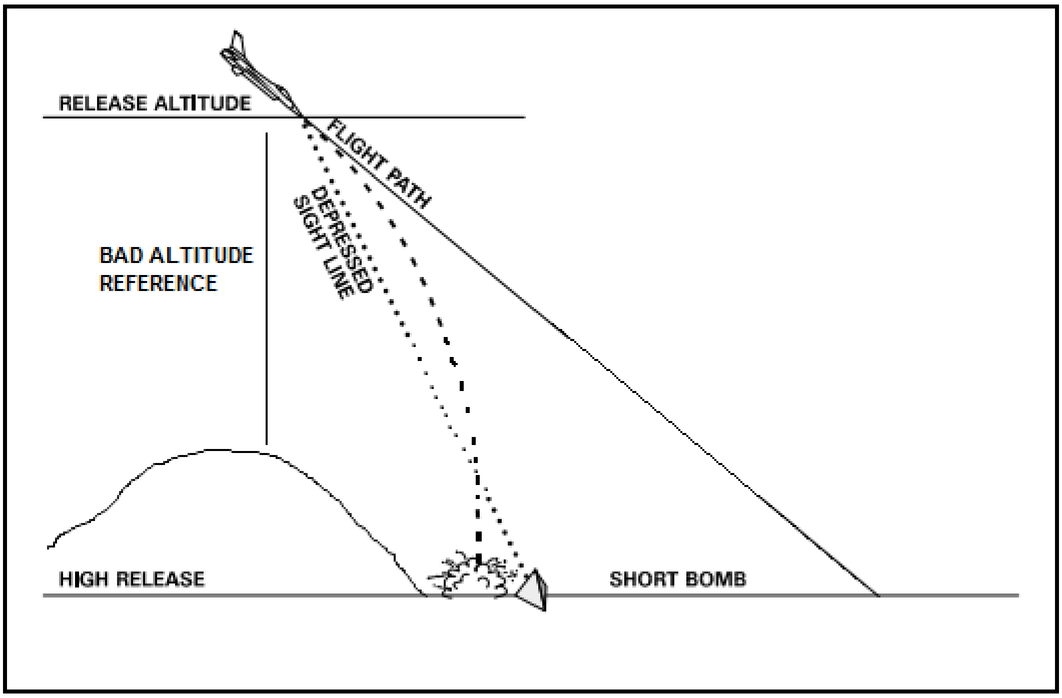
Different dive angles produce errors of varying magnitude. Dive bomb errors do not usually happen singly; i.e., a steep dive angle results in a lower release altitude and higher airspeed by the time you get the HUD reference on the target. The result is an unbelievably long hit. When discussing error analysis, we assume the HUD reference is on the target with all but one of the other delivery parameters met. The following errors affect accuracy: dive angle, release altitude, airspeed, bank angle, and skid.

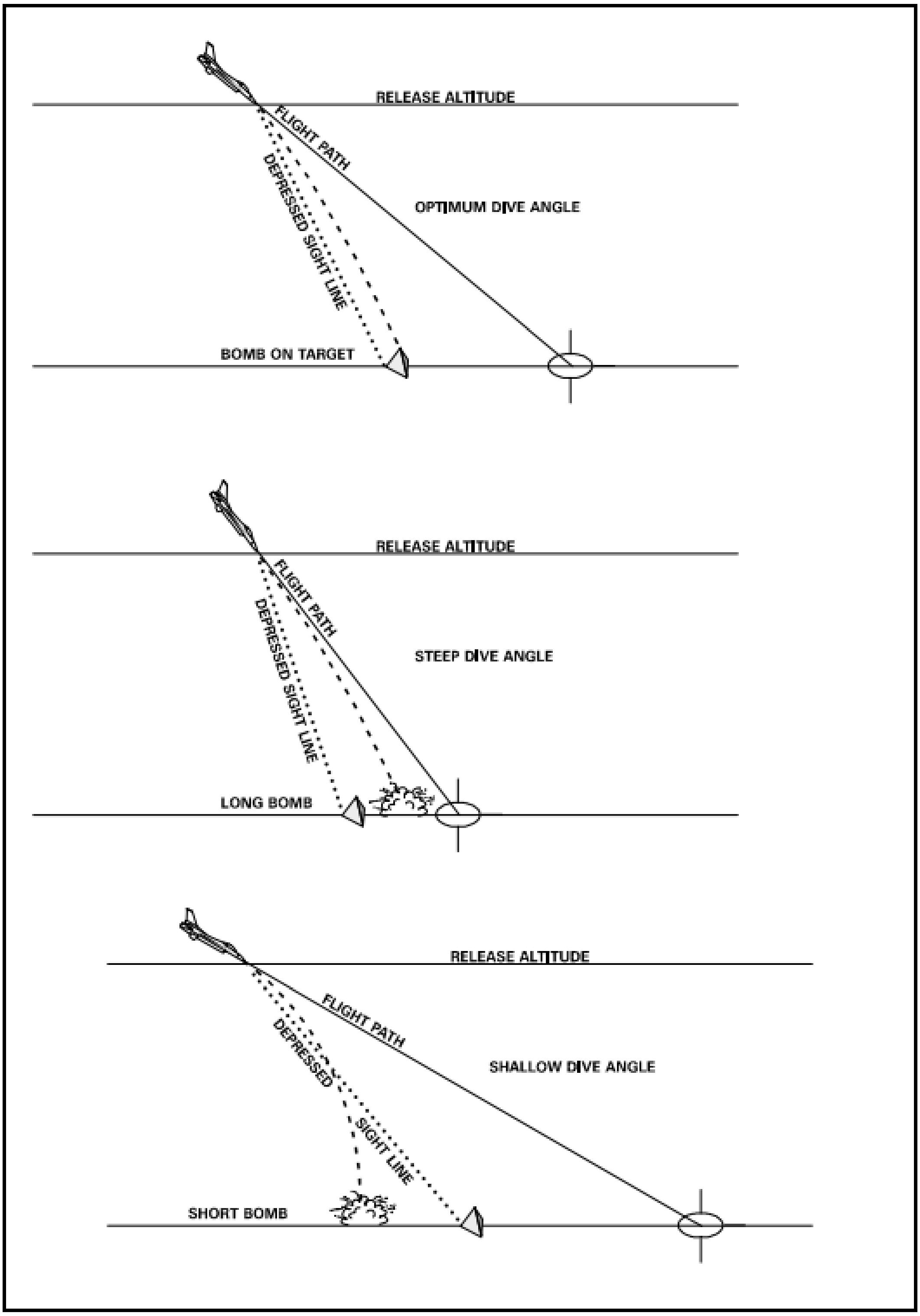
FUNCTION	AMOUNT	10°	20°	30°
AIRSPEED	+40 km/h	18m L	33m L	19m L
	-40 km/h	20m S	35m S	26m S
ALTITUDE	+30m	23m L	18m S	8m S
	-30m	16m S	14m L	5m L
	+60m	5m S	37m S	16m S
	-60m	28m L	29m L	11m L
	+150m	160m S	100m S	37m S
	-150m	N/A	63m L	30m L
DIVE ANGLE	+5°	19m L	47m L	32m L
	-5°	87m S	94m S	58m S
BANK	2°	11m LR 5m S	22m LR 9m S	13m LR 4m S
	5°	25m LR 13m S	54m LR 24m S	32m LR 10m S
	10°	48m LR 29m S	104m LR 52m S	64m LR 22m S
NOTE: L = Long Impact; S = Short Impact; LR = Lateral				

If correct aim-off distance is not established and release is made with the sight on target at the preplanned release altitude, impact errors caused by diveable deviations are the largest and therefore most critical. A steeper than planned dive angle places the aircraft further forward in space when the HUD reference arrives on the target. This is the release-point range error. In this situation, bomb trajectory is flattened.

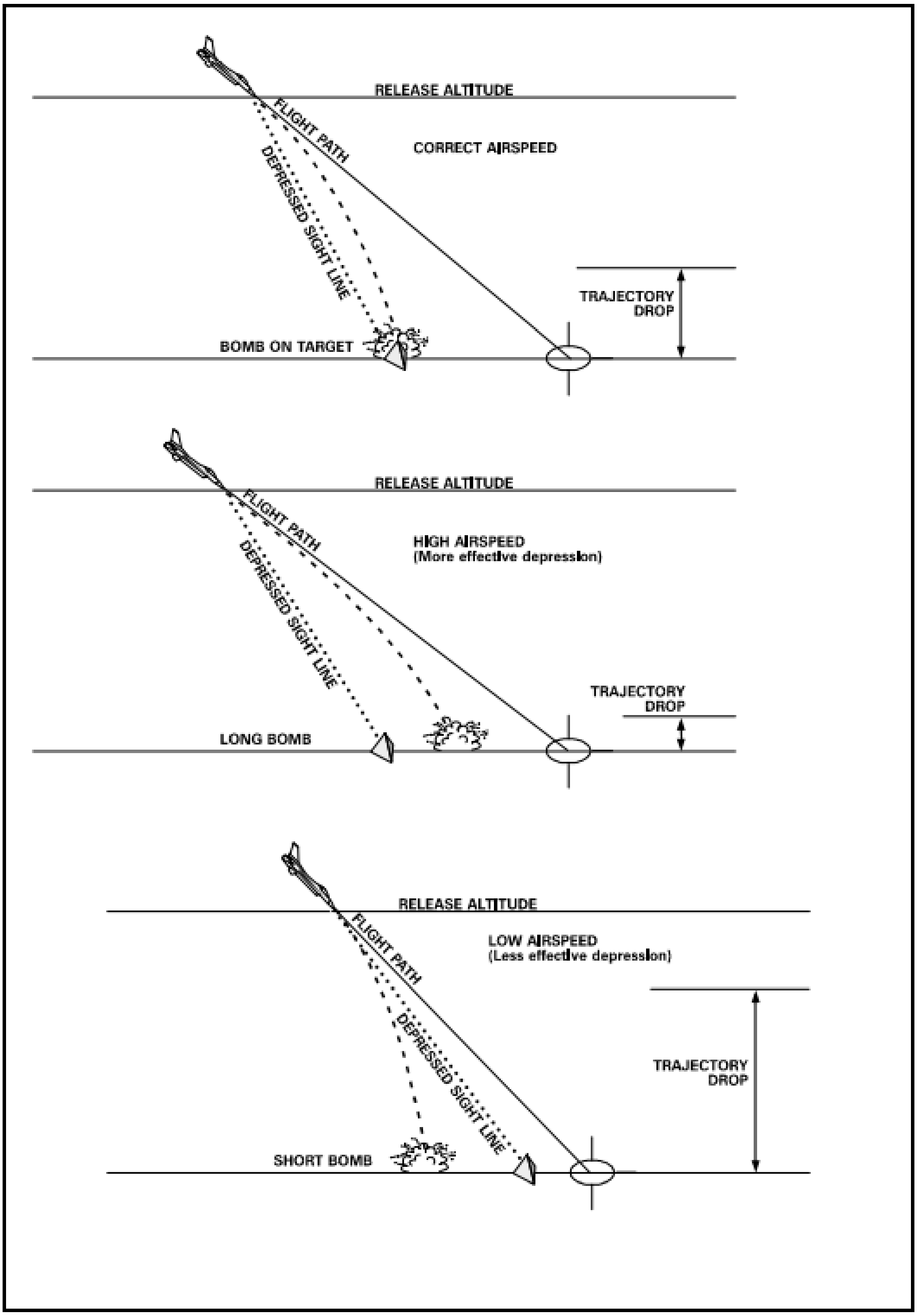
<u>Terrain error</u>

Especially in ArmA, terrain error comes into play. Since the altitude is measured from the aircraft directly down to the ground, there could be a significant difference in the required altitude at the release. In the example below you see the effect of a hill straight under the release point. So planning is esscential taking both Target elevation and and terrain elevation under the release point into account.

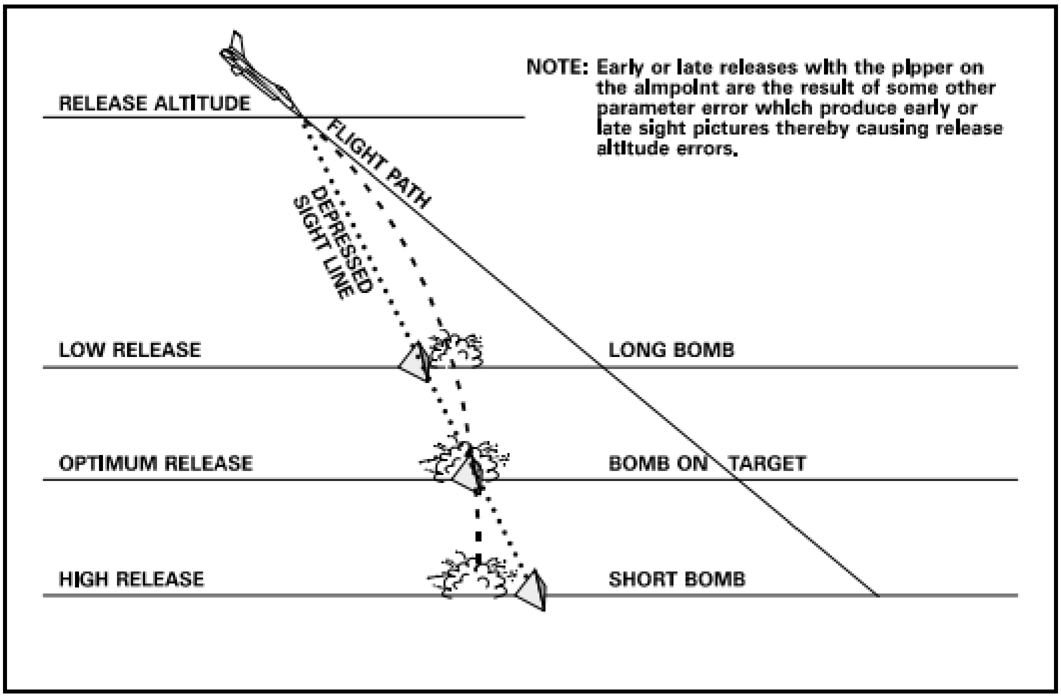




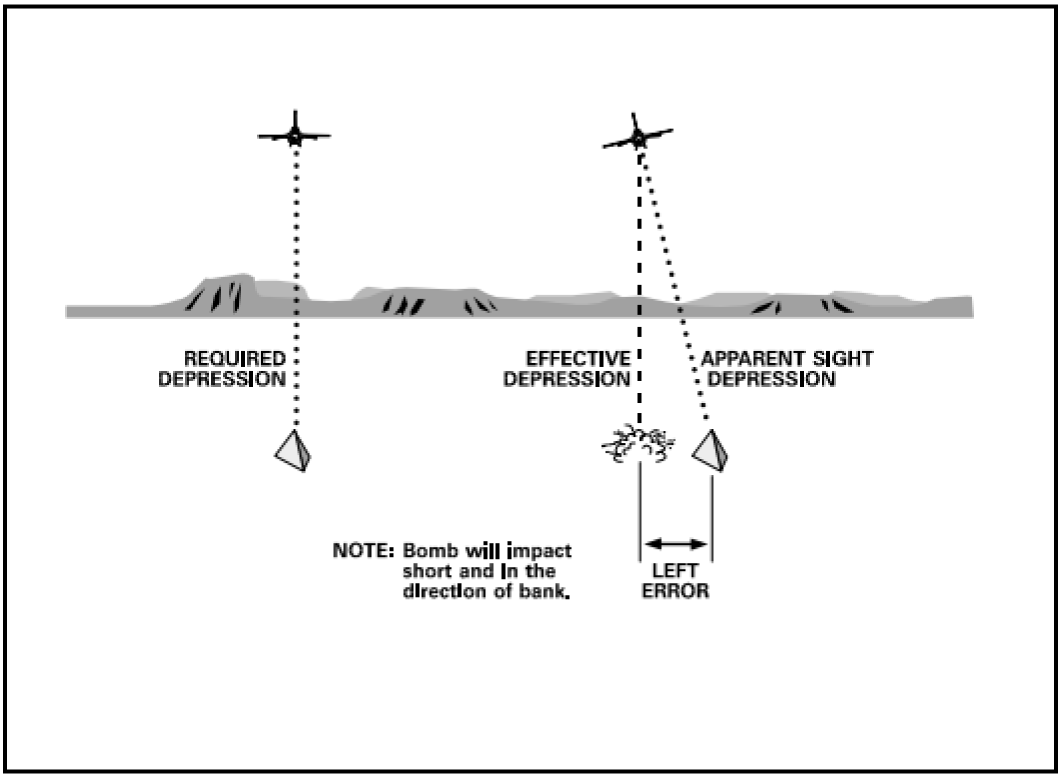
Effect of dive angle on bomb impact



Effect of Airspeed on bomb impact



Effect of Release Altitude on bomb impact



Effect of Bank angle on bomb impact

<u>Level deliveries</u>

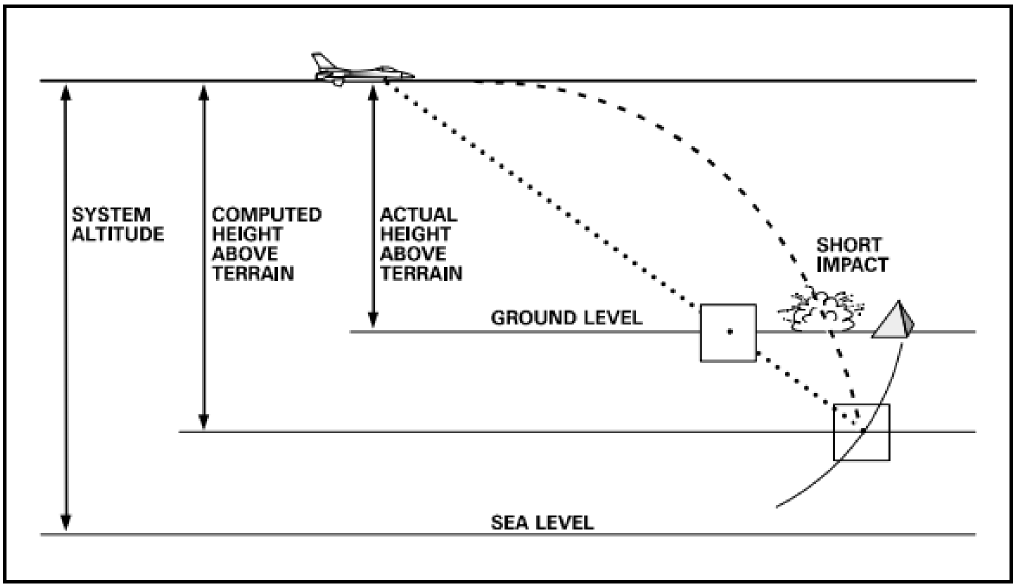
This type of delivery is flown when the weather or threat precludes steeper dive angles. Ingress the target area at low altitude, terrain masking and constantly jinking until just prior to weapon release. The pilot flies it's aircraft to a point in space where the bomb will fall gradually to it's point of impact. Since your approach to the target is a random flight path, good planning is required to arrive at an action point where target acquisition is initiated and weapons delivery commenced. If a level delivery is planned, simply arrive at the target on your proper altitude

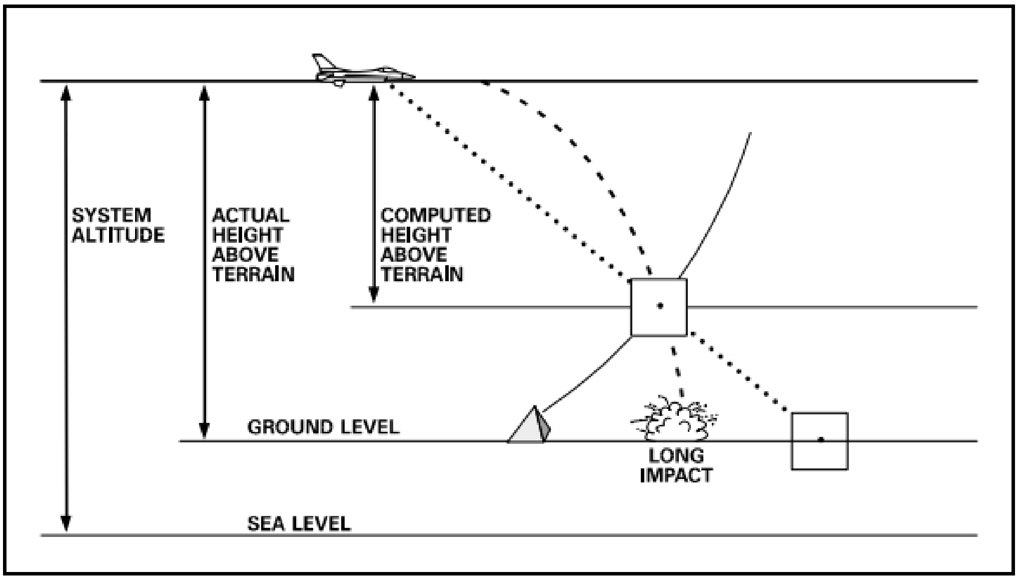
Pros:

- Comfortable flying at fixed power-settings
- Reduced pilot's overall workload
- Large stand-off from target

Cons:

- Low error margin
- Aircraft is an easy target





Strafe

Manual Low-Angle Strafe

Compared to bombing, strafe attacks are relatively simple. You need only point the aircraft at the target, correct for gravity drop and small amount of wind correction, and fire away.
Fly base and roll-in similar to low angle bomb pattern. Before you roll in, look at the target and pinpoint the general location of the open-fire range.
During roll-in, keep your eyes primarily on the target/aimpoint with an occasional cross-check of airspeed. As the target comes into the HUD FOV, play the roll out so that the guncross is initially short and slightly upwind of the target/ aimpoint. A crosswind component will require the gun to be pointed upwind 1m/km/h at 760m open-fire range, decreasing to 0.5m/km/h at 600m.
After roll out and initial guncross placement, check airspeed and adjust power. Recheck and readjust as required. Airspeed has little effect on bullet impact, but it does affect aircraft control. As you close toward the target, focus your eyes on the chosen aimpoint and monitor guncross movement with your peripheral vision. The guncross should be moving smoothly towards the aimpoint:

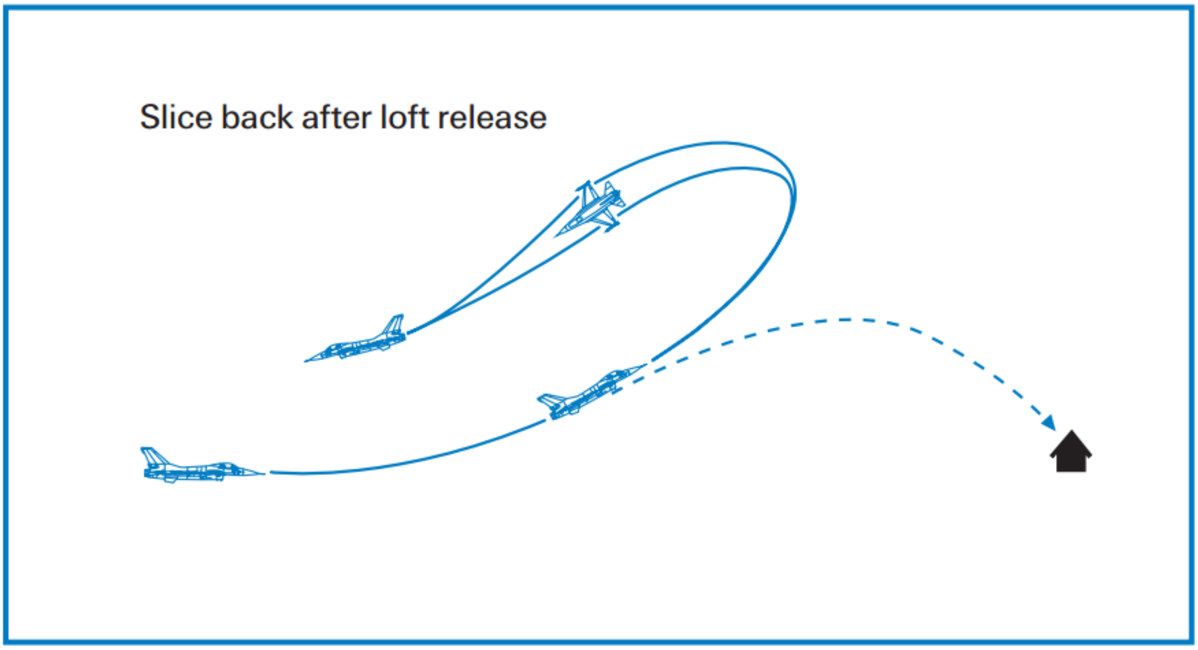
- Continuously estimate your closure rate toward the open-fire range.
- Use bank and rudder to place the target between the guncross and Flight Path Marker, with the Flight path marker being above the target and the guncross slightly below.
- Longitudinal (six/twelve o'clock) drift rates are critical and more difficult to correct.
- You want to open fire with the guncross on the aimpoint when you are approximately 750m from the target. Open fire range is more critical in manual strafe, as bullet drop increases dramatically as firing range increases. About 2 seconds of tracking is the maximum you'll be able to achieve. On the first strafe pass you may want to fire only a "sighter burst." The purpose is to verify guncross and validate your crosswind computation.
- When you confirmed you either were on target or confirmed you need some aim-off, note your findings for your next run.

Manual High-Angle Strafe

This delivery is difficult in that release parameters are near the outer limits of effective 20 mm gun range. In a 30º attack, a typical open fire slant range is 1800m which requires considerable gun elevation to counter the increase in gravity drop. Since the path of the bullets is no longer flat, open-fire slant range becomes more critical. As you reach 300m above open-fire altitude, move the guncross up to the aimpoint.
Track, fire, and track until the burst is completed. Execute the recovery immediately after the gun stops firing. Do not delay to watch bullet impact. Due to the increased range and corresponding increased time of flight of the bullets, if you see the impact, you may never see anything else, other than your own impact

Loft bombing

Loft bombing is a method of bombing where the attacking aircraft pulls upward when releasing its bomb load, giving the bomb additional time of flight by starting its ballistic path with an upward vector.
The purpose of toss bombing is to compensate for the gravity drop of the bomb in flight, and allow an aircraft to bomb a target without flying directly over it. This is in order to avoid overflying a heavily defended target, or in order to distance the attacking aircraft from the blast effects of a nuclear (or conventional) bomb.



Lofting is usually done using the assistance of computer. Even back in the 50´s the large B-47 bombers were utilising technology to make standoff attacks with free fall bombs. They were even known to do more daring manoeuvres like the 'over the shoulder bombing where they would release bombs half way through a manouver which looks like an immelman or half cuban-eight. Since accuracy is limited with this technique it would only make sense to do it with strikes using are effect weapons like cluster bombs and bombs with a big blast radius. Later lofting became more important with the precicion munitions like LGB's and JDAMs.
In ArmA we have none of such computers to help us. (Unless someone builds a script or Addon) However with some practice it should be possible to get on bomb within 50 meters of the desired target. Rippeling a serie of bombs could there for still give you the desired effect.

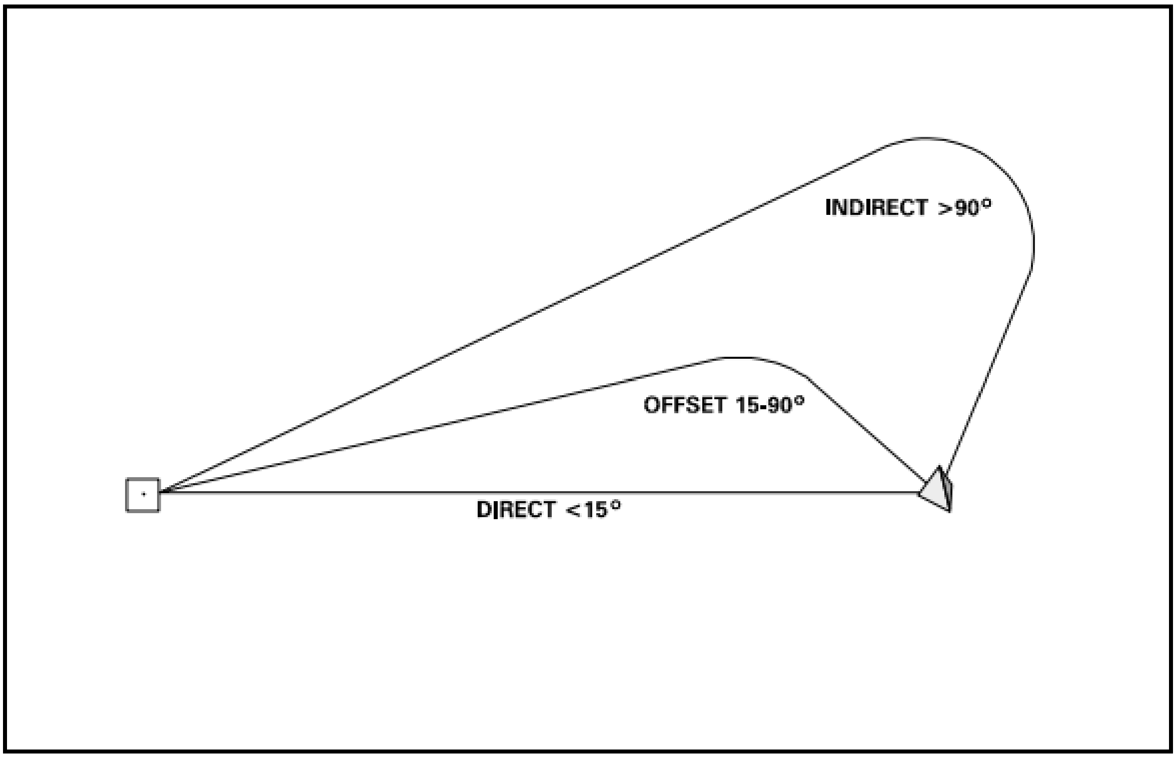
MORE DETAILS TO COME IN NEXT VERSION

Pop-Up deliveries

A highly sophisticated and integrated SAM/AAA/air-to-air threat environment or weather may force a low-level ingress and pop-up attack. While such tactics place us within the AAA and small arms environment, a properly planned and executed pop-up attack should give us our best possible odds against SAM or air-to-air threats and, in addition, can provide surprise and deception to enhance survivability against AAA. There are many variations of pop-up attacks. It is important that you understand the basics of the manoeuvre; namely how to plan and execute each type of attack. You will be establishing habit patterns and using rules of thumb which will ensure successful and safe attacks.

Definitions

- Approach Heading—The heading flown during wings-level pull-up and climb.
- Attack Heading—The heading flown during the wings level attack. Also called the attack axis.
- Angle-Off—The difference between approach and attack heading.
- Direct Pop-up—Angle-off less than 15º.
- Offset Pop-up—Angle-off greater than 15º.
- Indirect Pop-up—Angle-off greater than 90º.

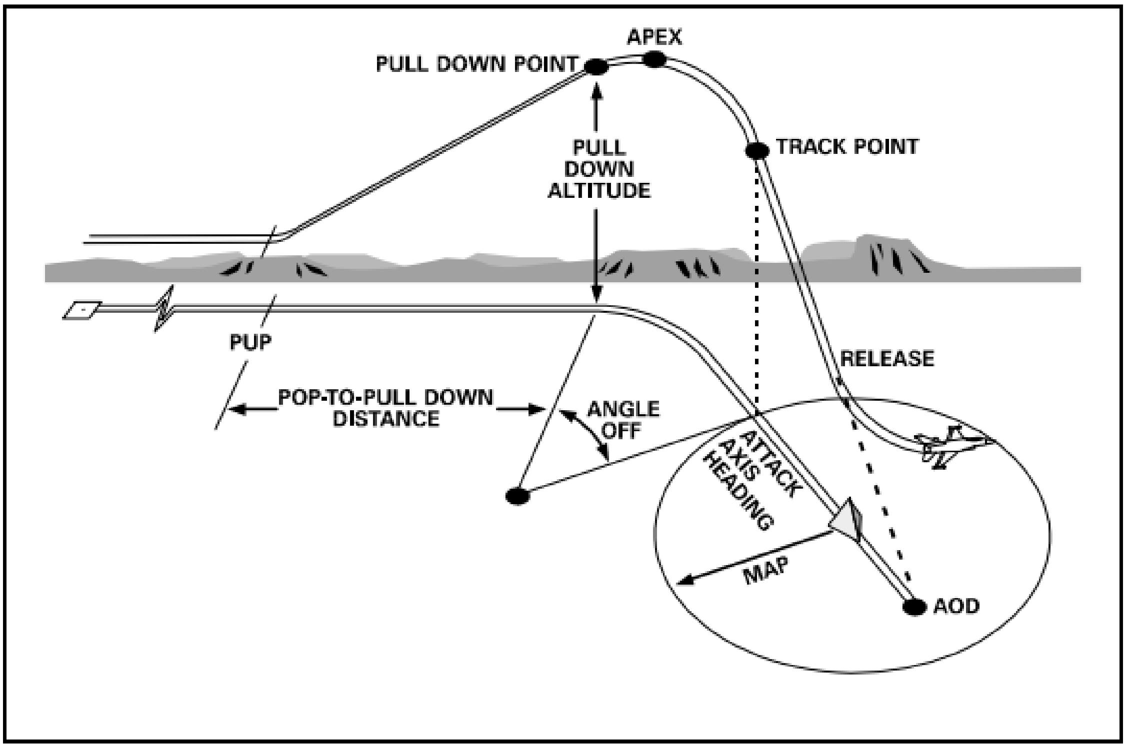


Offset pop-up definitions

- Initial Point (IP). The point where the last leg to the target begins. Normally, the IP is prominent, unique, and 18 to 36 Km out from the target. Action Point/Range.
- The point/range from the target where you take offset for an offset or indirect pop-up attack.

- Pop Point. A position at which the pop-up attack is initiated. The point where climb is initiated.
- Climb Angle. The angle of climb to be achieved following the initiation of the pop-up.
- Pop-to-Pull-Down Distance. Distance from the pop point to the pull-down point. This distance is predictable for a specific set of delivery parameters.
- Pull-Down Point (PDP). A manoeuvre point where you transition from the climbing to the diving portion of a pop-up delivery.
- Dive Angle. The selected angle of dive for weapons delivery.
- Apex. The highest altitude in the pop-up delivery profile.
- Minimum Attack Perimeter (MAP). An imaginary circle centered on the target equal to the distance from the target at which tracking begins. The radius of this circle varies with planned delivery parameters.
- MAP Distance. Distance from the MAP to the target. Composed of bomb range and horizontal distance covered while tracking.
- Tracking. That portion of the weapons delivery devoted to the final alignment of the aircraft sighting systems with the target.
- Tracking Time. Wings level time from roll out to weapons release.
- Horizontal Tracking Distance. The distance travelled across the ground during the tracking time.
- Vertical Tracking Distance. The vertical distance from the track altitude to the release altitude.
- Aim-off Distance (AOD). The ground distance at 12:00 from the target where you point your nose during tracking.
- Release Altitude. The altitude above the ground at which weapons delivery is accomplished.

<u>Typical Offset Pop-Up</u>
In this manoeuvre, the pop-up approach course is at an angle from 15º to 90º from the final attack heading. The approach course angle-off varies with the planned climb angle to permit the pilot to acquire the target as soon as possible and maintain visual contact until completion of weapons delivery. The pop-up is initiated over a preplanned pop point at a minimum airspeed of 450 KCAS, with training restrictions and ordnance loads usually being the limiting factors. The system can help you find the planned pop-up point. The air-to-surface target locator line helps to confirm desired angle-off. The pop point may be coincidental with this ground reference, or adjacent to it. At the pop point, select desired power (AB or military) make a 3–4 G wings-level pull to the desired climb angle and initiate chaff/flare program. The target should become visible in the front quarter of the canopy slightly off to the side of the planned roll-in direction. After popping you must maintain planned climb angle and monitor altitude gained. Approaching the preplanned pull-down altitude, make an unloaded roll in the direction of the target. Perform a 3–5 G pull-down to intercept the planned dive angle. Make corrections during the manoeuvre to compensate for minor errors in the pop point or unexpected winds in the climb to apex at the desired altitude. You normally achieve your planned apex altitude about half way through the pull-down manoeuvre.



<u>Pop-up Formulas</u>

The following formulas may be used (all altitudes are in feet AGL):

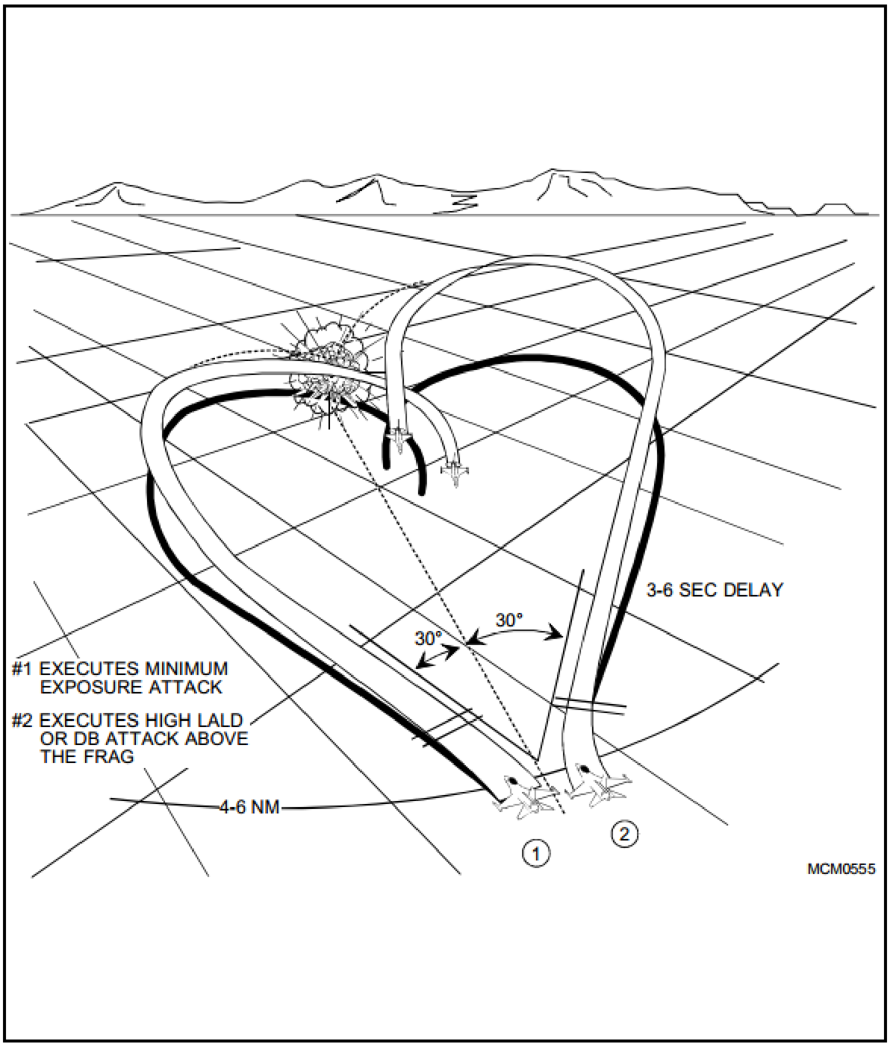
Horizontal tracking distance = GS x 1.69 x tracking time. Where, GS (zero wind) = TAS x cos (dive angle).
Vertical tracking distance = TAS x 1.69 x track time x sin (dive angle).
MAP distance = bomb range + horizontal tracking distance.
Track altitude = pickle altitude + vertical tracking distance.
AOD = (release Alt) / (tan (dive angle)) – bomb range.
Horizontal turn radius = V&2 / (GR x g) = (TAS x 1.69)2 / (GR x 32.2)
g = 32.2 and GR = cockpit G.
Climb angle = dive angle + 5º for dive angles < 15º
Climb angle = dive angle + 10º for dive angles > 15º.
Angle off = 2 x climb angle
Apex altitude For 3-3.5 G pull-down:
Apex Alt = track altitude + (dive angle x 50)
Apex altitude For 4.5-5 G pull down:
Apex Alt = track altitude + (dive angle x 37.5)
Pull-down altitude For 3–3.5 G pull-down.
Pull-down alt = apex alt – (climb angle x 50)
Pull-down altitude For 4.5–5 G pull down.
Pull-down alt = apex alt – (climb angle x 37.5)
Pop to pull down dist = Apex Alt ("AGL") x 60 / climb angle

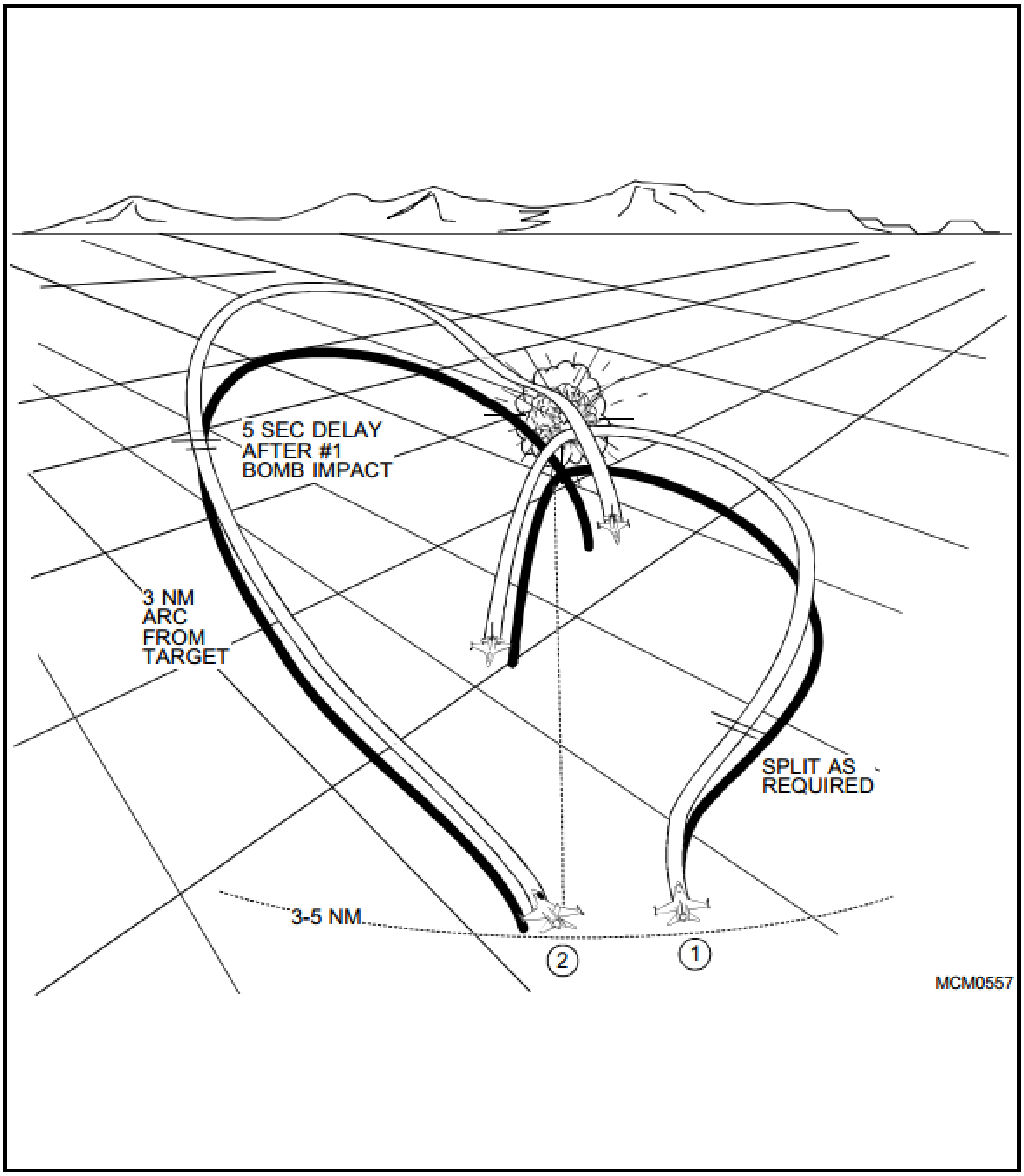
Two ship Employment considerations

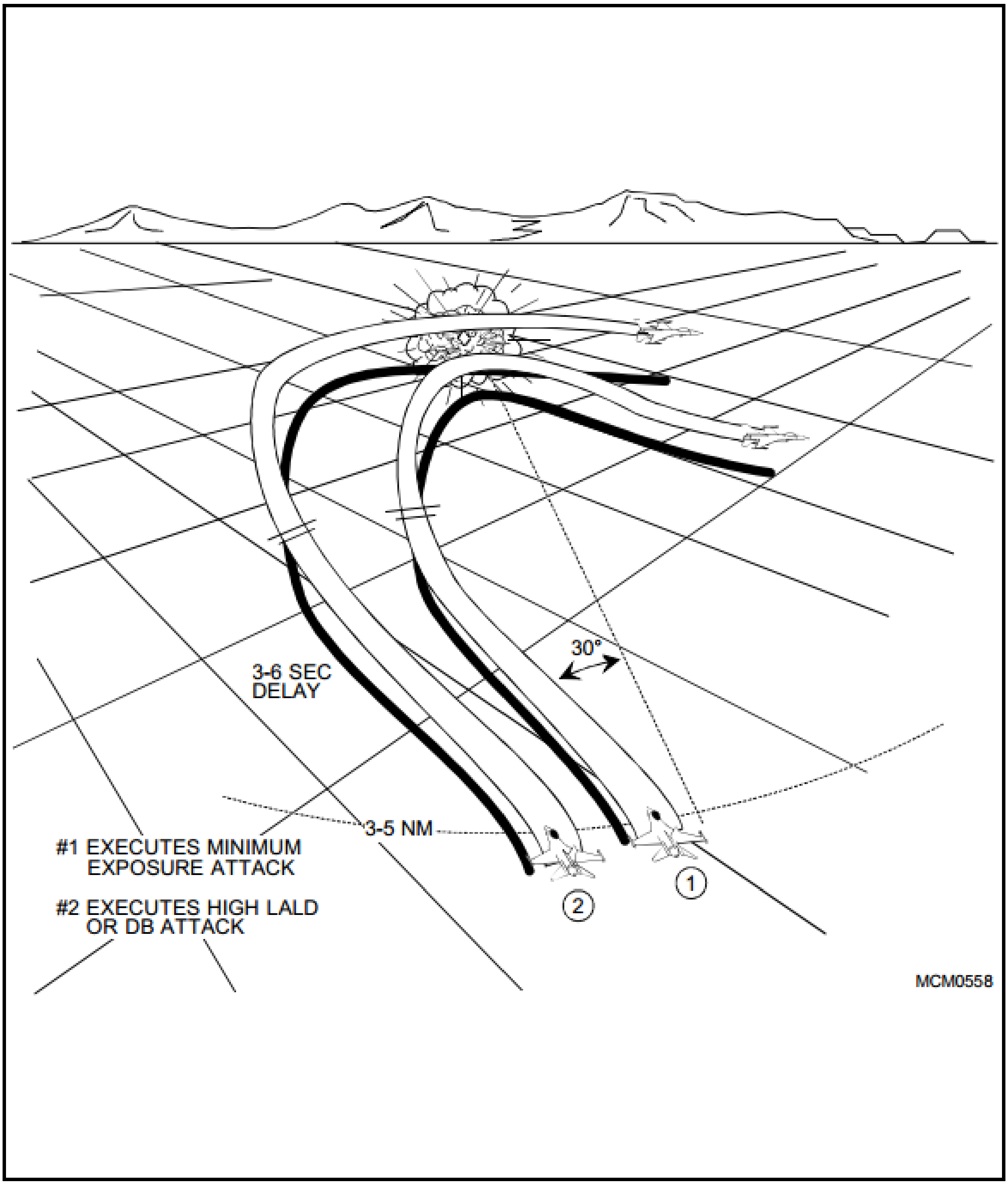
Deconfliction methods can include split, echelon, trail, shooter cover, and loft.

Split Pop Attack

This option is designed for minimum exposure while splitting the defences. Deconfliction can be achieved through altitude, distance, or timing. To achieve altitude separation, the first aircraft can use a level, low angle pop up, VLB delivery, offsetting as necessary for the planned delivery. The second aircraft splits at a predetermined point and pops to a high LALD or dive bomb delivery and pulls out above the frag envelope. To achieve distance deconfliction, the second aircraft can use LAT or a loft delivery pulling out with separation from the frag. For timing separation a split at sufficient distance to achieve the desired spacing is effective but reduces mutual support after the split. A split closer to the target requires arcing to remain within visual range and achieve timing separation. This allows the second aircraft to drop from a low altitude delivery. The distance of the arc from the target depends on the turning room necessary to achieve delivery parameters. As an example, the second aircraft arcs at 5 Km until the first aircraft's bombs explode, counts 5 seconds, turns to place the target at10 or 2 o'clock, then executes a LALD, or VLB delivery to give approximately 30 seconds spacing. Timing deconfliction forces an excessive amount of time in the target area. This technique should only be used for a single point target.

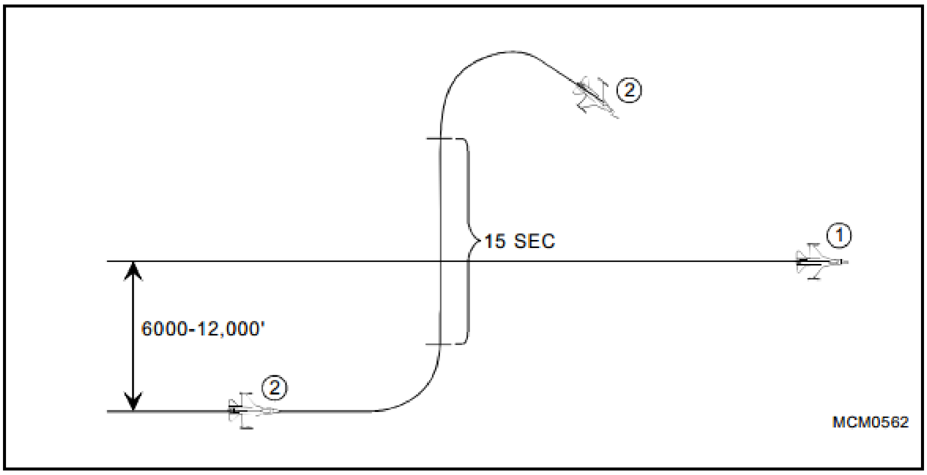


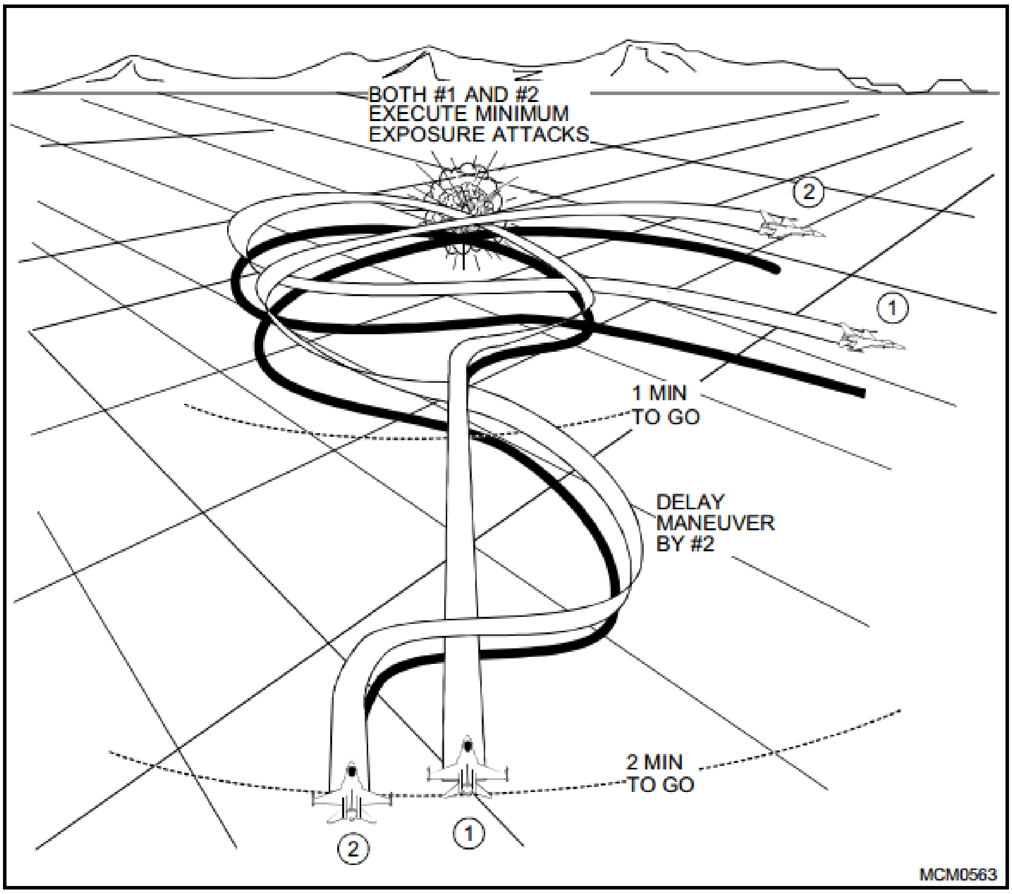

5 SEC DELAY
AFTER #1
BOMB IMPACT
3 NM
ARC
FROM
TARGET
SPLIT AS
REQUIRED
3-5 NM
2
1
MCM0557


30°
3-6 SEC
DELAY
3-5 NM
#1 EXECUTES MINIMUM
EXPOSURE ATTACK
#2 EXECUTES HIGH LALD
OR DB ATTACK
1
2
MCM0558

Trail Attacks

A trail attack provides timing deconfliction but gives up visual support for the second aircraft during ingress. Trail formation can be achieved by a spacing maneuver such as a 90/90 or by airspeed. Both aircraft use deliveries such as VLB or loft that minimize exposure to the terminal threats. The first aircraft breaks away from the target after release with the second aircraft watching for SAM launches. To provide visual support for the second aircraft, the first aircraft turns back across the ingressheading. This helps him reacquire the second aircraft while beaming the threats.





Shooter Cover

The shooter cover option can be flown by a two ship and allows one aircraft to attack the target using a preplanned profile. The second aircraft stays low and provides visual support by flying an arcing pattern outside the terminal threat. After the first aircraft has delivered ordnance, the second aircraft has the option of executing its own attack, or egressing with his element mate. This option is especially viable in a very high threat arena. The shooter's role is to find and destroy the target. If necessary, inform cover on target specifics and egress intentions. The shooter should adjust any follow-on attacks based on first-look observations. The cover role includes providing visual look-out for air and surface threats. The cover may engage or suppress pop-up threats according to prebriefed criteria. The cover should maintain overall battle situation awareness to include new threat locations (to avoid during egress and reattacks), egress direction, and target location.