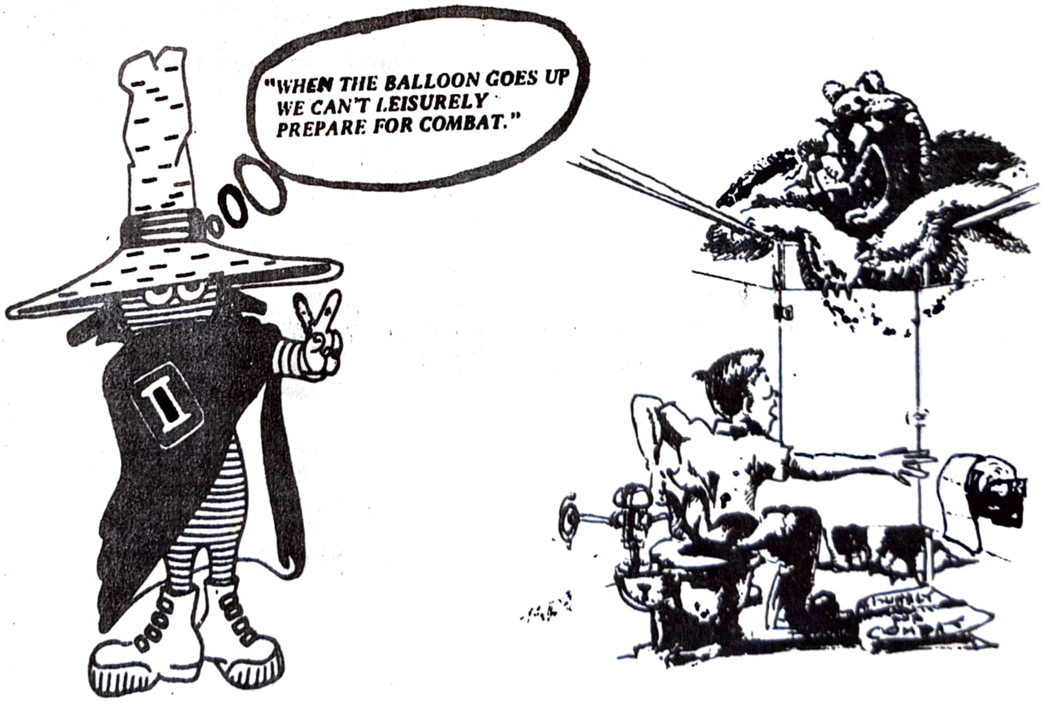
347 TFW
DOW

AIRCREW HANDOUT

NEW INFORMATION PAMPHLET # 30

DIVE TOSS



ARE YOU REALLY SERIOUS ???

Jun 80

347TFW/DOW
Moody AFB, GA 31601

Jun 80

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This NIP is designed to consolidate Dive Toss references, to aid aircrew training, and to increase meaningful cross talk between operations and maintenance.

NOTE for the reader. Initial printing of this NIP is limited. If you have corrections, additions, or complaints, put them in writing and send them to DOW for consideration during revision of this NIP.

DOW Staff

Maj Charlie Sarff
Capt Vic Hoffart
Capt Paul Thompson
Capt Terry Lester

Squadron Weapons Officers

68TFS: Capt Jack Moffatt
Capt John Phelps

70TFS: Maj Rick Schwartz
Capt Pete Tully
Capt Tim Rush

339TFS: Capt John Younghanse

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DIVE TOSS

Introduction

1. TALE OF THREE FIGHTER WINGS[1]

-- 1972, SEA: An F-4E Wing makes history through intensive maintenance systems peaking and thorough aircrew systems knowledge (systems knowledge forced by combat operations), and posts a 100' CEA for Dive Toss during combat operations.

-- 1977, CONUS: An F-4D Wing makes the news when Dive Toss systems cannot meet the accuracy requirements of aircrew qualification as listed in training manuals. Officials are required to respond to pointed questions--some based on fact and some based on innuendo.

-- 1978, CONUS: An F-4E Wing works hard at it's primary air-to-ground mission. Cooperation between Operations and Maintenance is high. Maintenance and aircrew experience is relatively high. Dive Toss is reliable and accurate; so much so, that aircrews would rather Dive Toss than Dive Bomb.

WHY DIVE TOSS?!

2. First lets talk about some times when you won't want to use Dive Toss, 1) In direct CAS with friendlies in the area and you cannot accept a long or short round. 2) Low angle high drag deliveries, and 3) planned 10° low angle bomb (you tend to shallow out and increase radar graze angle).

Note that the system has good capability down to 10° of dive angle according to the tech orders.

Note also that good success has been attained in high threat scenarios by this Wing when planning a 20° Dive Toss delivery with a 15° LALD backup for contingencies.

SO WHY DIVE TOSS???

- A good Dive Toss is invaluable in combat. The units CEA should remain constant with properly maintained systems, whereas Direct CEAs will not.
- With good aircrew procedures and techniques you can actually pull off the target earlier (pickle and pull) (not Dive glide).
- Dive Toss will compensate (within reason) for being off of parameters. Being off of parameters never happens in combat, right?, WRONG!
- Dive Toss will compensate for wind due to attack heading being different from that which was planned.
- Dive Toss will correct for unknown or unforecast winds.

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[1]Walker, Luke J., Rise and Fall of the Armored Knights, Chapter 3, "The Expansion Years".

- Long Range Dive Toss (LRDT) provides a measure of standoff for the non-PAVE SPIKE pod equipped aircraft which is delivering Laser Guided Bombs (LGBs) for a designator equipped aircraft. (Sounds like a highly probable mission for the 347TFW.)

- The same hamsters which generate the release signal for Dive Toss, also do the computations for PAVE SPIKE. If the Dive Toss associated systems such as the INS and WRCS are not well maintained, you give up your automatic PAVE SPIKE releases and your standoff delivery capability for designator aircraft.

DO YOU HAVE A GRIP!?

3. Maintenance: Let's look at maintenance first, since proper maintenance is essential for keeping the systems in top condition. A unit must continually take a hard look at:

----Maintenance personnel short falls. What is being done to fill key maintenance slots in AGS and CRS with respect to INS, WRCS and WCS systems?

----Skill level and experience of personnel. Is more OJT required in some cases?

----On-the-job-training (OJT). What is the depth and quality of the OJT which is being conducted? Do the young guys get to work with "real" experts during OJT or are they just told to "go for it"?

----Formal training such as FTD courses. How many personnel are qualified to attend; and how many have attended? Get a Grip! especially if FTD is located at your own installation.

----Supervision: Is supervision sufficient? Do supervisors care about the maintenance of so-called "nice-to-have" systems? What attitudes do they project to the guys on the line?

----Quality Control: Are QC levels sufficient?

----CND Rate: A continuously high CND rate could mean 1) aircrews don't know the systems, 2) a quick CND is easier than indepth troubleshooting of associated systems, 3) Maintenance personnel don't know how to troubleshoot systems, 4) proper test equipment is not being used, or 5) that occasional F-4 with weird electrons running around.

----Repeat and Recurring Writeups: Obviously indicates that the problem is still there and will require more work. Yes, sometimes it is difficult to isolate sources of trouble.

----Maintenance of INS: Tolerances held to 3nm/hr terminal PP error (present position Lat-Long counters); and eight Kts/hr or a maximum of 15 knots terminal ground speed.

----Maintenance of WRCS: Proper adjustment of WRCS θ pitch (dive angle) voltages. OSDU problems.

----Maintenance of Radar: Includes Range/Slope zero circuits, radar synchronizer, automatic gain controls, radar antenna boresight, and radar ranging voltages (air-to-ground optimization is 10 volts).

----Servicing of Engine Oil. Noted by some units as an aid to maintaining proper electrical frequency production.

4. OPERATIONS:

----Aircrew training. Are aircrews getting into the books on their own; or do they expect to be spoon fed? If you don't know how the system is supposed to operate, how can you employ it properly?

----Inflight techniques: Got a clue, Ace? Talk to the Weapons Officer. Get into the books.

----BIT checks, Systems checks, Inflight checks: Do you know what checks to do and what to look for?

----System writeups. Do aircrew conscientiously writeup systems? Are writeups clear and indepth? Bogus, unclear, weak writeups don't help maintenance in finding the problems. Another example is that if you had to aim 250 feet long to get a scoreable bomb, you need to writeup the system since it was out of tolerance.

----Squadron Dive Toss Monitor Program: How effective is it? Do you work closely with your AMU?

----Crew coordination: What's your plan for a bad lock or range gate wandering down the chute? Does everyone understand what the standard verbal calls mean?

----Fill out INS data cards (front and back) (MAFB Form 44, Inertial Navigation Flight Data Record) and turn them into maintenance debrief.

5. SYSTEMS CHECKS (See Also FWS Texts and T.O. 1F-4E-34-1-1)

a. BITS

(1) WRCS BIT - GO/NO GO: This will only warn off castastrophic circuitry failure.

(2) BIT 3: Checks radar synchronizer. No Aim Dot rotation is an indication of probable synchronizer problems. If the Aim Dot rotates outside of limits the automatic gain control is not working properly and you may have problems in getting or maintaining a lock in A/G. If locked onto the 10th target in BIT 3 and you get an HOJ indication, the synchronizer is bad.

(3) BIT 5: If auto-acq will not pass the first target, the synchronizer is bad. With A/G selected and locked onto the 4th BIT target, the B-sweep should gain out (clear) except for the range gate and a small amount of target. If the B-sweep does not gain out, suspect automatic aim control (AGC) problems. Ocassionally some of the other stronger BIT targets may be visible, but the B-sweep trace should be gone. If the range gate is placed between two targets (e.g., 2nd and 3rd) the range gate should sweep out to the 3rd target. Some "breathing" of the range gate is normal, but excessive wandering is not.

(4) RANGE/SLOPE ZERO CHECK: Radar - BIT 5, A/G, 5nm. Sight - A/G. Lock-on to 1st, 2nd and 3rd targets successively. The sight analog bar should read 5 o'clock, 3 o'clock, and 1 o'clock respectively. A slope error increases with range (e.g., with the lock-ons to the successive targets a slope error could appear as 5 o'clock, 2:45 o'clock, and 12:30 o'clock). A zero error is constant (e.g., with the successive lock-ons the error could appear as 4:50 o'clock, 2:50 o'clock and 12:50 o'clock). You can make a correction for a zero (constant) error, but accurate corrections for a slope error are difficult at best.

NOTE: With the sight in A/A and locked onto the 1nm A/A BIT target the VI meter and sight analog bar will read close to 5,800 feet in aircraft with the radar optimized for air-to-ground (1Øv).

(5) STATIC Release Check (Also called Quick Release Check or Drag Down Check)

(a) Dive Toss selected; Radar in A/G; BIT 5; locked onto 5th BIT target; Armament override - IN; Bombs; all stations deselected; INS in NAV; aircraft stationary.

(b) Set drag coefficient at about 1.00 and pickle. You will hear the release tone generated. Decrease the drag coefficient smoothly. The tone should cease at 0.03+0.02 in the drag coefficient window. Note that vertical velocities from the INS through the OSDU and dive angles are not inputs to this check.

b. Inflight Checks

(1) Determine INS accuracy (especially dirft errors and drift rates). Verify the wind within the flight.

(2) Check LCOSS drift against HSI/BDHI (Dive Toss selected and sight A/G).

(3) Check B-sweep drift (Radar - A/G and Dive Toss selected). Antenna should be looking where the sight is looking.

(4) Check INS present position in target area. It could be an indicator of INS drift rate.

(5) Conduct a dry dive toss pass - use planned dive angle and drag coefficient. Check that the radar maintains lock and range gate does not wander. Skin track light should be on. B-sweep should gain out. ASE circle should be present. LCOSS analog bar should come down smoothly and with no hang ups. Sight should not flash. Sight should be drift stabilized to put aircraft upwind of target. Check that the release tone is generated and that it ceases during the pullup as expected. Pullup light should come on.

c. GOOD LOCK-ON INDICATIONS

(1) Fixed ASE circle.

(2) Most of the target return gains out.

(3) B-sweep clear.

(4) Range gate tracks smoothly.

(5) Skin track light - on.

(6) FCP analog bar stable and decreases steadily.

d. BAD LOCK-ON INDICATIONS

(1) FCP searching analog bar.

(2) No Skin track light.

(3) Erratic range gate.

e. Full gyro-compass (GC) INS alignments on internal aircraft power are required for good Dive Toss success.

READ ON FOR MORE INFORMATION
See also FWS Texts
and TO 1F-4E-34-1-1

ARE YOU REALLY SERIOUS ABOUT DIVE TOSS?

Dive Toss: Another Instructor's View

by Capt Thomas Dyches, 414th FWS, 1977
[Edited by 347 TFW/DOW]

INTRODUCTION

Lots of people refuse to use the dive toss system because they don't really understand it. Properly maintained, however, the dive toss is very capable of giving outstanding results. An example of this is the SEA turkey shoot 39' CEA for a flight of 4 (6 bombs each) in high altitude dive deliveries (15,000' S/R). That's hard to beat. In addition the dive toss system is dumb--it doesn't realize that someone is shooting at you. It will give you the same results, CEA wise, in combat, as it will on a controlled range. Another big advantage is being able to pickle and pull out immediately, thereby reducing straight and level time on final and increasing your survivability. Another advantage is that being at other than preplanned parameters doesn't ruin your pass. It will compensate for that to some extent. You can attack from any heading and not be faced with recomputing wind values, etc. In actual combat conditions properly maintained dive toss systems have been proven to be more accurate.

SYSTEMS OPERATION

The dive toss uses radar slant range to determine:

1. The ground range to the target, and
2. The altitude above the target at pickle

Once these two things are done the system integrates vertical velocity and ground velocity from the INS to update the airplane's position relative to the target.

The system uses the aircraft velocity and the horizontal range to the target to determine the proper bomb range. The computer uses the drag coefficient that you set in to identify the type bomb being dropped. The bomb comes off when the computer solves this equation. What that all boils down to is that when the computer sees that the actual aircraft altitude is equal to the altitude required for the bomb to travel the proper computed time interval, it pukes the bomb off.

Now let's look at the operational envelope of the system. Realize that the numbers on the envelope only indicate design computer accuracy limits. In practice you can get much more accurate bombs than this. You'll notice that at longer slant ranges accuracy goes down. Makes sense, right!

WRCS limitations restrict us to:

1. 2500' to 25,000' slant range
2. dive angles of between 10^{o} and 60^{o}
3. airspeeds of between 300 and 650 KCAS
4. 18,000' max altitude
5. climb angle of 10^{o} or bomb cancel (we've found this isn't really so).

Generally speaking you'll get the best results when dropping in the heart of those parameters. Obviously tactical considerations will frequently dictate other than heart of the envelope releases. The system can still be good for area munitions at very long slant ranges (good standoff).

GROUND PROCEDURES/DELIVERY TECHNIQUES

INS

There are lots of things you can do to help your dive toss accuracy. One is to realize how important the INS is to the dive toss system. As a weapons officer you need to make sure that the crews religiously write up INS systems that are out of tolerance; and you must work closely with maintenance to insure that they understand the importance of good INS performance. The system uses the INS for drift, pitch angle, ground speed and vertical velocity integration; and if you don't have a good INS you can't really expect good dive toss accuracy.

To give yourself the best shot you've got, you should always make sure to get a good alignment on internal power (2 preferred). Allow it to flash as long as feasible to minimize NAV time and, therefore, errors. As a flight lead it is a good plan to allow sufficient time for good INS alignments whenever possible (arming area, etc.).

WRCS

The WRCS normally doesn't cause a lot of problems. You do need to make sure maintenance checks the WRCS voltages regularly, particularly if you can determine that an airplane has a consistent pattern of dropping long or short. Sometimes this is caused by bad pitch angle voltages which causes the computer to see a different pitch angle from that of the actual aircraft pitch angle. This obviously induces an error.

WRCS inputs that you have direct control of are drag coefficient and release advance. Maintenance sets ejection velocity, and some places use different ejection velocities with varying degrees of success. McDonnell Douglas did some extensive testing in this area and came up with a figure of 75 milliseconds as the optimum rack delay, for vertical and horizontal acceleration, regardless of whether you're talking about a MER, TER or SUU. Nellis (57 TTW) uses 75 milliseconds, but you might check on your own base and find out what they are using and why.

The drag coefficient you set in is found in the -34 and varies with the type bomb and planned release conditions. The WRCS BITs being good, basically means you have a good chance of not having a catastrophic malfunction. A NO GO means you are fairly likely to have a failure.

Release advance is set in only when you plan to drop a stick of bombs. If for example you wanted to drop a 5 bomb ripple (or any odd number) and you wanted the middle bomb on target, you could use the formula:

$$RA = \frac{I_R\ (N-1)}{2} = \frac{.1\ (5-1)}{2} = .2 \text{ or } 200 \text{ milliseconds}$$

Where RA = release advance
IR = intervalometer setting in M_S (milliseconds)
N = number of bombs to be released

If you wanted to drop an even number of bombs, let's say 6, and you wanted to bracket the target with the 3rd and 4th bombs, use the same formula:

$$RA = \frac{I_R\ (N-1)}{2} = \frac{.1\ (5)}{2} = .25 \text{ or } 250 \text{ milliseconds}$$

If you wanted the 1st middle bomb on target (i.e., 3rd bomb) use the formula:

$$RA = \frac{I_R\ (N-2)}{2} = \frac{.1\ (4)}{2} = .2 \text{ or } 200 \text{ milliseconds}$$

If you wanted the 2nd middle bomb (i.e., 4th bomb) on target use the formula:

$$RA = \frac{IR\ (N)}{2} = \frac{.1\ (6)}{2} = .3 \text{ or } 300 \text{ milliseconds}$$

If you don't want a stick, RA = 0. Make sure that you zero out release advance after the BIT checks.

RANGE SLOPE/ZERO CHECK

This is another important check (F-4E only) as it checks the range slope zero circuits which provide a reference for radar range calibration. If range slope zero is inaccurate all radar ranges will be affected and this will affect the position of the analog bar on the optical sight and will affect the accuracy of dive toss. In the F-4E, A/G, BIT 5, 5nm lock onto the first, second, and third targets successively. The range analog bar should read 5 o'clock, 3 o'clock, and 1 o'clock respectively.

If instead, your analog bar is at 4:50, 2:40, and 12:30 you have at slope error. This is not a linear error. But the synchronizer is still the most common problem we have. If you have a bad synchronizer and for some reason have excessive ground returns (operator factor or you are on a low angle delivery perhaps), you can expect the range gate to wander around trying to find the strongest return. If it doesn't happen to be there (on the strongest return) at pickle you have a bad slant range input.

B-sweep noise after lockon should disappear except for a very small portion of the return that the range gate is tracking if the AGC (automatic gain control) is functioning properly.

Some synchronizer breathing is a normal part of the range gate tracking process. I think you'll notice it more with DSCG airplanes, but don't sweat it.

The "biggie" is making sure that range gate doesn't go wandering off somewhere after lockon, but prior to pickle. If it does--manual track (also called hand track). Theres not much you can do about it except write it up. The -34 recommends using another delivery mode. I recommend dropping a bomb and checking where it hits.

If your analog bar is at 4:50, 2:50, and 12:50 you have a zero error. In this particular case the analog bar is "long" of where it should be and the bomb will also be long, so you need to aim a little short to compensate for this. Theoretically, you should aim short of the target the amount of error noted (i.e., 500' in this example x cosine of dive angle). In practice, aim a little short (about 3/4 of the error).

Another important part of the radar checks involves the range gate. It must track the target smoothly during the pass in order to provide an accurate slant range at pickle. This has to do with the synchronizer, which has been a real problem for maintenance in the past with F-4Ds, but less of a problem with F-4Es.

You can get a fair idea of how good your synchronizer and AGC are functioning during the ground checks.

1. BIT 3: lockon to 10th target. If the HOJ light comes on you probably have a bad synchronizer. If the aim dot rotates out of limits, suspect AGC problems.

2. BIT 5 auto acq check: if it won't auto acq past the 1st target, the synchronizer is bad.

3. BIT 5: lockon to 4th target and the B-sweep should clear except for the range gate and a small target return by the range gate. If you still have noise in the B-sweep or other targets present after lockon, suspect a bad AGC and possibly synchronizer too.

AIRBORNE CHECKS

All the checks done on the ground can give you a reasonable clue as to your dive toss capability, but there are several more things that can be done once airborne to further build your confidence in the system.

The first thing I like to do is get a good check on the accuracy of my INS inflight. I try to verify the wind and drift that I am reading with that of the other flight members.

Then I check the gunsight to make sure that the drift it is displaying agrees with the drift I am reading on the HSI/BDHI. I need to be in A/G on the sight mode selector and Dive Toss on the Weapons selector for this check. The sight should shift downwind 17.5 mils per degree of drift. If it doesn't I'll go cage and manually offset for any crosswind I might have. Occasionally a sight will shift into the wind (BACKWARDS).

When I am approaching the target area or in it, I'll check the INS present position against my actual coordinates. If a large error exists I may not elect to use dive toss.

When I checked the sight displacement for drift, I should have also checked the B-sweep for drift. It is sometimes difficult to tell precisely how far it has moved, but at least it should move in the proper direction.

Some place enroute to the range I like to roll in and go through a dry dive toss pass; or at least lockon during a non-dive toss delivery on range and check that

1. the skin track light comes on.

2. the range gate tracks the target properly (doesn't drift off). If it drifts off or won't lockon plan on manual [hand] track).

3. the AGC gains out excessive returns.

4. the ASE circle appears after lockon.

5. LCOSS analog bar comes into view after lockon.

6. check that I do get a release signal.

All these checks are real fine and do serve to build your confidence in the system, but by far the best way to check the system is to drop a bomb (practice bomb) and see where it hits. If you have a place to do this it's highly recommended. Its nice if you have a row of targets to attack--at least three (3). Then you can roll-in along that axis at planned parameters and pickle on the middle target, making sure to note the mils displacement from the pipper of the other two. For example:

In this case one target is 12 mils long--one 12 mils short. Then I note where the bomb hits--let's say between the 1st and 2nd targets. I can then say that the system appears to be hitting 6 mils short and can aim 6 mils long to compensate for that error.

DELIVERY TECHNIQUES

Delivery techniques are similar to those used in manual dive bombing, with a few exceptions. The main differences lie in sight handling, lockon techniques, and recovery.

A good dive toss pass begins with having the switches properly set up. Sounds easy, but more than one of you will blow a pass because of a switch error. You have all heard this a million times and will hear it a few million more times before you turn in your G-suits, but it still bites us in the a-- all the time.

The whole pass is still affected by the wind, so don't forget about it. Adjust your base leg, and roll-in point to allow for the wind. Some guys think that all your problems are solved if you are in dive toss, so they disregard winds and other parameters such as dive angle, pickle slant range, etc., and wonder why they don't get good dive toss scores. If you try to fly as close to planned parameters as possible you'll get better scores. Why do you think they give you all those dive toss tables and different parameters? Seems obvious!

From the WSO's viewpoint, optimum tuning of the return can be fairly critical because we want to make sure we get a main beam lockon. It is possible to get a side lobe lock which obviously will cause an error. Getting the return gained down to minimum size should preclude a bad lockon. This is sometimes difficult in low angle events. I recommend that you experiment with full-system automatic lockons and manual (hand) tracking and compare the results. I find that good results are possible with both methods, and a lot of pitters swear by manual (hand) tracking. In tactical scenarios automatic tracking has some very obvious advantages, like freeing the pitter to check six or the wingman, etc. Thats why I recommend being very critical of the systems. If they don't track properly with an automatic lockon--write'em up.

The rules of thumb for where to lock-on to the returns at different dive angles are probably good, particularly if you suspect a synchronizer problem (i.e., the center of the return for dive angles of 30^{o} or more; the 1st 1/3rd of the return for dive angles of less than 30^{o}). If your synchronizer is good it will take care of getting onto the strongest return automatically.

Indications of a good lock should be checked. They are:

1. fixed ASE circle.
2. all but a small portion of return gains out.
3. rest of B-sweep is clean.
4. range gate tracking smoothly.
5. skin track light on.
6. analog bar is stable and decreases smoothly.

A bad lock may be indicated by:

1. a searching analog bar.
2. an immediate break lock.
3. no skin track light.
4. an erratic range gate.

It's not really critical that you be wings level prior to lock-on in E models. But in D models it is important.

There are two major types of deliveries using this system, 1) dive toss and 2) dive glide. Dive toss involves a 4G in 2 sec wings level pull immediately after pickle. A dive glide maneuver involves a lower G (usually 2G) pull to break the dive. Primary advantages of the dive toss maneuver are that they allow you to recover at a higher altitude and it reduces your wings level exposure time on final (i.e., you are predictable for a shorter period of time).

The dive glide maneuver has some advantages and disadvantages too. We'll discuss them in a minute.

We also have the option of using a caged sight with Drift Out selected in the rear cockpit; or the fully drift stabilized sight and radar which we'll discuss in further detail later.

The dive glide maneuver has proven more accurate than the dive toss for several reasons. The lower G pullout allows the pilot to see the target longer and therefore comes closer to flying across it and as a result reduce azimuth errors. It also tends to give that old and slow analog computer a little more time to solve the ever changing problem that it sees, thereby providing a more accurate solution. The lower G at release also helps minimize problems that plague the toss maneuver such as:

1. delayed rack opening.

2. bomb lug hang up.

3. damaged suspension equipment.

4. long stick lengths.

So overall with the glide maneuver you get better accuracy, but more exposure time. The tradeoffs you make will be based on tactical considerations.

Let's contrast the use of a drift stabilized sight versus a caged sight. The big advantage of using a drift stabilized sight is that it really is a big help in getting the crosswind problem solved; so that my airplane's ground track is projected through the target. This is particularly difficult to estimate for long slant range, standoff type deliveries. The big disadvantage of using it is that the drift stabilized sight is sloppy. During roll-in it bounces all over the combining glass and there is a tendency among many people to chase it around. To overcome that, roll-in disregarding the sight until it has a chance to settle down. Aim up wind just like a normal manual dive bomb delivery. Wait until the sight settles down a little and then track.

The triple ranging analog bar helps you determine slant range. Its better to pickle at the planned slant range--better accuracy.

Roll tabs can be used to aid in establishing a wings level pull.

A flashing sight tells you that the system has aborted for some reason and needs to be reset by cycling out of dive toss and back in.

There are times when using a caged sight and having the WSO select Drift Out can be beneficial. For example, if you have known wind shears, the drift stabilized sight will be rapidly changing its azimuth solution and you will have lots of trouble trying to follow it. Caged helps here. It also helps if you have planned a short slant range delivery, particularly when tracking time is at a minimum (which hopefully it will be if you're at a short slant range), because there is little time for you to allow the sight to settle out in this type of delivery. Another time you might want to use it is when you have extreme crosswinds. The system will only account for 25 knots of crosswinds. Anytime you use CAGE and Drift Out you should manually offset into the wind for whatever crosswind component you have figured.

TARGET TRACKING

Personally, I believe that you can cut your dive toss scores in half by "tracking" the target in much the same way that you track a Mig or a strafe target. Instead of letting the pipper drift through the target and pickling as it passes through, I try to slow the rate of pipper movement toward the target so that as the pipper actually arrives on the target it is stopped there. I "track" momentarily, pickle, and continue to track or follow through. I think this gives a better, more stable slant range input to the system. At least I have had significantly and consistently better results using this method. In all cases after pickle project, your ground track across the target. Biggie!

LOW ANGLE TECHNIQUES

Very good results can be achieved with the dive toss down to about 10^{o} of dive angle. Below that, the accuracy deteriorates very rapidly. For that reason, anytime I plan a low angle dive toss delivery I make damned sure not to get shallow. Another thing I have noticed about low angle dive toss is that nearly all airplanes will drop a little short. I use the bottom eyebrow as a pipper in low angle unless I know that airplane's track record in low angle from my squadron's dive toss records.

FUDGE FACTORS (tweaking C_B) (on scoreable ranges)

Some guys use a change in drag coefficient to adjust the bomb impact. For example, if your first bomb hits long, let's say 150 feet long, you need to subtract some drag coefficient thus telling the computer that the bomb is a little cleaner. Therefore it should release sooner. All kinds of numbers are used, but I use a .01 correction for every 30-40 feet:

CREW COORDINATION

As in most F-4 operations, crew coordination is a very necessary part of the dive toss delivery. Good coordination is needed to prevent dry passes. You need to work up some kind of terminology to use between the two of you. It should be as concise as possible, and apply to checks on the system as well as normal operations.

It's also very important that I have a planned backup if everything goes to hell in a hand basket. A backup mil setting should already be dialed in for a Direct delivery at a 5^{o} shallower dive angle than the dive toss delivery was planned (because of AOD). Use whatever terminology you are both comfortable with in the cockpit.

Your indications of release are:

1. pull up light comes on.

2. tone ceases.

3. analog bar goes away.

4. bomb(s) "thump" off the aircraft.

PROBLEM AREAS

Rough terrain can cause a side lobe lockon. That radar beam is 120 mils wide, so try to put the pipper on the nearest flat spot thats close to the target and fairly close to target altitude prior to lockon when you have to bomb in rough terrain. A steeper dive angle will help reduce the problem but that might not always be feasible.

Some times you will get an instantaneous release or no release at all. If that happens you can help isolate the problem for maintenance by trying a dive laydown delivery. If you get a good release in this mode, you have a problem with the Vertical Velocity input, because Dive Toss and Dive Laydown use exactly the same inputs except dive toss also uses vertical velocity and drag coefficient.

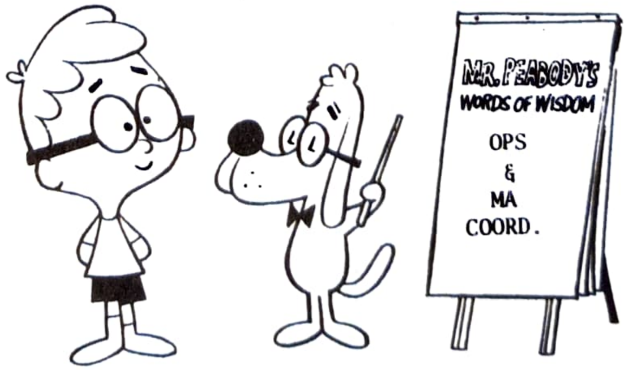
Generally no release means a bad climbing vertical velocity input and an instantaneous release means a bad diving vertical velocity input.

As a weapons officer you need to make your crews aware of this to insure that they are capable of making good writeups. It takes maintenance 16 hours to fully bench check the entire system properly. If you can help them isolate the problem, you can save them a lot of work. You'll get them on your side and you will probably find a lot fewer CND's.

Stick length is a major factor in dive toss, particularly if you have a point target. If thats the case, use dive glide whenever feasible to reduce stick length. The release advance also must be set to center your pattern on target (as we have already discussed).

Operations Officers, Weapons Officers and Dive Toss Monitors can really make or break the Dive Toss capability of his Wing/Sq depending on how he handles maintenance and operations relationships. Take it upon yourself to coordinate the work done by the radar, WRCS and INS shops in CRS, and under POMO, much emphasis must be placed on the work done by AGS. If you get yourself familiar with the work on the flightline and in the various shops, the people down there will be genuinely interested in what you are doing. Little things like letters of appreciation, attaboys, and occasional pats on the back go a hell of a long way towards improving your combat capability. Everyone appreciates a little recognition, so give 'em some. Those guys can give you lots of help on technical problems--use it.

You can also help yourself out by keeping a track record of each aircraft's performance over a period of time. The airplanes tend to be consistent, so if you can go out with a good idea of where the system has been dropping you can make a compensation on the first pass and save yourself a quarter. The big problem here is getting the crews to religiously log their scores; and making sure that the form you use to log those scores has a block to log important delivery data. The analysis of gun camera film to confirm pipper position can be very helpful.



FWS Text Excerpt

(Contains F-4D and F-4E Information)

DIVE TOSS

1. INTRODUCTION:

a. OBJECTIVES: At the end of this period of instruction, the student should:

(1) Be familiar with the dive toss system components and operation.

(2) Know and understand how to help maintenance provide accurate systems.

(3) Know and understand dive toss delivery techniques and procedures.

(4) Know and understand system malfunctions and how to compensate for them.

b. MOTIVATION: Many aircrews are reluctant to use dive toss due to a lack of knowledge of the system's operation and capabilities. It has been conclusively proven that well-maintained systems employed by knowledgeable aircrews have significantly reduced CEAs and combat losses. Its accuracy at variable release parameters, in unknown wind, cannot be ignored.

2. SYSTEM OPERATION:

a. The dive-toss delivery mode is unique in that the only preplanned parameter required by the system is drag coefficient (release advance may be required for multiple releases). This delivery mode is the most versatile of the WRCS modes for low drag munition delivery. A random approach to the target may be made on any heading; a dive may be initiated toward the target from any angle between 10 and 60 degrees; and a pullout commenced prior to weapon release. This combat tested delivery has reduced CEPs and allows release altitudes that are above the effective range of the deadliest anti-aircraft fire. Weapon release may occur at any altitude or airspeed thus the aircrew is not tied to a preplanned set of delivery conditions to insure a hit on a target. The relative simplicity of this mode reduces the training problem of inexperienced aircrews and allows the green pilot to score as well as the experienced dive-bomber with a minimum of indoctrination sorties.

b. The drag index that is inserted into the computer control panel is extracted directly from ballistics tables and no further premission planning is required. Unknown wind, the greatest single accuracy degrader, is compensated for by the system during the delivery and the only error remaining is bomb trail which is minimal for low drag munitions.

c. The radar is the primary range finder for this mode of delivery. As in dive-laydown, actual range-to-target is sampled by the computer at the instant of pickle. The radar is operated in the air-to-ground mode and the 5- or 10-mile range (10-mile F-4D). The pilot selects A/G on the LCOSS and the sight becomes drift stabilized at 35 mils depression when dive-toss is selected on the bombing mode switch. The radar antenna is also drift stabilized thus the pipper position is also the center of the radar beam. As soon as the dive is stabilized toward the target with the sight pipper in the general vicinity of the target, radar lock-up to the ground return may be accomplished by the aircrew member in the rear cockpit. Prior to lockup, the scope must be tuned to optimum ground return to insure accurate main beam lockon. Optimum tuning is defined as that gain setting just prior to return breakup on the scope. For shallow dive angles the return will naturally be longer in range than for steeper angles. Optimum tuning for a 25-30 degree dive angle will yield a return of approximately 1/2 mile in length. When the tuning is sufficiently accurate, the acquisition symbols are positioned to bracket the return and the action trigger depressed to 1/2 action. The range gate will appear centered in the acquisition symbols and may be moved to the center of the return with the radar control handle. The trigger is then depressed to full action and the set is locked to the return. The high intensity center of the beam (approximately 14 mils) will be tracked by the range gate. Lockon may be detected by the appearance of the range analog bar on the sight reticle, an ASE circle on both scopes and an illuminated skin track light on the radar (angle lock light on the APQ-109 provided this circuitry is selected). A lockon to side lobe energy will induce errors in the release but usually will be detected by a searching analog bar or break lock. Aircraft attitude at lockon is not critical. Range rate is the critical factor for maintaining lock for other than wings-level lockons. Lockon may be accomplished inverted and maintained if a smooth, constant rate rollout is performed. This smooth rollout will be seen by the radar as a constant range rate and the lock will hold.

d. For shallow dive angle lockons, (<30°) the range gate should be positioned approximately 1/3 of the distance up the return length to insure lock to the center of the nutating beam. Figure 7-1 depicts the reason for this rule-of-thumb, i.e. increased graze angle of the radar beam which lengthens the return on the far side.

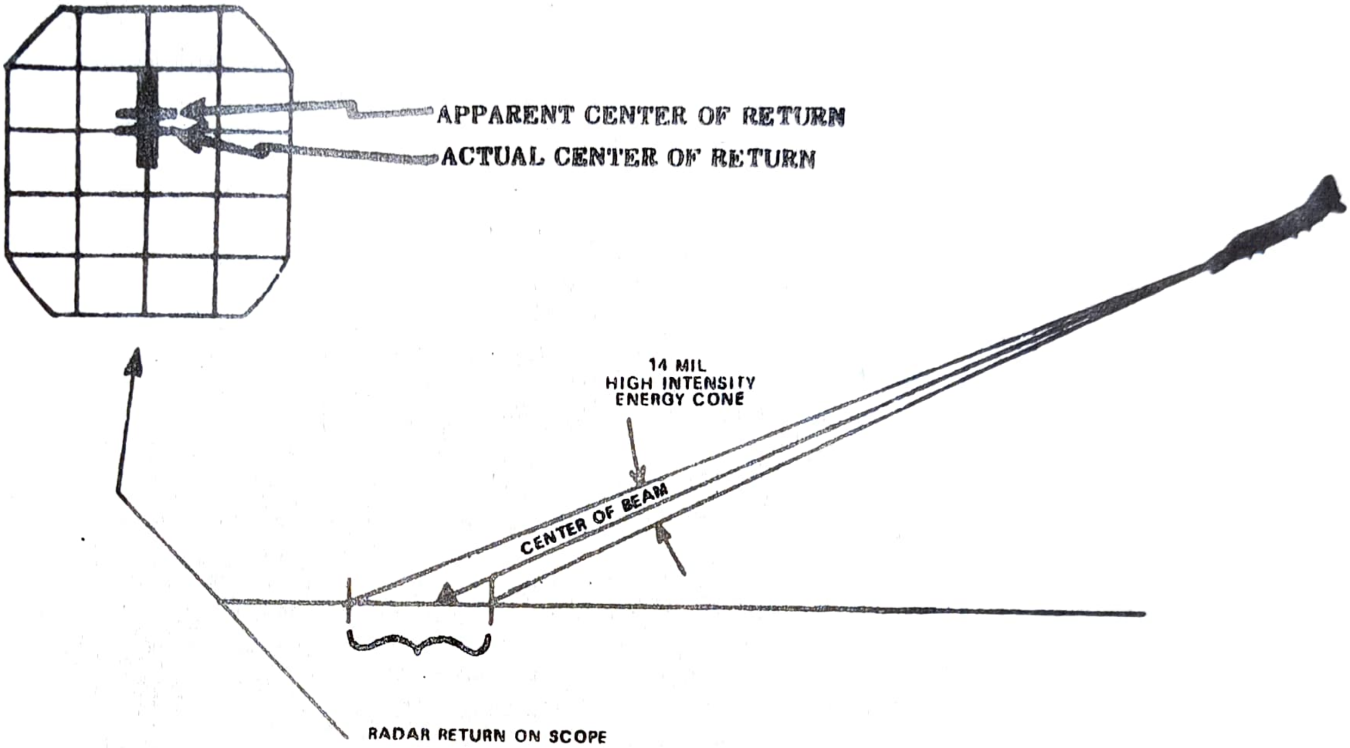


FIGURE 7-1

e. After lockon to the return, the pilot may begin the delivery maneuver. Two factors will determine the accuracy of the delivery; ability of the pilot to accurately track the desired point of impact and execute the pullout in a perfectly wings-level attitude. Tracking of the target must be accomplished with as much finesse as in tracking a dart or strafe target. This may be difficult since the sight reticle will be offset right or left to compensate for the wind sensed by the INS platform at that point in space. The pilot should attempt to hold the pipper stabilized on the target for at least one second before pickling to insure a stabilized range rate is seen by the radar. Variances in winds encountered in the dive portion of the delivery will cause the sight to deflect in the appropriate direction to crab the aircraft directly across the aiming index (pipper). The delivery computation commences at pickle. Radar ranging is no longer required after depressing the pickle button. After pickling, the pilot begins a wings-level pullout until weapon release. Two displays aid the pilot in maintaining the wings-level attitude. The best reference is the sight roll tabs compared to the indices. An alternate indicator of wings-level attitude is the bank steering bar (BSB) on the ADI. Yaw/roll steering information to heading at pickle is available but of limited value. The sensitivity of the BSB (3:1) makes it very difficult to fly and additionally the pilot must shift his vision from the target to the ADI.

f. The computer was designed for a 4-G wings-level pullout initiated in 2 seconds for the dive-toss mode; however, combat and range experience has indicated that the dive-glide maneuver yields higher accuracies. The dive-glide maneuver is merely a lower G pullout initiated to break the dive angle, then G is relaxed until weapon release. This type delivery also minimizes bomb release problems such as delayed rack opening or bomb lug hang-up.

g. Rapid-G onset and higher than four-G releases are discouraged because of reduced accuracy and the chance of damaging release and suspension equipment.

h. Indications of fire signal generation are illumination of the pullup light, cessation of headset tone and disappearance of tne range analog bar on the sight. A continuous head-set tone will be heard from time of pickle to fire signal generation.

i. Problem cancellation or early release of the pickle button will be detected by cessation of the headset tone and a flashing sight reticle. The delivery cannot be continued if this occurs. To reset the system, cycle the bombing mode selector from dive-toss to another mode and back.

j. Computer solution of the dive-toss bombing problem is initiated at pickle. Computer mathematics of the solution are as follows: At pickle, dive angle (θp -2°) and radar slant range (R_S) are summed to compute altitude at pickle (H_0) and initial ground range-to-go (R_{GO}). Ground speed (V_G) and ground range at pickle are integrated to compute the decreasing range-to-go. The change in vertical velocity (V_V) is integrated to compute the vertical distance traveled from pickle point and summed with H_0 [$H_0 = R_S SIN(\theta P - 2°)$] to provide a constantly changing height (H). Actual internal operation of the ballistics computer that results in the fire signal generation occurs in an amplifier circuit (Σ4A) that compares the effect of drag coefficient(handset) and gravity on the bomb trajectory, vertical release advance (if used), vertical bomb rack delay time, present aircraft altitude, and time of fall times instantaneous bomb velocity. When the amplifier output is zero, the circuit is shunted to ground. This event occurs when the computer "sees" that the time required for the bomb to fall to the target in a vertical plane equals the time required for the bomb to travel the remaining distance to the target in a horizontal plane. This results in the fire signal and weapon release. See Figures 7-2 and 7-3.

k. Rack delay time and ejection velocity are calibrated inputs to the equation and must be set by maintenance personnel. These factors will be further discussed later in this text.

l. The drag index (coefficient of drag) value that is preset by the aircrew is not a real value for the weapon carried. This value is merely a reference number that specifies a certain set of conditions in the ballistics computer that governs the initial parameters for the amplifier circuit that solves the problem. The drag coefficient (C_b) is directly related to the ejection velocity (V_e) setting in the computer. Thus, V_e must be properly calibrated for C_b (set by the aircrew) to be valid for the weapon aboard. Maintenance TOs thoroughly cover the adjustment of V_e.

m. Figure 7-4 depicts the operational envelope and expected accuracy of the dive-toss mode. Dive angle limits at weapon release are 60° of dive to 10° of climb. The accuracy of the computer is not guaranteed for climb angles above 10 degrees, however good results have been achieved at these climb angles. Additionally, the actual accuracy of the system has historically proven to be significantly better than the computer accuracies depicted in Figure 7-4, assuming properly maintained systems.

n. The F-4D/E dive toss systems only operating limitations are: (See Figure 7-4)

(1) Slant Range - 2500' to 25,000'.

(2) Dive Angle - approximately 10° to 60°.

(3) Velocity - 300 to 650 KTAS.

(4) Altitude - 18,000' maximum.

(5) Climb Angle at Release - 10°. (Release signals will be generated at climb angles in excess of 10°, however computer accuracy may be degraded at these climb angles).

3. MAINTENANCE:

a. RECOMMENDED PROCEDURES:

(1) Maintenance of the different systems is equally as important as an understanding by the aircrew of the operation of the system. The effectiveness of the maintenance program in any unit depends in part upon the manning of the unit and how well the different specialists work together. It is the responsibility of the weapons officer to see that all radar, inertial and weapons specialists work together rather than "pass the buck".

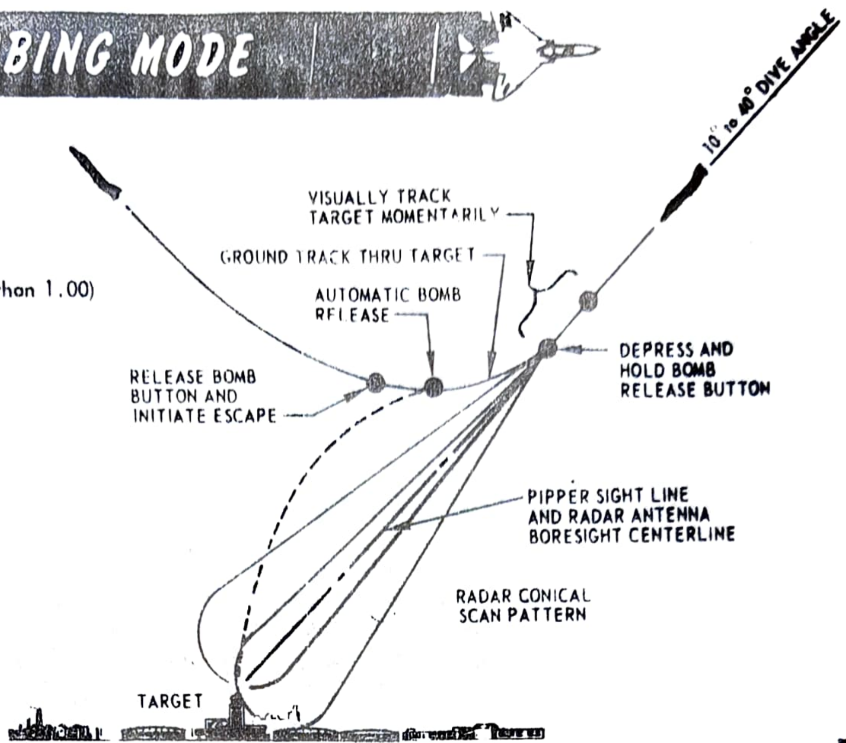
DIVE TOSS BOMBING MODE

OPTICAL SIGHT:
1. Drift Stabilized
2. Reticle caged to the radar boresight line.

WRCS Manual Inputs:
1. Drag coefficient (not set less than 1.00)
2. Release Advance.

AN/APQ-120 MODE:
1. A/G
2. AI Range

INS Supplies:
1. Groundspeed
2. Pitch Angle
3. Vertical Velocity



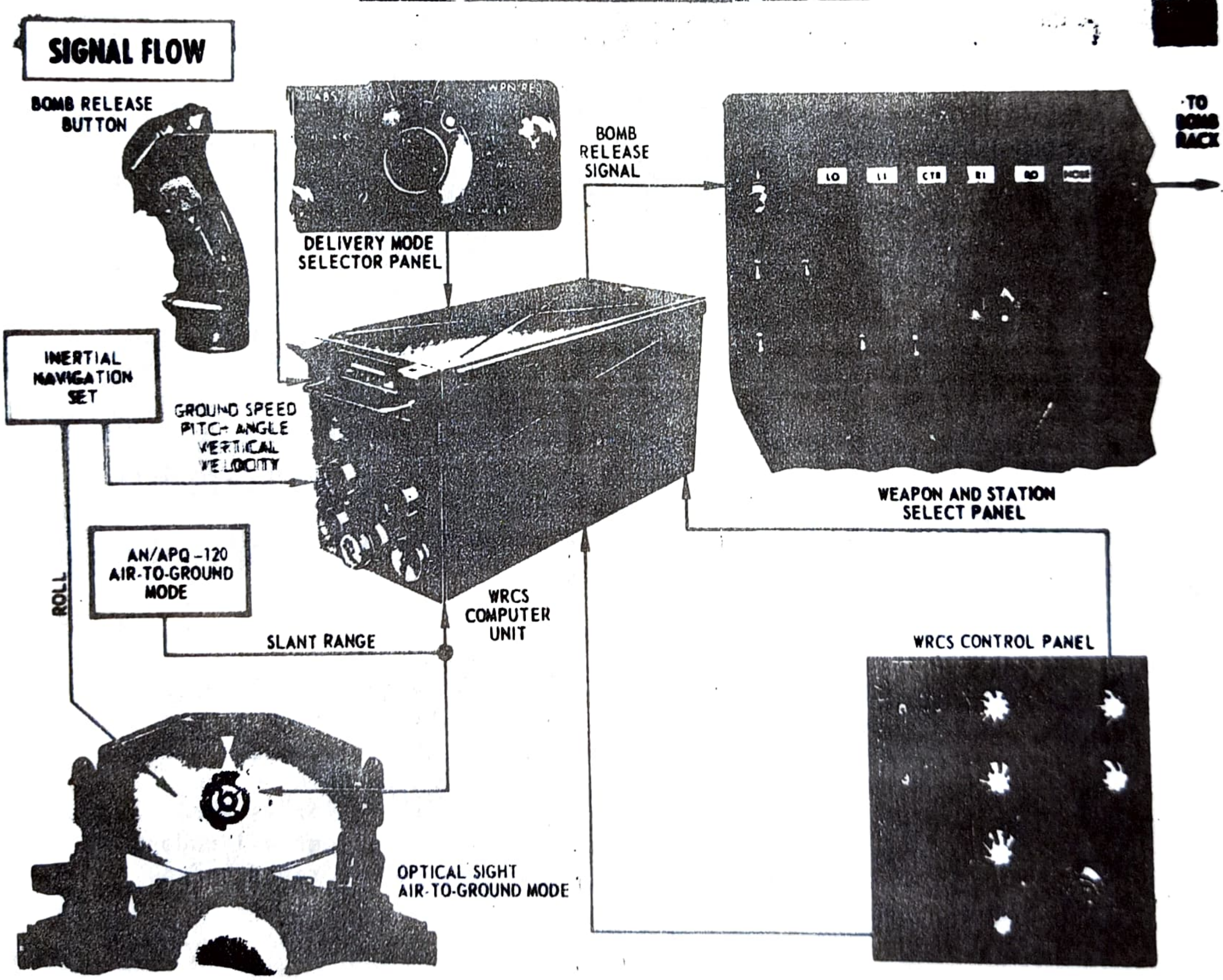
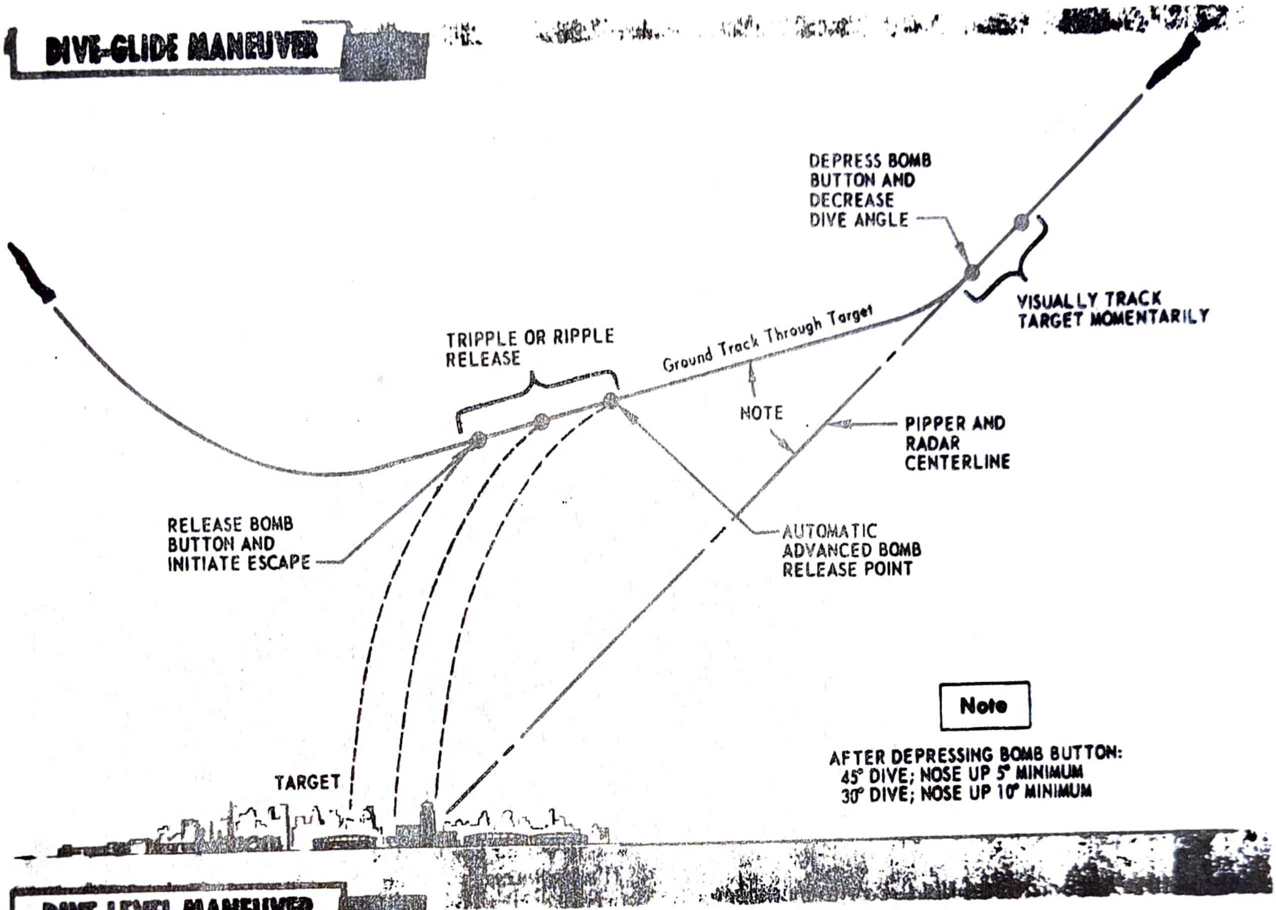


FIGURE 7-2

DIVE-GLIDE MANEUVER



DIVE-LEVEL MANEUVER

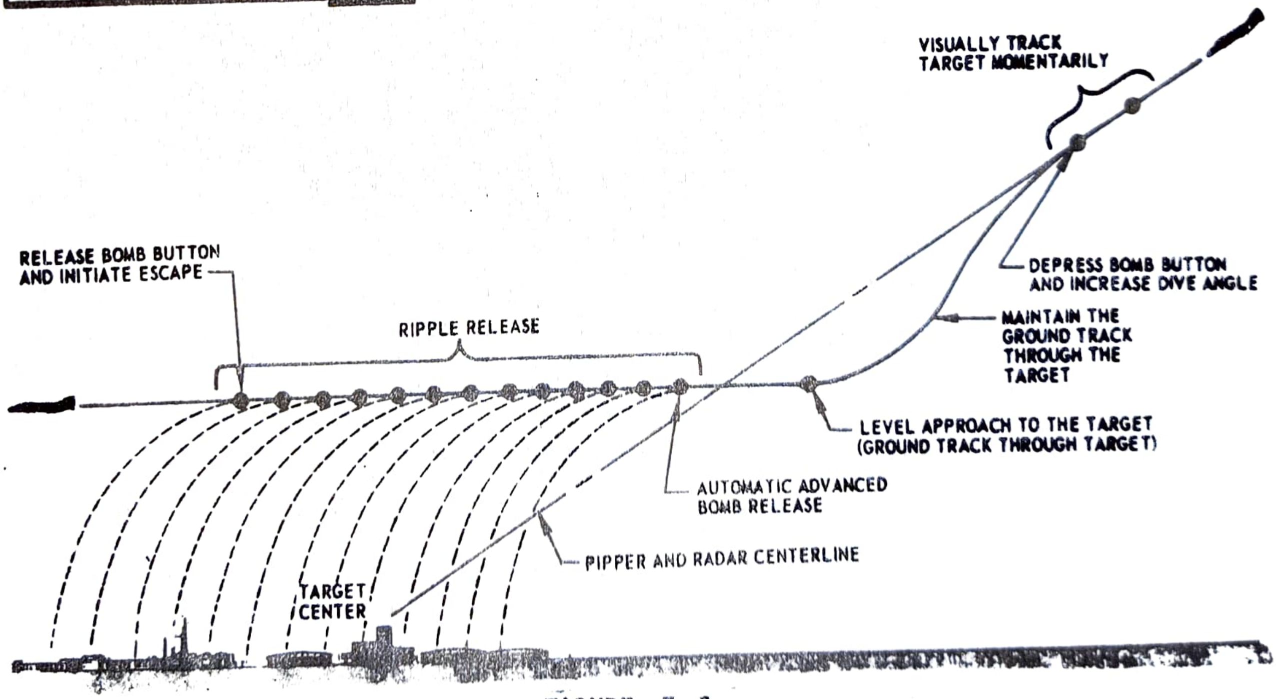
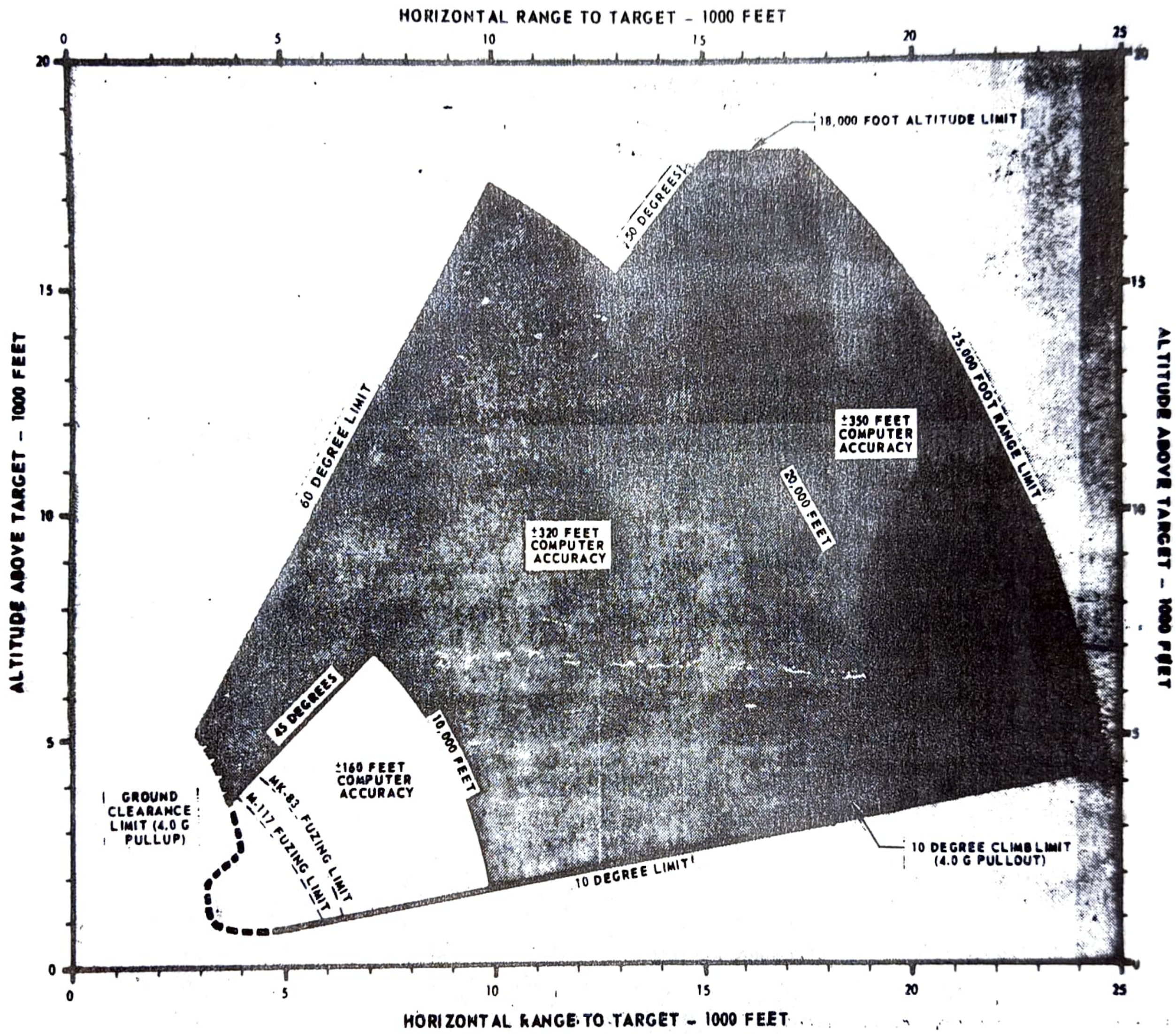


FIGURE 7-3

DIVE TOSS OPERATIONAL ENVELOPE

F-4D

F-4D AFTER T.O. 1F-4-702 AND ALL F-4E



- OUTER LIMITS ARE BASE ON COMPUTER OPTIMUM OPERATIONAL CAPABILITIES WITH INCORPORATION OF T.O. 1F-4-702.
- ACCURACY BOUNDRIES DEFINE EXPECTED COMPUTER ACCURACY ASSUMING OTHER INPUT SYSTEMS PERFORM AS SPECIFIED.
- ALL BOUNDRIES ARE BASED ON AIRCRAFT POSITION AT TIME OF PICKLE.
- FUZING AND GROUND CLEARANCE LIMITS BASED ON 4.0G PULLUP ATTAINED IN 2.0 SECONDS, 480 KNOTS TAS.
- M-904 NOSE FUZE ASSUMED FOR MK-83 BOMB.
- M-163 NOSE FUZE ASSUMED FOR M-117 BOMB.

Figure 7-4

(2) Several procedures have been tried and used successfully by different units to improve the working relationships and coordination between operations and maintenance personnel. Two recommended procedures are:

(a) The weapons officer should meet the NCOIC of each shop and determine the problem areas with which he is confronted. Discuss the problems with him and let him know you are interested in his problems and in working out solutions. Ask questions and rely upon him for technical data that you normally do not have available at your finger tips. A positive demonstration of interest can greatly improve the maintenance of the mechanics and specialists with improved maintenance a likely result.

(b) Thorough write-ups by knowledgeable aircrews save time in trouble shooting, finding the malfunction and correcting it. Attend debreifings and assist aircrews with precise and accurate write-ups. If you cannot personally attend, insure that a qualified substitute is present. Follow up to see what corrective action was taken. A good follow-up procedure is to maintain a file of work orders by tail number.

b. TOLERANCES: Maintenance must be kept advised of the operational tolerances that are required if the tolerances exceed those specified by the manufacturer or those listed in the TO.

(1) The INS is a critical sensor in obtaining satisfactory dive toss results. Operational tolerances must be held to 3NM/hr terminal error (present position Lat-Long counters) and eight Kts/hr or a maximum of 15 knots terminal ground speed. With good INS drift and bad sight drift stabilization, there is a good probability that the INS computer or the Output Signal Distribution Unit (OSDU) drift outputs are bad. Neither of these problems necessarily affect the present position windows or the ground speed indicator.

(2) <u>WRCS:</u>

(a) The WRCS has proven quite reliable, but the voltages do require checking. If an aircraft consistently drops its bombs 150-200 feet long or short, the WRCS θ pitch (dive angle) voltages are probably out of tolerance. The out-of-tolerance condition could therefore result in the aircraft being at a different dive angle than the one the computer was using to solve the problem when the bomb was released.

(b) A good release in dive lay with no release in dive toss indicates a bad vertical velocity output from the OSDU. This is true because dive lay uses all the inputs that dive toss uses except vertical velocity and drag coefficient.

(3) Radar is obviously a critical input to the problem solution. Two key factors which affect accurate radar inputs are the range slope zero circuits and the synchronizer.

(a) Range slope zero circuits provide a reference point for radar slant range calibration. If range slope zero is inaccurate, all radar ranges will be similarly affected. There is no way to accurately check these circuits in the F-4D as a dummy voltage is used. Consistently long or short hits, however, could indicate that the range slope zero is inaccurate. In the F-4E, Air/Grnd, BIT 5, Range 1, lock onto the first target and the range analog should read 5 o'clock (triple ranging). No VI indication is available in the Air/Gnd mode.

(b) The range gate must track the target properly in order to obtain proper slant range with a full system lock-on. This involves the synchronizer and unfortunately continuing maintenance is required in this area on the APQ 109 but many of these problems were eliminated in the APQ 120.

(c) The most common radar problem involves excessive ground return and noise in the B-sweep after lock-on (and after PLMS for the F-4D) during a dive toss delivery. Figure 7-5 shows a good air-to-ground lock-on. All but a very small portion of the ground return has been gained out, leaving just the range gate tracking the return. The rest of the B-sweep is clean. A very discerning eye might notice a slight expansion and contraction of the visible ground return as the synchronizer "breathes". This is a normal and essential part of proper range gate tracking and will probably not be seen in the heat of a delivery pass. Figure 7-6 shows a bad synchronizer, and this is a common dive toss problem. Note the excessive ground return around the range gate after lock-on (and PLMS F-4D). With this problem the range gate

DIVE TOSS SCOPE PRESENTATION

NOTE: Because actual scope camera film loses so much definition during enlargement, the following illustrations were substituted. Although the illustrations are of an APQ 109 scope, the ground return and range gate relationship is valid for the APQ 120.

AIR-TO-GROUND LOCK-ON WITH GOOD RANGE GATE TRACKING

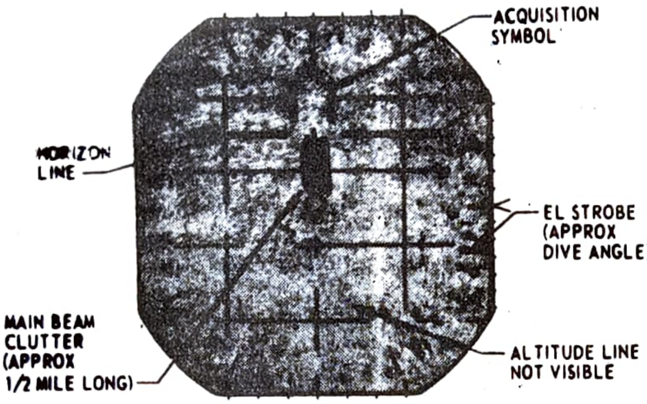


FIGURE a. The ground return after roll-in before gain has been reduced.

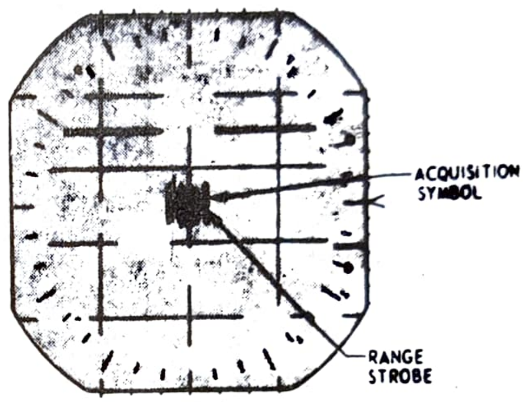


FIGURE c. Half action with the range gate in the middle of the ground return.

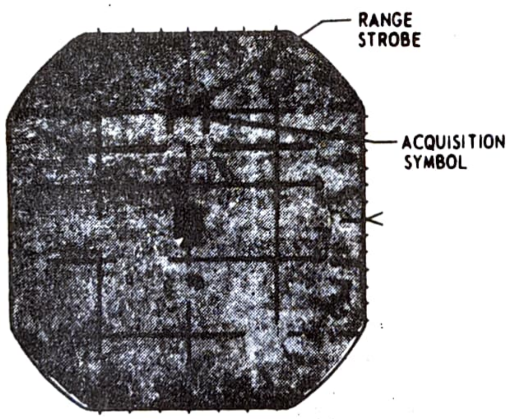


FIGURE b. Radar gain has been reduced until the ground return started to break up and then increased until the smallest possible solid return is obtained.

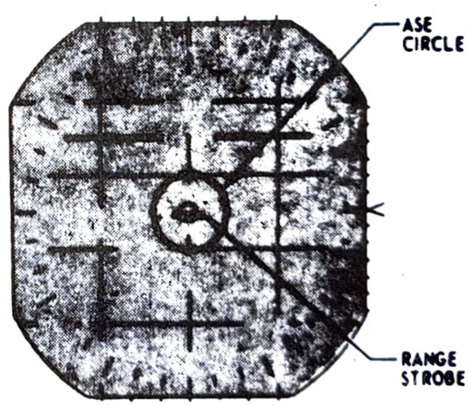


FIGURE d. After full action, lock-on, and PLMS. All but a small portion of the ground return is gained out. The rest of the B-sweep is clean and the range gate will smoothly track down the scope until slant range begins to increase during the pullout.

FIGURE 7-5

DIVE TOSS SCOPE PRESENTATION

AIR-TO-GROUND LOCK-ON WITH BAD RANGE GATE TRACKING

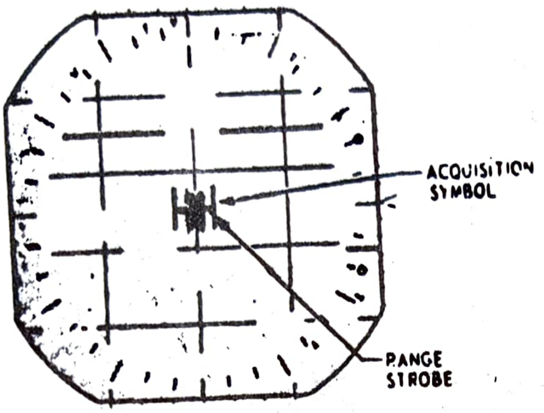


FIGURE a. The beginning of a normal pass.

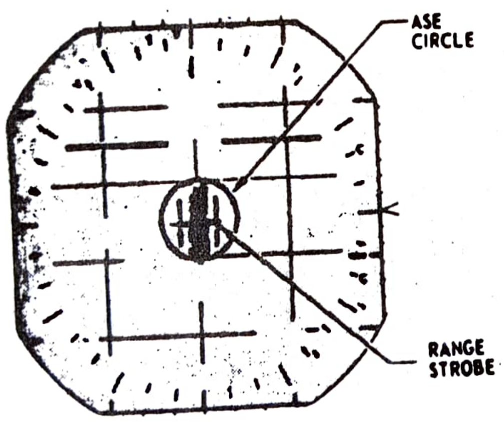


FIGURE b. After lock-on and PLMS the ground return is *not* gained out of the B-sweep. This pass should be converted to hand track immediately.

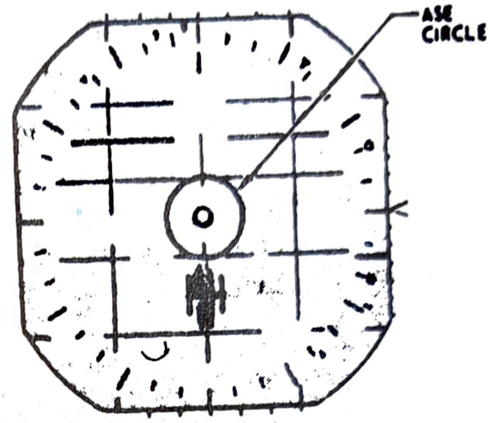


Fig. c.

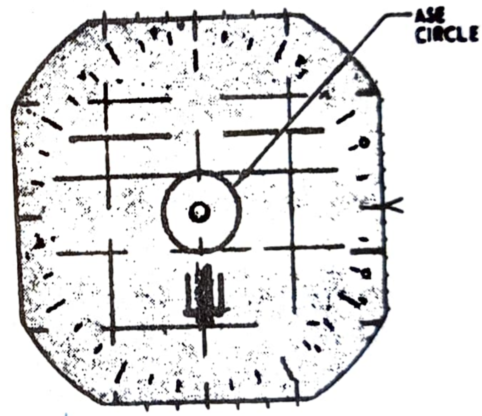


Fig. d.

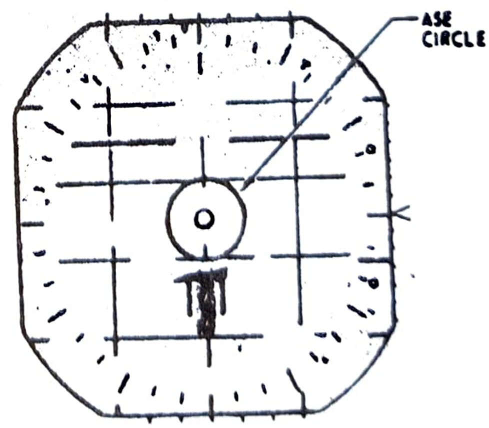


Fig. e.

FIGURE c thru e. Full system lock-on has been maintained as the ground return moves down the scope, the range gate wanders in the return and does not track the center of the return (the target) properly.

FIGURE 7-6

will eventually wander and will not track the center of the ground return (target). Since the slant range inserted into the WRCS depends solely upon the position of the range gate at pickle (no ground return necessary) bomb impact could be long, short, or even a "bull" depending upon where the range gate had wandered at the instant of pickle. Generally, when a synchronizer first starts to get out of alignment, some excessive ground return will appear in the B-sweep after lock-on and the range gate will appear to track properly for a short time. As the synchronizer gradually gets further out of alignment, the ground return will get larger, and the range gate will start to wander. If the range gate wanders enough, the sight range analog bar will visibly fluctuate. It is significant that if synchronizer problems exist, the radar will rarely break lock.

(d) In the air-to-air ground mode, the antenna is drift stabilized and boresighted with the AN/ASG-22/26 sight reticle. It is therefore extremely important that the sight and radar be properly boresighted in accordance with TO 1F-4C-2-18. Design specifications for the radar are 10-40 degrees of dive angle, and bank angle corrections of less than 20°. Original radars in F-4D aircraft were set to power level mode switch (PLMS) 2 seconds after lockon. These units were subsequently modified for instantaneous PLMS. All F-4E aircraft have instantaneous power level mode switching.

(4) Extensive experimentation was accomplished during TAC 66-34B (F-4D CAT III, Air-to-Ground Evaluation) with various ejection velocities, rack delays, and drag coefficients. McDonnell-Douglas Corporation utilized the data to prepare and publish drag coefficients predicated on 75 milliseconds rack delay in vertical (TEV) and horizontal (TEG): 95 milliseconds rack delay for acceleration in vertical (TEA); and zero rack ejection velocity (V_E). These settings are the same regardless of the munitions being released from either a MER/TER or SUU-20/21. The unit weapons officers should therefore monitor fire control specialists to insure correct voltages are set in the ASQ 91. Although the drag coefficient (C_B) varies with release conditions, two C_Bs will normally cover the tactical operating envelope; however, as shown in the Dash 34, BDU-33s have eight different C_Bs, based on pickle slant range and velocity. This is due to the ballistic characteristics of the BDU-33 practice bomb. Consequently, aircrews should meet the slant range and airspeed parameters as closely as possible to get the best impact accuracy.

c. Aircrews should possess enough knowledge of the systems to be able to determine which "black box" is the probable cause of the problem. The ability of the aircrews to diagnose system errors will greatly assist in the isolation of problems by maintenance personnel and reduce aircraft "down" time since it takes 16 hours on the bench to trouble shoot a good INS and find nothing wrong.

4. **DELIVERY TECHNIQUES AND PROCEDURES:**

a. GROUND CHECKS:

(1) INERTIAL NAVIGATION SYSTEM: Get a good double alignment with the second being on internal power. Different frequencies between aircraft generators and APUs, plus power surges, do not aid the inertial in its fine alignment. As the green light starts to flash, switch immediately to NAV. At this point the system is within 10 minutes of arc (1/6 degree) of true north. There is no way to determine when the accuracy of the system improves or is degraded. It is worthwhile to delay takeoff if necessary to achieve good alignment.

(2) RADAR: There are two checks for the radar synchronizer. If the light adjacent to the scope illuminates in BIT-3, the synchronizer is out of adjustment. The same is true in BIT-5 if auto-acc won't pass the first target. If the sweep does not gain clear in A/G or you can see other targets after lock-on (PLMS F-4D) the synchronizer is starting to get out of adjustment. Remember slight breathing is normal.

F4D

(3) WRCS: Fortunately the WRCS is inherently reliable since the BIT checks only provide assurance that no catastrophic malfunction has occurred. Release advance is due some comment here. When rippling bombs in the dive toss mode, the release advance is used in conjunction with the intervalometer to advance the release signal (in milliseconds). The R_A setting that will place the middle bomb on target (odd number of bombs dropped) or bracket the target (even number of bombs dropped) can be determined by the following equation:

$$R_A = \frac{I_R\ (N-1)}{2}$$

R_A = Release Advance Setting in milliseconds.

I_R = Release Intervalometer Settings in milliseconds (.06, .10, and .14).

N = Number of bombs to be released.

When tossing bombs, the release advance does not program Gs. As a result, after the programmed bomb is released, succeeding bombs will be "long" with excessive spacing between impacts. Consequently, during ripple release, program the fourth bomb, in a six-bomb stick, to hit the target. The equation is:

$$R_A = \frac{I_R\ (N)}{2}$$

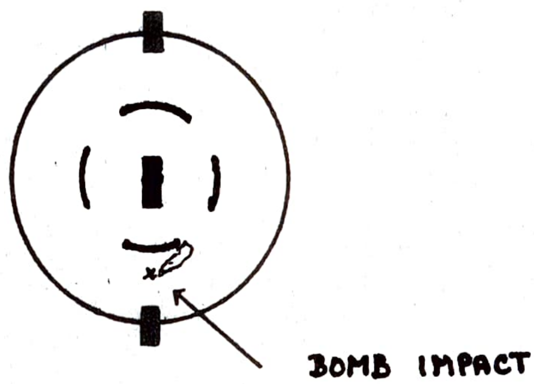
b. INFLIGHT CHECKS:

(1) Determining the accuracy of your INS in flight is important in determining whether or not you will use the dive toss system. Verify the wind and drift indications with other aircraft in the flight. Put the LCOSS in A/G and the LABS weapon selector in dive toss. The sight should move downwind 35 mils for every 2 degrees of drift shown on the HSI (17.45 mils per degree). When in the target area check your present position coordinates with the real target coordinates to determine what INS errors may exist.

(2) When checking the sight drift the B-sweep should move downwind in accordance with the drift indicated on the BDHI. Lock-on should be effected during a non-dive toss delivery to check radar tracking. The angle/skin track light is an aid, but have the pilot/WSO study the range gate for wandering in the ground return and gaining out of the B-sweep.

(3) Attempt a dry pass to check the entire WRCS system. With proper drag and release advance settings (all other checks OK) you should get a release light (pull-up) at approximately the planned release parameters.

(4) The best check of the dive toss system is to drop a bomb at planned release parameters and see where it hits. Ideally the attack axis should be the same as that planned in the target area. Find three targets that are aligned and in close proximity to each other. During the pass, aim at the middle target and note the mil relationship of the other two at the pickle point. Pull off and oberve the bomb impact. Let's say the bomb impacts a little less than halfway between the first and second targets. A mil correction should then be applied to your aimpoint on the next pass.



In this example, the new aiming index should be approximately 16 mils at 6 o'clock to the pipper.

c. TECHNIQUES:

(1) In wind shears, or at short slant ranges, consider caging the sight and aiming upwind. If the aircraft picks up a different drift at bomb release than was being sensed at pickle (uncaged sight on the target) the original computer drift solution was in error. Further, at short slant ranges, the pilot can easily tell what drift is occurring and adjust for it manually. When using a caged sight, use drift out on the radar so both the reticle and radar are "looking" at the same point. Drift out is only available in the F-4E.

(2) At long slant ranges or shallow delivery angles where the target disappears under the nose very early during pull-out, a drift stabilized sight is an invaluable aid because it is hard to determine the drift the aircraft is experiencing. However, after pickle when using the cage/drift out method, insure that you crab the aircraft across your computed upwind aimpoint. Do not point the nose of the aircraft towards the target or you will be directing your aircraft downwind and your bombs will hit unbelievably long in that direction.

(3) If the radar synchronizer is bad, manual track is an excellent backup. A discerning pilot/WSO can tell if there is going to be a break-lock by monitoring the radar for range gate drift. This will give a more immediate indication than the skin track light.

(4) If the INS drift and ground speed inputs are erroneous, two options remain.

(a) Attempt short solution time by pickling at the pre-computed release altitude. The error then will only be inserted for the shortest (at least 1/4 second) time between pickle and weapon release.

(b) If a large error exists in the INS, use DIRECT.

(5) Rough terrain presents some problems when using dive toss. The radar beam is 120 mils across and therefore has difficulty ascertaining the proper slant range. To compensate for the uneven terrain, lock on with the pipper at the flattest spot possible near the target which approximates the targets altitude. Steep dive angles also help since steeper dive angles reduce the radar graze angle.

(6) If an instantaneous release or no release occurs, attempt a delivery in dive lay. If dive lay works properly, the problem is in the vertical velocity as dive lay and dive toss use identical inputs except that dive toss also uses vertical velocity and drag coefficient. No release indicates a faulty climbing vertical velocity input while instantaneous release indicates a faulty diving vertical velocity input. It takes maintenance 16 hours to bench check a good system so isolation of this type problem is paramount if you don't want CNDs on write-ups.

(7) Stick length is a very important consideration in dive toss. If bombing a point-target, a dive glide maneuver will give a small pattern length but will require the aircraft to be in a steady tracking position longer than in the dive toss maneuver, which is obviously not desirable in a heavily defended area. Consequently, use of the glide or toss technique will depend upon enemy defenses and priority of the target.

(8) To assure best possible accuracy the aircrew should know the approximate release parameter for the delivery being performed. Attempting to meet these parameters, as in a direct delivery, will produce better accuracy. This should be tempered with judgment based upon enemy defenses and target importance.

(9) The radar technique of the WSO is important in dive toss delivery. Gain should be lowered until the return starts to break up and then raised a "tad" to give the finest possible return. At low dive angles (less than 30°) lock on to the first 1/3 of the return, while at steeper dive angles lock on 1/2 way through the return because of the radar graze angle. A good synchronizer will automatically seek the point of strongest return, but this

technique helps overcome less than optimum gain control or a synchronizer that is starting to go bad. When using manual track several problems exist. First, the manual/auto track switch has nothing to do with manual track in dive toss. Manual track is merely inserting slant range into the problem, at pickle, by positioning the range gate. Half-action or even loss of magnetron power (although not practical) will not affect the fact that the slant range inserted at pickle happens to be determined by the position of the gate marker on the scope at that time. It is easier to control the gate marker by holding the hand control against the right or left stop. This is permissible because the gate marker will not move in azimuth, but only in range, with Air/Gnd selected on the radar control panel. Whether half-action is used is a matter of technique. It is easier to see the gate marker when half-action is used. However, due to the sensitivity of the hand control, when moving the gate marker, you may have a better tracking solution if half-action is not used as your hand will be steadier. Try several passes both ways and determine for yourself which method you prefer.

d. CREW COORDINATION: Dive toss is a two-man operation and good crew coordination is required for good scores or the prevention of a dry pass in combat.

(a) Certain items should be prebriefed. The terminology to be used, the system checks to be made, whether to cage the sight or use the A/G position, plus the crews plan of action if the radar breaks lock, must be decided in advance. There are no "rules" but this technique should be discussed to be certain both crewmembers are "on the same frequency". Flying integrated crews is one of the best methods of assuring crew coordination.

(b) The aircrew should anticipate what is likely to be said over the intercom during the "heat" of a pass. This will eliminate confusion or a possible misunderstanding because of similar phrases or commands such as "clear to lock-on" or "clear to pickle".

(v) If the radar breaks lock it is useless for the pilot/WSO to use manual track if the A/C goes to DIRECT. A crew that flys together continually will not have these problems as they will have worked out the "bugs" in their procedures and each crewmember will know what the other is thinking.

5. SYSTEM CHECKS AND COMPENSATION: The following "Quickie Chart" is included for your convenience in using the dive toss system.

QUICKIE TROUBLE-SHOOTING CHART

IMPACT ERROR	SYSTEM INDICATION	PROBABLE CAUSE
Miss left/right	INS and drift stab look good	Crosswing change after pickle with AC not crabbing over target
Miss left/right	INS present position error excessive	Bad platform or alignment
Miss left/right	INS drift good but drift stab bad	1. Bad outputs from OSDU or INS computer 2. Pilot could have crabbed over target
Inconsistently long/short	Excessive ground return after lock on or range gate wanders--possible indication in BIT 3/5	Radar synchronizer out of adjustment
Consistently long/short	Error in INS present position or ground speed indication	Bad INS platform or alignment
Consistently long/short	Present position and ground speed are accurate	1. WRCS pitch voltage out of adjustment. 2. Range slope zero out of adjustment. 3. OSDU ground speed input to WRCS inaccurate. 4. Ejection delays (long impacts)
No release	Continuous pullup tone and no pullup light	Vertical velocity failure climbing, especially if release occurs in dive laydown
Instantaneous release	Short tone and immediate pullup light	Vertical velocity failure diving. Try dive laydown

The following pages include four articles from Fighter Weapons Review which have addressed Dive Toss and related systems. Note that information about F-4Ds and F-4Es is included in the articles, some empirical data is given, as well as some opinion.

LET'S GET SERIOUS ABOUT DIVE TOSS

...FROM SEPTEMBER 1970

CAPTAIN ... H. BAXTER
...TH FIGHTER ...NS SQUADRON
...NSTRUCTOR

All F-4D and E drivers have dropped bombs accurately with dive toss at one time or another. When the system works well, even the most diehard iron sight advocate stands to be impressed. A *good* dive toss system will probably beat you on your home range, even against such formidable odds as your own box pattern and your personally massaged hip pocket sight settings. However, accurate dive toss does not require the exacting delivery parameters required for accurate manual deliveries. The more that manual accuracy decreases as a result of increased release slant ranges, unfamiliar terrain, heavy defenses, and tactical deliveries, the more *good* dive toss has to offer. I use the term *good* dive toss because you probably all have witnessed spectacularly *bad* dive toss. What are the causes of *bad* dive toss? Can you tell in advance if your bird will toss well? If scores are bad, why are they bad? Aircrew error? Maintenance? If maintenance, which black box?

The dash 34 description of dive toss systems and techniques is good as far as it goes. The *USAF Fighter Weapons Newsletter* articles "F-4 Dive Toss," March 1968 and "F-4 Harmonization," June 1968 are excellent and are "must" reading for both aircrews and maintenance. Still, many techniques and trouble shooting procedures are missing, and this article is an attempt to fit a few more pieces into the dive toss puzzle.

DRIFT STABILIZATION

There seems to be confusion in the field about just what drift stabilization will and will not do. so before getting into drift problems, let's look at a perfect drift stabilized sight. When using drift stabilization, you place the pipper on the target and *if* the wings are level and *if* you then make a wings level pull, your left/right error is eliminated. Right? Maybe! The pipper is indicating your ground track when the aircraft is wings level, so the sight forces a crab into the wind flying you over the target. That is why a drift stabilized pipper won't move left or right with a little rudder—the aircraft yaws a bit, but the flight path over the ground does not change and neither does pipper position. Drift stabilization will not, however, eliminate that error caused by bomb trail. On the average this will only be two to three feet per knot of crosswind, and you can eliminate it by aiming that much upwind. Now, what about that wings level pull? If you pull out with exactly zero bank, you will maintain the crab angle the drift stabilization established at pickle throughout the pull. The crux of the issue is that crab angle can easily be wrong because the crosswind component of the air mass through which the aircraft passes during the pullout may or may not be the same as that at pickle altitude. The error is a straight function of the change in crosswind velocity and time from entry into the shear until bomb impact. Assume that it takes 15 seconds from pickle to impact, which is a reasonable average for a 12,000- to 15,000-foot slant range at pickle. Also assume that the aircraft instantaneously accepts a wind change (two seconds are actually required). Now, if you fly through a crosswind change of 10 kts just as you start your wings level pull, the impact will be 255 feet downwind! (15 sec x 1.69 ft/sec kt x 10 kts). Remember, the drift stabilization is working perfectly, but you are not—simply because you are not watching where you are going. A dive toss delivery is just a long range skip bomb pass with a drift stabilized sight to help you crab the seat of your pants over the target. If you notice that the sight is driving you left or right of the target, or you start sliding off to either side during the pull, CRAB OVER THE TARGET! Admittedly, you might be in a bank at release. This will cause some errors, but they will be less than the error caused by not flying over the target. If you don't crab your aircraft any closer than 200 ft. left/right of the target, your bombs won't hit any closer than that at best. Most units with dive toss problems average roughly 20% of their unqualifying scores at 3 or 9 o'clock and those scores can be brought inside criteria on the next mission.

The above pilot techniques should get you close laterally even if your drift stabilization is bad, but how can you tell if it's bad before you roll in? In a drift stabilized mode, both the sight and radar B-sweep receive INS drift inputs and will be off to the extent INS drift is bad. Information gained on any navigation leg should give you a good idea of INS drift accuracy, especially if you have a good wind forecast. Crab indicated by a drift stabilized sight should correspond to the drift angle you read from the HSI heading and Course Window (Nav/Nav). If you hold a steady heading and have a two-degree drift angle, the sight should jump 35 mils (17.45 mils = 1 degree) when moved from Cage to A/G with a drift stabilized mode selected. A drift stabilized sight always moves downwind forcing a crab into the wind. If the drift stabilization is bad, you can either crab over the target or cage the sight and use a 3 or 9 o'clock crosswind aimpoint. Should you use a caged sight and a crosswind aimpoint, select Drift/Stab out on the Radar Control Panel or the radar will not be aligned with the sight at zero degrees azimuth. With an unknown and/or high crosswind you will probably do better by crabbing across the target after pickle. The above checks will certainly not be wasted even if your sight is bad, inasmuch as they allow you to isolate the problem for maintenance. With good INS drift and bad sight drift stabilization your chances are excellent that the INS Computer or Output Signal Distribution Unit (OSDU) drift outputs are bad. Neither of these problems necessarily affect the present position windows or the ground speed indicator.

RADAR

The APQ 120 (F-4E) is in heavy clutter whenever air-to-ground is selected on the Radar Control Panel. With the APQ 109 (F-4D) in air-to-ground, the radar is in normal clutter until after lock-on. The instantaneous PLMS mod will help your F-4D dive toss. The clutter switch is inoperative with the APQ 109 in air-to-ground.

Most of the dive toss system problems which I've encountered were caused by a malfunctioning radar, yet a good system check of the radar air-to-ground operation does not exist. Range slope zero and synchronizer adjustment are key terms in dive toss conversation, and both can cause gross errors. Range slope zero circuits provide a reference point for radar slant range calibration. If range slope zero is inaccurate, all radar ranges will be similarly affected. This is one of the probable causes if one aircraft drops consistently long or short. However, even if range slope zero is accurate, the range gate must track the ground return properly in order to obtain accurate radar slant range with an automatic lock-on. This involves the synchronizer, and unfortunately, a lot of continuing maintenance is required to keep the APQ 109 radar peaked for dive toss.

Many of the APQ 109 air-to-ground problems were eliminated with the APQ 120, and the F-4E requires less continuing air-to-ground radar maintenance. The most common radar problem involves excessive ground return and noise in the B-sweep after lock-on (and after PLMS for the F-4D) during a dive toss delivery. Figure 4 shows a good air-to-ground radar lock-on. All but a very small portion of the ground return has been gained out, leaving just the

DIVE TOSS SCOPE PRESENTATION

NOTE: Because actual scope camera film loses so much definition during enlargement, the following illustrations were substituted. Although the illustrations are of an APQ 109 scope, the ground return and range gate relationship is valid for the APQ 120.

AIR-TO-GROUND LOCK-ON WITH GOOD RANGE GATE TRACKING

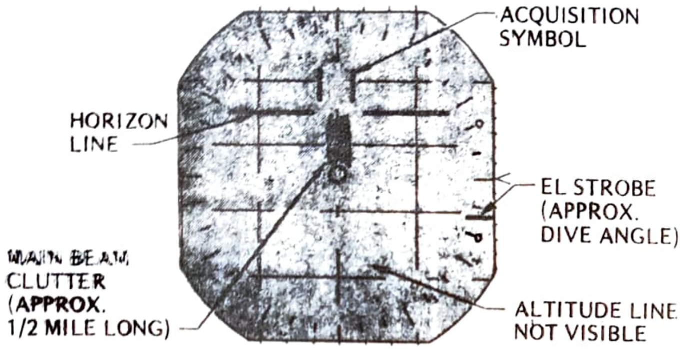


FIGURE 1. The ground return after roll-in before gain has been reduced.

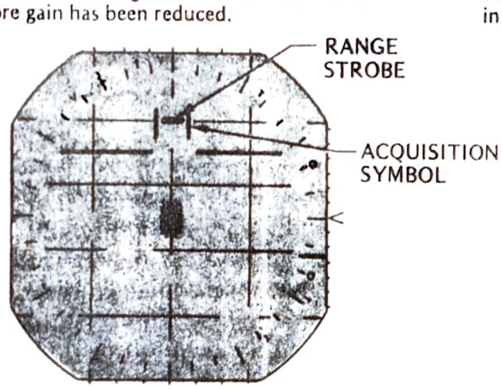


FIGURE 2. Radar gain has been reduced until the ground return started to break up and then increased until the smallest possible solid return is obtained.

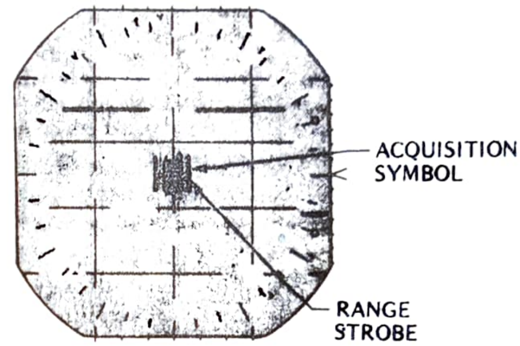


FIGURE 3. Half action with the range gate in the middle of the ground return.

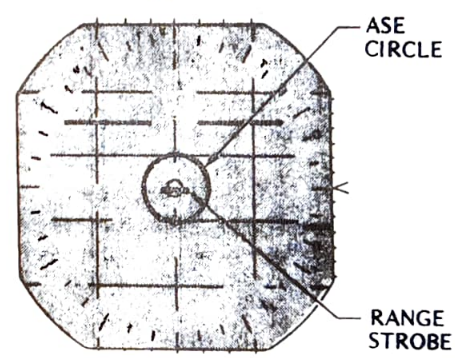


FIGURE 4. After full action, lock-on, and PLMS. All but a small portion of the ground return is gained out. The rest of the B-sweep is clean and the range gate will smoothly track down the scope until slant range begins to increase during the pullout.

range gate tracking that return. The rest of the B-sweep is clean. A very discerning eye might notice a slight expansion and contraction of the visible ground return as the synchronizer "breathes." This is a normal and essential part of proper range gate tracking and will probably not be seen in the heat of a delivery pass. Figures 6-9, however, show a bad synchronizer, and this is a common dive toss problem. Notice the excessive ground return around the range gate after lock-on (and PLMS F-4D). With this problem the range gate will eventually wander and will not track the center of the ground return (the target).

Since the slant range inserted into the WRCS depends solely on the position of the range gate at pickle, bomb impact could be long, short, or even a bull, depending on where the range gate was when you pickled. If you are taking scope camera pictures and witness mark at pickle, impact will be in the same direction that the range gate wandered off at pickle (assuming no other system problem). For example, if the range gate wandered out (up on the scope) at pickle, the slant range inserted into the WRCS will be excessive with a corresponding long bomb impact. Generally, when a synchronizer first starts to get out of alignment, some excessive ground return will appear in the B-sweep after lock-on, but the range gate will track properly for a while. The synchronizer will gradually get farther out of alignment, the ground return will get larger, and the range gate will finally start to wander. I have seen synchronizers so bad the ground return broke into two distinct returns with the range gate either clinging to one or oscillating back and forth between the two. I have also seen so much ground return and noise in the B-sweep after lock-on that the range gate ran off the scope. If the range gate wanders enough, the sight range analog bar will visibly fluctuate. Significantly, if synchronizer problems exist, the radar will rarely break lock. Accordingly, the back seater is not looking for the most probable malfunction if he continuously monitors the angle-lock/skin-track light

DIVE TOSS SCOPE PRESENTATION

AIR-TO-GROUND LOCK-ON WITH BAD RANGE GATE TRACKING

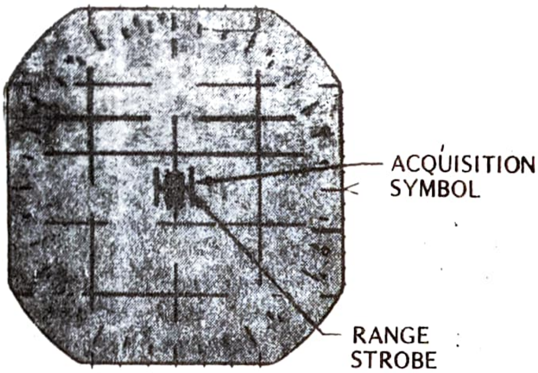


FIGURE 5. The beginning of a normal pass.

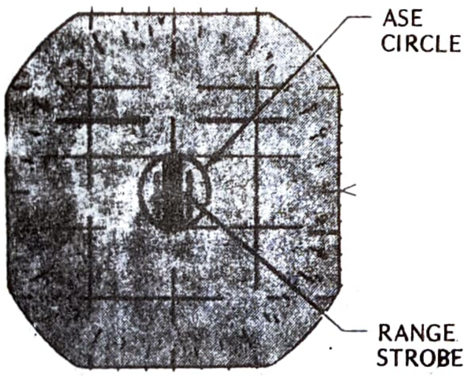


FIGURE 6. After lock-on and PLMS the ground return is *not* gained out of the B-sweep. This pass should be converted to hand track immediately.

FIGURES 7 thru 9. Full system lock-on has been maintained as the ground return moves down the scope, the range gate wanders in the return and does not track the center of the return (the target) properly.

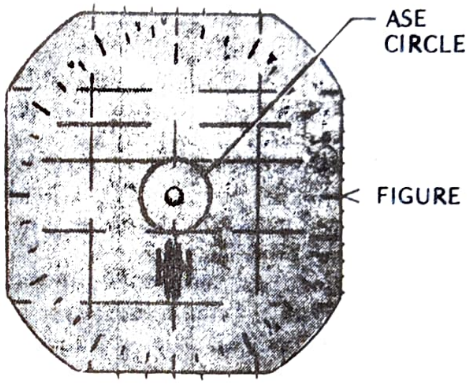


FIGURE 7

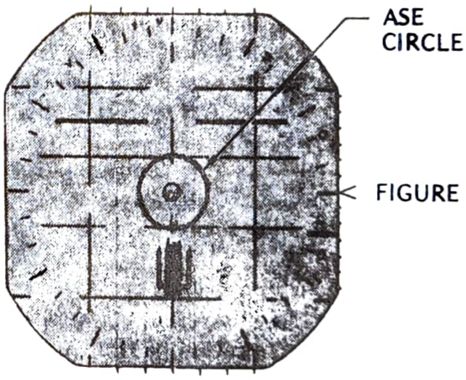


FIGURE 8

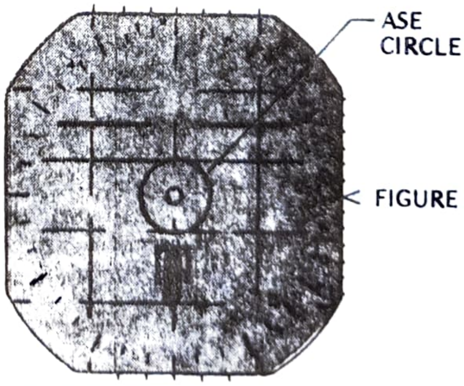
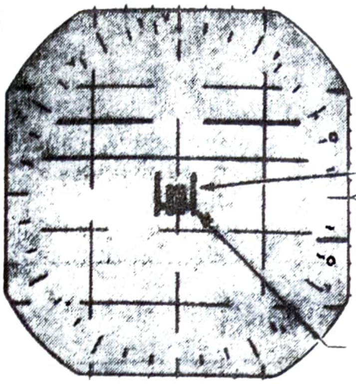


FIGURE 9



HAND TRACK

FIGURE 10. HAND TRACK. Gain technique is the same as that for an automatic lock-on. The back seater has gone half-action and placed the range gate one-third of the way into the return. This is the desired range gate position at pickle. After pickle, the position of the range gate is immaterial.

during the delivery. His efforts are better utilized by checking the light after lock-on (and PLMS) and then checking the ground return to insure good tracking before clearing the AC to pickle. If excessive ground return is observed, manual track—but more about that later. When scores randomly fluctuate long and short on the same aircraft, suspect a wandering range gate.

Unfortunately, you may or may not be able to determine whether the synchronizer is aligned well enough for good automatic lock dive toss until you try a delivery. Even if not, you will at least be able to identify the problem for maintenance. This is critical because maintenance cannot identify this problem on the ground except by checking synchronizer voltages (this is an FMS function for the APQ 120). Present maintenance procedures will CND a "dive toss drops long/short" write-up caused by bad range gate tracking. Post flight analysis of dive toss scope camera film will really pinpoint radar synchronizer problems.

In some cases, a bad sync can be detected in Bit 5 A/G. As in an actual delivery, once you lock-on to a bit target (and PLMS), the B-sweep should gain clean except for the range gate and some of the bit target. If you have noise in the B-sweep and especially if the other bit targets are visible or appear as the radar "breathes" after lock-on, your sync is bad or at best questionable, and you should manual track. If the sync is really gross, the light below the scope will illuminate when you lock onto the 10th target in Bit 3, and the radar might never get past the first bit target in Bit 5 auto acquisition.

INS

Virtually all of the dive toss test evaluation concluded the INS was the biggest source of dive toss errors. As critical as the INS is, this can be misleading. When dive toss systems are really peaked and scores are good, INS drift and Shuler pendulum effects are frequently the reason good scores aren't even better. When scores are bad, the cause frequently lies elsewhere. If the INS drives off excessively, you will get bad but consistent scores long or short (or left/right if you do not crab over the target). This problem is easily identified since your ground speed will be off and/or your present position windows will drive off excessively in the direction opposite your scores. Just check the present position windows when entering and leaving the range.

Other INS problems are, unfortunately, not so obvious. Even with excellent terminal error and ground speed readings and good offset bomb scores, dive toss INS problems occur. Output Signal Distribution Unit (OSDU) and INS Computer vertical velocity, drift, and ground speed outputs to the sight and WRCS can be erroneous while the readouts in the present position windows and ground speed indicator are accurate. Vertical velocity failures usually result in the vertical velocity output signal driving virtually straight down or straight up. In the first case, a near immediate release will occur. In the second and more common instance, there will be no release. Most of the no release problems I've encountered in dive toss were caused by a bad vertical velocity output from the OSDU (assuming a good pylon, SUU, etc.). You can isolate this problem by making a dive laydown delivery since dive laydown utilizes all dive toss inputs except vertical velocity and drag coefficient (rarely a problem). A release in dive lay with no release in dive toss means bad vertical velocity from the OSDU. If aircraft downtime is important to you (have any MND's?), isolating this problem can be significant since it takes some 16 hours on the bench to trouble shoot even a good INS, and you might not have a spare system. Additional INS problems encountered were bad ground speed inputs to the WRCS (even though the ground speed indicator was accurate), and the drift problems previously mentioned.

WRCS

The WRCS itself has proven quite reliable, but do check your WRCS voltages. Several of our birds dropped consistently 150-200 ft. long or short and WRCS θ pitch (dive angle) voltages were off a little. Basically, the WRCS computed for a dive angle that was different than actual and dropped consistently long or short.

TECHNIQUE

Besides using drift stabilization as an aid to crabbing over the target, you might consider several additions to published techniques.

MANUAL TRACK

Manual track techniques are not mentioned in the dash 34 but are described in the article titled "F-4 Dive Toss" published in the March 1968 *USAF Fighter Weapons Newsletter* magazine. Terminology can be confusing here since you DO NOT select manual track. DO NOT go full action, and DO NOT use the V_C knob for manual track dive toss. Basically, you are substituting hand tracking of the ground return for automatic synchronizer tracking *with a lock-on.* From now on I will refer to this as hand tracking. Gain techniques are the same for auto and hand track. When hand tracking, go half action to get the range gate; bring the range gate up from the bottom of the scope and into the ground return one-third of the length of the return. Moving the hand control against the side stops will steady your hand, but the range gate will remain in the B-sweep.

The hand control is quite sensitive on 5 or 10-mile scope so, rather than attempting to track the ground return while the AC positions his pipper, the AC should track the target (wings level) and call "tracking." With 35 mils depression the difference between angle of attack and pipper depression is so small the pipper has little forward drift. This allows the AC to comfortably track the target with little or no hunt. When the AC calls "tracking," position the range gate where you want it and give clearance to pickle.

AUTO TRACK

If defenses permit, be close to wings level with the pipper on or barely short of the target before locking-on to the ground return. With instantaneous PLMS this supposedly is not necessary. However, less demand will be placed on the radar, and your radar just might be marginal. Placing the pipper so close to the target minimizes range rate change for the radar and, most importantly, allows you to immediately convert to hand track. If after lock-on excessive ground return appears around the range gate, the back seater should call "track," break the lock, and hand track. With the pipper just short of the target, the AC can almost immediately call "tracking," and proceed with a hand track delivery. The conversion from auto to hand track can be accomplished that quickly. However, if the pipper was way short of the target when you decided the radar was bad, you probably will not have time to get the pipper on the target and hand track. The backseater will also have difficulty tracking the ground return while the AC is maneuvering the aircraft.

Hand track introduces potential operator error into range gate position so let's assume you will make multiple passes and hit 500 feet short on your first hand track pass. The error could be caused by bad INS, by range slope zero or θ pitch being out of calibration, or by improper range gate positioning. All but the last should give pretty consistent errors, so instead of trying to guess what 500 ft. worth of range gate position error in the ground return is, duplicate the pass with the range gate in the same position but aim 500 feet long. It works.

How accurate is hand track dive toss? At the USAF Fighter Weapons School (FWIC), hand track scores are highly competitive with good automatic track scores, and many of the FWIC students have never hand tracked! Since hand track does not rely on the synchronizer, the more synchronizer problems you have, the better the relative merits of hand track.

Hopefully, this article will remove some of the mystery about bad dive toss and improve your trouble shooting capability. Dive toss problems are unit problems, and coordination between INS and WCS shops is critical as is coordination between ops and maintenance. Although dive toss demands less aircrew stick and rudder finesse than direct deliveries, more aircrew systems knowledge and application is required. Even dry passes can identify bad radar synchronizers and good records of aircraft scores are invaluable.

DIVE TOSS SYSTEM TROUBLE-SHOOTING GUIDE		
IMPACT ERROR	SYSTEM INDICATIONS	PROBABLE CAUSE
MISS LEFT/RIGHT	INS AND DRIFT STABILIZATION LOOK GOOD.	CROSSWIND CHANGE AFTER PICKLE WITH AC NOT CRABING OVER THE TARGET.
MISS LEFT/RIGHT.	INS PRESENT POSITION WINDOW ERROR EXCESSIVE.	BAD INS PLATFORM OR BAD ALIGNMENT.
MISS LEFT/RIGHT.	INS DRIFT GOOD BUT DRIFT STABILIZATION BAD.	1. BAD DRIFT OUTPUTS FROM THE OSDU OR INS COMPUTER. 2. PILOT STILL COULD HAVE CRABBED ACROSS THE TARGET.
INCONSISTENTLY LONG AND SHORT.	EXCESSIVE GROUND RETURN AFTER LOCK-ON AND PLMS. RANGE GATE WANDERS. POSSIBLE INDICATION IN BITS 3 AND 5.	RADAR SYNCHRONIZER OUT OF ADJUSTMENT.
CONSISTENTLY LONG OR SHORT.	EXCESSIVE INS PRESENT POSITION WINDOW ERROR. GROUND SPEED INDICATION INACCURATE.	BAD INS PLATFORM OR BAD ALIGNMENT.
CONSISTENTLY LONG OR SHORT.	INS PRESENT POSITION WINDOWS AND GROUND SPEED INDICATOR APPEAR ACCURATE.	1. WRCS θ PITCH VOLTAGE OUT OF ADJUSTMENT. OTHER WRCS VOLTAGES COULD ALSO BE BAD. 2. RANGE SLOPE ZERO OUT OF CALIBRATION. 3. OSDU GROUND SPEED INPUT TO WRCS INACCURATE. 4. BOMBS MIGHT BE HANGING ON RACK. (LONG IMPACT.)
NO RELEASE.	CONTINUOUS PULLUP TONE AND NO PULLUP LIGHT.	OSDU VERTICAL VELOCITY FAILURE ESPECIALLY IF RELEASE OCCURS IN DIVE LAYDOWN.

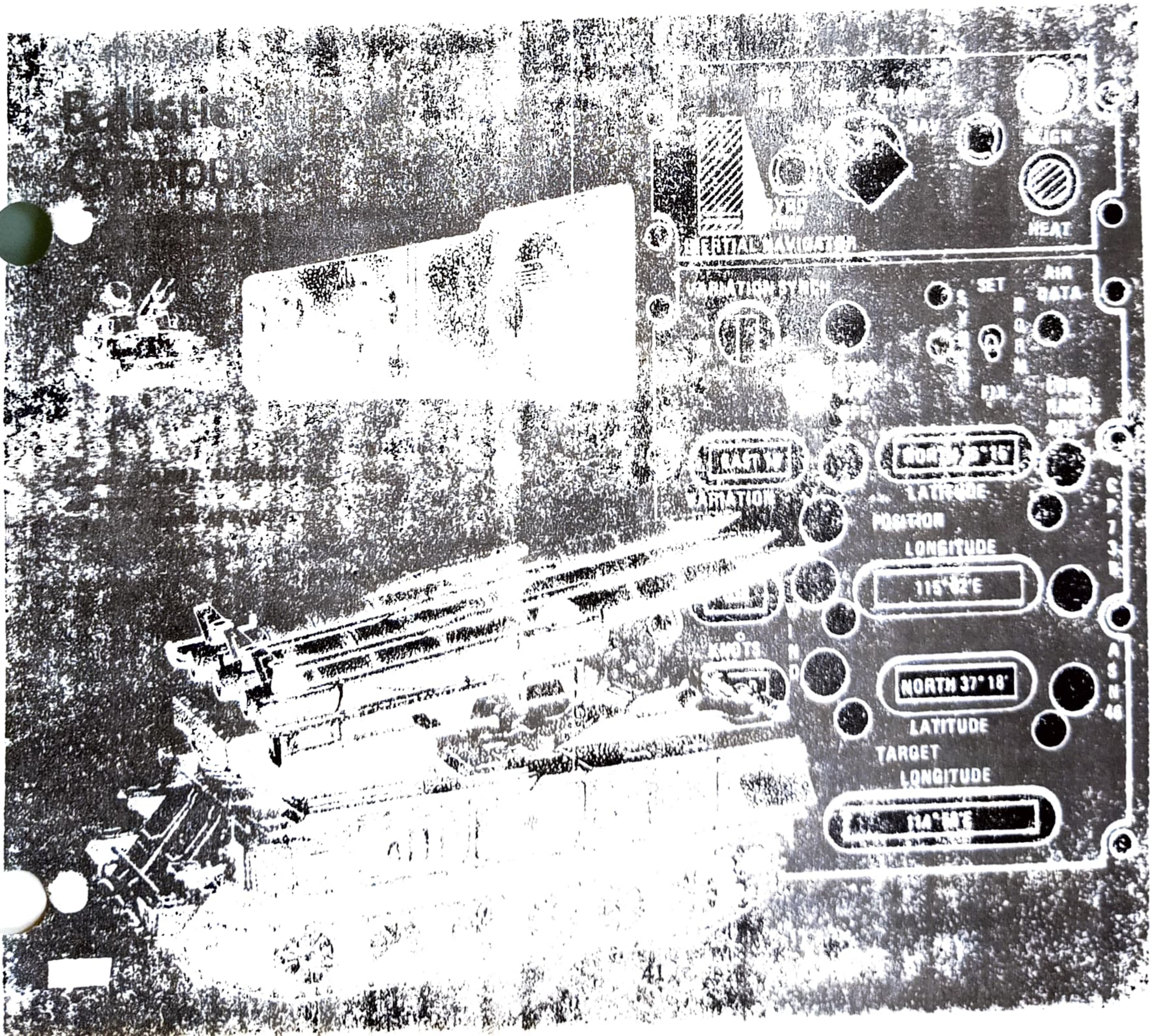
Most F-4 aircrews will say that the dive toss system works well -- when it works. The greatest problem in dive toss bombing, then, is getting the system to work more often. A part of doing this is insuring that the WRCS ballistic computer is set up for minimum error. This, of course, has to be done before the computer is installed in the aircraft, since the aircrew has no way of checking it for accuracy.

Two suggestions are set forth here. The first is a method of calibrating the ballistic computer for minimum error. This method is not in common use, although it is within existing tech data limits, and will have to be "sold" to maintenance by the ops side of the house. The second is that even when the ballistic computer is set up for minimum error, a small residual error remains, as proven by statistical analysis conducted in the 4th TFW. This residual error can be corrected with extra, or less, drag coefficient. The amount of drag coefficient correction will depend on the direction and magnitude of the residual error, as determined by local analyses.

COMPUTER CALIBRATION

Ballistic computer release time settings are made by maintenance personnel in the shop. IAW Technical Manual 5N1-3-15-2 (Weapon Release Computer Set, AN/ASP-91), the computer is bench-checked at three separate checkpoints. Each of those checkpoints consists of an input dive angle and release airspeed at the edges and center of the dive toss release envelope:

1) 10° dive angle and 300 knots,
2) 28° dive angle and 450 knots, and
3) 60° dive angle and 300 knots. The 28° is at the approximate center of the dive toss envelope. At each checkpoint, the time (in milliseconds) is measured from



pickle to the release signal. Each checkpoint has a corresponding time/millisecond envelope, or calibration area, in which the release signal must occur ("ring in"). If the release signal doesn't "ring in" inside the envelope, two trim potentiometers are adjusted (biased) to make the signal "ring in" there.

The 28° checkpoint has a calibration area which runs from 16054 to 16836 milliseconds after pickle. This calibration area has a total value of 782 milliseconds, which is a sizeable amount of ground distance as shown in Figure 1. The horizontal component of 450 knots at a 28° dive angle is 397.33 knots, or 671 feet per second. At 671 feet per second, an object travels 524.72 feet in 782 milliseconds, or about 0.67 feet per millisecond.

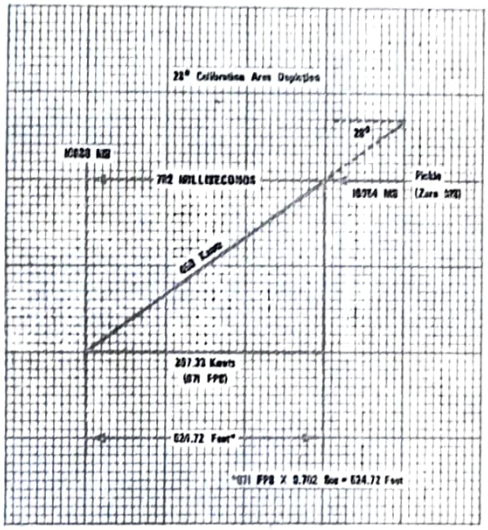


FIGURE 1

An ideal time setting for the ballistic computer can be established through theoretical data and verified through local documentation. In the case of the F-4E, the "ideal spec" is at the arithmetic center of the 28° calibration area. In this case, if the ballistic computer releases early (at the bottom of the envelpope, or 16054 milliseconds), the resulting bomb score will be 262 feet short. Based on present tech data, a computer that "rings in" this way is considered to be correctly biased in spite of the fact that it drops bombs which hit 250-plus feet short.

The way to minimize F-4E dive toss errors at all dive angles is to bias the ballistic computer to "ring in" at the center of the 28° checkpoint calibration area. This point, sometimes called the "center spec" point, is 16446 milliseconds from pickle. INS technicians can bias a ballistic computer to within 10 milliseconds of a given "spec," and in the case of the F-4E, this is within the limits of the existing tech data. A letter of understanding/agreement between operations and maintenance will insure that a given "spec" calibration is accomplished on each ballistic computer. The normal time period required to complete this for all aircraft in a fighter wing is approximately six months. NOTE: For particular information on the "center spec" calibration technique, contact Mr. Bob Stevenson at 4th AMS, Seymour Johnson AFB, NC.

This 16446 millisecond center spec does not apply to the F-4D due to differences in radar range inputs. Mr. Jim Kelly, an AFTEC working for the 4th AMS, has compiled a set of theoretical figures which show the "ideal spec" for the F-4D to be at 16091 milliseconds from pickle. No actual figures have been compiled to verify this, but if actual records show that the F-4D dive toss scores are mostly long, then the 16091 "spec" may be valid.

DRAG COEFFICIENT CORRECTION

A statistical analysis of 3400 dive toss deliveries was conducted at Seymour Johnson AFB in May 1976. Analysis conditions were as follows:

1. Single pass, single drop BDU-33 practice bombs were used.

2. Time span - 2½ years.

3. F-4E aircraft were used.

4. MR/MC/MQ aircrew scores were included together.

5. Good dive toss systems were assumed, and obviously bad bomb scores were thrown out.

6. 30° and 45° deliveries were included together.

Figure 2 is the resulting distribution curve. The mean bomb score is 64 feet short. If this distribution is moved (skewed) to the left in some way, dive toss scores should improve.

One way to move this distribution is to increase the drag coefficient, causing a later release and a longer bomb. The footage per 0.01 drag coefficient at 450 knots release airspeed was established by 4th TFW personnel with INS shop bench test equipment. The findings are as follows:

DIVE ANGLE	FOOTAGE
30°	30′
45°	20′

NOTE: Empirical data for low angle dive toss bombing was collected by the 414th FWS. Their findings show that .01 drag coefficient affects a bomb's ground distance by 30 feet.

According to the table, adding 0102 to all 30° drag coefficient settings and 0103 to all 45° settings will move the curve 60 feet to the left. This would allow the aircrew to put the pipper on the target rather than "aim off" to compensate for the 64-foot error. Remember that the above drag coefficient data applies only to the F-4E and BDU-33 bombs.

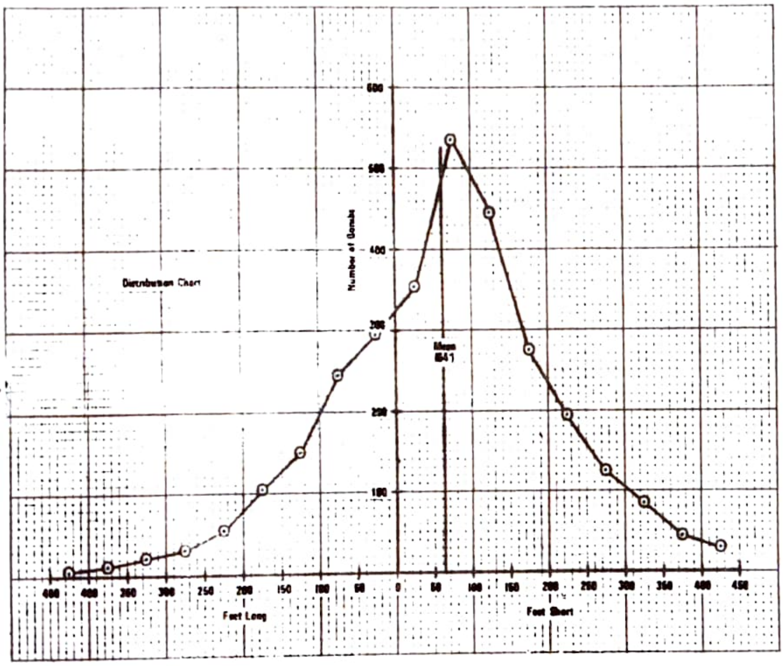


FIGURE 2

SOME RESULTS

The 4th TFW began center spec calibration and adopted the drag coefficient correction described above in June '76. At this time (July '76), half of the wing aircraft have a ballistic computer calibrated at the center-spec, so the returns are only partial. The dive toss CEA's shown are: 1) Five months prior to June '76, and 2) June '76 and afterward. The number of bombs dropped is included.

High Altitude Dive Toss

(1) 218.29′ (601 bombs)
(2) 128.73′ (122 bombs)

Dive Toss

(1) 176.92′ (551 bombs)
(2) 113.65′ (155 bombs)

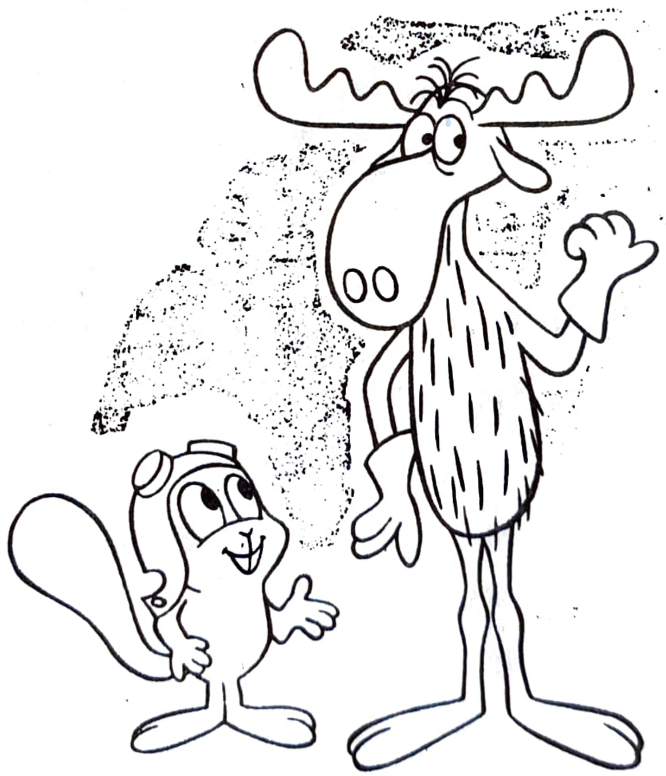
In addition to a CEA reduction, the maintenance reliability rate for dive toss systems went from an average of 79% to 88% and the aircrew success rate increased from an average of 70% to 80%. The CEA trend is generally down, and CEA's will continue to decrease as more ballistic computers are calibrated. Calibration is normally done in response to system write-ups, or when an aircraft is sent through WCS calibration. The best estimates here are that the entire calibration job will be done in another four months.

Good dive toss scores are based on two factors: 1) Good techniques, which get the most out of a good system, and 2) Good systems themselves. "Ideal spec" calibration is an important part of providing good systems because it guarantees minimum error in the ballistic computer and provides an extra measure of standardization in weapons system calibration. The remaining system error can be determined through system documentation and statistical analysis. Corrections for the residual error (either short or long) can be made with drag coefficient. While most of the foregoing applies to the F-4E, an "ideal spec" point can be determined for the F-4D, along with drag coefficient corrections to compensate for the residual error. Although this is not the "end all" solution to dive toss problems, it will provide better dive toss scores and higher system reliability.

Concerning the Previous Article

NOTE 1: The previous article, "Ballistic Computer Considerations", discusses drag coefficient correction techniques used by the 4th TFW to improve scores on scoreable ranges with known ground references. A correction of this sort for "first look" combat targets is a high threat, one-pass scenario is unrealistic.

NOTE 2: The relationship between down range travel and drag coefficient is not liner. In Sep 77 Capt Jim Summers, 68TFS Weapons Officer, requested clarification from the Weapon Evaluation Branch (DLYW) of the Air Force Armament Laboratory (AFSC), Eglin AFB, FL. See their answer on the following page.



DEPARTMENT OF THE AIR FORCE
AIR FORCE ARMAMENT LABORATORY (AFSC)
EGLIN AIR FORCE BASE, FLORIDA 32542

REPLY TO ATTN OF: DLYW (Mr. Hooton/AV872-4455) 5 Oct 77

SUBJECT: Dive Toss Drag Coefficients (CB) (Your Ltr, 8 Sep 77)

TO: 68 TFS/Ops (Capt Summers)
Moody AFB GA 31601

1. In response to your request, the following equations may be utilized to hand compute CB settings:

$$VG = V \cos T + 7.5 \sin T \quad (1)$$

$$VV = V \sin T - 7.5 \cos T \quad (2)$$

$$CB = .06216 \left[\left(\frac{VG}{R} \right) VV + H \left(\frac{VG}{R} \right)^2 \right] \quad (3)$$

Where: R = Downrange Travel of Weapon - Ft
V = Release Velocity - Ft/Sec
H = Release Altitude - Ft
T = Release Angle - DEG (dive is -)

2. As you can see from equation (3) above there is not a linear relationship between the downrange travel of the weapon and the CB value. The method of correction you described, for a miss on the target, would only work for a range of specific delivery conditions and should not be applied across the board. A suggestion would be to adopt a set of standard delivery parameters and utilize the CB equation to determine the sensitivity of the CB value to selected error sources.

3. The dive toss ballistic table for low drag bombs (Attachment 3 of your letter) is equally applicable to the current USAF practice ordnance.

4. WRCS drag coefficients (CB values) were computed for the delivery parameters specified in your letter and are attached. Note that at pickle the aircraft was allowed to attain full military power and execute a 4 "g" maneuver in 2 seconds.

SIGNED

PRISCILLA O. KIPPEN, Chief
Weapon Evaluation Branch

1 Atch
CB Values

Copied by 347TFW/DOW for reproduction purposes.

Readiness is our Profession

CB VALUES

ORDNANCE BDU-33 A/B - B/B

FULL MILITARY POWER - 4 g's, 2 SEC MANEUVER

Suspension Equipment	Dive Angle at Pickle (Deg)	Pickle TAS (KTS)	Pickle Slant Range (Feet)				
			7500	10000	15000	20000	25000
SUU-20/A	20	500	1.25	1.23	1.25	1.28	1.32
		550	1.26	1.26	1.27	1.31	1.35
		600	1.31	1.29	1.31	1.35	1.39
	25	500	1.26	1.24	1.26	1.29	1.32
		550	1.27	1.26	1.28	1.31	1.36
		600	1.32	1.30	1.33	1.37	1.41
	30	500	1.27	1.25	1.26	1.29	1.32
		550	1.29	1.27	1.29	1.32	1.35
		600	1.34	1.32	1.34	1.39	1.43
SUU-21A	20	500	1.17	1.18	1.21	1.26	1.30
		550	1.19	1.19	1.23	1.29	1.33
		600	1.21	1.22	1.27	1.32	1.37
	25	500	1.18	1.18	1.23	1.26	1.29
		550	1.19	1.20	1.24	1.28	1.33
		600	1.22	1.23	1.28	1.33	1.39
	30	500	1.18	1.19	1.22	1.26	1.30
		550	1.20	1.20	1.24	1.29	1.33
		600	1.23	1.24	1.29	1.35	1.40
MER/TER	20	500	1.07	1.14	1.27	1.38	1.46
		550	1.07	1.14	1.28	1.40	1.49
		600	1.07	1.15	1.29	1.41	1.52
	25	500	1.07	1.14	1.26	1.37	1.45
		550	1.07	1.14	1.28	1.39	1.47
		600	1.07	1.14	1.28	1.40	1.49
	30	500	1.06	1.13	1.26	1.36	1.44
		550	1.06	1.13	1.27	1.37	1.47
		600	1.06	1.14	1.27	1.38	1.48

Attachment to DLYW Letter


A little systems study really helps!
FLIGHT LINE

In the past the Fighter Weapons Review magazine has printed numerous articles on Dive Toss. One especially excellent article was published in September 197[illegible] by (then) Captain Robert Baxter. However, we feel this is one subject which merits frequent discussion, especially for our young, new officers who may not have had the opportunity to read previously published articles on this very important subject.

This paper presents the latest word on all known Dive Toss checks, as explained and clarified by the most experienced master sergeants and tech reps who could be found within the 4th AMS.

First, a quick review of how the system works – when the pickle button is depressed, the radar identifies to the WRCS the point to be hit, and at the same time, the WRCS begins computing a bomb trajectory using INS ground speed, pitch angle, and vertical velocity. When the trajectory passes through the target, the bomb is released.

How can you tell, before you get to the range, if your system will in fact do that? If it tosses poorly, how can you help the guys in Maintenance [illegible] brief figure out why? Let's look at [illegible] by sub-system.

WRCS

This is the most reliable component in the Dive Toss system. Being an analog computer, its computations are based on preset voltages, and these can get out of whack, but usually they don't. An incorrect voltage will cause consistently long or short bombs. The only way to discover this problem, short of bench-testing the unit, is to drop bombs.

The Dive Toss bit test on the WRCS panel isolates the Dive Toss circuitry from all other inputs and basically says that electrons will run through it. A "GO" indication does not tell you anything about accuracy; a "NO-GO" indication means there is virtually no chance the system will even release.

INS

The INS is generally considered the least reliable component and, unfortunately, it is also frequently impossible to tell beforehand if INS is going to cause problems. Part of the reason for this is a box called the Output Signal Distribution Unit, which takes the basic INS outputs from the platform and branches it out to the various systems in the aircraft. For example, it is possible to have good information going to the Nav Computer, but bad information going to the WRCS. If the present position windows are drifting off and the ground speed still looks good, then the odds are 50-50 that Dive Toss will be unaffected. But, if ground speed is running away too, then the odds approach 100% that Dive Toss will be bad.

The rest of the reason that INS can surprise you with bad bombs is that Dive Toss makes use of vertical velocity, which is virtually impossible to check in the cockpit. (There is a way, rather shakey, that will be covered later.) Runaway vertical velocity is usually the cause when bombs release either very early or not at all (assuming a good WRCS bit test.)

As always, you cannot say enough about a good INS alignment (or two, if at all possible). Most folks agree that a second alignment should be attempted in the arming area if the ground speed is 5 knots or more. If a second alignment is not possible, or the ground speed refuses to go below 5, there are varying schools of thought as to how much you should accept before forgetting about Dive Toss. A consensus is that 8 knots is getting awfully high. There is no official written guidance as to how much is too much – T.O.'s only specify that ground speed should be 5 knots or less after the first gyrocompass alignment.

All INS errors can be minimized by pickling as close as possible to the bomb release point. The further out you pickle, the more time the computer has to work with the wrong information. For example, if ground speed is high, the computer will think it has reached the release point earlier than it should and bombs will be short. If ground speed is low, the opposite will occur. INS errors produce consistently long or short bombs.

DRIFT STABILIZATION

With the sight in AG and Dive Toss selected, the pipper should move downwind to indicate the aircraft ground track. Therefore, if you pickle wings level with the pipper on target and make a wings level pull, you should fly across the target and kill your 3-9 error. That is, if the equipment is working correctly and if the wind doesn't change from pickle to bomb release.

The equipment can be checked enroute to the range by selecting HSI mode Nav Comp and noting the drift, then checking to see that the pipper moves downwind 17.5 mils per degree of drift. If drift stabilization checks bad, then cage the sight and select "Drift Out" on the radar. If you normally use a caged sight, it is still a good idea to check the drift; if it looks good, the radar should be left in drift stabilization; if not, select "Drift Out."

Neither an excessive crosswind nor bad drift stabilization should be an excuse for bad bombs at 3 or 9 o'clock, as the pilot ought to be watching where he is going. With low drag bombs, you have to fly across the target to hit it. It may be necessary to release in a bank, which induces some errors, but these will be much less than the error caused by not flying over the target.

RADAR

The radar has to track the ground return accurately until pickle, and provide the true range while doing so. These are two separate and distinct problems, so we will talk about them separately – tracking first, then ranging.

After lock-on, the range gate should stay in that portion of the ground return where you put it. If it doesn't, i.e., if it drifts up or down the scope after lock-on, then you have a bad synchronizer (that's the item that tells the radar when to transmit and when to listen) or a bad radar receiver. An indication of either problem is excessive clutter in the B-sweep after lock-on; normally everything should gain out except a small portion of the target and the range gate. This can be checked on the ground in Bit 5 AG, as well as monitored during the delivery itself. If it looks bad, then the back seater can revert to manual track. Synchronizer and/or receiver problems will seldom cause the radar to break lock, and in the rush of a delivery the back seater probably will not see the range gate beginning to drift. Probably the best "last second" indication of a wandering range gate is the analog bar. If it unwinds smoothly at first, then begins to jerk or suddenly slow or accelerate (assuming a constant, smooth dive at the target), you have this problem and you're going to get an interesting bomb if you pickle on this pass. Try manual track the next time around.

The worst case of this problem is the range gate that hangs in there most of the way down the chute, then slides just a little off at the last instant before pickle, giving you, let's say, a long bomb. You don't know what happened, but next time around you aim a little short, and as luck would have it, this time the range gate decides to wander downward on the scope and you get an unbelievable at six. If scores are inconsistently long or short, this is your problem.

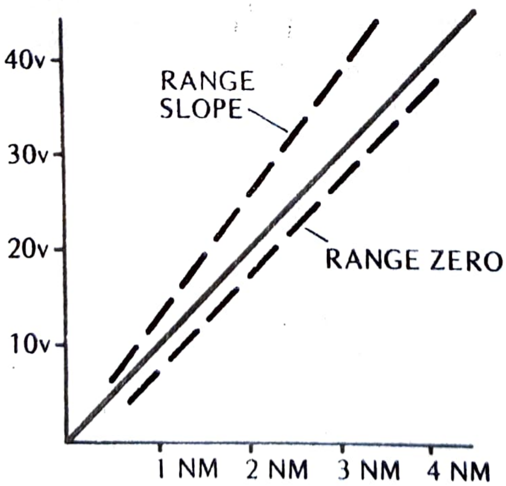


FIGURE 1

The synchronizer and receiver may work perfectly, but the radar still can cause errors, simply because it's not calibrated to tell the true range. The radar, like everything else in the F-4 computes using analog, and it so happens that to the APQ-120, one mile = 10 volts when the AG mode is selected. If you graph it out, it looks like Figure 1.

The solid black line, where 40v = 4 NM, 30v = 3 NM, etc., is the ideal. Our radar being what it is, there are many things that can put the line in a less than ideal place, and the RANGE SLOPE and ZERO check is intended to discover this. If you lock on to the first, second, and third bit targets and find that the analog bar is off by varying amounts at 5, 3, and 1 o'clock, then you have range slope error; if off by constant amounts, you have range zero error. A WAG at how much off can be made by comparing where the analog bar is in Bit 1 with where it is when locked on to the 2nd Bit target (see Figure 2).

If you're sure you have a range slope or zero error, neither one is necessarily an insurmountable problem. For the illustrated problem, pickling 200'/12 when the analog bar reaches 3 o'clock should theoretically bring you consistent shacl Range slope and zero can be completely in left field, but so long as you pickle at the same range with the same correction, you'll get good bombs.

The zinger in the range slope and zero check is that the analog bar is not an exact piece of equipment. Even if it has just been calibrated, the allowable tolerances are so great that you should take what you see with a grain of salt. A better check is to lock on to the first bit target, select RDR or BST, and take a look at the VI meter (E model). If it reads 6000' to 6200', the odds are in your favor that radar calibration will not be responsible for a bad bomb. If it reads less than 6000' and you do not know the Dive Toss history of that particular aircraft, your best bet is to aim long by the amount that the VI meter reads less than 6000'. It is interesting to note that if the radar is set precisely for air-to-ground (not just within specs), the VI meter will read 6100' to 6200' when locked on to the first bit target, and auto-acquisition probably will not work.

NOTE: Systems peaked to 10v for air-to-ground will read 5800' to 6000' on the VI meter.

DIVE TOSS QUICK RELEASE CHECK

All checks discussed so far pertain to a particular component of the Dive Toss system. The Quick Release Check is a way to test the entire system for its ability to generate a release signal. It was originally in the T.O.'s for the F-4D as a way of quickly trouble-shooting a no-release write-up, but was taken out for the F-4E because it would only work when the aircraft was almost exactly level. However, it appears that the check may be valid as long as the aircraft is taxiing. To perform the Quick Release Check, the AC selects Dive Toss, Bombs, Master Arm – "ARM," Armament Override – "IN."

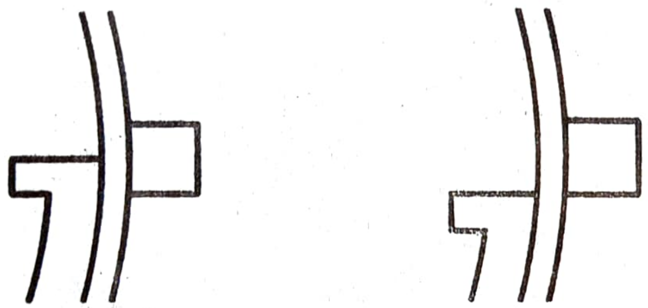


FIGURE 2 (See note below)

DO NOT SELECT A LOADED STATION OR YOU WILL BOMB THE TAXIWAY!! The WSO locks on to the fifth bit target, sets about 1.00 in the drag coefficient, holds down the pickle button, and cranks down the drag coefficient. The tone should go out and the pull-up light should come on when the drag coefficient reads 0.03 ± .02. This is the coefficient a theoretical bomb would need to travel five miles, with the small amount of ground speed normally in the INS on the ground. If the tone will not go out and you are taxiing, it <u>may</u> be that your system will not release. If the tone goes out early, you can expect a short bomb – maybe. The cause could be computer or INS; this is the one place where bad vertical velocity inputs will show up.

This check can only show short bombs up to shacks – there is no way for it to show a probable long bomb. For the time being, the best application of this check seems to be to run it, attempt to drop some bombs, and see if there is any correlation. If we could get enough people running it and get some experience with it, we might have ourselves a good check.

To summarize all checks discussed:
- Quick Release Check
- Dive Toss Bit Button

Arming area – INS ground speed and present position
- Bit targets gain out after lock-on
- Range Slope and Zero Check
- VI meter reads 6000' to 6200' in RDR

Airborne – Check sight drift stabilization

During pass – AC monitor analog bar for good lock-on.

That about covers everything you can do to discover and compensate for faulty equipment. We haven't talked about how to get good bombs if everything is working the way it should; that is another story, and happily it's a rather simple one. That's the beauty of Dive Toss.

It may have occurred to you in the course of reading this that the best check of all is to drop some bombs. Half the things that can go wrong with Dive Toss will show up in any kind of check. If something shakey is found in a check, go ahead and drop a bomb or two anyway, if at all possible. You may uncover something else.

Captain Charles Brammeier
Seymour Johnson AFB, North Carolina

NOTE: 1. INS must be in NAV.
2. 347TFW maintenance says that this check should be done while the aircraft is stationary.

We know that dive toss system errors exist, but past emphasis has been on aircrew technique, and there is very little information on latent system errors. Because of this, separating aircrew errors from dive toss system errors becomes a real problem, complicated by the fact that system errors don't show up well in any kind of system record. Two of these latent system errors were uncovered through empirical data from 18TFG/DOW at Kadena AB, Japan, and are discussed here. These errors have their sources in: (1) Electrical frequency production, and (2) LCOSS mount alignment.

ELECTRICAL FREQUENCY PRODUCTION

Principal components of the dive toss system depend on a 400 Hertz (Hz) electrical frequency for accurate measurement and calculation. The frequency tolerance of these components is surprisingly small, and each one is discussed below.

Latent Dive Toss System Errors

By
CAPTAIN RALPH S. REINHART II
(Weapons and Tactics Officer/F-4)
18TFG/DOW
Kadena AB, Japan

(1) INS: The INS frequency tolerance is ±2 Hz. An input electrical frequency outside this limit will: (a) cause the platform to operate inaccurately, (b) cause the platform outputs to be inaccurate, and (c) damage the platform, or at least reduce its life span by a considerable amount.

(2) Fire Control System: The Fire Control System depends on 400 Hz for the timing reference in all of its ranging computations. If the ranging circuits are not supplied with 400 Hz (±2.5), their outputs will be inaccurate. The Fire Control System cannot tolerate an extended electrical frequency fluctuation of more than 2.5 Hz without suffering some sort of damage.

(3) WRCS Ballistic Computer: Like the Fire Control System, the Ballistic Computer depends on a 400 Hz frequency for its timing reference. If it doesn't receive 400 Hz, its calculations and outputs will be inaccurate. Actually, the Ballistic Computer is affected in three ways by an inaccurate power frequency: (a) the inputs from the INS will be inaccurate, (b) the inputs from the Fire Control System will be inaccurate, and (c) the Ballistic Computer's calculations will be made improperly, with inaccurate inputs.

Based on the information above, dive toss system accuracy depends on the accuracy of its electrical frequency input. This input depends on the condition of the aircraft generators. One way to guarantee generator condition is to insure that correct oil servicing procedures are followed. This will contribute not only to generator condition, but also to an accurate frequency input to the dive toss system's components.

Production of an accurate 400 Hz (±1) depends on the operation of the F-4's Constant Speed Drive (CSD) units, which drive the generators. A Frequency Load and Control Box fine-tunes the generator output(s) by making minute corrections in generator rotating speed, and also matches the generator's output frequencies within seven (7) Hz of each other. The CSD is hydraulically-driven with engine oil, and is totally dependent for its correct operation on having the correct amount of engine oil to work with, e.g., its operation is sensitive to the amount of oil available. The CSD's operation can be affected if the engine oil reservoir is as little as five (5) pints low, because with this amount (37 pints), it is possible for oil to drain away from the CSD intake port under certain flight conditions. If an operating CSD is suddenly deprived of oil from the reservoir, the oil remaining in the CSD is trapped there to maintain continuous CSD operation and prevent generator failure. This trapped oil is neither filtered nor cooled, and can break down rapidly. The effect of this oil drainage also creates two power surges: the first when oil is removed from the intake port, and the second when oil is returned to the intake port. These surges affect the operation of all the frequency-sensitive electrical systems in the aircraft, including the components of the dive toss system. The Frequency Load and Control Box cannot compensate for surges of this magnitude. The effect of these power surges on the dive toss system's component is that errors are created, and the condition of the components will become progressively worse. The aircrew, of course, will have no indication of this because there is no generator failure and no indication is provided. No indication for problems of this nature is necessary if proper oil servicing procedures are followed.

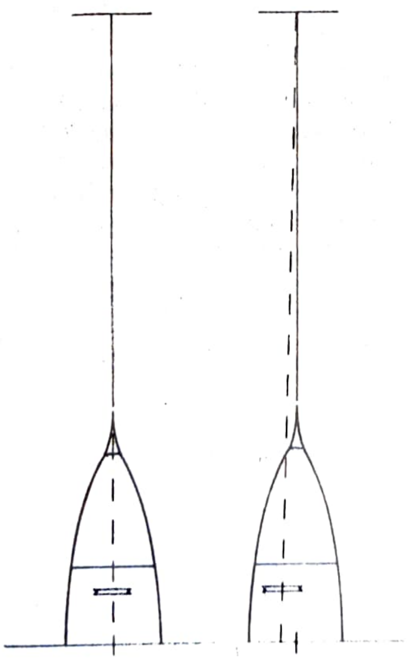
Servicing requirements for F-4 aircraft dictate that oil reservoirs must be serviced at the end of each flying day. The J79 engine consumes, on an average, 1-2 pints of oil per sortie, and due to the heavy demands on aircraft engines during surge or multiple-turn operations, some maintenance organizations require oil servicing following each sortie. During a surge, a high-volume flying operation, it is entirely possible to deplete an engine's oil reservoir by more than five pints without servicing at some time in the middle of the flying day. This can lead to a myriad of electrical problems later on, which creates further problems for the dive toss system.

There are three indications, either separately or in conjunction with each other, that inadequate oil servicing may be causing problems in unit aircraft. These indications are:

(1) Dive toss scores are extremely inconsistent, and they cannot be attributed to either aircrew error or system error; the aircraft check out well, but the scores are bad. This is a cause for further investigation.

(2) INS platforms in unit aircraft fail at a high rate. A normal rate is about four platforms per month per 24 U.E. squadron.

INDUCED PARALLAX ERROR
(Not to scale)



Sight mounts adjusted. LCOSS boresight and aircraft boresight lines coincide. No parallax error.

Sight mounts not adjusted, LCOSS boresight and aircraft boresight do not coincide. LCOSS biased to boresight, with a resulting parallax error. This error exists even if the LCOSS is not biased.

(3) CSD/Generator failures occur in unit aircraft at a high rate. A normal failure rate for the CSD/Generator system is about 1-2 per month per 24 U.E. squadron.

If (2) and (3) each occur separately, there is a very definite possibility that unit oil servicing procedures are inadequate. If (2) and (3) occur together, inadequate oil servicing is a certainty.

The key to solving this problem is to insure that aircraft oil servicing requirements are being satisfied within the unit, and that adequate provision has been made for servicing during surge operations. Incidentally, oil servicing must be accomplished within 30 minutes after engine shutdown to avoid overservicing. If the unit has a problem with its oil servicing procedures, then improvement in this area will improve not only dive toss scores, but the operation of other systems as well. Although it sounds trite, empirical data shows that aircraft which have regular and sufficient oil servicing have fewer electrical system malfunctions overall, and more consistent dive toss scores. **NOTE:** the frequency output of the flightline M32A-60 power cart is not always an exact 400 Hz. The aircraft's frequency output is supposed to be 400 Hz (±1), and this is the reason why INS alignments on aircraft power are preferred over alignments on ground power.

LCOSS MOUNT CALIBRATION

In order for the LCOSS indications to be correct, the sight head must be properly aligned with the aircraft. Proper alignment does not simply mean that the LCOSS reticle is boresighted; the mounts that hold the sight head in place must also be correctly aligned.

The LCOSS mount is equipped with a set of adjustable shock mounts, whose purpose is to stabilize the sight head and its presentations through all aircraft maneuvers and protect its internal components. If the shock mounts are not correctly aligned, the sight presentation will be in error equal to the amount of misalignment. LCOSS shock mount alignment is supposed to be checked in WCS Calibration (IAW Tech Data), in conjunction with the electronic boresighting of the sight head. The sight head and its shock mounts are "boresighted" independently of each other for reasons which will become evident.

In the specified "boresighting" process, the sight head is removed for calibration in the shop, and the shock mounts are aligned with a Boresighting Assembly Fixture, which is installed in the shock mounts, and a Boresighting Board. This Boresighting Assembly Fixture is weighted with lead to match the weight of the sight head, and is called a "Lead Log." Using a telescope on the Lead Log, the technician adjusts the shock mounts so that the telescope crosshairs center on the boresighting mark on the board. If the shock mounts are sufficiently worn, they must be replaced.

When the sight head is returned from the shop, it is reinstalled in the mounts and its calibration is checked with the board. This is the final check on the sight head's calibration, and its boresight (35 mils) setting must fall within two mils of the mark. Maintenance personnel are authorized to bias the sight's gyros no more than two mils. If a bias greater than two mils is required to bring the sight to boresight, the sight head must be replaced. A bias greater than two mils creates a parallax error, as shown in the accompanying illustration. NOTE: "Boresighting" the sight head is really a misnomer. The sight head is calibrated in the shop, and its boresight setting is checked with the boresighting board, but it is never really boresighted.

The material in the shock mounts deteriorates with time and use, creating the requirement for periodic adjustment. Empirical data from Kadena AB shows that F-4D shock mounts were out of alignment by an average of five mils after approximately two years of no calibration. This five-mil error cannot be detected by the aircrew, and while it has little effect on manual dive bombing, it has a catastrophic effect on dive toss scores—up to 150 feet of miss distance. NOTE: WCS Calibration crews will sometimes cut corners by checking the shock mount alignment with a calibrated sight head instead of a Lead Log, assuming that the sight head's boresight setting is correct. This is not a valid shortcut in the author's opinion because, according to the specified procedure, the sight head's calibration remains to be checked. If the sight head's boresight setting is incorrect, then the mount alignment will also be incorrect.

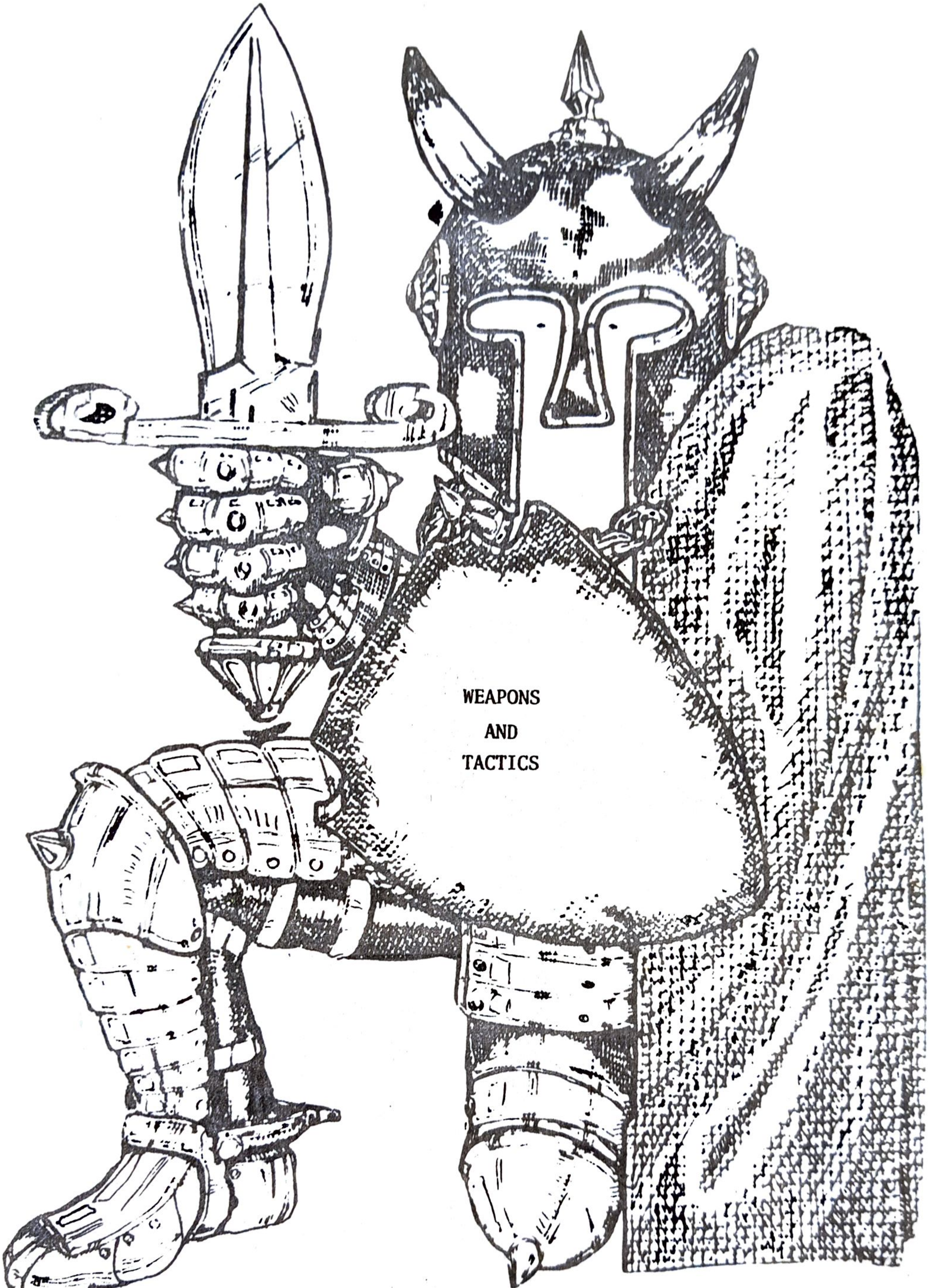
There are two indications of a shock mount misalignment problem:

(1) Inconsistency in dive toss scores from airplane to airplane. These errors are predominately short, with perhaps some particularly large, unexplained left/right errors.

(2) The occurrence of a double-pipper image in some aircraft. A double pipper image means that the shock mounts are sufficiently misaligned (12+ mils) to hold the combining glass so that the pilot sees the reticle image on the front and rear surfaces of the glass, creating the illusion of two pipper images. This phenomenon can be verified only in the aircraft, because the problem exists only in the shock mount alignment, and will not show up on the LCOSS Test Bench.

The way to resolve this problem is to make sure that correct boresighting procedures are being followed (IAW existing F-4D Tech Data). Cutting corners in this area can create gunnery errors which are difficult to pin down. In the case of the F-4D aircraft, some aircraft fuselages may be sufficiently warped so that the LCOSS mounts cannot be adjusted to hold the sight head at the correct alignment. If this is the case, the shock mounts should be adjusted to some neutral position, and the remaining error noted. This error can be compensated for with a mil or drag coefficient correction.

The two latent sources of dive toss system error discussed above can be responsible for many poor dive toss scores. Neither the aircraft's electrical frequency output, nor the LCOSS shock mount alignment can be sufficiently monitored to determine if they are in error. These latent errors must be identified and corrected before aircrews fly aircraft. If the considerations listed here are satisfied, along with Ballistic Computer Calibration (FWR, Fall '77), most of the latent errors in the dive toss system can be eliminated. Eliminating these errors makes it easier to sustain an effective dive toss program.



Knowledge of Weapons and Tactics is your sword and shield in combat. Are you doing any self study in tactics manuals, FWS Texts and weapons tech orders??? Or do expect to be force fed? It's too late to study when you step out the door for that minimum notice combat mission you thought you would never fly. As TAC aircrews you are the cutting edge of the sword. You may well be the initial thrust. Are you ready?

BE PREPARED!