

NAVAL AIR TRAINING COMMAND



NAS CORPUS CHRISTI, TEXAS

CNATRA P-912 (Rev. 04-18)

FLIGHT TRAINING INSTRUCTION



LOW ALTITUDE TRAINING (LAT)

2018



DEPARTMENT OF THE NAVY
CHIEF OF NAVAL AIR TRAINING
250 LEXINGTON BLVD SUITE 179
CORPUS CHRISTI TX 78419-5041

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CNATRA P-912 (Rev. 12-21) CHANGE TRANSMITTAL 1

Subj: FLIGHT TRAINING INSTRUCTION, LOW ALTITUDE TRAINING

Encl: (1) Change 1 Pages iv, v, 1-7, and 1-19.

1. Purpose. To publish Change 1 to the basic publication.
2. Action.
 - a. Remove pages iv, v, 1-7, and 1-19 and replace with pages in enclosure (1).
 - b. Record Change 1 on the Summary of Changes page.
3. Future printing of this Flight Training Instruction will incorporate the change. POC is CNATRA Training Officer, N71, DSN 861-2356.

A handwritten signature in black ink, appearing to read "T. P. Atherton", is written over a horizontal line.

T. P. ATHERTON
By direction

Releasability and distribution:

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Subj: FLIGHT TRAINING INSTRUCTION, LOW ALTITUDE TRAINING

1. CNATRA P-912 (Rev. 04-18) PAT, "Flight Training Instruction, Low Altitude Training (LAT)" is issued for information, standardization of instruction, and guidance for all flight instructors and student aviators within the Naval Air Training Command.
2. This publication shall be used as an explanatory aid to all fixed wing flight below 1500 feet AGL outside of the terminal environment. It will be the authority for the execution of all flight procedures and maneuvers herein contained.
3. Recommendations for changes shall be submitted via the electronic TCR form located on the CNATRA website.
4. CNATRA P-912 (07-07) PAT is hereby cancelled and superseded.

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S. E. HNATT
By direction

Distribution:
CNATRA Website

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**FLIGHT TRAINING INSTRUCTION FOR
LOW ALTITUDE TRAINING**

P-912



CHANGE 1

LIST OF EFFECTIVE PAGES

Dates of issue for original and changed pages are:

Original...0...13 July 07(this will be the date issued)

Revision...1...20 Apr 18

Change Transmittal...1...3 Dec 21

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 34 CONSISTING OF THE FOLLOWING:

Page No.	Change No.	Page No.	Change No
COVER	0		
CHANGE LETTER	1		
PROMU LETTER	0		
(blank)	0		
iii	0		
iv – v	1		
vi – viii	0		
1-1 – 1-6	0		
1-7	1		
1-8 – 1-18	0		
1-19	1		
1-20 – 1-22	0		
A-1	0		
A-2 (blank)	0		

INTERIM CHANGE SUMMARY

The following Changes have been previously incorporated in this manual:

CHANGE NUMBER	REMARKS/PURPOSE
1	Changes made per transmittal letter (3 Dec 21)

The following interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER	REMARKS/PURPOSE	ENTERED BY	DATE

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CHAPTER ONE LOW ALTITUDE TRAINING (LAT)

100. INTRODUCTION

The projection of sea power ashore brings to the theater of war a unique blend of capabilities and vulnerabilities. Capabilities, because modern Naval power can physically travel to the vicinity of a conflict with vast firepower and sustainment, and at the same time provide a formidable presence to support diplomatic operations. Vulnerabilities, because not only are operations from the sea intense and dangerous, particularly from the standpoint of Naval Aviation, but because by nature of the limited space available aboard a Carrier Strike Group (CSG) and associated Amphibious Ready Group (ARG), Naval Strike Aviators and their aircraft cannot be tightly specialized, but must have the ability to execute a wide range of tactical missions.

Because of the unique performance requirements imposed on Naval Aviation to safely meet these challenges, the Naval Aviator will not only be required to develop expertise in the execution of a variety of tactical missions, but within subcategories of similar missions, we must acquire the knowledge and capability to employ flexible techniques in order to achieve mission success in a variety of external factors. The Low Altitude Training (LAT) presented in the TRACOM serves as a foundation to establish basic skills of low altitude visual navigation, terrain avoidance, and time-speed management. Proficiency in these fundamental skills will carry forward to more advanced tactics used in high performance fleet aircraft. *Fleet style tactics are not the objective or intent of LAT in the Training Command.*

This instruction is intended as a safety supplement to the Flight Training Instructions for any stage that contains fixed wing flight below 1500 feet Above Ground Level (AGL) not in the takeoff or landing phase of flight. Its primary purpose is to standardize the rules of conduct and training in the low altitude flight regime for all CNATRA fixed wing aircraft. This FTI provides information and procedures on: High speed flight in the low altitude environment; task loading and its effects; the physics of maneuver close to the ground; the hazards of low altitude flight; Terrain Clearing Tasks; Mission Crosscheck Time; Basic Maneuvers; and LAT Training Rules.

101. BACKGROUND

Rediscovery of the tactical potential of low altitude flight after WWII resulted in a great deal of training emphasis in that environment. But until fairly recently, the training always focused on low-level navigation, target area mechanics, weapons employment, and threat avoidance. There was no emphasis in the area of terrain avoidance. Only in the most cursory manner were the mechanics of avoiding the ground addressed, and such treatment was at best non-standard. Tragically, the loss of aircraft and lives reflected the lack of standardization in Low Altitude Training.

It was the Arizona Air National Guard's, 162nd Tactical Fighter Group, flying head-up display (HUD) and inertial navigation system (INS) equipped A-7 Corsair II's out of Tuscan Arizona, who first developed the concepts that are addressed in this FTI. With a bit of higher mathematics and a lot of flight testing, the 162nd Tactical Fighter Group (TFG) developed such low altitude instructional concepts as the "Bucket," Terrain Clearance Tasks (TCT), Mission Tasks (MT),

Knock it Off (KIO), Climb to Cope and various dive recovery rules. These concepts are now used fleet wide in Navy and Marine Corps Strike/Fighter communities. Although originally designed for HUD/INS equipped tactical aircraft, the LAT concepts presented in this FTI are applicable to safe conduct of any airframe flying low and fast.

102. THEORY OF FLIGHT IN THE LOW ALTITUDE ENVIRONMENT

High-speed flight in the low altitude environment is a regime of aircraft operation that is both high workload and high risk. Task saturation can quickly overtake a pilot before there is clear awareness of developing danger in an environment. In order to help mitigate the potential consequences of task saturation during low-level flight, it is important that aircrew exposed to low altitude flight training have, at the minimum, a basic understanding of the following concepts:

Bucket. The “bucket” is an illustrative reference used to describe the finite capacity a human pilot has for input and subsequent action in the low altitude environment. The analogy of a finite bucket represents maximum human capacity, and subdivisions within that set equal the divisions of tasking in terms of priority.

The bucket illustration is a visual means of showing the only acceptable task prioritization in the low altitude environment. Within the bucket are two categories of tasking:

1. **Terrain Clearance Tasks (TCT)**, which involves any mental or physical effort expended to avoid hitting the ground. TCT includes four sub-tasks:
 - a. **Aerodynamic control of the aircraft.** Process of maintaining the aircraft within its operating envelope to include angle of attack (AOA), airspeed, and G limits. Basically what is required to keep the aircraft flying.
 - b. **Vector control.** Process of assessing and modifying the aircraft vector in elevation, azimuth, and velocity relative to the terrain. Vector control includes attitude (pitch and roll) and is the key TCT crosscheck variable.
 - c. **Altitude control.** Process of assessing and modifying the aircraft altitude in relation to the terrain. Vector and altitude are the two physical variables that define the boundaries of safe low altitude maneuvering.
 - d. **Time control.** Involves knowing when and for how long to “ignore” vector and altitude control. Time control is the key to proper task management, it is the least measurable part of TCT, the hardest to learn and by far the most difficult to control.

2. **Mission Tasks (MT)**, which encompasses all remaining activities required to accomplish the mission. Within the category of MT, there are two subdivisions:
 - a. **Critical Tasks (CT)**, which are functions demanding immediate attention in order to successfully accomplish the mission.
 - b. **Non-Critical Tasks (NCT)**, which are functions that can be addressed on a more flexible time window.

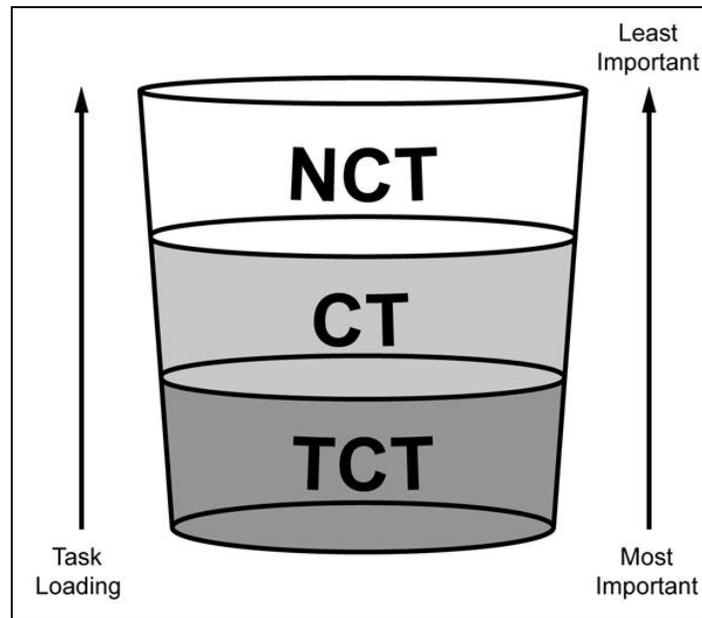


Figure 1-1 Task Management “Bucket”

NOTES

1. Remember that TCT is your primary task and therefore should be **FIRST IN** and **LAST OUT** of the “Bucket.”
2. Mission Crosscheck Time (MCT) can be easily visualized as the unfilled portions of the bucket after TCT but before MTs (CT and NCT) are added.
3. After all TCT have been accomplished, we add CT and NCT, respectively, in the room remaining in the bucket.
4. Generally speaking, we do fine when all of our tasking is within the bucket and we manage them in order of priority. Sometimes there is simply not enough room for all of the tasks at hand. When this occurs, and you have either more TCT than the bucket will hold or you allow some of your TCT to be replaced by MT, ground impact will result.

Tasking Priorities

Many accidents have occurred in the low altitude environment because of a wrong application of tasking priorities. Controlled flight into terrain results when a pilot prioritizes MT over TCT at a critical point in the flight. With terrain obviously being the biggest threat, ***no MT should ever take precedence over TCT***. To further prioritize activities while flying low and fast, mission tasks are divided into the two subcategories of critical task and non-critical tasks.

1. ***Critical tasks*** such as maintaining situational awareness, threat awareness (other than terrain awareness), and route navigation are crucial to mission accomplishment and must therefore claim priority after TCTs.
2. ***Non-critical tasks*** on the other hand, such as communications, stores selection, HUD mode changes, and environmental control adjustments, while having impact on the mission, can be accomplished on a flexible basis, as the situation allows.

When task loading becomes extremely high, the first tasking to be loadshedded are non-critical tasks. As task loading continues to increase, critical tasks are eliminated, and in certain regimes of low altitude flight such as during a turn, all mission tasks must yield to TCTs.

Overtasking Cues are the signs of psychological and physiological stress which manifest themselves in one or more of the ways listed below.

1. Momentary indecision or confusion (feeling of being “behind the aircraft”).
2. Wasted movements in the cockpit.
3. Missed tasks and checks.
4. Erratic or inconsistent basic airwork.
5. Loss, late, or non-standard verbal response.
6. Loss of overall situational awareness.

It cannot be overemphasized that aircrew need to understand these cues in order to have a frame of reference for recognizing overtasking and misprioritization of cockpit tasking.

MCT is that time spent away from TCTs for the purpose of accomplishing either a CT or a NCT. Stated another way, it is the time available to accomplish critical and non-critical tasks after TCTs have been performed. Remember there is only 1 second for MCT while in a turn and that is reserved for scanning your flight path and upcoming terrain. A sample task management timeline for straight and level flight with five seconds MCT might look something like the following illustration:

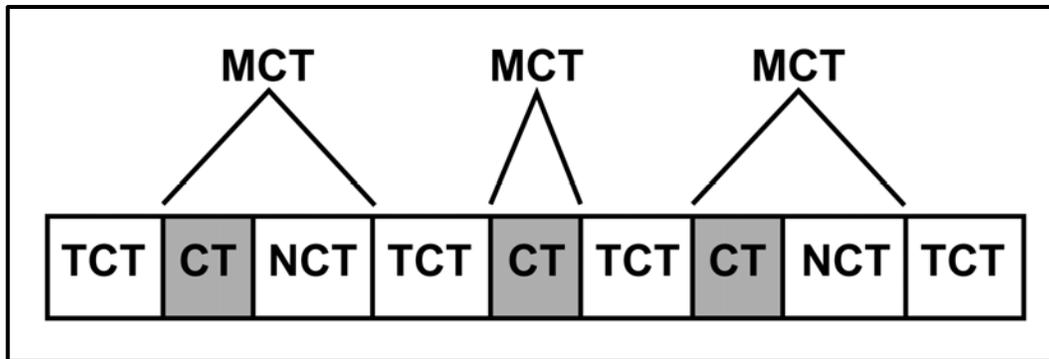


Figure 1-2 Task Management Timeline

Whether single-seat or multi-crew, the same set of priorities and sequence has to take place. For example, take a mission “time slice” and look at the tasks facing you as shown in Figure 1-2. At time $t = 0$, you start with and establish safe TCT. Based on several factors, you may have some MCT available to divert from TCT to accomplish part of the CTs and maybe even some of the NCTs; however, after a given amount of time you must return to TCT. The cycle continues – TCT, then CT, and NCT, and back to TCT. This is simple in concept and easy to do for a short period of time, but it is extremely demanding to accomplish for long periods. It is obvious that any error in MCT control can lead to missing a critical TCT cycle, resulting in ground impact.

Without a doubt, the most difficult part of low altitude flying is the constant task management of time control. Although visual illusions (misperceptions) or a basic lack of hand-eye flying skills can cause ground impact, the vast majority of accidents are caused by a lack of proper *task management*. Not knowing or forgetting: *what* to look for, *when* to look for it, *where* to find it, or *how* to use it are basic ingredients of almost all low altitude accidents. In short, the pilots placed some MT ahead of TCT. This misplaced priority or task saturation occurs when the existing task loading requires more capability than we have available at that particular moment. We can only do so much at any given point, and the acceptance and ability to detect this in ourselves is a requirement for low altitude survival.

The level of effort expended by a pilot to maintain terrain clearance tasking is affected by four major factors:

1. **Maneuver:** Bank angle, “G” loading, and speed.
2. **Aircraft capability:** Status of aircraft equipment (e.g., HUD, Radar Altimeter, etc).
3. **Pilot capability:** Currency, “Do I feel up to the task today, or behind?”
4. **Environment:** Terrain - flat, rough, up-sun, down sun, visibility clear, hazy...

These various factors can lead to tasking conflicts, which ultimately call for the pilot to judge personal performance limits. If a conflict occurs between TCT and CT, the pilot has no choice but to either cease MT temporarily and concentrate on TCT, or decrease maneuver intensity in order to reduce TCT demands thereby allowing room in the bucket for MT.

103. PHYSIOLOGICAL CONSIDERATIONS

Visual (Central v. Peripheral). Human vision is divided into two basic categories; central vision and peripheral vision. Central vision with its small field of view of approximately 2° is the primary means of information gathering and is consciously controlled. Central vision has very good acuity, can distinguish objects with very low contrast, and has a high “G” tolerance. The capabilities of central vision are in direct contrast to peripheral vision, which in human visual perception, acts more as a spatial orientation tool. Peripheral vision is subconsciously controlled and has a very wide field of view. Acuity is poor with a limited ability to discriminate high contrast objects. Significantly, peripheral vision has a low “G” tolerance, an attribute which can be used by the pilot to recognize personal “G” limitations.

Optical Flow Pattern. This low altitude phenomenon actually contributes to a pilot’s ability to predict and control ground track, direction and rate of movement toward or away from a desired course. It is based on the way objects flow below, around, and past the pilot’s eye flying over and around terrain. Without actually focusing on any one object or portion of terrain near the aircraft, by subconsciously evaluating the optical flow, a pilot can determine spatial position relative to terrain and man-made obstacles. With experience, a pilot can use this phenomenon with a surprising degree of accuracy, but it is by no means a substitute for proper use of instrumentation.

Speed Rush Baseline. This is another low altitude phenomenon that is established by subsequent perceptual evaluations of altitude above ground level and speed. Speed rush is a sensation of rapid movement created by the apparent relative motion of the optical flow pattern. At a given speed and above ground level (AGL) altitude, it takes a pilot about 30 to 60 seconds to adapt to the rapid movement of the flow pattern, establishing a perceptual baseline.

From the pilot’s standpoint, the more time spent at a given speed and AGL, the greater the comfort level and the perception of safety. While such a comfort level can allow a pilot to maneuver confidently in the low altitude environment, it is an unreliable indicator of safety. Only frequent crosschecks of an accurate radio altimeter and a positive flight path angle when engaged in heavy mission tasking will provide protection from impacting the terrain.

Seat of the Pants. Without going into a lengthy medical discussion on how the inner ear vestibular and peripheral somatosensory sensors work, there is an important point to be made on how they play a role in low altitude flight and spatial orientation. These sensors are “caged” for 1 G flight, therefore the “seat of the pants” feel is unreliable in anything other than 1 G flight.

Therefore a crosscheck of aircraft instrumentation coupled with visual sensory information should be used in the Low Altitude Training (LAT) environment for spatial orientation.

104. LOW ALTITUDE SAFETY CONSIDERATIONS

Safety Considerations

1. **MTR** stands for Military Training Route. According to Flight Information Publication - General Planning, “Airspace of defined vertical and lateral dimensions established for the

conduct of military flight training at airspeeds in excess of 250 knots indicated airspeed (KIAS).” MTRs are used by all four Services for routine training. There are several types of MTRs published in the Area Planning (AP/1B):

- a. **Instrument Flight Rules (IFR) Military Training Routes (IR)** – Routes used by the Department of Defense for the purpose of conducting low-altitude navigation and tactical training in both IFR and Visual Flight Rules (VFR) weather conditions below 10,000 ft mean sea level (MSL) at airspeeds in excess of 250 KIAS.
- b. **VFR Military Training Routes (VR)** – Routes used by the Department of Defense for the purpose of conducting low-altitude navigation and tactical training under VFR below 10,000 MSL at airspeeds in excess of 250 KIAS.
- c. **Slow Speed Low Altitude Training Routes (SR)** – Not an MTR according to General Planning (GP), but otherwise treated just like one. SRs are low-level routes at or below 1500 ft AGL, 250 KIAS or less.

If you’re planning a Low-Level (whether you’re flying on an MTR or not) you should be plotting crossing MTRs on your chart. This will give you the heads up you need to avoid a midair.

2. **Weather conditions** should always be taken into consideration. CNATRA has established a ceiling of 3000 ft AGL and visibility of at least 5 statute miles (1500ft/3sm for multi-engine aircraft operating less than 250KTS) as the minimum acceptable weather conditions in which to conduct low altitude operation. Weather minimums have been established for the preservation of life and assets. Such minima constitute a lawful written order, which must be adhered to. Cloud layers, prevailing visibility, obscurations such as smoke, fog and haze need to be carefully considered even if the weather minimums are legal for proposed low altitude training, as these conditions can adversely affect visual perception.

3. **Obstacles** in the low altitude environment range from natural to man made, and all of them can potentially bring low altitude operations to a sudden and disastrous halt. Natural obstacles can be anticipated by detailed preflight chart study while the AP/1B and Chart Update Manual (CHUM) can be used to annotate and mark the latest man-made obstacles. Together, these steps in preflight planning will provide reasonable protection against the ever-changing landscape of communication towers, power lines, and logging cables in the more mountainous areas.

4. **Bird-strikes** have occurred as high as FL 200, but by far the greater numbers of strikes have occurred in the low altitude environment. As part of preflight planning, attention must be paid to local Bird/Animal Strike Hazard (BASH) conditions. BASH advisories take in to account migratory bird seasons, time of day when most large birds of prey are likely to be flying, and the normal concentration of bird population in specific geographical location. As an in-flight consideration, most large birds tend to dive upon encountering an aircraft, though on occasion they’ve been known to climb. Regardless of the bird reaction to an encounter, in the low altitude environment for obvious reasons, the pilot should always climb. Flying with the visor down is another important safety consideration and will pay great dividends should a strike occur in the vicinity of the windscreen.

5. **Sun position** has been a contributing factor in a number of low altitude mishaps. Glare in the early morning or late afternoon can effect visual perception of the pilot heading into the sun, or create deep shadow which can mask significant terrain features for the pilot headed away from the sun.

6. **Turbulence** can actually make the low altitude environment unflyable. In extreme conditions, a pilot's planned flight path can be drastically altered by powerful up or downdrafts. Mountainous areas of the country must be treated with respect. If a pilot encounters moderate turbulence in flats areas between mountains, it is a good indication that more extreme turbulence will be encountered at the point where the air is pushed vertically by the terrain.

7. **Over water low altitude flying** has always been deceptively dangerous. Not only is there a false sense of security with the absence of vertical obstacles, but certain sea conditions virtually eliminate the pilots ability to judge his height above the water. At 360 KIAS, water is just as hard as any terrain; therefore flying over it demands the same strict adherence to terrain clearance tasks, observance of minimum altitudes and the use of radar altimeter.

8. **Other Aircraft** are always a concern especially in a VFR environment. Just because you might be operating in a Restricted Area, a Military Operating Area or on a MTR doesn't mean you are the only show in town. There may be other military aircraft operating around you or just some light civil aircraft trying to find its way home. Lookout doctrine is necessary in peacetime or war and you can't let that break down. If it does, then you are task saturated and flying too low. You should always check the vicinity of your operating area or low-level route for victor airways, small airfields and other crossing low-level routes.

105. LOW ALTITUDE PHYSICS

While there is no difference in the physics that govern high altitude flight and low altitude flight, there is a significant difference in physics application with respect to safety. Safe operation in the low altitude environment demands greater preflight knowledge and in-flight awareness of specific laws and pilot controlled variables than operation at altitude. There are four pilot controlled variables involved in terrain clearance tasks:

1. Flight path angle (FPA)
2. Centripetal acceleration or "G"
3. Bank angle
4. True Airspeed

By knowing these variables, we are able to determine a valid Time To Impact (TTI) for any regime of low altitude flight. For example, the formula used to determine **TTI resulting from straight and level** FPA deviations is expressed as follows:

	$TTI = \sqrt{\frac{\text{Altitude (AGL)}}{(\text{TAS} \times 1.69) \times \sin(\text{FPA})}}$			
	FPA = -1°		FPA = -2°	
	<u>480 kts</u>	<u>240 kts</u>	<u>480 kts</u>	<u>240 kts</u>
100 AGL	7	14	3.5	7
300 AGL	21	42	10.5	21
500 AGL	35	70	17.5	35

Table 1-1 Straight and Level Time to Impact Values (in seconds)

At 500 ft AGL, 360 KTAS, a flight path deviation of just -2° would render a TTI of 21.2 seconds. A deviation of -10° would result in a 9.4 second TTI. This assumes 1 G flight and all other variables remain constant.

TTI for a wings level bunt is another matter. The primary factors in calculating TTI for this regime is AGL, “G” factor and time. For a wings level bunt, the TTI is calculated based on AGL and the time that zero “G” is held. The following equation is used to calculate TTI in a wings level bunt. Note that the TTI is the same for a given AGL regardless of TAS and the only other variable is time. You are accelerating each second and the altitude lost is proportional to the square of time. This means that in the third second you will lose nine times the altitude you lost in the first second. Therefore the important item to take away from this discussion is that time is the key factor in performing a bunt. Too much time can result in burying the nose beyond the point of possible recovery.

	$TTI = \sqrt{\frac{2 \times \text{AGL}}{(32.2 - (G \times 32.2))}}$
	<u>Any Airspeed</u>
100 AGL	2.5 sec
300 AGL	4.3 sec
500 AGL	5.5 sec

Table 1-2 Wings Level Bunt Time to Impact (Zero G)

Calculating the TTI for turns is a bit different from wings level or zero “G” bunt. Bank Angle beyond that required for a level turn (over-bank) and G-forces are the primary factors. The real danger in over-banking close to the ground is in the failure to detect the condition until it is too late. Most pilots associate “G” force in a turn as the element required to accomplish a level turn. As angle of bank (AOB) increases, so does the centripetal acceleration requirement to maintain level flight. The graphic below shows the exact AOB and “G” required for each turn to maintain level flight. Unfortunately, visual perception of proper AOB and seat of the pants perception of required G-force in a turn is unreliable for the following reasons:

1. Normal environmental visual cues do not provide the AOB sensitivity to detect over-banks. For a given turn, it is virtually impossible for a pilot to distinguish between an under-bank and an over-bank until the aircraft begins to physically displace. Monitoring bank angle is a function of TCT that is ignored or neglected only at a pilot's peril.

2. In normal turns, most pilots are accustomed to the feel of the "G" force required to hold an aircraft level. In the high load turns common in the low altitude environment however, the "G" felt by the pilot seems exactly the same in a slight under-bank as it does in a slight over-bank. At altitude there is no consequence for this misperception, as the time to discover the deviation results only in the gain or loss of a few hundred ft. Next to the ground at 500 ft AGL; however, the lack of time available to discover the error and implement a correction can be fatal. G-force, while a significant variable in TTI calculations, is *not* a reliable cue for the pilot in determining the status of his low altitude turn. Many pilots have impacted the ground in controlled flight, while experiencing a high degree of comfort from "seat of the pants" feel!

	2 G 60 deg <u>(70 deg)</u>	3 G 71 deg <u>(81 deg)</u>	4 G 75 deg <u>(85 deg)</u>	5 G 78 deg <u>(88 deg)</u>	6G 80 deg <u>(90 deg)</u>
100 AGL	4.4	2.7	2.6	2.5	2.5
300 AGL	7.7	4.7	4.5	4.3	4.3
500 AGL	9.9	6.1	5.8	5.7	5.6

Table 1-3 Time to Impact (sec), Turn with 10° Overbank

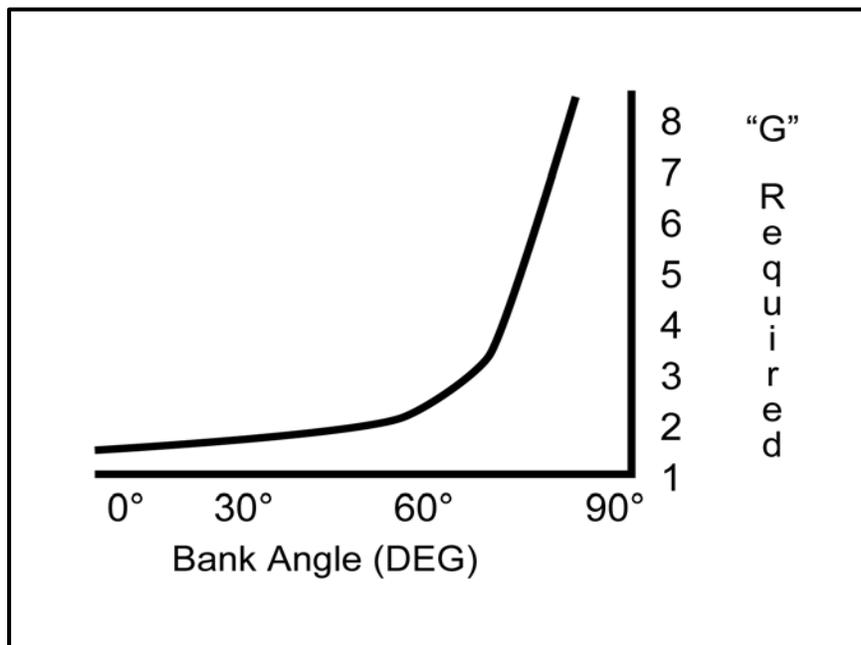


Figure 1-3 Level Turn Bank Angle And "G"

106. 50% RULE AND DIVE RECOVERY RULE

The 50% Rule and associated Dive Recovery numbers are platform specific and dependent on several factors including aircraft performance capabilities. It is mentioned here because it is an important concept in the fleet. An extensive amount of flight testing and evaluation goes into calculating the specific numbers. *Dive recovery numbers for Training Command (TRACOM) aircraft have NOT been validated. Until the numbers are validated, Chief of Naval Air Training (CNATRA) has directed that the “minute to live” rule shall be utilized to get to the low altitude environment.*

107. BASIC MANEUVERS

Basic Maneuvers (Techniques). There are some basic maneuvers that must be learned in order to operate at low altitude.

1. Straight and Level

- a. **Purpose.** To discuss the proper use of visual cues, available mission crosscheck time and flight techniques for holding a constant altitude at low altitudes.
- b. **Technique**
 - i. Scan terrain to detect and assess slope and obstacles.
 - ii. Visual cues to include in scan:
 - (a). Vertical Speed Indicator (VSI) - Remember, VSI at 0 ft per minute (FPM) does not guarantee you will not impact the ground (upslope).
 - (b). Velocity Vector - Back up visual assessment of terrain clearance.
 - (c). Radar Altimeter - Should remain steady, even if VSI shows you are in climb/descent (upslope/downslope).
 - iii. Aircraft Trim - Most feel comfortable with neutral to nose high trim. The nose high trim insures a climb during straight and level flight by relaxing backstick pressure. This could be useful during MCT.
 - iv. MCT - Flying straight and level is relatively simple when MCT is not required; however, the low altitude mission will always require mission tasking in some form (flying formation, visual lookout, navigation, radar work, etc.). Utilize 3-5 second chunks of MCT. After MCT, complete a new visual assessment of the terrain and scan available visual cues. Example: If the mission requires map study, check terrain, check visual cues, spend 3-5 seconds on map study, start cycle over. If you cannot find what you are looking for on the map - **Do not break 3-5 second MCT!** Abandon MCT, complete TCT and try again.

- v. Airspeed Selection - A slower speed in the LAT environment and its apparent decrease in workload and stress/anxiety levels can provide a false sense of security but may actually decrease your safety margin. If you find yourself below your comfort level (e.g., not able to complete mission tasks) an increase in AGL altitude is always acceptable in TRACOM aircraft. A decrease in airspeed should normally be reserved for minor timing corrections. See Low Altitude Training Rules for minimum airspeeds in TRACOM aircraft.
 - c. **Comments**
 - i. Do not allow aircraft stability and long TTI to create a false impression of unlimited MCT. Utilize 3-5 second blocks of MCT maximum.
 - ii. Be aware of how changing flight environments, varying speeds, and pilot workload affect comfort level. Over prolonged periods of straight and level flight, comfort level may change depending on the changing conditions of the mission and the terrain.
 - d. **Common Errors**
 - i. Exceeding available MCT.
 - ii. Poor airspeed/altitude/heading control.
2. **Level Turns**
- a. **Purpose.** To discuss the procedures and techniques for executing level turns at low altitude.
 - b. **Technique**
 - i. Visually clear the terrain prior to starting the turn. Assess slope, as velocity vector/nose position will have to be adjusted immediately if terrain is rising.
 - ii. Roll into the turn and apply "G" passing through 30-45° AOB, depending on roll rate. Attain the desired "G" while adjusting bank angle to hold level flight. Adjust power to maintain airspeed.
 - iii. As the turn begins, monitor the nose position relative to the horizon. You should be watching for any small amount of lateral nose drop (nose slice) to the inside of the turn. This can be observed by picking a reference on the aircraft (nose, canopy bow, mirror) and watching it track level across the horizon. In HUD equipped aircraft, the velocity vector provides a rapid cue to detect nose slice. *If nose slice is detected, it must be corrected immediately.* It is corrected by first decreasing bank angle, and second, by increasing the "G." If you try to correct the situation by just applying more "G," you will accelerate your descent towards the ground!

- iv. Scan - Since TTIs are extremely small during low altitude turns, scan must be expeditious. The proper scan should move from the aircraft reference or HUD out to the canopy bow and back. In this way aircraft position in relation to the horizon and upcoming terrain are scanned in the turn. The following cues should be monitored:
 - (a). Cockpit/aircraft Reference - As discussed above.
 - (b). Velocity Vector - Remember, for rising terrain the velocity vector will have to be maintained above the horizon in order to remain at the same AGL altitude.
 - (c). VSI - Can aid in detecting descents.
 - (d). Radar Altimeter - Depending on the angle of bank during the turn, the radar altimeter may not be useful. Most radar altimeters are only good up to about 30-45° AOB; however, often they will work past that AOB. If working, it will provide an immediate indication of altitude loss. One last point to think about; if you roll into a turn at 500 ft AGL the radar altimeter may show approximately 530-540 feet due to the bank angle. **Do not** mistake this as a climb and try to correct. Maintain a level turn. Whether in a turn or straight and level, a radar altimeter or other Low Altitude Warning shall be honored with an expeditious climb to regain parameters, then verbally acknowledge with a "Radalt, Climbing" and/or other amplifying communication (i.e. "Ridgeline").
- v. MCT - There is 1 second available for mission crosscheck in a turn. Other than scans of the airspace and terrain into the turn all your scan should be focused on TCTs. **Turning and looking is extremely dangerous.** The procedure should be: check for nose slice and that turn is level, scan ahead of turn for obstacles and slope of terrain (1 second max), recheck for nose slice.
- vi. Clearing Vertical Oriented Terrain - If, during a turn, a piece of terrain is not moving on the canopy then you are on a path to Controlled Flight Into Terrain (CFIT); ease your turn and you will pass behind the terrain. If any doubt exists, reduce bank angle, increase "G," and climb over the terrain.
- vii. Rollout - Rollout at desired heading, adjust power and altitude as required. Begin straight and level scan and MCT. Avoid climbing by properly reducing "G" as AOB decreases.

c. **Comments**

- i. The velocity vector/cockpit reference (if equipped) is the most consistent cue to FPA positions and rate of change. This should be the primary reference during the level turn.
- ii. If you descend, reduce bank while maintaining current "G" and climb back to the original altitude. If climbing, adjust your G/AOB combination to stop the climb. ***Do not try to correct back down to the original altitude during a turn***, wait until after you roll out. ***All turns below 1000 ft AGL shall be level.***
- iii. In some aircraft, the buildup of AOA as the turn is started can lead to a false perception that a climb has been initiated because the nose can move up significantly relative to the horizon.
- iv. If mission tasks require attention during a turn, you have two alternatives; rollout and complete tasks (preferred) or decrease bank/increase "G" and enter a climbing turn (this increases MCT to 2 seconds max). ***Do not attempt to perform mission tasks while in a level turn!***

d. **Common Errors**

- i. Not clearing turn/checking terrain.
- ii. Improper G/AOB combinations causing slight climbs.
- iii. Not noticing and correcting nose slice ***immediately.***
- iv. Looking while turning or exceeding 1 second MCT.

3. **Ridgeline Crossings**

- a. **Purpose.** To discuss the procedures and techniques for performing ridgeline crossings safely and expeditiously. These techniques are used to negotiate terrain and are part of low level maneuvering. In the TRACOM, they are to be demonstrated and performed on a basic introductory level. These procedures are for ridgelines along what would otherwise be straight and level flight. ***Ridgelines in vicinity of turn points shall be negotiated level at 500 ft AGL above the highest terrain within the aircraft's flight path.***
- b. **Technique.** There are three methods for negotiating ridgelines; utilizing natural breaks, the straight-ahead approach, and the 45° angle off/parallel method described below.

- i. Natural Breaks. Probably the best way to negotiate a ridge is to do a good map study during your preflight planning, find natural breaks, and go through the gaps and passes.
- ii. Straight Ahead. The simplest method is to approach the ridge straight-ahead, climb to clear it and then descend down the back slope. This task presents one of the biggest challenges for your low altitude maneuvering skills. You must determine when to pull up and when to recover on the backside. Additionally, these demands require perceptual judgments in the areas where your visual perception is the weakest: distance estimation.
 - (a). The first step is to determine when to start your climb. As a general rule, you can wait until the top of the ridgeline is about 3 to 5° above the horizon bars on your HUD (or above the horizon for non-HUD equipped aircraft). Now pull to place the velocity vector (or waterline) to a *minimum* of five degrees above the ridgeline to ensure a *minimum clearance of 500 ft crossing the ridge*.
 - (b). As the terrain begins to pass under the horizon bars, begin a gentle push in order to cross the terrain in a level attitude. This is critical in order to prevent excessive climb once you have cleared above the terrain.
 - (c). Now that you've solved when to pull-up, the level off and crossing over the top, how do you get back down? You have three options:
 - (1). The Wings Level Bunt is the easiest, safest, and in many tactical cases, the best. It allows you to assess the backside for hidden ridgelines prior to committing your nose below the horizon. The bunt should be started as the top of the ridgeline falls to the bottom of the HUD/canopy FOV. Use the radar altimeter for AGL altitude control. If at any point you can't rely on the radar altimeter or accurately assess the terrain gradient, *stop the bunt at -10° FPA MAX* and start your recovery.
 - (2). The second option is to roll to 90 - 120° AOB, letting the intentional overbank help you achieve a roll-out dive angle for recovery. Again stop your rollout at -10° FPA and accomplish a standard recovery. This method offers a more comfortable ride. In both cases, you're falling like a rock; but with the bunt you're floating, and with the overbank and the requisite amount of positive "G" (approximately 1-2Gs) you remain in the seat.
 - (3). The last method is the most aggressive and involves either an inverted turning pull or a pure inverted pull. While these techniques are used in high performance fleet aircraft, both the inverted turning pull and pure inverted pull are *prohibited in the TRACOM*. If you find yourself too high on the backside of a ridgeline, whether from

terrain or a late climb prior to the ridge, intercept the minute to live rule to return to your planned route altitude. *At no time in the TRACOM is it acceptable to be over 120° AOB when below 1500 feet AGL.*

- (d). In summary, use the velocity vector (or waterline) to start your pull-up and set your terrain clearance. Watch out for shadowing with low sun angles and low contrast hills. If in doubt, start up early. Plan your method of recovery and stop it at not more than -10° FPA.
- iii. 45°/Parallel. In cases where your navigation will allow deviation this approach is optimum.
 - (a). As you approach the base of the ridgeline, a turn is executed to place your aircraft approximately 45° off axis in respect to the ridgeline. The aircraft is then flown up the side of the ridgeline utilizing the same pull up and recovery described in the Straight Ahead method.
 - (b). What this maneuver should look like is a shallow climb to a level turn across the terrain, to an over banking turning pull to roll out and recover down the backside.
- c. **Comments**
 - i. The best method is to do your mission planning and avoid crossing high peaks.
 - ii. It is critical to cross the terrain in a level flight path. This increases SA.
 - iii. It's better to start the *pull up early* rather than late.
- d. **Common Errors**
 - i. Pulling up late and trying to maintain low altitude up the face of the terrain. Results in "ballooning" over the top.
 - ii. Not crossing the top of the terrain in level flight.
 - iii. Starting the bunt or pull down late.

4. **Maximum Recovery Maneuver**

- a. **Purpose.** To discuss procedures and techniques for performing an Emergency Recovery from an unsafe situation in the low altitude environment, also referred to as an "MRM." The procedures herein will differ slightly from those executed in the fleet but the objective is the same: to safely recover from a near CFIT or inadvertent IMC in the LAT environment when terrain clearance is in question. This should be

- trained to in the simulator, not the aircraft, and executed when directed via a "MRM" call. However, being told to "Climb" does not necessarily require these procedures.
- b. **Procedure.** The following procedure for recovery assumes a worst case scenario where the aircraft attitude is 180° AOB (fully inverted) and descending into terrain. If the aircraft is in a more favorable position (e.g., closer to level flight) begin actual execution from that point. "MRM" procedures:
- i. Unloaded roll to less than 90° AOB
 - ii. Loaded roll to wings level
 - iii. Throttle MRT or maximum
 - iv. 4 G (not to exceed NATOPS for T/M/S) pull to optimum AOA (17 Units in T-45) to at least +15° Flight Path Angle or two positive indications of climb that guarantee known or anticipated terrain clearance
 - v. Level off no lower than Minimum Safe Altitude.
- c. **Technique**
- i. If at any point before reaching wings level the lift limit is reached and aileron effectiveness is reduced, ease the pull slightly to increase aileron effectiveness and get your wings fully underneath you. When greater than 30° AOB it is more important to expedite a corrective roll than increasing pull.
 - ii. Once wings level (less than 30° AOB) a max performance pull (either max G or lift limit) should be used if CFIT is still a concern. Be aware of the aerodynamic limits at your given energy package and the potential for reduced nose authority if pulling at or past the lift limit.
 - iii. The level-off timing is at aircraft commander discretion. If only climbing to 1500 feet AGL, level-off may begin rapidly after starting the upward pull, but never before the hazard is cleared. The requirement here is to avoid terrain, not execute a perfect level-off at the planned altitude.
- d. **Comments**
- i. If greater than 90° AOB avoid the temptation to execute a max G/lift limit pull. A longitudinal pull in this situation is making matters worse.
 - ii. The loaded roll is a gradual increase in back stick pressure to arrive at desired parameters when wings level. Do not apply a max performance pull immediately after passing 90° AOB. It may decrease aircraft performance and delay recovery.

- iii. The 15° benchmark for the climb is a starting point. The priority is to avoid flying into terrain. In flat terrain, VMC, and terrain clearance is assured the level off may start before hitting 15° FPA. In contrast, if executed while approaching a mountain the climb may need to be much steeper.
 - iv. "Two positive indications of climb" is intended to be interpreted as the aircraft increasing its relative AGL altitude. Depending on terrain, FPA may vary and increasing MSL altitude does not always translate to increasing AGL altitude.
 - v. If a MRM is executed in the aircraft it shall be followed by a KIO once clear of terrain.
- e. **Common Errors**
- i. Attempting a loaded roll with the lift vector still pointed at the ground.
 - ii. Starting the longitudinal pull too early, before the lift vector is pointing up.
 - iii. Pulling into "pitch-buck."

108. CNATRA LOW ALTITUDE TRAINING (LAT) RULES

Aircraft specific LAT Rules shall adhere to all CNATRA LAT Rules plus any platform specific considerations. The collection of all applicable rules for an aircraft will be known as "(platform) Low Altitude Training Rules." For example: "T-45 Low Altitude Training Rules" encompasses all CNATRA rules and T-45 specific rules.

Required Briefing Items

1. Verify currency of all aircrew.
2. Weather requirements:
 - a. Daylight between 30 minutes after sunrise until 30 minutes before sunset
 - b. VMC with a defined horizon
 - c. 3000 ft AGL ceiling & 5 sm visibility along the entire route/area. (1500ft/3sm for multi-engine aircraft operating less than 250KTS)
 - d. Weather shall be continuously assessed throughout the LAT phase of the sortie.
 - e. Descent through a solid over cast in an attempt to achieve VMC conditions below, while not under positive IFR control, is prohibited.
3. CFIT Avoidance:
 - a. Use local altimeter setting.
 - b. Terrain Clearance Tasks take priority over all other tasking.
 - c. Mission Crosscheck Time (MCT) *maximum* is one (1) second in a turn, five (5) seconds straight and level.
 - d. Low Altitude Warning system (RADALT): _____ ft AGL
 - e. Minimum altitude: _____ ft AGL
 - f. Area Emergency Safe Altitude: _____ ft MSL
 - g. Minimum airspeed: _____ KCAS
 - h. Wingman never flies below lead's altitude (not required if single aircraft)
 - i. Wingman is primarily responsible for flight deconfliction and collision avoidance except for TAC turns into wingman; however, all members of the flight are responsible for collision avoidance (not required if single aircraft)
 - j. All turns below 1000 ft AGL shall be made level and closely monitored for nose slice.
 - k. Pilot shall take immediate, proactive steps to maneuver aircraft back within briefed limits if any altitude warnings, aural or visual, are triggered or if airspeed drops below minimums.
4. LAT Checks shall be completed prior to entering the LAT environment (T-6 and T-45); multi-engine aircraft checks per FTI P-557.
5. All aircraft shall monitor a common frequency.
6. Any aircraft may call "knock it off" ("KIO"). All aircraft shall acknowledge the KIO call, roll wings level and climb-to-cope above the LAT environment (1500 ft AGL minimum or Emergency Safe Altitude if IMC). Aircraft shall KIO for any of the following reasons:
 - a. Interloper aircraft enters the mission area and is detrimental to flight safety
 - b. Inadvertent IMC or weather deteriorates below minimums
 - c. Birdstrike
 - d. Loss of Situational Awareness

- e. Unsafe Situation / Emergency
 - f. Crossing border of authorized training area
 - g. Actual or suspected A-LOC or G-LOC
 - h. Overstress
 - i. Training rule violation
 - j. BINGO Fuel
 - k. Any aircraft descends and remains below the pre-briefed minimum altitude for an unsafe duration (not to exceed 3 seconds) or does not respond immediately to calls to correct
 - l. Any aircraft descends in a turn that was intended to be level
 - m. Aircraft rocking its wings
 - n. Aircraft goes NORDO or loses ICS
 - o. Two or more aircraft lose sight
 - p. Training Objectives achieved
- 7. Be aware of the high mid-air potential following a KIO.
 - 8. Do not attempt to re-enter a MTR after leaving the route structure.

Planning Requirements / Standard Operating Procedure

1. The Low Altitude Training (LAT) environment is defined as any fixed wing flight below 1500 ft AGL when not in the takeoff or landing phase.
2. All aircrew shall have flown at least once in the previous 30 days before flying in the LAT environment.
3. Daylight, outside 30 minutes of sunrise or sunset, are specific to flight in the LAT environment and do not have to include transit to or from above 1500 ft AGL unless further restricted by Training Wing.
4. Minimum altitude for CNATRA aircraft in the LAT environment is 500 ft AGL. This may be further restricted by local SOP.
5. Low Altitude Warning system (e.g., RADALT) shall be set to no lower than 10% below the briefed minimum altitude. For Pop Attacks, the planned run-in altitude shall be referenced.
6. Area Emergency Safe Altitude shall be briefed and is defined as the highest of either 1500 ft AGL or 1000 ft (2000 ft in mountainous terrain) above the highest terrain or obstacle within 25 nm of any point of the planned low altitude environment.
7. Minimum Safe Altitude is defined as 500 ft AGL above any obstacle within 5 nm of centerline for each leg of a route.
8. LAT flight requires (if equipped) operable RADALT, HUD and GINA. Any other installed systems that aide in terrain avoidance shall also be operational and in use (e.g., TAWS, GPWS).
9. Routes shall be coordinated/scheduled with all local agencies in accordance with Flight Information Publication (FLIP) AP/1B, respective Training Wing instructions, procedures, and directives.
10. All crossing MTR's/routes shall be deconflicted and should be annotated on charts.
11. LAT sorties shall include a thorough brief of the planned route and operating area to include route restrictions, crossing routes, obstacles, potential hazards, an assessment of possible environmental factors (smoke, haze, sun angle, etc), and all planned tactical turns.
12. LAT checks shall be completed (T-6 and T-45) prior to entering the LAT environment and verbalized between all aircrew in an aircraft:
 - a. Mask - Securely Fastened
 - b. Visor - Down
 - c. Good "R" in the HUD (if equipped) with good warning tone.
 - d. Loose Items - Stowed and secured
 - e. G-warm complete
13. The G-Warm shall be conducted at a safe altitude with maximum G approaching amount anticipated on that flight.
 - a. The spacer-pass on a strike flight, to include Pop Attacks, shall satisfy the requirement for a G-Warm. Do not descend in the spacer pass.
 - b. If planned G is less than 4 G's a G-Warm is not required but it is recommended.
14. LAT terminology:
 - a. A "KIO" call stops the entire mission for the flight and all aircraft shall Climb-to-Cope above the LAT environment (1500 ft AGL minimum or Emergency Safe Altitude if IMC). Training shall not be resumed after a "KIO."
 - b. "Terminate" directs an aircraft to cease a maneuver.

- c. "Abort" is applied to an Air-to-Surface delivery and directs initiation of the safe escape maneuver with a clear flight path. It does not necessarily direct an exit from the LAT environment unless briefed.
 - d. "Climb" is a directive call to increase altitude above a hazard or to regain parameters.
 - e. "Climb," "Abort," and "Terminate" do not imply a "KIO" or leaving the LAT environment.
15. Except for a "KIO", training may resume once all aircraft:
 - a. Have verbal confirmation of what caused the situation
 - b. Agree the situation no longer affects the flight, and
 - c. With Mission Commander approval
 16. Planning factors pertaining to G and airspeed are described in pipeline specific FTIs. G, AOA, and aerodynamic limitations of any T/M/S NATOPS shall not be exceeded to include accelerated stalls e.g., pitch-buck for T-45 aircraft.
 17. Minimum airspeed for the T-45 in the low altitude environment is 300 KCAS.
 18. Minimum airspeed for the T-6A/B in the low altitude environment is 180 KCAS.
 19. Minimum airspeed for Multi-Engine aircraft in the low altitude environment is 150 KIAS.

APPENDIX A GLOSSARY

A100. GLOSSARY OF LOW ALTITUDE TRAINING (LAT) TERMS

Speed-rush Baseline (SRB): A physiological phenomenon whereby human peripheral visual perception becomes accustomed to high rates of terrain passage. This physical speed acclimatization requires lower and/or faster flight to deliver the same speed sensation.

Bucket: A graphic illustration of a pilot's capacity to maintain situational awareness during high task loading and a means of teaching load shedding priorities.

Climb to Cope (CTC): This is a maneuver where by the pilots stops his maneuvering close to the ground and climbs to a predetermined *AGL* altitude in order to address an urgent/emergency situation. Resumption of low altitude flight can only occur with verbal concurrence from all members in the flight.

Comfort Level (CL): The minimum *AGL* altitude, at which a pilot can fly and accomplish all Terrain Clearance Tasks and Mission Tasking. A perceptual concept, CL concedes individual differences and is never a hard altitude. It will vary according to terrain, aircrew skill, currency, and degree of training in the low altitude environment.

Dive Recovery Rules: Mathematically derived low altitude dive recovery rules which incorporate initial dive angle, maximum TAS, minimum G-loading and pilot reaction time in order to safely step down to comfort level or in the case weapons delivery avoid impact with the ground or shrapnel. Dive Recovery Rules are not utilized or flight tested in NATRACOM.

Mission Tasks (MT): Administrative tasks conducted at comfort level essential to mission accomplishment: Navigation, lookout doctrine, communication, switchology, and threat avoidance/reaction etc. ($MT = CT + NCT$)

Mission Crosscheck Time (MCT): The maximum permissible time, which a pilot can safely divert attention from *TCT* in order to attend to *MT*.

Terminate / Knock it off: A radio call made in the low altitude environment which: results in the suspension of an intended low altitude maneuver (*terminate*), or causes a cessation of low altitude flight entirely, combined with an immediate climb to a pre-briefed *AGL* altitude (*KIO*).

Terrain Clearance Tasks (TCT): Cockpit tasking involved entirely with avoiding terrain.

Time to Impact (TTI): Time, measured in seconds, in which deviation from low altitude level flight will result in terrain impact. Time to Impact is affected by *AGL* altitude, TAS, and the angle of deviation in degrees from level flight.

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