# GBU-31, GBU-32 AND GBU-35 JOINT DIRECT ATTACK MUNITIONS (JDAM)

# TACTICAL MANUAL

**AND** 

# **USER GUIDE**



FOR USN SERIES AIRCRAFT

F/A-18C/D

CDR Ed Gassie, USN
JDAM Project Office, Code 47HE00D
Naval Air Warfare Center, Weapons Division
NAWS China Lake, CA 93555-6100

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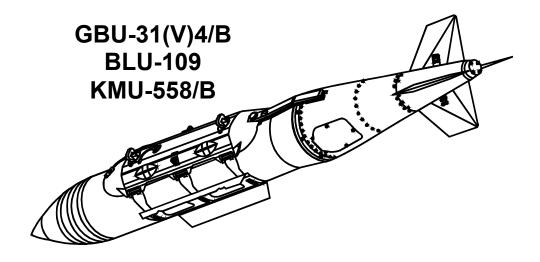
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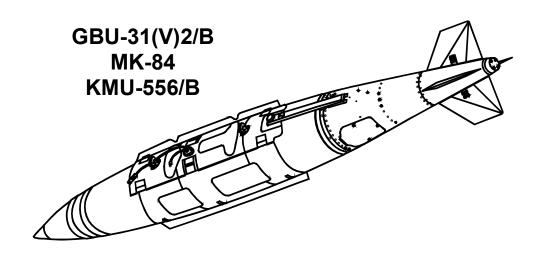
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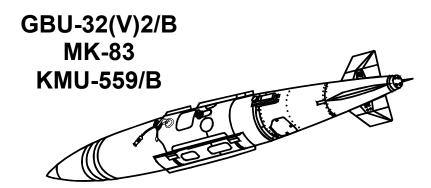
UPDATED 01 October 2002

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# Joint Direct Attack Munitions (U)







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# **DEFINITION OF TERMS (U)**

#### The following informational terms are used throughout the text:

#### NOTE

A "NOTE" provides information that amplifies or clarifies a procedure, function or operation.

#### **CAUTION**

A "CAUTION" provides information that, if not regarded, may result in a mission failure.

#### **WARNING**

A "WARNING" provides information that, if not regarded, may result in damage or injury.

#### The following acronyms and terms are associated with JDAM as integrated on the F/A-18C/D aircraft:

A/A Air-to-Air

ACIZLAR Aircraft In-Zone Launch Acceptability Region

A/G Air-to-Ground AGL Above Ground Level AMU Advanced Memory Unit

A-S Anti-Spoofing

AS/SV Anti-Spoofing/Satellite Vehicle

ATACS Automated Tactical Manual Supplement

BIT Built-In Test

BOC Bomb On Coordinates

C/A [Code] Coarse Acquisition Code (for GPS)

CMBRE Common Munitions BIT Reprogrammable Equipment (AN/GYQ-79)

CMPM Common Mission Planning Module

DMA Defense Mapping Agency
DMPI Desired Mean Point of Impact
DOP Dilution of Precision (of GPS)
DPPDB Digital Point Position Data Base

ECEF Earth Centered Earth Fixed

FFCS Fuze Function Control System

FD Flight Director

GCU Guidance Control Unit
GPS Global Positioning System
GPSRM GPS Receiver Module

HAE Height Above Ellipsoid HSI Horizontal Situation Indicator

HUD Head-Up Display

IBIT Initiated Built-In-Test
IMN Indicated Mach Number
IMU Inertial Measurement Unit
INS Inertial Navigation System

IRLAR In-Range Launch Acceptability Region IZLAR In-Zone Launch Acceptability Region

JDAM Joint Direct Attack Munitions

JMEM Joint Munitions Effectiveness Manual JPF Joint Programmable Fuze (FMU-152)

KCAS Knots Calibrated Airspeed KMU Kit, Maneuvering Unit

LAR Launch Acceptability Region

MAGR Miniaturized Airborne GPS Receiver

MPM Mission Planning Module

MSL Mean Sea Level MU Memory Unit

NIMA National Imagery and Mapping Agency

NM Nautical Miles

ODS Offset Data Set

P [Code] Precise Code (for GPS)
PD Probability of Destruction
PDOP Positional Dilution of Precision

PLGR Portable Lightweight GPS Receiver (AN/PSN-11)

PP Pre-Planned

PPDB Point Position Data Base

PPIZLAR Pre-Planned In-Zone Launch Acceptability Region

PTAM Periodic Transfer Alignment Message

S/A Selective Availability

SCS Software Configuration Set (aircraft OFP)

SMS Stores Management System

TAMPS Tactical Aircraft Mission Planning System

TAS Tail Actuator Assembly TDS Target Data Set

TLE Target Location Error TOF Time of Flight

TOO Target of Opportunity
TOT Time On Target
TTFF Time To First Fix
TXA Transfer Alignment

UERE User Equivalent Range Error

UFC Up-Front Control

WDEGD Weapon Degraded WFAIL Weapon Fail

WGS-84 World Geodetic System-1984 (datum)

WIP Weapon Insertion Panel

ZTOD Zulu Time Of Day

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# 1.0 WEAPON DESCRIPTION

#### **NOTE**

(U) This chapter is intended to be specific to the JDAM weapon, independent of host aircraft integration. JDAM integration specifically on the F/A-18C/D aircraft is discussed in Chapter 2.

#### 1.1 INTRODUCTION

**1.1.1 OVERVIEW.** (U) The Joint Direct Attack Munitions (JDAM) is a low-drag general-purpose bomb variant that employs autonomous guidance by means of an onboard Inertial Navigation System (INS) coupled to and aided by a Global Positioning System (GPS) processor. The JDAM guidance set provides accurate guidance in adverse weather, day or night. JDAM is a bomb-on-coordinate Guided Bomb Unit (GBU) that accepts precise targeting information in the form of World Geodetic Survey (WGS)-84 coordinates provided either during mission planning or in flight.

**1.1.2 CONFIGURATION.** (U) JDAM consists of an inventory general-purpose warhead, a strap-on aero-surface "strake" assembly, a bolt-on tail kit, and appropriate inventory fuzing components. There are currently three versions of the JDAM weapon kit (Figure 1-1). Table 1A lists the components that comprise the authorized USN configurations for JDAM.

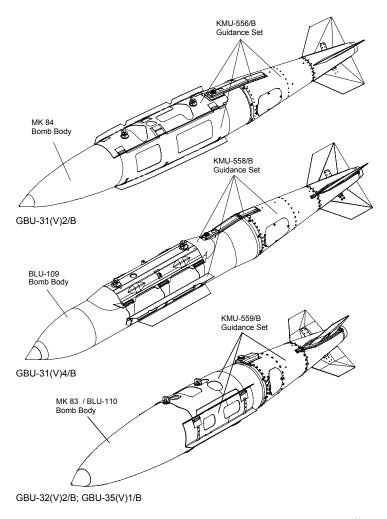


Figure 1-1 USN JDAM GUIDED BOMB UNITS (U)

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	ATTACK

٧	AR	IEA	D⁴			l	FUZI	E					SOR		FZU & COMPONENTS				C	MISC COMPONENTS					
			F288	AY94	EA73	F810	G119	EB05	F809	F849	BY01		NA								GW03	BWDO	1325	FW90	
JK84 (MOD 6 for Navy - F278)	BLU-109 (A/B for Navy - F142)	JK83 (MOD 5 for Navy - E510)	3LU-110A/B	:MU-152/B	:MU-152/B+I1	:MU-139A/B (Navy-w/o FZU-48/B)	:MU-139A/B (Navy-w/o FZU-48/B)	:MU-139B/B (Navy-w/o FZU-48/B)	:MU-143/B, B/B	:MU-143E/B	33A/B <sup>2</sup>	33A/B Cable <sup>2</sup>	33B/B <sup>2</sup>	JSU-33B/B Cable <sup>2</sup>	:ZU-32B/B	ZU-32 Cable	-ZU-48/B (Pckd w/G119, not w/F810)	-ZU-48 Cable	ZU-55/B	-ZU-55 Cable	AK 122 MOD 0 Safety Sw	AK 65 MOD 0 Cable Assy	:ZU Extender	งose Plug <sup>6</sup>	Support Cup <sup>6</sup>

				N)	109	$\mathbb{Z}$	10,	52	52	36	36	36	43	43	3∧	34	38	3E	2B	2 (	8/E	-48 (	2/E	5 (	2	Σ	xte	읎	ť							
	Weapon Designator	Guidance Set	NALC 0r DODIC	MK84	BLU-1	MK83	BLU-1	FMU-152	FMU-152	FMU-139	FMU-139	FMU-139	FMU-143	FMU-143	DSU-33A	DSU-33A	DSU-33B	DSU-33B	FZU-32B	FZU-32 (	FZU-48/E	FZU-4	FZU-55/E	FZU-55	MK 122	MK 65 M	FZU Exte	Nose Plu	Support	Applicable Work Package <sup>3</sup>						
				Р				Т									Ν								Χ			Χ	Χ	NAVAIR 11-5A-37 WP 072 00						
ns	GBU-31(V)2/B	KMU-556/B	EA69	Α						Т		Τ			Z	X	Ν								Χ			Χ	Χ	NAVAIR 11-5A-37 WP 072 00						
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fig	GBU-31(V)4/B	KMU-558/B	EA76		Α									Т					Χ	Х							Χ			NAVAIR 11-5A-37 WP 072 00						
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USN/USMC		KMU-559/B	EA97	EA97	EA97	EA97	EA97	EA97	EA97			Α					$T^5$						N	Χ			Χ	Χ						Χ	Χ	WP in Development
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<sup>&</sup>lt;sup>1</sup> N=Nose; T=Tail; B=Both (Nose and/or Tail)

Table 1A JDAM CONFIGURATIONS (U)

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P - Primary Configuration

A - Alternate Configuration

 $<sup>^{\</sup>rm 2}$  Optional Configuration - When Sensor is installed in nose, Nose Plug/ Support Cup is not used.

<sup>&</sup>lt;sup>3</sup> NAVAIR 11-5A-37 and TO 11K31-2-7 are combined into a joint Technical Manual.

<sup>&</sup>lt;sup>4</sup> Navy warheads are thermally coated; BLU-109A/B and BLU-110A/B use insensitive munitions fill, for use aboard ship.

<sup>&</sup>lt;sup>5</sup> AF or Navy fuze acceptable, but must have FZU-48/B, which comes packaged with AF but not Navy version.

 $<sup>^6</sup>$  MK 84 uses FW90 w/o support cup or FW35 w/support cup. MK83 / BLU-110 uses FW90 w/o support cup or FW32 w/support cup.

**1.1.3 WEAPON TO AIRCRAFT INTERFACE.** (U) JDAM is designed to interface and communicate with the host aircraft via a MIL-STD-1760 Class II primary interface signal set. The weapon and host aircraft are mated for digital communication using a standard or improved umbilical interface cable at the suspension pylon. The associated hardware to accomplish fuzing safe-and-arm functionality is independent of and not specific to the JDAM weapon system.

#### 1.1.4 DESIGN PHILOSOPHY

- **1.1.4.1 Storage, Usage and Maintenance Concept.** (U) JDAM is designed for simplicity and low maintenance. The JDAM service life specification is 20 years on the shelf (in the storage container) and 10 years once the storage container is opened. There is no requirement to track JDAM captive carriage usage or to perform recurring maintenance. A JDAM weapon is used until either it is expended or it declares an internal failure. Weapon utilization tracking (for captive carriage) is neither required nor intended.
- **1.1.4.2 Compatibility and Interoperability.** (U) JDAM is designed for compatibility existing warheads and conventional fuzing components. The JDAM kit provides access to the primary fuze charging well and aft fuze well as well as standard routing for fuze arming wires.
- (U) Navy inventory warheads are shipped with MK-122 switch power cables installed. In order to use a mechanical initiator such as the FZU-48, these MK-122 power cables are removed and the appropriate FZU power cables are installed in their place. This process inhibits simple conversion from one power system configuration to the other.
- **1.1.4.3 Physical Accommodation.** (U) JDAM is designed for suspension on the host aircraft using standard suspension lug widths provided by inventory warheads or specially machined, kit-specific suspension equipment. The design of the guidance kit is such that JDAM weapons may be hoisted for host aircraft loading using either SHOLS winching equipment or a mobile SATS loader.

#### 1.2 PHYSICAL DESCRIPTION

**1.2.1 GUIDANCE SET.** (U) The JDAM guidance set consists of a tail assembly section, including guidance electronics and control fins, and three mid-body aero-surfaces, or "strakes", that enhance weapon maneuverability. The guidance set components, when combined with the appropriate tail fuzes and assembled to the appropriate MK-83, MK-84, BLU-109 or BLU-110 gravity bomb warheads, form the GBU-31 (Figures 1-2 and 1-3), and GBU-32/35 (Figure 1-4) series weapons.

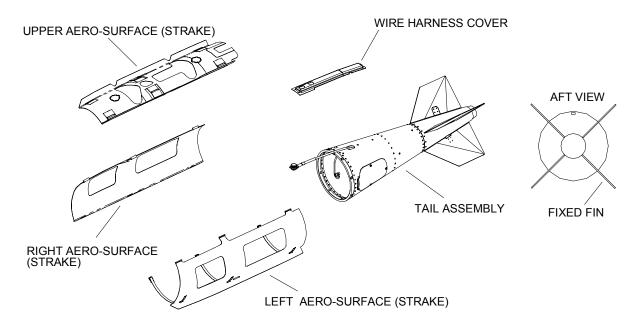


Figure 1-2 GBU-31(V)2/B GUIDANCE SET (U)

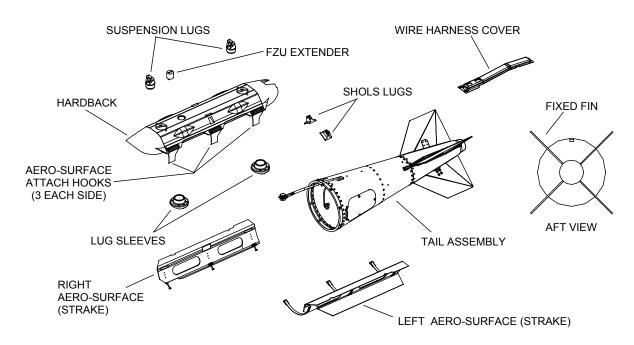


Figure 1-3
GBU-31(V)4/B GUIDANCE SET (U)

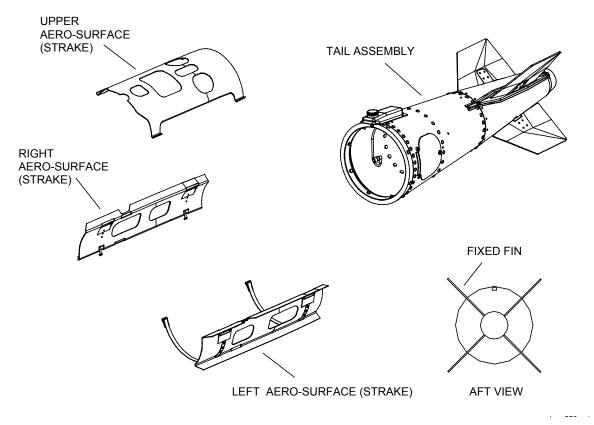


Figure 1-4
GBU-32 & GBU-35 GUIDANCE SET (U)

**1.2.2 TAIL ASSEMBLY.** (U) The JDAM tail assembly (Figures 1-5 and 1-6, GBU-32/35 not illustrated but similar) consists of the tail fairing and structure, tail actuator subsystem, wire harness, Guidance Control Unit (GCU), GPS antenna, three moveable control fins and one fixed control fin. While the tail assembly is similar for both GBU-31 variants, there are some differences. First, the TAS for the KMU-558/B guidance set is rotated 180° from the KMU-556/B position. This results in the fixed fin location being in a different position. On the KMU-556/B tail assembly, when viewing from the aft end looking forward with the fins in an "X" configuration, the fixed fin is located in the right hand, lower position (Figure 1-2). When viewed in the same manner, the KMU-558/B tail assembly fixed fin is located in the left hand, upper position (Figure 1-3). The guidance software is also unique to each configuration in order to compensate for differences in MK-84 and BLU-109 mass properties and subsequently unique flying characteristics. The GBU-32 and GBU-35 variants use warheads that differ only in explosive fill (MK-83 and BLU-110 warheads, respectively) and use the same tail assembly. Similar to the KMU-558/B tail assembly, the KMU-559/B fixed fin position is in the left hand, upper position (Figure 1-4) and is located over the GPS antenna cable cover.

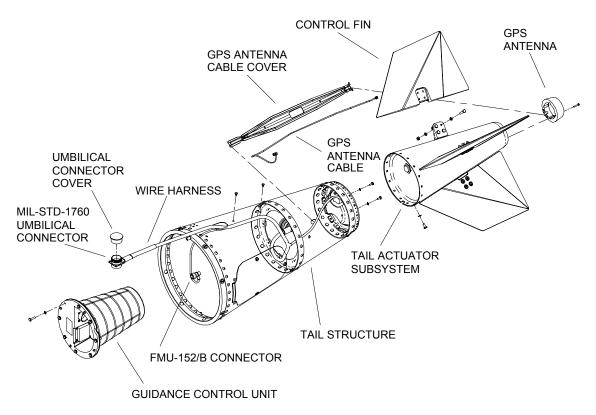


Figure 1-5
GBU-31(V)2/B TAIL ASSEMBLY (U)

- **1.2.2.1 Tail Structure.** (U) The tail structure consists of a conical aluminum assembly that attaches to the bomb body with eight setscrews. The tail structure contains the tail actuator subsystem, the GCU and the wire harness.
- **1.2.2.2 Tail Actuator Subsystem (TAS).** (U) The TAS consists of the aft tail assembly structure, four control fins, three electromechanical actuators to power the three movable control fins, a lithium thermal battery, and associated controlling electronics. The aft end of the TAS provides a mounting surface for the GPS antenna and mounting surfaces for the control fins. The controlling electronics process digital autopilot commands into independent fin control movements and provide fin position feedback, battery initiation, brake unlock commands, and BIT status. To prevent control fin movement during captive carriage in flight prior to weapon release, a fin restraining system is incorporated.

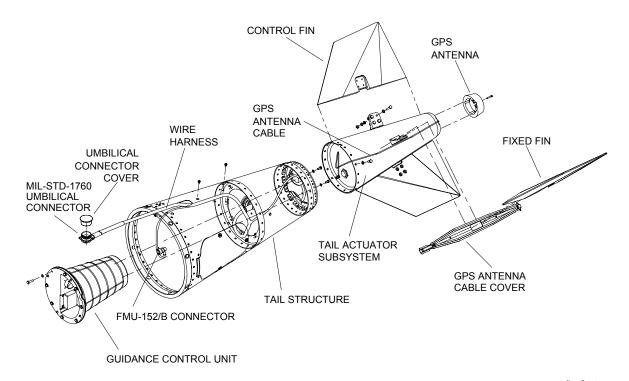


Figure 1-6
GBU-31(V)4/B TAIL ASSEMBLY (U)

**1.2.2.2.1 Friction Brake TAS**. (U) In GBU-31 tail kits manufactured in Lot 3 and prior, each control fin is held in place by a friction brake restraining device attached to the electric motor that actuates the control fin (Figure 1-7). The friction brake, along with the 30-to-1 mechanical advantage of the electric motor, is designed to hold the weapon fin positively in place during captive carriage until it is released after launch. A white stripe is painted on the TAS as a fin alignment mark to provide a visual indication of acceptable fin alignment position during weapon assembly and preflight inspection.

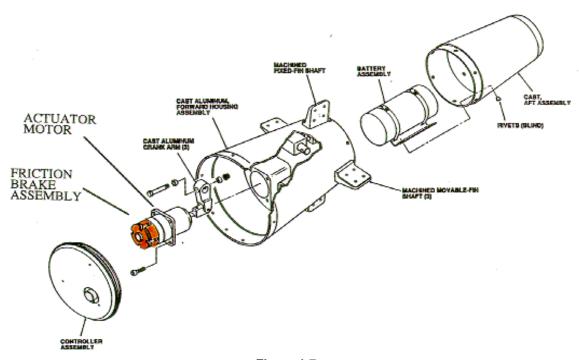


Figure 1-7
GBU-31 FRICTION BRAKE SCHEMATIC (U)

(U) Friction brake tail kits are identified primarily by the tail kit label and secondarily by the presence of the fin alignment mark and absence of the fin lock pins extending through the TAS structure skin into the control fins (Figure 1-8). Friction brake tail kits are labeled as KMU-556/B or KMU-558/B (vice "A/B").

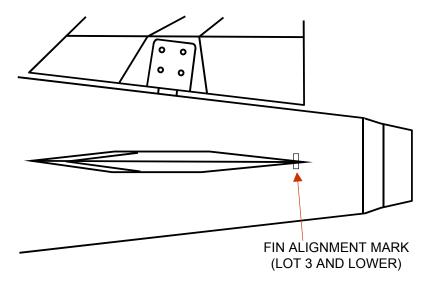


Figure 1-8
FRICTION BRAKE TAIL KIT IDENTIFICATION (U)

- (U) Flight test has determined that weapon fins restrained by the friction brake fin lock can move away from the "zero" position under the high aerodynamic loads, noise and vibration in the flight environment. Therefore, flight envelope restrictions may be required to reduce the possibility of weapon operational and material failures. Furthermore power application may be mandated during critical flight regimes in order to provide active control fin movement monitoring (Section 2.2.3.2). Also, harmonics resulting from inflight vibrations associated with this design have been demonstrated to interfere with the ability of the weapon to achieve and maintain a precise INS solution.
- **1.2.2.2.2 Pin Lock TAS.** (U) In all tail kits for all variants manufactured in Lot 4 and subsequent, an improved fin restraint design and new tail castings and fin shafts are incorporated to prevent undesirable control fin movement prior to release and to reduce overall weapon vibration susceptibility. Each control fin is held positively in place by a locking pin that extends through the TAS structure skin into the fin forward of the fin shaft. The pins are held extended against natural spring tension by an electrically actuated solenoid. After weapon release, the solenoid control allows the springs to retract the pins, physically unlocking the control fins. The remaining fin actuation hardware and fin position monitoring system are identical to the friction brake TAS design (Section 1.2.2.2.1).

#### NOTE

- (U) Locking pins are provided for all four control fins, including the fixed fin.
- (U) Pin lock tail kits are identified primarily by the tail kit label and secondarily by the presence of the fin lock pins extruding from the tail kit into the control fins (Figure 1-9) and absence of the fin alignment band. Pin lock GBU-31 tail kits are labeled as KMU-556A/B or KMU-558A/B (vice "/B"). However, all GBU-32/35 tail kits are manufactured with the pin lock system but are labeled as KMU-559/B vice KMU-559A/B, since only one design (pin lock) exists.
- (U) Flight test has verified that the pin lock design is more robust than the original friction brake design, effectively eliminating fin creep and greatly reducing vibration. Therefore, pin lock tail kits are relieved of any flight envelope restrictions that may be applied to friction brake tail kits in order to reduce the possibility of operational weapon failures. However, it is recommended that weapon power always be applied during critical flight regimes.
- **1.2.2.3 Wire Harness.** (U) The wire harness consists of the umbilical connector, an umbilical connector protective cap, the FMU-152 JPF connector, and a shielded harness that provides the electrical interfaces to the GCU and TAS.

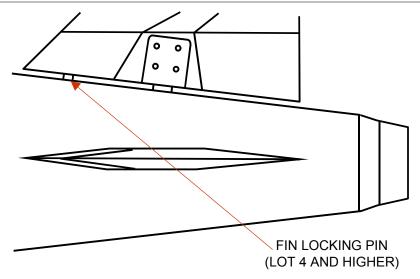


Figure 1-9
PIN LOCK TAIL KIT IDENTIFICATION (U)

**1.2.2.4 Guidance Control Unit (GCU).** (U) The GCU is an integrated electronics assembly that includes the mission computer, Inertial Navigation System (INS), GPS Receiver Module (GPSRM) and a power conditioning unit.

#### **CAUTION**

(U) JDAM continuous power-on time should be limited to 45 minutes below 1000 feet MSL with ambient temperature at or above 113 degrees F, in order to prevent overheating of the JDAM GCU components.

- **1.2.2.4.1 Inertial Navigation System (INS).** (U) The weapon INS is the primary source of attitude, position and velocity information used by the weapon mission computer in the computation of navigation and guidance commands. It consists of a three-axis ring-laser gyro IMU and associated accelerometers. The weapon INS is aligned to the aircraft INS using Periodic Transfer and Alignment Messages (PTAMs) transmitted via a digital interface connection whenever weapon power is applied. These transfer alignment messages contain the aircraft state vector, carriage station moment arm information and precise GPS time as required by the weapon. Weapon INS accuracy is such that it provides effective weapon precision in a GPS-denied environment (Section 1.4.2.2).
- **1.2.2.4.2 GPS Receiver Module (GPSRM).** (U) The GPSRM is a GPS receiver incorporated into the GCU. The GPSRM is connected to the GPS antenna on the tail of the weapon by a coaxial cable that runs outside of the tail assembly under a GPS antenna cable cover. In order to acquire GPS satellites, the GPSRM requires GPS crypto keys (AKAT A1001), GPS almanac and ephemeris, Zulu time and date, and current location from the host aircraft. The GPS crypto keys for the current week and upcoming week may be stored during mission planning and loaded during bulk data download each time the weapon is selected.
- (U) Lot 3 and prior weapons incorporate a 5-channel GPS receiver. All USN weapons delivered in Lot 4 and subsequent (identified by the pin-lock fin restraint, Section 1.2.2.2.2) incorporate a 12-channel "All In View" GPS receiver. The 12-channel receiver increases the total number of GPS satellites the weapon can track at any given time, which can increase the probability of the weapon maintaining a valid GPS solution throughout its time of flight and improve the time synchronization corrections for improved position keeping performance.
- (U) Because of poor GPS satellite visibility while the weapon is carried on the aircraft, due to aircraft wing or fuselage masking of the aft antenna location on the weapon, the GPSRM is not activated prior to weapon release. After launch, the GPSRM initially acquires satellites via Coarse Acquisition code (CA-code) before transitioning to Precise code (P-code). Once P-code is acquired, the GPSRM processes the GPS position and velocity information to achieve an initial, or first, fix to update the INS solution. The specified Time To First Fix (TTFF) is 27 seconds after GPSRM activation.

- **1.2.2.4.3 Mission Computer.** (U) The weapon mission computer contains software to condition the weapon for release and control the weapon in flight. Pre-release functions include establishing communication with the aircraft via the digital interface, accepting mission data from the aircraft, initializing and aligning the INS, and maintaining BIT monitoring of weapon subsystems. Post-release function consists of processing flight environmental information and translating it into guidance commands for the TAS.
- (U) The mission computer hosts the Operational Flight Software (OFS) that produces weapon functionality. Every JDAM mission computer contains the OFS for every weapon variant. OFS labeling and kit-discrete signals are used by the mission computer to determine which subset of the software is used by a particular weapon. Each OFS subset is labeled as "A" for GBU-32/35, "B" for GBU-32(V)2/B and "C" for GBU-31(V)4/B. A planned design improvement in the JDAM family of weapons includes the incorporation of an Advanced Core Processor (ACP). This includes refinements for low-cost full-scale production. Software designed to operate on the ACP is identified with a label as "OGx" vice "OFx", where "x" is "A", "B", "C", etc. The resident weapon software for any loaded weapon may be inspected by the host aircraft aircrew via the serial data connection with the weapon. The JDAM software ID consists of three alphabetic characters representing the OFS label and three numeric characters representing current version number (e.g., "OGA235").
- **1.2.3 AERO-SURFACES.** (U) The aero-surfaces, or "strakes", consist of three formed steel panels that attach to and wrap around the weapon warhead. The strakes produce aerodynamic lift and provide increased maneuverability. Since the BLU-109 warhead is not drilled to accept standard bomb lugs, the GBU-31(V)4/B kit incorporates a cast aluminum hardback structure into the upper strake panel. This hardback provides the appropriate interface for suspension on the delivery aircraft.
- (U) On thermally-protected USN bomb bodies, minor thermal coat crushing and wear has been noted under the strake panels after exposure to flight loads. Attention has been paid to strake security (tightness), which could be reduced by this crushing and allow strake misalignment under flight loads, thus reducing the clearance margin for the strake cut-out areas or negatively impacting weapon performance. However, there is no experience or data to date to suggest that strake misalignment due to thermal coat crushing has occurred. Weapon preflight procedures include inspection of strake position and security.
- **1.2.4 WIRE HARNESS COVER.** (U) The wire harness cover is a pre-formed steel part that, for the KMU-556 and KMU-558 tail kits, attaches between the tail assembly and the hardback or upper aero-surface. For the KMU-559 tail kit, this cover is physically mounted to the tail assembly. The cover positions the JDAM umbilical connector to correctly mate with the aircraft MIL-STD-1760 interface and retains the connector during separation.
- **1.2.5 GPS ANTENNA.** (U) The GPS antenna is located on the aft end of the tail kit and is connected to the GPS receiver via a coaxial cable running under the GPS antenna cable cover. The GPS antenna pattern is a cardioid shape oriented in the opposite direction from the nose of the weapon. Since the host aircraft wing or fuselage would effectively mask the JDAM GPS antenna from the satellite sky during captive carriage, JDAM does not attempt to acquire, track, or navigate from GPS satellites prior to release.

#### **1.2.6 WEAPON DIMENSIONS.** (U) Weapon dimensions vary according to variant (Table 1B).

CHARACTERISTIC	GBU-31(V)2/B	GBU-31(V)4/B	GBU-32/35
Weight (lbs) *	2046	2125	1058
Length (in) *	152.46	148.32	119.31
Strake Length (in)	48	35.93	40.37
Tail Length (in)	51.04	51.04	42.93
Tail Diameter (in)	25.32	25.32	19.62
Suspension Lug Width (in)	30	30	14

<sup>\*</sup> All-Up Round, including warhead and guidance kit

Table 1B JDAM WEAPON DIMENSIONS (U)

#### 1.3 WEAPON OPERATION

- **1.3.1 THEORY OF OPERATION.** (U) Typically, JDAM mission and mission support data is prepared before flight using automated planning tools. Data is stored on a memory device for transport to the host aircraft. The weapon and aircraft communicate digitally to transfer data regarding mission parameters and system health and display pertinent information to the aircrew in the cockpit. Once power is available, the weapon preconditions its avionics automatically and accepts stored data from the host aircraft.
- (U) Whenever the weapon is powered, the aircraft transfers necessary navigational data to allow the weapon to erect and align its internal navigation system to a fine degree. The weapon does not attempt to acquire GPS data while attached to the host aircraft. This transfer alignment procedure includes threshold aircraft maneuvering to generate the required navigation solution in the weapon. The weapon reports navigation system quality and subsystem health to provide feedback sufficient to support tactical decisions regarding weapon employment. The aircraft computes and displays valid launch regions and associated cues to assist the pilot in obtaining a release solution. The host aircraft provides appropriate manual and/or automated modes of weapon release.
- (U) Once released, JDAM performs a safe separation maneuver and commences autonomous guidance to the selected target according to the desired terminal parameters. Initial guidance is inertial only while the GPS acquisition process is accomplished but, once a valid fix is obtained, GPS navigational information is blended into the weapon guidance solution. JDAM requires three satellites to derive a ground plane (2-D) position solution and four satellites to obtain a position-and-altitude (3-D) solution. The weapon utilizes three-dimensional rhumb line navigation referenced to true heading for a point-to-point guidance solution. JDAM incorporates in its mission software guidance algorithm a prioritized hierarchy of mission objectives to maximize weapon effectiveness if an energy deficit is realized after launch.
- **1.3.1.1 Quantity Release.** (U) The general theory of operations applies to quantity releases with the following distinctions. The aircraft computes and displays valid employment cues to assist the pilot in obtaining a release solution common to the selected weapons. During release, the aircraft ensures that a minimum separation interval is maintained to prevent bomb-to-bomb collisions. Once released, each JDAM weapon guides independently to its assigned target.
- **1.3.1.2 Target of Opportunity (TOO).** (U) The general theory of operations applies to targets of opportunity (TOO) with the following distinctions. The TOO mission usually is not pre-planned, although general terminal impact parameters and/or fuze data may be preprogrammed instead of entered manually in flight. Aircraft-relative target designations using sensors specific to the host aircraft or via networking with sensors external to the host aircraft are converted into absolute targeting coordinates for the weapon. , assuming sufficient threshold precision,
- **1.3.2 DETAILED CONCEPT OF OPERATION.** (U) JDAM operation is divided into the mission planning, weapon preparation, initialization and test, transfer alignment, pre-release, release, separation, midcourse and terminal phases.
- **1.3.2.1 Mission Planning.** (U) JDAM mission planning is accomplished using automated systems. Specifics are discussed in Chapter 3 and Annex B. Mission and GPS data are preprogrammed and stored on a memory device, either a Memory Unit (MU) or Advanced Memory Unit (AMU) for transport to the host aircraft.
- **1.3.2.1.1 Mission Data.** (U) Mission data consists of target latitude and longitude specified in or converted to WGS-84 coordinates, target elevation specified in Height Above Ellipsoid (HAE) or height above Mean Sea Level (MSL), terminal impact heading, terminal impact angle and minimum terminal impact velocity. Specification JDAM performance assumes target coordinates of sufficient threshold accuracy. A minimum Target Data Set (TDS) consists of latitude, longitude, elevation and elevation datum. Each JDAM weapon may store up to six pre-planned (PP) and up to two target of opportunity (TOO) missions. Fuze arm time and functioning delay also may be stored if a programmable fuze (FMU-152 JPF) is specified.

#### **NOTE**

(U) Due to roundoff errors incurred during conversion, coordinates specified in a datum other than WGS-84 may lose a small amount of precision during weapon conditioning.

(U) Terminal heading and impact angle (Figure 1-10) are used to tailor the JDAM attack against a horizontally or vertically oriented target. The terminal impact angle defines the angle with respect to the horizontal from 0 to 90 degrees at which the weapon attempts to impact. The terminal heading defines the angle with respect to true north in the ground plane from 0 to 359 at which the weapon attempts to impact, and is used to tailor the JDAM attack against horizontally or vertically oriented targets. The terminal impact velocity defines the minimum desired velocity in feet per second, and is used to tailor the displayed JDAM valid release envelope to achieve the desired weapon velocity at impact.

#### **NOTE**

(U) JDAM does not attempt to fly along the specified terminal impact heading for any prescribed range, but instead maneuvers only to impact the target along the azimuth specified by the heading.

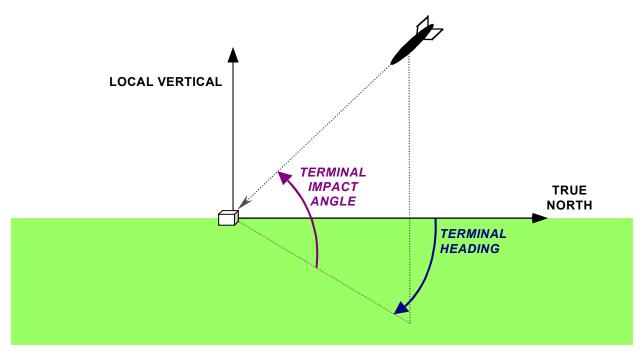


Figure 1-10
TERMINAL IMPACT ANGLE DEFINITIONS (U)

- 1.3.2.1.2 GPS Data. (U) GPS data consists of almanac, current weekly crypto key and anti-spoofing data.
- **1.3.2.2 Weapon Preflight Preparation.** (U) Weapon assembly consists of attaching the aero-surfaces to the warhead with torque bolts, attaching the (factory-preassembled) tail kit in a manner similar to existing bomb tail assembly attachment, and configuring the fuzing elements consistent with existing procedures. Specification JDAM assembly time is not more than 30 minutes per weapon. An approved Weapon Assembly Manual is available.
- (U) Weapon checkout is accomplished with an AN/GYQ-79 CMBRE (Common Munitions BIT Reprogrammable Equipment). This ground test set attaches and operates through the same weapon bus connector used for aircraft interface (Figure 1-11). The CMBRE verifies the software loaded in the weapon and updates the weapon software automatically if the CMBRE software is more current. The CMBRE also performs a comprehensive test of weapon subsystems to identify any failures or degrades prior to weapon upload on the host aircraft. Mission data is not preloaded in the tail kit; instead, all mission data is passed from the host aircraft via a digital umbilical cable after power-up.
- (U) JDAM is loaded and carried on the host aircraft in the "X" configuration using standard suspension equipment and either SHOLS winching equipment or a mobile SATS loader. Specification JDAM load time is not more than 14 minutes per weapon.

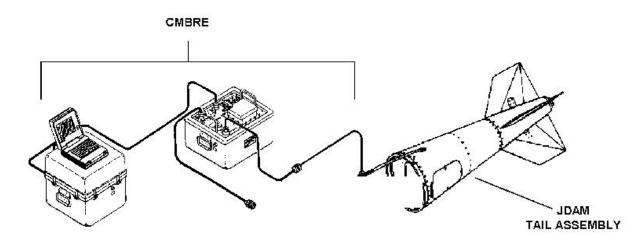


Figure 1-11
AN/GYQ-79 CMBRE INTERFACE (U)

- **1.3.2.3 Initialization and Test.** (U) After aircraft power-up, the weapon responds to aircraft inventory queries to establish its identity by variant as a JDAM. The weapon completes a BIT to identify any failed or degraded subsystems and reports the results to the aircraft. Subsystems monitored are computer processor, control section (TAS), IMU, power supply, battery squib, GPS receiver, JPF if installed, and telemetry if installed. The weapon passes the test as non-failed if no subsystem is declared failed, except for a GPS, FMU-152 JPF communication or telemetry failure, which results only in a weapon degrade. The weapon then receives and stores GPS data, mission targeting data and (if applicable) mission fuzing data from the aircraft. The weapon also requests and stores the Zulu Time Of Day (ZTOD) and date from the host aircraft for use in acquiring GPS satellites following release. The weapon defaults initially to the mission designated as such during mission planning, or otherwise to the first pre-planned mission ("PP1"). Following initialization, the weapon automatically performs periodic BIT and reports the result to the host aircraft. An initiated BIT (IBIT) may be commanded by the aircrew at any time, which requires 20 seconds to complete.
- **1.3.2.4 Transfer Alignment.** (U) The weapon does not attempt to acquire GPS satellites before release, since the extreme aft positioning of the GPS antenna on the tail kit results in antenna masking by the aircraft structure. Instead, the weapon accepts Periodic Transfer Alignment Messages (PTAMs) from the aircraft. The PTAM consists primarily of position, velocity and moment arm data from the aircraft, and is used by the weapon to align its onboard INS before release. A PTAM is expected and can be accepted by a powered JDAM anywhere from 10 times per second to once every six seconds, depending on the host aircraft integration, in order to maintain a valid INS alignment.
- (U) The weapon requires GPS-quality position, velocity and time information from the aircraft in order to align its INS accurately to the WGS-84 frame of reference. For this reason, the aircraft must maintain GPS-aided position keeping during this transfer alignment (TXA) process. If degraded PTAM data enters the weapon's navigation system, its Kalman filters cause the inaccurate information to wash out slowly over time, increasing the overall period of reduced weapon navigation accuracy. The aircraft is required to perform threshold maneuvers to generate a transfer alignment of adequate quality to support weapon release. Normally, these maneuvers consist of at least 30 degree heading changes in both directions for at least 30 seconds in each direction. For this reason, a satisfactory transfer alignment typically is accomplished only in flight. The weapon reports to the aircraft the quality of the transfer alignment and of its INS solution.
- **1.3.2.4.1 Transfer Alignment Quality.** (U) Transfer alignment quality is affected by the amount and type of aircraft maneuvering and the quality of information provided in successive PTAMs to the weapon. Transfer alignment quality is reported as a numeric value on a scale from 1 (best) to 10 (worst). High numeric values generally indicate that the weapon requires additional aircraft maneuvering to achieve a satisfactory INS alignment. High numeric values at all JDAM stations despite adequate maneuvering also may indicate poor or erratic aircraft navigation quality, and could be an indication of GPS degradation. However, chronically high numeric values on isolated stations can indicate a problem with aircraft PTAMs to that station, particularly if other weapons loaded on the aircraft achieve low numeric values at the same time. Therefore, cycling weapon power to reinitiate the transfer alignment (to all stations) may resolve chronically high numeric cues on a single station.

#### **CAUTION**

- (U) Cycling weapon power results in weapon unavailability during the reinitialization, warm-up and satellite reacquisition process, which can take as long as 5-7 minutes. Aircrew must consider tactical requirements and proximity to launch point before cycling JDAM power.
- **1.3.2.4.2 INS Quality.** (U) INS quality is affected by the quality of the transfer alignment and by environmental conditions. INS quality is reported as good, marginal or unsatisfactory. A "good" status indicates that the weapon is capable of meeting both GPS-aided and INS-only specification accuracy. A "marginal" status indicates that the weapon is capable of meeting GPS-aided but not INS-only specification accuracy. An "unsatisfactory" alignment indicates that the weapon is incapable of meeting either the GPS-aided or the INS-only specification accuracy.
- (U) INS quality is not purely a function of transfer alignment quality. Typically, more aircraft maneuvering causes improvement in the transfer alignment quality and, as a result, INS quality. However, optimum transfer alignment quality still may result in degraded weapon INS quality due to environmental conditions. In a case such as this, additional aircraft maneuvering will not improve the INS quality. For example, if a weapon displays a "01 MARG", it means that the weapon error estimates have exceeded reasonable expectations for 20 seconds or more, or that the weapon is experiencing vibrations that are degrading the INS alignment. Thus the transfer alignment data is good, but the weapon INS solution is not.

#### **CAUTION**

- (U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.
- **1.3.2.5 Pre-Release.** (U) In flight, the weapon maintains a passive captive carriage profile, with the control fins locked in a neutral position. Weapon functional operation does not change prior to release; regardless of aircraft function or weapon selection, JDAM weapons continue the transfer alignment process and weapon health reporting. In flight, the weapon accepts commands from the host aircraft to modify the assigned PP mission targeting and/or fuzing data, assign a different existing PP mission, or create and assign a new manually created PP mission. For TOO modes, the aircraft must employ onboard sensors of sufficient precision to automatically designate the target location for the weapon.
- (U) When a JDAM weapon is selected for release, the aircraft displays envelope cues for valid release. If a PP mode is selected, the aircraft displays pre-planned launch point, launch heading and LAR. If either PP or TOO mode is selected, the aircraft displays dynamic (i.e., flight condition-dependent) minimum and maximum ranges, direct attack cues and dynamic LAR calculated using JDAM 6-degree-of-freedom LAR algorithms stored in the aircraft mission computers. The aircraft formats these cues for display in order to provide adequate steering and release point information with which to achieve a valid launch condition for the selected mission parameters.
- **1.3.2.6 Release.** (U) The aircraft provides automatic or manual release modes. In automatic release modes, the aircraft calculates a valid release point for the weapon using the JDAM LAR algorithms stored in the aircraft, and release is inhibited until this point is reached. In manual release modes, the aircraft enables release any time, regardless of aircraft position with respect to a valid weapon envelope. In all cases, the aircraft inhibits release of a failed weapon but permits release of a degraded weapon. When the weapon station is commanded to release, the weapon communicates a final health status to the aircraft and the aircraft transmits a final transfer alignment update to the weapon. The weapon has no active physical operation during the aircraft release sequence. The aircraft configures the bomb rack solenoids and/or fuze power control, as appropriate, to ensure that the selected fuze status (armed or safe) is achieved. If a quantity release is in progress, the aircraft ensure that the minimum release interval for JDAM is met. The aircraft then sends the irreversible command for station release.
- **1.3.2.7 Separation.** (U) At the moment of release, the weapon initiates an internal timer. During the first moments of flight after release, the weapon retains the neutral control fin positions in order to allow for safe separation from the launch aircraft. For the GBU-31, this period is 1000 milliseconds, or one second. For the GBU-32/35, this delay is reduced to 300 milliseconds in order to damp higher post-ejection transient motions earlier in the weapon flight. This "early fin turn on" manages early energy usage to damp initial body rates in order to preserve expected terminal energy performance. At the end of the prescribed delay, the weapon commands the fins to unlock and enables the guidance system.

#### 1.3.2.8 Midcourse

**1.3.2.8.1 Initial Maneuvering.** (U) Initially, JDAM only damps weapon body rates due to ejection and establishes the desired flight orientation. In the case of the GBU-31(V)2/B, the weapon assumes the "+" configuration after fin unlock for free flight (Figure 1-12). For all other JDAM variants, the weapon maintains the "x" configuration for free flight. The weapon commands full guidance authority and then turns toward the inertially-computed target aimpoint.

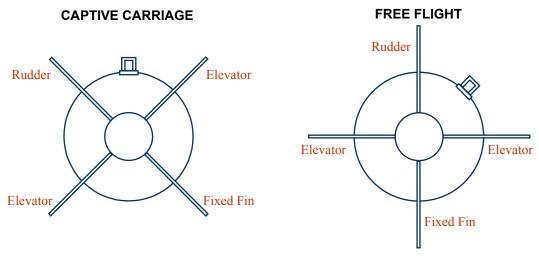


Figure 1-12
GBU-31(V)2/B CARRIAGE AND FREE FLIGHT ATTITUDES (U)

- **1.3.2.8.2 GPS Activation and Acquisition.** (U) The weapon GPSRM is enabled approximately 3 seconds after release, in order to avoid potential GPS multi-path errors due to aircraft proximity. The GPSRM uses 5 channels for satellite acquisition in Lot 3 and prior weapons, or 12 channels in Lot 4 and subsequent weapons. All but one channel acquire and track GPS satellite signals using the L1 band. The last channel sequences through the satellites tracked by the other channels using the L2 band in order to calculate ionospheric correction values to improve navigation accuracy. This last channel also searches for and receives data on any remaining reserve satellites in view.
- (U) The GPSRM searches the sky for GPS satellite signals using GPS almanac and ephemeris data and ZTOD. With good GPS data, the weapon typically acquires its first satellite within one second. Once the first satellite is located, the weapon updates "true" ZTOD and satellite ephemeris to aid in acquisition of other satellite signals. The JDAM then continues to acquire additional satellites, typically a second satellite within three seconds and a third satellite within seven seconds, and to make position measurement corrections and achieve an accurate GPS navigation solution of position, velocity and time.
- **1.3.2.8.3 Navigation Scheme.** (U) If a GPS navigation solution is achieved, the weapon blends the GPS information into the INS navigation solution in order to improve weapon accuracy. Per specification, the weapon nominally incorporates a GPS-aided navigation update into the guidance algorithm 27 seconds after GPSRM activation; that is, 30 seconds after weapon release including the delayed GPSRM activation. If the weapon time of fall (TOF) is less than 30 seconds, then the weapon flight profile is completed using only the weapon INS for navigation to the target. If after 30 seconds the weapon does not achieve a GPS navigation solution, it continues using INS-only navigation. However, over time the INS drifts from the original alignment at release; the weapon commands midcourse guidance in the same way as if GPS were available, but the net result is less accuracy as TOF increases. Figure 1-13 illustrates a typical GPS-aided JDAM flight using the GBU-31 1000 millisecond safe separation scheme.
- **1.3.2.8.4** Guidance Control Law. (U) During flight, the weapon utilizes a blended control law for weapon guidance in order to achieve the specified impact point and terminal parameters regardless of release point and release heading (Figure 1-14).

Chapter 1 Weapon Description

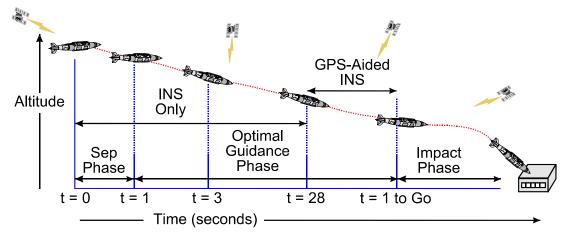


Figure 1-13
TYPICAL JDAM FLIGHT PROFILE (U)

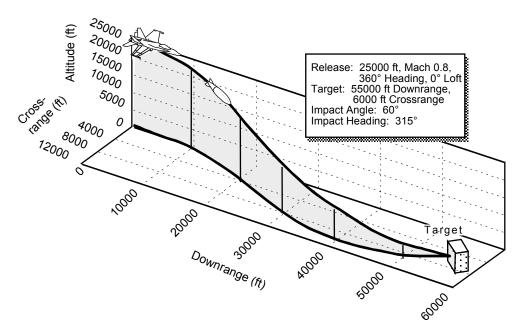


Figure 1-14
EXAMPLE OF JDAM BLENDED CONTROL LAW GUIDANCE (U)

- **1.3.2.8.5 Anti-Jamming.** (U) The JDAM weapon cannot determine the electronic jamming environment prior attempting GPS satellite acquisition following release. Currently, GPS anti-jamming techniques are limited to the ability of the GPS processor to identify and reject satellite data based on expected and compared values within the various channels of the receiver. Future upgrades of the JDAM weapon may include more robust anti-jamming techniques, including improved antenna hardware and dedicated processing changes.
- **1.3.2.9 Terminal.** (U) The weapon maneuvers to impact the DMPI according to the selected terminal parameters of impact heading and impact angle. In the last one second of flight, the weapon autopilot commands zero angle of attack, in order reduce the probability of weapon breakup due to case slap and to improve penetration.

# NOTE

(U) Actual impact velocity is determined by the total energy at launch and the actual flight profile, and is not actively controlled or adjusted by the weapon during flight. The specification of a minimum impact velocity tailors the displayed LAR in order to meet the computed launch energy requirement.

SECRET 1-15

Chapter 1 Weapon Description

- (U) If the weapon is launched with an energy deficit for the planned attack, the weapon guidance algorithm is designed to trade off the selected terminal parameters while maintaining maximum effectiveness. The weapon prioritizes guidance to:
  - (1) Reach the DMPI latitude, longitude elevation, then
  - (2) Meet terminal impact heading and impact angle, then
  - (3) Meet terminal minimum impact velocity.

# 1.4 DESIGN SPECIFICATION

#### WARNING

- (U) The limits listed in this section represent the specified weapon design envelope and do not reflect the authorized release envelope. Refer to the F/A-18 Tactical Manual or appropriate flight clearance for the authorized envelope limits.
- **1.4.1 DESIGN RELEASE ENVELOPE.** (U) The JDAM release envelope is within the airspeed and altitude limits presented in Table 1C. JDAM is capable of release at level, dive, and loft flight path angles from minus 45 degrees to plus 45 degrees, and at aircraft roll attitudes up to 90 degrees (curvilinear release).

#### NOTE

(U) Low altitude releases are limited both by safe separation criteria and by safe escape criteria for the applicable warhead and fuze combination.

WEAPON VARIANT	ALTITUDE (FT MSL)	AIRSPEED	
CDII 21 Coming	200 – 45,000	165 KCAS – 1.3 IMN	
GBU-31 Series	45,000 – 50,000	165 KCAS – 0.9 IMN	
GBU-32/35 Series	200 – 50,000	165 KCAS – 1.5 IMN	

Table 1C
JDAM AIRSPEED/ALTITUDE CAPABILITY (U)

# 1.4.2 WEAPON ACCURACY

**1.4.2.1 Error Contributors.** (U) JDAM Circular Error Probable (CEP) is a function primarily of weapon positional error, weapon guidance error and target location error. Weapon positional error is the location inaccuracy caused by less than optimum geometric orientation of satellites, or GPS Dilution of Precision (DOP), and to ranging and timing inaccuracies in the GPS receiver, referred to as the User Equivalent Range Error (UERE). Weapon guidance error is inaccuracy due to the finite autopilot precision available in response to computed guidance commands. Target location error (TLE) is the uncertainty in mensurating true target coordinates. Positional and guidance error components vary as a function of weapon type and weapon flight profile. TLE varies as a function of the target coordinate generation source and methodology (Annex A). These error contributions combine as the root-sumsquare of the individual components. Table 1D illustrates the contribution of the various JDAM error components.

GPS PERFORMANCE 1	POSITION <sup>2</sup> ERROR (M)	GUIDANCE <sup>3</sup> ERROR (M)	LOCATION <sup>4</sup> ERROR (M)	SYSTEM CEP (M)
Specification	9.9	2.5	7.2	12.6
Observed	6.4	2.5	7.2	10.0

- 1. Assumes a horizontal attack with terminal impact angle of 60 degrees.
- 2. Effects of PDOP and UERE (Annex A).
- 3. Effects of autopilot response accuracy and lag.
- 4. TLE assumed fixed at the specification value.

# Table 1D JDAM ERROR COMPONENTS (U)

SECRET 1-16

Chapter 1 Weapon Description

**1.4.2.2 Specification Accuracy.** (U) A specification CEP is assigned for each combination of target orientation, GPS availability and impact angles (Table 1E). Figure 1-15 illustrates the projected INS-only capability with a nominal handoff, or transfer alignment, from an aircraft employing GPS-aided INS position keeping.

GPS STATUS <sup>1</sup>	TARGET ORIENTATION	IMPACT ANGLE (DEGS)	SPECIFICATION CEP (METERS) <sup>2</sup>
	TT : 1	60+	13
Available	Horizontal	35-60	19
	Vertical	60+	17
11 111 3	Horizontal	60+	30
Unavailable <sup>3</sup>	Vertical	60+	30

- 1. Assumes a fixed GPS precision (PDOP) value of 4.4 meters.
- 2. Assumes a fixed location precision (TLE) value of 7.2 meters, typically guaranteed by standard mensuration sources.
- 3. Assumes a TOF limit of 100 seconds for on-axis attacks or 90 seconds for off-axis attacks.

Table 1E
JDAM SPECIFICATION ACCURACY (U)

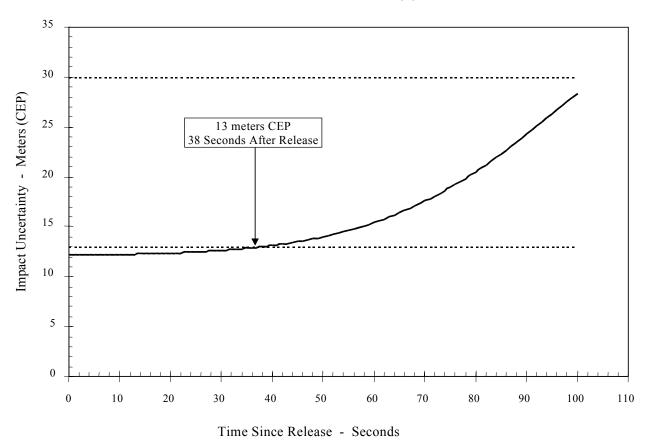


Figure 1-15
PREDICTED INS-ONLY ACCURACY (U)

**1.4.2.3 Demonstrated Accuracy.** (U) Early initial CEP data from flight test and contingency combat operations for GPS-aided deliveries to date demonstrate that JDAM exceeds the specification accuracy (Table 1F). This data reflects over 100 flight test drops and over 140 operational drops. Flight test deliveries were executed against surveyed targets, with a 0-meter TLE error component. Operational deliveries reflect a standard 7.2-meter TLE component and have been calculated to a 95% confidence rating.

SECRET 1-17

Weapon Description Chapter 1

DATA SOURCE 1	TARGET ORIENTATION	DEMONSTRATED CEP
Eliaht Tost	Horizontal	4.8 meters
Flight Test	Vertical	2.8 meters
0	Horizontal	9.2 meters
Operational <sup>2</sup>	Vertical	7.8 meters

Flight test TLE = 0 (surveyed targets), operational TLE assumed to be 7.2 meters.
 Operational CEP calculated to 95% confidence.

# Table 1F EARLY DEMONSTRATED JDAM ACCURACY (U)

1-18 **SECRET** 

# 2.0 F/A-18 INTEGRATION

# 2.1 AIRCRAFT INTERFACE

**2.1.1 PHYSICAL INTERFACE.** (U) The F/A-18C/D aircraft is capable of single-station carriage, jettison and release of JDAM stores at wing stations 2, 3, 7 and/or 8. No unique suspension equipment is required. JDAM mechanically interfaces via pylon suspension using a standard BRU-32 bomb rack with 30-inch lugs for GBU-31 variants and with 14-inch lugs for GBU-32/35 variants. If any JDAM variant is loaded on station 3, then the LTD/R laser inhibit envelope is set to "Min Left". If any wingtip store is loaded with a GBU-31 variant present on an outboard weapon station, Active Oscillation Control (AOC) is enabled.

# **NOTE**

- (U) When a GBU-32/35 is loaded on an outboard station with a wingtip store present, AOC is invoked only with SCS 15C+ and subsequent. Consult the F/A-18 Tactical Manual or ATACS, or the appropriate flight clearance for maneuvering limits for GBU-32 carriage using SCS 15C or prior.
- (U) The aircraft MIL-STD-1760 digital armament bus interface provides the necessary information transfer between the aircraft and the weapon in order to allow the aircraft to initialize and condition the JDAM and, if installed, the FMU-152 Joint Programmable Fuze (JPF). JDAM electrically interfaces with the aircraft directly at the weapon station through either a legacy or an improved MIL-STD-1760 umbilical cable.
- **2.1.2 SYSTEM REQUIREMENTS.** (U) JDAM minimum system requirements are presented in Table 2A. The F/A-18C/D aircraft requires installation of the AN/A?-??? Miniature Airborne GPS Receiver (MAGR) for employment of JDAM. The MAGR is factory installed in Lot XVII and subsequent aircraft and is retrofitted on selected aircraft from earlier production lots. The aircraft conditions pertinent information from several aircraft subsystems and transfers it to JDAM. Similarly, the JDAM weapon provides status feedback to the aircraft for cockpit display to the aircrew. This same digital interface provides access for support equipment to download software and upload ground test results.

SYSTEM	SYSTEM HARDWARE		SOFTWARE (GBU-32/35)
	F/A-180	C/ <b>D</b>	
Configuration	MAGR	SCS 13C+	SCS 15C
MC1	XN8+	13C+271U	15C- ???
MC2	XN8+	13C+272U	15C- ???
SMS	AYQ-9	13C-681U	15C- ???
SMS (SMUG)	AYK-22	13C-512U	15C- ???
	JDAN	1	
GBU-31(V)2/B	KMU-556/A	OFB 1.75	
GBU-31(V)4/B	KMU-558/A	OFC 1.75	
GBU-32(V)2/B	KMU-559/A		OGA 2.35???
GBU-35(V)1/B	KMU-559/A		OGA 2.35???

Table 2A
MINIMUM JDAM SYSTEM REQUIREMENTS (U)

# 2.2 ON-AIRCRAFT OPERATION

**2.2.1 WEAPON IDENTIFICATION.** (U) The appropriate JDAM weapon code must be entered into the Weapon Insertion Panel (WIP) prior to flight to ensure proper Stores Management Set (SMS) inventory. JDAM uses an "F0" weapon code for every JDAM variant, which is the standard weapon code for all MIL-STD-1760 class "smart" weapons. When the SMS encounters the "F0" weapon code, it is a signal to the aircraft to interrogate the store via the 1760 interface to determine store type. For JDAM Training Mode, training stations use a WIP code of "C0" (Section 2.6).

(U) During the stores inventory process, the aircraft queries the weapon station for a store ID. If the SMS is unable to establish communications with the JDAM store, then the SMS ceases communication with the station for the current inventory process, and the store is labeled "????" (i.e., unknown). Should a subsequent store inventory occur, then the SMS reattempts communication with the unidentified store to establish weapon ID.

**2.2.2 INITIALIZATION.** (U) The JDAM operational timeline as integrated on the F/A-18C/D aircraft is presented in Figure 2-1. Following initial inventory, aircraft weight and drag values are stored according to the weapon data maintained in the aircraft SCS and summarized in Table 2B. On initial aircraft power up, power is applied to all inventoried JDAM stations and an Initiated Built-in-Test (IBIT) is commanded for all JDAM weapons. When IBIT has been completed for all JDAM weapons, mission data, GPS almanac and ephemeris data are downloaded from the MU to all non-failed JDAM weapons. GPS keys and AS/SV data are downloaded to the mission computer (MC). When download is complete, power is removed from all JDAM stations. Whenever a JDAM variant weapon option ("J-83", "J-84" or "J109") is then selected on the STORES page, GPS keys and AS/SV data are downloaded to all loaded JDAM weapons of that variant.

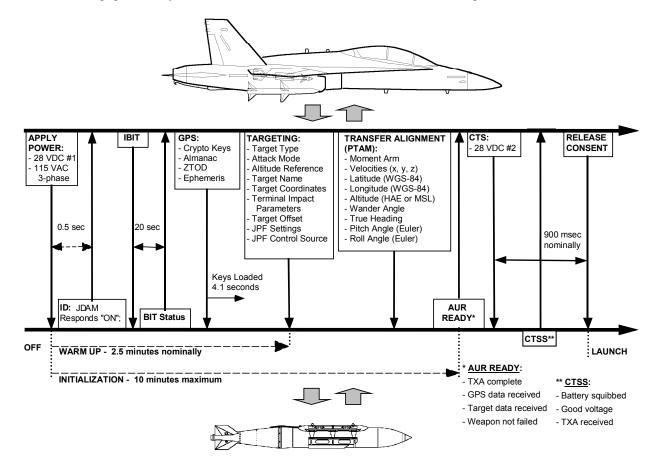


Figure 2-1
F/A-18 – JDAM OPERATIONAL TIMELINE (U)

VARIANT	WEAPON ID	WEIGHT (LBS)	DRAG COUNT
J-83	GBU-32(V)2/B GBU-35(V)1/B	1059	5.3
J-84	GBU-31(V)2/B	2046	7.5
J109	GBU-31(V)4/B	2125	7.5

Table 2B
JDAM WEIGHT AND DRAG DATA (U)

(U) Correct Zulu time of day (ZTOD) and date are required for proper JDAM initialization. If the aircraft GPS has not updated the system time, the SMS status (wing planform on the STORES format) for each non-failed JDAM station is set to "HOLD" and the Up-Front Control (UFC) is enabled for ZTOD entry (Figure 2-2). Once a valid ZTOD is entered, the SMS status for each JDAM station transitions to blank, "STBY", or "RDY".

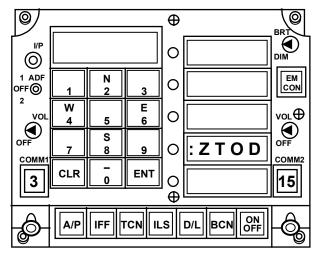


Figure 2-2 ZTOD ENTRY UFC FORMAT (U)

#### 2.2.3 CARRIAGE

- **2.2.3.1** Aircraft Communications. (U) While JDAM is carried on the F/A-18C/D aircraft with weapon power applied, the weapon automatically performs periodic BIT and reports the result to the aircraft. Once the aircraft has acquired GPS satellites, GPS ephemeris is provided to the weapon at fifteen minute intervals at 5, 20, 35 and 50 minutes after the hour, in order to ensure the best possible "map" of the satellite sky and the quickest possible satellite acquisition once the weapon is released. Regardless of aircraft master mode, the aircraft provides to each inventoried JDAM regular PTAM data to the weapon, including time and date from the SDC and the aircraft location and velocity state vector from the INS, at a rate of once per second (1 Hz).
- **2.2.3.2** Carriage Envelope. (U) JDAM airspeed and altitude design envelope limits are listed in Section 1.4.1. JDAM captive carriage is authorized up to the basic limits of the F/A-18C/D aircraft.

#### **NOTE**

- (U) When a GBU-32/35 is loaded on an outboard station with a wingtip store present, AOC is invoked only with SCS 15C+ and subsequent. Consult the F/A-18 Tactical Manual (or ATACS) or the appropriate flight clearance for maneuvering limits for GBU-32 carriage using SCS 15C or prior.
- (U) Fin movement had been demonstrated in the GBU-31 tail kits using the friction brake design when carried on F/A-18 aircraft inboard wing stations at altitudes below 15,000 feet MSL and airspeeds in the range of 0.85-0.90 IMN. Also, the amount of freeplay in the JDAM control section fins allow them to resonate at certain frequencies during flight. At altitudes below 10,000 feet MSL and mach numbers above 0.8, the fins may couple with the structural response of the F/A-18 aircraft and resonate at 150 Hz. This is a frequency to which the JDAM IMU is particularly sensitive, and may seriously degrade the JDAM weapon INS alignment.

# **WARNING**

- (U) GBU-31(V)2/B weapons incorporating a friction brake TAS are restricted to airspeeds at or below 0.82 IMN at altitudes less than 20,000 feet MSL when loaded on aircraft inboard wing weapon stations 3 and/or 7, due to friction brake TAS structural limits.
- **2.2.3.3 Carriage Life.** (U) The JDAM design is based-lined on a 50 cumulative flight hour life, but there is no operational limit on the number of flight hours allowed on a weapon. Weapon captive carriage is expected until either it is released or it declares an internal failure. Weapon utilization tracking is not required or intended. The weapon may be powered on continuously from engine start to engine shutdown.

# **CAUTION**

(U) JDAM continuous power-on time should be limited to 45 minutes below 1000 feet MSL with ambient temperature at or above 113 degrees F, in order to prevent overheating of the JDAM GCU components.

## **CAUTION**

- (U) All GBU-31 weapons incorporating a friction brake TAS are required to be powered continuously during flight below 20,000 feet MSL and airspeeds greater than 0.82 IMN when loaded on any aircraft weapon station, in order to detect excessive fin movement.
- **2.2.3.4 Shipboard Operations.** (U) There are no CV operating restrictions specific to JDAM, but aircraft NATOPS weight and asymmetry restrictions apply. The JDAM design is baselined on a 25 catapult/arrestment cycle life, but there is no operational limit to the number of catapult launches and arrestments allowed on a weapon.
- (U) Application of weapon power is recommended during catapult launches and arrestments. The weapon self-monitors subsystem health and can detect failures resulting from the associated loads, especially fin creep (i.e., "CS FAIL"). There is no technical data to date to establish that catapult launches degrade the JDAM navigation solution over the long term.
- **2.2.4 RELEASE.** (U) JDAM release modes include normal and backup modes similar to other stores. Section 2.4 details specific controls and displays associated with the release of JDAM weapons.
- **2.2.4.1 Primary Release Modes.** (U) JDAM weapons may be delivered singly or in quantity in either the Manual or Auto/Loft release modes.

#### NOTE

- (U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.
- **2.2.4.1.1 Single Release.** (U) When Manual release mode is selected, release is available whenever the A/G Ready requirements are satisfied. When Auto/Loft release mode is selected, the JDAM weapon at the priority station must satisfy the A/G Ready requirements and the aircraft LAR algorithm must indicated that the weapon is In Zone while the bomb button is depressed in order to initiate the release sequence.
- **2.2.4.1.2 Quantity Release.** (U) A quantity of up to four JDAM weapons of the same variant and same fuze configuration may be released in a single pickle. The quantity release sequence steps through aircraft stations as 8-2-7-3 for releasable weapons in the selected quantity, and is independent of the priority station. JDAM are released at a fixed minimum interval of 300 milliseconds. Once the release sequence is initiated, the SMS attempts to release all of the releasable JDAM weapons in the selected quantity. The hung/gone determination is made only at the end of the release sequence.
- (U) A/G Ready is achieved when at least one JDAM in the selected quantity has satisfied the A/G Ready requirements. In the Manual release mode, release is available whenever the A/G Ready requirements are satisfied. In the Auto/Loft release mode, the aircraft LAR algorithm must indicate that all weapons in the selected quantity are "In Zone" while the bomb button is depressed in order to initiate the release sequence. See Section 2.4.
- **2.2.4.2 Alternate Release Modes.** (U) In alternate release modes, the weapon battery squib is not fired, so weapon guidance avionics are not enabled and the release trajectory is comparable to that of an equivalent unguided weapon.
- **2.2.4.2.1 Emergency Jettison.** (U) Emergency jettison is a hardware function with a rapid execution time. All onboard weapons are jettisoned. No erasure of sensitive weapon data is attempted. It is recommended that, whenever possible, weapon data be manually erased via the ERASE JDAM option on the STORES or JDAM formats prior to initiating emergency jettison.
- **2.2.4.2.2 Selective Jettison.** (U) Upon initiation of a selective jettison, the selected weapons, including any hung stores, are powered up and commanded to erase all sensitive weapon data. After the erase command is sent, the weapons are jettisoned as soon as possible. It is recommended that, whenever possible, weapon data be manually erased via the ERASE JDAM option on the STORES or JDAM formats prior to initiating selective jettison.

**2.2.4.2.4 Auxiliary Jettison.** (U) An auxiliary jettison is recommended only if selective jettison attempts fail. With the Auxiliary Release switch enabled, when the Selective Jettison switch is depressed the aircraft sends auxiliary breech fire commands to the selected racks. The aircraft will not attempt to erase sensitive weapon data. It is recommended that, whenever possible, weapon data be manually erased via the ERASE JDAM option on the STORES or JDAM formats prior to initiating auxiliary jettison.

**2.2.4.3 Hung Release.** (U) A hung release (or "hang fire") is an abnormal release in which the weapon is enabled during a normal store separation sequence but does not separate from the launch aircraft. A hung JDAM weapon may have an activated battery, and the GCU and TAS may be functioning. Therefore, a hung JDAM may attempt to guide to the target once jettisoned. Average battery life is about 20 minutes. Therefore, jettison should not be attempted for 30 minutes after a hung launch unless absolutely necessary. Furthermore, the JDAM battery has a substantial thermal effect. If a hung weapon is recovered, the tail section can cause burns if handled without proper protection. A sufficient cool-down time of one hour is recommended to prevent unnecessary injuries.

#### WARNING

(U) During a quantity release, a hung JDAM weapon does not inhibit the remainder of the release. This may result in an asymmetric load beyond that authorized for or controllable by the aircraft.

# 2.3 FUZING

**2.3.1 AVAILABLE FUZE OPTIONS.** (U) Several fuze configurations are available on the F/A-18C/D to provide a variety of arm time and functioning delay options for weaponeering specific strike scenarios (Table 2C).

CONFIGURATION STORES FORMAT OPTIONS		JP	F FORMA	T OPTION	NS				
NOSE	TAIL	ARMING	MFUZ	EFUZ	ARM	ARM		DLY	
None	FMU-139	MK-122		OFF INST DLY1	5.5 sec 10 sec				
DSU-33	FMU-139	MK-122		OFF INST VT1	5.5 sec 10 sec				
DSU-33 or none	FMU-139	FZU-48	OFF TAIL		6 sec 7 sec 10 sec 14 sec 20 sec				
None	FMU-143	FZU-32	OFF TAIL		5.5 sec 12 sec				
DSU-33 or none	FMU-152	MK-122		OFF ON		5.5 sec 7 sec* 10 sec* 14 sec*	0 ms* 5 ms* 15 ms 25 ms* 35 ms 45 ms 60 ms 90 ms 180 ms*	5 min* 30 min 45 min	1 hr 4 hr* 8 hr 16 hr 20 hr 24 hr*

Faceplate selectable (i.e., default backup available)

Table 2C
ALLOWABLE F/A-18 FUZE OPTIONS FOR JDAM (U)

(U) Available fuze configuration components consist of the FMU-152 Joint Programmable Fuze (JPF) (Figure 2-3), the FMU-139 general purpose fuze (Figure 2-4), the FMU-143 hard target fuze (Figure 2-5), the DSU-33 proximity sensor, the FZU-48 and FZU-32 mechanical initiators, and MK-122 electrical fuze switch. The FMU-152 JPF is discussed in detail in Annex C. The DSU-33 proximity sensor is discussed in detail in Annex D.

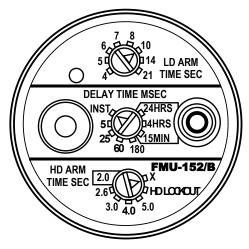


Figure 2-3 FMU-152 FUZE FACEPLATE (U)

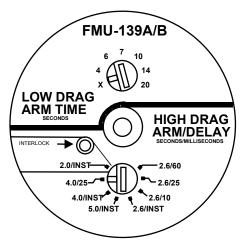


Figure 2-4
FMU-139 FUZE FACEPLATE (U)

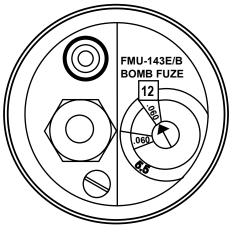


Figure 2-5 FMU-143 FUZE FACEPLATE (U)

**2.3.2 FUZE CONFIGURATION IDENTIFICATION.** (U) A specific fuze code representing the selected fuze configuration (Table 2D) of each weapon is entered into the Weapon Insertion Panel (WIP) prior to flight. During initial weapons inventory, the SMS assigns to all weapons of a specific variant (J-83, J-84 or J109) the fuze code of the first variant of that type inventoried successfully.

## **CAUTION**

(U) If the fuze code assigned to the first inventoried weapon of a specific variant is entered incorrectly, the incorrect fuze configuration code is assigned to all other weapons of the same specific variant.

#### NOTE

(U) Fuze codes other than those listed in the table below are not supported by the SMS for JDAM weapons. If an unsupported fuze code is entered for a JDAM station, a LOAD X advisory is displayed.

# **NOTE**

(U) A fuze code is required for designated Training JDAM stations to suppress a continual DUD cue.

FUZE (	CODES	FUZE C	CONFIGURATION	WEAPON VARIANT	WEAPON ID
NOSE	TAIL	NOSE	TAIL	WEAPON VARIANT	WEAPONID
0	8	None	FMU-152/MK-122	GBU-31(V)2/B	J-84
U	0	None	FWIU-132/WIK-122	GBU-32 or GBU-35	J-83
В	8	DCII 22	EMIL 152/MW 122	GBU-31(V)2/B	J-84
Б	0	DSU-33	FMU-152/MK-122	GBU-32 or GBU-35	J-83
0	3	None	FMU-139/MK-122	GBU-32 or GBU-35	J-83
В	3	DSU-33	FMU-139/MK-122	GBU-32 or GBU-35	J-83
0	7	N	EMIL 120/EZIL 40	GBU-31(V)2/B	J-84
U	,	None	FMU-139/FZU-48	GBU-32 or GBU-35	J-83
В	7	DCII 22	EMIL 120/EZIL 40	GBU-31(V)2/B	J-84
	7	DSU-33	FMU-139/FZU-48	GBU-32 or GBU-35	J-83
0	8	None	FMU-152/MK-122	GBU-31(V)4/B	J109
0	9	None	FMU-143/FZU-32	GBU-31(V)4/B	J109

# Table 2D F/A-18 WIP CODES FOR SUPPORTED JDAM FUZE CONFIGURATIONS (U)

- **2.3.3 FUZE SAFE/ARM CONTROL.** (U) Fuze safe/arm control may be mechanical or electrical, depending on the specific fuze configuration.
- **2.3.3.1 Mechanical Safe/Arm Control.** (U) Mechanical safe/arm control is used for fuze configurations employing a mechanical initiator, such as the FZU-48. A fuze arming wire generally is required, except for the FMU-152 when authorized by cognizant directives. Electrical charging power is applied continuously to the fuze following initiator deployment during release. Fuze safe/arm status is controlled through manipulation of the BRU-32 bomb rack solenoid latches. During the release sequence, the SMS determines cockpit safe/arm selections and provides the necessary power to the selected release station racks to power the solenoids open or closed. Application of an arming impulse results in the appropriate solenoid powering closed to retain the fuze arming wire, extracting it from the fuze gag rod and allowing fuze arming following the specified arm delay time. Application of a safing impulse results in the solenoid powering open to release the fuze arming wire; thus, even though the FZU-48 deploys and provides electrical power to the fuze, the gag rod remains physically pinned in place, preventing the fuze from arming.

SECRET 2-7

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<sup>(</sup>U) For JDAM equipped with mechanical fuze configurations, the "MFUZ" option on the STORES format controls fuze safe/arm status. Arm and functioning delay times are controlled via fuze faceplate settings only, except for the FMU-152 when serial communication with the aircraft exists. In all other cases, the arm time selected on the fuze faceplate must be identified to the SMS via the "ARM" option on the STORES format to support correct dud calculations.

# **CAUTION**

- (U) For mechanical fuze configurations (except the FMU-152 with serial communication with the aircraft), the fuze faceplate arm time should not be set to "X", but rather to the desired arm time. The "X" setting in a mechanical fuze configuration will safe the fuze irreversibly and cause a dud.
- **2.3.3.2 Electrical Safe/Arm Control.** (U) Electrical safe/arm control is used for fuze configurations employing an electrical safety switch, such as the MK-122 Mod 0. A fuze arming wire may be required for redundant safety, depending on the specific configuration, according to cognizant directives. Electrical charging power is applied selectively to the fuze during release. Fuze safe/arm status is controlled through the aircraft Fuze Function Control Set (FFCS). During the release sequence, the SMS determines cockpit safe/arm selections and applies or withholds electrical impulses generated by the AWW-4 avionics unit to the selected release stations. Application of an arming impulse results in the fuze capacitor charging prior to release and fuze arming following the specified arm delay time. The SMS automatically backs up electrical safe/arm impulses with corresponding control impulses to the bomb rack solenoids.
- (U) For JDAM equipped with electrical fuze configurations, the "EFUZ" option on the STORES format controls fuze safe/arm status. Arm and functioning delay times are encoded into the electrical charging pulse voltage and polarity, except for the FMU-152 when not in its default operating mode, and the fuze decodes the charging pulse to determine the desired operational settings.

#### NOTE

- (U) For electrical fuze configurations, the fuze faceplate arm time should be set to "X" according to cognizant directives.
- **2.3.4 GBU-31(V)2/B FUZE CONFIGURATIONS.** (U) The GBU-31(V)2/B may be configured using the FMU-152 powered via the MK-122 electrical switch or the FMU-139 powered via the FZU-48 mechanical initiator.

## NOTE

- (U) Use of the FZU-55 mechanical initiator with the FMU-152 is not authorized for Navy operations.
- **2.3.4.1 FMU-152 with MK-122.** (U) When the GBU-31(V)2/B is configured with the FMU-152, a DSU-33A/B or DSU-33B/B proximity sensor is authorized. Internal cables connect the FMU-152 and DSU-33 (if installed) to the MK-122 switch. The MK-122 switch passes FFCS voltage to fire the JPF battery initiator and DSU-33 battery initiator (if installed).
- (U) The FMU-152 connects to the JDAM tail kit via a serial connector to provide digital communication between the fuze and the JDAM GCU. The JDAM GCU provides the JPF with arm time and functioning delay selections transmitted via the aircraft 1760 digital interface. With serial communication active, the FMU-152 functions according to the values transmitted from the aircraft. If the serial communication is lost, the FMU-152 defaults to the preset faceplate settings.

# **NOTE**

(U) The arm time and functioning delay settings available on the JPF faceplate represent only a subset of all available delay settings available via programming. Therefore, not every combination of available arm time and functioning delay can be backed up with default settings. See Annex C.

# **NOTE**

- (U) "ARM" and "DELAY" option selections from the JPF format apply only to the selected mission on the priority JDAM station.
- **2.3.4.1.1 Arming Wire Routing.** (U) The MK-122 electrical switch is connected to the center positive arming latch of the BRU-32 bomb rack. The FMU-152 does not require a fuze arming wire in this configuration, unless specified in cognizant directives. See Figure 2-6.
- 2.3.4.1.2 Safe/Arm Control. (U) The "EFUZ" option on the STORES format provides "ON" and "OFF" selections.

**2.3.4.1.3 Arm Time Control.** (U) In normal operation, the FMU-152 sets the arm time to the value provided by the aircraft from the MU in the bulk data download or manually entered via cockpit selection, regardless of faceplate settings. If serial communication is lost, the FMU-152 defaults to the preset faceplate LOW DRAG ARM TIME setting for arm time. Authorized arm times are 10 and 14 seconds. HIGH DRAG ARM TIME is always set to "X".

## **CAUTION**

(U) Arm times below 10 seconds are available on the STORES and JPF formats, but are not authorized.

### **NOTE**

(U) Because of limitations imposed by the internal charging capacitor for the FMU-152, selection of the 25-second arm time may result in unreliable FMU-152 function when used with the MK-122 switch.

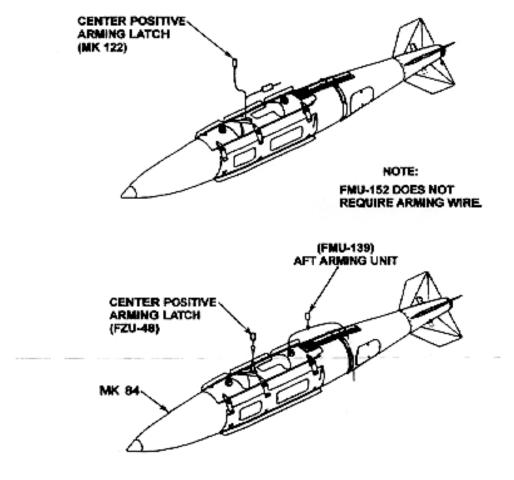


Figure 2-6
GBU-31(V)2/B ARMING WIRE CONFIGURATION (U)

- **2.3.4.1.4 Functioning Delay Control.** (U) In normal operation, the FMU-152 sets the functioning delay to the value provided by the aircraft from the MU in the bulk data download or manually entered via cockpit selection, regardless of faceplate settings. If serial communication is lost, the FMU-152 defaults to the preset faceplate DELAY TIME setting for functioning delay.
- **2.3.4.2 FMU-139 with FZU-48.** (U) When the GBU-31(V)2/B is configured with the FMU-139 (either the A/B or B/B variant), a FZU-48/B mechanical initiator is required; the MK-122 electrical switch is not authorized. A DSU-33A/B or DSU-33B/B proximity sensor is authorized. Internal cables connect the FMU-139 and DSU-33 (if installed) to the FZU-48. When deployed, the FZU-48 provides continuous electrical power to the fuze until weapon impact and the impulse to fire the DSU-33 battery initiator (if installed).

#### **NOTE**

- (U) In the mechanical fuzing configuration, there is no provision to disable DSU-33 proximity (VT) sensing and revert to instantaneous (contact) fuzing.
- **2.3.4.2.1 Arming Wire Configuration.** (U) The FZU-48 release cable is attached to the center positive arming latch of the BRU-32. A fuze arming wire is routed from the aft bomb lug, through a clip attached to the BRU-32 aft ZRF solenoid, then into the tail assembly and through the FMU-139 gag rod. See Figure 2-6.
- **2.3.4.2.2** Safe/Arm Control. (U) The FZU-48 always deploys during release and automatically provides electrical power to the FMU-139 and DSU-33 (if installed). The "MFUZ" option on the STORES format provides "OFF" and "TAIL" selections. No "nose/tail" selection is available since the supported JDAM fuze configurations only allow a nose plug or the DSU-33 proximity sensor, which requires no mechanical initiation.
- **2.3.4.2.3 Arm Time Control.** (U) Fuze arming time is selected via the LOW DRAG ARM TIME rotary switch on the fuze faceplate. Authorized arm times are 10, 14, and 20 seconds. Cockpit control is not provided; however, the selected arm time must be specified on the STORES format in order to support correct dud calculations.

# **CAUTION**

(U) If "X" is selected on the faceplate in the FZU-48 configuration, the fuze will dud.

# **CAUTION**

(U) SLIC v2.1 only supports 10- and 14-second arm times. Although 20-second arm times may be used, Safe Escape restrictions calculated for a 14-second arm time shall be followed.

#### NOTE

- (U) When planning safe escape using SLIC v2.1, there is no 14-second arm time option for FMU-139. In order to plan for this configuration, select FMU-152 with 14-second arm time. The resulting safe escape calculation will be valid.
- **2.3.4.2.4 Functioning Delay Control.** (U) Functioning delay is selected via the HIGH DRAG ARM/DELAY rotary switch on the fuze faceplate. Authorized settings are "2.6/INST", "2.6/10ms", "2.6/25ms" and "2.6/60ms". The high drag mode is never invoked with JDAM weapons, and the high drag arm time is ignored. Cockpit control is not provided.
- **2.3.5 GBU-31(V)4/B FUZE CONFIGURATIONS.** (U) The GBU-31(V)4/B may be configured using the FMU-152 powered via the MK-122 electrical switch or the FMU-143 powered via the FZU-32 mechanical initiator.

# NOTE

- (U) Use of the FZU-55 mechanical initiator with the FMU-152 is not authorized for Navy operations.
- **2.3.5.1 FMU-152 with MK-122.** (U) Configurations and characteristics are similar to those for GBU-31(V)2/B using the FMU-152 with MK-122 (Section 2.3.4.1 and subsections), except that a standard ogive nose plug is required; the DSU-33 proximity sensor is not authorized.
- **2.3.5.2 FMU-143 with FZU-32.** (U) When the GBU-31(V)4/B is configured with the FMU-143 fuze, the FZU-32 mechanical initiator is required; the MK-122 electrical switch is not authorized. A standard ogive nose plug is required; the DSU-33 proximity sensor is not authorized. Internal cables connect the FMU-143 to the FZU-32.
- **2.3.5.2.1 Arming Wire Configuration.** (U) The FZU-32 release cable is attached to the center positive arming latch of the BRU-32. A fuze arming wire is routed from the aft bomb lug, through a clip attached to the BRU-32 aft ZRF solenoid, then into the tail assembly and through the FMU-143 gag rod (Figure 2-7).
- **2.3.5.2.2 Safe/Arm Control.** (U) The FZU-32 always deploys during release and automatically provides electrical power to the FMU-143. The "MFUZ" option on the STORES format provides "OFF" and "TAIL" selections. No "nose/tail" selection is available since the GBU-31(V)4/B only allow a nose plug.

**2.3.5.2.3 Arm Time Control.** (U) Fuze arming time is selected via the ARM TIME rotary switch on the fuze faceplate. Only the 12-second arm time is authorized. Cockpit control is not provided; however, the selected arm time must be specified on the STORES format in order to support correct dud calculations.

**2.3.5.2.4 Functioning Delay Control.** (U) Functioning delay is fixed at 60 milliseconds. Faceplate selection and cockpit control are not provided.

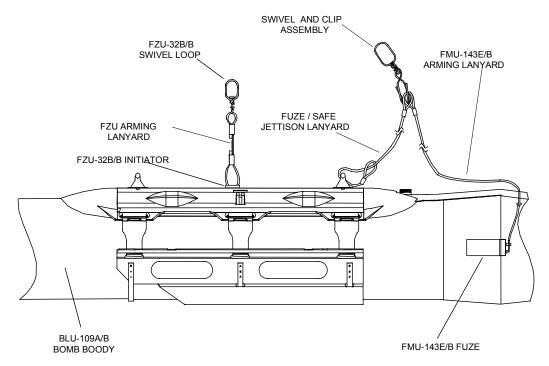


Figure 2-7
GBU-31(V)4/B ARMING WIRE CONFIGURATION (U)

**2.3.6 GBU-32(V)2/B AND GBU-35(V)1/B FUZE CONFIGURATIONS.** (U) The GBU-32(V)2/B and GBU-35(V)1/B may be configured with the FMU-152 powered via the MK-122 electrical switch or the FMU-139 powered via the FZU-48 mechanical initiator. These fuze configurations are similar to that for the GBU-31(V)2/B (Section 2.3.4).

#### NOTE

(U) Use of the FZU-55 mechanical initiator with the FMU-152 is not authorized for Navy operations.

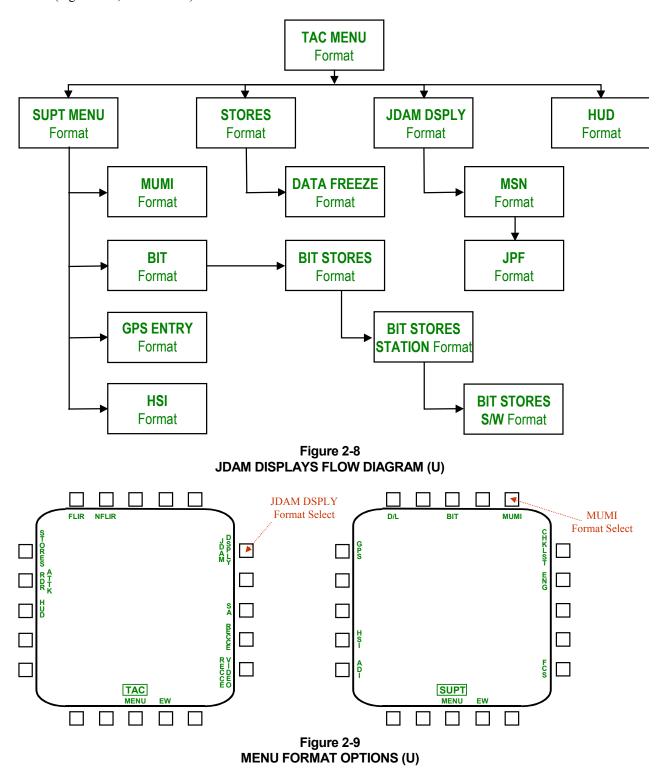
# 2.4 AIRCRAFT CONTROLS AND DISPLAYS

**2.4.1 OVERVIEW.** (U) F/A-18C/D controls and displays for the JDAM weapon consist of various DDI format options and cues. There are no other physical switches, lights or indicators in the aircraft cockpit directly associated with JDAM weapon. The logical flow for selecting JDAM-related formats is depicted in Figure 2-8.

## **NOTE**

- (U) When manipulating cockpit controls, a 1-2 second delay is recommended between individual selections. Digital bus communication errors resulting from rapid-fire request-and-response command inputs to the weapon may cause the aircraft to declare a healthy weapon as failed ("WFAIL").
- **2.4.2 MENU FORMATS.** (U) The menu formats provide control of basic display selections.
- **2.4.2.1** TAC Format. (U) A "JDAM DSPLY" option (PB11) is available on the TAC format (Figure 2-9) if a JDAM variant option is selected on the STORES format and a store is available for release (weapon not failed, rack unlocked, etc.). This option replaces the TAC MENU format with the JDAM format (Figure 2-24, Section 2.4.8).

**2.4.2.2 SUPT Format.** A "GPS ENTRY" option (PB 17) is available on the SUPT format (Figure 2-9), whenever a JDAM variant option is selected on the STORES format. This option replaces the SUPT format with the GPS ENTRY format (Figure 2-16, Section 2.4.3).



**2.4.3 MUMI FORMAT.** (U) The MUMI format (Figure 2-10) provides control of the memory transfer procedure. The "MORE" option (PB10, left) causes the "JDAM" mass data transfer option (PB8, right) and "RETURN" option (PB10, right) to appear whenever a JDAM weapon has been inventoried and a mission data file for JDAM is loaded on the MU.

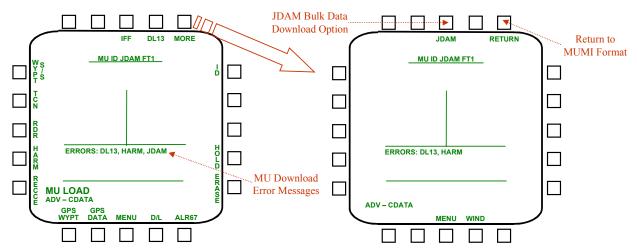


Figure 2-10
MUMI FORMAT OPTIONS AND CUES (U)

**2.4.3.1 "JDAM" Option.** (U) The "JDAM" option (PB8) on the MUMI:MORE format initiates download of JDAM mission data to all JDAM (all variants) inventoried on the aircraft. The "JDAM" option legend boxes until download is complete, whether download is successful or not. If a download is not successful, an "MU LOAD" caution appears and "JDAM" appears in the "ERRORS" window. Whenever bulk data is transferred to a JDAM weapon or whenever the "JDAM" option is selected if no bulk data is present, then MSP code "C05" is set and a "CDATA" advisory is displayed to indicate the presence of classified data in a weapon.

## NOTE

- (U) Selecting the "JDAM" option from the MUMI:MORE format will reload all preprogrammed mission data from the MU, causing any manual cockpit mission edits to be lost.
- **2.4.3.2 "RETURN" Option.** (U) The "RETURN" option restores the standard MUMI format options.
- **2.4.4 BIT FORMAT.** (U) The BIT format provides control of weapon and station status monitoring. The STORES and WPNS status cues on the BIT format includes JDAM among the weapons whose status is considered and displayed. (Figure 2-11 shows weapons degraded.) The "STOP" option (PB10) is not functional for JDAM weapons; JDAM IBIT cannot be halted once initiated.

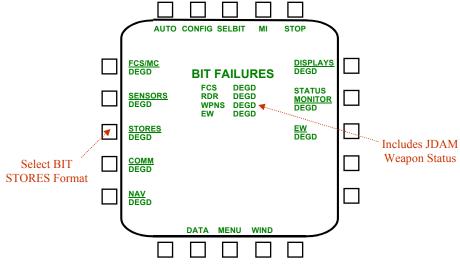
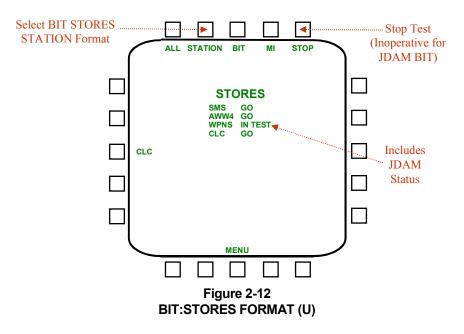


Figure 2-11
BIT FORMAT CUES AND OPTIONS (U)

**2.4.4.1 BIT:STORES Format.** (U) The WPNS status cue on the BIT:STORES format includes JDAM weapons whose status is considered and displayed. (Figure 2-12 shows weapons in test.) The "STOP" option (PB10) is not functional for JDAM. JDAM IBIT cannot be halted once initiated.



**2.4.4.2 BIT:STORES:STATION Format.** (U) A "JDAM" option (PB11) and "WPN S/W" option (PB16) are available on the BIT:STORES:STATION format (Figure 2-13), along with individual JDAM weapon status. The "JDAM" option initiates weapon BIT. The "WPN S/W" option displays weapon software loads as reported by the weapons to the aircraft mission computers. The "STOP" option (PB10) is not functional for JDAM. JDAM IBIT cannot be halted once initiated.

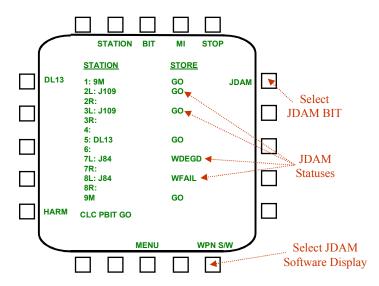
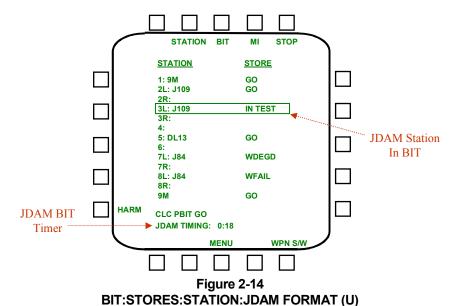


Figure 2-13
BIT:STORES:STATION FORMAT (U)

**2.4.4.2.1 "JDAM" Option.** (U) When the "JDAM" option on the BIT:STORES:STATION format is selected, all weapon IBIT options except "HARM" are removed from the display (Figure 2-14), and JDAM BIT is commanded on the priority station. If there is no priority station, BIT is initiated for all useable JDAM weapons inventoried on the aircraft. All other aspects of BIT initiation, status and timing work in the same manner as existing weapons. A JDAM warm-up countdown timer cue is provided at the bottom of the format. This timer cue initializes at "10:00" and counts down incrementally. JDAM warm-up only requires 2:30, and the timer cue is removed when it reaches "7:30". The "STOP" option (PB10) is not functional for JDAM. JDAM IBIT cannot be halted once initiated.



NOTE

(U) It is recommended that the BIT format remain displayed and no data entry be accomplished during JDAM BIT in order to prevent possible JPF data corruption.

**2.4.4.2.2 "WPN S/W" Option.** When the "WPN S/W" option is selected, the "ID" label and column replaces the "STORE" label and column, and the "WPN S/W" option is replaced with a "STATUS" option (Figure 2-15). The "STATUS" option returns the BIT:STORES:STATUS format to its original configuration. The JDAM software ID consists of three alphabetic characters representing the OFS label and three numeric characters representing the current version number; e.g., "OGA235" represents Advanced Core Processor ("OG") MK-83 variant ("A") OFS Version 2.35.

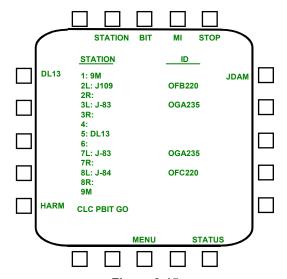


Figure 2-15
BIT:STORES:STATION:WPN S/W FORMAT (U)

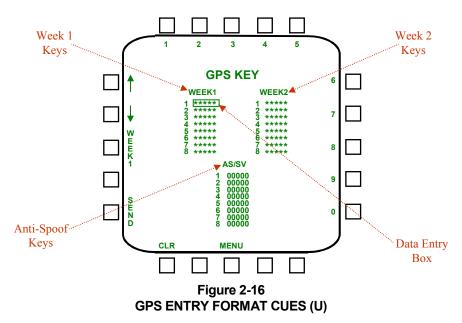
**2.4.5 GPS ENTRY FORMAT.** (U) The GPS ENTRY format provides manual control of GPS crypto keys. Controls are provided to select fields, enter or erase field data, and transfer the data into JDAM weapons.

# NOTE

- (U) All GPS crypto key data should be defined during mission planning and stored for electronic transfer. Manual GPS key entry is time-consuming and prone to data entry errors that cannot be identified after entry with the current display mechanization.
- **2.4.5.1 GPS ENTRY Format Cues.** (U) GPS ENTRY format cues consist of labeled field data and a data entry box (Figure 2-16). Data fields 1-8 in the "WEEK 1" column are the decimal values for Week 1 GPS crypto keys 1-8. Data fields 1-8 in the "AS/SV" column are the decimal values for AS/SV crypto keys 1-8. The data entry box is used to identify the field desired for manual editing. Asterisks are displayed in every GPS crypto key field whenever the GPS ENTRY format is selected or reselected, and the data entry box defaults to the first data field in the "WEEK 1" column. Manually entered data is displayed until the "SEND" option is selected or the GPS ENTRY format is deselected. If not previously classified, entry of any GPS crypto key data causes the MC to classify itself and post the "CDATA" advisory.

# **NOTE**

(U) The data entry box is a scratchpad. Data entered in the box is stored only if a complete field entry is made.



- **2.4.5.2 GPS ENTRY Format Options.** (U) The following options are used to enter or edit data (Figure 2-17).
- **2.4.5.2.1** " $\uparrow$  **Options.** (U) The " $\uparrow$ " (PB5) and " $\downarrow$ " (PB4) row selector options move the data entry box respectively within the currently selected data column. The arrows are mechanized to wrap from top to bottom and bottom to top. If a field is deselected with incomplete data in the data entry box, the data in the field reverts to the last stored value.
- **2.4.5.2.2 "WEEK1" Option.** (U) The column select option (PB3) defaults to "WEEK1". Repeated selection steps the data entry box to the first data field in the "WEEK1", "WEEK2" and "AS/SV" column, in order. If the column is changed with incomplete data in the data entry box, the data for the field reverts to the last stored value.

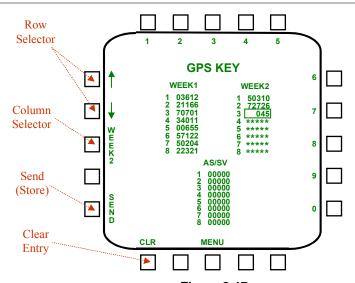
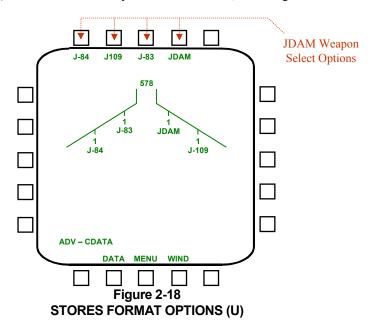


Figure 2-17
GPS ENTRY FORMAT OPTIONS, DURING DATA ENTRY (U)

- **2.4.5.2.3 "SEND" Option.** (U) The "SEND" option (PB1) sends the GPS and AS/SV crypto keys displayed on the GPS ENTRY format to all powered JDAM weapons. This causes the SMS and the JDAM weapons to become classified if not previously classified.
- **2.4.5.2.4 "CLR" Option.** (U) The "CLR" option (PB20) clears the current field under the data entry box.
- **2.4.5.2.5** "0"-"9" Options. (U) Since UFC support is not provided for the GPS ENTRY format, "0" through "9" Digit options (PB6-15) are provided to enter or edit GPS crypto key fields. Digits for each data field are entered from left to right. Selection of the first digit for a given data field clears the current 5-digit number before entering the selected digit (Figure 2-17). When the last digit of a field is entered, the data entry box automatically steps to the next data field and the finished entry is saved. When the last digit in the last field for any column is entered, the next column is selected, in order.
- **2.4.6 STORES FORMAT.** (U) The STORES format (Figure 2-18) provides control of weapon selection and management. JDAM acronyms are displayed on the wing planform when a JDAM variant is inventoried. JDAM weapon select options (PB6-10) are available for every inventoried variant, including "JDAM" training.



**2.4.6.1 Weapon Selection.** (U) Table 2E lists the available JDAM weapon options presently supported by the F/A-18 SMS, and the SCS required to support the variant.

(U) Selection of any JDAM weapon option on the STORES format applies power to every inventoried JDAM weapon. However, only the selected JDAM variant is available for A/G release. Power remains applied to JDAM variants until all variants are deselected. A JDAM variant is deselected only when the associated weapon select option is unboxed explicitly on the STORES format. Selected JDAM variants remain background-selected when another A/G weapon is selected or the aircraft master mode is changed from A/G to A/A or NAV. While background selected, operational power is applied and transfer alignment continues to all JDAM weapons, but none are releasable. When a JDAM variant is foreground-selected (i.e., variant legend is boxed), several options and cues are added to the STORES format.

OPTION	VARIANT	SCS REQUIRED	
"J-83"	GBU-32(V)2/B	15C	
J-83	GBU-35(V)1/B	130	
"J-84"	GBU-31(V)2/B	13C	
"J109"	GBU-31(V)4/B	13C	
"JDAM"	Training JDAM	13C	

Table 2E JDAM WEAPON SELECT OPTIONS (U)

#### NOTE

(U) Selection of a JDAM weapon option before achieving "POS/AINS" with 2-digit HERR and VERR values causes JDAM weapon transfer alignments to be seeded with inaccurate position information. The weapon may require up to 45 minutes to filter out the bad data, resulting in potentially degraded weapon accuracy during that period. JDAM weapon power should be selected after achieving "POS/AINS" with 2-digit HERR and VERR values. Otherwise, JDAM power should be cycled after achieving "POS/AINS" with 2-digit HERR and VERR values.

**2.4.6.2 STORES Format Cues.** (U) The following JDAM cues are available on the STORES format (Figure 2-19).

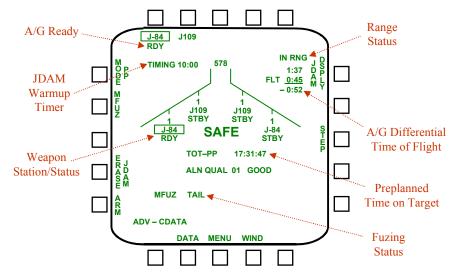


Figure 2-19 STORES FORMAT WITH JDAM SELECTED (U)

- **2.4.6.2.1 "RDY" A/G Ready Cue**. (U) The "RDY" A/G Ready cue indicates that the selected weapon variant is ready for release in A/G master mode.
- **2.4.6.2.2 "TIMING" Cue**. (U) The "TIMING" JDAM Warm-Up Timer cue initializes at 10:00 minutes and counts down until JDAM warm-up completes at 7:30 minutes, at which time the timing cue is removed.
- **2.4.6.2.3** Weapon/Station Status Cue. (U) The Weapon/Station Status cue is displayed below each JDAM station on the wing planform. The cues are presented according to priority (Table 2F). With a quantity release selected, the variant legend on the wing planform is boxed only at the priority station, but a "RDY" status is displayed at each useable station in the selected quantity, unless overridden by a higher priority status (e.g. "WFAIL"). If the status of any weapon in the quantity changes, the status reflects the change, but the weapon remains in the quantity.

STATUS CUE	MEANING
UNCPL	(Uncoupled). Rack is not responding.
H+LKD	(Hung and Locked). Store is hung with the rack locked.
H+ULK	(Hung and Unlocked). Store is hung with the rack unlocked.
H+TSN	(Hung and In Transition). Store is hung with the rack in transition.
FAIL	(Fail). Encoder/decoder communication failure or a high-current relay/driver failure.
LKD	(Locked). Rack is not unlocked in flight when it is expected to be.
ULK	(Unlocked). Rack is not locked in flight when it is expected to be.
EFAIL	(Erase Fail). Erase attempt has failed.
ERASE	(Weapon Erased). GPS crypto keys and mission data are erased.
TEST	(Weapon or Rack in Test). Store or rack IBIT in progress.
WFAIL	(Weapon Fail). Store failure has occurred that inhibits launch.
HOLD	(Hold). Entry of ZTOD on the UFC is required.
XFER	(Transfer). Data transfer is in progress.
RDY-D	(Ready But Degraded). Priority weapon/station is degraded.
DEGD	(Degraded). Station reports both SDEGD and WDEGD.
WDEGD	(Weapon Degraded). Store reports a non-critical failure. (GPS, TIK or JPF FAIL).
SDEGD	(Station Degraded). Station decoder BIT failure, station still releasable.
RDY	(Ready). Station is ready and selected for release.
STBY	(Standby). Station is ready but is not selected for release.

# Table 2F JDAM WEAPON/STATION STATUS PRIORITIES (U)

**2.4.6.2.4 "IN RNG/IN ZONE" Cue.** (U) The "IN RNG/IN ZONE" Range Status cue is presented for the JDAM weapon at the priority station. This cue is determined in accordance with MC dynamic LAR calculations. Initially, assuming the aircraft is out of range of the JDAM target, the cue is blank. When inbound toward the target and the aircraft enters the In-Range Circle cue on the HSI format (Section 2.4.11.1.3) an "IN RNG" is displayed. Continuing inbound toward the target, when the aircraft enters the In-zone region cue (Section 2.4.11.1.7), an "IN ZONE" is displayed.

- **2.4.6.2.5** A/G Differential TOF Cues. (U) The A/G Differential Time of Flight (TOF) cue consist of the prelaunch time, the post-launch time ("FLT"), and the difference between these two times. The pre-launch time is the dynamic TOF calculated from the JDAM LAR algorithm for the priority release store, and is displayed only when the aircraft is In Zone. The post-launch time is the time remaining to target impact for the last released JSOW, JDAM, HARM, SLAM, SLAM-ER or Harpoon store. If the difference is negative (i.e., post-launch greater than pre-launch), then the priority weapon is expected to impact the target before the last released weapon. If the difference is positive, then the last released weapon is expected to impact the target before the priority station.
- **2.4.6.2.6 "TOT-PP" Cue.** (U) The "TOT-PP" Pre-Planned Time On Target (TOT) cue provides the predicted Zulu time of day (ZTOD) of weapon impact for the currently selected mission in the JDAM weapon at the priority station under the sensed flight conditions. Cue logic is displayed in Table 2G.

REGION	"TOT-PP" CALCULATION	LEGEND DISPLAY
Prior to In-Zone	Current ZTOD + Time to Launch Point + Pre-planned TOF	Crossed out
In-Zone	Current ZTOD + Dynamic TOF	Not crossed out

# Table 2G TOT-PP CUE LOGIC (U)

**2.4.6.2.7** "ALN QUAL" Cue. (U) The "ALN QUAL" alignment quality cue indicates the priority station JDAM navigational state. The information presented is actual feedback from the weapon. This cue consists of a numeric value cue from "01" to "10" and a plain language cue of "UNST", "MARG" or "GOOD". All weapons initialize in the "10 UNST" state, and ideally progress toward the "01 GOOD" state. See also Section 1.3.2.4.

## **CAUTION**

(U) JDAM navigation quality status is not an interlock for Safe To Release. JDAM will be released even if an unsatisfactory navigation solution exists, which may cause wide misses or collateral damage.

### **CAUTION**

(U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.

#### NOTE

- (U) The plain language alignment quality cue may lag the numeric transfer alignment quality cue by up to 60 seconds due to Kalman filtering in the weapon INS.
- (U) The numeric cue represents the quality of the transfer alignment being provided by the aircraft to the weapon, and is affected by the amount and type of aircraft maneuvering and the quality of information provided in successive PTAMs to the weapon. A value of "01" is best and a value of "10" is worst. Cycling weapon power to reinitiate the transfer alignment (to all stations) may adequately correct chronically high numeric cues.

# **CAUTION**

- (U) Cycling weapon power results in weapon unavailability during the reinitialization, warm-up and satellite reacquisition process, which can take as long as 5-7 minutes. Aircrew must consider tactical requirements and proximity to launch point before cycling JDAM power.
- (U) The plain language cue (Table 2H) represents the quality of the weapon INS alignment, and is affected by the quality of the transfer alignment and environmental conditions.

CUE	MEANING
"GOOD"	Good INS quality, can meet both the GPS-aided and INS-only specification CEPs
"MARG"	Degraded INS quality, can meet the GPS-aided spec CEP but not the INS-only spec CEP
"UNST"	Poor INS quality, cannot meet either the GPS-aided or the INS-only specification CEPs

# Table 2H INS ALIGNMENT QUALITY CUES (U)

(U) The plain language cue is not a function of the numeric value but is related to it. For example, "06 MARG" is a typical cue, and indicates that more aircraft maneuvering ("06") is expected to improve INS alignment quality ("MARG"). However, it is possible to achieve optimum transfer alignment quality but still have a degraded weapon INS due to environmental conditions, such as excessive weapon vibration. This can result in a cue such as "01 MARG" or even "01 UNST". In general, "GOOD" can be achieved only with an "01" or "02", "MARG" can be achieved with "01" through "08", and "UNST" can be achieved with an "01" through "10".

# **NOTE**

- (U) The plain language alignment quality cue may lag the numeric transfer alignment quality cue by up to 60 seconds due to Kalman filters in the weapon INS.
- **2.4.6.2.8 "EFUZ" or "MFUZ" Fuze Status Cue.** (U) The "EFUZ" (electrical fuzing) or "MFUZ" (mechanical fuzing) fuze status cue indicates the armed or safed status of the fuzes for the selected JDAM variants.
- **2.4.6.3 STORES Format Options.** (U) The following JDAM options are available on the STORES format (Figure 2-20).

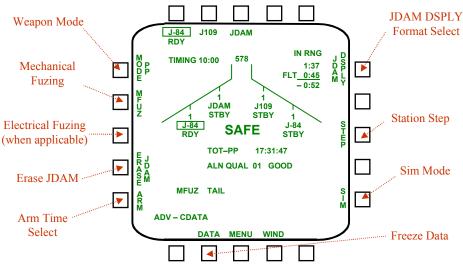


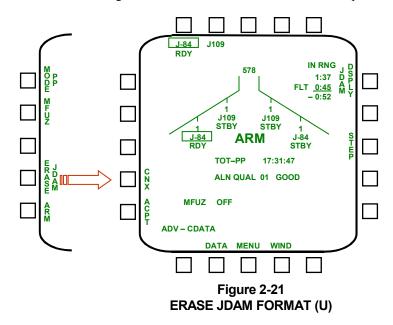
Figure 2-20 STORES FORMAT JDAM OPTIONS (U)

**2.4.6.3.1 "ARM" Option.** (U) The "ARM" option (PB1) replaces the standard options on the left side of the format with the available arm times. Selection of an arm time restores the standard options. Arming options are summarized in Section 2.3.2, Table 2C.

# WARNING

(U) Arm time selections of less than 10 seconds are available on the ARM option of the STORES format but are not supported by safe escape analysis and therefore are prohibited.

**2.4.6.3.2** "ERASE JDAM" Option. (U) The "ERASE JDAM" option (PB2) replaces the standard options on the left side of the format with "ACPT" (PB1) and "CNX" (PB2) options (Figure 2-21). The "ACPT" option boxes "ERASE" and commands all JDAM weapons on board (not just the selected variant) to erase stored mission data and GPS crypto keys. When all JDAM weapons have responded, "ERASE" unboxes and station status for each JDAM station is set to "ERASE" or "EFAIL" for successful or failed erasure, respectively. The "CNX" option cancels the request without erasure. Selecting "ACPT" or "CNX" restores the standard options.



- **2.4.6.3.3** "EFUZ" Option. (U) The "EFUZ" option (PB3) is available only when JDAM is configured for electrical safe and arm, such as with the MK-122 switch. Electrical fuze options are summarized in Section 2.3.2, Table 2C. The "EFUZ" option defaults to "OFF" and must be manually selected to the appropriate functional setting for an armed release. The "EFUZ" option replaces the standard options on the left side of the format with options specific to the fuze type (Figure 2-22), as described in the following paragraphs. Selection of any "EFUZ" option restores the standard STORES format options.
- **2.4.6.3.3.1 FMU-152 Options.** (U) FMU-152 JPF "EFUZ" options are "OFF" and "ON". The "OFF" option inhibits electrical power from being applied to the fuze during the release sequence, resulting in a safed release. The "ON" option enables electrical power to be applied to the fuze during the release sequence, resulting in an armed release using the arm time and functioning delay settings programmed automatically with stored mission data or manually using the JPF format options, or according to the fuze default logic if fuze communication is unavailable.
- **2.4.6.3.3.2 FMU-139 Options.** (U) FMU-139 "EFUZ" options are "OFF", "INST" and either "DLY1" or "VT1". The "OFF" option inhibits electrical power from being applied to the fuze during the release sequence, resulting in a safed release. The "INST" option enables specifically coded electrical power to the fuze during the release sequence that results in an armed release and selection of instantaneous fuzing. If a DSU-33 is present, selection of this option will inhibit initiation and functioning of VT proximity fuzing. The "DLY1" option, available when a DSU-33 is not present, enables specifically coded electrical power to the fuze during the release sequence that results in an armed release and selection of a functioning delay according to the fuze faceplate settings. The "VT1" option, available when a DSU-33 is present (see Section 2.3.1, Table 2C), enables specifically coded electrical power to the fuze during the release sequence that results in selection of both VT proximity fuzing and a functioning delay according to the fuze faceplate settings.

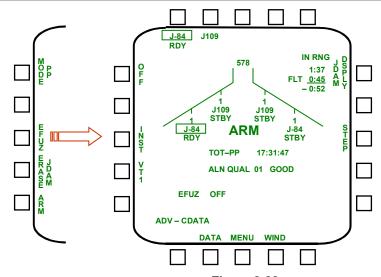


Figure 2-22 STORES FORMAT EFUZ OPTIONS, FMU-139 WITH DSU-33 EXAMPLE (U)

**2.4.6.3.4** "MFUZ" Option. (U) The "MFUZ" option (PB4) is available only when JDAM is configured for mechanical safe and arm, such as with the FZU-48 initiator. The "MFUZ" option replaces the standard options on the left side of the format with "OFF" or "TAIL" options (Figure 2-23). The "OFF" selection opens all rack solenoids during release, resulting in a safed release. The "TAIL" selection closes the aft rack solenoid during release on all stations within the selected quantity, resulting in an armed release. Selection of "OFF" or "TAIL" restores the standard options. Mechanical fuze options are summarized in Section 2.3.2, Table 2C.

## **NOTE**

(U) The DSU-33 requires no action on the part of the aircrew for operation and uses no mechanical lanyards for initiation. Current JDAM configurations do not require a nose ("NOSE") or nose/tail ("N/T") mechanical fuze selection for DSU-33 operation. See Annex D for details.

# NOTE

(U) In the mechanical fuzing configuration, there is no provision to disable DSU-33 VT proximity fuzing in order to revert to instantaneous contact fuzing.

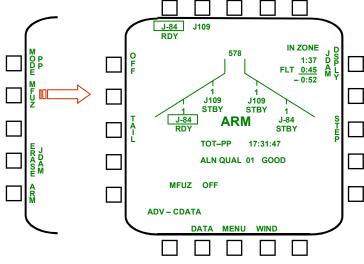
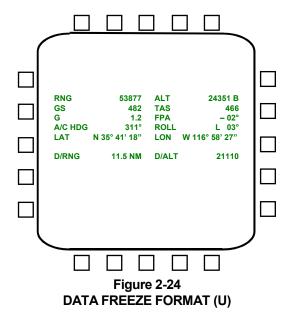


Figure 2-23 STORES FORMAT MFUZ OPTIONS (U)

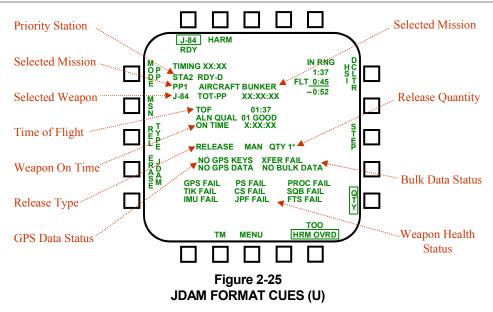
**2.4.6.3.5** "MODE" Option. (U) The "MODE" option (PB5) selects the JDAM targeting mode for the priority JDAM station. This option toggles the mode between Pre-Planned ("PP") and Target Of Opportunity ("TOO"). "PP" is the power-up default. "PP" instructs the priority weapon to execute the selected pre-planned mission. "TOO" instructs the priority weapon to cue to the sensor-designated target, if any. This function allows for quick transition between weapon targeting modes.

## **CAUTION**

- (U) TOO missions are not authorized in the F/A-18C/D aircraft.
- **2.4.6.3.6 "JDAM DSPLY" Option.** (U) The "JDAM DSPLY" option (PB11) replaces the STORES format with the JDAM format (Figure 2-25). See Section 2.4.8.
- **2.4.6.3.7** "STEP" Option. (U) The "STEP" option (PB13) is available only when more than one station is loaded with the selected JDAM variant. If a quantity of one is selected, the "STEP" option is not available. When no quantity release is defined, the "STEP" option steps release priority to the next releasable station of the same variant, according to the normal priority sequence of 8-2-7-3. When a quantity release is defined, the release priority steps only between stations within the quantity. The "STEP" option automatically decouples the Flight Director ("FD") release mode from the flight controls, if coupled.
- **2.4.6.3.8 "SIM" Option.** The "SIM" option (PB15) is available only with Master Arm set to "SAFE". This option enables selection of the "JDAM" training variant weapon select option on the STORES format. The JDAM Training Mode is discussed in Section 2.5.
- **2.4.6.3.9 "DATA" Option.** The "DATA" option (PB19) replaces the STORES format with the DATA FREEZE format (Figure 2-24).
- **2.4.7 DATA FREEZE FORMAT**. (U) The DATA FREEZE format (Figure 2-24) displays parameters for JDAM releases consistent with other A/G stores.



- **2.4.8 JDAM FORMAT.** (U) The JDAM format provides control of basic JDAM functionality and is accessible either from the TAC MENU or STORES format.
- **2.4.8.1 JDAM Format Cues.** (U) JDAM format cues are illustrated in Figure 2-25.



- **2.4.8.1.1** "STA" Priority Station Cue. (U) The "STA" Priority Station cue indicates the current priority station.
- **2.4.8.1.2 Selected Mission Cue.** (U) The Selected Mission cue indicates the PP or TOO mission number selected for the JDAM weapon at the priority station. At aircraft power-up, all JDAM weapons initialize to the PP mission defined during mission planning. If no missions are defined for a specific weapon, the station initializes to "PP1".
- **2.4.8.1.3** Selected Weapon Cue. (U) The Selected Weapon cue indicates the foreground-selected (i.e., boxed) JDAM variant.
- **2.4.8.1.4** "TOF" Cue. (U) The "TOF" cue indicates the time of flight (TOF) to target impact for the priority station. This value is calculated either during mission planning or by the MC using the JDAM LAR algorithm (Table 2I).

AIRCRAFT CONDITION	"TOF" DISPLAY	
Not In Range or In Zone	TOF = pre-planned TOF	
In Range	TOF = pre-planned TOF	
In Zone	TOF = dynamic TOF	
Inside minimum range	TOF marked invalid and removed from display	

Table 2I JDAM FORMAT TOF DISPLAY (U)

- **2.4.8.1.5 "ON TIME" Cue.** (U) The "ON TIME" Weapon On-Time cue indicates for the priority JDAM station the total time that uninterrupted power has been applied.
- **2.4.8.1.6** "RELEASE" Cue. (U) The "RELEASE" cue indicates the selected aircraft release mode. Available JDAM release modes are Manual, Auto/Loft and Flight Director (FD).

# **CAUTION**

(U) Use of the Flight Director release mode is not authorized. Coupled FD mode can cause a violent, zig-zag banking pattern just prior to release. Also, at either high or low altitudes, the Elevation Steering Line cueing on the HUD may be reversed (i.e., climb when descent is required, or vice versa).

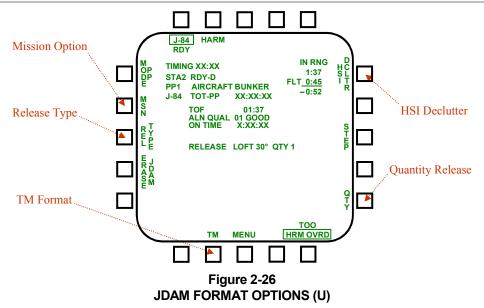
#### **NOTE**

- (U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.
- **2.4.8.1.7 GPS Data Status Cues.** (U) The GPS Data Status cues indicate the status of the GPS data transferred from the MU to the priority JDAM station. If GPS data is normal, the display is blank. A "NO GPS DATA" cue is displayed if GPS almanac, ephemeris, and/or satellite configuration data has not been received. A "NO GPS KEYS" cue is displayed if valid GPS crypto keys have not been received.
- **2.4.8.1.8 Weapon Health Cues.** (U) The Weapon Health cues (Table 2J) indicate specific subsystem failures as reported by the priority JDAM weapon. A blank field indicates no failures. Subsystem failures can result in either a "WFAIL" or "WDEGD" weapon status, indicated with the STORES format Weapon/Station Status cue.

CUE	SUBSYSTEM FAILURE	WEAPON STATUS	
"PROC FAIL"	Computer processor	"WFAIL"	
"CS FAIL"	Control section (TAS)	"WFAIL"	
"IMU FAIL"	Inertial measurement unit	"WFAIL"	
"PS FAIL"	Power supply	"WFAIL"	
"SQB FAIL"	Battery squib	"WFAIL"	
"GPS FAIL"	GPS receiver	"WDEGD"	
"TIK FAIL"	Telemetry instrumentation kit	"WDEGD"	
"JPF FAIL"	FMU-152 fuze communications	"WDEGD"	

# Table 2J JDAM FORMAT WEAPON HEALTH CUES (U)

- **2.4.8.1.9 Selected Mission Title Cue.** (U) The Selected Mission Title cue provides an alphanumeric title (of up to 16 characters) of the selected PP mission in the JDAM weapon at the priority station. No title is displayed for TOO missions. This title is derived from the route name assigned a particular mission in mission planning.
- **2.4.8.1.10 "QTY" Cue.** (U) The "QTY" Release Quantity cue indicates the number of releasable JDAM weapons selected for a quantity release. If one or more weapons selected for the quantity release is either not ready for release or unreleasable (e.g., WFAIL, hung, etc.), then a quantity override flag ("\*") is displayed after the number.
- **2.4.8.1.11 Bulk Data Status Cues.** (U) The Bulk Data Status cues indicate the status of the mission bulk data transferred from the MU to the priority JDAM station. If bulk data status is normal, the display is blank. A "XFER FAIL" cue is displayed if a checksum inconsistency indicates a bulk data transmission error. A "NO BULK DATA" cue is displayed if JDAM mission bulk data could not be found on the MU.
- **2.4.8.2 JDAM Format Options.** (U) The following JDAM options are available on the JDAM format (Figure 2-26).
- **2.4.8.2.1 "MSN" Option.** (U) The "MSN" option (PB4) replaces the JDAM format with the MISSION DATA format (Figure 2-30).
- **2.4.8.2.2 "HSI DCLTR" Option.** (U) The "HSI DCLTR" option (PB11) alternatively boxes and unboxes the "DCLTR" legend. When "DCLTR" is boxed, the Predictive Maximum Range, Pre-Planned In-Zone Region, Pre-Planned Launch Point and Bearing to Launch Point Line cues are not displayed.



**2.4.8.2.3 "TM" Option.** (U) The "TM" Telemetry Power option is available only when a telemetry-equipped JDAM weapon is inventoried and selected. This option alternately boxes and unboxes "TM". When "TM" is boxed, the TM transmitter is turned on for the priority JDAM station.

**2.4.8.2.4 "QTY" Option.** (U) The "QTY" Quantity Select option replaces the standard options on the right side of the format with "STA#" options (PB11-14), where "#" is a station inventoried with the currently selected JDAM variant, and a "RTN" option (PB15). Figure 2-27 assumes three GBU-31(V)2/B weapons inventoried on stations 2, 7 and 8.

### NOTE

(U) Selection of a single station defines a quantity of one, and quantity release functionality is applied to that single station.

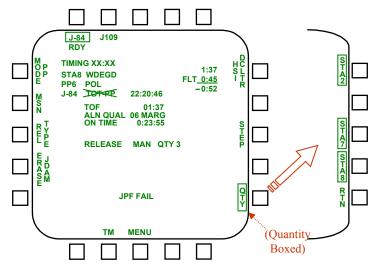


Figure 2-27
JDAM FORMAT QUANTITY RELEASE OPTIONS (U)

(U) On power-up, none of the station legends are boxed. Each "STA#" option alternately boxes and unboxes the corresponding legend, and selects or deselects that station for a quantity release. Quantity selection (and legend boxes) is retained for later display. If any station selected for a quantity release is or becomes unreleasable (e.g., WFAIL, hung, etc.), the selection (boxed) status is retained but the station legend is crossed out (Figure 2-28).

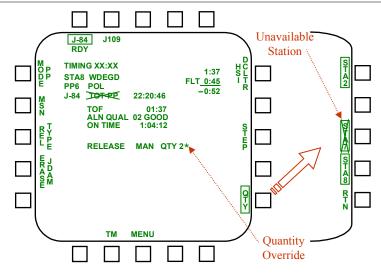


Figure 2-28
UNRELEASABLE JDAM STORE FOR QUANTITY RELEASE (U)

- (U) A quantity release is deselected by unboxing all stations, and the last station deselected becomes the priority JDAM station for single release. The "RTN" option restores the standard JDAM format options and boxes the "QTY" legend if at least one station is boxed.
- **2.4.8.2.5 "REL TYPE" Option.** (U) The "REL TYPE" option (PB3) replaces the standard options on the left side of the format with "FD", "AUTO/LOFT" and "MAN" release mode options (Figure 2-29).

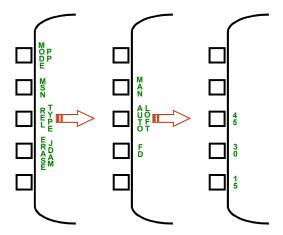


Figure 2-29
JDAM FORMAT RELEASE MODE OPTIONS (U)

- **2.4.8.2.5.1 "MAN" Option.** (U) The "MAN" option (PB4) enables the Manual release mode and restores the standard JDAM format options.
- **2.4.8.2.5.2** "AUTO/LOFT" Option. (U) The "AUTO/LOFT" option (PB3) replaces the release mode options on the left side of the format with "15" (PB1), "30" (PB2) and "45" (PB3) loft angle selections (Figure 2-29). Selecting a loft angle option enables the Auto/Loft release mode using the selected loft angle at release and restores the standard JDAM format options.

#### **CAUTION**

(U) The Auto/Loft release mode for GBU-32/35 weapon may cause releases outside of the envelope because the F/A-18C/D uses the GBU-31(V)2/B dynamic LAR for these weapons. Avoidance of "edge of the envelope" Auto/Loft releases reduces the probability of weapon misses due to this limitation.

#### **NOTE**

(U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.

## NOTE

- (U) Selection of waypoint steering when Auto/Loft release mode is selected will cause the aircraft waypoint steering cues to override Auto/Loft steering cues. However, if the steer waypoint is designated as a target, Auto/Loft cueing will be present.
- **2.4.8.2.5.3** "FD" Option. (U) The "FD" option (PB2) is available only when "PP" (vice "TOO") mode is selected and the launch point and ground track data are valid for the selected PP mission. The "FD" option enables the Flight Director release mode, with the autopilot uncoupled, and restores the standard JDAM format options.

# **CAUTION**

- (U) Use of the Flight Director release mode is not authorized. Coupled FD mode can cause a violent, zig-zag banking pattern just prior to release. Also, at either high or low altitudes, the Elevation Steering Line cueing on the HUD may be reversed (i.e., climb when descent is required, or vice versa).
- **2.4.9 MISSION DATA FORMAT.** (U) The MISSION DATA format provides monitoring, selection, entry and editing of the Target Data Sets (TDS) loaded in the JDAM weapon at the priority.
- **2.4.9.1 MISSION DATA Format Cues.** (U) MISSION DATA format cues represent the currently selected mission uploaded directly from the JDAM weapon at the priority station. These cues vary for a PP and TOO mission and whether an Offset Data Set (ODS) is present (Figures 2-30 and 2-31).

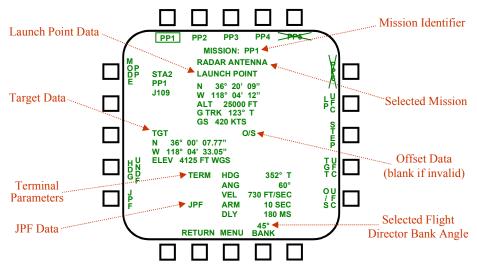


Figure 2-30
MISSION DATA FORMAT CUES, PP MODE WITH NO OFFSET DATA (U)

- **2.4.9.1.1** "TGT/ORP" Cue. (U) The "TGT/ORP" Targeting Data cue is displayed only when valid pre-planned launch target/offset reference point (ORP) data is loaded in the JDAM weapon on the priority station. This cue consist of the latitude and longitude (to the hundredth of seconds) and elevation values. These values represent the target ("TGT") if no offset data is provided, or the offset reference point ("ORP") if offset data is provided. If target/ORP data is blank when entry of latitude, longitude and elevation is initiated on the UFC, fields for which no data has yet been entered will be zero-filled until entry of all three values is complete.
- **2.4.9.1.2 "MISSION" Cue.** (U) The "MISSION" Mission Identifier cue identifies the currently selected mission as PP1-6 or TOO1-2 for the JDAM weapon at the priority station.

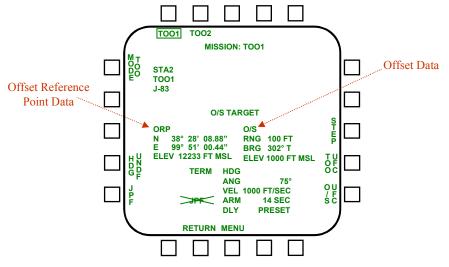


Figure 2-31
MISSION DATA FORMAT CUES, TOO MODE WITH OFFSET DATA (U)

- **2.4.9.1.3 Selected Mission Title Cue.** (U) The Selected Mission Title cue provides an alphanumeric title (of up to 16 characters) for PP missions only in the JDAM weapon at the priority station.
- **2.4.9.1.4 "LAUNCH POINT" Cues.** (U) The "LAUNCH POINT" Data cue is displayed only when the PP mode is selected and valid pre-planned launch point data is loaded in the JDAM weapon at the priority station. This cue consist of the latitude, longitude, altitude, ground track (aircraft heading to the launch point in degrees true) and ground speed values for the pre-planned release point. If launch point data is blank when entry of latitude, longitude and altitude is initiated on the UFCD, fields for which no data has yet been entered will be zero-filled until entry of all three has been completed. Launch point data is not displayed for TOO missions.
- **2.4.9.1.5** "O/S" Cue. (U) The "O/S" Offset Data cue is displayed whenever a valid, non-zero offset range is loaded in the JDAM weapon at the priority station. This cue consists of the offset range and true bearing values from the ORP to the intended target and the absolute elevation of the target for the selected mission.

# **CAUTION**

- (U) Offset elevation must be entered in the aircraft as absolute elevation for the desired impact point, in contrast to the differential elevation with respect to the offset reference point expected by the TAMPS CMPM. Confusion over the elevation entry format between the aircraft interface and the TAMPS interface may result in wide misses and undesirable collateral damage.
- **2.4.9.1.6** "TERM" Cue. (U) The "TERM" Terminal Impact Data cue consists of the selected terminal heading, angle, and minimum velocity values at target impact for the JDAM weapon if released when the aircraft has entered the In-Zone Region (Section 2.4.11.1.7).

# **NOTE**

- (U) Terminal values are desired only, and are used to calculate the displayed LAR on the cockpit HSI. Actual impact heading, angle and velocity may differ based on actual release conditions. See Section 1.3.2.9.
- **2.4.9.1.7** "JPF" Cue. (U) The "JPF" Fuze Program cue is displayed only for JDAM equipped with an FMU-152 fuze (Annex C). This cue consists of the arm time and functional delay selected from the JPF format (Figure 2-40). If the JPF has failed or if the JDAM is unable to program the JPF, then the JPF cue is crossed out and the JPF default values are displayed and used.

**2.4.9.1.8 Flight Director Bank Angle Cue.** (U) The Flight Director Bank Angle cue is displayed above the "BANK" option (PB17) only when the "FD" release mode is selected on the JDAM format and valid launch point and ground track data are present. This cue indicates the operational bank angle limit of the aircraft autopilot when coupled to the "FD" release mode.

#### **CAUTION**

- (U) Use of the Flight Director release mode is not authorized. Coupled FD mode can cause a violent, zig-zag banking pattern just prior to release. Also, at either high or low altitudes, the Elevation Steering Line cueing on the HUD may be reversed (i.e., climb when descent is required, or vice versa).
- **2.4.9.2 MISSION DATA Format Options.** (U) MISSION DATA format options are illustrated in Figure 2-32.

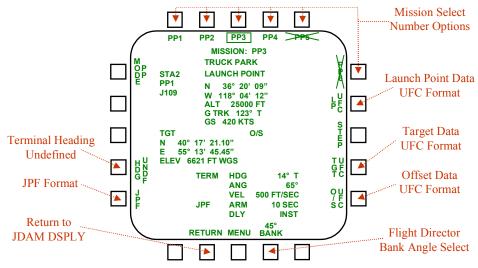


Figure 2-32
MISSION DATA FORMAT OPTIONS, PP MODE WITH NO OFFSET DATA (U)

- **2.4.9.2.1 "PP" Options.** (U) The "PP" (PP1-PP6) Pre-Planned Mission Selection options (PB6-11) are displayed only when the priority JDAM weapon is in PP mode. PP missions are selected by pressing the appropriate option, which boxes the associated option legend. A/G Ready cannot be achieved without selection of a valid mission for the JDAM weapon at the priority station. If any PP mission does not contain valid latitude, longitude or elevation, then the option for that mission is crossed out. However, an invalid (crossed out) mission may be selected and a valid set of mission data entered. TOO mission selection is not available in PP mode.
- **2.4.9.2.2** "LP UFC" Option. (U) The "LP UFC" Launch Point Data Entry option (PB12) is available only when the priority JDAM station is in PP mode. This option enables the UFC for entry or editing of launch point data for the currently selected mission (Figure 2-33). If launch point data is blank when latitude, longitude or altitude entry is initiated, fields for which no data has yet been entered will remain blank all three have been entered. Entered values outside of specified limits (Table 2K) cause "ERROR" to be flashed on the UFC scratchpad.
- **2.4.9.2.3** "TGT UFC" Option. (U) The "TGT UFC" option (PB14) is available when the PP mode is selected and no offset (O/S) data is entered. This option enables the UFC for entry or editing of target position, altitude and terminal parameters for the currently selected mission at the priority JDAM station (Figure 2-34). If target data is blank when entry of target position is initiated, fields for which no data has yet been entered will be zero-filled until entry of all three has been completed. Entered values outside of specified limits (Table 2L) cause "ERROR" to be flashed on the UFC scratchpad.
- **2.4.9.2.4 "O/S UFC" Option.** (U) The "O/S UFC" Offset Data Entry option (PB15) enables the UFC for entry or editing of offset parameters for the currently selected mission at the priority JDAM station (Figure 2-35). Individual terminal parameters may be entered. Entered values outside of specified limits (Table 2M) cause "ERROR" to be flashed on the UFC scratchpad.

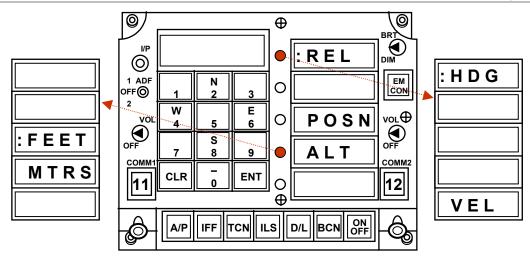


Figure 2-33 LP UFC FORMAT (U)

UFC OPTION	MISSION DATA	UNITS	LO LIMIT	HI LIMIT
POSN	Latitude (N/S) Longitude (E/W)	Degrees, Minutes, Seconds	Current Mechanization	
ALT	Altitude	Feet MSL Meters MSL	-328 -100	49,212 15,000
REL:HDG	Ground Track	Degrees True	0	359
REL:VEL	Ground Speed	Knots Ground Speed (KGS)	0	999

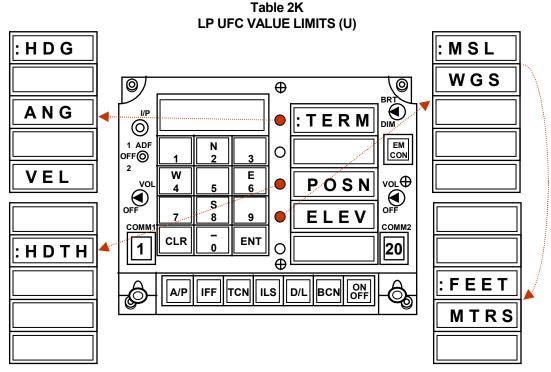


Figure 2-34 TGT UFC FORMAT (U)

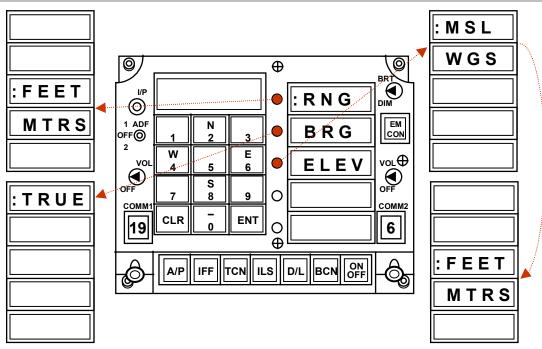


Figure 2-35 O/S UFC FORMAT (U)

UFC OPTION	MISSION DATA	UNITS	LO LIMIT	HI LIMIT
POSITION (LATLNSEC)	Latitude (N/S) Longitude (E/W)	Degrees, Minutes, Seconds, Hundredths of Seconds	Current Me	echanization
POSITION (LATLNDCML)	Latitude (N/S) Longitude (E/W)	Degrees, Minutes, Thousandths of Minutes	Current Me	echanization
ELEV:MSL	Elevation (MSL) Elevation (HAE)	Feet	-328	32,808
ELEV:WGS		Meters	-100	10,000
TERM:HDG	Terminal Impact Heading	Degrees True	0	359
TERM:ANG	Terminal Impact Angle	Degrees From Horizontal	0	90
TERM:VEL	Minimum Impact Velocity	Feet Per Second (FPS)	100	26,800

Table 2L TGT UFC VALUE LIMITS (U)

UFC OPTION	MISSION DATA	UNITS	LO LIMIT	HI LIMIT
RNG	Offset Range	Feet	0	53,753
		Meters	-100	16,384
BRG	Offset Bearing	Degrees, Minutes, Seconds True	0	359°59'59"
ELEV	000 (41 1 ) E1 (	Feet	-328	32,808
	Offset Absolute Elevation	Meters -100	10,000	

Table 2M O/S UFC VALUE LIMITS (U)

- **2.4.9.2.5** "BANK" Option. (U) The "BANK" Bank Angle Selection option (PB17) is available only when the "FD" release mode is selected and valid launch point and ground track data are present. This option enables the UFC for selection of "15", "30" or "45" degree maximum bank angle values for use when the aircraft autopilot is coupled to the Flight Director release mode.
- **2.4.9.2.6 "RETURN" Option.** (U) The "RETURN" option (PB19) restores the JDAM format.
- **2.4.9.2.7 "JPF" Option.** (U) The "JPF" option (PB1) is available only when a JPF-equipped JDAM weapon is loaded on the priority station. This option replaces the MISSION DATA format with the JPF format (Figure 2-40).
- **2.4.9.2.8 "ORP UFC" Option.** (U) The "ORP UFC" Offset Reference Point Data Entry option (PB14) is available when PP mode is selected for the priority JDAM station and offset (O/S) data is present (Figure 2-36). This option functions identically to the "TGT UFC" option. See Section 2.4.9.2.3.

# **CAUTION**

(U) TOO missions are not authorized in the F/A-18C/D aircraft.

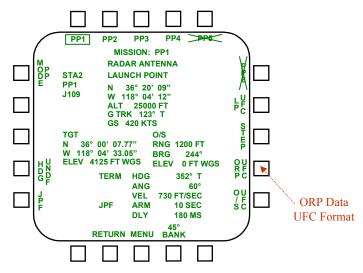


Figure 2-36
MISSION DATA FORMAT OPTIONS, PP MODE WITH OFFSET DATA (U)

- **2.4.9.2.9 "TOO" Options.** (U) The "TOO" (TOO1-2) Mission Selection options (PB6-7) are displayed in TOO mode (Figure 2-37). Functionality is similar to the "PP" Mission Selection options. See Section 2.4.9.2.1.
- **2.4.9.2.10** "TOO UFC" Option. (U)The "TOO UFC" Target Of Opportunity Data Entry option (PB14) is available whenever the TOO mode is selected, with or without offset data present (Figure 2-38). This option enables the UFC for entry or editing only of target of opportunity terminal parameters for the currently selected mission at the priority JDAM station (Figure 2-39). Individual terminal parameters may be entered. Entered values outside of specified limits (Table 2N) cause "ERROR" to be flashed on the UFC scratchpad.
- **2.4.10 JPF FORMAT.** (U) The JPF format provides control of JPF arm and delay settings. Unique settings may be entered for each JDAM weapon of the selected variant, including when a quantity release is selected.

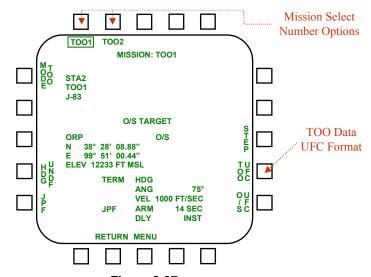
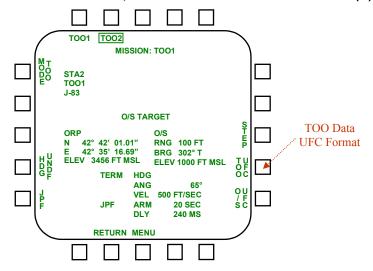


Figure 2-37
MISSION DATA FORMAT OPTIONS, TOO MODE WITH NO OFFSET DATA (U)



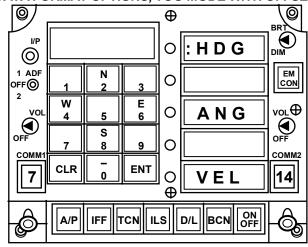


Figure 2-39 TOO UFC FORMAT (U)

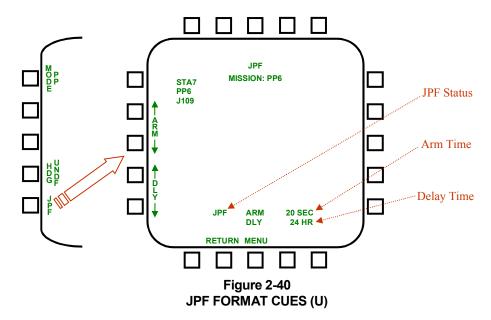
UFC OPTION	MISSION DATA	UNITS	LO LIMIT	HI LIMIT
TERM:HDG	Terminal Impact Heading	Degrees True	0	359
TERM:ANG	Terminal Impact Angle	Degrees From Horizontal	0	90
TERM:VEL	Minimum Impact Velocity	Feet Per Second (FPS)	100	26,800

# Table 2N TOO UFC VALUE LIMITS (U)

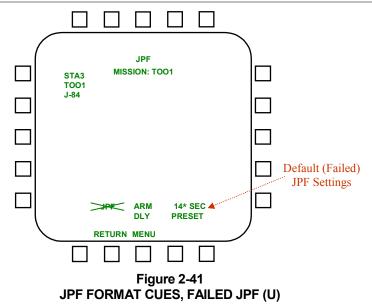
**2.4.10.1 JPF Format Cues.** (U) JPF electrically programmed fuze settings are uploaded from the JDAM weapon at the priority station for the currently selected mission and displayed as cues on the JPF format (Figure 2-40). JPF faceplates setting cues are not available in the cockpit.

## NOTE

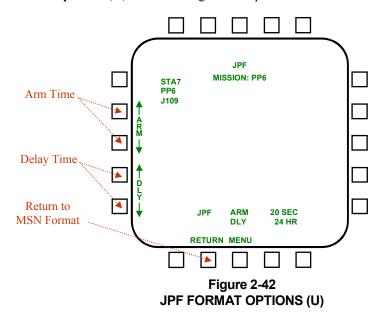
(U) The JPF cues uploaded from the JDAM weapon may not agree with the initialized "ARM" and "DLY" select option values on the left side of the JPF sublevel. The displayed cue values will be retained unchanged after exiting the format unless the "ARM" and "DLY" options are selected.



- **2.4.10.1.1 "JPF" Cue.** (U) The "JPF" Fuze Availability cue is crossed out if the JPF at the priority JDAM station fails or fails to program per JDAM instructions via serial cable (Figure 2-41). With normal JPF operation, this cue is not crossed out.
- **2.4.10.1.2 "ARM" Cue.** (U) The "ARM" cue displays the programmed arm time for the JPF at the priority JDAM station. If a JPF failure occurs, or if JDAM has failed to program the JPF, the "ARM" time is set automatically to "14\*" seconds.
- **2.4.10.1.3 "DLY" Cue.** (U) The "DLY" cue displays the programmed functioning delay for the JPF at the priority JDAM station. If a JPF failure occurs, or if JDAM has failed to program the JPF, the "DLY" time is set automatically to "PRESET".



**2.4.10.2 JPF Format Options.** (U) The following JDAM options are available on the JPF format (Figure 2-42).



**2.4.10.2.1** " $\uparrow$  **DLY**  $\downarrow$ " **Options.** (U) The " $\uparrow$  **DLY**  $\downarrow$ " options (PB1-2) are available only when the JPF cue is not crossed out. These options step through the available programmable JPF functioning delays. The options are mechanized to wrap around such that the shortest delay follows the longest delay when incrementing, and the longest delay follows the shortest delay when decrementing. The displayed functioning delay is transferred to the JPF at the priority JDAM station.

**2.4.10.2.1** " $\uparrow$  **ARM**  $\downarrow$ " **Options.** (U) The " $\uparrow$  ARM  $\downarrow$ " options (PB3-4) are available only when the JPF cue is not crossed out. These options step through the available programmable JPF arm times. The options are mechanized to wrap around such that the shortest arm time follows the longest arm time when incrementing, and the longest arm time follows the shortest arm time when decrementing. The displayed arm time is transferred to the JPF at the priority JDAM station.

**2.4.10.2.1 "RETURN" Option.** (U) The "RETURN" option (PB19) restores the MISSION DATA format.

**2.4.11 HSI FORMAT.** (U) The HSI format provides JDAM cueing from calculations based on a stored JDAM LAR algorithm in the aircraft mission computer.

#### NOTE

(U) JDAM cues on the HSI format are available in all master modes.

**2.4.11.1 HSI Format Cues.** (U) The HSI format cues (Figure 2-43) are provided for the currently selected mission in the JDAM weapon at the priority station. JDAM HSI cues are displayed only when the aircraft is within 160 nautical miles of a valid JDAM target. JDAM cueing on the HSI format varies as a function of mission type (PP or TOO) and aircraft position as it approaches the target.

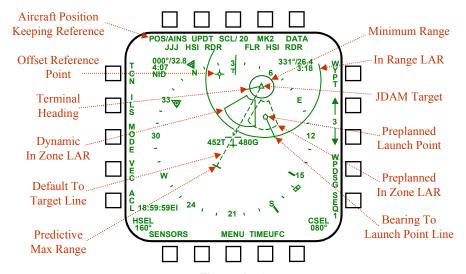


Figure 2-43
HSI FORMAT CUES, PP MODE WITH OFFSET AND TERMINAL PARAMETERS (U)

- **2.4.11.1.1 Default-To-Target Line Cue.** (U) The Default-To-Target Line cue is aligned along the most direct heading from the present aircraft position to the selected target. This cue is displayed as a segmented line drawn from the target to the Predictive Maximum Range cue (Section 2.4.11.1.2) along a bearing from the aircraft symbol. A plus sign ("+") marks the intersection of this cue and the In-Range Circle (IRLAR) cue (Section 2.4.11.1.3). This cue is removed when the aircraft is within the IRLAR.
- **2.4.11.1.2 Predictive Maximum Range Cue.** (U) The Predictive Maximum Range cue (Figures 2-44 and 2-45) represents the theoretical maximum launch range if the aircraft heading is aligned along the Default-to-Target Line cue. It is intended to provide the best case absolute maximum launch range for the existing flight conditions. This dynamic cue facilitates a quick, direct on-axis targeting solution without taking into any account terminal impact parameters. The Predictive Maximum Range cue is removed when the aircraft is within the IRLAR (Section 2.4.11.1.3) or if the HSI Declutter option is selected on the JDAM format.
- **2.4.11.1.3** In-Range Circle (IRLAR) Cue. (U) The In-Range Circle ("IRLAR") cue (Figure 2-46) represents the radius of range about the JDAM target from which a release under existing flight conditions provides a minimum impact angle of 35 degrees and a minimum impact velocity of 300 feet per second. This dynamic cue varies with aircraft groundspeed, altitude and heading. If the aircraft is aligned with the Default-To-Target Line, the IRLAR expands in radius to the Predictive Maximum Range (Section 2.4.11.1.2). The IRLAR is intended to provide a useable maximum launch range irrespective of launch conditions or terminal impact parameters when the expected mission cannot be completed optimally. This cue is removed when the aircraft is within the IZLAR, if a quantity release is selected, or if a Terminal Impact Heading is defined.

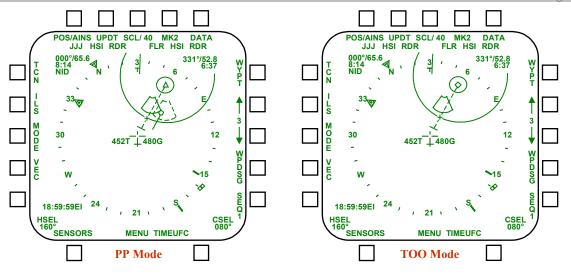


Figure 2-44
HSI FORMAT CUES WITH AIRCRAFT BEYOND PREDICTIVE MAXIMUM RANGE (U)

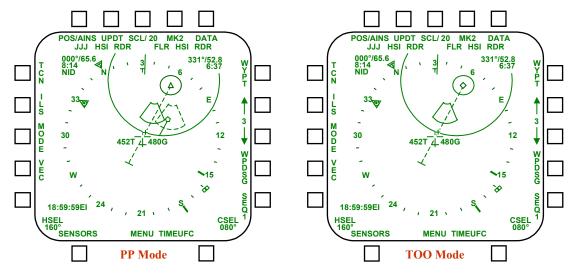


Figure 2-45
HSI FORMAT CUES WITH AIRCRAFT NOT IN-RANGE (U)

**2.4.11.1.4 Pre-Planned In-Zone Region (PPIZLAR) Cue.** (U) The Pre-Planned In-Zone Region (PPIZLAR) cue is developed using the launch and targeting data entered during mission planning or manually modified in flight. This static, dashed-line cue is intended to provide a representation of the selected mission as planned before flight. Theoretically, if the aircraft achieves the pre-planned launch conditions at the pre-planned launch point under the pre-planned wind conditions, the PPIZLAR and the ILZAR overlay exactly. The PPIZLAR is removed only when in TOO mode or if the HSI Declutter option is selected on the JDAM format.

**2.4.11.1.5 Pre-Planned Launch Point Cue.** (U) The Pre-Planned Launch Point cue is displayed only in PP mode when a valid launch point exists for the JDAM weapon at the priority station. This static, pentagon-shaped cue indicates the launch point defined during mission planning or manually entered in flight. It is intended to provide a reference with which to steer to the pre-planned release point. The Pre-Planned Launch Point cue is removed only when in TOO mode or if the HSI Declutter option is selected on the JDAM format.

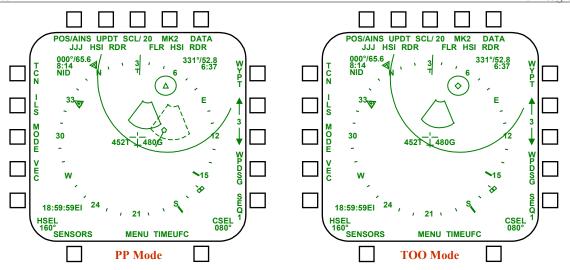


Figure 2-46
HSI FORMAT WITH AIRCRAFT IN-RANGE (U)

**2.4.11.1.6 Bearing-To-Launch Point Line Cue.** (U) The Bearing-To-Launch Point Line cue is displayed only in PP mode when a valid launch point exists for the JDAM weapon at the priority station. This static cue indicates the aircraft heading into the pre-planned launch point and is represented by a line is drawn outward from the launch point along the launch heading. It is intended to provide a simple means to achieve pre-planned release conditions by aligning the aircraft flight path with the launch point along the launch heading. The Bearing-To-Launch Point Line cue is removed if the HSI Declutter option is selected on the JDAM format.

**2.4.11.1.7** In-Zone Region (IZLAR) Cue. (U) The In-Zone Region (IZLAR) cue (Figure 2-47) indicates the region in which the JDAM weapon, if released, will impact its target and achieve the selected terminal attack parameters. This solid-lined cue is calculated dynamically, in real time, by the aircraft as a function of aircraft heading, altitude and airspeed using the JDAM LAR algorithm. The IZLAR is intended to provide a valid release envelope for any flight conditions, including those different from the pre-planned mission, with a high probability of achieving the selected terminal attack parameters.

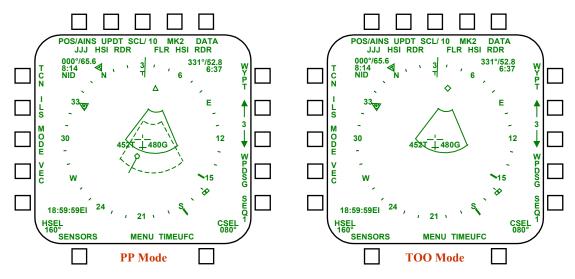
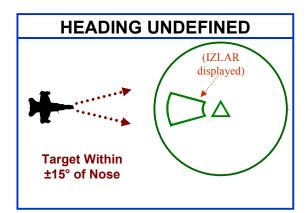


Figure 2-47
HSI FORMAT CUES WITH AIRCRAFT IN-ZONE (U)

(U) If no terminal impact heading is defined, then the IZLAR is displayed whenever the target is within 15 degrees of the aircraft heading. If a terminal impact heading is defined, then the IZLAR is displayed whenever the target is within 10 degrees of the aircraft heading and the terminal impact heading is within 15 degrees of the line of sight from the aircraft to the target (Figure 2-48).



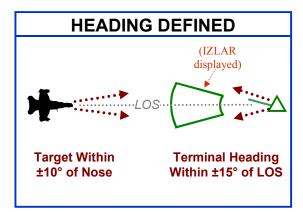


Figure 2-48
AIRCRAFT DYNAMIC IZLAR DISPLAY LOGIC (U)

**2.4.11.1.8 Loft Initiation Cue.** (U) The Loft Initiation cue (Figure 2-49) is displayed whenever the "AUTO/LOFT" release mode is selected and an IZLAR is displayed. This dashed-line arc indicates the earliest range at which a loft release profile can be achieved using the selected Auto/Loft release angle. It is intended to provide the earliest possible point to initiate a loft release maneuver. The Loft Initiation cue is not displayed unless a level release solution exists for the existing flight conditions. For shallower terminal impact angles, a level solution typically does not exist below 2000 feet AGL, while for steeper terminal impact angles, a level solution may not exist below 8000 feet AGL.

#### **NOTE**

(U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.

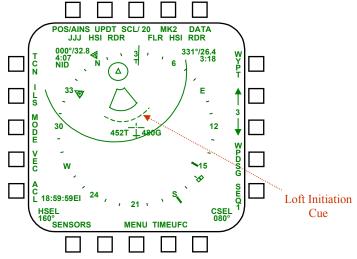


Figure 2-49
HSI FORMAT CUES, AUTO/LOFT RELEASE MODE (U)

- **2.4.11.1.9 Minimum Range Circle Cue.** (U) The Minimum Range Circle cue indicates the minimum acceptable launch radius for the selected weapon to impact the selected target regardless of terminal parameters. JDAM weapons released inside of this cue may not reach the selected target due to maneuverability constraints. This cue is intended to provide a minimum launch requirement to achieve target impact. The Minimum Range Circle cue is not displayed when the aircraft is within the IZLAR or if a quantity release is selected.
- **2.4.11.1.10 JDAM Target Cue.** (U) The JDAM Target cue indicates the location of the JDAM target relative to the aircraft for the priority JDAM station. If offset data is present, the JDAM Target cue indicates the location of the calculated impact point using the defined ORP and offset range, bearing and elevation. This cue is presented as a solid triangle when a PP mission is selected and as a solid diamond when a TOO mission is selected. The JDAM Target cue is intended to provide a graphical means of verifying correct target placement. This cue is displayed for the last selected JDAM mission whenever a JDAM variant is selected, regardless of aircraft master mode or weapon selected.
- **2.4.11.1.11 ORP Cue.** (U) The ORP cue is displayed only if offset data is defined. This circle-and-cross shaped cue indicates the location of the JDAM offset reference point from which the JDAM target is projected using the defined offset data set. The ORP cue is intended to provide a graphical means of verifying correct ORP placement and target offset. This cue is displayed whenever a JDAM Target cue (Section 2.4.11.1.10) defined using it is displayed.
- **2.4.11.1.12 Terminal Heading Cue.** (U) The Terminal Heading cue indicates the selected terminal impact heading oriented about the JDAM target symbol. This straight-line cue is intended to provide a graphical representation of the terminal heading that the assigned JDAM weapon will attempt to achieve after launch. The Terminal Heading cue is displayed whenever the associated JDAM Target cue (Section 2.4.11.1.10) is displayed.

#### **NOTE**

- (U) JDAM does not attempt to fly along the specified terminal impact heading for any prescribed range, but instead maneuvers only to impact the target along the azimuth specified by the heading.
- **2.4.11.1.13 Quantity Release Cues.** (U) Four JDAM weapons are the maximum allowable in a quantity release. JDAM quantity release cues on the HSI format (Figure 2-50) are modified from single-target cues as follows. First, a separate JDAM Target cue and Terminal Heading cue is displayed for each weapon in the selected quantity. Second, the displayed IZLAR represents the intersection of each individual weapon IZLAR for each weapon in the quantity that has a heading-undefined target located within 15 degrees of aircraft heading or that has a heading-defined target located within 10 degrees of aircraft heading with a Terminal Heading within 15 degrees of the line of sight from the aircraft to the target. Finally, the IRLAR and Minimum Range Circle cues are never displayed.

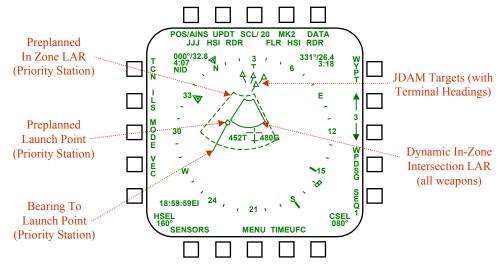


Figure 2-50
HSI FORMAT WITH A QUANTITY RELEASE SELECTED (U)

**2.4.11.1.14 "POS/AINS" Cue.** (U) The "POS/AINS" position keeping cue (PB6) indicates the source of aircraft position keeping. This cue indicates whether or not GPS aiding is available to the aircraft. Since JDAM weapons require a GPS-quality transfer alignment handoff prior to release a cue indicates other than "POS/AINS" indicates that JDAM accuracy may be degraded significantly.

# **CAUTION**

(U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.

## NOTE

- (U) Selection of a JDAM weapon option before achieving "POS/AINS" with 2-digit HERR and VERR values causes JDAM weapon transfer alignments to be seeded with inaccurate position information. The weapon may require up to 45 minutes to filter out the bad data, resulting in potentially degraded weapon accuracy during that period. JDAM weapon power should be selected after achieving "POS/AINS" with 2-digit HERR and VERR values. Otherwise, JDAM power should be cycled after achieving "POS/AINS" with 2-digit HERR and VERR values.
- **2.4.11.2 HSI Format Options.** (U) The only JDAM-related option on the HSI format is the "TIMEUFC" Time Data Entry option (PB17). This option enables the UFC for entry or editing of Zulu Time of Day (ZTOD) and Zulu Date. If the aircraft MAGR does not retain an accurate ZTOD during start-up as expected, the "TIMEUFC" option provides the aircrew with a means of manually entering ZTOD. The absence of a valid ZTOD causes all JDAM weapons to indicate a Weapon/Station Status cue of "HOLD" on the STORES format wing planform.
- **2.4.11.3 HSI AIRCRAFT DATA Format.** (U) The HSI AIRCRAFT DATA format (Figure 2-51) displays GPS performance parameters supplied by the aircraft MAGR. These consist of horizontal error ("HERR") and vertical error ("VERR") estimates. GPS ZTOD also is displayed. These displays are blanked if GPS satellite data is unavailable to the aircraft MAGR.

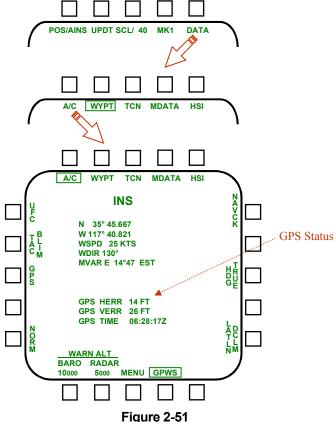


Figure 2-51
HSI AIRCRAFT DATA FORMAT CUES (U)

(U) "POS/AINS" position keeping is available when the HERR and VERR values are each less than 230 feet. If GPS data becomes invalid, then the aircraft navigation system transitions to "POS/INS" position keeping. If an invalid GPS condition exists for 65 seconds or more, the aircraft posts a "P/INS" advisory on the display containing caution and advisory messages.

# **CAUTION**

(U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.

#### NOTE

- (U) Selection of a JDAM weapon option before achieving "POS/AINS" with 2-digit HERR and VERR values causes JDAM weapon transfer alignments to be seeded with inaccurate position information. The weapon may require up to 45 minutes to filter out the bad data, resulting in potentially degraded weapon accuracy during that period. JDAM weapon power should be selected after achieving "POS/AINS" with 2-digit HERR and VERR values. Otherwise, JDAM power should be cycled after achieving "POS/AINS" with 2-digit HERR and VERR values.
- **2.4.12 HEAD-UP DISPLAY (HUD) A/G FORMAT.** (U) The HUD A/G format provides JDAM cueing for navigation to release point and release of a JDAM weapon for the currently selected JDAM mission. JDAM cueing on the HUD varies as a function of release mode (Manual or Auto/Loft) and release type, either single or quantity.
- **2.4.12.1 HUD A/G Format Manual Release Mode Cues.** (U) HUD A/G format cues for Manual release mode are presented in Figure 2-52.

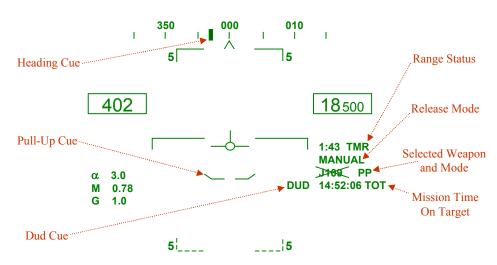


Figure 2-52 HUD FORMAT CUES, MANUAL RELEASE MODE (U)

- **2.4.12.1.1 Heading Cue.** (U) The Heading cue provides steering to guide the aircraft to the IZLAR. For quantity releases, if no valid intersection IZLAR exists (i.e., not displayed on the HSI format), then the Heading cue is not displayed. The Heading cue is replaced with the direct-steering cue if Waypoint ("WYPT") or Tacan ("TCN") steering is selected on the HSI format.
- **2.4.12.1.2 Range Status Cue.** (U) The Range Status cue consists of several text messages that are displayed depending on the aircraft position with respect to the JDAM target envelopes. The state of the Range Status cue is determined by dynamic LAR calculations for the JDAM weapon at the priority station. With a quantity release selected, the LAR calculations for all weapons in the quantity are considered.

- (U) The Range Status cue is blank until the aircraft is calculated to be within 10 minutes of the IRLAR, at which time it initializes to "9:59 TMR" and counts down minutes and seconds as the aircraft approaches the IRLAR. This cue is intended to provide the aircrew with the required aircraft TOF under current flight conditions to reach a first-launch opportunity.
- (U) When the aircraft reaches the IRLAR boundary, the Range Status cue transitions from "0:00 TMR" to "IN RNG". The "IN RNG" cue is intended to provide a clear indication that a valid launch condition has been achieved. This cue flashes if the aircraft is calculated to be within five seconds of flying outside of the IRLAR or inside of the Minimum Range Circle cue. If the aircraft passes outside of the IRLAR, the "IN RNG" cue is replaced with the "TMR" cue until the calculated time to maximum range exceeds 9:59 TOF.
- (U) When the aircraft enters the IZLAR, the Range Status cue transitions from "IN RNG" to "IN ZONE". The "IN ZONE" cue is intended to provide a clear indication that an suitable launch condition has been achieved to meet preplanned mission parameters. This cue flashes if the aircraft is calculated to be within five seconds of flying out of the IZLAR. If the aircraft leaves the IZLAR, the Range Status cue transitions from "IN ZONE" to "IN RNG". The Range Status cue is removed if the aircraft passes inside the Minimum Range Circle.
- **2.4.12.1.3** Release Mode Cue. (U) The Release Mode cue indicates "MANUAL" when Manual release mode is selected.
- **2.4.12.1.4 Selected Weapon/Mode Cue.** (U) The Selected Weapon/Mode Cue indicates the currently selected variant ("J-83", "J-84" or "J109") and mission type ("PP" or "TOO") for the priority JDAM station. If the priority JDAM station is not ready for launch (e.g., Master Arm to "SAFE"), then this cue is crossed out.
- **2.4.12.1.5** "TOT" Cue. (U) The Mission Time On Target ("TOT") cue indicates the calculated ZTOD at weapon impact for the priority JDAM station under the existing aircraft flight conditions. This cue is intended to provide the aircrew with a means of determining weapon impact time with respect to an absolute strike timeline. The "TOT" portion is displayed whenever a JDAM weapon is selected. The ZTOD portion, formatted in hours, minutes and seconds as "hh:mm:ss", is displayed if the aircraft is within a valid launch range (i.e., inside of the IRLAR and outside of the Minimum Range Circle cue). TOT is computed as a function of aircraft position with respect to the JDAM launch cues as show in Table 2O.

AIRCRAFT CONDITION	"TOT" CALCULATION	
Not "In Range" or no IZLAR present	TOT = Current ZTOD + pre-planned TOF	
"In Range" but not "In Zone"	TOT = Current ZTOD + calculated TOF at maximum In-Zone range	
"In Zone"	TOT = Current ZTOD + dynamic TOF	

# Table 20 TIME ON TARGET CALCULATIONS (U)

- **2.4.12.1.6** "DUD" Cue. (U) The "DUD" cue indicates that a condition exists that will result in at least one JDAM weapon selected for release not detonating on impact.
- (U) For a single release, the "DUD" cue is displayed if the computed TOF is less than the selected weapon arm time or, if the priority JDAM station is equipped with an FMU-152 JPF that has failed or is not communicating via serial bus, if the calculated TOF is less than the JPF default arm time of 14 seconds, or if the appropriate fuzing option ("EFUZ" or "MFUZ") has been set to "OFF".
- (U) For a quantity release, the "DUD" cue is displayed if the appropriate fuzing option ("EFUZ" or "MFUZ") for every weapon in the quantity is set to "OFF" or, if the priority JDAM station is equipped with an FMU-152 JPF that has failed or is not communicating via serial bus, if the calculated TOF is less than the JPF default arm time of 14 seconds, or if the computed TOF for any selected weapon is less than the selected arm time or is less than 14 seconds for ANY weapon equipped with a JPF that has failed or is not communicating via serial bus.

**2.4.12.1.7 Pull-Up Cue.** (U) The Pull-Up cue indicates the difference between the computed TOF and the fuze arm time for the JDAM weapon at the priority station. The Pull-Up cue, which normally appears below the velocity vector, is displayed within 3° of the velocity vector and within a 9.5° radius of the HUD optical center. Full deflection of the Pull-Up cue below the velocity vector signifies a JDAM TOF of 10 seconds or more than the selected fuze arm time. When the Pull-Up cue rises to meet the velocity vector, the weapon TOF is calculated to be equal to the selected fuze arm time, and when the cue is above the velocity vector, the "DUD" cue is displayed. This cue is intended to provide the aircrew with a comprehensible head-up indication of the fuze arm time margin.

**2.4.12.2** HUD A/G Format Auto/Loft ("AUTO LFT") Release Mode Cues. (U) In the Auto/Loft release mode, the Heading cue, Range Status cue, Selected Weapon Mode cue, Mission TOT cue, "DUD" cue and Pull-Up cue function exactly the same as for Manual release mode (Section 2.4.12.1). The following additional HUD A/G format cues are provided to support the Auto/Loft release mode (Figure 2-53).

### NOTE

(U) Selection of waypoint steering via the waypoint designate "WPDSG" option on the HSI format (PB14) does not inhibit display of Auto/Loft HUD cues on the HUD when JDAM is selected.

## **NOTE**

(U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.

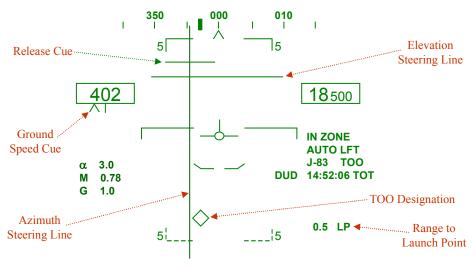


Figure 2-53
HUD FORMAT CUES, AUTO/LOFT RELEASE MODE (U)

- **2.4.12.2.1** Azimuth Steering Line Cue. (U) The Azimuth Steering Line (ASL) cue represents the computed wind-corrected heading to place the aircraft at the optimum launch point relative to the current aircraft heading. The ASL is a vertical line cue that deflects laterally away from the HUD velocity vector as the aircraft heading deviates from the optimum heading. The ASL is a "fly-to" cue, such that a deflection to the left of the velocity vector indicates the requirement for a left turn to intercept the optimum heading. When the velocity vector overlays the ASL, the aircraft heading is optimal. The ASL cue is not displayed in a quantity release if no valid intersection IZLAR exists.
- **2.4.12.2.2 Release Cue.** (U) The Release cue indicates the automatic release point for the selected JDAM delivery relative to the current aircraft position. This cue is a short horizontal line intersecting the ASL cue that initializes above the HUD velocity vector and moves down the ASL as the IZLAR is approached.

(U) The Release cue initially appears when a pull-up maneuver that meets the release requirements selected for the loft angle may be initiated. As the IZLAR is approached, this cue moves down the ASL toward the velocity vector. In a loft delivery, the velocity vector will rise to intercept the Release cue during pull-up. When the Release cue intersects the velocity vector, automatic release is available. If the bomb button is depressed and held prior to crossing the automatic release point, release will occur at the edge of the IZLAR. Launch may be delayed beyond the automatic release point (after the Release cue passes the velocity vector) by not pressing the bomb button prior to the computed release point; the A/G pickle is "hot" whenever the aircraft is within the IZLAR. This cue is not displayed in a quantity release if no valid intersection IZLAR exists.

# **NOTE**

- (U) The Release cue is an approximation and its calculations include enough uncertainty such that, if a loft release is commenced as soon as the Release cue appears, actual release may occur by as much as 7 degrees before or after the selected loft angle.
- **2.4.12.2.3 Elevation Steering Line Cue.** (U) The Elevation Steering Line cue represents the pre-planned launch point (GPS) altitude for the priority JDAM weapon relative to the current aircraft (GPS) altitude. This cue is a horizontal line that deflects vertically away from the HUD velocity vector as the aircraft altitude deviates from the selected release altitude. The Elevation Steering Line is a "fly-to" cue, such that a deflection above the velocity vector indicates the requirement for a climb to intercept the pre-planned launch point altitude. When the velocity vector overlays this cue, the aircraft altitude matches the selected launch altitude. The Elevation Steering Line cue is not displayed in TOO mode or in a quantity release if no valid intersection IZLAR exists.
- **2.4.12.2.4 Ground Speed Cue.** (U) The Ground Speed cue represents the pre-planned launch ground speed for the priority JDAM weapon relative to the current aircraft ground speed. This cue is a caret beneath the HUD airspeed box that moves laterally as aircraft ground speed changes. The Ground Speed cue centers below the box when aircraft ground speed matches the pre-planned launch ground speed. The caret deflects to the left and right when the aircraft ground speed is too slow or too fast, respectively. The Ground Speed cue is not displayed in TOO mode or in a quantity release if no valid intersection IZLAR exists.
- **2.4.12.2.5** Range to Launch Point "LP" Cue. (U) The Range to Launch Point "LP" cue indicates the ground range to the pre-planned launch point for the priority JDAM weapon relative to current aircraft position. It is available in PP mode when Auto/Loft or Flight Director release modes are selected.

## **CAUTION**

- (U) Use of the Flight Director release mode is not authorized. Coupled FD mode can cause a violent, zig-zag banking pattern just prior to release. Also, at either high or low altitudes, the Elevation Steering Line cueing on the HUD may be reversed (i.e., climb when descent is required, or vice versa).
- (U) This cue, displayed digitally as nautical miles to the tenth, replaces the Range to Waypoint/ORP cue at the bottom right of the HUD when waypoint steering is deselected by unboxing the WYPT option (PB11) on the HSI format. The "LP" cue is not displayed for a quantity release if no valid intersection IZLAR exists, or if the range to the pre-programmed launch point exceeds 99.9 nautical miles. The "LP" cue is replaced with the "TXA DEGD" cue whenever any weapon selected for release reports a navigation solution quality of "MARG" or "UNST" (i.e., not "GOOD"), and is available when all JDAM weapons selected for release report a navigation solution quality of "GOOD".
- **2.4.12.3 HUD A/G Format Flight Director ("FD") Release Mode Cues.** (U) In the Flight Director release mode, the Heading cue, Range Status cue, Selected Weapon Mode cue, Mission TOT cue, Elevation Steering cue, "DUD" cue, Pull-Up cue and Range to Launch Point cue function exactly the same as for Auto/Loft release mode (Section 2.4.12.2). The following additional HUD A/G format cues are provided to support the Flight Director release mode (Figure 2-54).

#### CAUTION

(U) Use of the Flight Director release mode is not authorized. Coupled FD mode can cause a violent, zig-zag banking pattern just prior to release. Also, at either high or low altitudes, the Elevation Steering Line cueing on the HUD may be reversed (i.e., climb when descent is required, or vice versa).

SECRET

Chapter 2 F/A-18 Integration

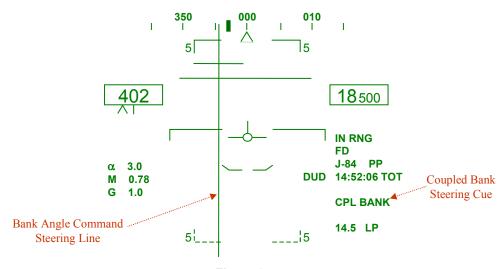


Figure 2-54
HUD FORMAT CUES, FLIGHT DIRECTOR RELEASE MODE (U)

**2.4.12.3.1 Bank Angle Command Steering Line Cue.** (U) The Bank Angle Steering Line cue represents the computed bank angle required to correct the current aircraft heading to place the aircraft at the optimum launch point relative to the current aircraft heading. This cue is a vertical line cue presented identically to the ASL (Section 2.4.12.2.1) that deflects laterally away from the HUD velocity vector as the aircraft angle of bank deviates from the computed bank angle required to achieve the optimum aircraft heading. The Bank Angle Steering Line cue is a "flyto" cue, such that a deflection to the left of the velocity vector indicates the requirement for a left roll to intercept the optimum bank angle. When the velocity vector overlays the line, the aircraft bank angle is optimal. This cue is not displayed in a quantity release if no valid intersection IZLAR exists.

**2.4.12.3.2** Coupled Bank Steering Cue. (U) The Coupled Bank Steering cue indicates that the aircraft autopilot has been coupled to the Bank Angle Command Steering Line cue and the Elevation Steering cue to facilitate handsoff, automatic aircraft guidance to the pre-planned launch point.

## 2.5 TRAINING MODE

**2.5.1 OVERVIEW.** (U) The JDAM weapon system program was conceived from the outset with a goal of providing maximum training while conserving operational assets, or specifically, weapon kits. Although the cost of a JDAM kit is low compared to other precision-guided munitions, a desire to preserve weapon inventory reflected the lessons learned during combat operations including Operation "Desert Storm", when in certain cases demand approached supply limits as well as manufacturing capability. Therefore, in a concept borrowed from the AGM-154 JSOW program, a Training Mode weapon simulation embedded in the aircraft software augments and substantially replaces normal captive carriage training flights. With this Training Mode embedded in SCS software, aircrews may rehearse JDAM missions with a high-fidelity simulation using most of the available JDAM/aircraft interface and without a requirement to load an actual JDAM-configured weapon onto the aircraft.

# **NOTE**

- (U) Although supported by the aircraft SCS, it is recommended that actual and simulated JDAM weapons not be loaded simultaneously on the aircraft.
- (U) The JDAM training mode is programmed to provide a realistic presentation to the aircrew of an actual JDAM mission. The simulation uses the actual LAR calculation and display algorithms used for actual JDAM weapons.

## 2.5.2 REQUIREMENTS

- **2.5.2.1 Mission Planning.** (U) No mission planning is required for JDAM Training Mode. All mission data may be created in the cockpit using the existing JDAM control options and display cues. However, if the onboard memory unit contains valid JDAM mission (PP and/or TOO) data for weapon station 2, it is used for JDAM Training Mode PP missions. Conversely, if planning a mission load specifically for a JDAM Training Mode sortie, mission data must be created and loaded for weapon station 2 during memory unit download. It is recommended that the missions be downloaded to all stations (2, 3, 7 and 8) for inflight flexibility.
- **2.5.2.2** Aircraft Preflight. (U) No JDAM store is required. JDAM Training Mode simulation is available for every valid JDAM station. The Training Mode is supported by closing the aircraft bomb rack hooks on at least one station prior to flight. For each training station, a "C0" weapon code is loaded into the WIP. Although not required to enable JDAM Training Mode, it is recommended that a valid fuze code also be entered for each training station. This prevents a continual "DUD" cue in the HUD due to the undefined fuze settings.

### NOTE

(U) A "LOAD X" advisory may indicate that at least one JDAM training station is coded as "C0" but has open vice closed bomb rack hooks.

#### NOTE

- (U) JDAM training stores on the outboard wing stations do not enable Active Oscillation Control (AOC) when wingtip stores are present.
- **2.5.2.3** Cockpit Setup. (U) JDAM Training Mode is selected by selecting the "SIM" option (PB15) on the STORES format. If valid JDAM training stations are inventoried, the SMS presents a "JDAM" training weapon option on the STORES format. The "JDAM" option enables the JDAM formats and the simulated JDAM interface.

#### NOTE

(U) The "SIM" option is available on the STORES format only if the Master Arm switch is in "SAFE".

#### 2.5.3 INTERFACE

- **2.5.3.1 Control Options and Display Cues.** (U) All JDAM-related formats are available. The following is germane.
- **2.5.3.1.1 Station Weapon Inventory.** (U) Each valid JDAM training station is inventoried and labeled "JDAM" on the STORES format wing planform display.
- **2.5.3.1.2 GPS Warm-Up Timer.** (U) The GPS warm-up timer is simulated fully during weapon initialization. The timer appears on the STORES and JDAM formats for one minute following weapon power-up, during which it simulates a countdown from "10:00" minutes to "7:30" minutes, and then is removed from the displays.
- **2.5.3.1.3 JDAM BIT.** (U) JDAM BIT is simulated for JDAM training stations, either individually or simultaneously per the existing BIT format interface. The simulation runs for 20 seconds. No BIT failures are displayed.
- **2.5.3.1.4 Available Missions.** (U) Up to six PP and two TOO missions are supported for each training station. Missions loaded for station 2 are used for all training stations.
- **2.5.3.1.5 JPF Fuzing.** (U) If a JPF tail fuze code is entered, the "EFUZ" option on the STORES format and the "JPF" option on the MISSION DATA format are available to control and modify JDAM fuzing selections.
- **2.5.3.1.6 Pre-Release Steering Cues.** (U) All pre-planned (if available) and dynamic LAR cues steering cues on the HUD A/G and HSI formats are presented. LAR presentations use the actual JDAM LAR algorithm and vary dynamically as a function of actual aircraft flight conditions.

- **2.5.3.1.7 "DUD" Cues.** (U) "DUD" cues are presented and calculated using computed TOF based on the current flight conditions and selected (simulated) arm time.
- **2.5.3.1.8 Quantity Releases.** (U) Quantity releases are supported in JDAM Training Mode. The STORES format "STEP" option is fully functional. Care should be taken when manually defining mission data for quantity releases to avoid an invalid (null) intersection IZLAR (i.e., no In-Zone cues and no release capability).
- **2.5.3.1.9 Weapon Release.** (U) A typical JDAM launch delay is implemented during simulated weapon release. Upon simulated JDAM release, freeze data is captured, post-launch time is activated, and the priority station steps automatically (if more than one training station is available). The training weapon station is not removed at release and is available for subsequent selection and release.
- **2.5.3.2 Training Limitations.** (U) Although a great deal of fidelity is included in the JDAM training simulation, the following limitations currently exist.
- **2.5.3.2.1 Weapon Status and Health Cues.** (U) Weapon and weapon subsystem failures degrades are not presented. Furthermore, degraded weapon navigation solution quality does not occur. JDAM training stations always indicate an "01 GOOD" navigation quality status. The typical transfer alignment procession from "10 UNST" to "01 GOOD" is not provided.
- **2.5.3.2.2 Post-Release Recovery of Training Mode.** (U) If only one training JDAM station is selected then, after a simulated release, cycling (i.e., unboxing and boxing) the "JDAM" training weapon option on the STORES format may be required in order to recover JDAM Training Mode.
- **2.5.3.2.3 Erroneous GPS Data Cues.** (U) Even if GPS data is included in the mission planning download, JDAM training station 2 will always display "NO GPS KEYS" and "NO GPS DATA" cues. This idiosyncrasy does not affect JDAM Training Mode operation for weapon station 2.
- **2.5.3.2.4 Freeze Data Limitations.** (U) Freeze data is provided for the first simulated release of each training JDAM station loaded on the aircraft. Freeze data functionality for any station can be reset for subsequent simulated releases by cycling the "JDAM" training weapon option on the STORES format.
- **2.5.3.2.5 "ERASE JDAM" Option.** (U) The "ERASE JDAM" option is removed from the STORES and JDAM formats.

# 3.0 MISSION PLANNING

# NOTE

(U) This chapter provides a discussion of the overall JDAM mission planning process. Actual JDAM mission planning procedures and checklists are provided in Annex B.

# 3.1 PREPLANNING CONSIDERATIONS

- **3.1.1 WEAPON VIABILITY.** (U) The first and most important decision regarding JDAM employment is determining its viability of use. While JDAM offers a variety of advantages over other inventory weapons for many strike scenarios, mission success in terms of single-round JDAM accuracy depends on two key environmental factors.
- **3.1.1.1 GPS Environmental Factors.** (U) Weapon GPS denial can occur in a threat GPS jamming or EA-6B (Band 4 or 6) jamming environment and can result in IMU-only guidance. To reduce the inaccuracies associated with IMU-only guidance shorten the weapon TOF to 28 seconds or less or increase the number of JDAM employed. There is no practical workaround for launch aircraft GPS denial. Launch aircraft GPS denial causes inaccurate aircraft position handoff to the weapon. Therefore, if a mission calls for JDAM as the best weaponeering solution and the possibility for aircraft GPS denial is high then choose another weapon.
- **3.1.1.2 Maneuvering Factors.** (U) JDAM is susceptible to transfer alignment errors induced by aircraft navigational uncertainties, particularly GPS denial when combined with large vertical velocity changes. GPS denial due to airframe antenna masking (i.e., inverted flight) is germane. When GPS altitude is lost, the F/A-18C/D reverts to baro-smoothed inertial altitude as the next-best source. However, the barometric lag error associated with high vertical rates induces a system altitude inaccuracy. Should "POS/AINS" position keeping be lost, causing reversion to "POS/INS", the aircraft navigation system requires 22 seconds to recover a GPS-aided solution after returning to "POS/AINS" position keeping due to filtering within the INS. This is the minimum delay before the JDAM weapon can be expected to receive a TXA with GPS-aided position and velocity information. This delay does not include filtering delays in the weapon itself.
- (U) Any altitude inaccuracy requires time to wash out of the weapon's Kalman filter. If the weapon is released with an erroneous altitude, then miss distance increases, particularly for low terminal impact angles. Although the weapon can correct TXA handoff errors of reasonable magnitude after launch given GPS and a sufficient TOF, specification accuracy is not assured unless a GPS-quality handoff is provided. Therefore, if radical defensive aircraft maneuvering to include inverted flight combined with large vertical velocities is required in the target area within minutes of the expected launch point, such that "POS/AINS" can be recovered for at least 30 seconds prior to the launch point, then it is recommended that JDAM not be released, unless the potential for a wide miss can be tolerated. This consideration includes the potential necessity for either preemptive or reactive anti-missile defense maneuvers and/or high-dive rollins. If a high altitude ingress and release profile can be employed to reduce the threat risk, and at the same time increase JDAM TOF, then JDAM viability is increased.
- **3.1.1.3 Targeting Accuracy.** (U) JDAM requires target coordinates mensurated to at least 7.2 meter TLE in order to meet its specification CEP. If this threshold targeting accuracy cannot be met, or if supplied coordinates cannot be verified in terms of guaranteed targeting accuracy, then the strike mission planner must consider the efficacy of employing JDAM balanced against the possibility of mission failure due to miss distance and/or collateral damage.
- **3.1.2 WEAPON EXPLOITATION.** (U) There are several capabilities inherent in the JDAM weapon system that may be exploited when planning and executing the strike mission. These capabilities combine for a high probability of mission success by providing extremely flexible weaponeering solutions against targets, regardless of environmental conditions and/or target area threat levels.
- **3.1.2.1** Autonomous Guidance. (U) There is no launch aircraft support after JDAM release. This provides the flexibility to minimize aircraft vulnerability in a high-threat target area, using only the achievement of a valid release point as the major planning factor in the target area.

- **3.1.2.2 High Off-Boresight Targeting.** (U) There is no requirement to aim ballistically or otherwise "point" JDAM at the desired impact point. Since the aircraft provides a situational display of the PPIZLAR and Launch Point regardless of aircraft orientation, the aircrew possesses sufficient cues to arrive at a pre-validated release point without ever pointing at the target (assuming the other pre-planned launch conditions can be met). This capability provides an excellent means of attacking defended targets while skirting the edge of the high-risk radius about the target. This capability is best exploited by executing PP missions as planned because dynamically computed real-time targeting cues are available only when the target is within a limited area about the aircraft heading, thus limiting the off-boresight advantage.
- **3.1.2.3 Programmable Impact Conditions.** (U) JDAM can execute a three-dimensional attack against a point target using terminal heading and impact angle to define the approach to the target. JDAM also can accept a minimum terminal impact velocity to optimize damage effects. This programmability provides an excellent means of tailoring attacks against vertically or horizontally oriented, hard or soft targets.
- **3.1.2.4 Flexible Fuzing.** (U) An important improvement brought with the JDAM system is the addition of the FMU-152 JPF. With it, inflight cockpit programmability in flight affords the aircrew a credible ability to create an effective strike mission in real time. Also, the strike planner is presented with an unprecedented selection of arm times and functional delays with which to weaponeer missions. This provides a flexible and effective fuzing solution for a variety of missions.
- **3.1.2.5 Shaped Trajectory.** (U) Since JDAM does not fall ballistically but rather follows a controlled, shaped midcourse trajectory, a single launch point may be defined to release a quantity of JDAM at targets widely separated and on different axes at release. For the same reason, a single JDAM quantity may be employed to strike both horizontally and vertically oriented targets in the same release. This force multiplication capability provides the option of reducing the total aircraft requirement by employing a single aircraft to attack several targets.
- **3.1.2.6 Point Targeting.** (U) Since JDAM is targeted precisely using a point-target bomb-on-coordinate scheme and ballistic dispersion is not a consideration, a single JDAM weapon may be employed against a target that otherwise would require a stick of several ballistic weapons. This force multiplication capability provides the option of reducing the total aircraft requirement by employing a single weapon to attack a single target. In weapons incorporating the 12-channel GPS receiver, more satellites are available to calculate horizontal and vertical position and velocity and to correct time errors. This results in both better horizontal and vertical position accuracy.
- **3.1.2.7 All-Weather Guidance.** (U) Since JDAM navigates using an internal INS and GPS radio signals, weather and/or other obscuring environmental conditions do not affect weapon accuracy or operation. This capability allows the option to avoid deferring or canceling strikes due to problematic conditions in the target area.
- **3.1.3 PLANNING FACTORS.** (U) In addition to the strike planning factors standard to other weapons, JDAM strike planning also considers sources for the target coordinate, GPS-related factors and guided trajectory factors.
- **3.1.3.1 Target Altitude Datum Selection.** (U) The HAE (Height Above Ellipsoid) elevation datum is recommended over the MSL elevation datum. As a GPS-aided weapon, JDAM naturally references HAE, which is referenced externally to the earth (based on the mean curvature of the globe), as opposed to MSL, which is referenced to a mean surface datum (sea level). MSL coordinates are converted to HAE for use with the weapon. If HAE coordinates are used, then one additional error contribution, truncation during conversion, is avoided.
- **3.1.3.2 Launch Parameter Selection.** (U) Launch parameter selection is influenced first and foremost by the weaponeering requirements for a given mission (i.e., weapon energy requirements), and secondly by the tactical threat environment. When flexibility is available, launch parameters may be chosen to optimize JDAM performance, as follows.
- **3.1.3.2.1 Launch Altitude and Airspeed.** (U) It is recommended that JDAM be employed at as high an altitude and as fast an airspeed as tactically feasible for the weaponeering solution. This results in better weapon accuracy due to more GPS tracking time and better weapon navigation solution accuracy, a more flexible launch decision due to a larger LAR, and better terminal parameter control due to more energy.

**3.1.3.2.2 Launch Point.** (U) It is recommended that JDAM be released from a point near the heart of the PPIZLAR envelope, ideally 75% deep along the launch axis. Avoiding the edge of the PPIZLAR reduces many uncertainties and increases weapon energy management margins.

**3.1.3.2.3 Launch Axis Heading.** (U) If a terminal impact heading is defined, then it is recommended that whenever possible the launch axis heading be as close as possible to the terminal impact heading, in order to maximize the LAR. Depending on where the release point is within the envelope in relation to minimum and maximum range, it is possible that even with over 30 degrees of heading change, the typical launch point (around 75% deep) remains within the LAR.

#### NOTE

- (U) JDAM does not attempt to fly along the specified terminal impact heading for any prescribed range, but instead maneuvers only to impact the target along the azimuth specified by the heading.
- **3.1.3.2.4 Launch Attitude.** (U) Level releases are optimum for JDAM; in many cases dives and lofts actually reduce the standoff range of JDAM for a given release condition (Figures 3-1 and 3-2). The weapon seeks a prescribed flight trajectory based on its current position relative to the target, so the additional energy potentially expended in nulling flight path deviations from its optimum profile can cause reduced performance. Also, dive release profiles do not improve JDAM terminal performance, in terms of impact velocity, penetration depth or overall effectiveness, and in many instances reduce it. Therefore, dive deliveries are not recommended, except in certain cases of tactical necessity. In summary, it is recommended that a level release be planned and employed whenever feasible.

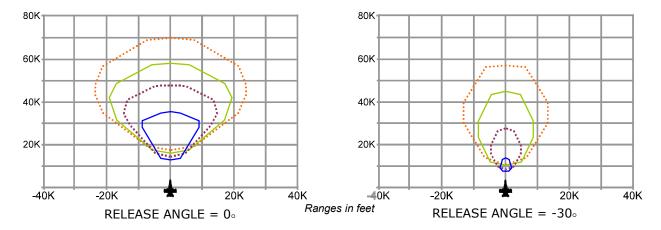


Figure 3-1
TYPICAL EFFECT OF DIVE RELEASE ON JDAM LAR (U)

- (U) Release attitude changes the overall weapon flight trajectory to the target (Figure 3-3) but, since the weapon flies to a fixed coordinate, it does not affect the final impact point.
- **3.1.3.3 Terminal Parameter Selection.** (U) Terminal parameter selection is influenced first and foremost by the weaponeering requirements for a given mission. When flexibility is available, terminal parameters may be chosen to optimize JDAM performance.
- **3.1.3.3.1 Terminal Impact Angle.** (U) Steeper terminal impact angles result in better accuracy because GPS navigation is more accurate in the horizontal ground plane (latitude and longitude) than in the vertical plane (altitude), due to higher uncertainty in the GPS vertical solution. Therefore, it is recommended that a target be designated and attacked as horizontal rather than vertical whenever the choice exists.

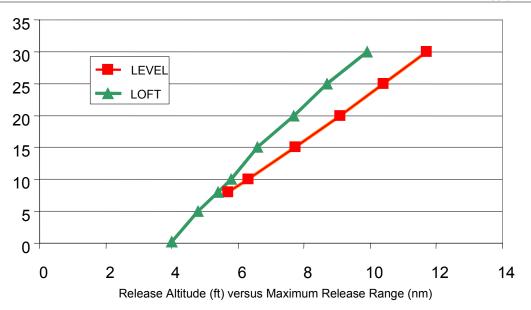


Figure 3-2
TYPICAL EFFECT OF LOFT RELEASE ON JDAM LAR (U)

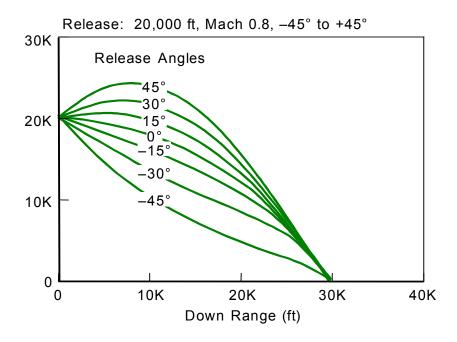


Figure 3-3
TYPICAL EFFECT OF LAUNCH ATTITUDE ON JDAM TRAJECTORY(U)

(U) The terminal impact angle influences JDAM in three ways. First, the flight profile of the weapon from the aircraft to the target changes with terminal impact angle (Figure 3-4). Second, as terminal impact angle is increased, the maximum and minimum launch ranges decrease, with a net effect of a significantly smaller displayed LAR, and the LAR itself shifts closer to the target, thus providing less standoff. Conversely, a shallower impact angle expands the displayed LAR and shifts it away from the target, thus providing more standoff available. (The LAR will again shrink as the impact angle is becomes acutely shallow.) Third, given a fixed launch point, as the terminal impact angle is increased, the weapon terminal velocity decreases, since the weapon expends additional energy through induced drag flying a flatter profile to the terminal dive point.

(U) It is recommended that a terminal impact angle of 65 degrees or more be selected against a horizontally oriented target, and no less than 30 degrees be selected against a vertically oriented target, in order to provide tactical utility for the weapon LAR. For very low angles less than 30 degrees or very high angles approaching 90 degrees, only a small increase in weapon effectiveness is gained with a large reduction in LAR. This is particularly true with respect to low impact angles, where a great deal of energy is required to achieve even a minimum launch range or impact velocity. It is possible that for impact angles less than 30 degrees, a valid LAR may not be displayed.

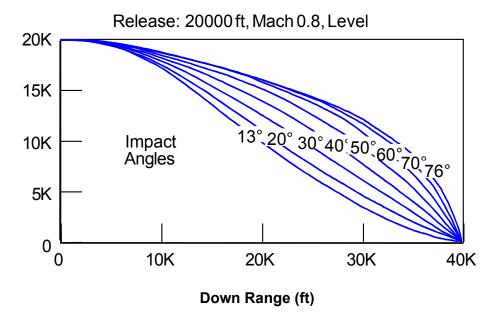


Figure 3-4
TYPICAL EFFECT OF TERMINAL IMPACT ANGLE ON JDAM TRAJECTORY (U)

(U) Figure 3-5 illustrates the effect of terminal impact angle on the GBU-31(V)2/B LAR for a subsonic, straight and level release from high altitude oriented directly on axis toward the target. A simple rule of thumb is a decrease in launch range of about 2 miles for every 10 degree decrement in impact angle.

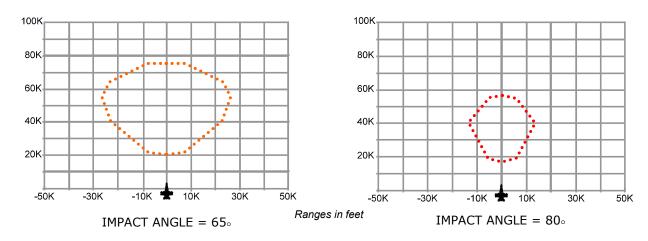


Figure 3-5
TYPICAL EFFECT OF TERMINAL IMPACT ANGLE ON JDAM LAR (U)

**3.1.3.3.2 Terminal Heading.** (U) It is recommended that a terminal heading be undefined whenever tactically feasible, in order to provide tactical utility in the weapon LAR. As the release heading moves farther away from the terminal heading, a large reduction in valid weapon launch zone occurs. Figure 3-6 illustrates the effect of terminal heading on the GBU-31(V)2/B LAR for a subsonic, straight and level release from high altitude oriented directly on axis toward the target.

#### NOTE

(U) For SCS 13C+ and prior, once a terminal heading has been assigned, it cannot be removed. With SCS 15C and subsequent, a "HDG UNDF" control option is available to remove an assigned terminal heading and recover a more tactically significant valid launch zone.

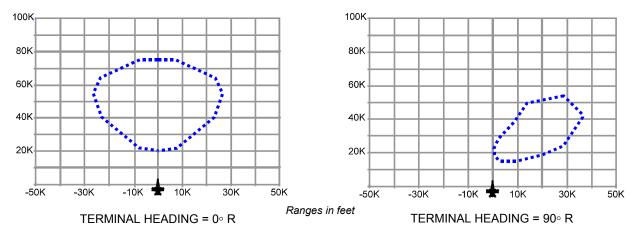


Figure 3-6
TYPICAL EFFECT OF TERMINAL HEADING NONALIGNMENT ON JDAM LAR (U)

- **3.1.3.4 Target Coordinate Generation.** (U) Target location error (TLE) comprises a large portion of the total JDAM system error. As such, highly accurate coordinates improve overall mission effectiveness by improving weapon accuracy to the greatest degree. There are several sources that provide mensurated target coordinates, each of which having unique characteristics. Coordinates obtained for a JDAM mission always should be appended with an accuracy statement, or TLE. Note that stated TLE usually is a threshold of coordinate accuracy. For example, a standard coordinate set with a TLE of 7.2 meters, which is the assumption for JDAM accuracy specifications listed in Section 1.4.1, is guaranteed to be accurate to at least 7.2 meters, even though it may be less than 7.2 meters from truth. See Section 3.4.2.1.
- **3.1.3.5 TOT Selection.** (U) Along with terrain masking, jamming and MAGR system errors (UERE), PDOP contributes to the uncertainty in a GPS position fix (Annex A). Strike planners must consider PDOP effects to reduce the risk of missing the target, causing collateral damage, and/or forcing a restrike that induces further risk. Although PDOP spikes may be short-lived, their coincidence with a TOT cannot be ignored. PDOP predictions for any given geographic location on any given day and at any given time are valid up to days in advance. Since PDOP cannot be controlled, good PDOP prediction and avoidance are germane. By avoiding PDOP spikes, the position navigation component of total system error may be reduced.
- (U) Whenever feasible, it is recommended that TOT for JDAM missions be planned when the PDOP for the target location is minimum within the allowable strike window. The strike planner is interested in PDOP sensitivity WRT time on target (TOT); that is, what the PDOP at TOT is and how much it changes as TOT is varied. This may accomplished on TAMPS only by replanning the mission using different TOT.

- (U) PDOP is represented in TAMPS planning by a circular reference marked in 15 minute increments in GPS Prediction dialog box, under Route Analysis. This prediction does not account for terrain masking in terms of GPS satellites and precision available. If a wedge is yellow in color, it represents a period when GPS PDOP is below the specification value, whereas a green wedge indicates that the specification GPS PDOP is met. DOP values also may be downloaded directly from the internet. The Space Battle Management Core System (SBMCS) is available via secure internet at {https://exercise.sbmcs.spacecom.smil.mil}, and runs on PC (vice TAMPS) using a downloadable internet browser application. It provides DOP predictions explicitly in CEP and SEP updated every 15 minutes. DOP information also is available via nonsecure internet at "http://sirius.chinalake.navy.mil/satpred/", "www.peterson.af.mil/usspace/gps support" or "www.usspace.spacecom.smil.mil/sj3/gps support".
- **3.1.3.6 Wind Consideration.** (U) The basic mission planning template does not consider winds. Due to TAMPS core software limitations, the basic default is Standard Day conditions with no winds ("Standard"). Current weather conditions ("Current") may be available and are only as current as the update uploaded by the TAMPS administrator. Note that even if current weather is uploaded, the data may not include winds. If current weather is not available, then historical winds may be used ("Historical"). The TAMPS LAR model can utilize manually entered winds or historical seasonal average winds. Manually edited winds may be copied from route to route.
- (U) JDAM LARs are based only on ground speed, not winds aloft. After JDAM is released, the weapon guidance and control logic calculates the flight path to the target. If the actual winds encountered during the TOF differ from release winds so much that they cause an energy deficit for the weapon, it employs an energy priority scheme to maximize effectiveness. See Section 1.3.2.9.

#### NOTE

(U) Stored wind data (i.e., STORES format WINDS option) is ignored in JDAM LAR calculation.

#### 3.1.4 WEAPONEERING

## 3.1.4.1 Weapon Effects

- **3.1.4.1.1 Blast.** (U) Blast generally is associated with a K-kill. Blast is a highly catastrophic damage mechanism, but generally is very localized, with a small Mean Area of Effectiveness (MAE). Blast is strongly influenced by warhead size and fuzing, and is less affected by terminal impact angle, terminal heading and terminal impact velocity. To maximize JDAM blast effects, employ GBU-31(V)2/B at impact angles of 65 degrees or greater with instantaneous or very short functional delay fuzing. To contain collateral damage effects, employ a terminal impact angle as high as possible, a terminal heading that optimizes the blast direction, a short functional delay, and the smaller GBU-32/35 warhead.
- **3.1.4.1.2 Fragmentation.** (U) Fragmentation generally is associated with a firepower, mobility, or loss-of-function kill. Fragmentation is a less catastrophic damage mechanism than blast, but provides a much greater MAE. Fragmentation effects are strongly influenced by fuzing, terminal impact angle and, as impact angle shallows, terminal heading. Fragmentation is less affected by terminal impact velocity. To maximize JDAM fragmentation effects, employ either the GBU-32/35 or GBU-31(V)2/B (both have similar fragmentation effects) at impact angles of 65 degrees or greater with DSU-33 proximity fuzing. Collateral damage is not considered against fragmentation objectives. Figure 3-7 illustrates typical fragmentation effects with and without (20-foot) proximity fuzing.
- **3.1.4.1.3 Penetration.** Penetration generally is associated with hard target loss-of-function kills. Penetration usually is coupled with blast and/or overpressurization in terms of damage mechanism, with a very small MAE and the associated need for precision. Penetration effects are influenced heavily by terminal impact velocity and angle of attack at impact, and to a lesser degree by terminal heading and terminal impact angle, although both are important in terms of target orientation.

#### NOTE

(U) Terminal impact velocity (and penetration) is a function of weapon launch energy, and thus is influenced primarily by altitude and airspeed at release. Terminal impact velocity is not controlled or affected by the selected minimum impact velocity; this value is used to tailor the PPIZLAR.

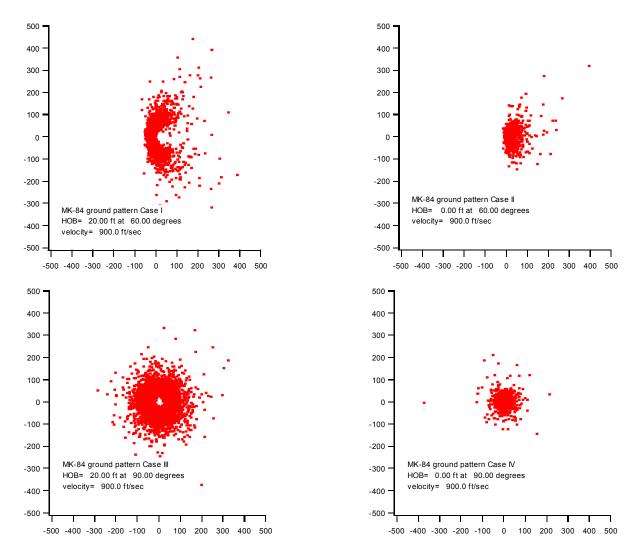


Figure 3-7
TYPICAL EFFECT OF PROXIMITY FUZING ON FRAGMENTATION (U)

(U) In order to maximize JDAM penetration effects, employ the GBU-31(V)4/B at impact angles of 75 degrees or greater for horizontal targets or at 35 degrees for vertical targets, using the FMU-152 JPF to select an appropriate functional delay calculated for the desired penetration depth from the wide selection available. The fixed 60-millisecond delay of the FMU-143 fuze is considered a liability when weaponeering to achieve a specific penetration depth.

#### NOTE

(U) A terminal impact angle less than 35 degrees against vertical target provides little additional penetration, but significantly affects the valid release envelope for any given flight condition by constricting the maximum and minimum employment ranges.

**3.1.4.1.4 Denial.** (U) Denial generally is associated with loss of access functionality. Denial usually is coupled with blast and to a lesser degree with fragmentation in terms of damage mechanism. Denial effects are influenced heavily by fuzing and are also affected by terminal impact velocity in terms of depth of burial. To maximize denial effects, employ the JDAM appropriate to the delivery requirements (soft or hard target) at impact angles of 65 degrees or greater to minimize bomb skip or breakup due to case slap, using the FMU-152 JPF to select a functional delay appropriate for the desired period of denial. The ability to select an independent functional delay for each JDAM allows the strike planner to create a series of single releases or a quantity release against a target that could deny it effectively for up to 24 hours if a JPF is used.

- **3.1.4.2 Fuzing Components Selection.** (U) Several fuzing components are available for JDAM applications. However, it is recommended that the FMU-152 JPF be employed whenever available. The following options currently are available.
- **3.1.4.2.1 FMU-152.** (U) The FMU-152 JPF is recommended for all JDAM applications due to its in-flight programmability and the flexibility it provides in weaponeering target cases. Use of the FMU-152 JPF requires the MK-122 Mod 0 electrical safety switch; the FZU-55 mechanical initiator is not supported on the F/A-18. The JPF is hardened sufficiently for use in hard-target penetration roles.
- (U) The FMU-152/MK-122 electrical fuzing configuration offers four advantages over the FMU-139/FZU-48 mechanical fuzing configuration. The first is cockpit programmability. The second is a much wider variety of arm time and functioning delay settings for weaponeering. The third is dual functionality, with a backup default mode should primary digital control be lost or disabled. The fourth is mission planning and downloading of fuze settings, reducing the overall cockpit workload for the aircrew.
- (U) The FMU-152 offers programmable and inflight cockpit-selectable arm time and functioning delay settings otherwise not available on the fuze faceplate. Since it is desirable to back up programmed arm time and functioning delay settings in the event of a serial communication failure to the JPF, it is recommended that whenever possible arm time and functioning delay be selected from the available fuze faceplate subset, such that if the default faceplate values become necessary, the weaponeering case remains valid.
- **3.1.4.2.2 FMU-139.** The FMU-139 provides adequate JDAM support and requires the use of the FZU-48/B mechanical initiator; use with the MK-122 switch for JDAM applications is not authorized. The FZU configuration provides authorized arm times in excess of 10 seconds, which relieves the constraints imposed on the MK-122 configuration by safe escape limitations, as calculated by the SLIC. The FZU configuration also allows for unrestricted TOF, which relieves the 60-second TOF restriction imposed on the MK-122 configuration due to the rated fuze capacitor discharge rate.
- (U) The FZU-48 (mechanical fuzing) configuration offers two advantages over the MK-122 (electrical fuzing) configuration. The first is that arm times greater than 10 seconds are authorized. This allows for less restrictive deliveries above 20,000 feet MSL, due to safe escape considerations with arm times of 10 seconds or less. The second is that planned Time of Fall (TOF) may exceed 60 seconds, which is the maximum TOF allowable with the MK-122 switch due to the FMU-139 capacitor specified discharge rate. The disadvantage of the FZU-48 configuration is that fuze options only are preset via faceplate settings before flight and are not modifiable in flight.
- (U) The FMU-139B/B variant is recommended over the FMU-139A/B variant. The B/B variant is of more recent manufacture, thus has a lower shelf life age, and is constructed with slighter more reliable and durable components. The two variants are functionally identical.
- **3.1.4.2.3 FMU-143.** (U) The FMU-143 with the FZU-32 provides a limited hard-target penetration capability. The fixed 60-millisecond delay of the FMU-143 fuze is considered a liability when weaponeering a hard-target penetration case, as compared to the hard-target flexibility inherent in the FMU-152 JPF.
- (U) The advantage of the FMU-143/FZU-32 configuration over the FMU-152/MK-122 configuration is relief of TOF limitations. The disadvantage of the FMU-143 is a fixed arm time and functioning delay when weaponeering specific cases.
- **3.1.4.2.4 DSU-33.** (U) The DSU-33 (Annex D) provides a reliable air burst function with an operational fixed height of burst specification of 5 to 35 feet. Furthermore, by selecting a functioning delay in conjunction with the DSU-33, it is possible to attack targets above ground that are shielded. For example, against an above-ground target shielded by a thick jungle canopy, the DSU-33 can detect the upper tree line and provide a proximity signal to the fuze, and use of the appropriate functioning delay permits the bomb to free-fall through the tree canopy for an above-ground burst prior to bomb burial.
- (U) Use of DSU-33 in quantity releases must be considered carefully in terms of bomb fratricide due to proximity bursts. This includes DMPIs assigned by the TAMPS QRM in the Single-Target Quantity Release module. See section ?.?.????.

- (U) When the DSU-33 is used in conjunction with the FMU-139 general purpose fuze, two important limitations exist:
  - If the FMU-139 is configured with the MK-122 electrical safety switch, the DSU-33 functions according to the polarized voltage received from the aircraft, like the FMU-139 fuze itself. The DSU-33 proximity function is enabled using the same voltage encoding used to select the faceplate functioning delay. Thus, there is no way to separate functioning delay and proximity fuzing using the FMU-139 and MK-122 configuration. When weaponeering, it is recommended that instantaneous fuzing be selected on the fuze faceplate ("INST"). This allows the aircrew the option of selecting either contact fuzing, by selecting the "EFUZ INST" on the STORES format, or selecting proximity fuzing, by selecting "EFUZ VT1" on the STORES format.
  - If the FMU-139 is configured with the FZU-48 initiator, the DSU-33 always is enabled and cannot be overridden, as no cockpit control options are provided or relevant, since the DSU-33 uses no arming lanyards for mechanical fuze control.
- **3.1.4.3 Bomb Fratricide Avoidance.** (U) The JDAM weapon system does not diminish the existing risk of bomb fratricide with existing inventory warheads. Warhead fragmentation and dispersion are not affected directly by the JDAM guidance system or kit. Therefore, JDAM weaponeering solutions, even though created by automated tools such as TAMPS and SLIC, must be screened by the strike planner for the possibility of sympathetic detonations in order to introduce the steps necessary to reduce the risk to acceptable levels. In particular, use of the DSU-33 proximity sensor in quantity releases against a single target greatly increases the risk of bomb fratricide and must be planned carefully.
- (U) A MK-84 fratricide study determined the probability of sympathetic detonation exceeds 10% inside of 150 feet warhead proximity but exceeds 50% inside of 50-100 feet warhead proximity. The study assumed instantaneous detonation vice partial bomb burial, a flat earth with no above-ground objects, and purely perpendicular fragment impacts. Therefore, these values represent a very conservative planning assumption. The probability of fratricide among BLU-109 warheads is significantly lower because the thicker bomb case reduces fragmentation/fragment velocity as well as case penetration characteristics, and because a functioning delay of greater than zero typically is employed, which result in bomb burial prior to detonation.
- (U) Thus, a very low probability exists for warheads arriving at 1000 feet per second more than 150 milliseconds apart or at 500 feet per second at more than 300 milliseconds apart. The F/A-18 aircraft releases JDAM weapons at a fixed interval of 300 milliseconds, but the shaped JDAM trajectories can result in the weapons arriving at the target closer than the release interval, and in some cases in a sequence different from release. Thus, JDAM minimum release interval cannot be used as the sole mitigation for fratricide. On the other hand, JDAM can partially offset fratricide risk through the use of its command terminal impact parameters. By carefully selecting valid and compatible terminal headings and angles, rudimentary bomb deconfliction can be effected. However, the resulting reduction in LAR, and particularly in intersection LAR, must be carefully balanced against the net effect in preventing fratricide.
- (U) Therefore, it is recommended that whenever possible quantity releases against a single target be planned with sufficiently spaced release intervals. Furthermore, it is recommended that DSU-33 proximity sensors not be used, as the F/A-18 minimum release interval is insufficient to adequately prevent bomb fratricide. Finally, when the JDAM attack is against an area target, in addition to the QRM automatic DMPI allocation, consideration should be given to the conservative use terminal headings and varied terminal impact angles, but not at the expense of a valid LAR adequate to support successful release of the JDAM quantity "In Zone".

# 3.2 PLANNING TOOLS

- **3.2.1 OVERVIEW.** (U) Primary JDAM mission planning is accomplished using the Tactical Automated Mission Planning System (TAMPS). TAMPS uploads mission and GPS data as a bulk data file onto a MU, which is hand-carried to the aircraft. The mission data is transferred automatically to the aircraft and to the onboard JDAM weapons when power is applied. However, other resources not integrated into TAMPS are required to complete all mission planning tasks. Therefore, a disciplined methodology is required.
- **3.2.2 HARDWARE.** (U) The JDAM mission planning technique is highly automated. JDAM mission planning requires access to both a TAMPS workstation and a generic personal computer (PC) workstation.

- **3.2.2.1 TAMPS Workstation.** (U) The TAMPS workstation hosts the TAMPS software, the F/A-18 and JDAM software modules, and various data relevant to JDAM mission planning. Before a JDAM mission can be planned, the workstation must be readied by loading current GPS almanac and crypto keys. A basic discussion of these procedures follows. Checklists for accomplishing these tasks are contained in Annex B.
- **3.2.2.1.1 GPS Almanac Loading.** (U) GPS almanac data should be loaded onto the TAMPS workstation once per week. Due to satellite irregularities, it is difficult to predict the constellation far in advance, and almanac can become stale. Stale almanac impacts the JDAM mission by increasing the amount of time required for the aircraft to locate and acquire GPS satellites.
- (U) GPS almanac data may be downloaded directly via a Precision Lightweight GPS Receiver, or PLGR (AN/PSN-11). Almanac data retrieved in this way requires conversion to the NAVSTAR.ALM format, which may be accomplished using a standard Windows-based PC running the PLGRALM.EXE software. Another method for obtaining GPS almanac is via Internet download. Annex B lists several trustworthy unclassified sites that provide NAVSTAR.ALM in the proper format for immediate download to floppy disk. These Internet almanac files are updated externally via PLGR each Monday, or Tuesday if Monday is a designated holiday.
- (U) It is recommended that, whenever feasible, GPS almanac be downloaded directly from a GPS satellite. Almanac data retrieved from other sources (such as downloads off the Internet) may not be free of transcription errors or as fresh as the assigned date indicates. If downloading is the only viable method, it is recommended that a professional military site be used. Regardless of where the NAVSTAR.ALM file is obtained, it must be reviewed to ensure that it is not corrupted. The downloaded file may be viewed in Windows Notepad. If the data doesn't appear in tabular form, it shouldn't be used.
- (U) Although JDAM does not use the GPS almanac uploaded from TAMPS into the MU, the GPS almanac must be maintained current in TAMPS. In addition to supporting other GPS weapons (like SLAM and JSOW), GPS almanac in TAMPS is required for JDAM mission planning to support GPS PDOP calculations for CEP estimation in support of weaponeering.

#### NOTE

- (U) GPS almanac data typically is downloaded into TAMPS by the TAMPS Administrator.
- **3.2.2.1.2 GPS Crypto Key Loading.** (U) GPS crypto keys may be loaded manually or automatically; the latter is recommended and is the only practical method. Two weeks of crypto keys are selected for JDAM bulk data file download, the current week and the upcoming week, based on the date in the TAMPS workstation internal clock.
- (U) The following common errors in loading GPS crypto keys are presented in the order of frequency of occurrence:
  - (U) Wrong key type should be weekly vice yearly or monthly, CVW vice GOV, and AKAT-A1001 vice AKAT-1101. Do not rely on an automatic selection of key type select the key type explicitly.
  - (U) Wrong week crossed KYK-13 channels.
  - (U) Wrong key non-GPS key erroneously entered as GPS key.
  - (U) Wrong system time TAMPS should be set by administrator, referenced to ZULU (GMT) time.
  - (U) Wrong crypto period.
  - (U) Wrong short title for CYZ-10 prevents keys from loading.
- (U) Weekly GPS rollover occurs at 0000Z Sundays. There are no known crypto key anomalies associated with event. Nonstandard loading procedures are not required for correct mission data creation and successful loading of GPS crypto keys. An MU upload on Saturday night for a Sunday mission is not required. Manipulation of the system clock to "trick" TAMPS into a "successful" download is not authorized and could result in mission failures due to corrupted mission data.

#### **CAUTION**

- (U) Do not tamper with the JDAM system time in order to control GPS crypto key status. TAMPS relies on the correct time and date for other important functions, such as weaponeering and GPS PDOP predictions.
- (U) Specific procedures for correct GPS crypto key loading are provided in Annex B.
- **3.2.2.2 PC Workstation.** (U) A common PC workstation is required for safe escape computational software and is desirable to accomplish other useful mission planning tasks. The PC must be Windows-based, but is not required to be networked. All supporting data is contained in the software; no additional PC file maintenance is required.

#### 3.2.3 SOFTWARE

**3.2.3.1 Minimum Versions.** (U) Minimum software versions for JDAM mission planning are provided in Table 3A.

SOFTWARE	MIN VERSION (GBU-31)	MIN VERSION (GBU-32/35)
TAMPS Core	6.2K	6.2K
JSOW/JDAM CMPM	6.2.1	6.2.1
F/A-18 MPM	13C-4.2.1	15C-4.1.2
SLIC	2.0	3.0
ATACS <sup>1</sup>	2.3	2.3
JAWS <sup>1</sup>	2.0	2.0
PCEFFECT <sup>1</sup>	???²	????²
PLGRALM.EXE 1	???	???

Desired but not required to complete JDAM mission planning.

# Table 3A MINIMUM SOFTWARE VERSIONS FOR JDAM MISSION PLANNING (U)

- **3.2.3.2 Planning Tools.** (U) Targeting data and other associated mission data are pre-programmed using the TAMPS-based F/A-18 Mission Planning Module (MPM) and JSOW/JDAM Common Mission Planning Module (CMPM). The JDAM Stick Length Interactive Calculator (SLIC) is used to validate releases for safe escape purposes. The Aircraft Tactical Loading System (ATACS) may be used to validate aircraft configuration and loadout. For all missions involving JDAM weapons, safe escape and release authorization is accomplished using the SLIC program; there are no cataloged release tables. Flight restrictions are determined by using an appropriate version of ATACS; if not available, an appropriate flight clearance shall be referenced. Aircraft planning is accomplished via the F/A-18 MPM.
- **3.2.3.2.1 GBU-31(V)2/B and GBU-32/35 Planning Tools.** (U) Missions for the GBU-31(V)2/B and GBU-32/35 variants are accomplished using the JSOW/JDAM CMPM v6.2.1 in TAMPS. This reference uses JMEM data and methodology to provide both an SSP<sub>D</sub> for a single weapon or a P<sub>D</sub> calculation for multiple weapons. The most accurate method of weaponeering involves both the CMPM and JAWS v2.0. The basic mission is planned with the CMPM, but the weaponeering module is ignored, except for date and TOT to account for GPS PDOP on accuracy. CEP is calculated in the CMPM dynamic display. JAWS v2.0 may then be used to weaponeer the mission. The default values for CEP must be accepted until they can be overwritten with the CMPM-calculated CEP.
- **3.2.3.2.2 GBU-31(V)4/B Planning Tools.** (U) Basic mission planning for the GBU-31(V)4/B (BLU-109) variant is accomplished in a manner similar to that of the GBU-31(V)2/B and GBU-32/35 weapons. The GBU-31(V)4/B is weaponeered using "PCEffect" software, which is included with JAWS v.2.0 software.

<sup>&</sup>lt;sup>2</sup> PCEffect included in JAWS 2.0.

- **3.2.3.3 CMPM Overview.** (U) The JSOW/JDAM CMPM provides a common automated interface for both the JSOW and JDAM weapons. The CMPM provides a means to define a Desired Mean Point of Impact (DMPI), select release conditions, calculate weapon and/or mission effectiveness, and upload mission data onto an MU for storage and transport for the JDAM weapon. The CMPM also supports the creation of missions that employ quantity releases against one or a group of DMPIs. In order to ensure that all steps of the mission planning checklist is accomplished, the CMPM provides a pull-down menu "Smart Checklist" as a guide for JDAM mission planning (Annex B).
- (U) When planning JDAM missions, the CMPM fulfills the majority of requirements, including weaponeering. The JDAM CMPM weaponeering module uses JMEM data and methodology to calculate the probabilities of destruction for both single and multiple weapons against a target. The CMPM provides a "JDAM Smart Checklist" to guide the planner through JDAM mission planning (Annex B.) Once a mission is planned with the CMPM, the data is digitally transferred to the TAMPS F/A-18 MPM, where it is combined with other mission planning data such as route of flight, refueling points, GPS keys and almanac data with which to build the final bulk data file.

### **NOTE**

(U) The JDAM CMPM weaponeering module has two important limitations. First, there are limited sets of target classes/subclasses from which to select. Second, the CMPM does not accurately take into account bomb burial for instantaneous detonations and may provide an optimistic damage estimate.

# 3.3 DATA REQUIREMENTS

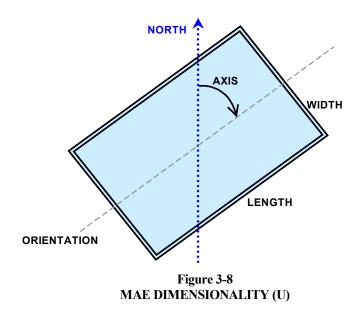
- **3.3.1 BULK DATA FILES.** (U) Each JDAM weapon carried aboard the F/A-18 aircraft can carry its own individual bulk data file. This bulk data file consists of eight target data sets and one set of up to two weeks of GPS crypto keys. The target data sets are broken down into six PP and two TOO missions. The bulk data file is initially created in the CMPM. This data file is output by the CMPM with space built in for GPS crypto keys. The bulk data file is selected for uploading into an aircraft weapon station file on the MU using the F/A-18 MPM. When a JDAM bulk data file, the JSOW/JDAM preprocessor writes the GPS crypto keys into the bulk data file and prepares the file for loading on the MU. Up to four individual bulk data files may be loaded on the MU in order to support up to four valid JDAM weapon stations. The F/A-18 MPM also assigns default startup missions for each station if not specified explicitly by the mission planner.
- **3.3.2 MINIMUM JDAM TARGETING DATA.** (U) In order to function, JDAM requires specific data. A minimum Target Data Set (TDS) is required to launch a JDAM weapon that guides successfully to the desired mean point of impact (DMPI). However, several supporting mission planning functions such as weaponeering, generation of GPS predictions, etc., may be required to provide the level of effectiveness to achieve full mission success.
- **3.3.2.1 Target Data Set.** (U) JDAM requires GPS-quality latitude, longitude and elevation coordinates, mensurated with sufficient precision in the WGS-84 datum (see Annex A). The JDAM specification coordinate requirement (i.e., TLE) for threshold accuracy is 7.2 meters. The only real measure of how accurate coordinates must be is the overall weaponeered effectiveness against the selected target. Allowable coordinate formats are {dd° mm' ss.ss"} or {dd° mm.mmm'} for the ground plane. JDAM also requires an elevation coordinate referenced explicitly either to Height Above Ellipsoid (HAE) or Mean Sea Level (MSL). Altitude coordinates entered in MSL are converted to HAE automatically by the weapon using an internal GPSRM algorithm.
- **3.3.2.2 GPS Crypto Keys.** (U) A minimum TDS will allow the weapon to guide to the target, but without the required GPS data navigation the weapon relies on INS only, and the specified GPS-aided accuracy cannot be achieved. Therefore, in a real sense GPS usage is critical to true weapon effectiveness, and GPS crypto keys are the most critical GPS data. JDAM cannot navigate on the Coarse Acquisition signal (CA-code). Therefore, a weapon release without GPS crypto keys results in INS-only navigation and its associated accuracy degradation.
- (U) The F/A-18 aircraft interface supports manual entry and editing of JDAM data from the cockpit. However, no practical method of entering valid GPS crypto keys in real time has been demonstrated. The only feasible method is a bulk data transfer of mission data from a MU. Even in reactive scenarios where it is anticipated that JDAM will be manually programmed in the air, the weapon still requires a MU mission data load generated by TAMPS in order to obtain GPS crypto keys. It is recommended that JDAM weapons be loaded with two weeks (present week and future week) of GPS crypto keys. The proper crypto key is the weekly AKAT A1001, which is loaded into the TAMPS system using the standard CYZ-10 unit connected to a TAMPS workstation serial port.

## **NOTE**

(U) GPS crypto keys are required for JDAM mission planning. TAMPS will not upload mission bulk data onto the MU in the absence of GPS crypto key, but instead will provide a message warning of no GPS crypto keys. A successful upload is indicated by the absence of this warning method.

#### 3.3.3 OTHER TARGETING DATA

- **3.3.3.1 Terminal Impact Data.** (U) Terminal impact parameters may be provided to tailor the weapon profile and trajectory into the target to maximize the desired damage mechanism. The CMPM may be used to program values for terminal heading, terminal impact angle and minimum terminal impact velocity. If no values are specified, the weapon uses default values. A terminal heading value is recommended only for vertically oriented targets.
- **3.3.3.2 Target Classification Data.** (U) If the CMPM is used to weaponeer the mission, certain target parameters are required. These include target hardness (hard, medium, or soft) and target orientation (vertical, horizontal, or buried). In order to calculate a P<sub>D</sub>, a Mean Area of Effectiveness (MAE) is required. MAE is calculated automatically by selecting target class and subclass from the CMPM list and specifying the desired kill level. MAE also may be entered manually. For area-type targets, target height, length and width are required (Figure 3-8). If the JDAM Quantity Release Manager is used to distribute aim points, the target dimensions and long-axis azimuth is required.



**3.3.3.3 Target Offset Data.** (U) A DMPI may be defined as an offset from a mensurated coordinate. This offset is specified as a range, bearing and a relative elevation change. If no values are specified, the offset is assumed to be zero.

## **CAUTION**

(U) The centroid of the target for a single target quantity release cannot be defined using offset data, because the offset field is used by TAMPS to generate each Desired Mean Point of Impact (DMPI). When generating the quantity release DMPIs, the QRM will overwrite any offset data, which may result in wide misses and/or undesirable collateral damage.

# **CAUTION**

(U) Offset elevation must be entered in the aircraft as absolute elevation for the desired impact point, in contrast to the differential elevation with respect to the offset reference point expected by the TAMPS CMPM. Confusion over the elevation entry format between the aircraft interface and the TAMPS interface may result in wide misses and undesirable collateral damage.

- **3.3.3.4 JPF Data.** (U) If an FMU-152/B JPF is used, fuze arm time and functional delay settings may be selected to load automatically into the bulk data file. If no values are specified, JPF defaults to preset values if serial communication with the JDAM exists and defaults to the faceplate settings if serial communication with the JDAM does not exist.
- **3.3.4 OTHER MISSION DATA.** (U) In order to weaponeer JDAM, the CMPM generates a CEP prediction for a specified release parameter. A JDAM CEP is based on the overall weapon system error and is affected by several factors (see Section 1.4.2). Other mission planning data may be provided or specified to TAMPS that does not contribute directly to navigation to the target but contributes to weapon effectiveness against the target by accounting for the various variable error components of the JDAM system. The weapon requires the following data to maximize its effectiveness.
- **3.3.4.1 TLE Estimate.** (U) A TLE estimate is provided to TAMPS to account for true position error. TLE may be calculated by the shipboard APPS detachment that provides the mensurated coordinates for a DMPI. TLE can be considered constant across a DPPDB cell; therefore, if TLE has already been calculated for a particular cell, that time-consuming step does not have to be repeated for another DMPI within that cell. This is an advantage of DPPDB usage.
- **3.3.4.2 TOT and Date.** (U) TOT and date provide TAMPS with a reference to calculate the PDOP, which accounts for GPS systemic error. An accurate TOT provides effective weaponeering in terms of calculating the  $P_D$  for a specific release or a recommended release to achieve a desired  $P_D$ .
- **3.3.4.3 GPS Almanac Data**. (U) The JSOW/JDAM CMPM uses GPS almanac data in the weaponeering process to calculate PDOP or GPS system error for the given TOT and date. However, GPS almanac data is forecast and predictive. GPS ephemeris data, on the other hand, is downloaded directly from the satellites in real time, making it more accurate in satellite position, error estimate and availability. Therefore, JDAM does use GPS almanac data made available by TAMPS for storage on the MU. Rather, JDAM receives GPS ephemeris data directly from the aircraft MAGR at regular intervals.

## **CAUTION**

(U) With the TAMPS system core Version 6.2K and earlier, do not select the "GPS Almanac" upload option when mission planning. This option corrupts the aircraft MAGR almanac due to a week-number formatting incompatibility, which can cause very long delays (up to 45 minutes) in aircraft acquisition of GPS satellites, and in turn may render all loaded JDAM weapons effectively unusable for a given mission. This deficiency is corrected with TAMPS system core Version 6.2.1 and subsequent.

# 3.4 METHODOLOGY

# 3.4.1 OVERVIEW

- **3.4.1.1 General Mission Planning Considerations.** (U) In order to minimize the overall planning and execution effort while maximizing the capability of JDAM weapons, the following considerations are recommended whenever possible.
  - (U) Plan and execute JDAM missions in WGS-84 coordinates.
  - (U) Use steeper dive angles (i.e., 60° or more) to increase JDAM accuracy.
  - (U) Attack a target as a horizontal target if a choice exists.
  - (U) Avoid using a terminal heading to minimize LAR constraints.
  - (U) Avoid dive deliveries, as they do not significantly enhance penetration but reduce weapon LAR.
  - (U) Avoid loft deliveries at medium to high altitudes, as they actually decrease standoff range (LAR).

- **3.4.1.2 General JDAM Mission Planning Flow.** (U) Planning a JDAM attack with multiple weapons on multiple aircraft can be extremely complex and confusing in the planning phase. To simplify the process, the following general planning rules are recommended.
  - (U) Establish a good, consistent naming convention for routes and missions in order to simplify planning.
  - (U) Plan each target as an individual weapon route and give it a simple name.
  - (U) Plan which aircraft will attack which set of DMPIs and write it down.
  - (U) Use the Quantity Release Manager to generate routes for targets requiring more than one weapon.
  - (U) Use the Quantity Release Manager to group weapon releases for each aircraft.
  - (U) Establish a consistent convention for placing missions in dataloads to simplify execution.
  - (U) Use the Mission Packages/Dataloads option.

#### 3.4.2 CREATING A NEW JDAM ROUTE

- **3.4.2.1 Target Coordinate Generation.** (U) Weapon coordinates either may be passed explicitly or must be mensurated implicitly from an assigned target. In either case, the coordinates must meet the minimum standard of accuracy for JDAM employment (Section 1.4.2). There are several sources that provide mensurated target coordinates, each of which having unique characteristics. Specification accuracy requires a TLE of 7.2 meters. Expected accuracy improves with smaller TLE and worsens with larger TLE. Currently, the only acceptable afloat method for mensurating JDAM-quality coordinates is the "controlled method" using a DIWS-A workstation or Precision Targeting Workstation (PTW).
- **3.4.2.1.1 Digital Point Position Database (DPPDB).** (U) DPPDB currently is one of two recommended sources for acquiring JDAM target coordinates. The advantages of DPPDB are good accuracy (superior to photo-based references), mensuration directly into the WGS-84 datum without conversion, the capability of conversion into another datum, and application for almost all targeting requirements. Caution should be exercised in ensuring that the proper datum is requested and received.
- (U) The National Imagery and Mapping Agency (NIMA) is developing the DPPDB as a deployable imagery-based product to support point-targeting. Imagery is provided on 8mm tape and can be hosted on the Digital Imagery Work Station (DIWS-A) or Precision Targeting Workstation (PTW).
- (U) A product known as Digital Precision Strike Suite (DPSS) is a system contained within a line-replaceable avionics unit for direct inclusion in strike aircraft. DPSS borrows the DPPDB technology of line-matching to mensurate target coordinates from referenced and indexed imagery by mathematical association. In this system, a target image template in the appropriate format is entered into the DPSS unit, and a target coordinate can be generated in real time. The goal is to integrate DPSS with onboard sensors and aircraft data processing in order to provide a true real-time, GPS-quality TOO capability in strike aircraft. The F/A-18C/D is not scheduled to integrate DPSS; however, other tactical aircraft may use DPSS to mensurate coordinates and pass the coordinates to a "shooter" F/A-18C/D aircraft.
- **3.4.2.1.2 NIMA Points Program.** (U) The NIMA Points Program currently is one of two recommended source for acquiring JDAM target coordinates. NIMA is very accurate graphic imagery (Figure 3-9). It provides the best possible coordinate accuracy (i.e., lowest TLE) for a specific known location and may be mensurated directly into the WGS-84 datum without conversion. The disadvantage of NIMA is that coordinates may not be available for routine or less prominent targets.

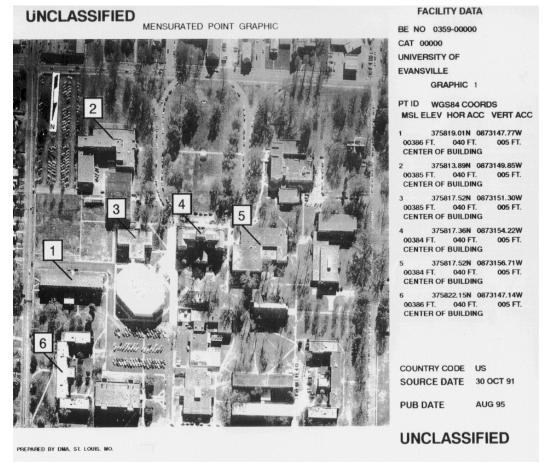


Figure 3-9
TYPICAL NIMA POINTS PROGRAM PRODUCT (U)

- **3.4.2.1.3 Point Precision Database (PPDB).** (U) PPDB, also known as MK-85, may be used, but is recommended only as a last resort. The mensuration source is photographic, and accuracy is marginal for JDAM applications. Coordinates are delivered in the WGS-84 datum.
- **3.4.2.1.4 Maps and Charts.** (U) Standard ground navigation maps and charts are notoriously inaccurate and imprecise, especially with regard to elevation, and therefore are never appropriate for JDAM targeting.
- **3.4.2.1.5 Databases and Publications.** (U) Encyclopedic databases and publications may be used for JDAM targeting only if the datum and source are verifiable. These sources seldom were compiled with the intention of providing target-quality coordinates.
- **3.4.2.1.6 Tasking Messages.** (U) Tasking messages may be used, but only if the datum and source are verifiable. Often, tasking messages arrive with no assigned TLE and no referenced datum. At a minimum, the producer, the source, the datum, the accuracy statement and the date of the message should be verified.
- **3.4.2.1.7 Tomcat Tactical Targeting (T³).** (U) Under certain flight conditions, the F-14 with its LANTIRN pod can produce JDAM targeting coordinates. This data is not used in real time. Referred to as Tomcat Tactical Targeting (T³), F-14 LANTIRN pods can generate LE/CE50-quality WGS-84 coordinates in {dd° mm.mmmm'} format with elevations referenced to HAE. If validity checks of the T³ coordinate data and CE/LE figures are determined to a satisfactory degree, the coordinates may be used for a JDAM mission. T³ coordinate manipulation is discussed in Sections B.1.2.2 and B.1.2.4.

- (U) The following criteria, derived from the post-flight review of a LANTIRN video, must be applied to determine the validity of the derived T<sup>3</sup> coordinates and CE/LE:
  - (U) A "\*\*1" message must be present in the pod data block (lower left quadrant).
  - (U) The target bearing in the target data block (lower right quadrant) must be within 30 degrees of either the aircraft heading (displayed above the steering bar) or the reciprocal of aircraft heading. If this specific criterion is not met, then the LANTIRN line of sight depression angle relative to the horizon, displayed in the pod data block (lower left quadrant), must be greater than 60 degrees, indicating overflight of the target.
  - (U) The combat laser must be selected (i.e., no "T" posted).
  - (U) The target location must be relative either to the AREA track crosshairs or the point in the center of the POINT track box.
  - (U) The slant range to the target must be less than 13.1 nautical miles and the aircraft altitude must be less than 25,000 feet MSL.
- **3.4.2.1.8** F/A-18C/D Airborne Sensors. (U) Although airborne sensors conveniently provide real-time coordinates (through computed transformations of sensed angles and range), the current state of F/A-18C/D tactical airborne sensors is such that coordinate accuracy (TLE) exceeds the minimum requirement for GPS guidance. This renders F/A-18C/D aircraft sensors unusable for JDAM employment either in real-time or as a second-party targeting source.
- **3.4.2.2 Route Definition.** (U) A route is created for each target using the CMPM according to the Smart Checklist. See Annex B. A route consists of at least an impact point and a release point with release conditions, the last of which must be applied before TAMPS will consider the route complete. TLE is specified as provided with the target coordinates. Impact parameters are specified or accepted as default.
- **3.4.2.3 Weaponeering.** (U) Weaponeering may be accomplished using either the native CMPM function or an external application.

#### NOTE

- (U) The correct TAMPS "Ground Plane" option must be selected when entering accuracy probabilities.
- **3.4.2.3.1 CMPM Functionality.** (U) The CMPM has two important limitations. First, it has a limited selection of target classes and subclasses for specifying Mean Area of Effectiveness (MAE). Second, it does not accurately account for bomb burial for instantaneous detonations, and may provide an optimistic damage estimate.
- **3.4.2.3.2 Fuzing-Related Messages.** (U) When mission planning a GBU-31(V)2/B mission configured with the FMU-139 and FZU-48 fuzing configuration, certain CMPM-generated messages are not valid in all cases, as described below.
- (U) The CMPM warning regarding level delivery of JDAM above 20,000 feet MSL should be ignored. Instead, refer to SLIC v2.0 or v2.1 to determine if a planned delivery is authorized with respect to safe escape.
- (U) The CMPM caution "The JDAM MPM calculated time of flight exceeds the maximum time for the selected fuze type" should be ignored. The CMPM assumes incorrectly that whenever the FMU-139 fuze is selected, the MK-122 electrical safety switch is being used. In this assumed configuration, a mandatory TOF limit of 60 seconds is imposed. However, the limitation is not applicable in the FZU-48 configuration. This anomaly is corrected in CMPM 7.0 and subsequent.
- **3.4.2.4 Launch Parameters.** (U) Launch parameters are specified. Once a target, impact, and launch parameters are defined, the CMPM calculates the IRLAR and IZLAR. The CMPM then tailors the IZLAR to approximate the PPIZLAR to be displayed on the F/A-18 HSI Format. With this presentation (Figure 3-10), a valid launch point may be chosen.

#### **NOTE**

(U) Warnings that the CMPM is "unable to calculate A/C LAR" should be ignored if a valid ACI6DOF LAR is generated and the launch parameters are within the attack axis and azimuth restrictions stated in the F/A-18 Tactical Manual.

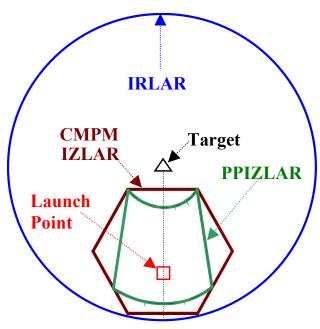


Figure 3-10 CMPM LAR PRESENTATIONS (U)

**3.4.2.5 Trajectory Parameters.** (U) Once a route is defined, crossrange and downrange travel and azimuth angle (Figure 3-11) must be recorded for use in safe escape determination. This is accomplished manually in the CMPM using the range and bearing tool (distance units in feet) to measure on the screen. If the release is on-axis, crossrange travel is zero and clicking on the release point and dragging to the target measures downrange travel. If the release is off-axis, downrange travel is measured along release heading and crossrange travel is measured perpendicular to release heading. Azimuth angle is the angle between the release heading and terminal heading. For heading-undefined releases, this angle is zero.

## 3.4.3 QUANTITY RELEASE

**3.4.3.1 Overview.** (U) A quantity release is defined as more than one JDAM weapon released by one aircraft against one or more targets. Several guidelines simplify the process of planning strikes involving multiple targets and./or aircraft. The most important recommendation for simplification is to load all MU devices identically whenever possible. This provides mission commonality and allows fewer required backup MU devices for the strike. Other ways to simplify this type of mission planning exist. Each target should be planned as an individual weapon route and be assigned a simple name. It is recommended that the plan of which aircraft is to attack which set of DMPIs should be decided and written down for reference before the planning process begins. A matrix kneeboard card formatted to reference the weapons and targets among the various release aircraft should be generated and carried in every cockpit to permit effective backup of primary missions or switching to secondary missions.

#### NOTE

(U) In order to plan a quantity release, at least one route must be defined first.

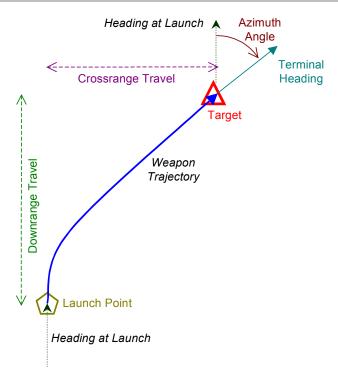


Figure 3-11 JDAM TRAJECTORY PARAMETERS (U)

- **3.4.3.2 CMPM Quantity Release Manager (QRM).** (U) The QRM offers several benefits in planning for both single-target and multiple-target JDAM quantity releases. The QRM "Multiple Weapons/Multiple Target" mode may be used to generate routes for targets requiring more than one weapon. The QRM "Multiple Weapons/Multiple Target" mode may be used to group weapon releases for each aircraft. However, the QRM is not required to plan a quantity of JDAM; the same information generated by the QRM for single and multiple targets can be calculated by hand and used to construct a JDAM quantity release. The QRM also has limitations that may make it cumbersome for a simple quantity delivery.
- (U) When a route is added to a quantity release set, a copy is made, and two versions of the route will exist. Editing one copy of the route will not apply the changes to the other copy. When a route is removed from the quantity release set, that copy is deleted and a single copy will exist on TAMPS, but will not include any changes made to the QRM-copied route. Furthermore, a route that has been added successfully to a quantity release set may be edited only through the QRM.

## **CAUTION**

- (U) If the QRM is closed via the CLOSE MANAGER button without first selecting OK or APPLY, then any changes to the quantity release will be lost.
- **3.4.3.3** Single-Target Quantity Release. (U) Ballistic dispersion characteristic of unguided munitions does not exist as such in guided weapons. In JDAM, ballistic dispersion is replaced with the analogous concept of "GPS dispersion", which is the effect of GPS system error (i.e., PDOP) and inherent autopilot error. Since GPS PDOP is a function of time, date and global position, JDAM weapons launched at the same time against the same target coordinates effectively experience the same GPS system errors and tend to impact in the same location, governed by the PDOP at that time. Therefore, for most single target quantity releases, it is desirable to introduce artificial "dispersion" into the targeting solution by selectively distributing DMPIs about the desired target. DOP is discussed in detail in Annex A.
- **3.4.3.3.1 Single-Target QRM Mode.** (U) The Single-Target QRM mode distributes JDAM weapons over a single target that requires multiple JDAM to achieve desired P<sub>D</sub>. This distribution is calculated geometrically using the user-specified target width, length and axis of orientation, and centered about the target centroid (Figure 3-12), which are the coordinates contained in the TDS.

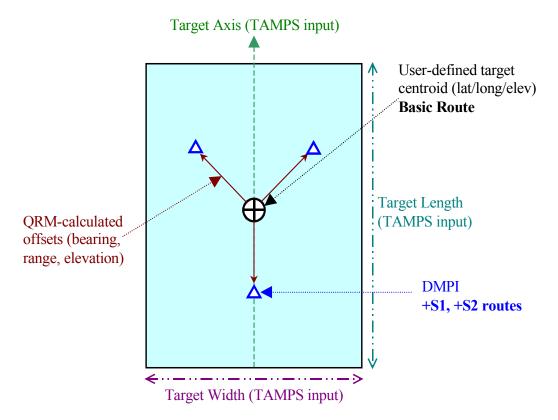


Figure 3-12 QRM DMPI DISTRIBUTION (U)

**3.4.3.3.2** Single-Target QRM Use. (U) Prior to entering the Single-Target QRM mode, the base route for the target is constructed. In the base route, the latitude, longitude and elevation of the target is specified for the centroid of the target, along with the target class, subclass, width and length dimensions, and axis of orientation.

#### **CAUTION**

- (U) The centroid of the target for a single target quantity release cannot be defined using offset data, because the offset field is used by TAMPS to generate each Desired Mean Point of Impact (DMPI). When generating the quantity release DMPIs, the QRM will overwrite any offset data, which may result in wide misses and/or undesirable collateral damage.
- (U) If the CMPM is used to weaponeer the attack solution, then the desired level of damage is selected. The Single-Target QRM computes the number of JDAM weapons required, up to four, to achieve the desired P<sub>D</sub>.

#### **NOTE**

- (U) The Single-Target QRM limitation of four weapons for P<sub>D</sub> weaponeering may result in an invalid case if the specified target size and desired damage level is calculated to require five or more DMPIs.
- (U) Once the number of weapons is determined, the Single-Target QRM then calculates the distribution of the DMPIs across the target and builds a corresponding weapon route for each DMPI. These routes are labeled identically to the base route name with a "+Sn" suffix appended, where "n" is a digit from 1 up to 4 for each DMPI created. In these "+Sn" routes, mission data is identical to that of the base route, except that individual offset data sets are stored in each route.

#### **CAUTION**

(U) If a Single-Target QRM base route includes any offset data, the offset will be lost when overwritten by the individual DMPI offsets as the "+Sn" routes are created. This will result in miss distances for each weapon in the quantity release by the magnitude of the original target offset.

- **3.4.3.4 Multiple-Target Quantity Release.** (U) The overriding concern in designing a quantity release against multiple targets is ensuring that a valid release point is available. As selected targets become more widely dispersed laterally (i.e., the cumulative angle off the aircraft launch heading increases), the available area for an In-Zone release for all the weapons becomes small. It is recommended that, for typical launches near the heart of the altitude and airspeed envelope, target dispersal be limited to 2 nautical miles. However, the CMPM may be used to investigate larger target dispersal and varied launch conditions in order to achieve the desired targeteering.
- **3.4.3.4.1 Multiple-Target QRM Mode.** (U) The Multiple-Target QRM mode provides the capability to plan a single aircraft release of multiple JDAM weapons against more than one DMPI. The Multiple-Target QRM synchronizes release conditions (altitude, airspeed, heading) and release point, and calculates an intersection PPIZLAR that represents a valid In-Zone region shared by every weapon in the quantity release.
- **3.4.3.4.2 Multiple Target QRM Use.** (U) Like the Single-Target QRM, the Multiple-Target QRM requires that the base route for each target be constructed already. A master route is designated among the target routes. The Multiple-Target QRM calculates an intersection of the valid IZLAR of all the selected routes. Copies of each route are saved with identical name (that of the master route) but with a "+Mnn" suffix appended, where "nn" are digits from 01 up to the number of routes included in the quantity release. In these "+Mnn" routes, target information is identical to the original routes, but contain the release location and conditions of the selected master route. Also, each "+Mnn" route has the calculated intersection LAR saved with it. This intersection LAR is displayed on the HSI format as the PPIZLAR (Figure 3-13).

#### **NOTE**

(U) In order to for TAMPS to calculate the intersection LAR, a launch point must be selected that falls graphically on the screen within the intersection of the individual route LARs.

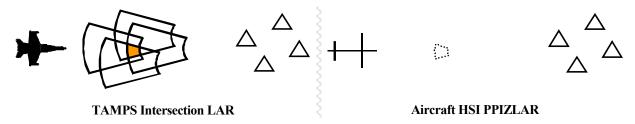


Figure 3-13
MULTIPLE TARGET QUANTITY RELEASE LARS (U)

(U) Once a quantity release has been created, the Multiple-Target QRM provides a practical method of simultaneously changing the release conditions for every route in the selected quantity. A disadvantage of the Multiple-Target QRM is that it effectively "freezes" route target data. Thus, in order to edit target data for one or more routes in the quantity, the original target route must be edited and the entire quantity release process must be repeated. However, the Multiple-Target QRM still may be used to edit the common release point and conditions.

#### 3.4.4 COMPLETING THE MISSION PLAN

**3.4.4.1 Aircraft Data.** (U) After route data has been saved in the CMPM, aircraft data may be added, including relevant waypoints such as ingress route to the launch point.

#### **NOTE**

- (U) Every JDAM pre-planned launch point and target aimpoint is displayed independently of aircraft waypoints. Also, steering to pre-planned launch point is available automatically in the aircraft without the requirement for creating an aircraft steering waypoint specifically for it.
- (U) With SCS 15C and subsequent, the F/A-18 aircraft automatically stores the coordinates of the selected JDAM weapon in waypoint files 51-54 according to Table 3B in order of the priority release station. These waypoints may be utilized during mission planning but will be overwritten as JDAM stations are selected for release, and typically should be reserved during aircraft mission planning.

AIRCRAFT WEAPON STATION	TARGET WAYPOINT FILE
8	51
2	52
7	53
3	54

## Table 3B JDAM TARGET WAYPOINT FILES (U)

(U) When an MU download is requested, GPS crypto keys automatically are appended to the bulk data file on the MU.

#### **CAUTION**

(U) TAMPS will not load the bulk data file onto the MU if valid GPS crypto keys are not available on the TAMPS workstation, but instead will post a "GPS Crypto Keys not available" caution. There is no indication that the MU loaded successfully except for the absence of the aforementioned caution.

#### **CAUTION**

- (U) With the TAMPS system core Version 6.2K and earlier, do not select the "GPS Almanac" upload option in the F/A-18 MPM while mission planning. This option corrupts the aircraft MAGR almanac due to a week-number formatting incompatibility, which can cause very long delays (up to 45 minutes) in aircraft acquisition of GPS satellites, and in turn may render all loaded JDAM weapons effectively unusable for a given mission. This deficiency is corrected with TAMPS system core Version 6.2.1 and subsequent.
- **3.4.4.2 Safe Escape Validation.** (U) For all live warhead JDAM deliveries, the only tool authorized for safe escape calculation is the Stick Length Interactive Calculator, or SLIC. Safe escape for both single and quantity releases is validated using the SLIC planning tool. The SLIC provides the same information provided in the "Authorized Fuze Arming Times/Maximum Stick Length" tables typically found in the F/A-18 Tactical Manual. The authorized fuze arming times and maximum stick lengths ensure that, in the event of a weapon detonation at the selected fuze arming time, the probability of hit on the launch aircraft is within acceptable limits.

#### NOTE

- (U) Safe escape tables for JDAM are not included in the F/A-18 Tactical Manual.
- (U) The SLIC minimum release altitudes keep the aircraft above the maximum fragment envelope for target elevations between sea level and 5000 feet MSL. For target elevations greater than 5000 feet MSL, the release altitude (recovery altitude for dives) must be maintained at least 5000 feet above the target elevation.
- **3.4.4.2.1 Safe Escape Factors.** (U) Safe escape is based on the fuze arm time, the type of warhead, the weapon flight profile and aircraft post-release maneuvering (i.e., relative paths from the release point). Ultimately, safe escape is a function of aircraft-weapon separation at earliest fuze arming time. Several conditions degrade safe escape. A common example is a maximum range, high altitude straight and level release with a straight and level recovery using a 10-second arm time (the minimum allowed). In this case, the long downrange travel reduces the bomb fall as it extends downrange to achieve terminal parameters, so the bomb flies nearer to the aircraft. So the aircraft basically flies directly over the weapon as it arms. A high release altitude aggravates the condition; the lower air density allows early-burst bomb fragments to travel further and faster, increasing the requirement for safe escape separation at bomb arm time.
- **3.4.4.2.2 SLIC Limitations.** (U) The SLIC JDAM impact angle option only has three choices. For angles not listed explicitly, the SLIC must be run for impact angle values that bracket the desired impact angle. The shortest resulting stick time must be used for authorized stick length. For example, if a 45 degree impact angle is desired (SLIC only has options for 25, 65, and 85), then the SLIC must be run for impact angles of 25 and 65. The worst-case result is the authorized stick-length. Interpolation of results is not authorized.

(U) The SLIC v2.1 and prior only supports safe escape calculation for 10 and 14 second arm times. Arm times less than 10 seconds are not authorized. A 20 second arm time may be selected, but restrictions with respect to the 14 second arm time calculations shall apply.

#### NOTE

- (U) SLIC v2.1 and prior do not provide an option for safe escape planning with an FMU-139 set for 14 seconds arm time. In this case, the FMU-152 option with 14 seconds arm time may be selected and used; results are valid for the FMU-139. SLIC 3.0 includes a 14-second option for FMU-139.
- **3.4.4.2.3** Unauthorized Releases. (U) Safe escape cannot be violated; therefore, if the SLIC issues a "UA" response (i.e., "unauthorized") for the specified release, the release must be modified. Fuze arm time may be increased or a breakaway maneuver after release may be specified. Also, changing the order of release may place the worst-case weapon in the best possible position. This is accomplished by moving the defined missions into JDAM on other weapon stations. (SLIC Version 3.0 and subsequent automatically recommends a mission distribution among JDAM release stations to provide safe escape if an unauthorized release is calculated.) In order to support safe escape, it is recommended to always use the longest arm time possible for the mission (while preventing a dud due to TOF) and to employ a breakaway maneuver (away from the target if possible), which is inconsequential to the launch-and-leave JDAM weapon.
- (U) To perform its calculations, the SLIC requires crossrange and downrange travel in feet and azimuth angle in degrees for each planned release. These values are measured in the CMPM. Since SLIC and TAMPS run on different host machines, the TAMPS values must be copied on paper and transferred manually into the SLIC.
- **3.4.4.3 Stores Limitations.** (U) Stores carriage and release limitations are available in the F/A-18 Tactical Manual (or the appropriate flight clearance). Automatic stores limitation determination is available using the Automated Tactical Manual Supplement, or ATACS, version 3.0 and subsequent. The JDAM SLIC 3.0 is integrated with ATACS 3.0 to provide a single reference software program.

#### 3.4.5 NON-EXPIRING BULK DATA FILE

- **3.4.5.1 Utility.** (U) There are many instances when a generic, non-expiring bulk data file is desirable. One example is if in-flight, real-time targeting is expected over a long period of time. A bulk data file with arbitrary information still requires using the CMPM. The non-expiring bulk data file allows the CMPM to be bypassed, but still loads GPS crypto keys on the MU. The non-expiring data load can be created once, in advance, and does not expire until three days after the expiration date entered in the load. This load provides GPS crypto keys to JDAM weapons, with the remainder of JDAM mission data entered manually in real time by the aircrew in the cockpit.
- **3.4.5.2** Creation. (U) Before a non-expiring bulk data file can be created, at least one route of some kind first must have been created and stored in the CMPM. The following steps are used:
  - (U) Open the JSOW/JDAM CMPM.
  - (U) Choose any available Oparea. The resulting data load is available in any Oparea.
  - (U) Create a new mission package and name it appropriately (e.g., "Dummy").
  - (U) Enter a mission package date that corresponds with the route date of any available route.
  - (U) Select that same available route as "PP1".
  - (U) Change the mission package date to a date far in the future. This may be over year in advance.
  - (U) Build the bulk data file and save it.

**3.4.5.3 Employment.** (U) Once a non-expiring data load has been created, the JSOW/JDAM CMPM may be bypassed in a time-critical situation. The non-expiring data load may be loaded for all JDAM stations using the "MU Init File" option in the FA-18 MPM. The aircraft JDAM DSPLY format shall display PP1 valid for all weapon stations included when loading the MU, while PP2 through PP6 shall be crossed out. However, all JDAM PP mission slots are available for entering mission data.

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## 4.0 TACTICAL EMPLOYMENT

#### 4.1 TARGET DESIGNATION

- **4.1.1 PP MISSIONS.** (U) Target and offset data, terminal impact parameters and fuze settings (if using a JPF) may be defined either during mission planning or entered manually in flight. PP mission target designation simply consists of selecting the desired JDAM station and PP mission combination and verifying the targeting and fuzing data stored in the weapon. Although not typical to the concept of operations, no stored PP data is required and missions may be created manually, including manual insertion of GPS crypto keys, provided that GPS-quality target coordinates are available. If a JDAM mission is created manually, only dynamic cues and not pre-planned cues are available in the cockpit.
- **4.1.2 TOO MISSIONS.** (U) TOO target designation is automated and is performed in real time using aircraft sensors or systems. Terminal impact parameters and fuze settings (if using a JPF) may be defined during mission planning or entered manually in flight. TOO target data is not stored. When designating using onboard sensors, the aircraft automatically performs the required transformation from polar coordinates of relative bearing and range from the aircraft to planar coordinates of absolute latitude, longitude and elevation using the aircraft navigational alignment for reference. If created manually or designated in real time, only dynamic cues and not pre-planned cues are available on the HSI format (Section 2.4.11).
- **4.1.2.1 Sensor As a Coordinate Generator.** (U) There are several factors that affect the usefulness of a sensor as a JDAM target coordinate generator. First, sensor command and control must be sufficiently precise. Second, the sensor platform must be sufficiently integrated with the sensor and the weapon. Third, the sensor must possess sufficient point and range measurement accuracy. Finally, aircraft/sensor positioning must meet a threshold pointing criteria, in order to relieve pointing uncertainty due to glancing angles; this factor is not platform-dependent but rather scenario-dependent and sensor-dependent.
- (U) The F/A-18C/D aircraft provides a capable automated interface with which to perform the required coordinate transformations for JDAM targeting and to pass critical targeting information to a JDAM weapon. It also possesses exceptional sensor integration and adequate sensor command and control with which to precisely designate a point target. However, F/A-18C/D sensors currently do not meet the JDAM threshold accuracy specification.

#### **CAUTION**

(U) JDAM TOO targeting currently is not recommended for the F/A-18 aircraft due to inherent sensor/system inaccuracies, unless mission failure or collateral damage due to wide misses can be tolerated.

#### 4.1.2.2 TOO Operation

**4.1.2.2.1 TOO Designation.** (U) JDAM TOO coordinates may be created or updated in the F/A-18C/D aircraft using waypoint designations, visual (HUD) designations, or real-time sensors designations from a FLIR, radar, etc. Coordinates cannot be entered manually into a TOO target data set; the "TOO UFC" option on the MISSION DATA format (Section 2.4.9.2.10) provides UFC entry of terminal impact parameters only. Only offset and terminal impact parameters may be entered or edited manually for a TOO mission.

## NOTE

- (U) When prosecuting a third-party target, the delivered target coordinate should be manually entered into a PP mission for direct target designation, rather that into an aircraft waypoint for subsequent TOO waypoint designation, even if "PRECISE" waypoint entry is available.
- **4.1.2.2.2 TOO Targeting.** (U) When JDAM TOO mode is selected, designation of a target causes the aircraft to pass the designated target as a TOO coordinate to every JDAM station in the currently selected quantity, or the priority station if no quantity is selected. Once a TOO has been designated, the coordinate is displayed continuously on the MISSION DATA format (Section 2.4.9) for each selected TOO mission. This TOO coordinate is updated and passed to the same weapons whenever the designation is slewed or is automatically updated.

- **4.1.2.2.3 TOO Retargeting.** (U) Stepping to another JDAM station or canceling a target designation causes the TOO target coordinate to be retained in the selected weapon(s) TOO mission without further update, such that choosing a particular weapon and TOO mission recalls any previously designated target for that TOO mission. This allows for designation of a different TOO target for each JDAM weapon loaded on the aircraft, and for each TOO mission in each weapon. The net result is the ability to designate and store for later attack up to two targets for each JDAM weapon loaded on the aircraft. If a TOO mission containing stored coordinates is selected when another target designation is created, the stored target coordinates are overwritten with the coordinates of the new target designation.
- **4.1.2.2.4 Waypoint TOO Updating.** (U) When a TOO is designated directly from a waypoint file, coordinates are assigned using the waypoint coordinates and elevation. TOO coordinate updates are not performed as long as the waypoint designation is maintained. If a sensor slaved to the waypoint is used to update, or slew, the designation, the target coordinates are updated according to the sensor inputs. The most important impact of this action is the possible significant change in the target elevation as the computation switches from stored to sensed. Therefore, it is recommended that slewing a waypoint designation using a slaved sensor update be accomplished as early in the attack as possible, to allow the weapon elevation solution to settle after any potential jump prior to release.
- **4.1.2.2.5 Radar TOO Updating.** (U) At the automatic IRA (Inverse Ranging Algorithm) update point at 17.5 miles range, updated target coordinates are not passed automatically to the weapon, which otherwise denies the best available targeting accuracy. This is corrected by manually slewing once inside of the 17.5 mile update range, which causes updated target coordinates to be sent to the TOO missions of the selected JDAM station(s).
- (U) If an expanded ground map is frozen via the ATTK format "FRZ" option, target designation slewing results in updated TOO coordinates. However, the radar image does not update when frozen, so the JDAM TOO coordinate does not include updated sensor information typically associated with manual radar slewing. If the "FRZ" option is deselected inside of the IRA range, then any manual slew results in a radar ranging update.

#### 4.2 PRE-RELEASE

- **4.2.1 NAVIGATION SYSTEM QUALITY.** (U) JDAM employment is optimized with GPS-aided weapon guidance. The weapon requires accurate time and date in order to search for, locate and lock onto GPS satellites after launch within the specification Time To First Fix (TTFF). JDAM weapons receive time synchronization from the aircraft, and if the aircraft system time differs sufficiently from actual ZTOD, weapon acquisition of satellites after launch may not occur, and accuracy will not exceed the higher, INS-only accuracy specification. The weapon always selects GPS information for use in navigation if it becomes available. In the cases where GPS guidance is not available, if TOF is less than 30 seconds or if GPS is denied, then the weapon continues to navigate using only the INS. Due to the drift rate of the INS after the transfer alignment ceases after release, accuracy degrades as a function of time (Figure 1-7). Therefore, in order to ensure the best possible weapon performance and maintain a capability to prosecute attacks using less than 30 seconds TOF, weapon INS quality becomes a tactical consideration. Also, neither aircraft nor weapon navigation quality is a conditional interlock checked by the F/A-18C/D aircraft prior to proceeding with a JDAM release. The aircraft and the weapon permit a release regardless of aircraft GPS availability and/or weapon INS quality.
- **4.2.1.1 Transfer Alignment Maneuver.** (U) During transfer alignment, the aircraft must maneuver to generate a navigation quality in the weapon INS adequate to support release. Normally, this maneuver consists of two legs of at least 90 seconds with at least 30 degrees of heading change in between. Once the weapon navigation status quality achieves "01 GOOD", dedicated maneuvering is no longer required. During long periods of nonmaneuvering straight and level flight, the navigation status quality may degrade, requiring additional maneuvering to reestablish "01 GOOD".

#### **CAUTION**

(U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.

(U) If weapon INS quality stalls at a value less than "01 GOOD", then recycling weapon power restarts the transfer alignment process. This should be accomplished only after ensuring that the aircraft position keeping source is "POS/AINS" to prevent seeding the transfer alignment with inaccurate data.

#### CAUTION

(U) Cycling weapon power results in weapon unavailability during the reinitialization, warm-up and satellite reacquisition process, which can take as long as 5-7 minutes. Aircrew must consider tactical requirements and proximity to launch point before cycling JDAM power.

#### NOTE

- (U) Selection of a JDAM weapon option before achieving "POS/AINS" with 2-digit HERR and VERR values causes JDAM weapon transfer alignments to be seeded with inaccurate position information. The weapon may require up to 45 minutes to filter out the bad data, resulting in potentially degraded weapon accuracy during that period. JDAM weapon power should be selected after achieving "POS/AINS" with 2-digit HERR and VERR. Otherwise, JDAM power should be cycled after achieving "POS/AINS" with 2-digit HERR and VERR values.
- **4.2.1.2 Weapon INS Quality.** (U) The weapon INS quality is the main concern prior to release. Transfer alignment quality is critical to satisfactory weapon performance; JDAM accuracy is only as good as the reference frame in which it operates. Although the transfer alignment quality cue presents worthwhile information to the aircraft for preparing a JDAM weapon for release, the INS quality determines the tactical employment doctrine. Weapon accuracy specifications are presented in Section 1.4.2. Sections 1.3.2.4 and 2.4.6.2.7 discuss JDAM navigation system status and F/A-18 cockpit cues.
- (U) If the INS quality is reported as "GOOD", then the weapon is capable of meeting both the GPS-aided and INS-only accuracy specifications and may be released anywhere in the aircraft IZLAR, regardless of TOF. If the INS quality is reported as "MARG", then the weapon is capable of meeting only the GPS-aided accuracy specification and not the INS-only accuracy specification, and should be released only in the aircraft IZLAR when TOF exceeds 30 seconds (in order to ensure GPS aiding). If the INS quality is reported as "UNST", then the weapon is incapable of meeting either the INS-only or GPS-aided accuracy specifications, and should not be released.
- **4.2.2 GPS STATUS DETERMINATION.** (U) GPS status includes both GPS availability and GPS quality.
- **4.2.2.1 F/A-18 GPS Status Determination.** (U) The F/A-18C/D aircraft provides marginal indications of GPS status, particularly on the display formats associated with JDAM employment. If GPS data becomes invalid for aircraft navigation support when IFA is selected on the Navigation Mode Switch, then the aircraft navigation system transitions to "POS/INS" position keeping. If an invalid GPS condition exists for 65 seconds or more, the aircraft posts a "P/INS" advisory on the display containing caution and advisory messages. Therefore, GPS degradation may be determined by the presence or absence of a "P/INS" advisory or a "POS/INS" position keeping cue. However, these cues are insufficient to determine if the requirement for JDAM specification accuracy is met. JDAM specification accuracy requires HERR and VERR values less than 100 feet each. "POS/AINS" position keeping is available with HERR and VERR values less than 230 feet each.
- (U) GPS HERR and VERR values may be observed directly on the HSI:DATA:ACFT format. This method of verifying the necessary conditions to achieve JDAM specification accuracy is tactically poor. HERR and VERR values are located two sublevels down on the HSI format. This format contains no other tactical information, commonly occupies the less visible HI/MPCD display head, and often is not used in favor of the SA format. Therefore, the location of these important values is considered a tactical liability in the F/A-18 aircraft.

## **CAUTION**

(U) JDAM INS quality does not account for aircraft navigation quality. JDAM INS quality may indicate "01 GOOD" when the aircraft is not in "POS/AINS" and the weapon navigation quality will not support specification accuracy. Aircraft navigation quality must be evaluated as close to the launch point as possible to ensure JDAM performance within the expected accuracy.

- **4.2.2.2 JDAM GPS Status Determination.** (U) JDAM mission planning tools automatically evaluate the availability and quality of GPS to the weapon only in terms of GPS satellite visibility and predicted PDOP. However, the status of GPS availability to a JDAM weapon cannot be determined by the F/A-18C/D aircrew prior to release. JDAM does not attempt GPS acquisition and tracking until after it is released from the aircraft. GPS degradation present in the terminal target area may have no effect on the launch aircraft at the release point. Thus, prediction or determination of GPS availability to the weapon after release in terms of GPS denial or other external factors must come from an external source, as the aircraft and/or aircrew cannot accomplish this autonomously.
- **4.2.2.2.1 Effects of GPS Quality on JDAM.** (U) Large GPS uncertainties must be avoided near the launch point, as any inaccuracies in the aircraft navigation solution propagate via transfer alignment into the weapon navigation solution, and require time to "wash out" of the weapon Kalman filter. A similar problem occurs if the GPS crypto keys are dumped, expire or fail. The resulting degradation in GPS accuracy due to loss of the encrypted P-code (known as Y-code) data may have the same effect of large GPS uncertainties. Note that loss of Y-code does not necessarily result in loss of "POS/AINS" position keeping, as long as Selective Availability dithering is suspended. Therefore, aircraft navigation quality should be monitored as regularly as possible, and then checked as close to the launch point as tactically feasible. If the aircraft displays large 3-digit HERR and VERR values, then JDAM employment is not recommended unless the possibility of large miss distances can be tolerated, as specification accuracy is not expected.
- (U) The requirement for a GPS-quality transfer alignment may be explained by dividing the problem into two simple cases. For a TOF of less than 30 seconds, GPS aiding is unavailable to the weapon. The weapon relies on INS-only navigation. However, the INS quality in the weapon is substandard due to the accuracy uncertainty in the INS transfer alignment hand-off. Therefore, the weapon frame of reference, which includes the sensed launch point and the target location, is inaccurate with respect to truth. With an inaccurate start and finish point, specification accuracy is not expected to be met. For a TOF of greater than 30 seconds, GPS aiding is available to the weapon. However, when the JDAM attempts acquisition of GPS, it must be assumed that the weapon experiences the same GPS uncertainties that the aircraft experiences. If the aircraft does not have GPS-quality information, then the JDAM won't either and, with degraded navigation, the specified weapon accuracy is not expected to be met.
- **4.2.2.2.2 Effect of GPS Availability on JDAM.** (U) In general, the primary tactical consideration is whether or not GPS will be unavailable to the weapon through denial or malfunction after release. If JDAM is expected to acquire GPS, then a TOF of 30 seconds or more allows GPS acquisition and provides more accurate guidance. This is balanced by the potential magnitude of the handoff error should the aircraft experience GPS unavailability. Conversely, if JDAM is not expected to acquire GPS, then a TOF of less than 30 seconds allows the weapon to preserve specification accuracy, and weapon accuracy continues to degrade as a function of TOF. Again, an INS-only release presumes a GPS-quality (100-foot or better HERR and VERR) transfer alignment from the aircraft in order to achieve specification accuracy.
- **4.2.2.3 GPS Antenna Masking.** (U) Section 3.1.1 discusses the considerations associated with JDAM performance when GPS is denied, which can include the case of GPS antenna masking due to maneuvering. Misses on the order of 100 to 400 meters were experienced during testing when presumably inaccurate handoffs due to GPS antenna masking (specifically, high-dive roll-in maneuvers) conspired with poor GPS PDOD and reduced TOF to sufficiently degrade the weapon's navigation solution.
- (U) Should "POS/AINS" position keeping be lost causing reversion to "POS/INS", the F/A-18 aircraft navigation system requires 22 seconds to recover a GPS-aided solution after returning to "POS/AINS" due to Kalman filtering. This is the minimum delay before the JDAM weapon can be expected to receive a TXA with GPS-aided position and velocity information. Note also that this does not include the filtering delay in the weapon itself. Therefore, it is recommended that JDAM not be released until at least 30 seconds after "POS/AINS" is indicated. If radical defensive aircraft maneuvering to include inverted flight combined with large vertical velocities is required in the target area within minutes of the expected launch point, such that "POS/AINS" cannot be recovered for at least 30 seconds prior to the launch point, then it is recommended that JDAM not be released, unless the potential for a wide miss can be tolerated. This consideration includes either preemptive or reactive anti-missile defenses maneuvers and/or high-dive roll-ins.

- **4.2.2.4 GPS Tactical Considerations.** (U) Tactically, the following decision matrix is germane. If the aircraft maintains GPS tracking and it is expected that the weapon will acquire GPS, then whenever possible JDAM should be released with a TOF of 30 seconds or more to exploit GPS aiding. If the aircraft maintains GPS tracking but it is expected that the weapon will not acquire GPS, then whenever possible JDAM should be released on-axis with a TOF to less than 30 seconds, to preserve INS-only accuracy before it drifts. Dive delivery is a method for reducing TOF, but GPS antenna masking is germane (Section 4.2.2.4). If the aircraft does not maintain GPS tracking, do not drop JDAM. Miss distance increases quickly over time when aircraft GPS is unavailable. This is grounds for a JDAM mission abort; there is no satisfactory workaround.
- (U) Releases designed to maximize JDAM accuracy through maximum TOF (i.e., long range and high speed) reduce the probability that the launch aircraft will receive indications of GPS denial due to target area jammers or terrain masking, which may degrade weapon accuracy. Releases planned for minimum GPS aiding, nearer 30 seconds TOF, increase the probability that GPS denial may be recognized due to closer proximity to the target area, but conversely reduce the amount of time available to recognize the conditions and modify the release profile in order to make the necessary TOF adjustment.

## **4.2.3 ENVELOPE MANAGEMENT**

#### **4.2.3.1 Ingress**

- **4.2.3.1.1 Ingress Steering.** (U) The aircraft provides a variety of static (pre-planned) and dynamic envelope cues in three dimensions on the aircraft HUD and HSI formats to assist the aircrew in arriving at an effective release condition. These include cues to allow the aircrew to achieve the pre-planned launch and terminal impact conditions as well as cues to provide the necessary flexibility to reach a valid unplanned, real-time release condition.
- (U) Every JDAM pre-planned launch point and target aimpoint is displayed independently of aircraft waypoints. Steering to the pre-planned launch point is accomplished by selecting the desired PP mission and deselecting HSI waypoint steering; launch point steering then is selected automatically. If waypoint steering directly to the target is desired, with SCS 15C and subsequent the F/A-18 aircraft automatically stores the coordinates of the selected JDAM weapon in waypoint files 51-54 (Section 3.4.4.1) in order of the priority release station.
- (U) The aircraft provides adequate cues for entry and exit of valid launch conditions. HUD A/G and HSI format cues of time with respect to maximum range, in range, in zone, leaving in zone and leaving minimum range, combined with visually distinguishable HSI envelope presentations, are useful and beneficial to the aircrew in gauging potential weapon effectiveness based on position within the various weapon envelopes.
- **4.2.3.1.2 Ingress Maneuvering.** (U) With the exception of the friction brake weapon limits for carriage on the inboard wing stations as discussed in Section 2.2.3.2, F/A-18 aircraft maneuvering otherwise is not constrained by JDAM weapon carriage; the full AOA, g-load, airspeed and altitude maneuvering limits of the aircraft are available. However, consideration must be made for GPS antenna masking in terms of aircraft attitude (Section 4.2.2.4).
- **4.2.3.2 IZLAR Optimization.** (U) The dynamic cues displayed in the aircraft are optimized for attack of horizontal targets using terminal impact angles near 65 degrees, but are valid for vertical targets as well. If a contradiction exists between the dynamic aircraft IZLAR and the static PPIZLAR, it is recommended that the dynamic IZLAR be used. Unless the PPIZLAR is planned to account for the correct target area conditions, such as winds, then the IZLAR provides a more accurate presentation of the valid launch region.
- (U) The displayed LAR may be constrained to a fairly small size if a launch is planned high-off axis, if a large terminal impact angle is commanded, if large weapon turn to achieve terminal heading is required, or if an attack of multiple, widely separated targets is selected. This LAR constriction is countered by maximizing weapon energy at release by increasing release altitude and airspeed

- (U) Combinations of airspeed and altitude may result in loss of LAR cues otherwise present for the same aircraft and target orientation, particularly at low altitudes. In particular, during low altitude loft ingress profiles, no valid IRLAR, IZLAR or Minimum Range Circle may be available for display. However, during the loft pull-up, these cues may appear, often quickly. Therefore, using PP missions to the maximum extent possible will maximize the cues available in the cockpit to prosecute JDAM targets.
- **4.2.3.3 JDAM LAR Cues Mechanization.** (U) F/A-18 JDAM LAR cues as displayed on the HSI format (Section 2.4.11.1) are intuitive and provide satisfactory aircrew situational awareness with respect to the employment of a JDAM weapon. The following example is provided to illustrate the mechanization of LAR cues during a typical ingress to a JDAM target.
- **4.2.3.2.1 General Rules of LAR Display.** (U) Once a JDAM weapon variant is selected (by boxing the associated legend on the STORES format), JDAM cues are available on the HSI regardless of aircraft master mode or weapon selected. This facilitates orientation of the aircraft with respect to the JDAM target and PP launch point (if in PP mode) while other ingress tasks, such as air-to-air search, are performed. However, JDAM LAR cues are not displayed until the aircraft is within 160 miles of a selected JDAM target. Inside of this range, the aircraft will display all JDAM-related LAR cues except for the dynamic IZLAR, which is calculated and displayed only when the aircraft heading meets certain criteria. If the "HSI DCLTR" option on the STORES format (Section 2.4.8.2.2) when in PP mode, selected static PP cues are removed from the HSI format display.
- (U) If no terminal impact heading is defined, then the IZLAR is displayed whenever the target is within 15 degrees of the aircraft heading. If a terminal impact heading is defined, then the IZLAR is displayed whenever the target is within 10 degrees of the aircraft heading and the terminal impact heading is within 15 degrees of the line of sight from the aircraft to the target (Figure 2-48).
- **4.2.3.3.2 Beyond Maximum Range.** (U) As the aircraft approaches the target, the dynamic LAR cues of IRLAR, IZLAR, Predictive Maximum Range and Minimum Range change significantly as a function of aircraft airspeed, altitude and heading, while the remaining cues remain static. If the aircraft is turned directly toward the target, the IZLAR appears as described above, the IRLAR expands to meet the Predictive Maximum Range cue, and the Minimum Range Circle expands. If the aircraft is turned away from the target, the IRLAR contracts away from the Predictive Maximum Range cue, the Minimum Range Circle contracts, and the IZLAR disappears as described above.
- (U) As the IRLAR boundary is approached, the HSI and HUD format Time to Maximum Range (TMR) Timer cues approach zero (0:00).
- **4.2.3.3.3 In Range.** (U) Once inside the IRLAR, the timers are replaced with the "IN RNG" cue. The dynamic cues continue to change as a function of aircraft flight conditions, except for the Predictive Maximum Range and Default to Target Line cues, which are removed. All PP cues are displayed. If the aircraft is steered toward the Pre-Planned Launch Point along the Bearing To Launch Point Line, and aircraft conditions are set to match the TAMPS-planned values, the dynamic LAR approaches the shape, size and orientation of the static PPIZLAR, with variations caused only by differences in the preplanned winds and the actual winds.
- **4.2.3.3.4 In Zone.** (U) Once inside of the dynamic IZLAR, the "IN RNG" cue is replaced with the "IN ZONE" cue on the HSI and HUD formats and the HSI format is automatically decluttered, such that the only remaining cues are the PPIZLAR and Pre-Planned Launch Point cues (if in PP mode), the dynamic IZLAR and the JDAM Target symbol, with the terminal heading cue if defined. If the aircraft is turned sufficiently, the IZLAR disappears ???
- (U) When the aircraft reaches a point where the mission computer calculates that it will exit the IZLAR in 5 seconds, the "IN ZONE" cue flashes to alert the aircrew to this condition. If the aircraft exits the IZLAR, the "IN ZONE" cue is replaced with the "IN RNG" cue, and the LAR cues return to those described in Section 4.2.3.1.3.3.
- **4.2.3.3.5 Inside Minimum Range.** (U) If the aircraft enters the Minimum Range Circle, all cues except for the JDAM Target cue, with the Terminal Heading cue if defined, the Default to Target Line cue and the Predictive Maximum Range cue are removed. The Range Status cue is removed from the HUD and the STORES formats.

#### 4.2.3.4 Wind Effects

- **4.2.3.4.1 Wind Compensation.** (U) In the F/A-18, the IZLAR is calculated referencing aircraft ground speed. This biases the valid launch zone away from the pre-planned LAR, which could place the pre-planned launch point (inside the PPIZLAR) outside of the dynamic real-time IZLAR. If there is a contradiction between PPIZLAR and IZLAR, it is recommended that the dynamic IZLAR be used for release.
- **4.2.3.4.2** "WINDS" Option. (U) The "WINDS" option on the STORES format is available but not functional when JDAM is selected. This option is mechanized for use in conventional high-altitude ballistic bombing. When boxed, the displayed wind data is added into the mathematical computations that determine a ballistic impact point for conventional weapons. JDAM is not aimed and does not fall ballistically, so this option is not applicable to JDAM.

#### **NOTE**

- (U) JDAM LAR calculations use only aircraft ground speed, and any stored aircraft wind data (i.e., "WINDS" option on the STORES format) is ignored.
- **4.2.3.5 Loft LAR Uncertainties.** (U) The dynamic IZLAR contains uncertainties that make it inadvisable for low-altitude lofts using the Auto/Loft release mode. It is recommended that the Manual release mode be used for low-altitude lofts.
- **4.2.4 PROPOSED TACTICAL TIMELINE.** (U) The tactical timeline for JDAM is straightforward. In the most optimistic case, JDAM weapons can be powered up, initialized and conditioned before aircraft takeoff, with no other action on the part of the aircrew besides navigating to the pre-planned launch point, selecting A/G and the desired release mode, selecting the Master Arm to "ARM" and pickling at the launch point. However, there are several decisions that must be made that have a direct effect on JDAM success.
- **4.2.4.1 T Minus 5.** (U) Within T-5 minutes of release, do not cycle JDAM power. There is a 2½ minute GPS warm-up timer, plus time to establish and complete a transfer alignment nominally four to five minutes total. There is no real action required at this checkpoint, but performing the above action inside of this point may result in an otherwise avoidable mission abort.
- **4.2.4.2 T Minus 2.** (U) At T-2 minutes from the planned release point, perform a final check of the navigation status of each weapon selected for release. This may be accomplished via the ALN QUAL cue on the STORES format or the JDAM format using the "STEP" option. The HUD "TXA DEGD" cue provides feedback if one or more JDAM selected for release does not have an INS quality of "GOOD". If the transfer alignment has degraded (due for example to a long, straight run-in) there is time to maneuver to improve the transfer alignment prior to release.
- (U) If a quantity release is selected, then all weapons must be checked individually. Non-failed weapons displaying "UNST" should be deselected and, time and stores and conditions permitting, backup weapons assigned to primary target. Non-failed weapons displaying "MARG" should be deselected if the computed TOF is less than 30 seconds, or the release point may be changed to facilitate a longer TOF.
- **4.2.4.3 T Minus 1.** (U) At T-1 minute from the planned release point, determine the final launch point in order to tailor the weapon TOF to the known or suspected GPS environment. If GPS jamming is expected, establish a TOF of less than 30 seconds prior to release (Section 4.4.1.5). If the aircraft GPS is jammed, abort the release.
- (U) Furthermore, do not execute inverted vertical maneuvering within one minute of release, as this may prevent a valid POS/AINS status at release. Without a POS/AINS status, JDAM effectiveness is degraded significantly.

## 4.3 RELEASE AND POST-RELEASE

**4.3.1 LAUNCH POINT AND LAUNCH PARAMETERS.** (U) For PP missions, it is recommended that actual release point and release parameters match the preplanned parameters as closely as possible whenever feasible, in order to ensure both weapon performance and mission effectiveness in accordance with mission planning. For TOO missions or PP missions that require deviation from the planned launch profile, higher and faster releases always are recommended (Section 3.1.3.2.1).

#### WARNING

- (U) Deviation from TAMPS-planned and SLIC-authorized launch parameters and/or post-release maneuvering may result in departure from the minimum safe escape envelope for the selected fuzing options.
- (U) The JDAM weapon design release envelope fully contains the F/A-18 aircraft basic envelope. Authorized release envelopes are contained in the F/A-18 Tactical Manual or ATACS or the appropriate flight clearance.
- (U) Two other important limitations on release conditions must be considered. The minimum recommended airspeed at release for weapons configured with the FZU-48 is 250 KCAS, in order to facilitate proper FZU operation in providing suitable electrical power to the weapon fuze. The minimum release speed for JDAM is specified as 165 KCAS, in order to provide minimum aerodynamic control by the guidance section.
- **4.3.2 RELEASE PROFILES.** (U) JDAM may be employed effectively in straight and level flight, which is the recommended delivery profile whenever GPS is available, in order to maximize altitude and standoff to prolong the TOF. Other delivery profiles are supported and may provide tactically important benefits, but do not improve and in some cases may degrade JDAM weapon effectiveness.
- **4.3.2.1 Dives.** (U) Dive release profiles do not improve JDAM terminal characteristics, in terms of impact velocity or penetration depth, or overall effectiveness. Furthermore, due to its guided vice ballistic trajectory, dive releases in most cases shrink the JDAM envelope. Therefore, dive deliveries are not recommended, except in certain cases of tactical necessity. Of course, defensive maneuvering to a nose-low attitude for release may be required. Also, if GPS is available for the launch aircraft but is expected to be denied to JDAM, then TOF is recommended to be less than 30 seconds, in order to minimize the INS drift over time. In this case, it is recommended that TOF be minimized by releasing as close to the target as possible within the displayed IZLAR in a shallow dive (Section 4.4.1.5). Regardless of profile, it is recommended that dynamic inverted maneuvers be avoided as the release point is neared (Sections 3.1.1 and 4.2.2).
- **4.3.2.2 Lofts.** (U) Loft delivery profiles do not improve JDAM performance characteristics, in terms of range or TOF, due to the shaped trajectory commanded by the weapon autopilot. To the contrary, in many cases, lofting actually reduces the range capability afforded by a straight and level release under the same flight conditions. Therefore, loft deliveries are not recommended except in cases of tactical necessity. In these cases, due to LAR uncertainties in the dynamic IZLAR at low release altitudes, it is recommended that low-altitude loft deliveries be planned and executed using the Manual release mode vice the Auto/Loft release mode. Regardless of profile, it is recommended that dynamic inverted maneuvers be avoided as the release point is neared (Sections 3.1.1 and 4.2.2).
- **4.3.3 QUANTITY RELEASE.** (U) If a quantity release is selected, then the SMS automatically releases all selected JDAM in the quantity that are inventoried as safe to release (e.g., not WFAIL, hung, etc.). The SMS automatically steps over non-releasable weapons in order to complete the quantity release sequence. Since the SMS employs no asymmetry protection, one or more failed weapons may create an undesirable or uncontrollable weight asymmetry.
- (U) The minimum release interval for JDAM quantities is fixed at 300 milliseconds within the F/A-18C/D SMS, and cannot be overridden by the aircrew. Release interval may be longer than this, but cannot be shorter. With an initial interval of 800-900 milliseconds for the first JDAM store, the minimum required time to release the maximum quantity of four JDAM is 1.7 seconds.
- **4.3.4 SAFE SEPARATION.** (U) The JDAM weapon has separation characteristics similar to that of the low-drag weapon using the same warhead, as the weapon auto-pilot is not enabled until a fixed period after weapon ejection. To ensure safe separation, the aircraft should not be maneuvered for one second after last bomb release.

- **4.3.5 SAFE ESCAPE.** (U) Since the JDAM weapon follows a guided vice ballistic fall trajectory after auto-pilot activation, the appropriate safe escape maneuver must be followed to prevent aircraft damage in the event of early warhead detonation. Note that the JDAM can "self-loft" back to or above release altitude to achieve the desired terminal impact parameters, particularly if the launch airspeed is greater than 460 KCAS. Specific safe escape maneuvers are dictated by the SLIC planning tool. The general rules of JDAM safe escape are:
  - (U) Execute a single turn away. Avoid multiple turns, including S-turns, after release. Avoid delayed turns back across the launch axis.
  - (U) Maintain or increase aircraft velocity.
  - (U) Climb if feasible.

#### WARNING

(U) Deviation from TAMPS-planned and SLIC-authorized launch parameters and/or post-release maneuvering may result in departure from the minimum safe escape envelope for the selected fuzing options.

## 4.4 SPECIFIC TACTICS

#### 4.4.1 AIRCRAFT TACTICS

- **4.4.1.1 Standoff Release.** (U) Standoff release, in order to maximize launch range, is accomplished with very high and fast level releases directly on axis to the target. The total potential (altitude) and kinetic (airspeed) energy of the weapon at release is the main contributor to maximum range and is optimized by direct, on-axis release. During developmental flight test of the GBU-32, a release from 35,000 feet and 1.2 IMN resulted in a maximum range release of 14 miles and a TOF of 136 seconds.
- **4.4.1.2 High Threat Targets.** (S) High threat targets are prosecuted ideally using a high and fast on-axis release. This maximizes threat standoff and allows for increased TOF to exploit GPS-aided guidance. If the high altitude block is denied, the weapon's high off-boresight capability and autonomous guidance may be exploited using tangential off-axis attacks along the primary threat ring. However, high off-boresight attacks require substantial weapon energy at release to overcome the envelope reduction common to off-axis JDAM attacks. Furthermore, the low altitude block may not be available for this tactic, as no valid LAR may exist, requiring instead a medium altitude attack. It may be possible to exploit a high-speed high-threat ingress to achieve a valid and useable off-boresight LAR with which to prosecute JDAM targets at low or medium altitudes.
- (S) Although low altitude on-axis tactics involving loft deliveries may provide improved aircraft survivability in very high threat environments, the reduction in minimum LAR range from low altitude loft deliveries actually can place the launch aircraft in closer proximity to and aligned more on axis with a defended target. The on-axis nature of loft releases may further reduce the threat standoff range in the moments after weapon release.

#### NOTE

- (U) The Auto/Loft release mode is not recommended for low-altitude loft deliveries due to LAR uncertainties in the dynamic IZLAR. It is recommended that the Manual release mode be used for low-altitude lofts.
- (U) In all cases, the best insurance for arriving at a valid JDAM LAR against a high-threat target is a well-planned TAMPS mission.

- **4.4.1.3** Coordinated Tactics. (U) Since JDAM is autonomously guided and independently targetable against up to six stored PP targets, there is little benefit in employing multiple aircraft for attacks that can be supported by a single aircraft, other than that in terms of survivability offered by standard multi-plane integrity and/or the potential backup capability for aircraft or high-level weapon system malfunctions. Therefore, coordinated tactics are not addressed as relevant specifically in terms of JDAM employment. However, in attacks involving multiple targets or multiple weapons against a single target, the redundancy afforded by multiple aircraft increases overall strike flexibility and reduces assumed mission risk. See also Section 4.5.2.
- **4.4.1.4 Penetration Missions.** (U) Penetration missions are optimized by executing according to plans established using mission planning software. When a penetration (e.g., GBU-31(V)4/B) mission is flown in real time, it is recommended that the terminal impact velocity and terminal impact angle values be specified in accordance with existing rules of thumb for penetration weapons in the appropriate reference documents. There is no specific rule of thumb associated with the JDAM guidance kit itself that optimizes penetrator warheads. Although the JDAM interface in the F/A-18C/D aircraft provides specific controls for assigning a commanded impact angle and minimum impact velocity, penetration effectiveness is a function of the warhead according to the established directives.
- (U) If a real-time penetration mission is expected, use of the FMU-152 JPF is recommended, as it provides maximum flexibility in assigning functional delay appropriate to the desired level of penetration and damage.
- **4.4.1.5 Tailoring TOF.** (U) Tailoring JDAM TOF in real time prior to release is an important ability in preserving weapon mission effectiveness. If potential weapon GPS denial can be confirmed during the strike ingress, the ability to modify the launch point and conditions in order to reduce weapon TOF, if the tactical environment exists, provide the aircrew with a means to preserve the best possible INS-only specification accuracy (13 meters). This is accomplished by reducing the weapon TOF to less than 30 seconds as a method to constrain the INS drift over time. Although the weapon possesses a specification accuracy of 30 meters for INS-only deliveries of 30 seconds TOF or more, this lesser accuracy reduces overall JDAM mission effectiveness and should be avoided if conditions permit.
- (U) JDAM TOF is a function primarily of standoff distance, release energy (airspeed and altitude) and terminal parameters. For a constant release altitude and airspeed, delaying the release point nearer to minimum range in order to reduce standoff range generally reduces TOF, but not necessarily significantly or sufficiently to achieve 30 seconds TOF if significant release energy is present. For a constant release airspeed, reducing airspeed also reduces TOF. For a constant altitude, reducing airspeed does not significantly reduce TOF. The combination of a reduction of release altitude and standoff range is the best way to reduce JDAM TOF. Therefore, an erect pushover (in order to maintain crucial GPS tracking) to establish a shallow dive delivery for a release below 25,000 feet (ROE permitting) near the displayed dynamic minimum range is the best tactical profile to reduce TOF.
- (U) Regardless of the profile required to reduce JDAM TOF, it is strongly recommended that a mission which provides less than 30 seconds TOF be planned in advance using TAMPS and stored as an alternate PP mission for selection in the cockpit. This provides the best probability of mission success should an alternate mission be required, and also provides the strike planner with a basis for coordinating an alternate strike support timeline. Real-time tailoring of JDAM TOF cannot be guaranteed to be effective, particularly under combat conditions, and should be avoided whenever possible.
- **4.4.1.6 Weapon and Master Mode Selection.** (U) There is no restriction on the selection of aircraft master mode and/or non-JDAM weapons prior to selection of JDAM for release. Once a JDAM variant is selected by boxing an appropriate select option on the STORES format (Section 2.4.6.1), power is applied to all inventoried JDAM variants. After proper conditioning, all JDAM variants then are passed and receive transfer alignment data continually, regardless of aircraft master mode or subsequent selection of a different A/A or A/G weapon. In order to release JDAM, all that is required of the aircrew is to select the A/G master mode, ensure that the desired JDAM variant is selected (boxed), and satisfy the A/G Ready requirements (i.e., weapon available, MAN release mode selected or "In Zone" and AUTO/LOFT release mode selected, etc.). This feature of the F/A-18 aircraft provides the aircrew with unparalleled flexibility in weapon system management options during ingress and egress on a JDAM strike mission.

#### 4.4.2 BATTLE USAGE

- **4.4.2.1 Optimized JDAM Phase-In.** (S) JDAM is particularly effective against fixed area targets where, when fixed strike loadouts are assumed, its point targeting capability becomes a tangible force multiplier as compared to conventional ballistic weapons. JDAM has a potential use against many high-value targets early in the battle timeline, particularly command and control structures, isolated fixed IADS elements, communications and industrial complexes, POL fixtures and transportation choke points such as bridges. However, due to its minimal standoff capability compared to other tactical weapons such as JSOW and propelled weapons, JDAM is not the most desirable weapon of choice against defended targets while the enemy IADS is still effective. Therefore, it is expected that JDAM utilization will increase after target area survivability is improved by initial attacks using true standoff weapons. Nevertheless, JDAM usage is perfectly compatible with and can materially enhance the effectiveness of standard integrated strikes employing on-timeline SEAD in the target area, in that the strike aircraft are exposed to the same threat level but enjoy the increased single- and multiple-weapon P<sub>D</sub> of JDAM.
- **4.4.2.2 Battle Area Interdiction.** (S) Although JDAM specification accuracy makes usage for battle area interdiction feasible, the lack of a moving target capability inherent in a bomb-on-coordinates weapon reduces the potential JDAM target set. Fixed or immobile mechanized artillery and troop placements are excellent candidates for JDAM attacks. However, due to the fixed turnaround time in mensurating and programming weapon targeting data, the potential for mobile target relocation reduces overall effectiveness. The F/A-18C/D aircraft currently has no sufficiently precise self-targeting TOO capability, and use of JDAM using a radar or FLIR handoff may reduce JDAM CEP sufficiently enough to render it no more effect effective than an unguided GP bomb.
- (S) Furthermore, fixed targets located inside of compact, high-wall berms present a challenge for JDAM, particularly if the DSU-33 proximity sensor is not used. JDAM's 13-meter specification CEP presents the potential for near misses inflicting little or no damage. The factors of target relocation and protected fixtures during Operation *SOUTHERN WATCH* combined to drive JDAM effectiveness below 50%, even though several fixed, open targets such as surface-to-air acquisition radars were included along with bermed artillery.
- (S) Unfortunately, due to the non-ballistic trajectory of JDAM and the nature of GPS guidance errors, doubling JDAM targeting is not always tactically effective. Experience has shown that multiple JDAM weapons released against a single DMPI have tended to cluster about a miss point relative to the target based more on GPS navigation error dispersion (relative to PDOD, or ZTOD of the drop) that the truly ballistic dispersion of the guidance error associated with the JDAM autopilot. That is, two bombs released near the same time may tend to miss by the same magnitude and direction based on GPS error. Therefore, especially against bermed targets or targets located amid other types of above-ground physical obstructions, altering planned weaponeering to include two warheads when one warhead meets the P<sub>D</sub> requirement does not necessarily increase the probability of kill. Double-targeting, however, does improve P<sub>D</sub> in terms of single-weapon fuzing failures.

#### 4.4.3 AIRWING INTEGRATION AND DECONFLICTION

- **4.4.3.1 JDAM** in the Electronic Jamming Environment. (S) The latest information on EA-6B and GPS weapons deconfliction is available on the NSAWC SIPRNET homepage. The decision to employ JDAM in an EA-6B (Band 4 or 6) or threat jamming environment can be reduced to the following options: 1) If possible, control the GPS jamming by destroying the threat GPS jammers or limiting EA-6B jamming if there is no threat to the strike aircraft, 2) If EA-6B jamming is required because of the threat or the threat GPS jammers can not be destroyed then employ JDAM in the weapon GPS denied mode (IMU-only) and reduce the TOF to 28 seconds or less. If a 28 second of less TOF can not be accomplished then use multiple JDAM or choose another weapon to accomplish tasking.
- (S) JDAM can not be employed when the launch aircraft is being denied GPS. The launch aircraft must have access to GPS information to provide JDAM with a valid transfer alignment prior to release. All valid JDAM tactics assume that the launch aircraft maintains POS/AINS at the launch point, and that GPS-aided CEP is only available with two-digit HERR and VERR values. If JDAM TOF exceeds 28 seconds (up to 90 seconds, by specification) and the weapon is denied GPS, then the weapon CEP will degrade from a GPS-aided 13 meters to an IMU-only 30 meters. A 30 meter IMU-only CEP should accomplish most tasking. (See NSAWC SIPRNET STANDARDIZATION webpage for examples of weaponeering.)

- **4.4.3.1.1 JDAM Guidance Priority.** (S) If a decision is made to prioritize full GPS guidance for JDAM weapons, then EW must be tailored to prevent L1 and L2 band (Bands 4 and 6, respectively, in EA-6B Prowler aircraft) jamming along the JDAM launch-point-to-target axis to allow for mission success.
- (U) For on-jammer-axis attacks, it is recommended that JDAM launch points be selected that are at least 20 miles from L1 jamming and at least 10 miles from L2 jamming, with the jamming aircraft offset away from the JDAM target area. Note, however, that with the rear mounting of its GPS antenna, JDAM is more vulnerable to standoff jamming from behind than other GPS-aided weapons, as no weapon masking occurs, and that increased standoff only improves the probability that weapon GPS acquisition will occur.
- (S) For off-jammer-axis attacks, it is recommended that JDAM launch points be selected that are outside of the jammer beam width cone oriented towards the enemy radar, which for an EA-6B Prowler is  $\pm$  28 degrees for Band 4 (L1) jamming and  $\pm$  20 degrees for Band 6 (L2) jamming. An off-axis release is strongly recommended if the minimum separation criteria for on-jammer-axis attacks cannot be met.
- (S) If the orientation of the jammer and strike aircraft is such that effective GPS jamming will be present anywhere from the launch point to the target, then it is recommended that L1 and L2 band jamming be inhibited from at least one minute prior to the JDAM launch point, to ensure the POS/AINS requirement can be met at the launch point, to at least 15 seconds after predicted impact, to support the GPS-aided CEP effectiveness.
- **4.4.3.1.2 EW Jamming Priority.** (S) With an EA-6B Prowler jamming in Band 4 and/or Band 6 inside of effective range (Section 4.4.3.1.1), the JDAM GPS receiver is expected to be denied valid GPS data. If the threat environment requires Band 4 and/or 6 jamming and JDAM employment is desired, JDAM IMU-only tactics are available, with TOF tailored to 30 seconds or less to preserve a 13-meter CEP effectiveness. It is recommended that, should GPS band jamming be expected in the target area, that backup missions be planned to allow for disciplined employment to achieve a TOF of less than 30 seconds.
- (S) Finally, the strike planner is always afforded the opportunity to deconflict strike EW simply by selecting weapons other than JDAM that are not vulnerable to the planned EW environment.
- **4.4.3.2 TOT Control.** (U) F/A-18C/D integration of JDAM includes excellent cockpit cues of TOT for a JDAM mission, including consideration for JDAM TOF. These timing cues, presented on both the HUD and STORES formats, provide the aircrew with sufficiently adequate and visible information with which to place JDAM on the selected target according to a very precise strike timeline. Furthermore, cockpit timing cues are dynamic and not tied to preplanned mission data, such that strike aircraft may switch to an alternate or emergency release profile and still reasonably meet a defined strike timeline.

#### 4.5 BASIC INFLIGHT TROUBLESHOOTING

#### 4.5.1 WEAPON POWER CYCLES

- **4.5.1.1 Effects.** (U) JDAM power is cycled in a variety of troubleshooting scenarios. The JDAM weapon has no static memory other than that required to store the weapon OFS; no other data can be stored with power off. GPS ephemeris data, GPS crypto keys, targeting data and the weapon transfer alignment are not maintained when power is deselected. When weapon power is cycled, the ephemeris is reloaded and the transfer alignment is reinitiated. If the weapon expects an ephemeris update but doesn't get one, it will post the NO GPS DATA advisory until a successful ephemeris download is completed. This is true also if a communication error prevents the weapon from receiving a valid ephemeris update from the MAGR.
- **4.5.1.2 Methods.** (U) Weapon power may be cycled by deselecting and reselecting (i.e., unboxing and boxing) the appropriate JDAM weapon variant legend on the STORES format, performing an IBIT on the weapon or weapons (via the JDAM option on the BIT:STORES:STATION format), or cycling the aircraft mission computers.

#### 4.5.2 TRANSFER ALIGNMENT PROBLEMS

- **4.5.2.1 Bad Alignment Data.** (U) If inaccurate transfer alignment data has been passed to JDAM, such as selecting the weapon before achieving "POS/AINS" aircraft position keeping, the quickest way to remove it is to reinitialize the weapon by cycling weapon power, which will re-seed the navigation solution. This in turn invokes the 2½ minute GPS warm-up timer. To avoid this, it is recommended that whenever possible JDAM not be powered up until an "OK" fine alignment is achieved and the MAGR is receiving quality position information. However, this may not always be practical, especially during embarked operations when GPS acquisition may be delayed due to interference but completing a weapon BIT before launch is critical. Therefore, if the initial transfer alignment data is suspect, cycling weapon power with known good alignment data will correct any potential accuracy problem, at the cost of a few minutes of weapon unavailability.
- **4.5.2.2 Poor Alignment Quality.** (U) Weapon alignment quality is continually reported from all JDAM weapons to the aircraft. Various cues and advisories are provided to alert the aircrew to a degraded navigation status for a JDAM weapon. The transfer alignment process requires time to achieve a satisfactory ("GOOD") alignment quality. Furthermore, the transfer alignment process is reinitialized any time the weapon power is cycled.
- (U) Before troubleshooting poor alignment quality, the TIMING cue should be referenced. Transfer alignment does not begin until the GPS is warmed up and initialization is complete. However, it is possible that weapon alignment quality never improves from the initial "10 UNST" or hangs up at some intermediate value before achieving a "GOOD" status. There are three possibilities, all of which require specific handling.
- (U) If the alignment quality appears to stall at "MARG" or "UNST" with a relatively high transfer alignment quality numeric (i.e., 4 or greater), then cycling weapon power will reinitialize the transfer alignment and will clear out potentially bad data in the weapon INS. In the vast majority of cases, the period of loss of weapon availability during reinitialization balances equitably with the loss of weapon utilization due to degraded navigation quality.
- (U) If the alignment quality appears to stall at "MARG" or "UNST" with a relatively low transfer alignment numeric, then most likely the aircraft is passing satisfactory transfer alignment data but some external environmental factor, such as vibration, heading misalignment, accelerometer inaccuracies, etc., is affecting the ability of the weapon INS to adequately resolve a state vector. In this case, there is little that the aircrew can do to rectify the situation. Cycling weapon power may have no effect at all.
- (U) If the alignment quality degrades from "GOOD" to "MARG" or "UNST", then most likely the aircraft maneuvering is insufficient to provide transfer alignment data of sufficient quality to support the weapon INS alignment. In this case, performing a transfer alignment maneuver (Section 4.2.2.1) should cause the alignment quality to return to a "GOOD" status.

#### **NOTE**

- (U) The plain language alignment quality cue may lag the numeric transfer alignment quality cue by up to 60 seconds due to Kalman filtering in the weapon INS.
- **4.5.2.3 TXA DEGD Advisory.** (U) The TXA DEGD advisory is displayed whenever any JDAM weapon selected for release has an alignment quality less than 01 or 02 GOOD. Note that this is normal on deck, before an adequate transfer alignment maneuver has been performed. This advisory is directly related to poor alignment quality. See Section 4.6.1.2.

#### 4.5.3 GPS PROBLEMS

**4.5.3.1 No Satellite Acquisition.** (U) No satellite acquisition may be indicated by no GPS time, a "HOLD" status for JDAM weapons on the STORES format wing planform, or no HERR or VERR values on the HSI:DATA:ACFT format. Normal GPS acquisition should occur within three minutes of selecting the GND align position on the INS switch, which applies power to the MAGR as well.

- (U) If the MAGR has not acquired satellites three minutes after power-up, the first step is to check Waypoint 0 for correct information. Then, ZTOD and date can be entered via the "TIMEUFC" option on the HSI format. The correct date is critical to satellite acquisition; while the MAGR can overcome errors in ZTOD if provided fresh almanac data, a date error can be terminal. Zulu date is entered by selecting SET:DATE and entering the date in "mmyydd" format, with no leading zeroes for the month. For example, March 29, 2002 is entered as "32902" and not "032902". ZTOD entry is straightforward.
- **4.5.3.2 "KEYS INVALID ENTRY" Advisory.** (U) The "KEYS INVALID ENTRY" advisory is an indication that the MAGR contains invalid keys. There is no remedy in the cockpit. The MAGR must be rekeyed with valid keys externally using a KYK-13. A MAGR is essential for a JDAM mission, and a backup aircraft should be used if available, or the JDAM mission should be aborted.
- **4.5.3.3** "NO GPS DATA" Advisory. (U) The "NO GPS DATA" advisory is an indication that valid GPS data has not been provided to the weapon. After startup, it is not uncommon to receive this advisory, as the MAGR and the JDAM weapons complete their startup tests and initialization routines. This may require 3-5 minutes. If the MAGR never acquires satellites, then this condition should be remedied first (see Section 4.6.2.1). If the MAGR acquires satellites but the advisory remains, then a problem probably exists in the weapon, and weapon power should be cycled (via the weapon variant on the STORES format). If after several weapon resets the advisory remains, the weapon may be released in INS-only mode, with a TOF less than 30 seconds, provided that the MAGR provides a GPS-aided navigation solution to the aircraft with 2-digit HERR and VERR values.
- **4.5.3.4** "NO GPS KEYS" Advisory. (U) The "NO GPS KEYS" advisory is an indication that valid GPS crypto keys for JDAM weapons cannot be located on the MU or cannot be verified by the JDAM weapons. If valid GPS crypto keys are not present on the MU, then the only practical solution is to use a backup MU to provide GPS crypto keys to the JDAM weapons. If a backup MU is not available, but printable GPS crypto keys are available in the correct format, then this information may be entered manually by the aircraft using the GPS ENTRY format. Note that this latter, manual method is time-consuming and vulnerable to entry errors that cannot be identified or verified easily and may result in GPS crypto key invalidation.
- (U) If valid GPS crypto keys can be confirmed on the MU but are not being verified by the weapon, then the problem may rest with the time/date indexing of the existing keys and the current ZTOD and date should be reentered. ZTOD and date are entered by selecting the TIMEUFC option on the HSI format. Zulu date is entered by selecting SET:DATE and entering the date in "mmyydd" format, with no leading zeroes for the month. For example, March 29, 2002 is entered as "32902" and not "032902". ZTOD entry is straightforward.

## 4.5.4 WEAPON STATUS PROBLEMS

- **4.5.4.1 WFAIL** Weapon Status Message. (U) A WFAIL status indicates two likely possibilities. If the WFAIL is accompanied by a subsystem failure message on the JDAM DSPLY format, then the failure status has been declared by the weapon BIT logic. If the WFAIL is not accompanied by a subsystem failure message on the JDAM DSPLY format, then the failure has been declared by the aircraft. This usually indicates a communication timing/synchronization problem between the aircraft and the weapon, where the aircraft does not receive a mandatory response from the weapon in the allotted time and assumes that the weapon has failed.
- (U) If a weapon is declared a WFAIL, the first step is to retest the weapon via an IBIT; this is accomplished by selecting the JDAM option on the BIT:STORES:STATION format. If the WFAIL clears, it is recommended that the mission be continued. If the WFAIL remains, IBIT should be attempted a second time after cycling the weapon power (via the weapon variant on the STORES format) and cycling the mission computers. If a WFAIL remains after the second WFAIL, it is recommended that the weapon be considered unreleasable, and whenever possible the mission should be aborted unless a backup weapon or event aircraft is available.
- **4.5.4.2 WDEGD Weapon Status Message.** (U) A "WDEGD" status indicates that a weapon has an internal subsystem failure which degrades its normal functionality but does not preclude launch because viable workarounds exist. The actual problem can be identified on the JDAM DSPLY format. This status may be caused by a "GPS FAIL", "TIK FAIL", or "JPF FAIL" subsystem message.

- (U) "TIK FAIL" indicates a telemetry package failure and should not preclude operational launch; no workaround is required. "JPF FAIL" indicates an FMU-152 communication failure; the fuze defaults to the faceplate settings. "GPS FAIL" indicates a weapon GPS receiver failure; the weapon still functions adequately in the INS-only mode. However, in order to retain the GPS-equivalent specification accuracy, weapon TOF must be reduced to 30 seconds or less, in order to avoid inaccuracy due to INS drift without GPS updates.
- **4.5.4.3 HOLD Weapon Status Message.** (U) A "HOLD" status indicates no valid Zulu time and/or date is available to the weapon. The correct ZTOD and date can be entered via the "TIMEUFC" option on the HSI format. The correct date is critical to satellite acquisition; while the MAGR can overcome errors in ZTOD if provided fresh almanac data, a date error can be terminal. Date is entered on the UFC "TIMEUFC" format by selecting SET, DATE and entering the date in "mmyydd" format, with no leading zeroes for the month. For example, March 29, 2002 is entered as "32902" and not "032902".
- **4.5.4.4 EFAIL Weapon Status Message.** (U) The F/A-18 has strict timing requirements for most aircraft functions. When an erase command is sent, the reply of completion must occur within a specified period. However, JDAM weapons do not complete the commanded crypto key auto-erase function in the 6 seconds currently prescribed in SCS 15C and prior. Upon landing, the weapon always degrades to EFAIL following auto-erase and sets the "C05" (weapon classified) MSP code. To avoid this expected auto-erase problem, whenever possible JDAM weapons should be erased before landing using the ERASE JDAM option on the STORES or JDAM DSPLY formats. After erasure, JDAM weapons may continue to be powered, and in fact this is recommended for TAS fault isolation purposes, particularly during arrested landings.
- (U) If JDAM is not erased airborne and sets EFAIL once on deck, the ERASE JDAM option is no longer functional. Two methods still are available to successfully erase JDAM. A ground crew may erase JDAM with a CMBRE after shutdown. If this is not feasible or desirable, such as during carrier operations, an SMS re-inventory may be forced by cycling the SMS circuit breakers or both generators to reset the weapon status. Then, the ERASE JDAM option erases the weapon correctly.
- (U) The auto-erase timing anomaly is corrected in SCS 15C+ and subsequent.

#### 4.5.5 BULK DATA PROBLEMS

- **4.5.5.1 Corrupted or Missing JDAM Data.** (U) In any case of identified JDAM bulk data transfer errors, the first step is to attempt a reload of the JDAM data. This is accomplished most simply via the "JDAM" reload option on the MUMU:MORE format. Reload also may be accomplished by removing and reseating the MU, cycling the mission computers, or deselecting and reselecting the JDAM variant option on the STORES format.
- (U) If the errors appear to be resident in the bulk data file itself, then the aircrew have various levels of recourse for workaround. Targeting and fuzing information may be inserted manually, provided that this information is provided on flight cards. However, if an error exists in the GPS crypto keys ("NO GPS KEYS"), then the aircrew have little recourse since hard copies of crypto keys are not carried in the aircraft as a matter of course.
- **4.5.5.2 ERROR: JDAM Advisory.** (U) This contingency is addressed in the same manner as corrupted or missing JDAM data.
- **4.5.5.3 MU LOAD Caution.** (U) If the mission computers show no communication with the MU, an MU LOAD caution is displayed. Communication can be restored with a functional MU by removing and reseating the MU, cycling the mission computers, or replacing the MU with a spare, if available.

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# ANNEX A JDAM Theory of Operation

## A.1 INTRODUCTION

**A.1.1 OVERVIEW.** (U) JDAM is a Bomb-On-Coordinates (BOC) weapon. Accurate guidance is accomplished through a self-contained GPS-aided INS that guides the weapon from the release point to precise GPS-referenced target coordinates regardless of weather, camouflage, or obscurants. This capability provides a simultaneously more lethal and survivable alternative to many other precision weapons and all general-purpose bombs. JDAM and other BOC weapons resolve the tactical shortcomings of many other precision weapons, such as Laser Guided Bombs (LGBs), which require both a clear line-of-sight to the target and continuous designation. BOC weapons also provide greater accuracy than conventional weapons, limiting collateral damage and providing a superior probability of destruction. The end result is enhanced aircrew survivability and increased mission effectiveness.

**A.1.2 CAPABILITY.** (U) JDAM is capable of release in sequential quantities against one or more targets. The JDAM guidance set controls the terminal trajectories of the weapon to achieve widely varied impact angles against both horizontally and vertically oriented targets at an angle of attack of less than 5 degrees. JDAM is capable of being released from a wide range of airspeed, altitude and attitude combinations, further adding to its versatility. The JDAM guidance law commands the optimum trajectory from the release point to obtain the planned impact conditions at the target.

#### A.2 BOC WEAPON COORDINATE SYSTEMS

- **A.2.1 GEODETIC SYSTEMS.** (U) Employing BOC weapons requires a common reference from which to extract precise target coordinates. This is accomplished through a geodetic datum system. A geodetic system is a mathematical model of the earth used to calculate coordinates on any map or chart. It is composed of a smooth, geometric ellipsoid reference model constructed about a reference point (origin) and contains a well-defined series of points (a control network) used for the placement of a coordinate system. A geodetic system is further broken down into both a horizontal datum and a vertical datum.
- **A.2.1.1 Horizontal Datums.** (U) The term "Horizontal Datum" is another name for a coordinate system. The most commonly used coordinate system is the latitude, longitude, and elevation system in which the prime meridian and the equator are the reference planes used to define latitude and longitude.
- (U) An Earth-Centered Earth-Fixed (ECEF) coordinate system is used to define three-dimensional positions with respect to the origin of a reference ellipsoid, which typically is the earth's center of mass. From the origin, the Z-axis points toward the north pole. The X-axis is defined by the intersection of the planes of the prime meridian and the equator. The Y-axis completes the system measured in the plane of the equator, 90° east of the X-axis. Of the several ECEF coordinate systems, only the WGS-84 system (Figure A-1) has been established as the standard for GPS and, thus, BOC weapons. It is critical that coordinates used by BOC weapons be defined using the WGS-84 system.
- **A.2.1.1 Vertical Datums.** (U) The term "Vertical Datum" is also referred to as a "Zero Surface". In any geodetic system, elevation is measured in reference to that system's zero surface. Just as there are many different horizontal datums, so there are many different vertical datums. Accurate elevation measurements depend upon defining an accurate zero surface from which to base them.
- (U) Traditionally, Mean Sea Level (MSL) is used as the zero surface for measuring topographic elevation. However, by definition, MSL varies with tidal shifts. It is nevertheless a close approximation of another, more accurate surface called the geoid. The geoid derives its accuracy by modeling changes in the earth's gravitational pull due to land mass. For example, a mountain represents increased mass and, thus, increased gravity, resulting in a rise in the contours of the geoid model. Because of its accuracy, the geoid is the true zero surface for measuring elevations, and MSL elevations are actually measured as height above the geoid.

(U) In addition to MSL, another common elevation is Height Above Ellipsoid (HAE). HAE uses as its zero surface the smooth, geometric model of the earth associated with a particular geodetic system. The WGS-84 ellipsoid is the zero surface used by the GPS system. Thus, GPS systems are based on HAE elevation.

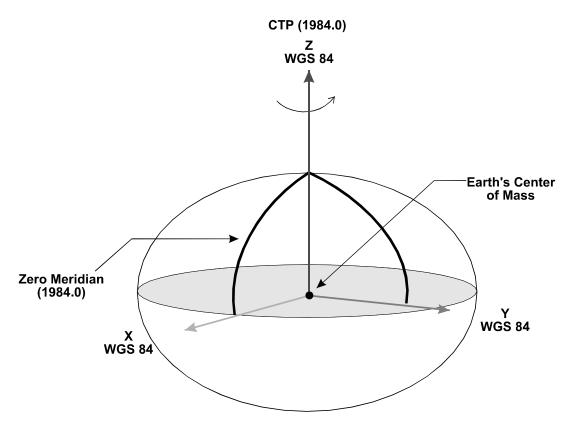


Figure A-1
EARTH-CENTERED, EARTH-FIXED REFERENCE SYSTEM, WGS-84 (U)

(U) Although most terrestrial elevations are stated in MSL, each GPS receiver contains a geoid model for converting MSL to HAE automatically. This model is used to define geoid height, which is the separation between the geoid and the ellipsoid (Figure A-2). When geoid height is applied to an MSL elevation, it converts that elevation to HAE for use by the receiver. Since little precision is lost in this conversion, when targeteering for BOC weapons it is acceptable to define target elevation in either MSL or HAE.

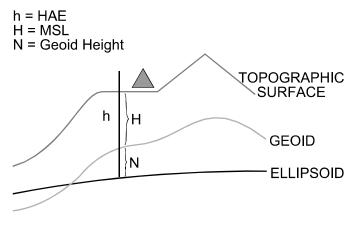
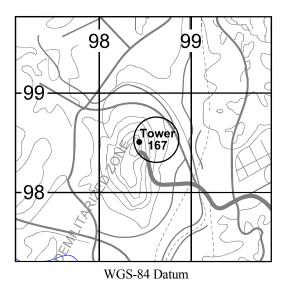
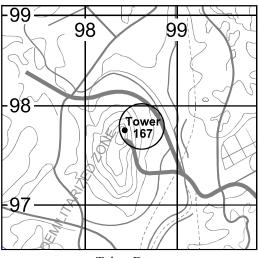


Figure A-2 VERTICAL DATUMS (U)

**A.2.2 WGS-84 REQUIREMENT.** (U) WGS-84, and its constituent horizontal and vertical datums, has been designated by the Department of Defense as the mandatory datum for use in the armed forces of the United States. However, the cost of immediate conversion of all mapping systems and sources is prohibitive. Because GPS requires the accuracy of WGS-84, any targeting process must include conversion if a different datum such as NAD-83 or WGS-72 is used to determine the coordinates and elevation of a DMPI. Failure to use the proper datum can introduce errors in the hundreds of meters. In summary, when defining the DMPI for a BOC weapon, the latitude and longitude must be defined using the WGS-84 coordinate system with elevation given in either MSL or HAE.





Tokyo Datum

Figure A-3
COMPARISON OF TWO DATUMS (U)

## A.3 GLOBAL POSITIONING SYSTEM (GPS)

- **A.3.1 THE GPS SYSTEM.** (U) GPS is a precise, worldwide radio-navigation system formed from a constellation of satellites and a network of ground control facilities. The space system consists of 24 NavStar satellite vehicles (21 inuse vehicles and 3 active spares) that orbit the earth every 12 hours in six distinct orbital planes. Orbital altitude is such that the satellites repeat the same ground track over any point on earth approximately every 24 hours, actually 4 minutes earlier each day. This distribution provides users with between five and eight satellites visible from any point on earth.
- (U) Control of the GPS system is provided by a master control facility and a worldwide monitoring network. The monitor stations use passive receivers to track satellites in view, collecting range data from each satellite. That data is passed on to the master control facility to determine orbits and to update the navigation message of each satellite. Periodically the master control facility transmits the updated information to each satellite for retransmission in the "NAV-messages".
- **A.3.2 GPS NAVIGATION THEORY.** (U) The basis of GPS navigation theory is the age-old concept of triangulation position fixes (Figure A-4). In order to perform triangulation, GPS receivers measure distance from the satellites using the travel time of radio signals. The GPS concept is based on accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a transmitting satellite to a user. Each satellite periodically transmits a signal at a specified time. Part of that transmission is a ranging code which enables a receiver to measure transit time of the signal and determine a pseudorange to the satellite. A navigation message in the signal enables the receiver to calculate the position of the satellite at the time of transmission. The receiver then uses the calculated ranges and satellite positions to solve for its position in three dimensions.

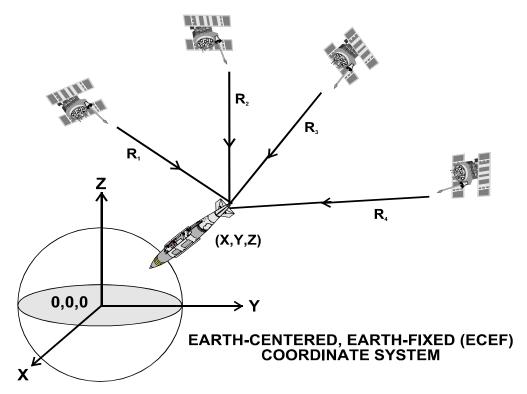
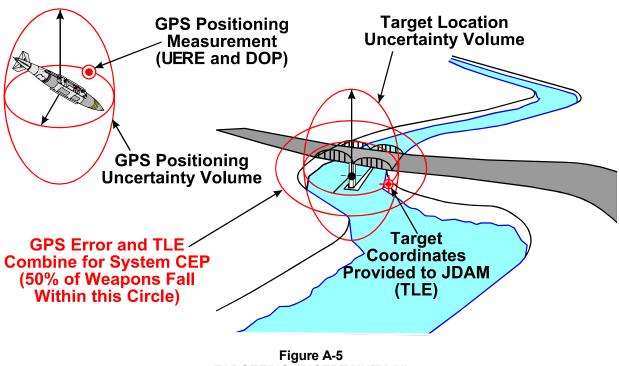


Figure A-4
GPS TRIANGULATION POSITION FIXING (U)

- **A.3.3 GPS SIGNAL PROCESSING.** (U) GPS satellites transmit messages on two carrier frequencies which are code modulated to provide ranging data and control access to the system. A Course Acquisition (C/A) code modulates one carrier and is the basis for the Standard Positioning System (SPS) used for civil navigation. A Precise (P) code modulates both frequencies and is the basis for a Precise Positioning System (PPS) available only to authorized users.
- (U) The "NAV" message is superimposed on both the C/A code and P-code. It contains GPS system time of transmission, ephemeris, and clock data for a particular satellite being tracked, and almanac data for all the satellites in the constellation. Orbital data for the satellites including altitude, position, and speed is constantly monitored by the control segment. Updated data is then periodically relayed back to the satellites for transmission in their navigation messages.
- A.3.4 GPS SECURITY. (U) Access to PPS navigation is controlled by two features using cryptographic techniques. A Selective Availability (S/A) feature purposely reduces GPS accuracy to unauthorized users by introducing controlled errors into the satellite signals. The effects of S/A provide 100 meter horizontal accuracy for civil users of GPS. The accuracy degradations can be increased if necessary (i.e., time of crisis or war) to deny accuracy to a potential enemy. An Anti-Spoofing (A-S) feature is invoked at random times to negate potential imitation of the PPS signals. The technique alters the P-code into a code known as the Y-code. The C/A code remains unaffected. Encryption keys and techniques are provided to PPS users which allow them to remove the effects of S/A and A-S. PPS capable receivers that do not have the proper encryption keys installed are subject to the accuracy degradations of S/A and are not able to track the Y-code.
- **A.3.4.1 PPS Predictable Accuracy.** (U) Predictable accuracy for PPS is 17.8 meters in horizontal accuracy, 27.7 meters in vertical accuracy, and 100 nanoseconds in time accuracy.
- **A.3.4.2 SPS Predictable Accuracy.** (U) Predictable accuracy for PPS is 100 meters in horizontal accuracy and 156 meters in vertical accuracy.

#### NOTE

- (U) Selective availability has been discontinued during peacetime. Therefore, actual SPS accuracy may exceed that listed for non-crypto users of GPS.
- **A.3.4 GPS ERRORS.** (U) Two major factors contribute to GPS positioning errors, called the User Equivalent Range Error (UERE) and Dilution of Precision (DOP). UERE is a measure of the error in the range measurement to each satellite as seen by a receiver. DOP magnifies those errors because of the geometric relationship of the satellites as seen by a GPS receiver. These factors contribute to overall GPS-guided weapon targeting uncertainty (Figure A-5).



TARGETING UNCERTAINTY (U)

- **A.3.4.1 UERE.** (U) UERE is introduced by satellite clock and ephemeris deviations, delays of the signals caused by atmospheric, specifically ionospheric, conditions and local obstructions or magnetic anomalies, and inherent noise and resolution characteristics of the GPS receiver.
- **A.3.4.2 DOP.** (U) Fundamentally, DOP is the quality of positioning data derived from GPS satellites, and is related directly to the geometric positioning of the satellite constellation. This positioning is changing constantly, because the 25+ NavStar GPS satellites are not geostationary, but instead orbit at an altitude of 11,000 miles, which generates relative motion of the satellites in the sky from a fixed reference on the Earth. Therefore, DOP is a function of the orientation of the satellite constellation with respect to Earth location and the time of day, as the "satellite sky" is changing constantly.
- **A.3.4.2.1 DOP Factors.** (U) Figure A-6 illustrates how the geometric relationships of satellites contribute to DOP. If two lines of position are necessary to establish a receiver position, the least amount of error is present when the lines cross at right angles. The greatest amount of error is present when the lines-of-sight between the receiver and satellites approach parallel or when the satellites approach the same plane. Ideally, to minimize DOP, the four satellites that a GPS receiver tracks are distributed evenly, with three near the horizon every 120 degrees and the fourth directly overhead. This configuration practically never occurs, and is uncontrollable anyway. When two or more satellites used in the GPS fix are clumped together in the same part of the sky, angularly close, DOP can be very large.

(U) Occasionally, satellite positioning and availability conspire to cause a large jump or spike in DOP. For example, over a period of 40 days in the southeast United States, there were seven significant PDOP spikes, the largest being 18.4, which lasted about six minutes. In March 2000, three satellites failed, causing spikes as high as 173 in the United States.

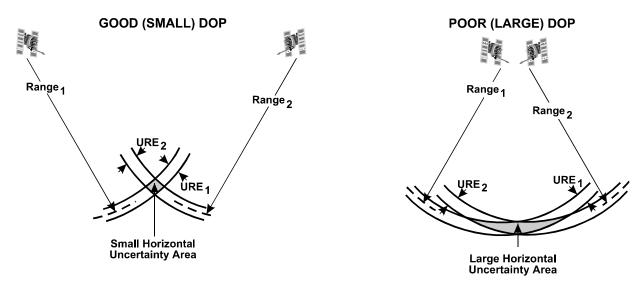


Figure A-6
GPS DILUTION OF PRECISION (DOP) (U)

**A.3.4.2.2 DOP Categories.** (U) There are several categories of DOP. These include horizontal DOP (HDOP), positional DOP (PDOP) and geometric DOP (GDOP). For JDAM, the DOP of interest is PDOP, because JDAM has no pitot-static system and GPS altitude error is relevant. For reference, PDOP value typically is 2.5 or higher. In fact, the JDAM specification accuracy assumes a PDOP value of 4.4 meters. F/A-18 MAGR HERR and VERR values are related to DOP, but more precisely represent the estimated GPS accuracy due to errors combined with satellite availability and accessibility

**A.3.5 GPS JAMMING.** (U) Several types of jamming can be used to degrade the accuracy of a GPS receiver, including the following:

- Spoofing
- CW Jamming (Spot Jamming)
- Wide Band Jamming
- Pulse Jamming
- (U) Typical GPS receiver encryption that allow access to P-code also inhibit spoofing. Noise jamming is overcome through various sophisticated techniques which allow a successful signal lock-on provided sufficient signal-to-noise thresholds are met.

## **ANNEX B**

## JDAM Procedures and Checklists

#### **B.1 MISSION PLANNING**

- **B.1.1** GPS ALMANAC DATA DOWNLOAD. (U) GPS almanac data should be downloaded weekly. The data can be obtained from several sources. The preferred method is via the Internet, which provides *navstar.alm* in its proper format for immediate download to 3.5" disk. Note that the internet will be updated via a PLGR on Monday unless Monday is a holiday. The caveat to this method is that validity of the GPS almanac data provided by websites is difficult to verify as accurate. There are numerous websites that provide GPS almanac data for download; however, even some government-administered sites are known to have posted corrupted, stale, and/or inaccurate GPS almanac data. Therefore, it is recommended that known accurate sites be used.
- (U) The second method is to download GPS almanac data directly from GPS satellites via a PLGR. However, GPS almanac data drawn from the satellites by the PLGR require conversion to *navstar.alm*. This is accomplished simply using a standard PC and a program called *plgralm.exe*.
- (U) Regardless of the acquisition method, once the *navstar.alm* file is saved to a 3.5" floppy disk, it must be checked using a text reader (e.g., Notepad or Wordpad) to ensure that it is in an uncorrupted tabular form before uploading the data into TAMPS. If the file does not appear "organized", it is corrupted and should not be used.

#### NOTE

(U) GPS almanac data downloading usually is accomplished by the TAMPS Administrator.

#### **B.1.1.1** Internet Download (U)

Access any website below

NIPRNET:

http://sirius.chinalake.navy.mil/pub/nawc/slam almanac/

http://strike.mugu.navy.mil/

SIPRNET:

ftp://206.36.97.10/slamgps.navstar.alm

Click on navstar.alm file

Select FILE - SAVE AS

Click on SAVE IN arrow

Select A: (3.5" floppy)

Click SAVE

Replace existing *navstar.alm* file with this copy if one exists. If copying to an empty disk, save as *navstar.alm* 

## B.1.1.2 PLGR Download (U)

#### NOTE

(U) Only download satellite PLGR data between Sunday and Wednesday.

Turn on PLGR in an area with unrestricted view of the sky

Ensure CONT is displayed in the upper left corner of the Startup Screen

If CONT not displayed

Select MENU

Toggle right until SETUP is flashing

Toggle up until SETUP MODE screen is displayed

Toggle right until SETUP MODE is flashing

Toggle up until setup mode reads CONT

Procedures and Checklists (U)

Select POS

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Toggle up until the TRK / SEARCH page displayed

Wait at least 15 minutes after ALM AGE reads ONE DAY

Connect the top port on back of PLGR to a PC comm port using a 9-to-15 pin female-to-female cable

Select the MENU key until the SETUP option appears

Toggle right until SETUP flashes

Toggle up until SETUP I/O appears

Toggle right until SERIAL MODE is STANDARD

On the PC, run the *plgralm.exe* program

When data transfer is complete, select the A: drive (3.5" floppy)

Enter navstar.alm as the FILE NAME

Select SAVE

Open navstar.alm in Wordpad or Notepad and ensure file contents are organized in tabular form

#### B.1.1.3 Uploading navstar.alm Into TAMPS (U)

## **B.1.1.3.1** Via the DBA UTILITIES LOAD Function (U)

Select the TAMPS menu bar

Select the DBA/DBA MODULE

Enter a password if prompted

Select UTILITIES - LOAD - GPS ALMANAC

Enter the effective date and classification

Insert the disk containing *navstar.alm* into the 3.5" drive

Ensure that the filename is *navstar.alm* (all lower case)

Select the 3.5" disk in TAMPS

Select OK

Select FILE - EXIT

## **B.1.1.3.2** Via the PARSE Function (U)

Select the TAMPS menu bar

Select SYSTEM ADMIN – SHELL – ACKNOWLEDGE

Wait until /home/tamps/tamps and nassau(tamps)1: appears

Type dosdir c: on the same line

Press ENTER key

Wait until the files on your disk appear

Wait until nassau(tamps)2: appears:

Type doscp c:\navstar.alm /home/tamps/tamps

Press ENTER key

Wait until nassau(tamps)3: appears

Select DBA - DBA MODULE

Wait for DATABASE ADMINISTRATION window

In DATABASE PASSWORD BOX select OK

#### **NOTE**

(U) No password is required in the DATABASE PASSWORD BOX when uploading GPS almanac data.

Select UTILITIES - GPS ALMANAC PARSER

From the gray window, select FILE - LOAD

From the FILES window:

Directory /home/tamps/tamps Scroll down to navstar.alm

Highlight navstar.alm

Select OK

From the gray window, highlight navstar.alm

Select FILE - PARSE

Wait until *navstar.alm* disappears from the gray window

**B.1.1.4 GPS CRYPTO KEY DOWNLOAD.** (U) GPS weapons require two weeks of crypto keys. TAMPS always loads the current and next week's crypto keys, based on time of mission download according to the TAMPS internal clock. The preferred method is via the KOY-18 & CYZ-10 using AKAT A1001. A back up method is manual entry using AKAK A1001. Both procedures for loading are listed below

### **B.1.1.4.1** Via the KOI-18 (U)

Select the TAMPS menu bar

Select START - APPLICATION - FILL

If protocol is not K18, select UTILITY – SETUP – PROTOCOL – CFD – {device} – K18

Select REC√

Press the ENTER key

Connect the KOI-18 to the TAMPS station

From the KOI-18

Press the RCV key

Run the paper strip through the KOI-18

Wait until the DTD displays RCVD

Select REENTER

Run strip through KOI again

At TEXT ID enter a name such as "JDAM {segment number}"

At SHORT TITLE enter "AKAT A1001"

Edition:

Segment number:

Reg number:

Classification:

When complete, go back and check what was issued.

## **B.1.1.4.2** Via the CYZ-10 (U)

Connect the DTD cable between the CYZ-10 port and Port 2 of the TAMPS workstation

On the CYZ-10

Select: APPL - F4 09 - UTILITY - SETUP - PROTOCOL - LMD

Press the ABORT key Select: XMIT – ISSUE

## NOTE

(U) After ISSUE is selected, the TEXT ID for the first key loaded on the CYZ-10 is displayed. The Short Title, Edition, Segment, and Reg can be viewed by pressing the down arrow. The second key loaded on the CYZ-10 can be viewed by pressing <pg dn> (<pg up> to return to first Key). To designate a key for transmission, move to TEXT ID of that key and SELECT. An "XMT" tag appears to the right of TEXT ID. The key is now designated for transmission to TAMPS. Designate all keys for transmission to TAMPS and continue.

Select SEND DIRECT

#### On TAMPS

Select DBA - GPS CRYPTO KEYS - FILE - LOAD DTD KEYS

Select SEND

Select OK

## On the CYZ-10

Press the CLR key

Wait for keys to load successfully:

## On TAMPS

Select KEY (double-click)

Enter valid dates

#### Procedures and Checklists (U)

## B.1.1.4.3 Using AKAT A1001 (U)

## ON TAMPS

Select DBA - GPS CRYPTO - EDIT - MANUAL ENTRY

Enter SHORT TITLE as "AKAT A1001"

Enter EDITION, REGISTER NUMBER, and SEGMENT NUMBER (first number next to S):

Enter a description (something that describes the crypto week)

Enter the key value

Verify WEEKLY is selected

Enter the start date

Select OK - APPLY

#### **B.1.1.5 KYK-13 CRYPTO KEY UPLOADING (U)**

Turn the PLGR on

Zeroize the PLGR

#### **CAUTION**

(U) Do not use the emergency zeroize function (simultaneously pressing the MARK and NUMLOCK keys), as this also will clear loaded GPS almanac.

#### NOTE

(U) The PLGR cannot contain keys prior to loading.

Toggle MENU until CRYPTO appears (lower left part of screen).

If CRYPTO does not appear, the PLGR already is zeroized.

## If CRYPTO appears

Toggle right until CRYPTO flashes

Toggle up until CRYPTO ZEROIZE appears

Toggle right until ACTIVATE flashes

Toggle up to zeroize

Ensure the KYK-13 is turned off

#### **CAUTION**

(U) The KYK-13 must be turned off when connecting it to the energized PLGR.

Connect the KYK-13 to the PLG

Turn the KYK-13 on

Wait for KEY LOADED or any type of error message

#### **NOTE**

(U) The KEY LOADED or other messages remain displayed until the KYK-13 is off.

Turn the KYK-13 off

Switch channels and repeat previous for a second key, if desired

Disconnect the KYK-13 from the PLGR

Verify crypto keys have loaded properly

Toggle MENU until CRYPTO appears

Toggle right until CRYPTO flashes

Toggle up until CRYPTO STATUS appears

## Troubleshoot CRYPTO STATUS as necessary

If HAVE TODAY'S KEYS and KEYS FOR xx DAYS appears, load is correct and complete

If NO KEYS FOR TODAY appears, PLGR failed to load properly (try again)

If WAITING FOR SV DATA appears on CRYPTO STATUS page, yearly keys were loaded (try again)

## **B.1.2 TAMPS CMPM PLANNING (U)**

## **B.1.2.1** Starting the JDAM CMPM (U)

Select the TAMPS menu

Select MISSION PLANNING - WEAPONS - JDAM

#### **B.1.2.2** Selecting Display Objects (U)

Open the Smart Checklist Select GETTING STARTED – JDAM OBJECTS Select desired objects for display onscreen Select OK

#### NOTE

(U) The JDAM OBJECTS menu controls display of footprints and LARs for all open routes. If LARs are not being displayed, they can be turned on via this menu.

## **B.1.2.2 Selecting Default Units.** (U) The CMPM defaults to the following format for units:

Point coordinates: HDD:MM:SS latitude and longitude

Bearing: DD.DDD degrees relative

Target coordinates: HDD:MM.SS.SS latitude and longitude

Grid: Latitude/longitude
Headings: Degrees true
Distance: Nautical miles

Elevation: Feet Datum: WGS-84

Select the Smart Checklist

Select GETTING STARTED – UNITS Select values for default (if desired)

#### **NOTE**

(U) Due to the precision required by JDAM, it is highly recommended that missions be planned and executed in the WGS-84 datum. Coordinates entered in a datum other than WGS-84 are converted to WGS-84 for the weapon, where some precision can be lost in the conversion.

## If planning a mission using T<sup>3</sup> (Tomcat Tactical Targeting) coordinates

Select HAE (vice MSL) for target ELEVATION DATUM Select the HDD:MM.MMM format for target coordinates

#### NOTE

(U) The HDD:MM.MMMM format used in  $T^3$  coordinates presently is not supported by TAMPS, and the truncation required for data entry in the HDD:MM.MMM format reduces the accuracy of the  $T^3$  coordinates by approximately 1 meter.

## **B.1.2.3** Selecting Mission Classification (U)

Select the Smart Checklist Select GETTING STARTED – CLASSIFICATION Select the proper classification level Select OK

## **B.1.2.4** Creating a JDAM Route (U)

Select the Smart Checklist Select ROUTE IDENTIFICATION – NEW ROUTE Enter ROUTE NAME

#### **NOTE**

(U) The route name always appears in capital letters and is stored in the dataload and displayed in the cockpit as the PP mission name. A simple, consistent naming convention for routes reduces confusion.

#### Enter ROUTE DATE

#### NOTE

(U) The route date is used to select the correct almanac data, perform an GPS PDOP prediction, and retrieve the forecast weather (if available).

Enter other route data as desired

Select IMPACT POINT DEF

Click on radio button to expand the IMPACT POINT/ORP POSITION dialog box

To retrieve an impact point from the database

METHOD 1

Enter WAC/BE

Impact point coordinates are retrieved from the database

METHOD 2 (assumes database targets are displayed)

Select the desired target symbol from the display

Select GET LOCATION from the IMPACT POINT/ORP POSITION dialog box

Impact point coordinates are retrieved from the database

## To create an impact point manually:

Enter TGT NAME

Enter target coordinates and elevation as listed in the source

#### NOTE

(U) Due to the precision required by JDAM, it is highly recommended that missions be planned and executed in the WGS-84 datum. Coordinates entered in a datum other than WGS-84 are converted to WGS-84 for the weapon, where some precision can be lost in the conversion.

#### Enter TOT

#### **NOTE**

(U) TOT is used to compute time to release during the mission and to perform a GPS PDOP prediction, which directly affects Pd calculations.

Expand the OFFSET pane to enter offset data, if required

#### NOTE

(U) Offset elevation is entered relative to impact point elevation rather than absolute MSL elevation.

## Expand TARGET LOCATION ERROR pane

For database targets, TLE should be filled in

## For manually entered targets

Select the desired TLE datum (50/90 CE/LE)

Enter the TLE value associated with the coordinate as listed in the source

#### NOTE

(U) TLE is required to perform weaponeering Pd calculations.

# For T<sup>3</sup> (Tomcat Tactical Targeting) coordinates

Select CE/LE and 50

Select 50

Select LE50 in HORIZ and VERT

Expand IMPACT CONDITIONS pane

## To use default values

Select TGT TYPE as HORIZONTAL or VERTICAL

For horizontal targets, select TGT HARDNESS

Default impact angle/velocity are displayed

#### To select values

Enter desired IMPACT ANGLE referenced from the horizontal (90 degrees being pure vertical)

#### NOTE

(U) JDAM generally is most effective at terminal impact angles steeper than 30°. Terminal impact angles shallower than 30° may restrict LAR excessively.

Enter desired IMPACT ANGLE and IMPACT VELOCITY

If a horizontal target is planned, select HDG UNDEFINED

If a vertical target is planned (as required)

Select IMPACT HEADING

Enter desired impact heading in degrees true

Expand the WEAPONEERING pane

To calculate MAE automatically

Select TGT CLASS and TGT SUBCLASS

Select desired KILL LEVEL

Calculated MAE is displayed

## To manually enter or override default MAE

Enter correct MAE in dialog box

#### **NOTE**

(U) MAE is required to perform weaponeering Pd calculations.

## For area targets (buildings, etc)

Enter target dimensional HEIGHT, LENGTH and WIDTH values

Enter target long-axis in degrees true

## **NOTE**

(U) Target height, length and width are required to perform weaponeering Pd calculations. Target axis is required for the Quantity Release Manager to distribute DMPIs over a target. This function assumes that the impact point is at the center of the target and that the target axis is defined as the angle between the target long-axis and true north.

Expand the FUZE DATA Pane

Select FUZE TYPE

Select ARM TIME

Select DELAY TIME

#### **NOTE**

(U) When planning using the FMU-139 fuze with the FZU-48 mechanical initiator, a CMPM advisory of "The JDAM MPM calculated time of flight exceeds the maximum time for the selected fuze type" should be ignored. The CMPM incorrectly assumes that the MK-122 electrical safety switch always is in use with the FMU-139 fuze, and is applying the 60 second TOF limitation inappropriately. This anomaly is corrected in the JDAM CMPM Version 7 and subsequent.

## **NOTE**

(U) Entering TAMPS fuze data does not change the aircraft SMS electrical fuzing startup default value of safe (OFF). Even if data is defined in TAMPS, the aircrew must select the appropriate EFUZ option on the STORES format prior to release in order to prevent a dud (i.e., fuze safed at release).

#### **NOTE**

(U) TAMPS programming of fuze data applies only to the FMU-152 JPF. FMU-139 and FMU-143 data are programmed via the SMS fuze options page and fuze faceplate, as applicable.

Select OK to close the dialog box.

The display should show a triangle for the impact point and a circle representing the IRLAR

## **B.1.2.5** Defining Release Conditions (U)

Select the Smart Checklist

Select DEFINE/EDIT RELEASE CONDITIONS

Select the desired RELEASE ALTITUDE DATUM (MSL or AGL)

Enter ALTITUDE for release

Enter RELEASE AIRCRAFT HEADING for release

Select the desired RELEASE AIRSPEED DATUM (KTAS or IMN)

Enter AIRSPEED for release

If desired, enter the desired RELEASE FPA and select CLIMB or DIVE

#### **CAUTION**

(U) Release attitude (FPA) may be restricted by higher authority. Consult the cognizant directives regarding authorized release conditions.

Select OK or APPLY

The display should now show a circular IRLAR plus the solid 6DOF IZLAR and the dashed PPIZLAR

Select the Smart Checklist

Select DEFINE/EDIT RELEASE POINT

Select GET LOCATION

Click on the screen at desired release point location

## **CAUTION**

(U) Release points outside of the displayed IZLAR are determined by the LAR algorithm to be unsatisfactory for the existing weapon release conditions. If a selected release point is not within the displayed 6DOF IZLAR, then the weapon is not expected to impact the target if the specified release conditions are used. In this case, a different release point must be selected or the release conditions must be altered to expand the IZLAR to include the desired release point.

Select OK or APPLY

The display should now show an IRLAR, an IZLAR, a dashed PP IZLAR, and a dashed predicted aircraft IZLAR. Select the Smart Checklist

Select SAVE ROUTE

## B.1.2.6 Creating a Single-Target Quantity Release (U)

Select the Smart Checklist

Select QUANTITY RELEASE

Select NEW

Enter a name for the quantity release

## NOTE

(U) The quantity release name serves only as a computer file identifier to allow the mission planner to return later easily to modify a calculated Quantity.

Select OK

Procedures and Checklists (U)

In the top window, select the quantity name

Select SINGLE TARGET

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Select OPEN ROUTE LIST

Select the desired route from those listed

To calculate the number of weapons to achieve a desired Pd

From the OPTION menu, select PD

Enter the desired Pd

Select COMPUTE

## To calculate a Pd given a specified number of weapons

From the OPTION menu, select NUM OF WEAPONS

Enter the desired number of weapons (up to 4 maximum)

Select COMPUTE

Select OK

The specified number of weapons are assigned to distributed DMPIs

#### **NOTE**

(U) The QRM currently only generates a maximum of 4 distributed-DMPI routes. Each new DMPI route is named with the route name and the extension "+Sn" where "n" is a number from 1 to 4 for each weapon assigned. Each route has the same impact coordinates but unique offset data to define the DMPI. These "+Sn" routes can be edited solely through the QRM.

# B.1.2.7 Creating a Multiple-Target Quantity Release (U)

Select the Smart Checklist

Select QUANTITY RELEASE

Select NEW

Enter a name for the quantity release

#### NOTE

(U) The quantity release name serves only as a computer file identifier to allow the mission planner to return later easily to modify a calculated Quantity.

Select OK

In the top window, select the quantity name

Select MULTIPLE TARGET

Select OPEN ROUTE LIST

Select routes

Select an individual route from the window by clicking on it

Select the "Route n" button to place the selected route in the quantity release

#### NOTE

(U) The route placed in the ROUTE 1 box is referred to as the "Master Route". The selected release point for this route must be placed in the intersection LAR for the routes in the quantity release.

## Select OK

## **NOTE**

(U) The QRM generates new routes identical to the selected routes, renaming them with the extension "+Mxx" where "xx" is an alphabetic combination that creates a unique name. (The originally selected routes are retained in TAMPS.) Quantity release routes can be edited only through the QRM.

## **CAUTION**

(U) When placing routes in a mission package, the routes with the "+Mxx" extension have an associated intersection PPIZLAR associated with them. Routes without the extension have the single release PPIZLAR associated with them. Care is required to ensure the correct routes are selected for upload onto the memory device.

## **B.1.2.8** Changing Quantity Release Conditions (U)

Expand the QRM pane Select RELEASE DATA

To change the release point

Select GET LOCATION

Click on the display to select a release point (inside of the intersection LAR)

## **CAUTION**

(U) Release points outside of the displayed IZLAR are determined by the LAR algorithm to be unsatisfactory for the existing weapon release conditions. If a selected release point is not within the displayed 6DOF IZLAR, then the weapon is not expected to impact the target if the specified release conditions are used. In this case, a different release point must be selected or the release conditions must be altered to expand the IZLAR to include the desired release point.

Enter new release conditions as desired (using the previous procedures) Select OK or APPLY

## **B.1.2.9** Creating a Mission Package (U)

#### NOTE

(U) All active routes must be closed before changes can be made to the weapon variant, aircraft type and/or aircraft OFP defaults.

Select the Smart Checklist Select MISSION PACKAGE ID Select NEW MISSION PACKAGE Enter the desired mission package name

## **NOTE**

(U) The selected mission package name also is assigned to the dataload for identification.

Enter a mission package description Enter the mission date

#### NOTE

(U) The mission date is used to select the correct almanac data and GPS crypto keys for upload onto the memory device.

#### To place routes in the package

From the AVAILABLE ROUTES window, select the desired route

Select a button labeled "PPn"

The route will be displayed in the selected window

## To rapidly create multiple packages/dataloads

Select the desired routes for the mission package

Select BUILD DLD

Select OK

Return to the MISSION PACKAGE dialog and build the next package

## B.1.2.10 Uploading a Mission Package to a Memory Device (U)

Select the F/A-18 MPM

Select MISSION PLANNING - FIGHTER - F/A-18

Select an OPAREA

Select MU/MDL INIT FILES

#### **CAUTION**

(U) Do not select the GPS ALMANAC upload option. Currently, a format incompatibility corrupts GPS almanac data when loaded into the aircraft MAGR, and may prevent GPS satellite acquisition and result in loss of the JDAM mission. The aircraft MAGR generally does not require TAMPS almanac data; it uses GPS ephemeris loaded and stored during the previous mission.

Select WEAPONS - CREATE - JDAM - BROWSE - SEARCH

Highlight the desired dataload

Select OK

To select dataloads for individual stations (if desired)

Select BROWSE - SEARCH

Highlight the desired dataload

Select OK

Select OK to close the window and return to MU INIT FILES dialog

## To upload to the memory device

Place the memory device in the appropriate receptacle

Select DOWNLOAD

Select MU ID

#### **CAUTION**

(U) TAMPS will not load mission onto the memory unit if the GPS crypto keys are not available. If no download occurs, a "GPS Crypto Keys Not Available" message is displayed. There is no indication that the GPS crypto keys load correctly other than the absence of the caution.

# **B.1.2.11** Printing Kneeboard Cards (U)

Select the Smart Checklist Select DISPLAY KNEEBOARD Select the desired dataload to display Select PRINT

**B.1.3 SAFE ESCAPE PLANNING.** (U) The JDAM Stick Length Interactive Calculator (SLIC) is the only method available to authorize JDAM releases with respect to safe escape.

## **WARNING**

(U) Deviation from TAMPS-planned and SLIC-authorized launch parameters and/or post-release maneuvering may result in departure from the minimum safe escape envelope for the selected fuzing options.

## **NOTE**

(U) The F/A-18 Tactical Manual does not include JDAM safe escape tables. All safe escape planning for JDAM missions must be accomplished using the SLIC planning tool.

#### **NOTE**

(U) For SLIC versions 3.0 and subsequent, GBU-31(V)2/B safe escape planning is used and required for GBU-3/35 release validation.

Run SLIC program

In PLATFORM pane, on the AIRCRAFT menu select F/A-18A/B/C/D In WEAPON CONFIGURATION pane, select WEAPON as appropriate

## **NOTE**

(U) The SLIC version 3.0 and prior does not include GBU-32/35 planning capability.

## In RELEASE CONDITIONS pane

Select the desired post-release MANEUVER

Enter planned AIRSPEED, FPA and ALTITUDE for launch point

Select the appropriate QUANTITY (1-4)

#### **NOTE**

(U) For JDAM, MULTIPLE is always 1 and INTERVAL is always 300 MSEC.

Select the WEAPON 1 tab

Select the appropriate FUZE (Mk-122 switch is assumed unless FZU is selected explicitly)

Select the appropriate ARM TIME

Select PROXIMITY SENSOR as appropriate

From the TAMPS planning, enter the TARGET ELEVATION, DOWNRANGE TO TARGET, CROSS RANGE

TO TARGET, IMPACT AZIMUTH ANGLE and IMPACT ELEVATION ANGLE

Repeat for each WEAPON tab for selected quantity

Select CALCULATE

??? I AM HERE

# **B.1.4** CARRIAGE/RELEASE/JETTISON LIMITATIONS PLANNING. (U) The ATACS 2.1 software is used in the place of traditional F/A-18 TacMan tables.

Run ATACS program

Select OK

Scroll to bottom of pane

Select CLOSE

From the menu bar select FILE

To use an existing loadout

From the menu bar, select OPEN - PREDEFINED LOAD or STORES PLAN as desired

Select the desired file from the Windows File Manager

#### To start a new loadout

From the menu bar, select STORES PLANNING - SELECT AIRCRAFT

Select PLATFORM - F/A-18

Select the appropriate MODEL/CONFIGURATION

Select the appropriate OFP (OFP 13C is required for JDAM support)

Select the appropriate ARMAMENT COMPUTER

Select AIRCRAFT WEIGHT

Select DEFAULT WT or select INPUT CUSTOM AIRCRAFT WEIGHT and enter a custom weight

Select appropriate TAKE-OFF CONDITIONS

Select appropriate ECM DISPENSER

Enter any desired REMARKS

Select OK

From the menu bar, select STORES PLANNING - EDIT LOAD

Select UPLOAD

Double-click on FUEL TANKS

Select appropriate fuel tank configuration (tanks are selected individually by clicking on the station of choice)

Select LOAD

Select FULL or EMPTY as appropriate or enter a custom fuel weight

Select OK - OK

Double-click on INTERNAL EXPENDABLES

Select the appropriate expendables configuration

Select OK

## NOTE

(U) It is not required to define empty pylons, racks or launchers for stations that will hold stores. ATACS assumes the appropriate pylon/rack combination when a store is uploaded. Only empty stations require definition using the EMPTY RACKS and EMPTY LAUNCHERS buttons.

Double-click on EMPTY RACKS

Select the appropriate pylon or rack for each appropriate empty station

Select OK

Double-click on EMPTY LAUNCHERS

Select the appropriate launcher for each appropriate empty station

Select OK

Select STORES

Select ADD

Select STORES CATEGORY - CONVENTIONAL BOMBS

Select STORE SUBTYPE - PRECISION GUIDED MUNITIONS (LGB/GBU)

Select the appropriate STORE for the JDAM variant

For GBU-31(V)2/B, select GBU-10D/B

For GBU-31(V)4/B, select GBU-24B/B

For GBU-32/35, select GBU-16B/B

Select the appropriate BOMB BODY for the JDAM warhead

#### <u>NOTE</u>

(U) ATACS assumes certain valid fuze and configuration requirements for individual weapons. When the minimum requirements are met, ATACS will display a message that "Stores Selection Is Complete". This is an indication that all other steps in the ADD checklist have only one option. Selecting YES will close the ADD pane and add the newly defined store to the UPLOAD pane for immediate selection.

Select CONTROL UNIT - MAU-169D/B CONTROL UNIT

Select NOSE TYPE - MXU-735/B NOSE PLUG

Select OK

(Repeat this process to define additional stores, as required)

#### NOTE

(U) If a TFLIR pod is carried, it is defined in the same way, using the UPLOAD – STORES – OTHER STORES – PODS option.

From the STORES pane, select OK

Double-click on the defined store

Click on the appropriate station to carry the selected store (may be more than one station selected)

Select OK

(Repeat this process to upload other defined stores)

From the UPLOAD pane, select CLOSE

From the EDIT LOAD pane

Use the UPLOAD and DOWNLOAD options to adjust the loadout as necessary

When the loadout is correct, select CHECK LOAD

Note the AIRCRAFT GROSS WEIGHT information

Select OK

Scroll to the bottom of the NOTES & RESTRICTIONS pane

## NOTE

(U) The NOTES and RESTRICTIONS review is the requirement for mission planning with ATACS.

Select OK

From the EDIT LOAD pane, select OK

Select other options as desired

To exit, select FILE – EXIT and the appropriate SAVE option

## **B.2 PREFLIGHT INSPECTION**

#### **B.2.1 AIRCRAFT WIP CODES (U)**

Verify that the proper weapon, nose fuze, and tail fuze codes are entered on the appropriate weapon stations

#### **B.2.2 WEAPON NOSE (U)**

If a nose plug is installed, verify that it is secure

If a DSU-33 is installed, verify that it is clean and undamaged (a 1/4" gap is allowed between the sensor and the bomb body)

# **B.2.3 WEAPON MIDBODY (U)**

Verify that the strakes are undamaged and secure (no movement by hand with reasonable effort)

If a FZU initiator is installed, verify that clearance exists between the FZU lip and the strake cutout

Verify that the sway braces are properly seated

Verify proper routing of the installed lanyards and arming wires

MK-122 switch: attached to the center positive arming latch

FZU initiator: attached to the center positive arming latch

FMU-139 and FMU-143 arming wires: routed through the aft lug and attached to the aft ZRF solenoid

FMU-152 JPF: no arming wire

DSU-33: no arming wire

## Verify the 1760 umbilical cable installation

Bale is looped through the rack baling rod

Connector is secure and undamaged

Tunnel is secure and undamaged

#### **B.2.4 WEAPON TAIL (U)**

Note the weapon label and identify the control fin locking design

Verify that the GPS coax cover is sealed

Verify that the tail assembly is secured and undamaged

Verify that the fuze is set properly and that the access cover door is secured

Verify that the fins are undamaged

Verify that the fins are secure (minimal freeplay by hand with mild effort)

For friction brake tail kits

Verify the fin faired position is within the fin alignment mark (Figure B-1) for friction brake tail kit

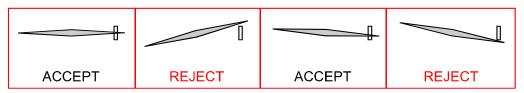


Figure B-1
FRICTION BRAKE TAIL KIT FIN ALIGNMENT INSPECTION (U)

# For pin lock tail kits

Verify that the pin extrudes from the tail kit into each tail fin

Verify that the GPS antenna is clean and undamaged

## **B.3 POST-START**

# **B.3.1 VERIFY MISSION DATA (U)**

Select the MUMI format

Verify the MU ID

Verify mission data download

If no download

Select MORE:JDAM until download is successful

Select HOLD ALL or HOLD MU as desired

## **B.3.2 BIT WEAPONS AND VERIFY SOFTWARE (U)**

Select the BIT:STORES:STATION format Select the JDAM option (perform BIT) Select the S/W option and verify that the proper OFS is listed

## **B.3.3 VERIFY AIRCRAFT NAVIGATION CAPABILITY (U)**

Select the HSI:DATA:ACFT format Verify good GPS ZTOD Verify 2-digit HERR and VERR values Select INS control knob to IFA

#### **B.3.4 INITIALIZE JDAM WEAPONS (U)**

Select the A/G Master Mode Select the STORES format Verify that the proper weapon variant ID legend is present ("J-84", "J-83" or "J109") Verify that the status of each JDAM station is "STBY"

#### **NOTE**

(U) "HOLD" will be displayed under the weapon and "ZTOD" displayed on the UFC until the MAGR acquires its first satellite and the GPS ZTOD is updated initially.

Select the desired JDAM variant option

#### **CAUTION**

(U) JDAM continuous power-on time should be limited to 45 minutes below 1000 feet MSL with ambient temperature at or above 113 degrees F, in order to prevent overheating of the JDAM GCU components.

## **NOTE**

(U) As long as at least one JDAM option on the STORES format is boxed, background power will remain applied to all JDAM weapons. This will aid in fault detection and will avoid the 2:30 wait incurred by the GPS warm-up timer. JDAM does not have to be deselected for catapult launch..

Select the desired arm time via the ARM option (automatically selected for JPF if planned in TAMPS)
Select the desired functioning delay time via the DLY option (automatically selected for JPF if planned in TAMPS)
Select the desired fuze safe-arm status (OFF or other) via the EFUZ or MFUZ option

## **B.3.5 PREPARE JDAM MISSION DATA (U)**

Select the JDAM DSPLY format Select PP or TOO option Select REL TYPE (MAN or AUTO/LOFT) If a quantity release is desired

Select QTY and box the desired stations for a quantity release

#### NOTE

(U) When no quantity release is defined, the "STEP" option steps release priority to the next releasable station of the same variant, according to the normal priority sequence of 8-2-7-3. When a quantity release is defined, the release priority steps only between stations within the selected quantity.

Select RTN

Verify NO GPS KEYS and NO GPS DATA cues are not present for each weapon (via the STEP option) Select the MSN format

For each mission (using the STEP option)

Verify or edit mission data as required

## **CAUTION**

(U) When editing a mission from the cockpit, once a terminal heading is defined for a mission, there is no means of clearing the heading (i.e., heading undefined) prior to SCS 15C. This may result in greatly reduced LARs and should be avoided unless essential for the mission.

#### If JPF present

Select JPF format Verify or edit JPF settings as required Select RTN

Select RTN

Select the desired mission (PP# or TOO# as appropriate)

## **B.4 MISSION EXECUTION**

#### **B.4.1 CHECK A/G STATUS (U)**

Select the A/G Master Mode
Select the STORES format
Verify that all JDAM stations selected for release show status RDY
Verify that the fuze safe-arm status is armed (i.e., EFUZE or MFUZ not OFF)

#### **B.4.2 VERIFY WEAPON HEALTH AND MISSION DATA (U)**

Select the STORES format Verify the JDAM weapon status cues

## WARNING

(U) JDAM weapons that indicate a WFAIL status are skipped by the SMS during the quantity release sequence, which in specific cases can result in an uncontrollable asymmetry following release. If a JDAM weapon selected for a quantity release indicates a WFAIL status, the aircrew must determine if the potential for an uncontrollable asymmetry after release exists.

#### **CAUTION**

(U) Troubleshooting within 5 minutes of the intended weapon release point that involves cycling (i.e., unboxing and boxing) JDAM weapons may cause mission failure due to weapon unavailability during the period of GPS warm-up countdown timer operation, satellite reacquisition and transfer alignment to a GOOD status.

Verify that ALN QUAL cue is 01 GOOD for all selected stations (via the STEP option) If ALN QUAL is not GOOD

Refer to Section B.4.3.1 (weapon INS alignment problems)

Select MSN format (if desired)

Verify mission (and JPF if equipped) data

**B.4.3 VERIFY THE GPS ENVIRONMENT.** (U) At the GPS jamming decision point (approximately 1-2 minutes prior to release), the aircrew must determine GPS availability for a JDAM weapon release. If GPS is expected to be available, then the planned release can be performed. However, if GPS is expected to be denied, then the release must be modified as necessary to produce a TOF of less than 30 seconds, since an INS-only guidance mode is valid and INS drift must be contained to ensure specified accuracy.

## **CAUTION**

(U) Aircraft cockpit cues only can indicate the availability of GPS to the aircraft at or near the intended point of release. There is no indigenous method available to aircrew to determine the availability of GPS to the weapon in the midcourse or terminal guidance phases.

Perform as many of the following steps as feasible

On the left DDI, verify no P/INS advisory is displayed

Select the HSI format

Verify that POS/AINS is displayed as the position keeping source

Select HSI:DATA:ACFT format

Verify a 2-digit HERR and VERR

If valid POS/AINS with 2-digit HERR and VERR is not available to the aircraft

Abort the JDAM mission

If valid POS/AINS with 2-digit HERR and VERR is available to the aircraft

Continue with the JDAM mission

Attempt to verify GPS availability in the terminal target area (if able)

If GPS aiding is not expected to be available in the terminal target area

Abort the JDAM mission

## B.4.4 RELEASE (U)

Select A/G Master Mode

Select the STORES format

Verify the ALN QUAL is 01 GOOD for the priority station

Verify that all stations selected for release indicate a RDY status

#### WARNING

(U) JDAM weapons that indicate a WFAIL status are skipped by the SMS during the quantity release sequence, which in specific cases can result in an uncontrollable asymmetry following release. If a JDAM weapon selected for a quantity release indicates a WFAIL status, the aircrew must determine if the potential for an uncontrollable asymmetry after release exists.

Select the Master Arm switch to ARM

If the AUTO/LOFT release mode selected

In the HUD, verify IN RNG is displayed (to achieve a releasable condition)

Select the STORES format

Verify that the selected JDAM option is not crossed out

In the HUD, verify that the weapon legend is not crossed out

If the weapon legend on the STORES format or in the HUD is crossed out

Do not release

If the weapon legend on the STORES format and in the HUD are not crossed out

At the desired release point, depress the A/G release button (pickle)

#### **NOTE**

(U) The time delay from aircrew release consent (pickle) to first JDAM store ejection is approximately 800 milliseconds. The release interval between JDAM stores is preset in the SMS to 300 milliseconds. Therefore, the expected worst-case time delay from pickle to last store separation, assuming a quantity release of 4 weapons, is approximately 1.7 seconds.

#### **B.4.5 POST-RELEASE (U)**

After all stores have been released, comply with the required safe escape maneuvering

Select the Master Arm switch to SAFE

Select Master Mode as required

Select the STORES format

Verify no stores indicate a HUNG or H+xxx status cue

If a hung store is present

Select the STORES format

Deselect (unbox) the applicable JDAM option

Select SIM (to lock the bomb racks)

Comply with applicable hung store recovery procedures

Do not cycle landing gear over populated areas

Do not select JDAM weapon options, even to erase classified data

## **B.4.6 POST-MISSION (U)**

Select the MUMI format

Deselect HOLD MU or HOLD ALL if selected to erase MU, SMS, and MCs after landing.

If a hung JDAM store is present

Do not select JDAM weapon options, even to erase classified data

## If no hung JDAM stores are present

Select the STORES format

Select (box) the JDAM option

Select the ERASE option and select ACPT

Verify all JDAM weapons indicate ERASE

If any store indicates an EFAIL status, then after landing perform the following

Alert ground maintenance crews to cycle the SMS circuit breakers

Wait for SMS initialization and inventory

Select the STORES format

Select (box) the JDAM option

Select the ERASE option and select ACPT

Verify all JDAM weapons indicate ERASE

If any store still indicates an EFAIL status

Alert ground maintenance personnel to perform a manual erase using the CMBRE

#### NOTE

(U) If the GPS crypto keys remain in the weapon memory, then the weapon must be secured until it is declassified via manual erasure.

After landing, verify that the auto-erase function executes properly Verify that no "C" MSP codes remain

## **B.5 TROUBLESHOOTING**

#### **CAUTION**

(U) Troubleshooting within 5 minutes of the intended weapon release point that involves cycling (i.e., unboxing and boxing) JDAM weapons may cause mission failure due to weapon unavailability during the period of GPS warmup countdown timer operation, satellite reacquisition and transfer alignment to a GOOD status.

## B.5.1 BULK DATA ERROR CUES, MU LOAD CUE, OR CORRUPTED JDAM/JPF DATA (U)

Select the MUMI:MORE format

Select the JDAM option

If the problem persists

Select the STORES format

Cycle (unbox and rebox) the JDAM option

If the problem persists

Eject and reinsert the memory device

If the problem persists

Replace the memory device with the backup memory device (if available)

If a backup device is not available or the problem persists

Cycle the mission computers

If the problem persists and GPS crypto keys are available for manual entry

Select the MSN format

Manually enter JDAM mission data

If a JPF is installed

Select the JPF format

Manually enter JPF data

Refer to Section B.5.2.3 (no GPS crypto key problems)

If the problem persists and GPS crypto keys are not available for manual entry

Abort the JDAM portion of the mission or reassign to another aircraft

# **B.5.2 GPS PROBLEMS (U)**

## B.5.2.1 No GPS ZTOD and/or HOLD Station Status (U)

Wait at least 3 minutes after initial powerup

Check IFEI data and time

If "HOLD" status remains

Enter ZTOD via the UFC

#### **CAUTION**

(U) When entering ZTOD via the UFC format, it is recommended that precise ZTOD (within a few seconds) be used. Gross ZTOD errors can result in weapon corruption once true ZTOD is received after satellite acquisition.

Enter Zulu date via the UFC

#### NOTE

(U) Zulu date is entered by selecting SET:DATE and entering the date in {mmyydd} format, with no leading zeroes for the month (e.g., March 29, 2002 is entered as {32902} and not {032902}).

If problem persists, respot the aircraft (possible GPS reception problem, especially if afloat)

## **B.5.2.2 NO GPS DATA Cue (U)**

Wait at least 3 minutes after initial powerup

Select the HSI:DATA:ACFT format

Verify waypoint 0 information

If ZTOD is not received

Refer to Section B.5.2.1 for GPS time problems

#### If ZTOD is present and accurate

Select the STORES format

Deselect any boxed JDAM option (to run a non-priority store BIT)

Select the BIT:STATION:STORES format

Select JDAM

#### **NOTE**

(U) If a JPF is installed, then it is recommended that the BIT format remain displayed and no data entry be accomplished during a JDAM BIT in order to prevent possible JPF data corruption.

Select the STORES format

Reselect the JDAM option

## If the problem persists

Recycle weapon power (unbox and rebox) periodically

If the problem persists and an ALN QUAL of GOOD is achieved

Modify the release profile to achieve a TOF of 30 seconds or less to minimize weapon INS-only drift

If an ALN QUAL of GOOD is not obtained or the release profile cannot be modified to reduce TOF

Abort the JDAM portion of the mission or reassign to another aircraft

# B.5.2.3 NO GPS KEYS Cue (U)

Refer to Section B.5.2.1 (GPS time problems)

If problem persists

Refer to Section B.5.1 (Bulk data problems)

If problem persists

Refer to Section B.5.1 (Bulk data problems)

If problem persists and GPS keys available for manual entry

Select the GPS ENTRY format

Enter GPS crypto keys manually

**NOTE** 

(U) Manual GPS key entry is time-consuming and prone to data entry errors that cannot be identified after entry with the current display mechanization.

#### If problem persists or GPS keys or time unavailable for manual entry

Abort the JDAM portion of the mission or reassign to another aircraft

# **B.5.2.4 KEYS INVALID ENTRY Cue (U)**

#### If on deck

Request that the MAGR be keyed via KYK-13 by ground maintenance personnel

#### If airborne

Abort the JDAM portion of the mission or reassign the JDAM mission to another aircraft

## **B.5.3 POOR WEAPON INS QUALITY**

## B.5.3.1. TXA DEGD, MARG or UNST Cues (U)

Select the JDAM DSPLY format

Verify that the TIMING cue is not present

If the TIMING cue is present

Wait for the TIMING cue to disappear and monitor the transfer alignment for normal progress

## If the TIMING cue is not present and the problem persists

Perform a transfer alignment maneuver

## If the problem persists

Select the HSI format

Verify that aircraft alignment is POS/AINS with 2-digit HERR and VERR values

Select the STORES format

Cycle (unbox and rebox) the JDAM option

## If the problem persists and the align quality numeric is 4 or higher

Continue periodic cycles of weapon power

If the problem persists, abort the JDAM portion of the mission or reassign to another aircraft

## If the problem persists and the align quality numeric is 3 or lower

Expect the align quality to never reach GOOD

Modify the release profile to achieve a TOF of 30 seconds or less to minimize weapon INS-only drift

## If the release profile cannot be modified to reduce TOF

Abort the JDAM portion of the mission or reassign to another aircraft

# **NOTE**

(U) The plain language alignment quality cue may lag the numeric transfer alignment quality cue by up to 60 seconds due to Kalman filtering in the weapon INS.

#### **B.5.4 WEAPON STATUS PROBLEMS**

## B.5.4.1 Weapon NOT RDY Cue (U)

Select the BIT:STORES:STATION format

Select the JDAM option

## If the problem persists

Select the BIT:STORES:STATION format

Deselect any boxed JDAM option (to run a non-priority store BIT)

Select the BIT:STORES:STATION format

Select the JDAM option

#### If the problem persists

Select the STORES format

Cycle (unbox and rebox) the JDAM option

## If the problem persists

Refer to Section B.5.1 for bulk data problems

## **B.5.4.2** Weapon WFAIL Status Cue (U)

Select the BIT:STORES:STATION format

Select the JDAM option

## If the problem persists

Select the BIT:STORES:STATION format

Deselect any boxed JDAM option (to run a non-priority store BIT)

Select the BIT:STORES:STATION format

Select the JDAM option

## If the problem persists

Select the STORES format

Cycle (unbox and rebox) the JDAM option

## If the problem persists

Abort the JDAM portion of the mission or reassign to another aircraft

## **B.5.4.3** Weapon WDEGD Status Cue (U)

Select the BIT:STORES:STATION format

Select the JDAM option

## If the problem persists

Select the BIT:STORES:STATION format

Deselect any boxed JDAM option (to run a non-priority store BIT)

Select the BIT:STORES:STATION format

Select the JDAM option

# If the problem persists

Select the STORES format

Cycle (unbox and rebox) the JDAM option

## If the problem persists

## If JPF FAIL cue present

Expect default (i.e., faceplate) arm and functioning delay times

Select the STORES format

Select the JPF faceplate arm time setting via the ARM option (for correct dud calculations)

Continue the JDAM mission

#### If GPS FAIL cue present

Refer to Section B.5.2.2 (weapon GPS problems)

## If TIK FAIL cue present

Continue the JDAM mission

#### If any other subsystem failures present

Abort the JDAM portion of the mission or reassign to another aircraft

# **ANNEX C**

FMU-152/B Joint Programmable Fuze (JPF)

# **C.1 GENERAL DESCRIPTION**

## C.1.1 OVERVIEW

- **C.1.1.1 Introduction.** (U) The FMU-152 Joint Programmable Fuze (JPF) is an electromechanical bomb fuze designed for installation in the tail fuze well of general-purpose warheads, and is compatible with all MK-80 series blast-fragmentation warheads. The JPF is equivalent in size and shape to the FMU-139 electromechanical bomb fuze. The JPF also is designed and manufactured to be sturdy enough to provide a hard-target penetration capability down to 20 feet, and may be used with the BLU-109 penetrator warhead. The FMU-152 specification stipulates a shelf life of 20 years and a service life of 10 years once the box is opened.
- **C.1.1.2 Design.** (U) The JPF is divided internally into two functional sections, called the "nonsurvivable" and "survivable" sections. The nonsurvivable section primarily controls fuze arming, and is powered by a capacitor that is charged during bomb release. The survivable section primarily controls the terminal functions of impact sensing, delay and detonation, This section is powered by an internal 24-hour battery that is fired during bomb release, and incorporates an internal digital signal processor to control terminal fuze operation.
- **C.1.1.3** Theory of Operation. (U) The FMU-152 is capable of internal digital programming via a serial data interface for applications that include digital communication with the host aircraft. A conventional fuze faceplate (Figure C-1) provides manual fuze settings selection for backup default of serial interface operation or for backwards-compatible, non-interfaced operation.

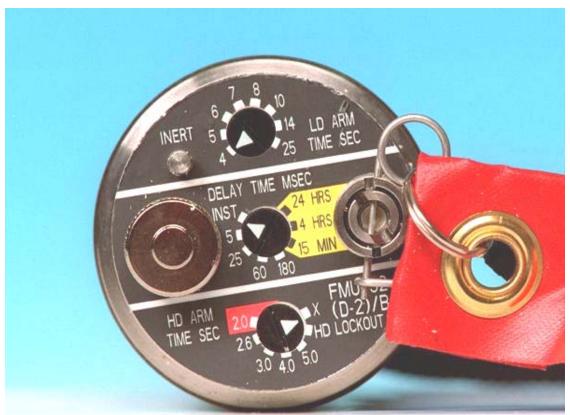


Figure C-1 FMU-152 FUZE FACEPLATE (U)

#### C.1.2 FUNCTIONAL DESCRIPTION

**C.1.2.1 Fuze Initiation.** (U) The FMU-152 is initiated by voltage either from the aircraft Fuze Function Control Set (FFCS) via the MK-122 arming switch or directly from the FZU-55/B mechanical initiator.

## **NOTE**

- (U) The FMU-152 is supported on the F/A-18 aircraft only using the MK-122 electrical safety switch.
- (U) Once the aircraft serial interface is severed during jettison, fuze operation is completely internal, unless an external arming wire is used. In this case, the fuze requires that the aircraft extract the arming wire from the fuze gag rod during the bomb release sequence in order for the fuze to provide a detonation pulse when commanded by the onboard processor.
- **C.1.2.1 Fuze Arming.** (U) Fuze arming is accomplished via the conventional method of physically rotating an explosive train within the fuze into alignment, which allows the fuze to propagate a low-order firing pulse into the warhead chamber for detonation. If an external arming wire is used to pin the fuze gag rod, then the wire must be extracted completely during the release sequence to allow the explosive train to rotate. Without this rotation to arm the fuze, an activated fuze may attempt to cause detonation but cannot, since the nonaligned explosive train will not propagate into the warhead.

## NOTE

- (U) An arming wire is not required for the FMU-152 when used on the F/A-18 aircraft with MK-122 electrical safety switch.
- (U) FMU-152 arm time tolerance is 10% (e.g., for a 10 second arm time, the fuze may arm between 9.9 and 10.1 seconds after release), which is similar to other general-purpose bomb fuzes.

## **CAUTION**

- (U) During mission planning, regardless of the fuze type, attack profiles and arm times should be chosen such that an adequate margin exists between calculated weapon time of fall and fuze arm time, in order to avoid unnecessary risk of duds.
- **C.1.2.2 Fuze Functioning.** (U) An internal microswitch senses deceleration above a nominal threshold and then signals the fuze processor that impact has occurred. The FMU-152 design specification threshold is 40-80g; that is, the fuze always functions above 80g and never functions below 40g. Once the impact signal is received by the processor, the specified functioning delay is applied and the firing pulse is initiated. A downstream channel allows for the insertion of a synthetic impact signal by the DSU-33 proximity sensor, in order to provide pre-impact functioning.

## C.2 APPLICATIONS

#### C.2.1 INTERFACED APPLICATION

**C.2.1.1 Available Fuze Settings.** (U) FMU-152 arm and functioning delay times when used with JDAM are segregated into two groups, cockpit-selectable settings and fuze faceplate settings. Cockpit-selectable settings include all available fuze settings, and are controlled and selected using aircraft controls and displays via the serial interface between aircraft, weapon and fuze. A useful subset of the settings are available via fuze faceplate settings for use in operational backup planning. Available FMU-152 fuze settings are listed in Figure C-2.

## **CAUTION**

(U) Arm times less than 10 seconds are not authorized for JDAM applications.

#### **NOTE**

(U) Due to limitations of the FMU-152 charging capacitor, use of the 25-second arm delay may result in a weapon dud.

LOW-DRAG ARM TIME			HIGH-DRAG ARM TIME 1		FUNCTIONING DELAY		
FACEPLATE	COCKPIT <sup>2</sup>		FACEPLATE	COCKPIT <sup>2</sup>	FACEPLATE	COCKPIT <sup>2</sup>	
4	4	4.5	2	2	INST	INST	15 ms
5	5	5.5	2.6	2.6	5 ms	5 ms	35 ms
6	6	6.5	3	3	25 ms	25 ms	45 ms
7	7	7.5	4	3.5	60 ms	60 ms	90 ms
8	8	8.5	5	4	180 ms	180 ms	240 ms
10	10	9	HD lockout	5	5 min	5 min	30 min
14	14	9.5	X		4 hr	4 hr	45 min
25	25				24 hr	24 hr	8 hr
							12 hr
							16 hr
							20 hr

- Notes: 1. High drag arm times are not used in JDAM applications.
  - 2. Settings in italics are selectable only through a serial interface.

# Figure C-2 FMU-152 AVAILABLE CONTROL SETTINGS (U)

**C.2.1.2 Fuze Control.** (U) When used in conjunction with weapons such as JDAM, where a serial digital interface is available between the weapon and the fuze, the JPF can accept discrete programmed settings data via the weapon 1760 umbilical interface from the aircraft, which are independent of and override the fuze faceplate settings. Typically, FMU-152 arm and functioning delay settings are set according to the values selected during mission planning and transferred from the memory device, but may be modified manually by the aircrew using existing cockpit controls and displays. In the absence of programmed settings (i.e., the serial interface is lost or is not present), then the JPF defaults to the fuze faceplate settings.

#### NOTE

(U) If a JPF fuze code is present, the FFCS always applies +195V for arming the JPF, provided that the fuze-enable signal is received from the cockpit (i.e., EFUZ ON selected on the STORES format).

#### NOTE

(U) For JDAM configured with the FMU-152 and DSU-33, there is no provision for disabling the proximity burst function of the DSU-33 as there is with the FMU-139. This weapon configuration always functions as proximity burst with the specified delay (i.e., selection of instantaneous fuzing results in pure airburst while a selection of a functioning delay results in delay from the sensed airburst altitude.

## C.2.2 NON-INTERFACED (BACKWARD-COMPATIBLE) APPLICATION

- **C.2.2.1 Available Fuze Settings.** (U) Available FMU-152 arm and functioning delay times are segregated into two groups, cockpit-selectable settings and fuze faceplate settings. Cockpit-selectable arm time settings in the backward-compatible mode are equivalent to typical FMU-139 fuze settings, with "5.5" and "10" second arm times available via the ARM option on the STORES format, except that the "10" selection has a different function. Any functioning delay setting on the fuze faceplate is available, with the ability to override this selection from the cockpit for instantaneous fuzing.
- **C.2.2.2 Fuze Settings Control.** (U) When used in a backward-compatible, non-interfaced application, such as a general-purpose bomb, FMU-152 arm time control is accomplished in a manner similar to that of FMU-139. During the release arming sequence, the application of electrical pulses encoded with specific voltage and polarity control the arm time and functioning delay selection (Figure C-3). All stations selected for release receive the same voltage signal representing the cockpit selections of arm time and functioning delay.

## **NOTE**

(U) The FMU-152 automatically duds if FFCS power is applied more than 375 milliseconds, in order to prevent the fuze from arming in the event of a hung release.

COCKPIT SELECTION		FFCS	LOW DRAG ARM	HIGH DRAG	FUNCTIONING	
ARM 1	DELAY	VOLTAGE	TIME	ARM TIME	DELAY	
"5.5"	"INST"	-195	5.5 seconds	2.6 seconds	Per DELAY switch 2	
"10"	"INST"	+195	Per LD ARM switch	2.6 seconds	Per DELAY switch 2	
"5.5"	"DLY1"	-300	5.5 seconds	2.6 seconds	Instantaneous 3	
"10"	"DLY1"	+300	Per LD ARM switch	2.6 seconds	Instantaneous 3	

NOTES: 1. The 5.5-second low-drag arm time is not authorized for USN use.

- 2. If a proximity signal is received, it is used to determine function and initiate functioning delay.
- 3. Any proximity signal is ignored.

# Figure C-3 FFCS VOLTAGE CONTROL (U)

**C.2.2.2.1 Arm Time Control.** (U) Cockpit selection of the "5.5" ARM option on the STORES format commands a 5.5-second arming time. However, cockpit selection of the "10" ARM option commands the fuze faceplate setting for low-drag arm time. Since each bomb arms according to its own fuze faceplate setting, the aircrew may vary bomb arm times (during bomb build-up) and select them from the cockpit.

## **CAUTION**

(U) The allowable low-drag arm time fuze faceplate settings for Navy applications only are 7, 10 or 14 seconds.

## **NOTE**

- (U) If the SMS inventories a store indicating a high-drag device and a JPF, the JPF always selects a high-drag arm time (HDAT) of 2.6 seconds.
- **C.2.2.2.2 Functioning Delay Control.** (U) Cockpit selection of instantaneous fuzing via the DLY INST option on the STORES format invokes instantaneous fuzing regardless of fuze faceplate setting. Cockpit selection of functioning delay via the EFUZ DLY1 option on the STORES format invokes the functioning delay associated with the high-drag arm time setting on the fuze faceplate, which can include INST. This allows a wide variety of JPF delay selections, since each station may have an independent and different functioning delay setting.

# **ANNEX D**

# **DSU-33 Proximity Sensor**

## **D.1 GENERAL DESCRIPTION**

## D.1.1 OVERVIEW

**D.1.1.1 Introduction.** (U) The DSU-33 (Figure D-1) is a electric bomb fuze proximity sensor for installation in the nose fuze well of general-purpose warheads. It is compatible with all MK-80 series general-purpose bombs and is intended to provide low-altitude proximity functioning in both low and high drag configurations.

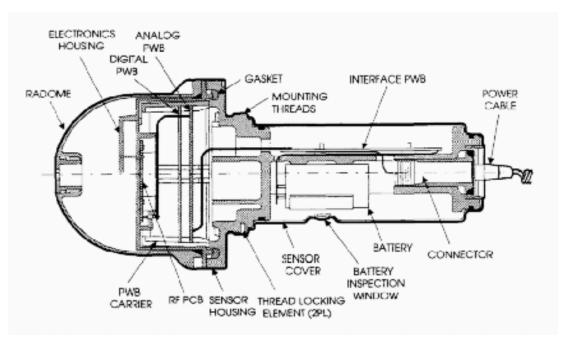


Figure D-1
DSU-33 CUTAWAY DIAGRAM (U)

- **D.1.1.2 Design.** (U) The DSU-33 incorporates a thermal battery to provide electrical power for autonomous operation. The sensor uses no other mechanical or moving parts. The DSU-33 utilizes a radio-frequency Doppler radar as a ranging source and incorporates built-in electronic countermeasures (ECM) resistance. All initiation and fuze pulse signals are accommodated through the sensor power cable.
- **D.1.1.3 Variants.** (U) The DSU-33 is available in two variants, which are operationally interchangeable.
- **D.1.1.3.1 DSU-33A/B Variant.** (U) The DSU-33A/B is the original variant, manufactured to a USAF specification. It has a nominal battery life of 90 seconds and a nominal shelf life of 180 days. The sensor has an battery status indicator that appears yellow before battery initiation and black after battery initiation. The DSU-33A/B has a design deficiency when employed with the MK-122 switch for quantity releases from the F/A-18 aircraft. This flaw is a sneak circuit that saturates the AWW-4 whenever –195 volts is applied. The AWW-4 cannot reset from the drain quickly enough in the 300ms JDAM release interval, and every bomb after the first bomb in the quantity may dud due to lack of charging power.

#### **CAUTION**

(U) Use of the DSU-33A/B (USAF variant) in quantity releases off of the F/A-18 aircraft may result in multiple duds.

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- **D.1.1.3.2 DSU-33B/B Variant.** (U) The DSU-33B/B is a newer variant, manufactured to a more stringent USN specification. It has a nominal battery life of 200 seconds and a nominal shelf life of 5 years. The sensor has a battery status indicator that appears white or light gray before battery initiation and dark gray or black after battery initiation. The DSU-33B/B corrects the sneak circuit design deficiency of the DSU-33A/B, which allows employment with the MK-122 switch for quantity releases from the F/A-18 aircraft.
- **D.1.1.4 Theory of Operation.** (U) The sensor provides a firing pulse signal prior to ground impact. The design height of burst is 5 to 35 feet. The sensor operates autonomously and automatically after battery initiation, requiring no control or management by the aircrew. In specific applications, DSU-33 functioning can be controlled selectively from the cockpit.

#### **D.1.2 FUNCTIONAL DESCRIPTION**

Annex D

- **D.1.2.1 Sensor Initiation.** (U) The DSU-33 is connected to the aircraft via a power cable to route voltage to the sensor during weapon release. The DSU-33 uses the same power that is applied to the weapon fuze in order to initiate its thermal battery. The sensor operates automatically upon receipt of the thermal battery initiation signal. No arming lanyard is required. There are no switches or settings on the DSU-33 itself. Provided that the sensor functions correctly, bomb detonation will occur at the specification height above the ground automatically, provided that the fuze has armed properly.
- **D.1.2.2 Sensor Function.** (U) After the DSU-33 receives a thermal battery initiation signal as the bomb is released from the aircraft, the sensor radiates RF energy to sense proximity. Once the sensor determines that the weapon has reached the design height of 5 to 35 feet height over all surfaces, it provides a proximity signal fuzing pulse to the fuze through the power cable. The actual fuzing height depends on the angle of approach and surface reflectivity. Steeper angles equate to a higher burst altitude. More reflective surfaces also result in higher burst altitudes (e.g., water is more reflective than sand and causes a higher burst altitude).
- (U) If a functioning delay is selected in conjunction with the DSU-33, the DSU proximity signal initiates the fuze functional delay timer before bomb impact occurs.

# **D.2 APPLICATIONS**

#### **D.2.1 SELECTIVE CONTROL**

- **D.2.1.1 Electrical Safe-Arm Control.** (U) When the DSU-33 is used in conjunction with electrical safe-arm control (i.e., MK-122 switch), proximity VT fuzing may be activated selectively via aircrew cockpit options.
- **D.2.1.2 Mechanical Safe-Arm Control.** (U) When the DSU-33 is used in conjunction with mechanical safe-arm control (i.e., FZU-48), proximity VT fuzing cannot be controlled selectively via aircrew cockpit options, and always is active after weapon release.

## **D.2.2 INTERFACE**

- **D.2.2.1 JDAM Serial Interface.** (U) When the DSU-33 is used in conjunction with a JDAM weapon, DSU-33 activation after weapon release is controlled by digital commands via the 1760 serial interface.
- **D.2.2.2 Backwards Compatible Interface.** (U) When the DSU-33 is used in conjunction with conventional (non-JDAM) weapons, DSU-33 activation after weapon release is controlled by selective voltage application only if electrical safe-arm control is used.

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