10

Tactical Intercepts

Confront the enemy with the tip of your sword against his face.
Miyamoto Musashi

Since the introduction of radar to the air combat scenario in World War II, its advantages have been widely recognized and accepted. These advantages include long-range warning of the approach of hostile aircraft, improved efficiency in the interception of these aircraft, and the ability to provide friendly fighters with an initial advantage over the enemy. At night or in poor visibility, radar may provide the only practical means of employing fighter aircraft; but even in good visibility and in the daytime, radar's advantages can be critical to the success of any fighter mission. One prominent example is the use of radar by the British in the Battle of Britain. Early warning of German attacks allowed the British to use the more efficient GAI defense concept to make the most effective use of limited fighter resources, to intercept incoming raids at the greatest distance from their target, to avoid German fighter sweeps, and, usually, to gain first sight of the enemy.

The operational theory of radar and some of the techniques and limitations involved in the employment of radar were covered in detail in the first chapter of this book. Radars can be classified by their use for early warning, acquisition, or guidance. Early-warning radars are generally low-frequency, long-wavelength sets requiring large antennas. Their size usually precludes their installation in fighters, so they are primarily used for GCI/AIC control. They are characterized by relatively long range and poor resolution. A single-aircraft target on an early-warning radar may be displayed on the controller's scope as a "blip" of light representing several miles in width, and many closely spaced aircraft may appear as a single target. Control by use of such equipment is limited to bringing the fighters close enough to the target for them to take over, either with their own higher-resolution equipment or visually.

Fighter radars are generally of the acquisition type, which have higher frequency, smaller antennas, shorter range, and better resolution. They often have the capability to "track" a target in order to gain more detailed information on its relative position, speed, altitude, etc. Often such radars are also capable of guiding air-to-air weapons to the target; that is, they may also serve as guidance radars. Advances in radar and microprocessors make it feasible now even to identify a target directly through its radar signature. The return from so-called "millimeter-wave" radars, rather than displaying only a target blip, may actually depict a recognizable target shape. This capability is not generally available to current fighters, however, so other means of identification are employed. Visual identification is most common, but there are also several electronic identification systems. Each system has its limitations: VIDs are dependent on visibility and have relatively short ranges, while EIDs are sometimes unreliable and are subject to deception and jamming.

This chapter is designed to provide insight into some of the considerations involved with tactical radar intercepts by describing a few of the most common intercept tactics. The scope of this discussion is generally limited to daylight visual conditions. All possible intercept tactics obviously cannot be included here, but an attempt has been made to present a representative sample that can furnish options to cover most tactical situations.

> No one can tell another what to do in a future air-to-air fight. ... In this game, there is a great demand for the individual who can "play by ear."
>
> Major Frederick C. "Boots" Blesse, USAF

Intercept Terminology

Before proceeding with the discussion of specific intercept tactics, it is necessary to define some terminology. Figure 10-1, which shows a target and an interceptor on convergent courses, illustrates some frequently used terms. The solid line between the two aircraft represents the radar line of sight (LOS). The angle between the LOS and the target's course is known as the target-aspect angle (TAA), target aspect, or simply "aspect." This aspect may be computed automatically by a sophisticated tracking radar, or it may be calculated mentally by the interceptor pilot based on target bearing (the orientation of the LOS with respect to magnetic north) and GCI's estimate of the target's magnetic heading. Lateral separation is the perpendicular distance from the interceptor to the bogey's flight path. This quantity is usually estimated by the pilot and is a function of target range and aspect. Lateral separation is important if the interceptor plans to make a "conversion turn" to the target's rear hemisphere, since allowance must be made for the interceptor's turn radius. The amount of lateral separation, or "displacement," required is a function of the interceptor's intended turn radius and the amount of turn necessary to complete the intercept. This conversion turn is often described by the number of degrees the interceptor must turn to parallel the target's course and is called "degrees to go" (DTG). DTG is determined by calculating the difference between interceptor heading and the estimated bogey heading.

At given target and interceptor speeds, the interceptor can use heading changes to control displacement. Assume that if both aircraft continue on their present courses in this example they will eventually collide. In that

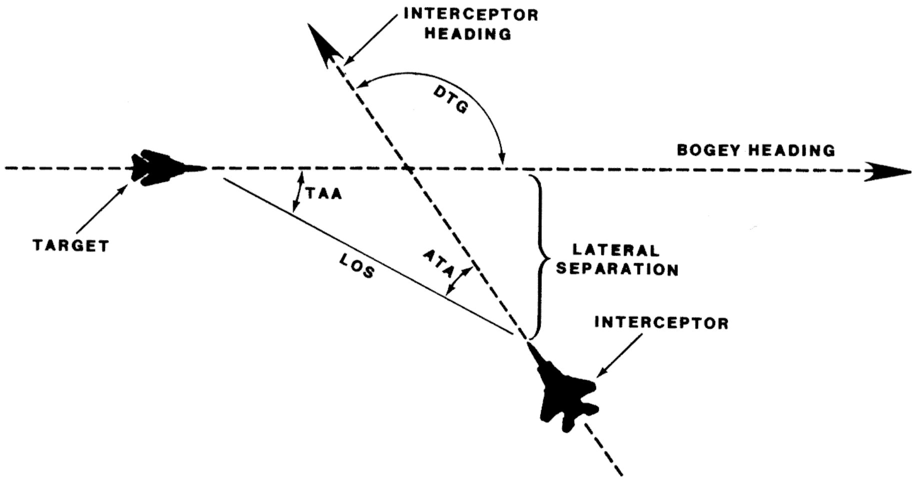

Figure 10-1. Intercept Terminology

case the interceptor is said to be on "collision heading." The angle between the interceptor's nose (heading) and the target LOS is known as the antenna-train angle (ATA), the target relative bearing, or the lead angle (lag angle if the interceptor is pointed behind the target). When the interceptor is on collision heading, the lead angle and target bearing remain constant and target range decreases. This constant target bearing is called "collision bearing," and the lead angle (or ATA) approximates target aspect when fighter and interceptor are roughly co-speed. As long as the interceptor maintains collision heading, target bearing, ATA, and target aspect will remain constant. If the interceptor turns a few degrees to the right in this case, and then flies straight, ATA will continue to increase and target aspect will decrease until the interceptor crosses in front of the target. Conversely, if the interceptor turns a few degrees to the left of collision heading (toward the target), and then flies straight, the target will appear to continue to "drift" toward the interceptor's nose (lead angle will decrease) until the target crosses in front of the interceptor. All the while target aspect will be increasing. A radical left turn by the interceptor placing it on a reciprocal course to that of the target, parallel to the target's course, maintains constant lateral separation, while both ATA and target aspect increase.

Forward Quarter

Description

As the name implies, the forward-quarter (FQ) intercept is one in which the interceptor approaches from the target's forward quarter. A special case of the FQ intercept is the head-on approach, where the interceptor reduces displacement to zero and the two aircraft converge "beak-to-beak." Figure 10-2 illustrates the more general case.

The goal of the FQ intercept is to approach the target from a specified angle off its nose (TAA) in the target's forward quarter. At time "1" in this example the interceptor makes radar contact (or receives a GCI call) which indicates a target slightly right of the nose at fairly long range. An estimate of the target's heading reveals that the two aircraft are on roughly reciprocal courses, and that the interceptor is displaced slightly right of the target's nose (right aspect). The interceptor pilot in this case would like to increase this aspect at intercept, so he turns left, taking a small cut away from the target's flight path. The pilot could have turned right instead, eventually crossing the target's nose and gaining aspect on the other side of the bogey's flight path, but since there was initially some right aspect it was faster to increase aspect in that direction.

Once on the new heading, the pilot of the interceptor monitors the decreasing range and the target's magnetic bearing as it continues to drift to the right. Target aspect is constantly computed to ensure that it is indeed increasing. When target aspect reaches the desired value, another interceptor course change will be required to stop and maintain this aspect. This is accomplished at time "2" by making a turn to collision heading. This heading can be estimated, in the case of co-speed target and interceptor, by turning until the lead angle approximates the desired target aspect (i.e., collision ATA equals desired TAA). Once the interceptor is steady on the new heading, ATA and target bearing should remain constant. If this is not the case small heading adjustments can be made to stop the target's drift. Adjustments can also be made from collision heading in case the desired target aspect has not been attained. Once they are established on a collision course, time "3," the aircraft should pass very close to each other in the horizontal plane.

Relative altitude is another consideration in this or any other intercept. The interceptor may receive an estimate of bogey altitude from GCI, or relative altitude may be computed automatically by the weapons system or mentally by the pilot based on radar antenna elevation and target range, in the same manner that lateral displacement is estimated. This calculation should be made as early as possible in the intercept so that the fighter will have sufficient time to climb or dive as necessary to achieve the

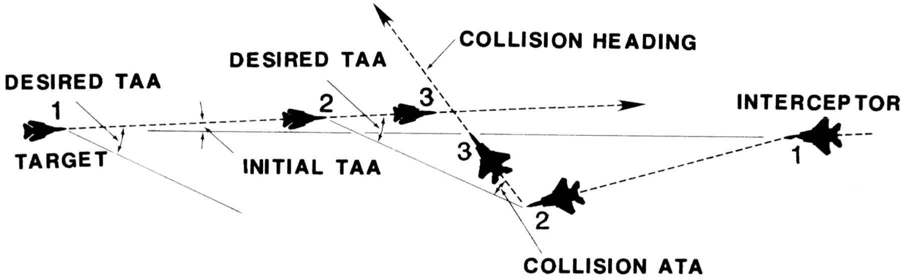

Figure 10-2. Forward-Quarter Intercept

desired altitude separation at intercept. Target altitude should also be monitored throughout the intercept to detect any changes.

Advantages and Disadvantages

The FQ intercept is useful for establishing an initial attack direction for the existing environmental conditions (coming out of the sun, etc.), or for some other purpose. Many all-aspect missiles (notably all-aspect heat seekers) have better capability from FQ firing positions than from directly head-on. Some target aspect during an intercept can also increase the range of a probable VID, since a profile view of the target is larger and usually more recognizable than a strictly head-on view.

Increasing or decreasing TAA does take time, however, allowing the bogey to gain further penetration toward its target. In addition, the method described does not ensure any particular target range once the desired aspect has been achieved; therefore the final approach course may be established well inside maximum weapons-firing range, and displacement might be insufficient for a stern-conversion option. This drawback can be alleviated by controlling displacement and aspect concurrently, a technique that is discussed in the next example. The FQ intercept is also relatively easy for the bogey to counter. In this example, for instance, the bogey could make a substantial turn (jink) away from the interceptor between times "1" and "2," generating so much displacement that the fighter pilot would be hard-pressed even to complete the intercept, much less to control the target aspect. The bogey could later turn back on course and possibly complete an "end run" around the interceptor, which may be thrown well back in trail of the target, out of range. Early detection of a target jink can be difficult for the interceptor between times "1" and "2," depending on the sophistication of its weapons system and GCI capability. Once the target is on collision bearing, jinks are more easily detected as a simple drift rate and a change in closure.

If the restriction of a specified target aspect is removed, the dangers of a target jink can be alleviated by turning the interceptor immediately to collision heading at time "1" and accepting whatever aspect is initially available. This method also minimizes bogey penetration and time to intercept.

Stern Conversion

Description

The stern-conversion intercept "converts" an initial FQ setup into a final rear-hemisphere position for the interceptor. Figure 10-3 depicts an example of a stern conversion.

The initial setup at time "1" is the same as in the previous example. This time, how ever, the interceptor intends a stern conversion. To accomplish this conversion requires a certain amount of displacement from the bogey's flight path, an amount dependent on how hard the interceptor pilot wants to turn during the final conversion and his true airspeed (i.e., the interceptor's turn radius). The conversion is often planned so that the interceptor's nose is pointed directly at the target through most of the turn to minimize the area of the fighter that is visible to the bogey pilot. The interceptor pilot needs a rough idea of the amount of displacement that is required. Having gained this displacement, the interceptor pilot must know at what target range, or conversion range, the intended conversion turn will bring the interceptor behind the bogey at the desired trail position. Taken together, the desired displacement and the conversion range define the "conversion point," which is the interceptor pilot's initial goal.

Assume for this example that the conversion range is 8 nautical miles (8 NM) with 20,000 ft displacement. At time "1" the target is 30 NM away and the interceptor's radar weapons system computes about 2° of target aspect. With a little mental gymnastics the interceptor pilot can estimate his displacement using the formula:

$$100 \times \text{TAA (degrees)} \times \text{Range (NM)} = \text{Displacement (ft)}.$$

In this case, $100 \times 2° \times 30$ NM = 6,000 ft, so more displacement is required. (Some weapons systems also compute this displacement for the pilot.) The interceptor pilot, therefore, takes a cut away from the bogey's flight path, being careful not to turn so far that his radar antenna gimbal limits are exceeded. The actual magnitude of this displacement turn should be great enough to generate the required displacement prior to the conversion range.

Between times "1" and "2" the interceptor pilot continuously monitors range, TAA, and displacement. At 20 NM range, aspect is determined to be about 10°, yielding the desired 20,000 ft displacement. Now the interceptor must maintain that displacement until conversion range (8 NM). To achieve this the interceptor turns to parallel the bogey's course at time "2," and simply drives in to 8 NM range, time "3." At this point the conversion turn is commenced and results in the interceptor rolling out at the desired distance behind the target. This distance is generally planned to be in the heart of the interceptor's RQ weapons-firing envelope. When this weapons range is short, such as for guns, much care must be exercised in the final stages of the conversion turn to avoid overshooting the bogey's flight path at close range.

The conversion range for this intercept is predicated primarily on the time required for the interceptor to complete its conversion turn. This time determines the interceptor's final roll-out distance behind the target.

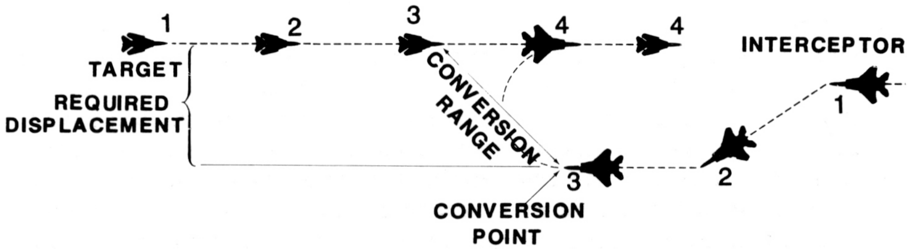

Figure 10-3. Stem-Conversion Intercept

If the turn is completed too quickly, the fighter may arrive in front of the target. Too slow a turn can result in excessive distance behind the bogey at roll-out. Since the rate of turn is linked to the turn radius at a given speed, adjusting turn rate during the conversion will also affect turn radius, on which the required displacement was based. Conversion range with the proper displacement usually assumes the interceptor arrives at the conversion point on a reciprocal heading relative to the bogey (i.e., 180 DTG), as in Figure 10-3. If this is not the case, an adjustment must be made if the conversion geometry is to work out properly. For example, if the conversion point is approached with the interceptor headed somewhat away from the bogey's flight path (DTG greater than 180), the normal conversion turn should be started a little early (i.e., range slightly greater than 8 NM) so that the reciprocal heading is reached at the conversion point. Conversely, if the conversion point is reached with the fighter heading somewhat toward the target's flight path (DTG less than 180), the conversion turn can be delayed slightly to avoid terminating too close to the bogey. In this case, since displacement will be decreasing during the delay, a somewhat harder turn may also have to be made to avoid overshooting the target's flight path.

Adjustments are also available for other than optimum displacement. With too much displacement the fighter pilot should begin his turn a little early (i.e., at greater than standard conversion range) and make an easier turn than usual. If too little displacement is available, the turn should be delayed somewhat and then made tighter than normal. Altitude differential with the target can greatly alter the required lateral displacement. Stern conversions can be made even with zero lateral displacement from below (Immelmann) or above (split-S) if vertical displacement is adequate.

If the interceptor is equipped with long-range FQ weapons and sufficient displacement can be generated, the FQ intercept and the stern conversion can be combined into what is called an attack-reattack. The interceptor pilot attains the necessary displacement, then turns in and fires the weapon at the proper FQ range. He then makes a turn back toward the reciprocal of the target's course until he closes to conversion range, at which time he completes a stern conversion and makes a rear attack.

Advantages and Disadvantages

Probably the primary advantage of the stern-conversion intercept is that it is completed behind the bogey in a tactically advantageous position. The rear-hemisphere position is also optimal for employment of many air-to-air weapons.

This technique does, however, take considerably more fuel and time than the "collision-all-the-way" or the FQ methods, and it allows the bogey to penetrate closer to its target. The stern conversion is also easy for the bogey to counter by jinking. A small bogey turn toward the interceptor early in this intercept will remove the displacement, forcing the fighter pilot to settle for a FQ intercept. Likewise, a jink away from the interceptor can allow the bogey to evade interception altogether and end-run around the fighter. Such jinks may be difficult to detect, since the target bearing and closing speed are changing continuously during this procedure. Another danger is presented by the conversion turn itself, which is a long, blind turn in close proximity to the target. The pilot is exposing the interceptor's belly to the whole world and daring someone to shoot. If there are other undetected bogeys in the area, the fighter pilot may never complete this intercept. It is usually good practice in any event to pause for a belly-check about halfway through the conversion turn. Generally stern conversions are not recommended in an unknown environment.

Although fighter speed is not critical to the conduct of a FQ intercept, an interceptor speed advantage over the target is highly desirable for the stern conversion. In general, the greater the interceptor's speed advantage, the more room there is for error in the conversion process. At co-speed, or with an interceptor speed disadvantage, timing and geometry must be nearly perfect or the fighter pilot is likely to complete the conversion too far behind the target for a successful attack.

Another drawback of the stern-conversion technique is the interceptor's vulnerability to chaff while it is in the target's beam region. It is difficult for most radars to discriminate between chaff and the real target when they are viewed from the target's flank, since closing velocity is so nearly identical. This situation often results in the interceptor pilot losing contact with the target at a critical time or completing an intercept on the chaff. Doppler-type radars are also susceptible to losing track of targets with beam aspects.

The FQ and stern-conversion intercepts comprise the basics of almost all tactical intercepts. The tactics presented in the remainder of this chapter apply these fundamentals to multiple-fighter scenarios. Although the examples depicted here usually show two fighters opposing two bogeys, each aircraft of either formation can be considered to be an element of any desired number, and the tactics can be applied to an encounter of essentially any size.

> Today it is even more important to dominate the . . . highly sophisticated weapon systems, perhaps even more important than being a good pilot; to make the best use of this system.
>
> Lt. General Adolph Galland, Luftwaffe

Single-Side Offset

Description

The single-side offset places all interceptors on one side of the target formation, and the fighter leader performs either a FQ intercept or a stem conversion, as shown in Figure 10-4.

In this example the fighter section detects the bogey formation roughly head-on, and the leader offsets to the north beginning at time "I," possibly to take advantage of prevailing environmental conditions. Ideally the first pilot with radar contact becomes the tactical leader throughout the intercept. The wingman, initially located on the south side, dives below the leader to increase speed, and then crosses the leader's flight path to emerge

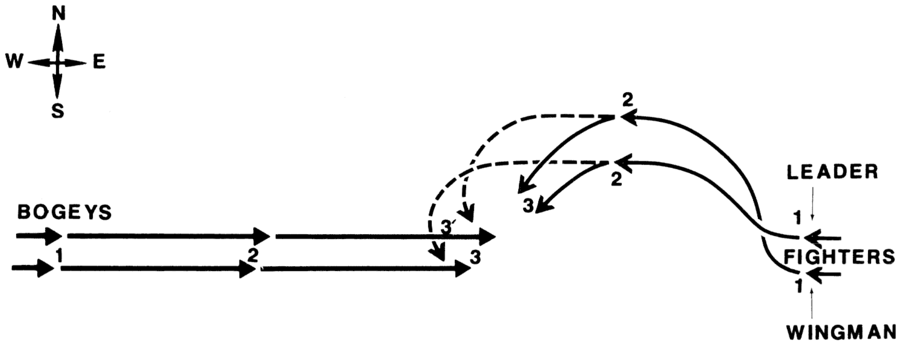

Figure 10-4. Single-Side Offset

on the other side in a good defensive-spread position. This maneuver enables the wingman to "look through" the leader's aircraft toward the bogeys, increasing the wingman's confidence that the threat sector is to the left of his nose. This limits the wingman's primary visual and radar-search sector and improves his safety later in the intercept.

At time "1" the fighter leader determines that he has sufficient displacement for his desired attack, and he continues with either a FQ intercept (point "3") or a stern conversion (point "3'"). The preferable tactic depends on the availability of reliable forward-hemisphere weapons, the amount of offset which can be generated, the time available for the intercept, the degree of certainty as to the enemy numbers and formation, etc. Most of the advantages and disadvantages of these two options have been discussed, but there are a few more. The FQ option is more appropriate for hit-and-run attacks against fighters, particularly in an unknown, hostile environment. It may also be useful against bombers that are heavily defended in the rear. The stern conversion facilitates repeated attacks on numerous targets and places the fighters in a more advantageous position to begin an engagement with enemy fighters. The stern conversion can be fatal, however, if there is an undetected trailing enemy element.

If the stern conversion is selected, or if a significant turn is required for a FQ attack, the wingman normally crosses beneath the lead once more between times "2" and "3." This allows the wingman to keep the leader and the threat sector on the same side of his nose and positions the wingman abeam the leader in a more defensible combat spread. The wingman should be very alert during this turn for bogeys appearing from the section's belly-side.

Advantages and Disadvantages

When the bogeys are deployed in a significant trail formation, there is often some difference of opinion as to which element should be attacked first. The initial choice is usually the trail element, of course, since it is more vulnerable. This may not be the best choice, however, particularly when the interceptors have forward-hemisphere weapons capability. Attacking the lead bogey element first, with a FQ intercept or head-on, may allow sequential attacks on trailing elements. Especially if the bogeys are bombers, it may not be wise to allow the lead element through unscathed.

When the interceptors are equipped only with rear-hemisphere weapons against trailing fighters and the trail element can be identified with some certainty, a stern conversion might be employed against this element. One situation which may develop, particularly against radar-equipped bogeys or those under close GCI control, is illustrated by Figure 10-5.

At time "1" in this example the fighter pilots have their desired offset from the bogeys' flight path and plan a stern conversion on the trail bogey. At time "2" the fighters have reached conversion range against the trailer, and the pilots are beginning their turns. Unfortunately, contact with the lead bogey has been lost because of the fighters' radar antenna gimbal limitations. Being closer, this lead bogey has already begun its own stern conversion against the fighters. At time "3," just when the fighter pilots are feeling confident of a kill, the lead bogey is slipping into firing position and the fighters are sandwiched. This situation can be particularly dangerous against a more maneuverable bogey, which can profit more from the available displacement than can the fighters.

Because of this danger, a single-side offset to a stern conversion is not recommended against fighters in trail. The alternatives are sequential FQ attacks with all-aspect missiles, guns, or rockets on each bogey in turn, or use of a more suitable intercept tactic (one of the tactics that follow).

Even with these limitations the single-side offset offers some advantages. Positively placing the bogeys on one side of the formation isolates the threat sector and reduces the chances of being bracketed by the enemy, as well as allowing the fighter pilots to choose the direction of their approach for environmental reasons. This tactic also provides reasonably good mutual support, since the fighters can remain fairly close together and are not required to venture far from a good defensive-spread formation. In general, however, the single-side offset is a rather defensive tactic, since it offers the fighters few significant advantages that are not also given to the enemy.

Trail

Description

A trail intercept is any intercept in which the fighters are arranged in a trail formation at the merge. Figure 10-6 depicts an example in which the two sections are approaching with some offset at time "1." The fighter leader turns immediately to collision heading for a FQ intercept. Meanwhile, the wingman repositions behind the leader in trail. The trailing distance is normally as great as visual conditions allow; the wingman must keep sight of his lead, and he cannot be so far behind that he cannot offer some support to the leader in case a bogey attacks the lead fighter from behind (i.e., trailer nose-tail distance should not greatly exceed weapons max-range). If the trailer intends to fire a head-on missile on the leader's VID, separation between leader and trailer should exceed missile min-range parameters.

In this case the leader's intent is to make a VID on the bogey aircraft before firing. Sometimes target aspect, bogey size, and visibility do not allow a positive VID to be made within the firing envelope of a fighter's all-aspect weapons. The trail formation is useful in this situation, since the leader can make and relay the VID to the trailing wingman, who then can

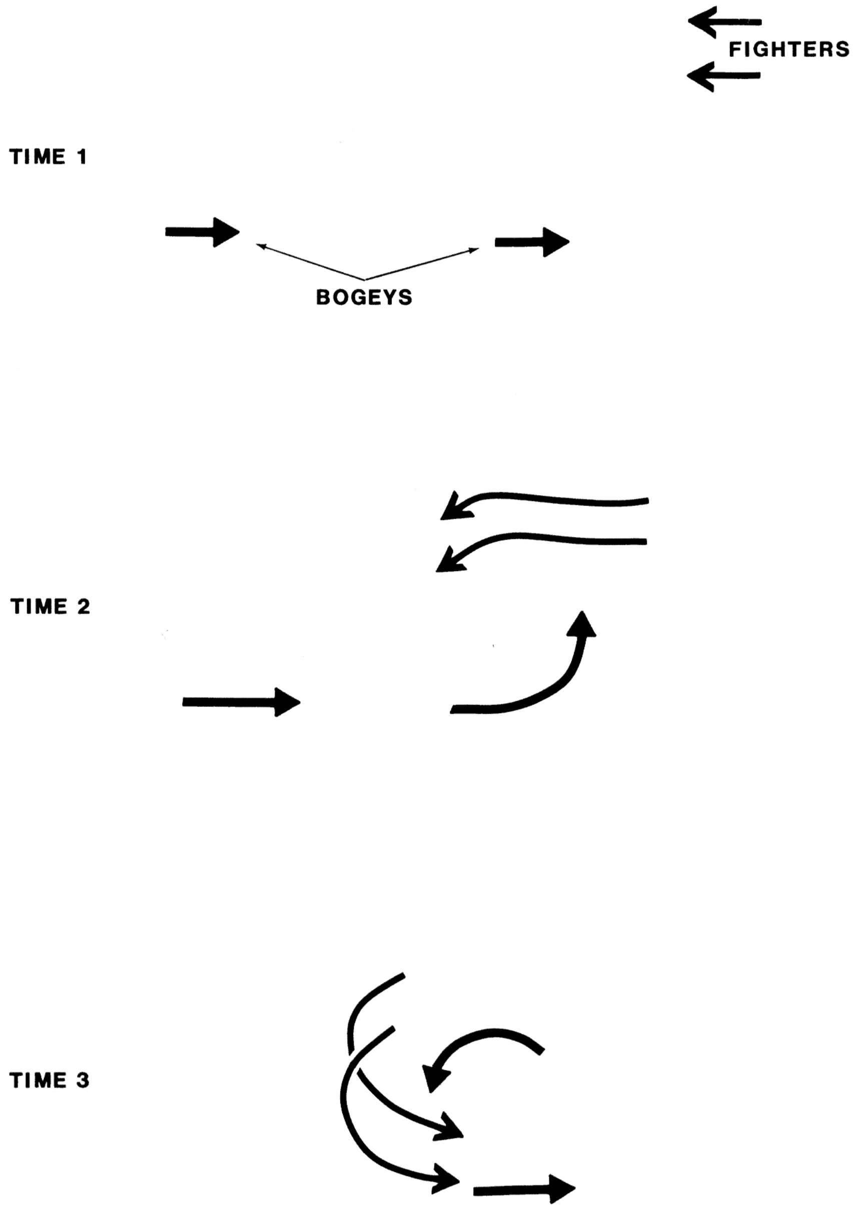

Figure 10-5. Stern-Conversion Hazard against Trail Fighters

shoot before penetrating his min-range limit. The shooter must be certain that his weapon is indeed locked on and guiding on a target, and not on his leader!

Once he gains sight of the bogeys, the leader should usually attempt to make a visual attack, forcing them into a defensive maneuver. The enemy may not have sight of the trailer, and such maneuvering will often present the trailing wingman with easy shot opportunities. Another, generally less desirable, option is to bait the bogeys by allowing considerable lateral separation at the pass. The enemy may be tempted into turning for an attack on the leader, again turning in front of the trailer. The trailing wingman should maintain considerable vertical separation with the leader to reduce the chances of being detected. A low trailer is often the most difficult to detect because of radar clutter and visual masking against the ground. The resulting look-up angle should also optimize all-aspect weapons performance.

Advantages and Disadvantages

The trail intercept, or actually an intercept in the trail formation, can be very effective offensively. The VID/forward-hemisphere advantage has already been mentioned. In addition, a bogey engaging the lead fighter is a grape for the trailing wingman, while a bogey not turning on the leader is likely to be attacked by him. In short, the bogey is caught between a rock and a hard place.

Although the trail arrangement is good offensively, it is rather poor on the defensive side, particularly for the trailer. His position and distance from the leader make it impossible for the leader to cover the trailer visually, and it would be very difficult for him even to lend support if the trailer was attacked. For these reasons trail tactics are extremely hazardous in an uncontrolled, hostile environment, and very high speeds should be maintained to help guard the trailer's rear hemisphere. This danger can be reduced significantly with the addition of more fighters, however. For example, placing two sections, each in combat spread, one behind the other, offers the advantages of the trail formation while retaining mutual support within each section. This is commonly called a "box" formation. A single with a trailing pair (vie) is another option.

Should the trail formation be employed in an uncontrolled environ-

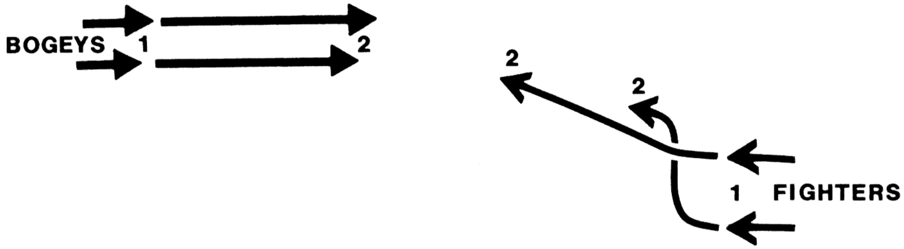

Figure 10-6. Trail Intercept

ment, and the fighters be lucky enough to complete the intercept, it is imperative that they reform as quickly as possible in a more defensive arrangement. A turn of about 90° in either direction by the leader after the pass, and then a reversal, should allow the trailer to close to a good spread position.

The trail formation can be a good defensive tactic against bogeys known also to be arranged in trail. This can allow the leader to perform a single-side offset for attack on the trail bogey with less fear of being attacked by the lead bogey (as he was in Figure 10-5). This is still a relatively defensive tactic, however.

Sweep

Description

The sweep intercept is essentially a stern conversion in a trail formation, as illustrated by Figure 10-7. At time "1" the fighters, in spread formation, are approaching the conversion point for a stern conversion against the bogey section. As the leader begins his conversion turn, the wingman, on the outside of the formation, delays his turn to gain nose-tail separation (time "2"). At time "3" the leader is approaching stern firing parameters with his wingman covering from behind.

Advantages and Disadvantages

This tactic can result in an effective offensive start for the fighters if they can remain undetected until about time "3." They are well set up for sequential attacks and have a good chance of hiding the trailer, especially if he has a good altitude split. The hidden trailer gives the fighters better offensive potential should the bogeys discover the attack and turn to negate it. Defensively, the sweep allows good mutual support until commencing the conversion turn. Against bogey trail formations, the fighter wingman can also provide some protection against the lead bogey as the lead fighter attacks the bogey wingman.

It is quite obvious, however, that the poor wingman is really hanging it out during the conversion turn. Assigning two fighters to the trailing

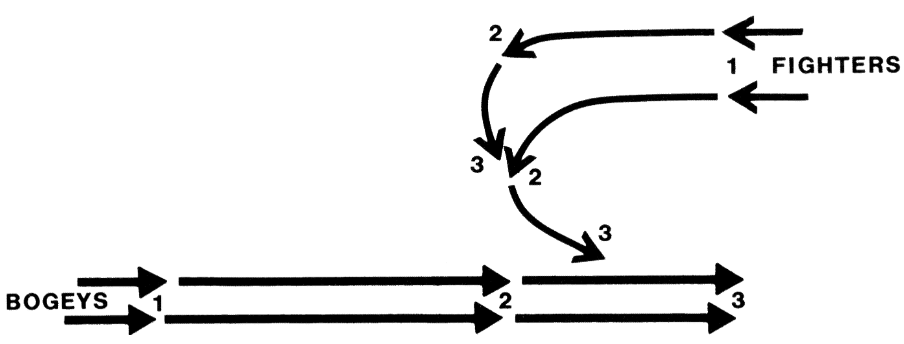

Figure 10-7. The Sweep

element, as explained earlier, offers added safety in an uncontrolled environment. With just two fighters, only a leader with designs on his wingman's wife or his stereo would call for this tactic under most combat conditions.

> During the course of this increasingly difficult fight it was proved that the leader of the fighter squadron only received full recognition if he asked nothing from his men that he was not prepared to do himself.
>
> Lt. General Adolph Galland, Luftwaffe

Pincer

Description

The pincer is a two-pronged, bracketing attack, also sometimes called a "heart-attack," which is analogous to the visual bracket attack. Figure 10-8 illustrates the pincer.

At time "1" the fighters, initially positioned with near-zero aspect, begin displacement turns in opposite directions for independent stern conversions or FQ attacks. Approaching time "2" the enemy fighters detect the attack and turn toward the northern fighter. As soon as such a bogey turn is noticed, the southern fighter must immediately turn to collision course to avoid being left out of the action. The northern fighter pilot continues his attempt to get outside the enemy section without giving away an angular advantage. At time "3" the northern fighter passes the bogeys nearly head-on, while the southern fighter has gained an offensive advantage.

Had the bogeys continued straight ahead, both fighters might have achieved offensive positions from opposite sides. Once again, the chance of escaping visual or radar detection is enhanced when the fighters split high and low to bracket the enemy in altitude during the attack.

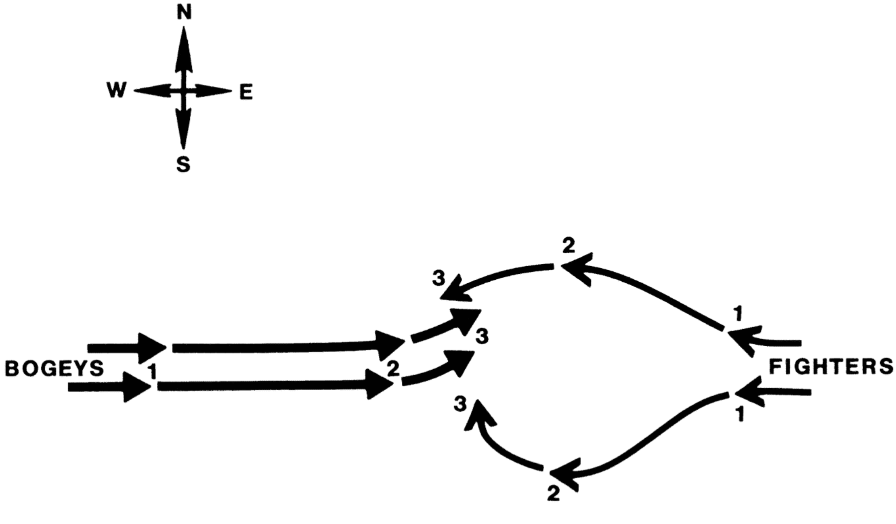

Figure 10-8. The Pincer

Advantages and Disadvantages

The pincer is an extremely effective offensive tactic, but pilots must have considerable training in its use for it to be consistently effective. The fighters are likely to be separated by several miles at time "2" and can provide little mutual support, so these are truly autonomous intercepts. When the pincer is performed at very high speeds and is limited to FQ attacks with all-aspect weapons, this temporary loss of mutual support may be justified, even in the hostile environment, to gain greater offensive potential. The fighter pilots should generally plan to rejoin after the attack, however, for better defense, and stern conversions should be avoided except in well-controlled situations. Again, the pincer is not recommended against bogeys in a significant trail formation.

A further complication with the pincer is the requirement that each fighter have radar contact with the bogeys, or at least have dual GCI close control, prior to the split. All the other tactics described to this point could be performed reasonably with only one operable radar in the section, or with close control only for the leader.

Another limitation for this tactic is the ability of the individual fighters either to defeat the bogeys one-on-one or to escape from a bogey after meeting from neutral positions. This is because the pincer invites the bogeys to split up also, which can easily result in two one-versus-one encounters. If the fighter pilots do not feel confident engaging the enemy one-on-one in the given situation, they can attempt to isolate and attack one bogey, as shown in Figure 10-9.

In this example the bogeys split (time "2") in response to the fighters' bracket attempt. Each fighter pilot continues to run his intercept against the nearest bogey, while at the same time discussing a plan via radio with the other pilot. The two pilots decide to neutralize the southern bogey and attack the northern one. At time "3" each fighter passes its respective

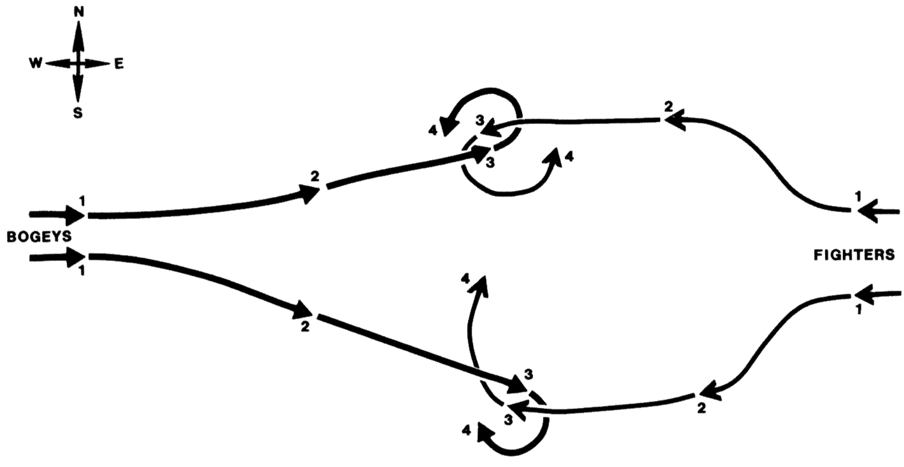

Figure 10-9. Pincer Isolation Tactic

bogey neutrally, on the side away from the other aircraft. The pilot of the southern fighter may want to give his bogey a little extra flight-path separation, if this can be done safely, to induce it to turn away from its wingman. After the pass, the pilot to the south heads for his wingman's position at max speed, leaving the southern bogey in the dust, time "4." By controller vector, by radar, visually, or by any other means available, the free pilot of the southern fighter must now locate the engagement to the north, attempt to pick off the northern bogey, and rejoin with the wingman before the southern bogey can re-enter the fight.

Obviously there are a lot of things that can go wrong in such a scenario; thus the recommended limitation on relative individual fighter performance. Comm-jamming, degraded radar and visual environments, and additional, unknown, bogeys are some of the greatest potential hazards. In addition, the geometry for this attack is difficult when there is considerable aspect early in the intercept.

Drag

Description

As with the visual drag attack described in an earlier chapter, this tactic involves baiting an enemy, inducing him to pursue one fighter while he presents a shot opportunity to another. Figure 10-10 illustrates one example of a drag intercept.

At time "1" the fighters contact bogeys on the nose and begin to shift into a trail or very sucked echelon formation. The idea is to ensure that the bogeys have radar contact with the lead fighter and to try to hide the trailer. Against bogeys with pulse-type radars and/or GCI control, this can usually be accomplished by having the trailer dive to very low altitude during the shift. Turning at right angles to the bogeys and dropping chaff is another effective tactic against both enemy fighter radars and controller radars. When the enemy fighters are expected to have Doppler radars, the same right-angle turn by the trailer, who passes fairly close to the lead aircraft if practical and then makes a significant altitude change before turning back on course, is generally sufficient to cause loss of contact with the trail fighter. In either case the leader can change altitude in the opposite direction, usually higher to enhance his chances of being detected, creating a large altitude differential between fighters which makes tracking both of them very difficult.

Nose-tail distance between the two fighters after the shift to trail (time "2") is generally near maximum visual range or 1.5 to 2.0 times the trailer's maximum RQ weapons range, whichever is less.

At some predesignated point, usually at about maximum visual range or approaching the bogeys' maximum head-on firing range (should they be equipped with all-aspect missiles), the leader makes a sharp turn away, preferably toward the trailer if he is in echelon formation. This turn usually places the bogeys near the lead fighter's radar antenna gimbal limits, but care should be taken not to let the bogeys exceed these limits, at least until the leader gains sight of the enemy. The turn-away from the

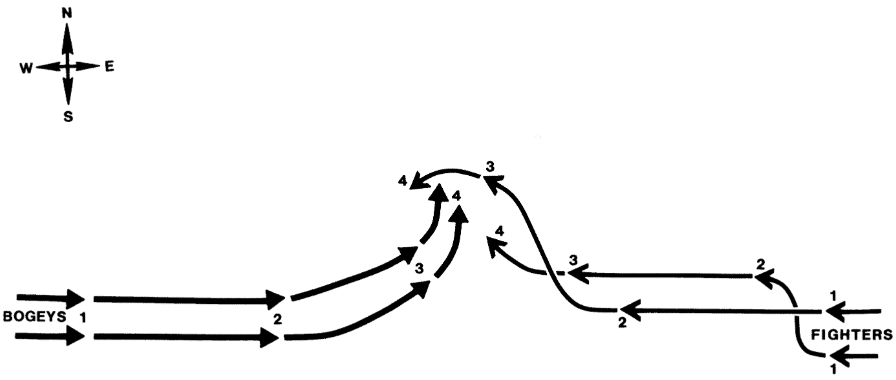

Figure 10-10. The Drag

bogeys serves three major purposes. It increases the enemy's chances of seeing, and therefore the likelihood of them pursuing, the lead fighter. It delays the bogeys' all-aspect-missile-firing opportunities by decreasing their maximum firing range, while simultaneously placing the lead fighter in a good position to defend against such a shot if it is forthcoming. Finally, it tempts the enemy to chase the leader and thereby turn in front of the trailer and provide an easy shot.

The trailer's task is to maintain visual contact with his leader while gaining radar contact with the bogeys. He is usually in the best position to detect whether the enemy is taking the bait, and he should pass this info to the leader. If the enemy continues for the trailer, the leader should turn back in for a FQ attack or a stern conversion with good advantage. This scenario transforms the drag into a lead-around tactic, which is discussed next.

Advantages and Disadvantages

The drag can be a devastating tactic, but, like any complex procedure, it requires much practice and many things can go wrong. As with other trail tactics, it is long on offense and rather short on defense, making it more appropriate for permissive situations. When undetected hostile fighters could be around, extremely high speeds should be used. Even so, the considerable maneuvering required by the lead fighter leaves it vulnerable to surprise attack.

The drag can be performed with only one operable radar in the section or with close control only for the leader, since the trailer can maintain position visually, but two radars are preferable. This tactic is normally not advisable in an all-aspect missile environment, since the enemy is usually afforded the first shot opportunity.

Drag tactics can be very effective against bogeys in trail. When the lead bogey takes the bait, it can usually be picked off by the trailing fighter before the second bogey becomes a factor. The threat of the second bogey must be kept in mind, however, and the pilot of the trailing fighter should be careful not to expose himself to this threat while he attacks the lead bogey. It is usually advisable for the lead fighter (dragger) to maintain a radar lock on the trail bogey and rely on the wingman for protection against the lead bogey, so that the position of the trailer can be determined at the merge. Two radars in the Fighter section are therefore highly desirable for conducting a drag attack against an enemy trail formation.

Lead-Around

Description

The lead-around (shown in Figure 10-11) is similar to the drag in that it is begun from a trail or sucked-echelon formation. The distance between the fighters in trail is usually close to maximum visual range, or about twice maximum RQ weapons range, whichever is less. As with other trail tactics, speed should be kept high to help clear the trailer's six o'clock. On reaching a predetermined range during a nearly head-on intercept (time "1"), the lead fighter breaks away to one side to build displacement for a FQ attack or a stern conversion. At time "2" the enemy section is faced with choosing which fighter to engage. If they turn on the leader, the bogeys present the trailer with an easy shot, but if they continue for the trailer the lead fighter will probably gain an effective offensive position.

The displacement turn for the lead-around is usually made away from a wingman if he is in echelon, as shown, in order to generate a wider bracket. This maneuver essentially creates a bracket attack from a trail formation, with both fighters reaching the bogeys at about the same time for best effect. Although it is still desirable to hide the trailing fighter, this is not essential for success of the lead-around. A good altitude split between the fighters, preferably bracketing the enemy vertically, is still recommended, however.

Advantages and Disadvantages

Again, this is a very good offensive tactic, but it is rather poor from a defensive standpoint because of the trail formation and the wide split between fighters. In a permissive environment, and using very high speeds, the offensive potential may well outweigh the risks. In most combat conditions, however, a stern conversion by the leader against enemy fighters is hazardous, and a FQ attack is preferable. The fighters should usually attempt to regain mutual support at the merge.

This intercept can be performed with one radar or with GCI control only for the lead fighter, since the trailer can generally maintain sight of the

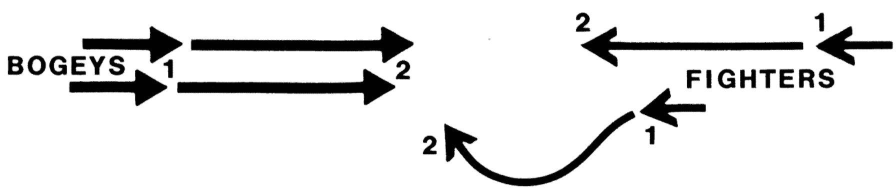

Figure 10-11. The Lead-Around

leader throughout; but two radars are better. The lead-around is generally less complex than the drag, since the fighters are not required to alter their attack significantly in response to bogey reactions. Chances of success are therefore materially improved. As with the drag, however, the lead-around may offer the first shot opportunity to an all-aspect-equipped enemy, limiting its application in some scenarios.

The lead-around is perhaps one of the best offensive tactics against bogeys arranged in trail. The fighter leader should take a radar lock on the trail bogey and run his attack on that aircraft while the fighter wingman guards against interference from the lead bogey. Two radars are still preferable for this situation, but generally the trailing fighter can perform his duties visually.

Hook

Description

The hook is an effective offensive tactic, well suited to the VID of very small bogeys. It has many of the attributes of the trail, in that one fighter (leader) performs the VID while the other (shooter) positions for the shot, but it is probably superior to the trail defensively. Figure 10-12 illustrates the hook.

At time "1" the fighters, in combat spread, detect unidentified radar contacts slightly right of the nose and closing. The leader (northern fighter) adjusts course slightly to place the contacts on collision bearing. At time "2" the wingman takes greater lateral separation from his leader and a large altitude split. Separation should be on the order of one turn diameter both vertically and laterally. If the bogeys are roughly co-altitude the wingman can split either high or low. Often environmental conditions (i.e., high or low cloud decks, sun position, etc.) will determine the better altitude for hiding the wingman. At high altitudes, aircraft performance may not permit the wingman to gain sufficient additional altitude in time

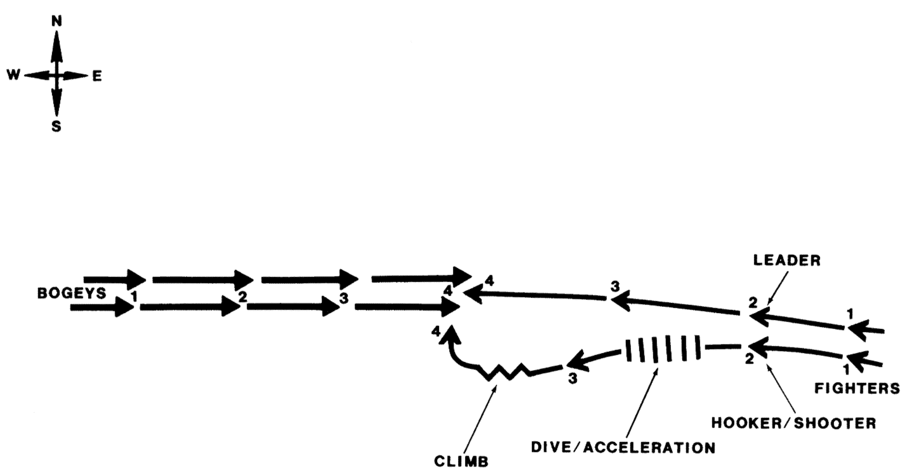

Figure 10-12. The Hook

for the intercept, so a dive may be preferable. Conversely, when intercepting low-level bogeys there may not be enough airspace below the targets, necessitating a climbing separation. If there is a significant altitude differential between the fighter lead and the bogeys, the leader will need to work off this altitude before the merge so that he meets the enemy approximately co-altitude. In this case the wingman may be able to stay at about his original level and allow the leader to create the desired separation during the intercept process.

There generally will be an obvious preference for a high or a low split by the wingman, but all else being equal a low split is often more effective because it usually makes radar detection of the wingman less likely and it allows the wingman to accelerate somewhat ahead of the leader, as shown at time "3," for a better offensive position at the pass. When he is required to climb well above the leader, the wingman must usually settle for a sucked position, slightly behind the leader. In this case the bogey can pass the leader head-on and then turn up toward the wingman, denying him an offensive advantage.

At time "3" in this example, the wingman (shooter or hooker) begins a programmed turn (based on range calls from the leader) timed for him to point at the lead fighter at the merge with the bogeys. During this time the leader is attempting to remove all lateral and vertical separation with one of the bogeys for a close pass. Usually the leader will be able to VID the bogey first and call the aircraft type to the shooter, who is then cleared to fire at an enemy. Sometimes, however, the "hooker's" greater aspect will allow him the earlier VID. In either case both fighters have all-aspect-missile-firing opportunities at the moment of the VID, but with a very small bogey the leader may already have penetrated min-range for his weapons. The hooker should have an all-aspect missile shot at the pass or be in good position to convert to a rear-hemisphere envelope. He should be careful, however, to ensure separation between his leader and the target from weapons launch to impact.

Against a single bogey, or closely spaced multiple bogeys, the lead fighter generally will attempt to place the enemy between himself and the hooker at the pass. This diverts the enemy's attention away from the shooter and often induces the bogeys to turn away from the hooker after the pass, providing him with a sweet belly-side or RQ shot. With widely separated bogeys, such as in this example, the leader will usually try to bracket the enemy closest to the shooter while informing the hooker of the position of any other hostile fighters. This technique helps prevent the shooter from inadvertently turning in front of an enemy and being bagged from the belly-side. The leader should pass the intended victim closely (time "4") and call out the exact instant of the pass to help the shooter get sight (tally) of the target.

Advantages and Disadvantages

The hook has a great many positive attributes. When properly executed it can provide the fighters with an offensive advantage at the pass and, quite often, the quick elimination of one bogey. When the fighters are equipped only with guns or RQ missiles, however, the bogey can often escape an immediate lethal situation by turning hard toward the hooker at the pass, providing the bogey pilot knows (or guesses) the threat sector. This is a very tough tactic to beat, however, when the fighters are armed with all-aspect ordnance and the enemy is not.

Unlike the trail, the hook does not require the fighter wingman to sacrifice all hope of mutual support for a firing opportunity at the pass. The fact that the hooker probably will be more widely separated from his leader, and possibly somewhat acute or sucked, reduces defensive mutual support potential to some extent, but this arrangement is still much superior defensively to a trail formation. This tactic can be performed quite adequately with only one operable radar in the section, but some increased measure of safety can be provided by the wingman also having a radar to check for trail bogeys. Normally the tactical leader of the section is determined by which fighter has a radar contact and is closer to the bogeys' flight path when reaching the point at which the hooker must take his separation, time "2" in this example. Should radar contact be lost subsequent to this split, the fighters should try to return expeditiously to a more defensive spread formation.

When combined with a straight collision-bearing intercept, as in this example, the hook minimizes the enemy's penetration into friendly airspace, which can be an important consideration. The hook is most effective, however, against single bogeys or fairly tight formations. When the bogeys are widely separated either vertically or laterally, it may be impossible for the fighter lead to pass one bogey with the prescribed minimum separation without allowing another enemy to become a serious threat at the pass. In other words, this tactic may allow the bogeys to run a hook of their own.

A trail formation also poses a difficult problem for the hook. This situation usually requires the fighter leader to pass each hostile element with minimum separation with the intent of hooking the last bogey. Achieving this close pass with each bogey is necessary to deny the bogey leader a lead-turn opportunity and to "mark" the trail bogey for the hooker; but such close passes normally require the leader to have sight of the bogey aircraft at some distance before the pass. The necessity of an early tally, in turn, usually requires the leader to have a radar lock on the lead bogey. Most weapons systems provide the pilot with an indication of the radar line of sight when they are locked on a target, which narrows the visual search area enormously and greatly increases the chances of an early tally. Unfortunately, most fighter radars can lock only one target at a time, so while the system is locked on the bogey leader the trial bogey cannot be monitored. After passing the lead bogey element the leader seldom has sufficient time to acquire the trailer and maneuver for a close pass. Even sophisticated track-while-scan radars, which can track more than one target at a time, usually can provide only one LOS cue for the pilot, so these offer little additional help. Therefore, for a hook to be very effective against a trail formation the fighter section needs two radars so the leader can lock the lead bogey while the hooker locks the trailer.

In an uncontrolled scenario the hook can be dangerous for the shooter, since additional, undetected, bogeys may take advantage of the hooker's turn for a belly-side attack. If a shot is not forthcoming within about 90° of turn in this environment, the hooker should break off the attack, perform a rapid turn reversal to clear his belly, and rejoin in a good supporting position with the leader. In such unknown situations the shooter generally should avoid the acute position, since this requires greater than 90° of turn to point at the bogey at the merge with the fighter lead. An abeam or slightly sucked position necessitates less turning but also results in less angular advantage for the hooker at the pass. With the resulting beam or FQ geometry at the pass, the shooter's hopes for a quick kill may be dependent on an all-aspect weapon or a bogey turning away from the hooker's position.

Under the right circumstances the hook can be a very effective intercept tactic, but it does require a well-trained fighter section for optimum results.

Option

Description

The option intercept is essentially the single-side offset tactic described earlier, with the added "option" of making a transition to a bracket attack. Figure 10-13 illustrates an example of this tactic.

At time "1" the fighters detect the bogeys nearly head-on at long range. The pilot with the first radar contact generally should assume the lead and maneuver as necessary to generate displacement for a stern conversion or FQ attack. In this case the wingman is already positioned on the side away from the threat, so he stays on that side. The displacement turn into the wingman may throw him a little acute, as shown at time "2," but this is a temporary state of affairs, as the lead will soon be turning away to place the formation back into combat spread. In a relatively controlled situation the wingman may choose to accept the temporary acute position, but in a very hostile or unknown situation he should maneuver as necessary (normally zoom high in this case) to regain a more optimum defensive position abeam the leader.

At time *"1"* the fighter lead determines that adequate displacement has been generated for his desired intercept. Choosing between a stern conversion and a FQ attack has been discussed previously, and the decision usually depends on the tactical situation (degree of confidence in situation

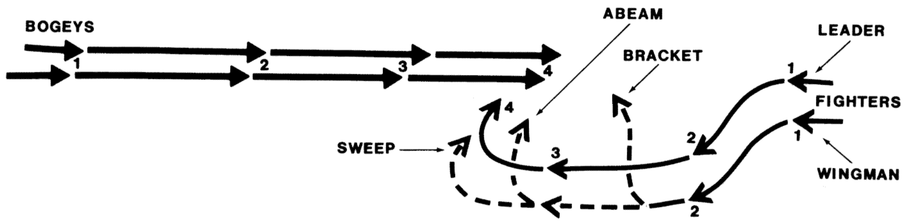

Figure 10-13. The Option

awareness), weapons available, displacement available, etc. For the FQ intercept the lead will normally turn to collision heading once the desired aspect has been generated. In this case, however, the stern conversion is selected, which calls for paralleling the bogey's flight path to maintain lateral separation. The leader's altitude should be adjusted as necessary for environmental or weapons considerations. The wingman will want a good altitude split on the leader at the point of attack to make himself harder for the bogeys to see, so he should be planning the direction of this vertical split and how it can best be achieved.

It is the leader's responsibility during the intercept to inform the wingman of the planned intercept geometry, bogey numbers, formation, altitudes, etc., as available. Wingman positioning during the attack is best left to the wingman, since he is better able to assess his own capabilities as to positioning, radar status, situational awareness, etc. The wingman has three options with this tactic. He can take an early cut to the inside of the leader's turn in an attempt to bracket the enemy, he can perform a tac turn with the leader to maintain an abeam position for the attack, or he can make the transition to a trail position during the conversion turn for a sweep option. Whichever option he chooses, the wingman should inform the leader of his intentions.

For the bracket option the wingman may be required to dive below the leader at high speed in order to reach a position on or across the bogey's flight path at the intercept. If this maneuver is performed within possible visual range of the bogeys, the wingman should try not to pass too close to the leader, since this could give the enemy a chance for a tally on both fighters. Unlike the classic pincer attack, this bracket option is performed visually by the wingman with reference to the leader, so it is not necessary for the wingman to have a radar contact with the bogeys. The bracket option can be a good choice when the fighters are all-aspect capable and the enemy is not. When this option is properly performed, both fighters should have shots by the time the leader can VID the bogeys. Wingman positioning in this case should provide for satisfying his weapon's min-range constraints as the leader terminates the intercept.

The abeam option is simply a section stern conversion or FQ intercept with the wingman holding an abeam position in defensive spread throughout. This option can provide optimum defensive potential in a hostile environment while giving the fighters some tactical advantage at the intercept. It can be very effective offensively when both the fighters and the enemy have all-aspect weapons. The bogeys can easily counter this tactic, however, if the fighters have only RQ weapons, by turning hard into the attack. The fighters may still achieve some tactical advantage if detection of the attack can be delayed until late in the game.

The sweep option is essentially the sweep tactic already described. This option is less well suited to all-aspect weapons than are the previous choices, because normally only the leader is in firing parameters at the moment of the VID. The sweep can be very effective with less capable weapons, however, especially when extended maneuvering is anticipated with enemy fighters, as the trail formation provides good offensive potential, particularly when the leader has an initial angular advantage on the enemy. The pressure applied by the leader in this case often results in bogeys turning in front of the trailer. The trail formation is also good for sequential attacks against bombers, transports, etc. As discussed earlier, however, this is not a healthy option in an uncontrolled, multi-bogey environment because of the poor defensive position of the trailer, particularly if the leader conducts a stern conversion.

Advantages and Disadvantages

The primary advantage of the option intercept is its flexibility. The leader does essentially the same thing regardless of the option, and the wingrnan positions as the situation dictates. Offensive options are available for both controlled conditions (sweep) and more hostile environments (bracket), and the more defensive option (abeam) can be chosen for highly uncontrolled conditions. The option is compatible with either FQ or stern conversion intercept geometry. The choice here often depends on weapons available and the permissiveness of the environment. The stern conversion is more applicable to controlled situations with RQ weapons, while the FQ geometry may be preferable in poorly defined scenarios and when the fighters have all-aspect missiles.

Against bogeys in a significant trail formation, the bracket is generally the option of choice. The fighter leader in this case should normally lock and attack the trailing bogey, while the fighter wingman's position inside the conversion turn provides protection from the lead bogey. It is highly desirable for the wingman to have radar contact with the lead bogey in this situation to aid in visual detection. The fighter wingman will usually take his split for the bracket earlier against a trail formation so that he can be in position and avoid being detected visually by the bogey leader, which may be considerably closer at this time than is the trail bogey, which is being attacked by the lead fighter.

All three options offered by this tactic allow the fighters to remain close enough together and near abeam to facilitate lead changes in the initial stages of the intercept, which may be required if the leader loses contact with the bogeys or suffers a radar malfunction, etc. Even in the latter stages of a sweep or bracket option the fighters should not be so far apart that they cannot rejoin expeditiously for defensive purposes or a bugout. When the fighters are arranged in trail (sweep option), a 90° turn in either direction by the leader allows the trailer to rejoin in spread. Following a bracket attack the fighters should pass fairly close to each other with high track-crossing angles. In this case nose-to-nose turns by both fighters put them back abeam.

There are some problems with the option, however. It places a lot of responsibility on the wingman to select the best option for the tactical situation and position accordingly. The bracket option, particularly, requires the kind of timing that is gained only through extensive training. Because of the many options available to the wingman, the fighter leader may enter a fight without sight of his teammate or even knowledge of his position, especially in limited-comm conditions. The wide offensive splits and positioning of the sweep and bracket options gain tactical advantage at the expense of defensive mutual support. In addition, the FQ or stern-conversion geometry allows greater enemy raid penetration than head-on or collision geometry. The intercept mechanics for this geometry are also more difficult and complex, and they are more vulnerable to bogey jinks at long range. Late bogey jinks tend to confuse the attack geometry and timing, but an attack might still be salvaged by fancy fighter footwork, provided the jink can be detected quickly.

Break-Away

> With an inferior weapon system you cannot fight a superior one. You can have surprise success but not success for a long time.
>
> Lt. General Adolph Galland, Luftwaffe

Description

In the game of air combat, the break-away is what might be called a "stunt" or a "trick" tactic. Its purpose is to deceive and confuse enemy fighter and GCI radars, to degrade the bogey's situational awareness at the merge, and to get at least one fighter into the merge unobserved. One variation of this tactic is depicted in Figure 10-14.

At time "1" the fighters are in a fairly tight formation so that, on the enemy's airborne and GCI radars, they appear as only one target outside visual range of the bogeys. The maximum allowable separation may be only a few feet, or it may be many hundreds of feet, depending on the characteristics of the specific threat radars. This tactic should induce some doubt in the enemy as to just how many fighters they will be engaging.

Once the bogeys are detected, the fighters turn as necessary to establish collision geometry. If there is sufficient range, either head-on or FQ intercept techniques may be employed instead. At time "2" the fighters are still outside the bogeys' visual range, but they are approaching the final stages of the intercept, where the enemy can be expected to be taking radar locks for their attack. This typically occurs by the time the fighters are within one minute to intercept, but the timing can vary widely. The fighters'

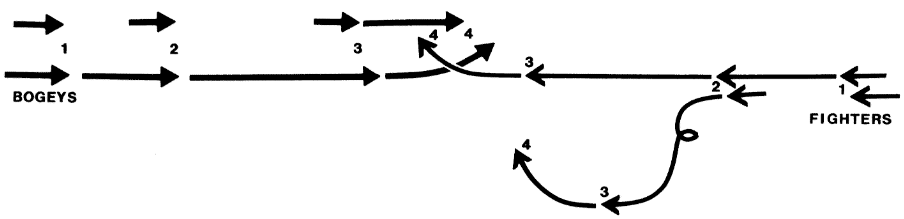

Figure 10-14. The Break-Away

RWR equipment may be of assistance in determining when the bogeys are locked.

At this point the fighter wingman rolls over and pulls hard into a split-S until the aircraft is pointing vertically downward. When the bogeys are equipped with Doppler-type radar systems, this maneuver should place the enemy at 90° to the wingman's aircraft so quickly that the aircraft will be invisible to the bogeys' radar before fighter separation is wide enough to allow both aircraft to be displayed separately. By the time the wingman pulls out of his dive, time "3," he will probably be out of the bogeys' radar scan volume. In addition, the bogeys' look-down angle caused by the wingman's dive will result in clutter problems for enemy pulse radar systems. A hard break-away is essential at time "2," especially against Doppler radars. If the fighters can be in the vicinity of corner speed at this point, a max-G break produces the 90° turn as quickly as possible with the least separation between fighters. Chaff deployment by the wingman just as he approaches the vertical attitude is also very effective against pulse radars, and can even produce false targets on a Doppler radar in high-wind conditions. Paradoxically, the better the enemy's radar performs against targets with a beam aspect, the more vulnerable it is to chaff. Chaff is also useful in confusing enemy GCI controllers, who now probably detect a veritable explosion of targets and may have insufficient time remaining to determine which are real fighters. When it is performed at medium altitudes, the wingman's split-S may also place him too low for the enemy's GCI coverage.

Once his aircraft is purely vertical the wingman does a 180° roll and a wings-level pull-out on the original collision heading at high speed. At this point he should regain visual contact with the leader, who should now be slightly ahead and very much higher, and if time permits he can gain radar contact with the bogeys. The leader should resist changing heading between the wingman's break and his "visual" call, since the wingman may never regain sight if he does. If a heading change must be made, the new course should be relayed to the wingman immediately.

Approaching the merge the leader should call ranges frequently so the wingman can time his pull-up so he is pointing at the leader at the pass. The wingman is essentially performing a vertical hook, so the leader desires a close pass with the bogeys to help the wingman (shooter) get a tally. In this case the leader should try to pass slightly above the bogeys, possibly in a climb, to draw attention away from the low shooter, and possibly tempt the bogey into a pull-up right in front of the hooker.

Advantages and Disadvantages

When it works, this tactic will cause lots of laughing and scratching back at the bar; but when it doesn't, there will no doubt be much incredulous head shaking. The break-away throws caution to the winds for the advantages of deception and surprise. The only positive defensive point that can be made in its favor is the adage "A good offense is the best defense." The fighters are in a poor defensive posture throughout the intercept. They are usually too close for good mutual support before the break-away, and the low, trailing wingman is vulnerable after the split. A well-controlled situation is a prerequisite for this tactic, since an unexpected attack by enemy fighters before the break-away would probably be disastrous.

> As a fighter pilot I knew from my own experiences how decisive surprise and luck can be for a success, which in the long run only comes to the one who combines daring with cool thinking.
>
> Lt. General Adolph Galland, Luftwaffe

The situations in which the advantages outweigh the risks of this tactic include a permissive environment in which the enemy's radar system and aircraft performance are decidedly superior to those of the friendly fighters. When facing a definite mismatch, good execution of sound tactics may not be enough. In boxing terminology, "A good big man will beat a good little man most of the time." In this case a good offense may be the *only* defense, and some exotic stunts may be justified if they result in enemy confusion and degraded awareness at the pass. Obviously, however, such tactics require considerable pilot training and a high level of proficiency before they can be relied on in combat; even then they cannot be expected to work as a steady diet, since the enemy will soon figure them out.

There are many variations on the break-away tactic, but most begin with an initial close formation and employ a radical formation change at close range to sow confusion among the enemy. As with most hook and bracket-type attacks, the break-away is not recommended against an enemy in a significant trail formation.

Cross-Block

Description

The cross-block, also called the weave, is another stunt tactic that is often successful against superior fighters that have a propensity for independent attacks. Figure 10-15 shows this tactic.

At time "1" the fighters and bogeys detect each other about head-on, and the bogeys commence a pincer attack in an attempt to bracket the fighters. The fighter pilots detect this move and continue straight ahead in combat spread until they reach a point at which the bogeys can be expected to have individual radar locks on the fighters on their respective sides of the formation for the terminal phase of attack. Once again, this usually occurs by one minute to go in the intercept, and the fighters' RWR gear may provide further clues.

At this point, time "2," the fighter pilots also take individual locks, but on the bogey on the opposite side of the enemy formation. This process is known as "cross-locking." The fighters then turn toward each other, crossing flight paths, in an effort to get outside the bogey each has locked, time "3." If the bogeys continue their intercepts on their originally in-tended victims, they too can be expected to turn inward in response to the fighters' maneuvers. The geometry of the situation tends to draw the bogeys together as they approach the merge (time "4"), making it easier for each fighter pilot to tally both bogeys, and dragging each bogey in front of

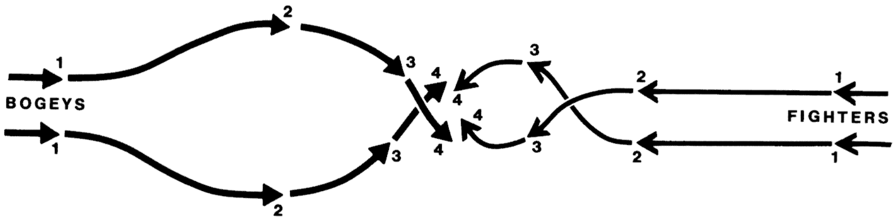

Figure 10-15. The Cross-Block

an unseen fighter. Each fighter should have an unobserved belly-side or RQ shot on its target while meeting the other bogey nearly head-on. The bogeys, on the other hand, are bracketed at the pass; neither enemy pilot is likely to have sight of his wingman, and each probably does have a tally on one fighter—but not the fighter posing the greater threat. Obviously this is a very favorable situation for the friendly fighters!

Advantages and Disadvantages

The cross-block, like most other stunt tactics, is a complex intercept requiring highly proficient aircrews and a good deal of luck. In addition, this procedure depends on two operable radars. Offensively the cross-block can be very effective against a pincer attack. Defensively it is not as poor as many other tactics. The fighters can stay in a defensive spread formation until late in the intercept, and although they are essentially independent during the terminal phase of the maneuver, they usually are not so far separated that they are unable to offer mutual support quickly if it is needed. A serious problem can occur, however, if one fighter loses contact with its bogey in the terminal phase. If this happens, the other pilot should continue his intercept while the pilot without contact attempts to regain a visual cover position for his wingman.

The cross-block offers an effective offensive response to a pincer attack by superior bogeys, even in a hostile environment. With superior fighters in a more controlled environment the pincer isolation tactic shown in Figure 10-9 might be a preferable alternative, since dealing with one bogey at a time is generally less hazardous. A simpler, more defensive option might be a single-side offset to either side in an attempt to get outside the enemy's bracket. This alternative, however, offers little offensive potential and likely will not be highly effective against superior bogeys; but it can be executed with only one radar.

Division Intercepts

As stated previously, any of the intercept tactics described so far in this chapter for use by one or two fighters can be employed by greater numbers. Some major advantages are provided by more fighters, including improved mutual support for fighters in trail formations and for fighters using intercepts that rely on wide offensive splits. This can allow the fighters to choose more offensive tactics without incurring unacceptable degradation

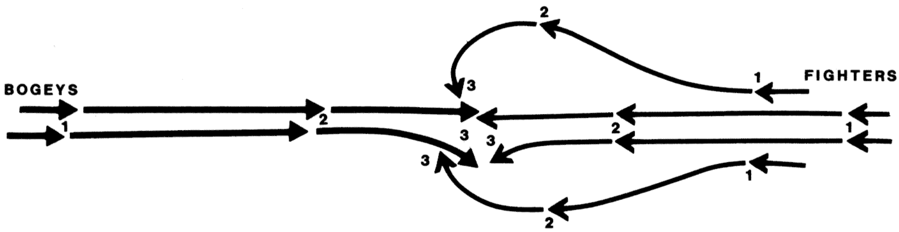

Figure 10-16. Double Lead-Around or Pincer and Trail

of defensive potential. Figures 10-16 and 10-17 are examples of lead-around and pincer attacks adapted to divisions of four fighters.

Visual Considerations in Air Combat

> One of the secrets of air fighting was to see the other man first. Seeing airplanes from great distances was a question of experience and training, of knowing where to look and what to look for. Experienced pilots always saw more than the newcomers, because the latter were more concerned with flying than fighting. . . . The novice had little idea of the situation, because his brain was bewildered by the shock and ferocity of the fight.
>
> Air Vice-Marshal J. E. "Johnnie" Johnson, RAF

The importance of surprise in air combat is illustrated by the fact that about nine out of ten air-to-air victims are not aware of their imminent danger until they are actually fired on. It stands to reason, then, that considerable thought and planning should be devoted to achieving and maintaining sight of the enemy in a visual air combat arena and, conversely, to avoiding visual detection by the opponents. Some attention has been devoted to this topic throughout this book. This section re-emphasizes some of the aforementioned techniques for maintaining and avoiding visual contact and introduces a few others. Although they are presented here in the context of radar intercepts, most of these considerations and techniques are equally relevant to all phases of air combat.

The visual scan is the system used by a fighter pilot to search for and find other aircraft. The sky can be an amazingly big place, and airplanes incredibly small and elusive targets. A fighter pilot just cannot expect to look out and see enemy aircraft at useful distances consistently without a great deal of training, practice, and discipline. In addition, although bogeys are probably the most important things he can see, the fighter pilot has other visual responsibilities, such as keeping track of wingmen, navigating, monitoring aircraft performance, etc. To accomplish all these tasks effectively requires a method or scan pattern.

> It is always the one you don't see that gets you.
>
> Major Thomas B. "Tommy" McGuire, USAAF

First of all, these tasks must be made as simple as possible, so that they can be accomplished quickly and efficiently. The spacing and arrangement of fighters in defensive formations should be such that each pilot can comfortably keep sight of his wingmen and their vulnerable areas. If a wingman is too far away or is arranged high in the sun, maintaining visual contact can take too great a percentage of the pilot's available scanning time, detracting from his lockout. When a high, bright sun is a significant factor, the highest element of a defensive formation should normally be positioned down-sun (i.e., on the side of the formation away from the sun).

The pilot's flight equipment and the aircraft design and maintenance are also important factors. A pilot's flight clothing should be as lightweight and nonrestricting as possible so that movement in the cockpit is not hindered. It is often necessary to turn almost completely around in the seat in either direction to look directly behind, no easy task in a full pressure suit. Restraining straps must also be designed and adjusted to allow this freedom of movement.

The Japanese early in World War II considered this cockpit freedom so important that their fighter pilots generally did not even wear parachutes. Another factor in this personal decision was the fact that they generally fought over enemy territory, and their code of *Bushido* (the *Samurai* code) did not permit them to be captured. This policy was self-defeating, however, since, in combination with the general lack of armor protection and self-sealing fuel tanks, it led to high attrition of experienced pilots and caused great problems for the Japanese later in the war.

Flight controls should be designed for use by either hand, so the pilot can rotate his body completely in either direction and still fly the airplane. The helmet is one of the pilot's most critical flight-gear items. It must be as lightweight as possible, otherwise it can get pretty unwieldy and be hard on the neck under 9 Gs. Neither should it restrict the pilot's vision. This means no part of the helmet should be visible to the pilot wearing it. It must also be fitted and secured so that it doesn't rotate out of place under high G or with pilot movement. The helmet should be fitted with a dark visor that can be quickly flipped into position if it becomes necessary for the pilot to follow a bogey very near the sun. In general, however, visors should not be used in combat, since anything between the pilot's eyes and the bogey, even a "clear" visor, degrades vision to some extent. Dark visors

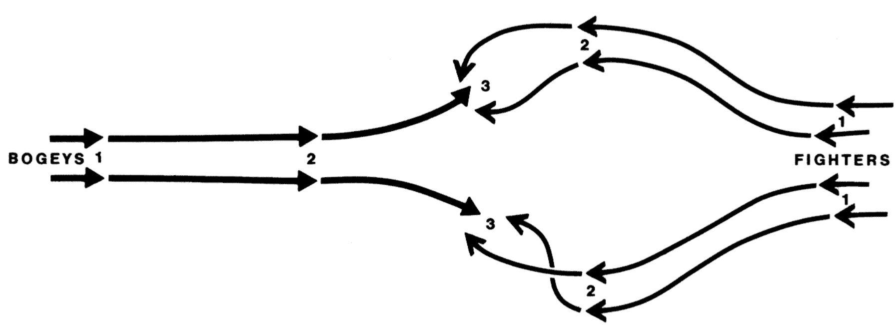

Figure 10-17. Double Pincer or Double Option

also have the effect of reducing the pilot's visual depth of Held. All flight gear, and anything else inside the cockpit, should be dark colored and nonreflective. Otherwise, they will cast light-colored images on the canopy, severely restricting visibility. Canopies must be kept spotless and free of scratches. Touching a canopy is a hanging offense. A hard helmet should be covered with some soft material to avoid canopy scratches.

> Whenever you're over the lines you have to keep twisting your neck in all directions every minute, or you're sure to be surprised.
>
> Captain Edward V. "Eddie" Rickenbacker, USAS

Rear-view mirrors have been used on many fighters for some time now, generally with good success. When properly placed they can significantly expand the pilots' rearward field of view. This is the purpose to which they should be put, however; they should not be used as an excuse for not turning the entire head and body to cover those areas that can be seen without the aid of the mirrors. Mirror placement is quite important; mirrors must be located outside the canopy or their effectiveness will be nullified by canopy glare and reflections. Aircraft designers resist this placement because external mirrors mess up the nice, clean lines of the aircraft and increase drag. This is the same mentality that results in fighters being designed with low-drag canopies faired into the fuselage rather than with bubble-type canopies, which provide a much better field of view.

Monitoring aircraft performance can also be facilitated by design. At the very least, airspeed and altitude instruments should be large, easy to interpret, and located as high as possible in the cockpit. A better idea is to display this and other critical information on some sort of "head-up display" (HUD) that is focused at infinity, so that the pilot is not required to look inside the cockpit at critical moments. Coming inside means refocusing and adjusting to cockpit lighting conditions, and then refocusing and readjusting when returning the scan to the outside. HUDs are usually incorporated in the fighter's gunsight, but they can also be part of the pilot's helmet, with the display projected on the visor. Each method has limitations: the pilot must be looking forward to use the gunsight, and he requires a visor for the helmet unit.

Since much of a fighter's combat time is likely to be spent at high G, the effect of this acceleration on the pilot's vision is an important consideration. As G increases the heart must work against higher gravity forces to pump blood to the pilot's head. The greater the height of the pilot's head above the level of his heart, the lower the blood pressure to his eyes and brain will be under these conditions. Under protracted high-G conditions, blood tends to pool in the pilot's lower extremities and abdomen area, denying an adequate blood supply to the head, which affects both vision and brain function. The first noticeable effect is normally "tunnel vision," which is a gradual reduction of the pilot's field of peripheral vision down to a very few degrees directly along his line of sight. Eventually this "tunnel" can close completely, totally blinding the pilot in what is called a "gray-out." This condition is often accompanied by the "seeing of stars." Under these conditions, the pilot will see nothing until G is relaxed, but he is still fully conscious and aware of what is happening to him, and he can still fly the airplane by feel. If the G is maintained, however, or if load factor is increased still further, reduced blood pressure to the brain will eventually result in "blackout," or total loss of consciousness, during which the pilot loses complete control and is unaware of his condition. Generally at this point the pilot collapses and relaxes completely, releasing the aircraft to return to a low-G condition, which allows him to recover consciousness. Occasionally, however, blackout may be accompanied by convulsions. Recovery from a blackout can be a fairly slow process, during which the pilot may be disoriented and even unaware that he is in an aircraft for some time after vision returns. Obviously this is a very unhealthy condition for a pilot, particularly in combat.

G tolerance is an individual thing, heavily dependent on the pilot's physical health and fitness, height, fatigue, smoking habits, drug intake, etc. Most fighter pilots, with training, can learn to sustain about 5 Gs for a considerable time without ill effects. In addition to training shorter fighter pilots (a personal favorite), there are certain techniques and equipment which can increase G tolerance. In the area of equipment, the G suit is the most common. This is usually a trouserlike garment that incorporates inflatable bladders in the abdominal area and along the legs. These bladders are usually inflated by high-pressure air from the aircraft by an automatic valve in proportion to the G level at any moment. The G suit squeezes the pilot's lower extremities, and this tends to restrict the pooling of blood in these areas, thereby leaving more blood available for the upper body and head. A properly fitted G suit can typically increase a pilot's tolerance by about 1 G. Semireclining seats are another anti-G device that has recently come into vogue (notably in the General Dynamics F-16 fighter). These are also apparently effective to some degree by reducing the vertical heart-to-head distance. Someday a prone pilot position (lying either on his back or on his stomach) may prove to be the answer to high-G tolerance in fighters, if the problems of lockout in all directions under G can be solved.

Techniques that the pilot can use to increase G tolerance include a constant or repetitive straining or "grunting" routine that tenses the body, increasing blood pressure and reducing blood pooling in the abdomen. Another useful technique is to lean sharply forward in the seat against the full extension of the shoulder harness. If the harness restraint system allows, this method can reduce heart-head elevation distance much like a reclining seat. Another practice that can aid in G tolerance is the use of a moderate G-increase rate when beginning turns. Snapping on the G very rapidly, aside from being conducive to aircraft overstresses, may not allow the pilot or other crew members to tense their bodies in anticipation of the increased G loads. Lack of preparation can reduce G tolerance, result in awkward body positions (i.e., faces buried in laps, etc.), or even cause injuries.

Visual Scan Techniques

The best technique a pilot can use in searching for enemy aircraft is the object of considerable dispute. Some schools teach that the sky should be divided into many small segments, say 30° by 30° sectors, and each sector should be searched thoroughly for several seconds to ensure it is clear of targets before shifting to the next sector, and so on. Other schools suggest that the eyes should be moved constantly, never being allowed to stop unless something requires closer investigation. As might be anticipated, each of these techniques has strong and weak points.

The brain cannot interpret visual images when the eyes are moving. When a person scans a wide area quickly, the eyes actually move in many small jerks, pausing repeatedly for a fraction of a second to allow the brain to interpret what is seen. In order to search a sector as thoroughly as possible, the eyes must be focused at the proper distance. Unfortunately, the eye does not provide us with a reliable indication of focal distance. This distance can only be determined by estimating the range to an object in focus. When the eyes have nothing on which to focus, such as when a person is staring into blue sky, they tend to focus at just a few feet away. This focal range is often closer to the canopy than to the bogey, so spots, smudges, and scratches on this surface tend to attract the focus of the eyes.

> [Inexperienced] pilots are really blind in the air for the first couple of months.
>
> Colonel Erich "Bubi" Hartmann, GAF

The problem of focus can seriously degrade visual effectiveness in the air. The usual technique is to focus on a distant object, such as a cloud or a surface feature on the horizon, and then quickly shift the scan to the area of interest. The eyes can usually be held in focus at long range in this manner for a few seconds before the procedure must be repeated. Experienced pilots normally do this continuously and even subconsciously as they shift their scan from place to place. Their lack of a technique for focusing at a distance is probably the primary reason inexperienced pilots see very little in the air.

> Look around—what you see won't hurt you. Keep your head out and use it.
>
> Captain Thomas J. "Tommy" Lynch, USAAF

In daylight, maximum visual acuity is found in the very center of the scan, in an area that covers only a fraction of a degree of arc around the midpoint. Any object outside this very small central area is generally detected by peripheral vision only if it contrasts markedly with the background, is very large, or shows relative motion. (It is primarily motion that catches the attention of peripheral vision.) This explains the value of a radar LOS indication for obtaining the earliest possible tally on a bogey. The LOS cue normally indicates the position of the bogey, quite often in relation to some point on the gunsight, usually within less than 1° of its actual position. The pilot can then search carefully near the indicated point in space (sometimes called "spot scanning"), generally with the aid of gunsight images focused at infinity to help in finding and holding proper focal range, and can detect very distant and low-contrast targets.

One peek is worth a thousand [radar] sweeps.

Unknown

In some cases pilots have been provided with telescopic devices to allow more distant visual acquisition and VID of airborne targets. Some means of extending VID range is often required if full use is to be made of the head-on capability of all-aspect missiles. Such devices can be as simple as a hand-held telescope or binoculars, or as exotic as a high-powered video telescope slaved to the fighter radar's LOS. In general, even the simpler devices can be effective, but hand-held equipment presents problems of loose gear flying around in cockpits, and hands that are busy performing other required functions in a complex cockpit may not be available for its operation. Usually a better solution is to fasten these devices securely to the aircraft and point them straight ahead. The radar can then be used to point the aircraft, and the telescope, directly at an unidentified target for closer examination. Obviously the telescope's field of view must be compatible with the accuracy of the radar LOS-indicating system.

He who sees Hrst, lives longest.

Unknown

The smallness of the area of maximum visual acuity limits the effectiveness of detailed sector search unless the target's LOS can be limited substantially. It can take several seconds to scan thoroughly an area extending even 1° about a given point. Therefore, dividing the entire world into sectors for consecutive detailed inspection becomes ludicrous. Even if each individual search was limited to only one second, it would literally take all day to complete even one cycle of this process. Based on such realities, it just isn't practical to rely on a detailed sector-search scan technique to produce acceptable results for defensive purposes. Offensively, however, careful inspection of narrow sectors is usually the method that yields tallyhos of the longest range.

The alternative is to devise a scan technique based on peripheral vision, which allows coverage of a very large area in a relatively short time. This method involves moving the eyes (and the head) back and forth across the entire field of view at a fairly rapid rate. Although the head may appear to move smoothly during these sweeps, the eyes will actually make rapid jerks of several degrees at a time, and a fairly large area can be searched by peripheral vision at each pause. This technique is somewhat analogous to speed-reading methods, as opposed to focusing on individual words on a printed page. The actual speed of the scan is dependent on proficiency, as the eyes must be trained to make these movements faster for greater scan speed. If the eyes are not allowed to pause repeatedly, very little will be seen.

There should be a regular pattern to these visual sweeps; both above and below the horizon and from forward to aft visibility limits on both sides of the aircraft should be searched. These visibility limits can usually be extended by rolling, turning, or skidding the aircraft in conjunction with the scan pattern. The scan should be allowed to sweep distant objects periodically (every few seconds) to provide adjustment of focal range.

Likely threat sectors should be limited when practical, possibly by flying very high or low, or by offsetting the threat sector to one side, and the most threatening area should receive the most attention. No sector, however, should be completely ignored for extended periods. Flying in pairs allows each pilot to concentrate his search toward his wingman, and multi-crew fighters can divide visual search areas of responsibility for maximum efficiency.

> What you find with your eyes is the movement, because the country is quiet. Then, all at once you see—movement; an aircraft.
>
> Colonel Erich "Bubi" Hartmann, GAF

Another useful technique is to move the head forward and back, and from side to side during the scan process. This helps clear areas hidden behind canopy rails, etc., and also aids in reducing the distraction of canopy scratches, bugs, and spots. Anything on a canopy will appear to move opposite to the direction of head movement, and the brain can use this motion to "filter out" these objects from external targets, which do not react to pilot head movement. There are two categories of fighter pilots: those who have performed, and those who someday will perform, a magnificent defensive break turn toward a bug on the canopy.

Although use of peripheral vision as the primary scanning mode does not generally result in tallyhos as distant as those provided by the sector-search method, the chances of seeing the bogey at all are greatly enhanced, and defensively this is the more important objective.

Camouflage

The value of camouflage as a means of hiding a military target is well recognized. Fighters, however, have a particular problem when camouflage is considered. Their mission makes it likely that they will be viewed from any direction: from above with a surface background, or from below with a blue-sky background. Additionally, since the range of aircraft is so great, surface coloration is likely to vary widely on each mission. The maneuvering requirements for fighters add to the problem, since from any direction the enemy might just as easily be presented with top, side, or bottom views of the aircraft as it rolls and turns in different planes.

Lighting conditions have a dramatic effect on the appearance of an aircraft. In front-lighted situations (viewed object fully illuminated) the actual shade and color of the aircraft are apparent, but when it is back lighted (viewed object in shadow) the presented surface appears to be a shade of gray and darker than its actual color. Since airplanes are generally very angular machines, the many appendages cast shadows on various parts of the aircraft, and these shadows move around as the fighter banks and turns. Regardless of whether an aircraft is up-sun or down-sun from the viewer, large portions of its body may appear to be in shadow, depending on its heading or pitch and bank attitudes. The greatest portions of the aircraft will be in shadow, and therefore will appear darker than they actually are, whenever the viewer and the sun are on opposite sides of the aircraft's nose (vertically or horizontally) or the plane of its wings. In general, these shadow patterns can change very rapidly and would be very difficult to predict accurately under real-time operational conditions, but if a camouflage scheme is to be effective, it must make allowance for these shadow effects.

One means of achieving this objective is to use fairly light colors overall, since a large portion of the aircraft is likely to appear darker anyway because of shadows. If the remainder of the surface is a lighter color, there is greater chance that either the light or the dark portions will blend well with the background at a given instant, which reduces the apparent size of the aircraft. If the entire aircraft is a darker shade it may be very difficult to see against a dark background, but it will stick out like a sore thumb when it is viewed against lighter areas. Lighter colors overall tend to offer a better compromise.

The actual color is not nearly as important as the shade. Bright colors should be avoided, however, since they rarely occur in nature and tend to attract attention. Dull, flat, pastel grays, blues, tans, and greens, although not highly inspirational, are much more effective for camouflage purposes. The actual colors are usually chosen to blend with the normal surface tones for better effect while the aircraft is on the ground or at low altitudes. High-gloss paint and shiny bare metal have no place on combat aircraft because of their tendency to reflect sun flashes. The actual colors chosen are not so important for two reasons. First, a large portion of the aircraft is likely to be in shadow and appear gray regardless of its real color. Second, colors cannot be distinguished at great distances. Even with the rather large size of many of today's fighters, it is usually impossible to distinguish between aircraft painted in muted pastel colors of the same reflectance (shade) at distances greater than two or three miles under optimum lighting and aspect conditions. (This is not very far in today's terms, since fighter turn diameters may exceed one mile, and even "short-range" missiles can be lethal from several miles.) Very bright colors, however, might be recognizable under the same conditions at distances greater than ten miles. The general rule is to avoid the use of colors that are distinguishable at normal visual ranges.

> Weapons should be hardy rather than decorative.
>
> Miyamoto Musashi

The most effective camouflage technique for fighter aircraft seems to involve the use of two or three different shades of paint of either the same or different colors (but all flat, light pastels). The camouflage scheme should be designed so that each view of the aircraft is composed of approximately equal percentages of each shade. The intent of this method is for one of the various shades to blend well with a given background, making that portion of the aircraft difficult to see and effectively reducing the apparent size of the fighter. A greater variety of paint shades increases the probability that one will blend well with the background but reduces the percentage of total area covered by each shade, and therefore the effect of blending is also reduced. This factor leads to a tradeoff in determining the optimum number of shades. Generally speaking, two shades seem to be best for smaller fighters, since a relatively large apparent-size reduction is necessary to make a substantial difference in likely visual range. Three shades may be better for larger fighters, as even a small percentage reduction in the apparent size of these aircraft can decrease visual range a great amount in real terms.

The camouflage pattern should appear to be random, much like shadows cutting across various parts of the aircraft, to break up the recognizable shape of the fighter. Whether straight lines or curves are used does not seem to make a great deal of difference.

Aside from making the aircraft harder to see, there is another important purpose of camouflage for a fighter, namely, disguising its attitude and maneuver. For this reason there should be no significant variation in the camouflage patterns or colors on the top and bottom of the aircraft. On fairly large fighters, even painting a mock canopy on the belly and simulated weapons rails on the top of the wings (to simulate whatever would be carried in a combat situation) can be extremely effective. Such camouflage patterns make it difficult to determine whether the fighter is turning toward or away from the enemy at medium ranges. The direction of this turn may be critical to the enemy's maneuver selection and also to his weapons envelope (is this a forward- or rear-hemisphere shot?). A good paint job can cause the enemy a few valuable seconds of confusion until relative motion clears up the ambiguity, and any delay or confusion in combat can be crucial.

The fighter pilot should be aware of his paint scheme and try to make best use of it during an intercept. Tactical advantage, however, must not be sacrificed for environmental considerations, as the enemy may detect the attack anyway and place the fighter at a severe disadvantage. The importance of avoiding light-colored clouds that could silhouette the fighter has been discussed before. An aircraft of essentially any color when viewed against a cloud background will stand out like a bug on a sheet. Approaching from out of the sun is also a well-known tactic from the earliest days, since a bright, high sun tends to restrict the enemy's vision. Other factors to consider are the shades (lightness or darkness) of the surface and sky backgrounds. Generally the pilot should look for a background that matches the average shade of his aircraft most closely. When in doubt, the darker background is usually better because of the darkening effects of shadows on the aircraft. Particularly when approaching from high or on the sun side, the fighter is more likely to appear much darker than when it is low or down-sun, where its presented surfaces are more likely to be fully illuminated and its real colors more prominent. It should also be recognized that the shade of the sky usually darkens looking upward from the horizon. Approaching a target at co-altitude is usually not a good plan, since pilots tend to spend most of their time looking level. In addition, the lighter background near the horizon often provides better conditions for visual detection, much like clouds. The pilot should be especially cautious about approaching out of a low sun that lacks brilliance. The combination of a light pastel background and the dark shadows on the back-lit fighter, with no visual degradation as with a bright sun, can lead to 30-mile tallys. Varied backgrounds, such as scattered clouds against a dark surface, or a variegated landscape, are often good for hiding against, since a high-contrast object is less noticeable with them. About the only uniform background that makes for a good approach is clear blue sky, since this presents the enemy with a focusing problem. Of course, whenever practical, the fighter's nose can be pointed directly toward the bogey to present the smallest possible profile view when the fighter is within visual range. Alternatively, collision-course intercept geometry can be used to reduce relative motion with the target, making detection by the enemy's peripheral vision less likely.

One condition that can effectively destroy the effects of even the best camouflage is low-level flight over a light-colored homogeneous surface on a sunny day. Even an aircraft as high as 2,000 or 3,000 ft may leave a nice black shadow on such a surface to attract the enemy's attention. Once alerted, the enemy can use spot-scanning techniques to pick up the actual aircraft in the near vicinity of the shadow. Darker or variegated surfaces generally do not present this problem. If he is forced to fly under these conditions, however, the pilot should carefully watch the surface for hostile shadows. It works both ways. This can be a useful defensive technique.

Other visual considerations in the approach are contrails and engine smoke. Little needs to be said about the effect of contrails on visual detection range, since probably everyone has seen airliners a hundred miles away. The contrail level simply must be avoided. Smoke can also be a very serious problem, as heavy smoke trails can be seen for twenty to thirty miles under some conditions, especially against light backgrounds. In addition to selecting a darker background and engine operating conditions that minimize smoke (discussed in a previous chapter), avoiding collision-course intercept geometry can also help. A fighter on a collision course tends to remain in one spot in the sky when viewed by the enemy, so the smoke trail appears to be concentrated behind the fighter and becomes darker and more noticeable. An early displacement turn away from the bogey's flight path, and stern-conversion geometry, can make the trail appear thinner and make it more difficult to see against lighter backgrounds.

Summary

The purpose for presenting many sample intercepts here is to acquaint the tactician with the various intercept concepts currently in use and to provide a selection of tactics from which to choose in a given tactical scenario. The first quality of any intercept tactic which must be considered is controllability: the reasonable assurance that the intercept can be completed in some manner. The factors involved here are both geometry and complexity. Stern-conversion and FQ intercepts, for instance, may be missed altogether if the bogey jinks away. The stern conversion is also generally more difficult to perform effectively than some others, and it may require a speed advantage over the target. Probably the easiest intercept to run is a pure-pursuit course, where the fighter simply holds the target on the nose. Unfortunately this technique provides little control over intercept geometry. When it is started near the bogey's flight path, pure pursuit usually results in a very high angle-off at the intercept with little fighter advantage. When it is begun with lots of target aspect, it generally ends in a tail chase, possibly well out of firing range. A pure-collision intercept is also fairly simple, offers minimum raid penetration, and probably provides the best chance of completing the intercept. Again, however, the geometry may not be optimum for a VID or weapons employment. The choices of intercept tactics should be limited by the capabilities of the aircrews, weapons systems, and air controllers. If proficiency is not high enough to ensure completion of a stern conversion, for instance, then tactics that employ simpler techniques, such as pure-collision geometry, should be chosen.

Probably the next most important factor to consider in selection of intercept tactics for use against fighters, or in a hostile environment, is defensive potential. Formation, separation, and flexibility are the keys to defensive potential. Many tactics require extended portions of the intercept to be run in trail formation or with very wide, offensive splits. Such conditions are not conducive to defensive mutual support. Flexibility becomes important when something unexpected happens, such as a radical bogey jink, attack by an undetected enemy, or perhaps the leader's radar shooting craps late in the intercept. A flexible tactic permits ease of adjustment to such circumstances by quick maneuvering, immediate defensive support, lead changes, etc. Flexibility is degraded by great distances between fighters, and particularly by nose-tail separation. Tactics that require an early shift into such configurations may be asking for trouble, particularly in poorly controlled situations.

The third most important factor in selection of intercept tactics is offensive potential. When the fighters are intercepting bombers or are in a permissive scenario, this factor may even be more critical than defensive potential. Offensive potential implies that the fighters will have a tactical advantage over the enemy at the completion of the intercept. This generally means arriving in a firing envelope before the enemy does, or at least being closer to this firing position than the enemy. Relative weapons capabilities are therefore essential to evaluating the offensive potential of any intercept. A head-on approach is offensive if the fighters have all-aspect weapons and the enemy does not. A stern conversion is offensive in most cases. The rules of engagement must also be considered, especially the requirement for a VID. Optimum offensive capability provides for the earliest possible VID, which generally implies some displacement from the bogey's flight path to generate a planform or profile view for enhanced recognition. Offensive potential is further improved if the VID occurs in the fighter's weapons envelope. Another desirable offensive feature is surprise: increased probability of an unseen attack by one or more fighters.

Unfortunately, there is usually a tradeoff between offensive and defensive potential, since the offense is normally enhanced by large splits, trail formations, etc. The general rule is to select the most offensive tactic available within the capabilities of the fighter crews which allows what is considered to be adequate defensive potential under the tactical conditions at the time. Obviously there is a considerable amount of judgment, experience, and tactical knowledge involved here. Usually two or three different intercepts are chosen, each of which is considered optimal in one likely combat scenario, and these tactics are practiced constantly under the most realistic conditions possible to develop and maintain proficiency. Then, when the pilots get their chance for real, they select the most appropriate tactic and go for it.